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MINISTRY OF AGRICULTURE

NATIONAL AGRICULTURAL LABORATORIES

KENYA SOIL SURVEY

SEMI-DETAILED SOIL SURVEY OF KELELWA FARM

(NAKURU DISTRICT)

by

D. O. Michieka

SEMI-DETAILED SOIL SURVEY REPORT No. S9

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Summary

This report describes the results of a semi-detailed soil survey of a farm of approx. 1,060ha (information from Farm and Land Management Division) situated approximately 15 kilometres north of Rongai township on the Nakuru-Eldama Ravine road. The average annual rainfall figures vary from 888mm at Kampi ya Moto-Rongai to 1082mm at Esageri Grazing Scheme. Rainfall is bimodal and the rainy seasons occur generally in the months of April-August when the average rainfall is 555mm and September-March when it is 420mm. The probability that rainfall is less than 2/3Eo during the April-August and September-March periods is 20 and 100 percent respectively. Based on the climatic study, the area is placed in agroclimatic zone III, which has medium high potential for small-holder arable farming.

Five main landforms, namely piedmont plains, volcanic plains, minor valleys, bottomlands and badlands occur on the farm. These landforms are associated with twelve major soil units which are indicated on the accompanying soil maps (appendix 2) at scale 1:10,000.

The soils are developed on pyroclastics and sediments from pyroclastic rocks of the Rongai plains. The moderately deep to deep and well drained to imperfectly drained soils occupy the low-lying areas of the volcanic plains and bottomlands. The shallow and extremely eroded soils are found in the badlands. The majority of the soils are clayey in texture and have medium pH and low level of phosphorous, organic carbon, Zn and Cu.

Erosion poses a big problem in the farm and the surrounding areas although strict measures have been taken to control it on the farm. About one quarter of the farm has a slight erosion hazard, one fourth a moderate erosion hazard and one quarter a moderate to severe, or severe erosion hazard. Gullies of approx. 3-30 metres deep and several metres wide occupy the central portion of the farm (unit VGE in appendix 2) and the surrounding areas especially the area bordering the farm from the east.

To evaluate the suitability of the land for maize, millet, sorghum, sunflower and livestock farming with advanced technology, the following land qualities were considered:

1. climatic characteristics
2. soil moisture storage capacity
3. possibilities of mechanization (use of agricultural implements)
4. resistance to erosion (sheet and gully erosion after clearing)
5. presence/hazard of water-logging (availability of oxygen for root growth)
6. chemical soil fertility
7. nutritional value of vegetation
8. presence of overgrazing
9. treadibility
10 hindrance by vegetation

The criteria for the suitability classification are given in table 5 and 6. The results of the suitability classification are outlined in appendix 3 and are summarized in table 7 and 8.

The following suitability classes are used:

1.1. highly suitable
1.2. moderately suitable
1.3. marginally suitable
2. unsuitable

Out of a total of approx. 950* ha. of land, 288 ha are considered highly suitable for arable farming, 343 ha. highly-moderately suitable, 48 ha. moderately suitable, 53 ha. marginally suitable to unsuitable and 208 ha. unsuitable. For livestock farming, roughly 385 ha. are highly suitable, 185 ha. highly to moderately suitable, 97 ha. moderately suitable, 57 ha. marginally suitable and 204 ha. unsuitable

* This total was calculated on the basis of the soil map.

1 Introduction

The semi-detailed soil survey was carried out at the request of the Provincial Director of Agriculture (Nakuru). The investigation was conducted after a site evaluation of the farm had revealed that there exist different kinds of soils within the farm and therefore a soil survey at semi-detailed level would be required to show these soil differences (Michieka, 1980). The aim was to establish and describe the conditions of these soils within the farm for arable farming and animal production. The semi-detailed soil survey which was started in August 1980 took two months to complete with the labour being provided for by the station. The survey team comprised of the author, two technical assistants and a driver.

The author wishes to acknowledge the cooperation and help rendered by the staff of the farm. Also acknowledged is the cooperation of the chemistry section of the National Agricultural Laboratories which undertook the soil analyses. Messrs. H. Onyono and T. Wachira are also acknowledged for taking part in the soil survey.

2. The environment

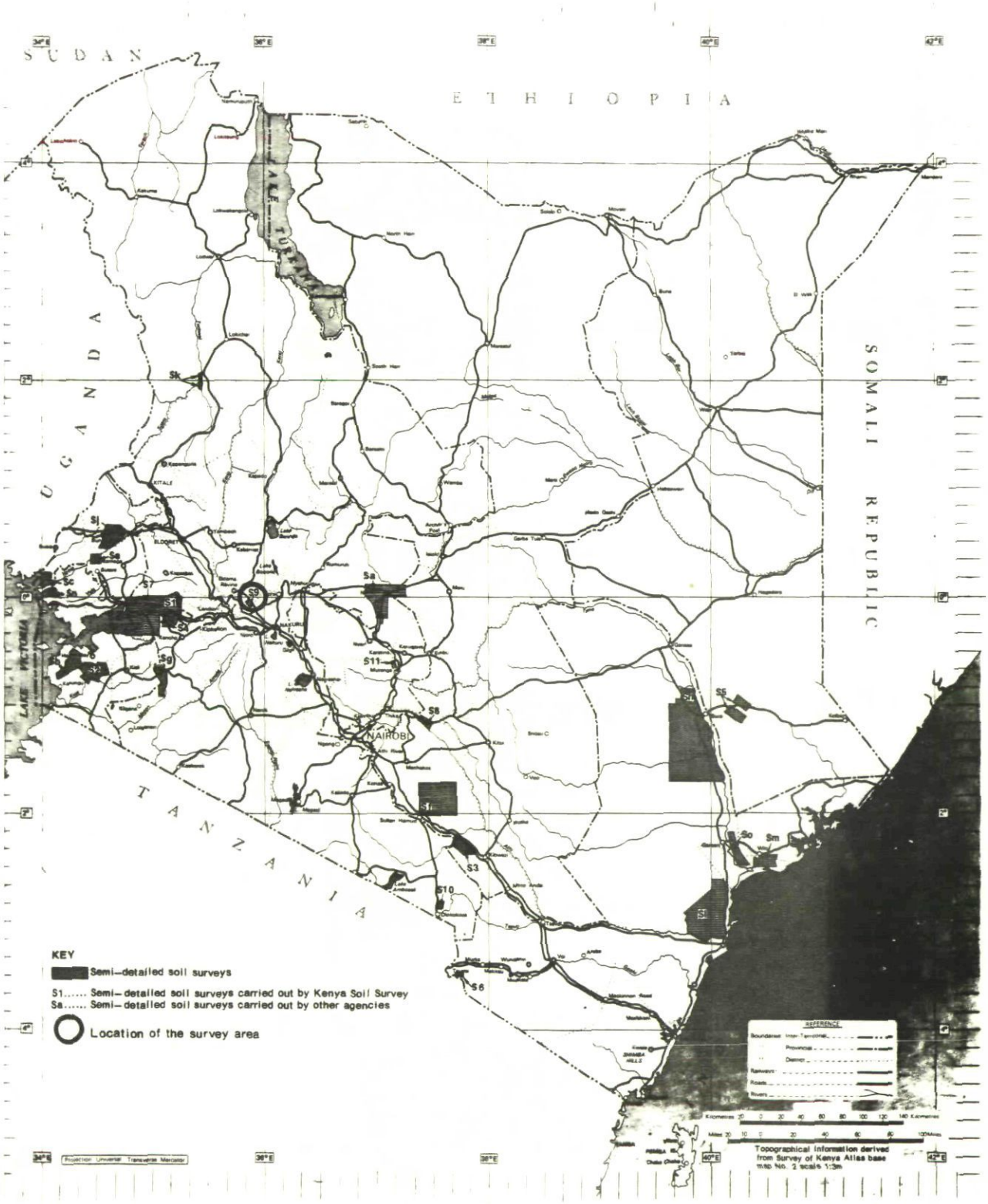
2.1. Location, communication and population

The survey area is situated approximately 15 kilometres north of Rongai township on the Nakuru-Eldama Ravine road, on the piedmont and volcanic plains east of Kilombe Hills. The farm covers approximately 1,060 ha. (2,400 acres). It lies within an area bound by approx. latitudes 0° 03'S and 0° 05'S and approx. longitudes 35° 52'E and 35° 54'E at a mean altitude of 1,740m (5,700ft) above sea level (see fig. 1).

The Nakuru-Eldama Ravine road which is tarmacked forms the northern farm boundary and is the major road which passes through the area. The farm is served by several tracks and cutlines which are only motorable during the dry season.

The population is mainly concentrated along the Nakuru-Eldama Ravine road. Mogotio which is approximately 8 kilometres north east of the farm is the main shopping centre. It has a hospital, a police station, a post office and several government offices. Other small shopping centres in the area are Muserechi and Molo river.

Fig. 1 Location of the survey area and other semi–detailed soil surveys



Drawing No. 79043

2.2. Climate

The climatic conditions of the survey area can be described with data from three nearby stations, viz. Chemogoch Range Station (Station No. 89.35141), altitude 5300ft, 10.5km NE of Kelelwa farm, Esagari Grazing Scheme (Station No. 89.35087), altitude 5700ft, 10km NW of the farm and Kampi ya Moto-Rongai (Station No. 90.35022), altitude 6350ft, 9.5km SE of the farm (see fig.2). These stations have rainfall data of 11, 15 and 46 years respectively (EAWD Serial Publications 1961, 1971, 1972 respectively).

The average annual rainfall varies from 888mm at Kampi ya Moto-Rongai to 1082mm at Esageri Grazing Scheme. The rainfall distribution is shown in table 1. The area is characterized by a five month heavy rainy season in the period April-August when the average rainfall is 555mm. The period September-March has an average rainfall of 420mm and is considered to be a dry period.

The average annual temperatures are 20°C at Chemogoch Range Station, 19°C at Esagari Grazing Scheme and 19°C at Kampi ya Moto-Rongai (EAWD, 1970)

The average annual potential evaporation is in the order of 1739mm (Woodhead, 1968). The average annual rainfall (r) and potential evaporation values of 975mm and 1739mm respectively result in a r/Eo ratio of 55%. This puts the area in agro-climatological zone III, which has medium high potential for small holder arable farming (Braun, 1977b). The water balance data of the area is given in table 2. They show that for the greater part of the year the rainfall falls short of the estimated crop-water requirement (2/eEo), except in the April-August period when there is an average surplus of 115mm. Whether or not this surplus can be stored will depend on the depth and moisture holding characteristics of the soils. On annual basis, there is an average deficit of 214mm.

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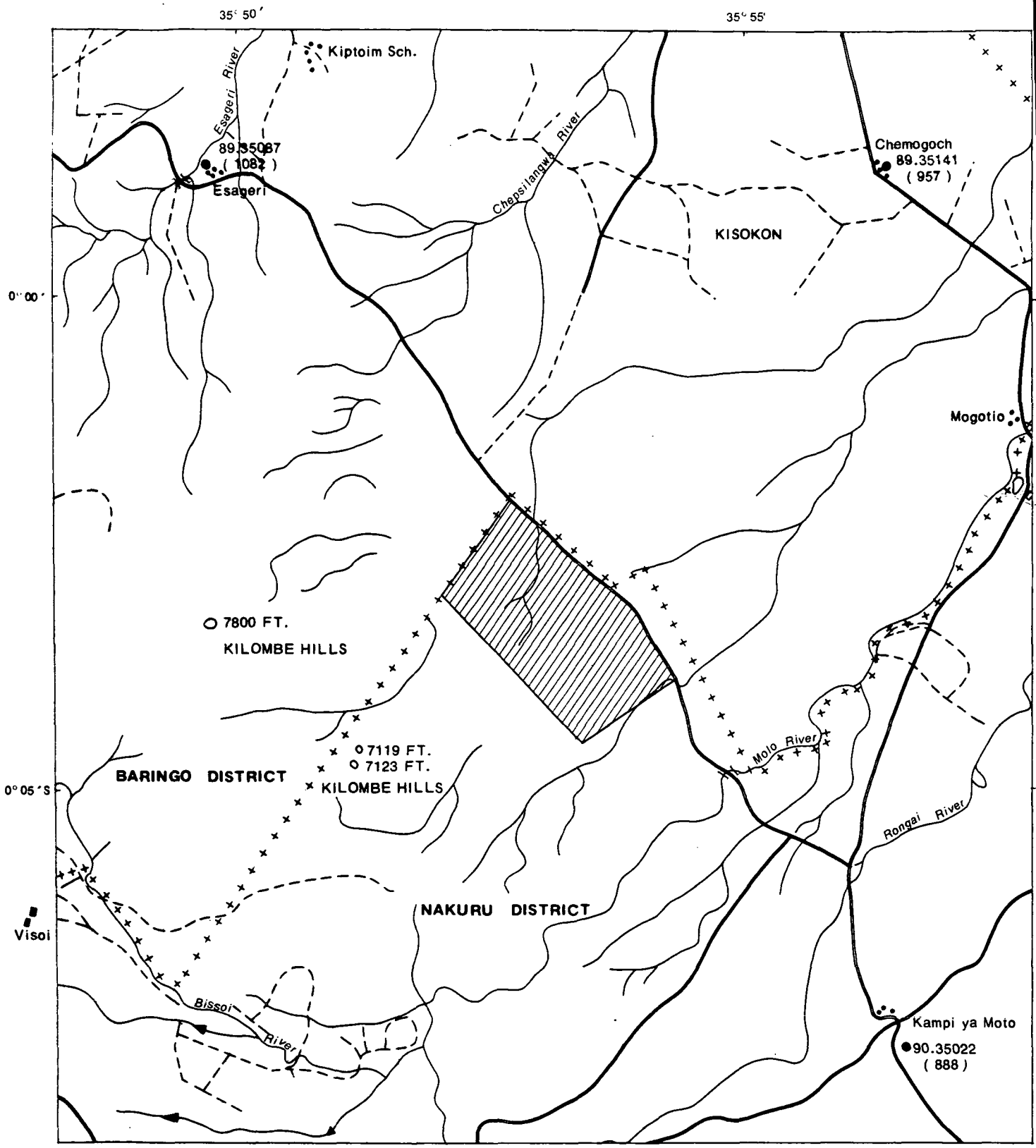
Fig 2. Location of rainfall stations



Basemap compiled and simplified from 1.50,000 Survey of Kenya topographical maps, 1966.

SCALE 1:100,000

0 1 2 3 4 5 6 Km

KEY

- ● 90.35022 rainfall station with number
- (888) average annual rainfall (in mm)
- all weather road, bound surface
- track suitable for wheeled traffic
- river, dam
- bridge
- + + + district boundary
- railway line
- Kelelwa Farm

Table 1. Rainfall data (in mm) of three stations around Kelelwa Farm

Station name	Station number	Altitude (in m)	Air Temp. (°C)	Number of years	J	F	M	A	M	J	J	A	S	O	N	D	Year	r/Eo
Chemogoch	89.35141	1620	20	11	32	39	76	129	101	66	105	97	72	79	106	55	957	52
Esagari Grazing Scheme	89.35087	1740	19	15	52	48	74	133	136	98	132	118	65	73	94	59	1082	60
Kampi ya Moto (Rongai)	90.35022	2220	18	46	21	29	68	134	125	76	113	104	65	59	56	38	888	51
Areal means					35	39	73	132	170	80	117	106	67	70	85	51	975	54

source: EAWD, Serial publications for the years 1961, 1971 and 1972.

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Table 2. Water balance data of the areas around Kelelwa farm

	Rainfall (mm)[1]	Eo(mm)[2]	Et(mm)[3]	r-Et(mm)
January	35	179	119	-84
February	39	179	119	-80
March	73	179	119	-46
April	132	161	107	+25
May	120	143	95	+35
June	80	125	83	- 3
July	117	108	72	+45
August	106	125	83	+23
September	67	143	95	-28
October	70	143	95	-25
November	85	143	95	-10
December	51	161	107	-56
Year	975	1789	1189	-214

1. rainfall: areal means from table 1

2. potential evaporation (Eo) estimated with Woodhead's (1968) equation Eo = 2422 - 0.38h where Eo is potential evaporation of open water in millimetres and h is altitude in metres. Mean monthly potential evaporation was taken as a percentage of the yearly total on the basis of measured evaporation at stations in the Nakuru-Timboroa area.

3. potential evapotranspiration (Et): this was estimated to be 2/3Eo

The seasonal rainfall and crop-water requirement estimates for the area are given in table 3. The crop-water requirement during the growing season has been estimated to be 2/3Eo. The probability that rainfall is less than 2/3Eo during the April-August and September-March periods is 20 and 100 percent respectively.

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Table 3. Seasonal rainfall and crop-water requirement estimates for the areas around Kelelwa Farm

Season	Rainfall (mm)[1]	2/3Eo (mm)[2]	P(r < 2/3Eo)[3]
April-August	555	428 (May - September)	20%
September-March	420	741 (October - April)	100%

Source:

1. Rainfall: areal means from table 1
2. Potential evapotranspiration estimated to be 2/3Eo
3. The probability that the rainfall is less than the estimated crop-water requirement, P(r < 2/3Eo), was estimated using Braun's (1977a) tables.

2.3. Geology, geomorphology and hydrology

2.3.1. Geology

The major part of the area is composed of pyroclastic rocks and sediments. The tuffs and ashes of Mogotio occupy the area around the store and the minor valley along the Nakuru-Eldama Ravine road. The sediments consist of medium and fine-grained, banded, tuffaceous deposits (Jennings, 1971). They show coarse and fine-grained beddings and unconformable cross-cutting of earlier beds by later ones. The clayey soils which have developed in these sediments and pyroclastics are very susceptible to erosion.

2.3.2. Geomorphology

The farm extends from the piedmont plains of the Kilombe Hills eastwards to the Rongai plain. The topography changes from very gently undulating, slope class AB, along the Nakuru-Eldama Ravine road to undulating, slope class BC, at the piedmont plain and footslopes of the Kilombe Hills.

The central portion of the farm consists of deeply incised eroded gullies. The area has a very irregular topography. In general the larger part of it has gently undulating to undulating topography, slope class BC. Minor valleys with gently undulating to undulating topography, slope class BC, are found in the western side of the farm and around the store. The bottomlands with flat to very gently undulating topography, slope class AB, are found near the experimental area along the Nakuru-Eldama Ravine road.

2.3.3. Hydrology

There is no permanent stream on the farm. However, during the rainy season, a lot of water from the Kilombe hills runs through the minor valleys of the farm and drains into the Molo river which ultimately end up into Lake Baringo. The Molo river, which is approximately two kilometres east of the farm, is the only permanent stream and is the main source of water for the farm. The water is normally pumped from the river and used for consumption in the farm and the surrounding area. This is supplemented by water from a recently constructed borehole. The water from the borehole is normally hot; it is cooled down in tanks before it is used. Several permanent dams have recently been constructed in the farm.

To establish the suitability of the water for both home consumption and irrigation (irrigation for lucerne or other fodder crops is planned for in and around unit Prp, verbal information from the Assistant Farm Manager), water samples were taken from the borehole and the Molo river. The analytical data are given in table 4, together with the classification of the water for irrigation according to Handbook No. 60 (Richards (e.d.), 1954).

Water samples from the borehole have a medium salinity and medium sodium hazard (C2-S2). This water can be used on most crops and most soils of the farm. However, infiltration problems may develop on imperfectly drained soils, unless gypsum is present to leach the excess sodium. Molo river water has a medium salinity and low sodium hazard (C2-S1). The water can be used on most soils and most crops. Appreciable leaching of salts may be necessary on salt sensitive crops.

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Table 4. Results of water analyses for irrigation

Sample No.	Borehole	Molo River
pH	8.3	8.6
Conductivity micromhos/cm	750	400
Sodium me/litre	6.96	2.96
Potassium me/litre	0.67	0.46
Calcium " "	0.22	0.46
Magnesium " "	0.54	0.58
Carbonates " "	1.80	0.44
Bicarbonates" "	6.00	3.14
Chlorides " "	0.55	0.45
Sulphates " "	0.07	0.02
Sodium Adsorption Ratio	11.36	4.1
Classification Handbook No. 60	C2-S2	C2-S1

2.4. Present land use

The 1,060ha (2,400 acres) land was acquired in order to raise cattle for milk production. At the time of the soil survey approx. 125ha (300 acres) was under finger millet (Eleusine corocana) 4ha (10 acres) under groundnuts and more than half of the farm under Chloris gayana (Rhodes grass or Pokot grass). The farm had over 300 heads of cattle specifically being fattened for meat production. The Kenya Seed Company had set aside approx. 1ha of land for maize and sunflower experiments. Maize, sunflower, sorghum and finger millet are being grown in small quantities in the surrounding area.

On a large part of the farm, which had gone through severe cycles of sheet and gully erosion, erosion has been brought undercontrol. However, the central portion of the farm still has an irregular type of macrorelief, consisting of pyramid-shaped or dome-shaped islands which are 10 to 20 metres in diameter and 15 to 20 metres in height. The area is covered by bushland thicket of vegetation with a very low and unspecific grass cover.

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It is inhabited by few wild animals like dik-dik and antelopes. To prevent further soil erosion and to create more grazing land for the cattle much of this area is being cleared, levelled and planted with Rhodes grass (Pokot grass). Cutoff drains, ridge terraces and small dams have been constructed in the area in order to slow down the rapid movement of rainwater from Kilombe Hills

Fish farming is being practised in a few of the dams. However, production is being threatened by pelicans feeding on young fish.

3. Survey methods

3.1. Office methods

As a first step in the semi-detailed soil survey of the Kelelwa farm the available aerial photographs, topographic and geological maps together with all other existing information were collected and studied.

The surveyed area is covered by recent aerial photographs at scale 1:50,000 and 1:12,500 flown in 1967 and 1978 respectively. These aerial photographs were received from the Survey of Kenya.

Prior to the fieldwork all photographs were studied stereospically. Systematic interpretation of photographs proved very valuable. All interpretation boundaries were transferred to a base map, scale 1:5,000, prepared by the Soil Conservation section of the Land and Farm Management Division of the Ministry of Agriculture, Nakuru. During the field work all interpretation boundaries were checked, and where necessary, boundaries were adjusted and new soil boundaries added to the same base map. This final field map, to which symbols were added, was handed over to the draughtsman together with the final soil legend.

3.2. Field methods

The actual fieldwork was carried out from a field station in the survey area between August and October, 1980. The soil survey was done by one survey team (one soil surveyor and two technical assistants, one driver and several labourers).

Routine augerings were done using a grid system of about 300m by 500m. Augerholes were made to a depth of 150cm, soil depth permitting. In most mapping units representative sites were selected for 180-200cm deep profile pits, depth to rock or murram permitting.

All observation sites were plotted on the topographical maps. Land and soil properties were recorded on standard soil profile description forms, following the standards applied by the Kenya Soil Survey and "Guidelines for Soil Profile Description" (FAO, 1977). Soil colours were noted using Munsell Colour Charts (Munsell Colour Co, 1973). A total of 19 profile pits and 122 augerings were described (for their location see app. 2). All these description forms are kept in the Data Storage of the Kenya Soil Survey in Nairobi. In the profile pits each soil horizon was sampled for physical and chemical analyses in the laboratory. In addition, composite samples of topsoils (0-30cm) were taken from various sites for soil fertility evaluation (Mehlich et al, 1962).

3.3 Laboratory methods

Standard analysis

All soil samples entering the laboratory received the following treatment:

Preparation	:	Breaking up of aggregates by careful pounding with pestle and mortar; sieving through 2mm sieve.
Texture (hydrometer)	:	Nomechanical treatments to remove cementing agents, shaking overnight with sodium hexametaphosphate/sodium carbonate in an end-over-end shaker at 40 r.p.m. Measurement of silt + clay (0-0.05mm) and clay 0-0.002mm) with a hydrometer ASTM 152H, after 40 seconds and 2 hours respectively. Sand fraction (0.05-2.0mm) obtained by difference (Day, 1956).
Natural clay	:	As above for clay, but omitting the dispersing agent during shaking.
pH and electrical conductivity	:	Determined in 1:2.5 soil: water suspension. For soils with an EC over 1.2 mmhos/cm at 25°C, a saturation extract is prepared for pH and EC measurement.
pH-KCl	:	pH measurement in a 1:2.5 soil-N KCl suspension. For fertility analysis 1:1 suspension in all cases.
C%	:	Walkley and Black method (Black, 1965, pp. 1372/6).
N%	:	Semi-micro Kjeldahl method (Black, 1965, pp. 1374/5).

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Cation exchange capacity	:	For soils with pH above 7.0, CEC determined by successive leachings of the soil with N sodium acetate of pH 8.2, 75% ethyl alcohol and N ammonium acetate of pH 7.0. Determination of Na in the last leachate by EEL flamephotometer. For soils with pH below 7.0 the CEC was determined with N ammonium acetate of pH 7.0 as the saturating solution. After a washing step with 96% ethyl alcohol and leaching with acidified calcium chloride, NH_4 was determined by steam distillation and titration.
Determination of micronutrients	:	Soil samples are extracted using 0.1N. HCl and concentration of Zn, Cu, and Fe are measured on the AAS (Atomic Absorption Sepectrum).
Exchangeable cations	:	Leaching of the soil with N ammonium acetate of pH 7.0. Determination of Na, K and Ca by EEL flame-photometer, with addition of Lanthanum chloride for the last element. Colorimetric determination of Mg with Thiazol yellow reagent (Mehlich et al, 1962). Saline soils are prewashed with 70% ethanol until free of Cl and SO_4.
Exchange acidity (Hp)	:	Titrimetric determination of the acidity in a leachate of 0.6N Barium chloride, not buffered at any pH (Mehlich et al, 1962).
"Mass Analysis" for available nutrients (on A-horizons only)	:	Extraction of the soil by shaking for 1 hour at a 1:5 ratio with 0.1N HCl/0.025N H_2SO_4. Determination resin treatment for Ca. For Mg the same procedure as for exchangeable Mg. For P, the Vanadomolybdo-phosphoric yellow method is followed. Mn is measured colorimetrically using phosphoric acid-potassium periodate for colour development (Mehlich et al, 1962).
Water analysis	:	Determination of Na, K, Ca, Mg, CO_3, HCO_3, Cl, SO_4 by methods described in USDA Handbook No. 60 (Richards, 1954).

3.4. Cartographic methods

A base map at scale 1:5,000 surveyed and drawn by the Soil Conservation section of the Land and Farm Management Division of the Ministry of Agriculture, Nakuru, was reduced to 1:10,000 using an optical pantograph.

The reduced version was subsequently scribed. The soil boundaries were scribed on a separate plate and additional information (symbols, legend, marginal information) stuck on it.

The soil map was printed in steps using five printing plates. Each plate was used to print in a different colour. The colours employed were black, grey, yellow, cyan and magenta, thus black for soil boundaries, legend, soil symbols, depth classes, slope classes and other marginal information. Grey for topography such as rivers, fences, terraces, pipelines, drainage lines, water holes, water tanks and dams.

The colours of different units are a combination of three basic colours, namely: yellow, cyan and magenta in different densities.

After preparation of all the plates, a proof was made on white astrafoil using a mechanical process.

The map was finally printed by Messrs. Prudential Printers, Nairobi,* on an offset printing press, using the plates mentioned above.

4. The Soils

4.1. The Legend

The legend (see app. 1) describes the essentials of the various mapping units delineated on the soil map. The differences between the soils of the various mapping units can only be explained considering the geological and geomorphological history of the area. Well known factors of soil formation are for instance parent material and topography. Therefore the legend is built up in such a way that the influence of landscape and geology is clearly shown. Because Kelelwa Farm has only one geological formation, the geological entrance is given at the end of the legend so as to avoid the repetition.

At the highest level the various landscapes have been separated. This is followed by a description of the mapping units.

Each mapping unit description describes the following soil characteristics (order as indicated):

- drainage condition
- depth
- colour when moist
- consistence when moist
- calcareousness (if present)
- texture, including stoniness and rockiness (if present)
- soil classification

* erroneously indicated in appendix 2 as having been printed by Survey of Kenya.

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The terminology of the legend of the legend follows closely definitions as given by the Soil Survey Staff (1975) and in the "Guidelines for Soil Profile Description" (FAO, 1977). The soils are classified according to the FAO-Unesco legend for their "Soil Map of the World" (FAO-Unesco, 1974).

The following letter symbols were used to code the mapping units:

Y	piedmont plains
P	volcanic plains
V	minor valleys
B	bottomlands
U	badlands
r	red
b	brown
P,p,p	depth classes (explained in key on soil map)
M	" " " " " " " "
1,2	non specific differentiation
C	complex of several mapping units

For each mapping unit also the slope class is indicated on the soil map. Where an area belonging to one mapping unit consists of two parts with different slope classes, these two parts are separated. The indications for the slope classes are given underneath the mapping unit symbols.

The following symbols are used:

A 0-2% slope, flat to very gently undulating
B 2-5% slope, gently undulating
C 5-8% slope, undulating

4.2. General properties of the soils

The soils of Kelelwa farm show a strong variation in most of their properties. The following soil regions can be distinguished:

I	soils of the piedmont plain
II	soils of the volcanic plain
III	soils of the minor valleys
IV	soils of the bottomlands
V	soils of the badlands

The soils of the piedmont plain are normally moderately deep to very deep. They are well drained to moderately well drained and have clay loam to clay texture. The majority of the soils are compact during the dry periods. In places they are shallow and are overlying pyroclastic gravel cemented by calcium carbonate or piso-and petroplinthite. Their colour varies from dark reddish brown to dark brown or yellowish red. The soil structure is weak to moderate angular blocky or weak subangular blocky. The transition from A to B-horizon is clear and smooth. The cation exchange capacity of the soil in the B horizon varies from 18 to 24 me/100g. The organic carbon decreases from 1.5 percent in the A horizon to 0.27 percent in the B horizon. The soils with less than 50 percent base saturation are classified as chromic* Acrisols and those with more than 50% base saturation as orthic and vertic Luvisols. Other soils are classified as eutric Cambisols (see app. 2).

The soils of the volcanic plain are well drained to moderately well drained, very shallow to deep, friable or firm and of sandy clay loam to clay texture. The colour of the soil varies from dark reddish brown to strong brown or yellowish brown. The majority of the soils have weak to moderate, fine to medium subangular or angular structure and have weak to moderate clay skins. The transition from A to B horizon is normally clear and smooth. The soils show a wide range in chemical properties. The pH water ranges from 4.2 to 7.5 and organic carbon in the A horizon from 0 5% to 2.9%, decreasing to the range of 0.2% to 0.8% in the B horizon. The cation exchange capacity of the soil is in the order of 10 to 28 me/100g. The base saturation is usually high. The soils which show some signs of clay illuviation have been classified as vertic, orthic and chromic Luvisols. Those with low CEC and less than 50% base saturation have been classified as dystric Cambisols. The remainder has been classified as eutric Cambisols and mollic Andosols. The very shallow ones have been classified as Lithosols (see app 2).

The soils of the minor valleys and bottomlands vary widely in their characteristics. They range from well drained to poorly drained, shallow to deep, dark yellowish red to very dark greyish brown, friable or firm, clay loam to clay. Mottles and soft plinthite start from 25-50cm. The soils have weak to moderate, medium, angular and subangular blocky structure. Common, weak to moderate, slickensides and clay skins are present. The transition from A to B-horizon is clear and smooth. The soil pH is 5.9. The organic carbon ranges from 0.7 to 2.2% in the A horizon and 0.6 to 0.9 in the B horizon.

prefixes marked with * are tentative terms, which have been introduced by Kenya Soil Survey (see misc. Paper No.15).

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The CEC soil is about 24 me/100g and the base saturation varies from 56 to 70%. The soils have been classified as plinthic Gleysols and eutric Cambisols.

The soils of the badlands are well drained to moderately well drained, shallow to deep. The colour is yellowish brown or dark yellowish brown. They are compact during the dry season. They have a clay loam to sandy clay texture. The soils have a weak, fine and medium, angular blocky structure. The transition from A to B-horizon is clear and smooth. Signs of stratification are present in most profiles. Some calcium carbonate concretions are commonly found on the surface. Severe gully and sheet erosion is the major feature of these soils.

Chemically the soils are medium acid, pH ranging from 6.0 to 6.3. The organic carbon is low in the topsoil due to soil truncation. It is about 0.4% in the topsoil and 0.3% in the subsoil. The exchange capacity of the soils is about 22 me/100g, while the base saturation ranges from 78 to 88%. Due to fine stratifications and a base saturation of more than 50%, the soils were classified as eutric Fluvisols. Erroneously this classification is not shown in the legend of appendix 2.

4.3. Description of soil mapping units

For each mapping unit the total area is given, followed by brief descriptions of the parent material, relief, land use and erosion. Surface stoniness, flooding, groundwater level, salinity and alkalinity are only described if present. The soils are described in more detail, with the soil classification at the end of each description.

The terminology follows closely the "Guidelines for Soil Profile Description" (FAO, 1977). Colour notation is based on the Munsell Colour Charts and refers to moist conditions, unless stated otherwise. Descriptions of structure and consistence usually refer to the B horizon. Soil classification is according to FAO-Unesco (1974).

4.3.1 Soils of the piedmont plains

Mapping unit Yr

Total area	:	5ha.
Parent material	:	pyroclastic material.
Relief, macro	:	gently undulating to undulating (slopes 3-6%).
Relief, meso/micro	:	common active termite mounds 50m apart.
Erosion	:	nil.

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Vegetation/Land use	:	maize.
Soils, general	:	very deep, porous, medium acid soils with an A-Bt-C sequence of horizons. Horizon transitions are clear to diffuse and smooth.
colour	:	A-horizon: dark reddish brown to dark yellowish brown (5YR 3/3 to 10YR 3/4)
texture	:	sandy clay in the A-horizon, clay in the B-horizon. Clay % in the A horizon is 40 and 60 in the B-horizon, giving a clay ratio of 1.5 for B/A horizon. Silt/clay ratio in the B-horizon is 0.23.
structure	:	moderate, very fine to medium, angular blocky.
consistence	:	slightly hard when dry, friable when moist, sticky and plastic when wet.

Chemical properties

A-horizon	:	organic C% about 1.5; pH-H_2O is 5.4 and pH-KCl is 4.3. CEC of the soil is 21 me/100g. The base saturation is 43%.
B-horizon	:	CEC of the soil is 18.6 me/100g. Base saturation is 28.5%
Soil classification	:	chromic[=] Acrisols.

For the description of a representative profile with analytical data see appendix 1 profile description no.1.

Mapping unit Ybp

Total area	:	125 ha
Parent material	:	pyroclastic material.
Relief, macro	:	gently undulating to undulating (slopes 3-6%).
Relief, meso/micro	:	levelled termite mounds and eroded gulleys.
Erosion	:	strong gully erosion towards the badlands.
Vegetation/Land use	:	Rhodes grass (Pokot grass) (grazing area).
Soils, general	:	deep, porous, medium acid soils with an ABC sequence of horizons. Horizon transitions are clear and smooth.
colour	:	A-horizon: dark yellowish brown to very dark greyish brown (10YR 4/4 to 10YR 3/2); B-horizon: dark yellowish brown (10YR 3/4 to 10YR 3/6).

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texture : clay in the A-horizon, clay to clay loam in the B-horizon. Average clay % in the A-horizon is 43 and in the B-horizon 40 giving a clay ratio of approx. 0.9 for B/A horizon. Silt/clay ratio in B-horizon is 0.8.

structure : weakly coherent, porous massive to weak, fine and medium, subangular blocky structure or weak, medium and coarse subangular blocky structure.

consistence : slightly hard when dry, firm when moist, sticky and plastic when wet.

Chemical properties

A-horizon : organic C% 1.1 to 1.5; pH-H_2O 5.8 to 6.1 and pH-KCl 4.3 to 5.1. CEC of the soil is 22 to 25 me/100g. Base saturation ranges from 58 to 63%.

B-horizon : CEC of the soil ranges from 19 to 25 me/100g and base saturation 52 to 54%.

Soil classification : eutric Cambisols and orthic Luvisols.

For the description of a representative profile with analytical data see appendix 1 profile description no.2

Mapping unit Ybp

Total area : 50ha.
Parent material : pyroclastic material.
Relief, macro : gently undulating (slope 2-3%).
Relief, meso/micro : levelled land.
Erosion : strong gully erosion towards the badlands.
Vegetation/Land use : finger millet (Eleusine corocana).
Soils, general : moderately deep to deep, non-calcareous to strongly calcareous with an ABC sequence of horizons. Horizon transitions are clear and smooth.

colour : A-horizon: very dark greyish brown to dark yellowish brown (10YR 3/2 to 10YR 3/6);
B-horizon: dark brown to dark yellowish brown (10YR 3/3 to 10YR 4/4).

texture : sandy clay loam to clay loam in the A-horizon and clay loam to clay in the B-horizon.

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Average clay % in the A-horizon is 28 and in B-horizon is 38 giving a clay ratio of 1.35 for B/A horizon. Silt/clay ratio in the B-horizon is 0.7.

structure : strong to moderate, fine and medium, angular blocky.

consistence : hard when dry, firm (compact) when moist, sticky and plastic when wet.

Chemical properties

A-horizon : organic C% is 0.6 to 0.8, pH-H_2O is 5.4 to 5.8 and pH-KCl is 4.3 to 4.4. CEC of the soil varies from 15 to 21 me/100g. The base saturation is about 60%.

B-horizon CEC soil ranges from 24 to 29 me/100g. and base saturation from 83 to 100%.

Soil classification : vertic Luvisols and eutric Cambisols.

For the description of a representative profile with analytical data see appendix 1, profile description no.3

4.3.2. Soils of the volcanic plains

Mapping unit Pbp

Total area : 222 ha
slope class AB: 83 ha
slope class B: 134 ha
slope class BC: 5 ha

Parent material : pyroclastics and sediments derived from pyroclastics of the Rongai plain

Relief, macro : gently undulating (slopes 2%).

Relief, meso/micro : flattened termite mounds.

Erosion : nil.

Vegetation/Land use : predominantly under rhodes grass (grazing area)

Soils, general : deep to deep, medium to slightly acid soils with an ABC sequence of horizons. Horizon transitions are clear or gradual and smooth.

colour : A-horizon: dark reddish brown to dark brown 5YR 3/2 to 10YR 3/3;

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texture : sandy loam to clay loam in the A-horizon and sandy clay loam to clay in the B-horizon. Average clay % in the A-horizon is 30 and in the B-horizon 36, giving a clay ratio of 1.2 for B/A horizon. Silt/clay ratio in the B horizon is 0.9.

structure : weak to moderate, fine to medium angular blocky structure.

consistence : slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet.

Chemical properties

A horizon : organic C% is about 1.1%, pH-H_2O varies from 5.9 to 6.6 and pH-KCl from 4.7 to 5.1. The CEC of the soil ranges from 11 to 15 me/100g. The base saturation ranges from 68 to 84%.

B horizon : The CEC soil ranges from 10 to 20 me/100g and base saturation from 58 to 78%.

Soil classification : orthic Luvisols.

For the description of a representative profile with analytical data see appendix 1, profile description no.4

Mapping unit Prp

Total area : 59 ha

Parent material : pyroclastics and sediments derived from pyroclastics of the Rongai plains.

Relief, macro : gently undulating (slopes 2-5%).

Relief, meso/micro : active termite mounds, approx. 100m apart.

Erosion : nil

Vegetation/Land use : under rhodes grass (grazing)

Soils, general : well drained, moderately deep to deep, slightly acid soils with an ABC sequence of horizons. They have gradual and smooth transitions between the horizons.

colour : A-horizon: yellowish red to dark brown (5YR 5/8 to 7.5YR 3/2).

B-horizon: dark reddish brown to yellowish red (2 5YR 3/4 to 5YR 4/6).

texture : clay to clay loam in the A-horizon, clay in the B-horizon. Average clay content is 40% in the A-horizon and 52% in the B-horizon. Clay ratio of B/A horizon is 1.3 Silt/clay ratio in the B-horizon is about 0.6.

structure : weak, very fine to medium angular blocky structure.

consistence : slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet.

Chemical properties

A-horizon : organic C% ranges from 0.5 to 2.2; pH ranges from 5.6 to 5.8 and pH-KCl from 3.8 to 4.5. The CEC soil is about 18 me/100 with a base saturation of 43-70%.

B-horizon : CEC of the soil varies from 16 to 23 me/100g and the base saturation from 36 to 54%.

Soil classification : chromic Luvisols and eutric Cambisols, piso-ferric phase.

For the description of a representative profile with analytical data see appendix 1 profile description no.5.

Mapping unit p1H

Total area : 53 ha
slope class AB: 13 ha
slope class B: 30 ha

Parent material : pyroclastics and sediments derived from pyroclastics of the Rongai plains.

Relief, macro : gently undulating to undulating (slopes 2-6%).

Relief, meso/micro : flattened termite mounds.

Erosion : strong sheet and gully erosion along (dry) streams.

Vegetation/Land use : grazing area.

Soils, general : well drained, very shallow to moderately deep, slightly acid soils with an ABC sequence of horizons. Horizon transitions are gradual and smooth.

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colour : A-horizon: dark yellowish brown to dark yellowish brown (5YR 3/2 to 10YR 3/4);

B-horizon: dark yellowish brown to yellowish brown (10YR 3/4 to 10YR 5/8).

texture : sandy clay loam to sandy clay in the A and B-horizon. Clay percentage in the A-horizon is 24 and in the B-horizon 30, giving a clay ratio of 1.25 for B/A horizon. Silt/clay ratio in the B-horizon is about 0.7.

structure : weak, very fine and fine subangular blocky structure.

consistence : slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet.

Chemical properties

A-horizon : organic C% is 1.7; pH-H_2O is 5.9 and pH-KCl 5.0; The CEC soil is in the order of 16 me/100g and the base saturation is 53%

B-horizon : The CEC soil is 12 me/100g and base saturation is 43%.

Soil classification : dystric(cambisols, petroferric phase and Lithosols).

For a description of a representative profile with analytical data see appendix 1, profile description no. 6.

Mapping unit P2P

Total area : 4 ha.

Parent material : pyroclastic materials.

Relief, macro : gently undulating to undulating (slope 3-6%).

Relief, meso/micro : few inactive termite mounds.

Erosion : slight gully and sheet erosion.

Rockiness/stoniness : rocky and bouldery.

Vegetation/Land use : grazing area.

Soil, general : well drained, very shallow to moderately deep, slightly acid soils with an ABC sequence of horizons. The horizon transitions are gradual and smooth.

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colour : A-horizon: dark reddish brown to strong brown (5YR 3/3 to 7.5YR 5/6);

B-horizon: dark reddish brown to dark brown (5YR 3/3 to 7.5YR 3/3).

texture : sandy clay loam in the A and B-horizons. Clay percentage in the A and B horizon is 28 and 34 respectively, which gives a clay ratio of 1.2 for B/A horizons. Silt/clay ratio of the B-horizon is 0.7.

structure : weak, fine to coarse, subangular blocky structure.

consistence : slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet.

Chemical properties

A-horizon : organic C% is about 1.5; pH-H_2O is 6.5 and pH-KCl 4.7; CEC of the soil is 16 me/100g, the base saturation is 56%

B-horizon : CEC of the soil is 13 me/100g and base saturation is about 58%

Soil classification : eutric Cambisols, partly lithic phase and Lithosols

For a decription of a representative profile with analytical data see appendix 1, profile description no.7.

Mapping unit p3p

Total area : 20 ha.

Parent material : pyroclastic material.

Relief, macro : gently undulating to undulating (slopes 3-6%)

Relief, meso/micro : levelled area

Erosion : slight gully and sheet erosion.

Vegetation/Land use : finger millet (Eleusine corocana).

Soils, general : well drained to moderately well drained, deep mildly to moderately alkaline soils with an ABC sequence of horizons. The horizon transitions are clear and smooth.

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colour	:	A-horizon: very dark greyish brown to dark yellowish brown (10YR 3/2 to 10YR 4/6) B-horizon: dark yellowish brown to greyish brown (10YR 4/4 to 10YR 5/2).
texture	:	clay loam to clay throughout. Clay percentage in the A horizon is 46 and in the B horizon 44. The clay ratio of the B/A horizon is about 1.0. Silt/clay ratio of the B-horizon is about 0.7.
structure	:	moderate, very fine to medium, subangular to angular blocky structure.
consistence	:	slightly hard when dry, friable when moist, sticky and plastic when wet

Chemical properties

A-horizon	:	organic C% is 0.8; pH-H_2O is 7.1 and pH-KCl 6.3; CEC of the soils is 34 me/100g and the base saturation is about 90%.
B-horizon	:	CEC of the soil is 28 me/100g and the base saturation is 100%
Soil classification	:	mollic Andosols.

Remark: There are many calcium carbonate concretions on the surface.

For a description of a representative profile with analytical data see appendix 1, profile description no.8

Mapping unit P4p

Total area	:	151 ha slope class AB: 63 ha slope class B: 88 ha
Parent material	:	pyroclastic rocks and sediments derived from pyroclastic rocks of the Rongai plains.
Relief, macro	:	very gently undulating to gently undulating (slopes 1-3%).
Relief, meso/micro	:	few active termite mounds.
Erosion	:	nil
Flooding	:	seasonally flooded.

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Vegetation/Land use	:	Rhodes grass (Pokot grass)/grazing area
Soils, general	:	moderately well drained, deep, neutral soils with an ABC sequence of horizons. Horizon transitions are either clear and smooth or gradual and smooth.
colour	:	A-horizon: very dark greyish brown to dark brown (10YR 3/2 to 10YR 3/3); B-horizon: dark yellowish brown to greyish brown (10YR 3/4 to 10YR 5/4).
texture	:	clay loam to clay throughout. Clay percentage in the A horizon varies from 36 to 46 and in the B horizon from 40 to 56 giving an average clay ratio of 1.25 for B/A horizon. Silt/clay ratio in the B-horizon is 0.5.
structure	:	moderate, fine and medium subangular and angular blocky structure.
consistence	:	hard when dry, firm when moist, sticky and plastic when wet.
Chemical properties		
A-horizon	:	organic C% ranges from 1.3 to 2.9; pH-H_2O varies from 5.9 to 6.4 and pH-KCl from 4.9 to 5.3. The CEC soil is about 23 me/100g, while the base saturation ranges from 68 to 100%
B-horizon	:	The CEC soil ranges from 20 to 30 me/100g and the base saturation from 70 to 100%.
Soil classification	:	vertic Luvisols, orthic Luvisols and eutric Cambisols

For a description of a representative profile with analytical data see appendix 1, profile description no.9

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4.3.3. Soils of the minor valleys

Mapping unit VC

Total area : 50 ha
slope class AB: 11 ha
slope class BC: 39 ha

Parent material : alluvial from pyroclastic rocks and sediments derived from pyroclastic rocks.

Relief, macro : very gently undulating to undulating (slope 1-5%).
Relief, meso/micro : flattened and levelled termite mounds and gullies.
Erosion : remnants of old erosion gullies are common.
Rock outcrops : fairly rocky
Vegetation/Land use : grazing area.

Soils, general: well drained to moderately well drained, shallow to deep, slightly acid to neutral soils with an ABC sequence of horizon development. The horizon transitions are clear and smooth.

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

B-horizon: dark yellowish brown to greyish brown (10YR 3/6 to 10YR 5/2).

texture: clay loam in A and B-horizons. Clay percentage in the A-horizon is about 30 and in the B-horizon about 36%, which gives a clay ratio of 1.2 for the B/A horizons. Silt/clay ratio of the B-horizon is 1.1.

structure: weak to moderate, very fine to medium, subangular blocky structure.

consistence: slightly hard when dry, friable when moist, slightly sticky and plastic when wet.

Chemical properties

A-horizon : organic C% is 2.2; pH-H_2O is 6.3 and pH-KCl 5.3; CEC soil is 16 me/100g and the base saturation is 97%.

B-horizon : the CEC soil is 24 me/100g and the base saturation is 70%.

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Soil classification : eutric Cambisols.

For description of a representative profile with analytical data see appendix 1, profile description no. 10.

4 3.4. Soils of the bottomlands

Mapping unit Bp

Total area	:	1 ha
Parent material	:	alluvium derived from pyroclastic rocks
Relief, macro	:	very gently undulating (slope 1-2%)
Relief, meso/micro	:	few active termite mounds
Erosion	:	nil
Flooding	:	seasonally flooded
Vegetation/Land use	:	partly a grazing area and partly experimental area
Soils, general	:	imperfectly drained to poorly drained, deep, slightly acid soils with an ABC soil profile development. The horizon transitions are gradual and smooth
colour	:	A-horizon: very dark greyish brown to dark brown (10YR 3/2 to 10YR 3/3)
		B-horizon: very dark greyish brown to brown (10YR 3/2 to 10YR 5/3)
texture	:	clay in the A-horizon and clay loam to clay in the B-horizon. Clay percentage in the A and B horizons are 54 and 40 respectively, which gives a clay ratio of 0.8 for B/A horizons. Silt/clay ratio of the B-horizon is 0.5.
structure	:	moderate, medium and coarse, angular blocky structure
consistence	:	hard when dry, firm to very firm when moist, sticky and plastic when wet

Chemical properties

A-horizon	:	organic C% is 0.7; pH-H_2O is 5.8 and pH-KCl is 4.8; CEC of the soil is 27 me/100g with a base saturation of 66%
B-horizon	:	CEC of the soil is 24 me/100g with a base saturation of 56%

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Soil classification : plinthic Gleysols

For description of a representative profile with analytical data see appendix 1, profile description no.11.

4.3.5. Soils of the badlands

Mapping unit WCE

Total area	:	204 ha slope class B: 66 ha slope class BC: 138 ha
Parent material	:	pyroclastic rocks and sediments derived from pyroclastic rocks
Relief, macro	:	gently undulating to undulating (slopes 2-6%)
Relief, meso/micro	:	dome-shaped hillocks caused by water erosion and deeply incised gullies
Erosion	:	severe sheet and gully erosion
Rock outcrops	:	fairly rocky and fairly stony
Vegetation/Land use	:	forest area
Soils, general	:	well drained to moderately well drained, very shallow to deep, slightly acid soils with C1, C2, C3 sequence of soil development. The horizon transitions are clear and smooth
colour	:	C1-horizon: dark brown to dark yellowish brown (5YR 3/4 to 10YR 4/4) C2-horizon: yellowish brown to dark yellowish brown (10YR 5/4 to 10YR 4/4)
texture	:	clay loam throughout, with a clay % of about 30%.
structure	:	weak, fine to coarse, subangular blocky structure
consistence	:	hard when dry, firm when moist, slightly ticky and slightly plastic when wet.

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Chemical properties

A-horizon	:	organic C% is 0.4, pH-H_2O is 6.3 and pH-KCl 5.3. The CEC of the soil is 21 me/100g and the base saturation is about 30%.
B-horizon	:	CEC of the soil is 21 me/100g and the base saturation is about 90%.
Soil classification	:	eutric Fluvisols[1].

For a description of a representative profile with analytical data see appendix 1, profile description no.12.

4.4. Soil classification and correlation

4.4.1. Introduction

For the accommodation of the soils encountered in the survey area into an internationally recognized framework of classification, the FAO-Unesco legend (1974) for their Soil Map of the World was applied. Considerations on the choice of this system of reference are given in the Kindaruma report (van de Weg and Mbuvi, (eds.), 1975).

The place of the soils in the system reflects major differences in chemical and physical soil characteristics and can be used for both national and international correlation purposes. In the Kelelwa farm the following major classification units are recognized: Luvisols, Acrisols, Andosols, Gleysols, Cambisols and Lithosols. This sequence reflects partly a trend in profile development, i.e. old to young or chemically poor to rich. For a comprehensive description of all soils in the FAO-Unesco legend, and the definition of the diagnostic horizons involved reference is made to Volume I of the "Soil Map of the World" (FAO-Unesco, 1974).

4.4.2. The major classification units

(a) Acrisols

These are strongly weathered and strongly leached soils with an ABC sequence of horizons. An ochric or umbric A-horizon overlies an argillic B-horizon of which at least a part has a base saturation below

1 not indicated in appendix 2 because of many variations within the complex and laboratory data for the profile pit was available after the map had been printed.

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50%. The argillic B-horizon is characterized by clear signs of clay illuviation. The characteristics of the argillic B-horizon, and the limited merit of the base saturation criterion are discussed in the Kindaruma report (op cit.).

In the survey area only the soils of mapping unit Yr are "regular" Acrisols, in this case chromic* (i.e. "red") Acrisols[1].

(b) Andosols

These are soils which have a mollic or an umbric A-horizon possibly overlying a cambic B-horizon or an ochric A-horizon and a cambic B-horizon. To a depth of 35cm or more they either have a bulk density (at 1/3 bar water retention) of the fine earth (less than 2mm) fraction of the soil of less than 0.85g/cm^3 and an exchange complex dominated by amorphous material, or they have 60 percent or more vitric volcanic ash, cinders or other vitric pyroclastic material in the silt, sand and gravel fraction.

In the survey area Andosols occur in mapping unit P3p. They have a mollic A-horizon and have a smeary consistence with clay loam to clay texture within 100cm of the surface. They are classified as mollic Andosols.

(c) Luvisols

These are moderately weathered mineral soils with an ABC sequence of horizons. An ochric or umbric A-horizon overlies an argillic B-horizon with a base saturation of more than 50% throughout. Three subunits are found in the survey area, orthic, chromic and vertic Luvisols. The orthic (brown) ones, mapping unit Pbp and parts of Ybp and P4p are normal Luvisols, i.e. without any of the specific features characteristic for other subunits. The chromic (red) Luvisols, occupy parts of unit Prp. The vertic Luvisols of parts of mapping unit Ybp and P4p have vertic properties.

(d) Cambisols

These are "young" and little weathered soils. They have an ABC sequence of horizons, but the B-horizon has not developed into a recognizable argillic or oxic one. This cambic B-horizon contains many weatherable primary minerals. Its structure is subangular blocky or weakly coherent porous massive.

1) Where tentative new names are introduced or the officially described concepts have been modified to suit Kenyan conditions ("Kenya concept"), they are indicated by* (see also Siderius and van der Pouw, 1980).

The consistence is often friable and the horizon transition are gradual. Cambisols are frequent in the area. The following sub units were encountered: eutric and dystric.

The eutric Cambisols (unit VC and parts of units Ybp, Ybp, P2p, Prp and P4p) have an orchric A-horizon and a regular cambic B-horizon. The base saturation is more than 50%. The dystric Cambisols which occupy part of unit P1M have an ochric A-horizon and a base saturation of less than 50%.

(e) Gleysols

These are poorly drained mineral soils without clear textural diffentiation. Hydromorphic properties occur within 50cm of the surface. They are caused by periodic or permanent saturation by ground water, which is reflected in dominant greyish hues or prominent mottling. In the survey area Gleysols occur in mapping unit Bp. They have plinthite within 125cm of the surface and therefore are classified as plinthic Gleysols.

(f) Lithosols

These are shallow soils with an ACR or AR sequence of horizons. The topsoil is low in organic matter (ochric A) and there is no B-horizon of any kind. They should have continuous coherent and hard rock within 10cm of the surface (FAO-Unesco, 1974), but in the survey area this limit was put at 25cm which is considered more suitable for Kenya conditions. These soils occupy parts of units P2P and P1M.

4.5. Soil fertility aspects

For the soil fertility appraisal of the survey area composite topsoil samples were taken at the sites of representative profile pits and analysed according to a mass analysis method for soil fertility evaluation (see chapter 3.2).

The relevant data are given on the laboratory data sheet of appendix 1. Due to the limited number of composite topsoil samples analysed, this appraisal should be regarded as indicating general tendencies only.

(a) Macronutrients

According to the analytical data (see appendix 1) all the soils in the farm have low organic matter content. For all the units the organic C% varies from 0.6 to 1.8. Nitrogen deficiency is also reflected in all the mapping units, the lowest is 0.03% and the highest is 0.16.

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Phosphorous is also remarkably deficient in almost all the units apart from unit P3p and VC where it ranges from 27ppm to 46ppm. In unit Ybp the phosphorous content varies from 14ppm to 25ppm. The availability of bases such as potassium, calcium, magnesium and manganese are adequate in all the units.

(b) Micronutrients

Samples analysed for the trace elements (Cu, Zn and Fe) show that all the soils are deficient in Cu. The bulk of the soils also reflect marked Zn deficiency. The availability of Fe is adequate in all the units.

Following the analytical data one may arrive at the following conclusions:

- frequent use of phosphate and nitrogenous fertilizers is necessary in order to replenish soils with the deficient elements
- application of single super-phosphate will take care of calcium and sulphates into the soil
- for nitrogen, the application of calcium ammonium nitrate (CAN) will supply calcium in addition to nitrogen
- for the trace elements, $CuSO_4$ of Cuocl (copper oxychloride) can be applied by dressing the seeds and later on $ZnSO_4$ and $CuSO_4$ can be applied as foliar spray.

4.6. Surface sealing, runoff and erosion

Surface sealing is a common phenomenon in the drier areas of Kenya which have no complete vegetation cover. It is mainly caused by the direct impact of raindrops on the soil. The sealing reduces the infiltration rate and consequently increases the runoff and erosion. Surface sealing cannot be detected by use of aerial photographs but can be observed in the field where it is described by its grade (weak, moderate or strong) and thickness (in cm).

Runoff can simply be defined as the flow of rainwater or irrigation water over the soil surface. The effect of the runoff on the soil is erosion. During the fieldwork erosion is described by its features (type) and the degree. Some of the identifiable erosion features on the aerial photographs include rills, gullies and badlands. Sand overwash and deposits can also indicate the presence of sheet erosion. The degree of erosion is described as slight, moderate or severe.

The factors affecting runoff and erosion are similar, i.e.:

- climatic factors (rainfall intensity, distribution, etc.)
- parent material; some rocks e.g. quartzite are more resistant to weathering than volcanic rocks
- relief; little erosion is to be expected on flat areas e.g. plateaus and valley bottoms
- vegetation (soil cover), which intercepts and reduces the impact of the raindrops on the soil
- soil properties; organic matter content, structure stability and texture
- man; poor soil management practices, e.g. overgrazing.

Coarse fragments (gravel etc.) on the soil surface in a way tend to have the same effect as vegetation for they can also serve the following purposes::-

- intercept the raindrops and thereby reduce the effect of splash erosion (raindrop erosion)
- reduce both the speed with which the micro-rills are formed and subsequntly the pirating of those rills which may otherwise lead to the formation of gullies

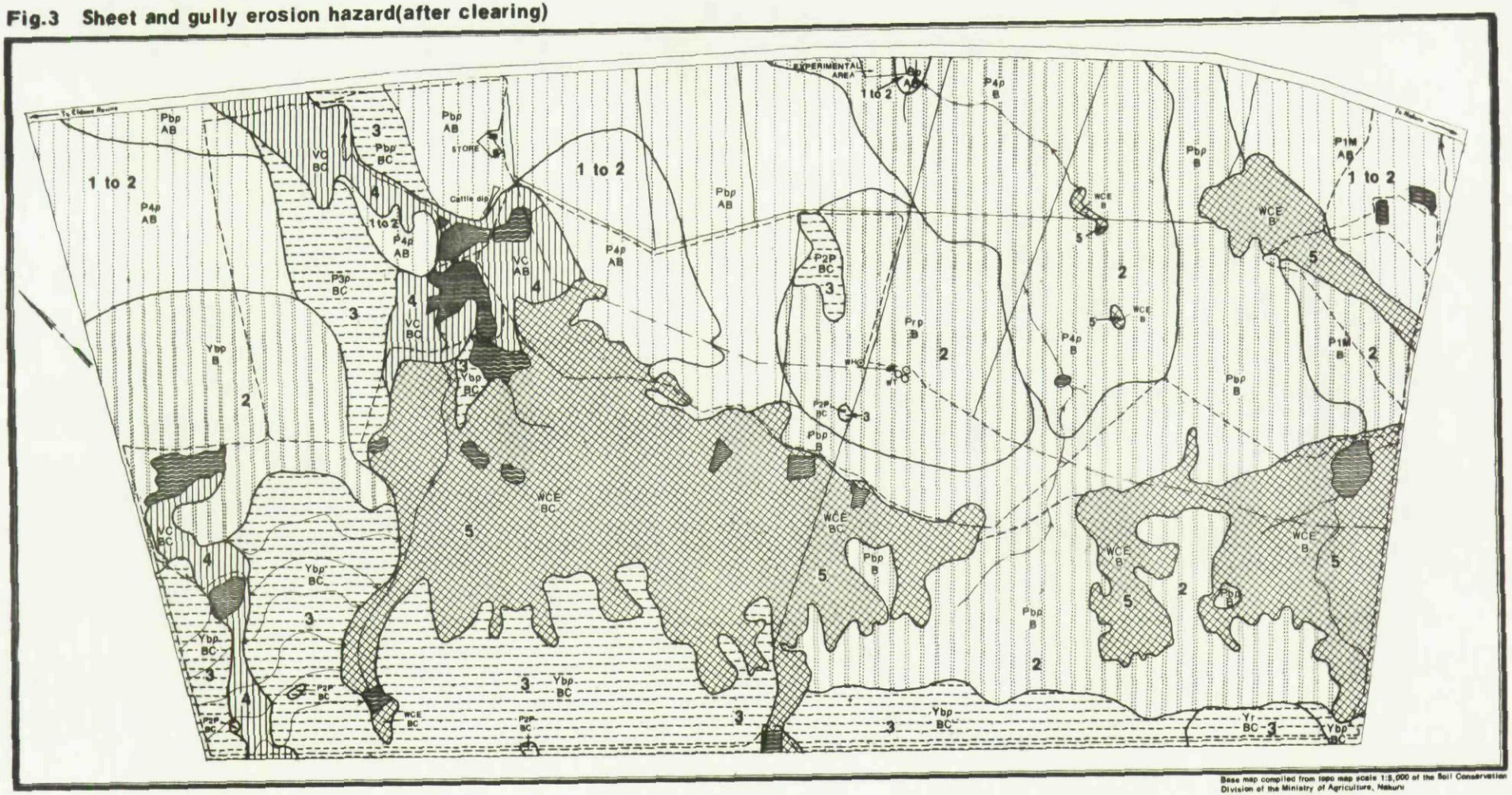
In evaluating the resistance of soils to erosion the following aspects were considered:

- climatic factors
- slope class
- slope length
- erodability, taking into consideration the organic matter content (%C)and the silt/clay ratio of the topsoil

These aspects were evaluated for each mapping unit of the survey area, eventually resulting in a rating for the resistance to erosion of each mapping unit (see appendix 3). These final ratings were transmitted in to erosion hazards, which are presented in fig. 3.

Fig. 3 shows that about one quarter of the survey area has none to slight erosion hazard, one quarter a slight erosion hazard, one fourth a moderate erosion hazard and one quarter a moderate to severe, or severe erosion hazard.

Fig.3 Sheet and gully erosion hazard(after clearing)



SCALE 1:20,000

0 400 800 1200 1600 2000 metres

KEY

1 to 2 none to slight

2 slight

3 moderate

4 moderate to severe

5 severe

4.7. Measures of erosion control

Gully erosion takes place where the concentrated runoff from a slope is sufficient in volume and velocity to move heavy quantities of soil and curve deep gullies. Gullies often have their runoff water concentrates. They also develop in the trails of livestock, in ruts left by the wheels of farm machinery and in furrows between crop rows which run up and down the slope. Thus, cultivating up and down slopes and poor location of roads and cow paths can be causes of gully formation. Usually their appearance in a field or pasture means that the land has been overstocked. When land begins to gully at frequent intervals it has reached the condition of old age, if not the beginning of the death stage, from the point of view of agricultural use (Agricultural Extension Manual; Maina and Voelkel, eds., 1968.)

Although strict measures have been taken to control the soil erosion in the farm, these measures cannot completely work out because the runoff is concentrated towards the footslopes of Kilombe hills where there are rather steep slopes and the practice of over-grazing and cutting of wood for charcoal burning are common practices.

A stress on this subject should be emphasised due to deteriorating conditions on the surrounding areas where large quantities of soil have been carried away and deep gullies of more than 10 metres deep and several metres wide have been formed.

Practices best suited to prevention of these gullies are a combination of contour farming, terracing, crop rotation and strip cropping. If cultivated land cannot be protected by these methods, it should not be cultivated; such land should be put to its most profitable use e.g. properly managed permanent pasture or woodland.

Once appropriate soil conservation practices are put into use, many gullies may be eliminated by filling or grading, controlling the runoff with diversion ditches or terrace systems. When runoff entering the gully is held to a minimum by diversion ditches or terraces, other conservation measures should be carried out, such as planting soil binding vegetation.

It should be stated here that many of these measures have been carried out in the survey area. However, little of this information has been transmitted to the local farmers in the surrounding areas where the condition are getting worse and worse in every rainy season. It is anticipated that these practices of erosion control in the survey area will reach the surrounding farmers through the knowledge of agricultural extension staff and the soil conservation section of the Farm and Land Management Division of the Ministry of Agriculture.

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5. Land management

While carrying out the field work it has been noticed that some soils are very hard in the dry season. In such a condition these soils are very difficult to be ploughed by tractor or oxen while it is almost impossible to work them manually. Thus it is not surprising that land preparation is done after rains have started and as a result there is late planting which affects the yields of most crops in the farm and the surrounding areas. It seems therefore advisable to carry out land preparation during the dry season whenever the soils are moist enough for successful ploughing or hoeing.

It was also noticed that some soils have a compact layer at a very shallow depth (10-15cm). Such soils affect the rooting system of most of the plants. This might probably have been one of the causes of the finger millet failure in the farm. Deep ploughing should be practiced to improve aeration and free water movement into the soils, thereby increasing the soil moisture storage capacity of the soil.

6. Land evaluation for maize, millet, sorghum, sunflower and livestock farming; high level of technology

6.1. General

The land evaluation exercise is based on the present land use (see chapter. 2.4) in the survey area and the information received from the local farmers. It is felt that maize (Katumani variety), millet, sorghum and sunflower (the dwarf variety) if planted at the start of the rains and in a well prepared land, will give favourable yields. Livestock farming for meat and milk production is the common practice in the survey area and its surroundings.

6.2. Procedure

The approach to land evaluation, adopted by the Kenya Soil Survey, closely follows the proposals of FAO (1976). In the "Soils of the Kindaruma area" (van de Weg and Mbuvi, 1975) an elaborate account of this approach to land evaluation has been given. A short summary of the basic concepts is given here:

- land evaluation is based on land qualities that can be quantified and rated
- these land qualities are used to establish specifications for each land suitability class
- land qualities usually are combinations of single land characteristics (see below)
- for each "tract" of land a rating of all land qualities is made

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For the land evaluation for maize, millet, sorghum, sunflower and livestock farming in the survey area the following land qualities were used:

a. climatic characteristics
b. soil moisture storage capacity
c. possibilities of mechanisation (use of agricultural implements)
d. resistance to erosion (sheet and gully erosion after clearing)
e. presence/hazard of water-logging (availability of oxygen for root growth)
f. chemical soil fertility
g. nutritional value of vegetation
h. presence of overgrazing
i. treadibility
j. hindrance by vegetation

A short account of the single land characteristics used in the rating of the land qualities is given below. For an account of the methods followed to arrive at the final rating of each land quality, reference is made to KSS Internal Communication No. 7 (Kenya Soil Survey, 1977). The final ratings of the land qualities are given in app.3 followed by the final suitability class for the various land utilization types.

(a) Climatic characteristics

Climatic characteristics are very important in land evaluation. For instance the amount of rainfall and its distribution over an area has a strong influence on crop yields. The survey area falls in the agroclimatic zone III, which is moderate for most of the crops considered and livestock farming. To assess the climatic water availability, use is made of estimated r/Eo boundary values (see chap. 2.2.), which are presented in table 5 and 6.

(b) Soil moisture storage capacity

Among other things, plants require an ample moisture supply for their sustained growth. Plants may wilt temporarily or even permanently with a strong decrease of moisture in the soil. The soil moisture availability depends on the interplay of climatic and soil characteristics.

For the rating of the land quality "soil moisture storage capacity" the following land characteristics were considered:

- the total productive available moisture (TPAM), which is considered to be a function of soil depth and texture;
- the hindrance to root development.

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The easier the penetration of roots to deeper horizons the better available the soil moisture is to plants. Hindrance to root development is considered slight in profiles with oxic, argillic and cambic horizons, moderate in profiles with a pronounced argillic horizon or pronounced sedimentary stratification and strong in case of a planic horizon (abrupt textural change) natric horizon or impermeable layers.

(c) Possibilities of mechanisation

The use of agricultural implements is important in order to speed up the operation of the farm practices such as: seedbed preparation, harvesting and transportation.

For the rating of the above land quality, the following land characteristics were considered:

- slope length
- steepness of slope
- width of the field
- stoniness/rockiness 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 dry and moist consistence of soil.

(d) Resistance to erosion

For the rating of this land quality the following land characteristics were considered:

- climatic factors
- topography, length and steepness of slope
- erodability (soil characteristics)

for the sub rating of "erodability" the following factors are normally considered:

- organic matter content (% carbon)
- silt/clay ratio of the topsoil
- bulk density of the topsoil

No use was made of the flocculation index and the bulk density due to lack of analytical data. However, use was made of field observations on the occurrence of erosion in all soil mapping units.

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(e) Presence/hazard of waterlogging

Plant roots need oxygen for their normal growth. Oxygen (air) present in the soil macropores can be displaced by water upon water-logging and as a result plant die for lack of it. In order to avoid this condition proper drainage measures should be employed. Excessive water supply in the soil can also affect the quality and even the quantity of the yields. For the rating of the above land quality, the soil drainage class as determined in the field was the main criterion.

(f) Chemical soil fertility

Low levels of chemical soil fertility can be corrected by use of fertilizers, timely weeding and use of soil conservation measures e.g. control of runoff. Timely weeding reduces the competition between plants and weeds for the nutrients available in the soil.

In the rating of the above land quality, the following characteristics were considered:

- CEC (cation exchange capacity) of the topsoil (0-30cm)
- available nutrients of the topsoil
- total nutrient content of the topsoil (mineral reserve)

(g) Nutritional value of vegetation

For the rating of this land quality, the species composition of the grasses were taken into consideration. In the survey area the dominant grass is Rhodes grass (Chloris gayana). In general it is of better nutritional value than most of the grass species like Sehima nervosum, Themeda triandra or Chloris roxburghiana. However its nutritional value depends on variety, growth stage, climate, soil type, fertility and grazing and mowing stages.

(h) Presence of overgrazing

The rating of this land quality was based on present status and percentage of overgrazed land by visual observation of herbaceous cover and composition.

(i) Treadibility

Although no suitable rating system has been developed for this land quality nevertheless the following land characteristics used in the Kiboko report (Michieka and van der Pouw, 1977), were taken into consideration:

- soft ground, hardness of ground (or: consistence when dry)
- stickiness of the soil (or: consistence when wet)
- extreme stoniness or rockiness (degree of surface stoniness and rockiness)
- steep slopes (degree of slope)

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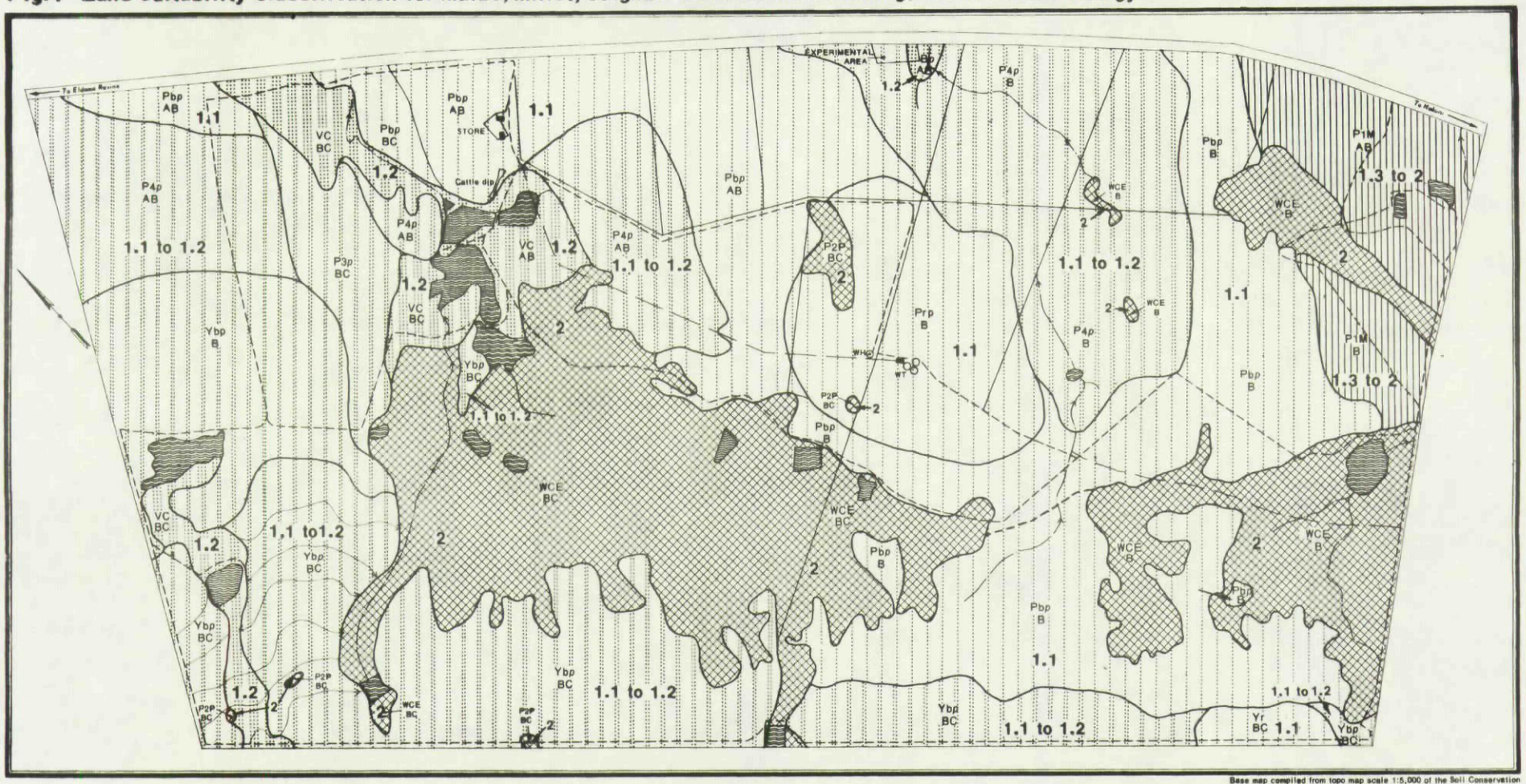
Fig.4 Land suitability classification for maize, millet, sorghum and sunflower farming; advanced technology



Base map compiled from topo map scale 1:5,000 of the Soil Conservation Division of the Ministry of Agriculture, Nakuru

SCALE 1:20,000

0 400 800 1200 1600 2000 metres

KEY

1.1 highly suitable

1.1 to1.2 highly to moderately suitable

1.2 moderately suitable

1.3 to 2 marginally suitable to unsuitable

2 unsuitable

(j) Hindrance by vegetation

For the rating of this land quality the denseness of shrub vegetation was taken into account. The dotted line in fig.5 for example is a vegetation boundary affecting the land suitability of unit Pbf.

(k) Other land qualities

Other land qualities which might be important for land evaluation, but which for various reasons were not taken into account, are:

- sodicity: high level of sodium in the soil will cause dispersion of structural aggregates which may result in poor aeration in the soil
- salinity: high level of salts in the soil may lead to dying of plant roots owing to the difficulty with which plant roots will absorb water from the soil

High levels of salinity and sodicity do not occur in the farm.

- availability of drinking water (distances to permanent or temporary/seasonal water supply). In Kelelwa farm water points are available all over the area
- tse-tse hazard: tse-tse flies do not occur in Kelelwa farm
- availability of shade: sufficiently available in Kelelwa farm

6.3 Results of the suitability classification

The ratings of the individual land qualities of all mapping units are given in appendix 3. The suitability classification given is essential for arable farming (maize, millet, sorghum and sunflower) and livestock farming under present conditions or with minor modifications.

The suitability of the individual soil mapping units is expressed by the following classes (see fig. 4 and 5 and also appendix 3):

1.1 highly suitable
1.2 moderately suitable
1.3 marginally suitable
2. unsuitable

The criteria for these classes, in terms of specifications for the final ratings of the land qualities, are given in table 5 and 6. The results of the suitability classification as outlined in appendix 3, are given in fig.4 and 5 and are summarized in table 7 and 8. The results show that out of a total of approx. 950ha of land, for arable farming roughly 238ha are considered highly suitable, 343ha highly-moderately suitable, 43ha moderately suitable, 53ha marginally suitable to unsuitable and 208ha unsuitable.

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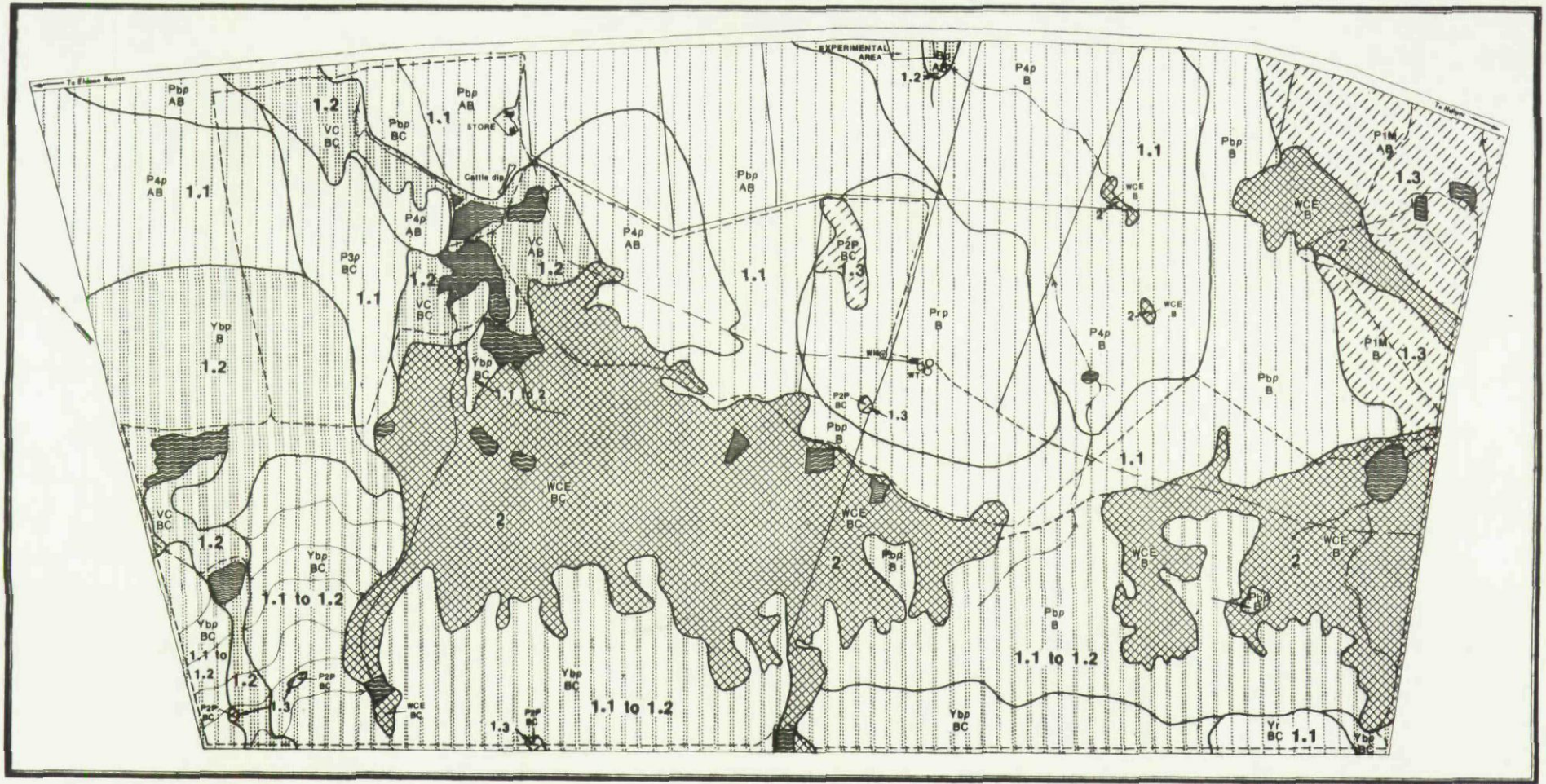
Fig.5 Land suitability classification for large scale livestock farming;advanced technology



Base map compiled from topo map scale 1:5,000 of the Soil Conservation Division of the Ministry of Agriculture, Nakuru

SCALE 1:20,000

0 400 800 1200 1600 2000 metres

KEY

1.1 highly suitable

1.1 to 1.2 highly to moderately suitable

1.2 moderately suitable

1.3 marginally suitable

2 unsuitable

Drawing No. 81047

For livestock farming, roughly 385ha are highly suitable, 185ha high to moderately suitable, 97ha moderately suitable, 57ha marginally suitable and 204ha unsuitable.

Table 5: Land quality criteria for the suitability classification of soils for maize, millet, sorghum, and sunflower "advance technology" ("conversion table")

Land Quality / Suitability class	r/Eo (%)	Soil moisture storage capacity	Chemical soil fertility	Resistance to erosion	Possibility of mechanisation	Hazard or presence of water-logging
1.1. Highly suitable	54	1	2-3	1-2	1-2	1-2
1.2. Moderately suitable	54	2-3	4	3	3	3
1.3. Marginally suitable	54	4	5	4	4	4
2. Unsuitable	54	4	5	5	5	5

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Table 6: Land quality criteria for the suitability classification of soils for livestock farming "advanced technology" (conversion table)

Land Quality / Suitability class	r/Eo (%)	Soil moisture storage capacity	Chemical soil fertility	Resistence to erosion	Possibility of mechanization	Hazard or presence of water-logging	Nutritional value of vegetation	Presence of over-grazing	Hindrance by vegetation
1.1 Highly suitable	>54	1	2-3	1-2	1-2	1-2	1-2	1	1
1.2 Moderately suitable	>54	2-3	4	3	3	3	3	2	2
1.3 Marginally suitable	>54	4	5	4	4	4	4	3	3
2 Unsuitable	>54	5	5	5	5	5	5	5	5

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Table 7: Results of the suitability classification for maize, millet, sorghum and sunflower

Suitability class	Mapping unit	Area ha	Area %
1.1 Highly suitable	Yr	5	0.6
	Pbp	224	23.6
	prp	59	6.2
Total for class 1.1		288	30.4
1.1 to 1.2 Highly to moderately suitable	Ybp	125	13.2
	Ybp	50	5.3
	P4p	158	16.6
	P3p	20	2.-
Total for class 1.1. to 1.2		353	37.2
1.2 Moderately suitable	Bp	1	0.1
	VC	47	4.9
Total for class 1.2		48	5.0
1.3 to 2 Marginally suitable to unsuitable	P1H	53	5.6
Total for 1.3 to 2		53	5.6
2. Unsuitable	UCE	204	21.5
	P2p	4	0.4
Total for class 2		208	21.9
(grand total)		950	100.1

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Table 8: Results of suitability classification for large scale livestock farming

Suitability class	Mapping unit	Area ha	Area %
1.1 Highly suitable	Yr	5	0.6
	Pbp	174	18.3
	Prp	59	6.2
	P4p	158	16.6
	P3p	20	2.1
Total for class 1.1		416	43.8
1.1 to 1.2 Highly suitable to moderately suitable	Ybp	125	13.2
	Pbp	50	5.2
Total for class 1.1 to 1.2		175	18.4
1.2 Moderately suitable	Ybp	50	5.2
	VC	47	4.9
	Bp	1	0.1
Total for class 1.2		98	10.2
1.3 Marginally suitable	P1M	53	5.6
	P2P	4	0.4
Total for class 1.3		57	6.0
2 Unsuitable	WCE	204	21.5
Total for 2.		204	21.5
(grand total)		950.	99.9

7. Conclusions and recommendations

The Kelelwa farm offers enough scope for arable and livestock farming provided the present soil conservation measures and livestock standards are well maintained.

Out of a total of approx. 950 ha of land, roughly 288 ha are considered highly suitable, 353 ha highly to moderately suitable, 48 ha moderately suitable, 53 ha. Marginally suitable and 208 ha unsuitable for arable farming.

For livestock farming, roughly 416 ha are highly, suitable, 175 ha high to moderately suitable, 93 ha. moderately suitable, 57 ha marginally suitable and 204 ha unsuitable.

Soil units Yr, Ybp, Pbp and Prp are highly suitable for a variety of crops, however fertilization and early planting during the rains is necessary to obtain sustain high yield. The soil units P3p, Ybp, P4p and Bp also offer possibilities, however because of their chemical and physical properties, they need a divergent management. Soil mapping unit P1H which is generally shallow over petroplinthite (murram) or rock can only be used for extensive grazing.

The central portion of the farm (soil mapping unit WCE) with severe gully and sheet erosion could be developed into a good grazing area in future if the present land improvement is complete. This is by levelling the land and filling in of the gullies, construction of the diversion ditches or terraces; and planting the land with grasses or binding vegetation.

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Appendix 1:

Detailed descriptions and analytical data of representative soil profiles.

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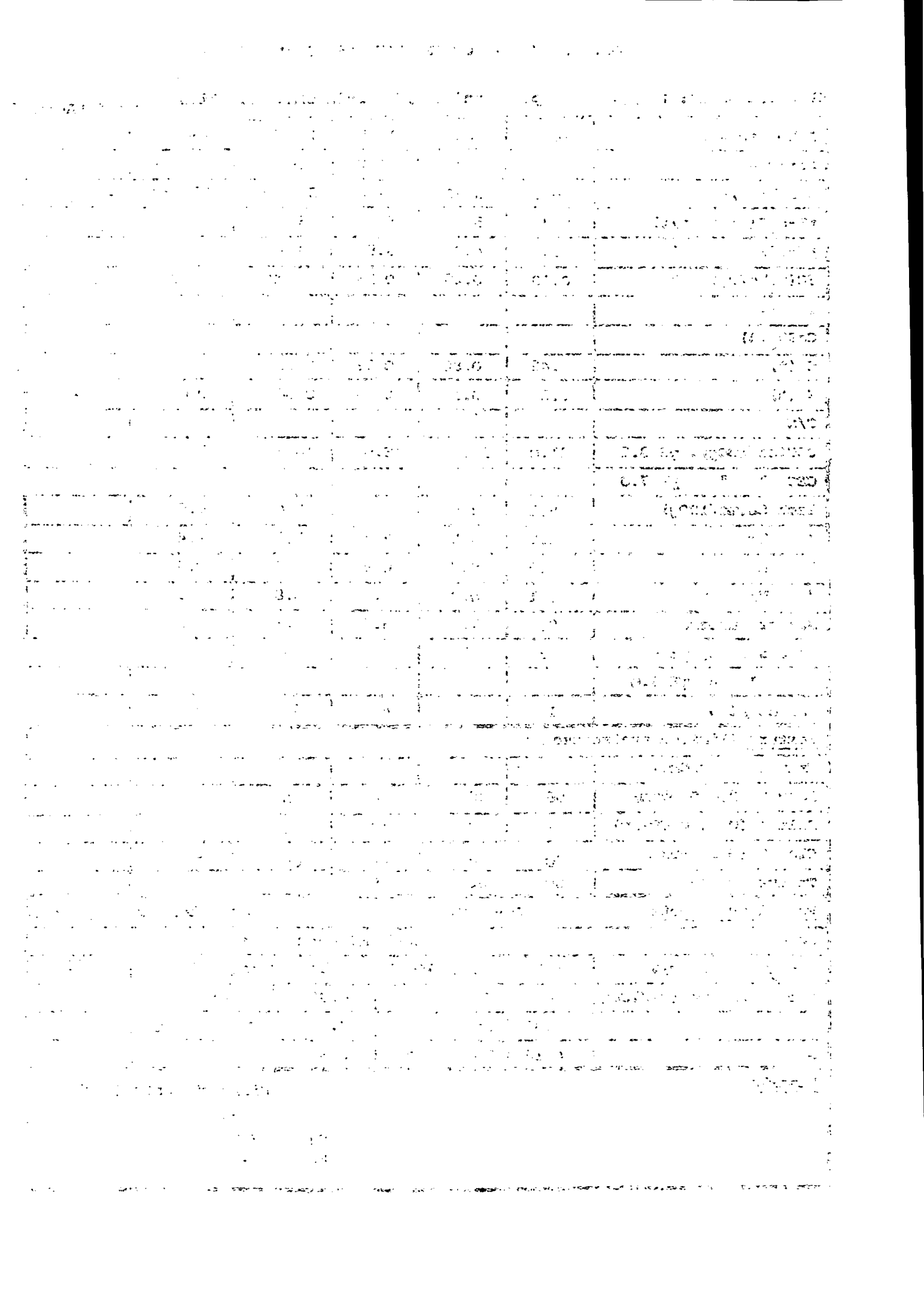

LABORATORY DATA OF PROFILE DESCRIPTION No. 1

Observation no: 118/2-127 Mapping unit: Yr Soil classification: chromic*Acrisol

Laboratory no. /	11403	11004	11405	11406	11407	
Horizon	A	Bt1	Bt2	Bt3	BC	
Depth(cm)	0-13	13-30	30-50	50-125	125-150	
pH-H_2O(1: 2½ v/v)	5.4	5.3	5.1	5.2	5.4	
pH-KCl "	4.3	4.0	3.8	3.7	4.0	
EC(mmho/cm) "	0.10	0.25	0.23	0.08	0.04	
$CaCO_3$(%)						
$CaSO_4$(%)						
C (%)	1.46	0.86	0.39	0.36	0.18	
N (%)	0.2	0.1	0.04	0.04	0.02	
C/N						
CEC(me/100g), pH 8.2	21.0	15.4	18.6	18.6	15.8	
CEC " " pH 7.0						
Exch.Ca(me/100g)	5.1	2.9	2.8	2.0	4.9	
" Mg "	2.9	3.5	2.3	1.7	2.4	
" K "	0.9	0.7	0.6	0.8	0.9	
" Na "	0.1	0.2	0.7	0.8	1.3	
Sum of cations	9.0	7.3	6.4	5.3	9.5	
Base sat. %, pH 8.2	43	47	34	29	60	
" " %, pH 7.0						
ESP at pH 8,2	1	1	4	4	8	
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	56	48	30	26	34	
Silt % (0.05-0.002mm)	4	2	16	14	24	
Clay % (0.002-0mm)	40	50	54	60	42	
Texture class	SC	SC	C	C	C	

Fertility aspects 0 - 30 cm **Laboratory no.** 11373 / 80

General		Available nutrients			
pH-H_2O (1: 1 v/v)	5.6	Na/me/100g)	0.12	Mn(me/100g)	1.22
Exch. acidity (me/100g)	-	K "	0.84	P (ppm)	14
C %	1.85	Ca "	3.9	P-Olsen(ppm)	
N %	0.14	Mg "	3.9		

Remarks:

Micronutrients (ppm)

Cu	0.06
Zn	17.0
Fe	31.5

Profile description No. 1

Observation no/date	:	118/2-127 of 17/10/80
Unit	:	Yr
Soil classification	:	chromic * ACRISOL
Ecological zone	:	III
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastic material
Physiography	:	Piedmont plains
Relief, macro	:	Gently undulating to undulating
Relief, meso, micro	:	Active termite mounds which are 50m apart
Land use	:	Maize
Erosion	:	Nil
Surface stoniness/rockiness	:	Nil
Slope gradient	:	5%
Salinity/alkalinity	:	Nil
Surface sealing	:	1-2mm, weak
Effective soil depth	:	More than 125cm
Drainage class	:	Well drained

A	0-13cm	Dark brown (7.5YR 4/4 dry, 7.5YR 3/2 moist); sandy clay; strong, very fine to medium, sub-angular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common, very fine to coarse pores; common fine, few, medium and coarse roots; clear and smooth transition to: (sample no. 118/2-127a)
Bt1	13-30cm	Dark reddish brown (5YR 4/6 dry, 5YR 3/4 moist); sandy clay; moderate, very fine to medium angular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common, moderate clay cutans; common, very fine to medium pores; common fine, few medium and coarse roots; clear and smooth transition to: (sample no. 118/2-127b)

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Bt2	30–50cm	Dark reddish brown (2.5YR 3/6 dry, 2.5YR 3/4 moist); clay; moderate, very fine to medium angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common, moderate clay cutans; common very fine to medium pores; few fine to coarse roots; common to many, iron and manganese (5mm) concretions; diffuse and smooth transition to: (sample no. 118/2-127c)
Bt3	50–125cm	Dark reddish brown (2.5YR 3/4 dry, and moist); clay; moderate, very fine to medium angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common, moderate clay cutans; many, very fine to coarse pores; few, fine to coarse roots; common to many, iron and manganese (5mm) concretions: (sample no. 118/2-127d)
BC	125–150cm	Reddish brown (10YR 4/4 dry, 5YR 4/4 moist): clay; common to many, iron and manganese (5mm) concretions: (sample no. 118/2-127d)
C	150–200cm	Dark greyish brown (10YR 5/4 dry, 10YR 4/2 moist); sandy clay; common to many, iron and manganese (5mm) concretions

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LABORATORY DATA OF PROFILE DESCRIPTION No. 2

Observation no: 118/2-125 **Mapping unit:** Ybp **Soil classification:** eutric Cambisol

Laboratory no. /	11396	11397	11398			
Horizon	A	AB	Bt			
Depth (cm)	0-15	15-30	30-98			
pH-H_2O (1: 2½ v/v)	5.8	5.7	6.1			
pH-KCl "	4.3	4.2	4.8			
EC (mmho/cm) "	0.10	0.08	0.17			
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	1.57	0.77	0.45			
N (%)	0.2	0.1	0.01			
C/N						
CEC (me/100g), pH 8.2	22.0	22.0	24.4			
CEC " " pH 7.0						
Exch. Ca (me/100g)	7.5	6.2	9.5			
" Mg "	3.8	3.8	3.8			
" K "	1.0	0.9	0.7			
" Na "	0.5	1.0	1.6			
Sum of cations	12.8	11.9	15.6			
Base sat. %, pH 8.2	58	54	64			
" " %, pH 7.0						
ESP at pH 8.2	2	1	7			
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	20	20	26			
Silt % (0.05-0.002mm)	34	32	34			
Clay % (0.002-0mm)	46	48	40			
Texture class	C	C	C/CL			

Fertility aspects 0 - 30 cm **Laboratory no.** 11371/ 80

General		Available nutrients			
pH-H_2O (1: 1 v/v)	5.5	Na/me/100g)	0.32	Mn (me/100g)	1.24
Exch. acidity (me/100g)	0.2	K "	0.92	P (ppm)	21
C %	1.01	Ca "	5.7	P-Olsen (ppm)	
N %	0.11	Mg "	3.9		

Remarks:

Micronutrients (ppm)

Cu	0.06
Zn	8.5
Fe	84.0

Profile description no. 2

Observation no/date	:	118/2-125 of 17/10/80
Unit	:	Ybp
Soil classification	:	eutric CAMBISOL
Ecological zone	:	III
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastic materials
Physiography	:	Piedmont plains
Relief, macro	:	Gently undulating to undulating
Relief, meso, micro	:	Nil; (Levelled gulleys and termite mounds)
Vegetation/land use	:	Rhodes grass (Chloris gayana)/Grazing
Erosion	:	Nil
Slope gradient	:	5-6%
Surface stoniness/rockiness	:	Nil
Salinity/alkalinity	:	Nil
Surface sealing	:	3mm, moderate
Effective soil depth	:	85cm
Drainage class	:	well drained

A	0-15cm	Dark yellowish brown (10YR 5/4 dry, 10YR 4/4 moist); clay; weak, medium and coarse, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; few, very fine to medium pores; common, fine to coarse roots; clear and smooth transition to: (sample no. 118/2-125a)
AB	15-30cm	Dark yellowish brown (10YR 6/4 dry, 10YR 3/4 moist); clay; weak, fine, medium and coarse, subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; many, very fine to medium, pores; common fine, medium and coarse roots; clear and smooth transition to: (sample no.118/2-125b)
BU	30-98cm	Dark yellowish brown (10YR 5/4 dry, 10YR 3/4 moist); clay to clay loam; moderate,

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fine to coarse, angular blocky structure, hard to very hard when dry, firm when moist, sticky and plastic when wet; few weak clay cutans; few, very fine to fine pores; few, fine to medium roots:

(sample no. 118/2-125c)

Remarks : 100 cm+. very hard to auger

2. Many manganese coatings at the depth of 30-98cm.

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LABORATORY DATA OF PROFILE DESCRIPTION No. 3

Observation no: 118/2-78 Mapping unit: Ybp Soil classification: Vertic Luvisol

Laboratory no. /	11388	11389	11390	11391		
Horizon	Ap	Bt1	Bt2	BC		
Depth (cm)	0-18	18-60	60-80	80-100		
pH-H_2O (1: 2½ v/v)	5.8	5.8	7.4	7.6		
pH-KCl "	4.4	4.6	6.4	6.2		
EC (mmho/cm) "	0.11	0.60	0.65	0.30		
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	0.83	0.56	0.42	0.33		
N (%)	0.1	0.06	0.04	0.03		
C/N						
CEC (me/100g), pH 8.2	15.4	28.8	29.4	27.8		
CEC " " pH 7.0						
Exch. Ca (me/100g)	4.9	13.6	20.0	16.4		
" Mg "	3.1	5.8	5.4	3.8		
" K "	1.2	2.4	2.6	2.4		
" Na "	0.4	1.9	2.1	1.9		
Sum of cations	9.6	23.7	30.1	24.5		
Base sat. %, pH 8.2	62	82	100+	88		
" " %, pH 7.0						
ESP at pH 8.2	3	7	7	7		
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	50	32	32	36		
Silt % (0.05-0.002mm)	26	16	24	26		
Clay % (0.002-0mm)	24	52	44	38		
Texture class	SCL	C	C	SL		

Fertility aspects 0 - 30 cm Laboratory no. 11369 / 80

General		Available nutrients			
pH-H_2O (1: 1 v/v)	5.5	Na/me/100g)	0.22	Mn (me/100g)	1.34
Exch. acidity (me/100g)	0.2	K "	0.84	P (ppm)	14
C %	1.0	Ca "	5.2	P-Olsen (ppm)	
N %	0.11	Mg "	3.0		

Remarks:

Micronutrients (ppm)

Cu	0.02
Zn	4.5
Fe	64.0

Profile description no. 3

Observation no/date	:	118/2-78 of 22/9/80
Mapping unit	:	Ybp
Soil classification	:	vertic LUVISOL
Ecological zone	:	III
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastic materials
Physiography	:	Piedmont plain
Relief, macro	:	Gently undulating
Relief, meso, micro	:	Nil
Vegetation/land use	:	Millet (Eleusinecoracana)
Erosion	:	Nil
Surface stoniness/rockiness	:	Nil
Slope gradient	:	2-3%
Salinity/alkalinity	:	Nil
Surface sealing	:	Nil
Effective soil depth	:	80cm
Drainage class	:	Moderately well drained

Ap	0-18cm	Very dark greyish brown (10YR 5/4 dry, 10YR 3/2 moist); sandy clay loam; weak, very fine to fine subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; few to common, very fine to fine pores; many, very fine roots; clear and smooth transition to:
		(sample no. 118/2-78a)
Bt1	18-60cm	Very dark greyish brown (10YR 3/2 moist); clay; strong, medium to coarse prismatic breaking to strong, fine, medium and coarse angular blocky structure; hard when dry, friable when moist, sticky and plastic when wet; common, weak clay cutans; common, fine roots; common, calcium carbonate concretions; clear and smooth transition to:
		(sample no. 118/2-78b)

Bt2 60-80cm : Dark brown (10YR 3/3 moist); clay; common, medium, yellowish brown (10YR 5/8) distinct mottles; strong, fine and medium angular blocky structure; friable when moist, sticky and plastic when wet; common, moderate clay cutans; few fine roots; common, calcium carbonate concretions; gradual and smooth transition to:

(sample no. 118/2-78c)

BC 80-100cm Dark brown (10YR 3/3 moist); clay; common, medium distinct yellowish brown (10YR 5/8) mottles; weak, fine and medium subangular and angular blocky structure; friable when moist, sticky and plastic when wet; few, weak clay cutans; few fine roots; common (1-3mm) calcium carbonate concretions; slightly calcareous;

(sample no. 118/2-78d)

Remarks in the BC horizon

1. Fragments of weathering rock which contain feldspars and quartz.
2. Common cracks of 5mm in diameter and 20cm deep occur in the profile.

LABORATORY DATA OF PROFILE DESCRIPTION No. 4

Observation no: 118/2-137 Mapping unit: Pbp Soil classification: Orthic Luvisol

Laboratory no. /	11437	11438	11439	11440		
Horizon	Ap	AB	Bt	BC		
Depth (cm)	0-18	18-35	35-70	70-110		
pH-H_2O (1: v/v)	6.6	6.9	6.7	7.2		
pH-KCl "	5.1	4.9	5.4	6.0		
EC (mmho/cm) "	0.40	0.09	0.07	0.14		
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	1.09	0.59	0.50	0.53		
N (%)	0.1	0.06	0.05	0.05		
C/N						
CEC (me/100g), pH 8.2	15.4	17.0	20.2	21.0		
CEC " " pH 7.0						
Exch. Ca (me/100g)	5.7	6.9	8.4	11.5		
" Mg "	2.4	3.2	3.9	3.5		
" K "	2.2	2.4	3.1	4.2		
" Na "	0.2	0.3	0.4	0.7		
Sum of cations	10.5	12.8	15.8	19.9		
Base sat. %, pH 8.2	68	75	78	95		
" " %, pH 7.0						
ESP at pH 8.2	1	2	2	3		
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	58	54	46	54		
Silt % (0.05-0.002mm)	22	16	20	22		
Clay % (0.002-0mm)	20	30	34	24		
Texture class	SCL/SL	SCL	SCL	SCL		

Fertility aspects 0 - 30 cm Laboratory no. 11383 /80

General		Available nutrients			
pH-H_2O (1: 1 v/v)	6.3	Na/me/100g)	0.10	Mn (me/100g)	1.22
Exch. acidity (me/100g)	-	K "	1.98	P (ppm)	30
C %	1.13	Ca "	4.6	P-Olsen (ppm)	
N %	0.11	Mg "	2.9		

Remarks:

Micronutrients (ppm)	
Cu	0.04
Zn	5.5
Fe	75.0

Profile description no. 4

Observation no./date	:	118/2-137 of 22/9/80
Mapping unit	:	pbp
Soil classification	:	orthic LUVISOL
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastics and sediments derived from pyroclastic rocks of the Rongai plain
Physiography	:	Volcanic plain
Relief, macro	:	Flat to gently undulating
Relief, meso, micro	:	Nil
Vegetation/land use	:	Rhodes grass (Chloris gayana)/Grazing area
Erosion	:	Nil
Slope gradient	:	2%
Salinity/alkalinity	:	Nil
Surface sealing	:	Nil
Effective soil depth	:	110cm
Drainage class	:	Well drained

Ap	0-18cm	Dark reddish brown (5YR 4/3 dry, 5YR 3/2 moist); sandy loam to sandy clay loam; weak, fine, medium and coarse subangular blocky structure; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few, very fine to coarse pores; few, fine roots; gradual and smooth transition to: (sample no. 118/2-137a)
AB	18-35cm	Dark reddish brown (5YR 4/3 dry, 5YR 3/2 moist); sandy clay loam; moderate, fine to coarse angular blocky structure; slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet; common, very fine to medium pores; few, fine roots; gradual and smooth transition to: (sample no. 118/2-137b)
Bt	35-70cm	Dark brown (10YR 4/4 dry, 10YR 3/3 moist) sandy clay loam; moderate, fine, medium and coarse angular blocky structure; slightly hard when dry, firm when moist,

slightly sticky and slightly plastic when wet; few, thin clay skins; common, very fine to medium pores; gradual and smooth transition to:

(sample no. 118/2-137c)

BC 70-110cm Dark yellowish brown (10YR 5/6 dry, 10YR 3/6 moist); sandy clay loam; weak, fine and medium angular, blocky structure; slightly hard when dry, firm when moist, sticky, and plastic when wet; few, very fine to medium pores

(sample no. 118/2-137d)

R 110cm+ Pyroclastic rock.

LABORATORY DATA OF PROFILE DESCRIPTION No.5

Observation no: 118/2-132 Mapping unit: Prp Soil classification: Chromic Luvisol

Laboratory no. /	11420	11421	11422	11423		
Horizon	Ap	Bt1	Bt2	Bs		
Depth(cm)	0-15	15-40	40-60	60-110		
pH-H_2O(1: $2\frac{1}{2}$ v/v)	5.6	5.8	5.3	5.2		
pH-KCl "	3.8	4.9	3.7	3.8		
EC(mmho/cm) "	0.05	0.06	0.15	0.06		
$CaCO_3$(%)						
$CaSO_4$(%)						
C (%)	2.20	0.71	0.39	0.35		
N (%)	0.2	0.07	0.04	0.04		
C/N						
CEC(me/100g), pH 8.2	17.8	16.2	16.2	18.0		
CEC " " pH 7.0						
Exch.Ca(me/100g)	6.5	2.5	2.2	4.0		
" Mg "	4.5	2.8	1.9	2.0		
" K "	1.3	0.9	0.8	1.4		
" Na "	0.1	0.2	0.9	1.3		
Sum of cations	12.4	6.4	5.8	8.7		
Base sat. %, pH 8.2	70	40	36	48		
" " %, pH 7.0						
ESP at pH 8.2	1	1	6	7		
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	36	30	26	28		
Silt % (0.05-0.002mm)	24	22	16	14		
Clay % (0.002-0mm)	40	48	58	58		
Texture class	C/CL	C	C	C		

Fertility aspects	0 - 30 cm			Laboratory no.11378 /80	
General		Available nutrients			
pH-H_2O (1: 1 v/v)	5.9	Na/me/100g)	0.09	Mn(me/100g)	.24
Exch. acidity (me/100g)	-	K "	1.16	P (ppm)	12.0
C %	1.34	Ca "	4.1	P-Olsen(ppm)	
N %	0.15	Mg "	3.9		

Remarks:

Micronutrients (ppm)

Cu	0.08
Zn	6.0
Fe	28.5

Profile Description No.5

Obse_vation no./date	:	118/2-132 of 21/10/80
Mapping unit	:	Prp
Soil classification	:	chromic LUVISOL
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastics and sediments derived from pyroclastic rocks of the Rongai plain
Physiography	:	Volcanic plain
Relief, macro	:	Very gently undulating
Relief, meso, micro	:	active termite mounds, 100m apart
Vegetation/land use	:	Rhodes grass (Chloris gayana)/Grazing area
Erosion	:	Nil
Slope gradient	:	2%
Salinity/alkalinity	:	Nil
Surface sealing	:	Nil
Effective soil depth	:	110cm
Drainage class	:	Well drained

Ap	0-15	Dark brown (7.5YR 4/4 dry, 7.5YR 3/3 moist); clay loam to clay; weak, fine and medium sub-angular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common, very fine to medium pores; few, fine roots; clear and smooth transition to: (sample no. 118/2-137a)
Bt1	15-40cm	Dark reddish brown (2.5YR 4/6 dry, 2.5YR 3/4 moist); clay; weak, fine and medium angular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common, thin clay skins; common, very fine to medium pores; few, fine roots; gradual and smooth transition to: (sample no. 118/2-132b)
Bt2	40-60cm	Dark reddish brown (2.5YR 5/6 dry, 2.5YR 3/4 moist); clay; weak, very fine, fine and medium angular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common, moderate clay skins,

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common, very fine to medium pores; gradual and smooth transition to:

(sample no. 118/2-132c)

Bt3	60-110cm	Dark reddish brown (2.5YR 3/4 dry and moist); clay; weak, very fine, fine and medium sub-angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common, moderate clay skins; few, very fine to medium pores;

(sample no. 118/2-137d)

Remarks:	110cm+	Many piso and petroferric material (marrum)

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LABORATORY DATA OF PROFILE DESCRIPTION No. 6

dystric CAMBISOL,

Observation no: 118/2-128 Mapping unit: P1M Soil classification: petreferric phase

Laboratory no. /	11408	11409				
Horizon	A	Bs				
Depth (cm)	0-13	13-25				
pH-H_2O (1: 2½ v/v)	5.9	5.6				
pH-KCl "	5.0	4.0				
EC (mmho/cm) "	0.06	0.20				
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	1.69	0.83				
N (%)	0.2	0.1				
C/N						
CEC (me/100g), pH 8.2	15.8	11.8				
CEC " " pH 7.0						
Exch. Ca (me/100g)	5.5	2.5				
" Mg "	2.9	2.0				
" K "	0.7	0.4				
" Na "	0.1	0.2				
Sum of cations	9.2	5.1				
Base sat. %, pH 8.2	58	43				
" " %, pH 7.0						
ESP at pH 8.2	1	2				
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	56	50				
Silt % (0.05-0.002mm)	20	20				
Clay % (0.002-0mm)	24	30				
Texture class	SCL	SCL				

Fertility aspects 0 - 30 cm Laboratory no. 11374 /80

General		Available nutrients			
pH-H_2O (1:1 v/v)	5.7	Na/me/100g)	0.09	Mn (me/100g)	1.20
Exch. acidity (me/100g)	-	K "	0.82	P (ppm)	10
C %	1.58	Ca "	3.6	P-Olsen (ppm)	
N %	0.13	Mg "	3.0		

Remarks:

Micronutrients (ppm)	
Cu	0.08
Zn	7.0
Fe	50.0

Profile Description No. 6

Observation no./date	:	118/2-128 of 18/10/80
Mapping unit	:	P1M
Soil classification	:	Dystric CAMBISOL, petroferric phase
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastic and sedimentary rocks of the Rongai plain
Physiography	:	Volcanic plain
Relief, macro	:	Flat to gently undulating
Relief, meso, micro	:	Flattened termite mounds
Vegetation/land use	:	Grazing area
Erosion	:	Nil
Slope gradient	:	1%
Salinity/alkalinity	:	Nil
Surface sealing	:	3mm, moderate
Effective soil depth	:	50cm
Drainage class	:	Well drained

A 0-13cm

Dark yellowish brown (10YR 5/4 dry, 10YR 3/4 moist); sandy clay loam; weak, very fine and fine subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; few, very fine and fine pores; common, iron and manganese concretions of 7-10mm in diameter; many, fine and medium roots; clear and smooth transition to:

(sample no. 118/2-128a)

Bs 13-25cm

Yellowish brown (10YR 5/6 dry, 10YR 5/8 moist); gravelly sandy clay loam; weak, very fine and fine subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few, very fine and fine pores; many iron and manganese concretions of 7-10mm in diameter; few, medium and coarse roots; gradual and smooth transition to:

(sample no. 118/2-128b)

/cs

BCcs	25-50cm	Dark yellowish brown (10YR 5/6 dry, 10YR 4/6 moist); gravels
	50cm+	petroferric material (marrum)

LABORATORY DATA OF PROFILE DESCRIPTION No. 7

Observation no: 118/2-131 Mapping unit: P2P Soil classification: eutric Cambisol

Laboratory no. /	11417	11418	11419			
Horizon	A	Bu	BC			
Depth(cm)	0-15	15-40	40-75			
pH-H_2O(1: 2½v/v)	6.5	6.0	5.6			
pH-KCl "	4.7	4.9	4.1			
EC(mmho/cm) "	0.08	0.23	0.07			
$CaCO_3$(%)	1.46	0.68	0.48			
$CaSO_4$(%)	0.1	0.07	0.05			
C (%)						
N (%)	16.2	13.2	10.0			
C/N						
CEC(me/100g), pH 8.2	4.8	2.9	4.8			
CEC " " pH 7.0	3.0	2.1	1.3			
Exch.Ca(me/100g)	1.1	0.3	0.6			
" Mg "	3.0	2.1	1.3			
" K "	1.1	0.3	0.6			
" Na "	0.2	0.2	0.8			
Sum of cations	9.1	5.5	7.5			
Base sat. %, pH 8.2	56	42	75			
" " %, pH 7.0						
ESP at pH 8.2	1	2	8			
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	36	42	50			
Silt % (0.05-0.002mm)	36	24	26			
Clay % (0.002-0mm)	28	34	24			
Texture class	CL	CL	SCL			

Fertility aspects 0 - 30 cm Laboratory no.11377 /80

General		Available nutrients			
pH-H_2O (1: 1 v/v)	5.7	Na/me/100g)	0.10	Mn(mc/100g)	1.40
Exch. acidity (me/100g)	-	K "	0.70	P (ppm)	10
C %	1.77	Ca "	4.6	P-Olsen(ppm)	
N %	0.16	Mg "	3.3		

Remarks:

Micronutrients (ppm)

Cu	0.06
Zn	7.0
Fe	26.5

Profile description no. 7

Observation no./date	:	118/2-131 of 21/10/80
Unit	:	P2P
Soil classification	:	eutric CAMBISOL
Ecological zone	:	III
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastics and sediments derived from pyroclastic rocks of the Rongai plain
Physiography	:	Volcanic plain
Relief, macro	:	Gently undulating
Relief, meso, micro	:	Few inactive termite mounds
Vegetation/land use	:	Grazing area
Erosion	:	Slight gully and sheet erosion
Slope gradient	:	3%
Surface stoniness/rockiness	:	Very rocky
Salinity/alkalinity	:	Nil
Surface sealing	:	3mm; moderate
Effective soil depth	:	75cm
Drainage class	:	Well drained

A	0-15cm	Dark reddish brown (5YR 4/6 dry, 5YR 3/3 moist); clay loam; weak, fine and medium subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many, very fine to medium pores; much animal activity (krotovinas); few, fine roots; gradual and smooth transition to: (sample no. 118/2-131a)
Bu	15-40cm	reddish brown (5YR 5/6 dry, 5YR 4/4 moist); clay loam; weak, fine, medium and coarse subangular blocky structure; slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet; many, very fine to medium pores; much animal activity (krotovinas); many, fine roots; gradual and smooth transition to: (sample no. 118/2-131b)

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BC	40-75cm	Dark reddish brown (7.5YR 5/6 dry, 5YR 3/4 moist); sandy clay loam; weak, very fine, fine and medium subangular blocky structure; slightly hard when dry, firm when moist, slightly sticky and slightly plastic when wet; common, very fine to medium pores.

(sample no. 118/2-131c)

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LABORATORY DATA OF PROFILE DESCRIPTION No.8

Observation no: 118/2-136 Mapping unit: P3p Soil classification: mollic Andosol

Laboratory no. /	11434	11435	11436			
Horizon	Ap	BU1	BU2			
Depth (cm)	0-18	18-48	48-110			
pH-H_2O (1: $2\frac{1}{2}$ v/v)	7.1	7.3	8.1			
pH-KCl "	6.3	6.2	6.7			
EC (mmho/cm) "	0.50	0.35	0.20			
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	0.77	0.38	0.21			
N (%)	0.08	0.04	0.02			
C/N						
CEC (me/100g), pH 8.2	33.6	22.8	27.8			
CEC " " pH 7.0						
Exch. Ca (me/100g)	26.0	15.5	22.0			
" Mg "	2.5	1.4	2.2			
" K "	1.7	0.6	1.7			
" Na "	0.4	0.5	1.9			
Sum of cations	30.6	18.	27.8			
Base sat. %, pH 8.2	81	79	100			
" " %, pH 7.0						
ESP at pH 8.2	1	2	7			
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	28	24	28			
Silt % (0.05-0.002mm)	26	38	28			
Clay % (0.002-0mm)	46	38	44			
Texture class	C	CL	C			

Fertility aspects 0 - 30 cm Laboratory no. 11382 / 80

General		Available nutrients			
pH-H_2O (1: 1 v/v)	7.5	Na/me/100g)	0.20	Mn (me/100g)	0.67
Exch. acidity (me/100g)	-	K "	0.56	P (ppm)	27
C %	0.48	Ca "	17.6	P-Olsen (ppm)	
N %	0.06	Mg "	2.1		

Remarks:

Micronutrients (ppm)	
Cu	0.06
Zn	1.5
Fe	25.5

Profile description no. 8

Observation no./date	:	118/2-136 of 22/10/80
Unit	:	P3p
Soil classification	:	mollic ANDOSOL
Ecological zone	:	III
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastic and sediments derived from pyroclastic rocks of Rongai plain
Physiography	:	Volcanic plain
Relief, macro	:	Very gently undulating
Relief, meso, micro	:	Nil
Land use	:	Fingermillet (Eleusine corocana)
Erosion	:	Nil
Slope gradient	:	2%
Surface stoniness/rockiness	:	Nil
Salinity/alkalinity	:	Nil
Surface sealing	:	Nil
Effective soil depth	:	110cm
Drainage class	:	Well drained

Ap	0-18cm	Very dark greyish brown (10YR 4/3 dry, 10YR 3/2 moist); clay; weak, very fine and fine subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common, very fine to fine pores; few, fine roots; clear and smooth transition to: (sample no. 118/2-136a)
2Bu1	18-48cm	Yellowish brown (10YR 7/3 dry, 10YR 5/4 moist); clay loam; moderate, fine and medium subangular to angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; slightly calcareous; few, very fine pores; many manganese concretions of 3-5mm in diameter; many fine roots; clear and smooth transition to: (sample no. 118/2-136b)
3Bu2	48-110cm	Dark yellowish brown (10YR 5/8 dry, 10YR 4/6 moist); clay; moderate, very fine and fine angular blocky structure; .../71

slightly hard when dry, friable when moist, sticky and plastic when wet; moderately calcareous:

(sample no. 118/2-136c)

110cm Pyroclastic rock

Remark:

1. Many calcium carbonate concretion of 5-15mm on the surface
2. Three distinct volcanic ash layers in the profile.

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LABORATORY DATA OF PROFILE DESCRIPTION No. 9

Observation no: 118/2-79 Mapping unit: P42 Soil classification: Orthic LUVISOL

Laboratory no. /	11392	11393	11394	11395		
Horizon	Ap	Bt1	Bt2	C		
Depth (cm)	0-15	15-45	45-70	70-120		
pH-H_2O (1: $2\frac{1}{2}$ v/v)	6.4	5.6	7.5	7.9		
pH-KCl "	5.2	4.3	6.2	6.7		
EC (mmho/cm) "	0.19	0.25	0.50	0.40		
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	1.31	0.59	0.62	0.15		
N (%)	0.13	0.06	0.06	-		
C/N						
CEC (me/100g), pH 8.2	23.6	26.0	30.5	16.2		
CEC " " pH 7.0						
Exch. Ca (me/100g)	10.4	11.9	22.0	13.6		
" Mg "	3.2	4.0	5.7	1.4		
" K "	1.7	1.3	1.9	1.7		
" Na "	0.7	0.6	1.1	2.6		
Sum of cations	16.0	17.8	30.7	19.3		
Base sat. %, pH 8.2	68	68	100+	100+		
" " %, pH 7.0						
ESP at pH 8.2	3	2	1	2		
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	38	30	28	60		
Silt % (0.05-0.002mm)	22	14	18	28		
Clay % (0.002-0mm)	40	52	54	12		
Texture class	C/CL	C	C	SL		

Fertility aspects 0 - 30 cm Laboratory no. 11370 /80

General		Available nutrients			
pH-H_2O (1: 1 v/v)	6.2	Na/me/100g)	0.78	Mn (me/100g)	0.71
Exch. acidity (me/100g)	-	K "	0.82	P (ppm)	16
C %	1.13	Ca "	7.2	P-Olsen (ppm)	
N %	0.11	Mg "	3.0		

Remarks:

Micronutrients (ppm)

Cu	0.04
Zn	2.5
Fe	31.0

Profile description no. 9

Observation no./date	:	118/2-79 of 22/9/80
Unit	:	P4p
Soil classification	:	orthic LUVISOL
Ecological zone	:	III
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastic and sediments derived from pyroclastic rocks of Rongai and Mogotio
Physiography	:	Volcanic plain
Relief macro	:	Very gently undulating
Relief, meso, micro	:	Levelled area?
Vegetation/land use	:	Rhodes grass (Chloris gayana)/grazing
Erosion	:	Nil
Slope gradient	:	2%
Surface stoniness/rockiness	:	Nil
Salinity/alkalinity	:	Nil
Surface sealing	:	Nil
Effective soil depth	:	120cm
Internal drainage	:	Moderately well drained

Ap	0-15cm	Dark brown (10YR 5/3 dry, 10YR 3/3 moist); clay loam to clay; moderate, very fine, fine and medium subangular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; common, very fine to fine pores; many very fine to fine roots; clear and smooth transition to: (sample no. 118/2-79a)
Bt1	15-45cm	Dark brown (10YR 3/3 moist); clay; moderate, fine and medium angular blocky structure; hard when dry, friable to firm when moist, sticky and plastic when wet, common, thin clay skins; few, very fine to fine pores; common, very fine, to medium roots; gradual and smooth transition to: (sample no. 118/2-79b)

Bt2	45-70cm	very dark greyish brown (10YR 3/2 moist); clay; moderate, medium and coarse angular blocky structure; hard when dry, firm (compact) when moist, sticky and plastic when wet; common, moderate clay skins; few, very fine to fine pores; many calcium carbonate concretions 0-3mm in diameter; few, very fine to medium roots; clear and smooth transition to:
		(sample no. 118/2-79c)
C	70-120cm	Dark brown (10YR 5/3 dry, 10YR 3/3 moist); sandy loam; structureless; hard when dry, very fine when moist, non-sticky and non-plastic when wet; moderately calcareous; few, very fine to fine pores:
		(sample no. 118/2-79d)
R	120cm+	Pyreclastic rock
Remark:		From the depth of 45cm the soil is very compact.

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LABORATORY DATA OF PROFILE DESCRIPTION No. 10

Observation no: 118/2-138 Mapping unit: VC Soil classification: eutric CAMBISOL

Laboratory no. /	11441	11442	11443			
Horizon	Ap	BU	BC			
Depth(cm)	0-18	18-43	43-86			
pH-H_2O(1: 2½ v/v)	6.3	5.9	6.3			
pH-KCl "	5.3	4.8	5.0			
EC(mmho/cm) "	0.21	0.21	0.60			
$CaCO_3$(%)						
$CaSO_4$(%)						
C (%)	2.21	0.88	0.32			
N (%)	0.2	0.09	0.03			
C/N						
CEC(me/100g), pH 8.2	15.8	23.6	9.0			
CEC " " pH 7.0						
Exch.Ca(me/100g)	7.7	7.5	5.4			
" Mg "	4.7	5.4	2.5			
" K "	2.8	3.2	1.1			
" Na "	0.2	0.5	0.2			
Sum of cations	15.4	16.6	9.2			
Base sat. %, pH 8.2	97	70	100+			
" " %, pH 7.0						
ESP at pH 8.2	1	2	2			
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	30	26	74			
Silt % (0.05-0.002mm)	40	38	8			
Clay % (0.002-0mm)	30	36	18			
Texture class	CL	CL	SL			

Fertility aspects 0 - 30 cm Laboratory no. 11384 /80

General		Available nutrients			
pH-H_2O (1:1 v/v)	6.1	Na/me/100g)	0.12	Mn(me/100g)	1.55
Exch. acidity (me/100g)	-	K "	2.60	P (ppm)	46
C %	1.99	Ca "	8.6	P-Olsen(ppm)	
N %	0.11	Mg "	5.3		

Remarks:

Micronutrients (ppm)

Cu	0.06
Zn	20.5
Fe	27.0

Profile description no. 10

Observation no./date	:	118/2-138 of 23/4/80
Unit	:	VC
Soil classification	:	eutric CAMBISOL
Ecological zone	:	III
Geological formation	:	Recent volcanics
Local petrography	:	Pyroclastics and sediments derived from pyroclastic rocks of Rongai and Mogotio
Physiography	:	Minor valley
Relief macro	:	Gently undulating
Relief meso, micro	:	Nil
Vegetation/land use	:	Rhodes grass (Chloris gayana)/Grazing area
Erosion	:	Nil
Slope gradient	:	3%
Surface stoniness/rockiness	:	Nil
Salinity/alkalinity	:	Nil
Surface sealing	:	Nil
Effective soil depth	:	86cm
Internal drainage	:	Well drained

Ap 0-18cm

Very dark greyish brown (10YR 5/3 dry, 10YR 3/2 moist); clay loam; weak, very fine, fine and medium subangular blocky structure; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; common, very fine to medium pores; many, very fine, to medium roots, few coarse roots; clear and smooth transition to:

(sample no. 118/2-138a)

Bu 18-34cm

Dark brown (10YR 5/4 dry, 10YR 3/3 moist); clay loam; weak, to moderate, very fine, fine and medium subangular blocky structure; friable to firm when moist, slightly sticky and slightly plastic when wet; common, fine to medium pores; few, coarse pores; common, very fine to medium roots, few, coarse roots; abrupt and smooth transition to:

(sample no. 118/2-138b)

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2BC	34-86cm	Dark yellowish brown (10YR 4/4 dry, 10YR 3/6 moist); sandy loam; weak, very fine, fine and medium subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; few, fine to medium pores; few, very fine to medium roots: (sample no. 118/2-138c)
	86cm+	Pyroclastic rock

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LABORATORY DATA OF PROFILE DESCRIPTION No. 11

Observation no: 118/2-129 Mapping unit: Bp Soil classification: Plinthic gleysol

Laboratory no. /	11410	11411	11412	11413		
Horizon	A	Bgs1	Bgs2	Bgs3		
Depth (cm)	0-25	25-50	50-70	70-104		
pH-H_2O (1: v/v)	5.8	5.3	5.9	5.7		
pH-KCl "	4.8	4.9	4.4	4.5		
EC (mmho/cm) "	0.04	0.13	0.13	0.11		
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	0.74	1.13	0.62	0.59		
N (%)	0.07	0.1	0.06	0.06		
C/N						
CEC (me/100g), pH 8.2	27.0	21.8	23.6	21.0		
CEC " " pH 7.0						
Exch. Ca (me/100g)	11.5	10.0	8.0	7.7		
" Mg "	4.3	3.5	3.5	3.0		
" K "	1.5	1.7	0.9	0.6		
" Na "	0.4	0.4	0.7	0.9		
Sum of cations	17.7	15.6	13.1	12.2		
Base sat. %, pH 8.2	66	72	56	58		
" " %, pH 7.0						
ESP at pH 8.2	2	2	3	4		
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	20	24	42	40		
Silt % (0.05-0.002mm)	26	34	20	20		
Clay % (0.002-0mm)	54	42	38	40		
Texture class	C	C	CL	C/CL		

Fertility aspects 0 - 30 cm Laboratory no. 11375 /80

General		Available nutrients			
pH-H_2O (1: v/v)	5.5	Na/me/100g)	0.24	Mn (me/100g)	1.44
Exch. acidity (me/100g)	0.1	K "	1.18	P (ppm)	18
C %	1.21	Ca "	5.9	P-Olsen (ppm)	
N %	0.13	Mg "	3.8		

Remarks:

Micronutrients (ppm)

Cu	0.10
Zn	5.5
Fe	34.0

Profile description no.11

Observation no./date	:	118/2-129 of 13/10/80
Unit	:	Dp
Soil classification	:	plinthic GLEYSOL
Ecological zone	:	III
Geological formation	:	Alluvium
Local petrography	:	Alluvium derived from pyroclastic rocks
Physiography	:	Bottomland
Relief macro	:	Very gently undulating
Relief meso, micro	:	Common, active and inactive termite mounds (approx. 30m. apart)
Vegetation/land use	:	acacia spp; grazing area
Erosion	:	Nil
Slope gradient	:	1%
Surface stoniness	:	Nil
Salinity/alkalinity	:	Nil
Surface sealing	:	Nil
Effective soil depth	:	70cm
Internal drainage	:	Imperfectly drained

A	0-25cm	Dark brown (10YR 5/4 dry, 10YR 3/3 moist); clay; strong, medium, coarse and very coarse prismatic structure breaking into moderate, fine and medium angular blocky structure; very hard when dry, firm when moist, sticky and plastic when wet; few, very fine to fine pores; many, fine to medium roots; clear and smooth transition to: (sample no. 118/2-129a)
Bg	25-50cm	Brown (10YR 6/3 dry, 10YR 5/3 moist); many, medium, distinct mottles (7.5YR 5/8); clay; medium and coarse angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; few, thin, slickensides; few, very fine to fine pores; few, fine to medium roots; gradual and smooth transition to: (sample no. 118/2-129b)

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Bgs1	50-70cm	Dark brown (10YR 6/3 dry, 10YR 4/3 moist); many, medium distinct mottles (7.5YR 6/6); clay loam; moderate, medium and coarse, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common, moderate slickensides; few, very fine to fine pores; many iron and manganese concretions of approx. 5mm in diameter very few, fine roots; gradual and smooth transition to: (sample no. 118/2-129c)
Bgs2	70-104cm	Dark yellowish brown (10YR 3/4 moist); many, fine distinct mottles (7.5YR 6/6); clay to clay loam; moderate, medium and coarse, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; few, very fine to fine pores; many iron and manganese concretions of approx.55mm in diameter (sample no. 118/2-129d)

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LABORATORY DATA OF PROFILE DESCRIPTION No. 12

Observation no: 118/2-133 Mapping unit: WCE Soil classification: eutic Fluvisol

Laboratory no. /	11424	11425	11426			
Horizon	C1	C2	C3			
Depth (cm)	0-30	30-70	70-110			
pH-H_2O (1: v/v)	6.3	6.0	6.3			
pH-KCl "	5.3	5.0	5.3			
EC (mmho/cm) "	0.09	0.14	0.35			
$CaCO_3$ (%)						
$CaSO_4$ (%)						
C (%)	0.35	0.38	0.32			
N (%)	0.04	0.04	0.03			
C/N						
CEC (me/100g), pH 8.2	21.0	21.0	22.7			
CEC " " pH 7.0						
Exch. Ca (me/100g)	11.9	12.5	12.5			
" Mg "	3.0	3.9	3.2			
" K "	1.2	1.3	1.2			
" Na "	0.9	0.8	0.8			
Sum of cations	17.0	18.5	17.7			
Base sat. %, pH 8.2	81	88	78			
" " %, pH 7.0						
ESP at pH 8.2	4	4	4			
Texture (limited pretreatment)						
Gravel % (>2.0mm)						
Sand % (2.0-0.05mm)	40	38	36			
Silt % (0.05-0.002mm)	30	32	36			
Clay % (0.002-0mm)	30	30	28			
Texture class	CL	CL	CL			

Fertility aspects	0 - 30 cm			Laboratory no. 11379 /80	
General		Available nutrients			
pH-H_2O (1: 1 v/v)	6.5	Na/me/100g)	0.29	Mn me/100g)	1.42
Exch. acidity (me/100g)	-	K "	0.80	P (ppm)	14
C %	0.35	Ca "	5.9	P-Olsen (ppm)	
N %	0.03	Mg "	2.6		

Remarks:

Micronutrients (ppm)	
Cu	0.08
Zn	3.5
Fe	74.0

Profile description no. 12

Observation no./date	:	118/2-133 of 21/10/80
Unit	:	WCE
Soil classification	:	eutric FLUVISOL
Ecological zone	:	III
Geological formation	:	Alluvium
Local petrography	:	Alluvium derived from pyroclastic rocks
Physiography	:	Badlands of the volcanic plain
Relief macro	:	Gently undulating
Relief meso, micro	:	Few active termite mounds, 10m high and 2-5m wide; steep, rounded erosion remnants of about 10m height and 20m width
Vegetation/land use	:	Bushland under game reserve
Erosion	:	Severe sheet and gully erosion
Slope gradient	:	3%
Surface toniness/rockiness	:	fairly stony
Salinity/alkalinity	:	Nil
Surface sealing	:	Nil
Effective soil depth	:	110cm
Internal drainage	:	Well drained

C1	0-30	Dark brown (10YR 5/4 dry, 10YR 3/3 moist); clay loam; weak, fine, medium and coarse subangular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common, fine pores; few krotovinas; many fine roots; clear and smooth transition to: (sample no. 118/2-133a)
C_2	30-70cm	Dark yellowish brown (10YR 5/4 dry, 10YR 3/4 moist); clay loam; hard when dry, firm when moist, sticky and plastic when wet; weak, medium and coarse subangular blocky structure; many, very fine to fine pores; few, fine roots; clear and smooth transition to: (sample no. 118/2-133b)

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C_3 70-110cm Dark yellowish brown (10YR 5/6 dry, 10YR 3/6 moist); clay loam; weak, fine, medium and coarse angular blocky structure; slightly hard when dry, friable when moist, sticky and plastic when wet; few, very fine roots:

(sample no. 113/2-133c)

Remark

1. Few calcium carbonate concretions on the surface
2. Many manganese concretions of 2-3mm in diameter throughout the profile
3. The profile has several thin layers of gravel and sand (stratification) which cannot be separated.

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Appendix 3: Rating of land qualities and suitability classification of the individual soil mapping units for maize, millet, sorghum and sunflower (Advanced technology with minor improvements)

Mapping unit and slope class	climate (r/Eo)	LAND QUALITIES					Suitability class for maize, sorghum, millet and sunflower	Limitations
		Soil moisture storage capacity	Chemical soil fertility	Resistance to erosion	Possibility of mechanisation	Hazard/ presence of water logging		
1 Yr/BC	SUITABLE	1	3	3	1	1	1.1 Highly suitable	- moderate soil chemical fertility - slight resistance to erosion
2 Ybp/BC	SUITABLE	3	3	3	1	1	1.1 Highly suitable to moderately suitable 1.2	- moderate chemical soil fertility - moderate soil moisture storage capacity - slight resistance to erosion
3 Ybp/B	MODERATELY	3	3	2	2	2	1.1 Highly suitable to moderately suitable 1.2	- moderate resistance to erosion - moderate soil moisture storage capacity - moderate soil chemical fertility
4 Pbp/AB PBp/B PBp/BC	MODERATE	3	3	1-2 2 3	1	1	1.1 Highly suitable	- moderate soil moisture storage capacity - moderate soil chemical fertility - slight to moderate resistance to erosion
5 Prp/B	MODERATE	3	2	2	1	1	1.1 Highly suitable	- moderate soil moisture storage capacity - moderate resistance to erosion

Appendix 3: Rating of land qualities and suitability classification of the individual soil mapping units for maize (Katumani), sorghum, millet and sunflower (dwarf variety) (Advanced technology with minor improvement)

Mapping unit and slope class	Climate (r/Eo)	LAND QUALITIES: Soil moisture storage capacity	Chemical soil fertility	Resistance to erosion	Possibility of mechanisation	hazard/ presence of water logging	Suitability class for maize, sorghum, millet and sunflower	Limitations
6 P1M/AB P1M/B	zone III	5	3	1-2 2	5	1	1.3 Marginally to suitable to 2 Unsuitable	- very low soil moisture storage capacity - moderate soil chemical fertility - moderate resistance to erosion - very poor workability
7 P2P/BC	SUITABLE	4	2	3	5	1	2 Unsuitable	- low soil moisture storage capacity - slight resistance to erosion - very poor workability
8 P3p/BC	SUITA	3	2	3	1	2	1.1 Highly suitable to 1.2 moderately suitable	- moderate soil moisture storage capacity - slight resistance to erosion
9 P4p/AB P4p/B	ATELY	3	2	1-2 2	2	2-3	1.1 Highly suitable to moderately suitable to 1.2	- moderate soil moisture storage capacity - - slight to moderate hazard of waterlogging
10 VC/AB VC/BC	MODER	4 5	2	4	3	2	1.2 Moderately suitable	- low soil moisture storage capacity - very slight to slight resistance to erosion - moderate workability

Appendix 3: Rating of land qualities and suitability classification of the individual soil mapping units for maize (Katumani), sorghum, millet and sunflower (dwarf variety) (Advanced technology with minor improvement)

Mapping Unit and slope class	Climate (r/Eo)	LAND QUALITIES						Limitations
		Soil moisture storage capacity	Chemical soil fertility	Resistance to erosion	Possibility of mechanisation	Hazard/ presence of water logging	Suitability class for maize, sorghum, millet, and sunflower	
11 Dp/AB	SUITABLE	3	2	2	3	3	1.2 Moderately suitable	- moderate soil moisture storage capacity - moderate workability - moderate hazard of waterlogging
12 WCE/B WCE/BC	MODERATELY	4	2	5	5	1	2 Unsuitable	- low soil moisture storage capacity - very slight resistance to erosion - very poor workability

Key:
1 = very high
2 = high
3 = moderate
4 = slight
5 = very slight

Appendix 4: Rating of land qualities and suitability classification of the individual soil mapping units for large scale livestock farming (Advanced technology)

Mapping unit	Climate r/Eo	LAND QUALITIES										Limitations
		Soil moisture storage capacity	Chemical soil fertility	Resistance to erosion	hazard/ presence of water logging	Posibility of mechanisation	Nutritional value of vegetation	Presence of overgrazing	Treadability	Hindrance by vegetation	Suitability class for livestock farming	
1 Yr	zone III	1	3	2	1	1	1	0	-	0	1.1 Highly suitable	- moderate soil chemical fertility - moderate resistance to erosion
2 Ybp	zone III	3	3	2	1	1	1	0	-	0	1 1 Highly to suitable 1 2 to moderately suitable	- slight hindrance by vegetation - moderate chemical soil fertility - moderate soil moisture storage capacity - moderate resistance to erosion
3 Ybp	zone III	3	3	2	1-2	2	4	0	-		1.2 Moderately suitable	-moderate resistance to erosion -moderate soil moisture storage capacity
4 Pbp	zone III	3	3	2	1	1	1	0	-	3	1.1 Highly suitable to 1.2 moderately suitable	-moderate soil moisture storage capacity -moderate soil chemical fertility -moderate resistance to erosion -moderate hindrance by vegetation

Appendix 4: Rating of land qualities and suitability classification of the individual soil mapping units for large scale livestock farming (Advanced technology)

Mapping unit	Climate r/Eo	LAND QUALITIES										Limitations
		Soil moisture storage capacity	Chemical soil fertility	Resistance to erosion	hazard/ presence of water logging	Possibility of mechanisation	Nutritional value of vegetation	Presence of overgrazing	Treadability	Hindrance by vegetation	Suitability class for livestock farming	
5 Prp	zone III	3	2	2	1	1	1	0	-	0	1.1 Highly suitable	- moderate soil moisture storage capacity - moderate resistance to erosion
6 P1M	zone III	5	3	2	1	5	3	0	-	3	1.3 Marginally suitable	- very low soil moisture storage capacity - moderate soil chemical fertility - moderate resistance to erosion - very poor workability - moderate hindrance by vegetation - moderate nutritional value of vegetation

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Appendix 4: Rating of land qualities and suitability classification of the individual soil mapping units for large scale livestoc farming (Advanced technology)

Mapping unit	Climate r/Eo	LAND QUALITIES										Limitations
		Soil moisture storage capacity	Chemical soil fertility	Resistance to erosion	hazard/ presence of water logging	Possibility of mechanisation	Nutritional value of vegetation	Presence of overgrazing	Treadability	Hindrance by vegetation	Suitability class for livestock farming	
7 P2P	zone III	5	3	2	1	5	3	1	3	3	1.3 Marginally suitable	- moderate nutritional value of vegetation - moderate hindrance by vegetation
8 P3p	zone III	3	2	3	2	1	0	1	-	0	1.1 Highly suitable	- moderate soil moisture storage capacity - slight resistance to erosion
9 P4p	zone III	3	2	2	2-3	2	0	2	1	0	1.1 Highly suitable	- moderate soil moisture storage capacity - slight to moderate hazard of water logging
10 VC	zone III	4	2	4	2	1	0	3	-	0	1.2 Moderately suitable	- low soil moisture storage capacity - slight resistance to erosion - moderate workability

Appendix 4: Rating of land qualities and suitability classification of the individual soil mapping units for large scale livestock farming (Advanced technology)

	LAND QUALITIES											
Mapping unit	Climate r/Eo	Soil moisture storage capacity	Chemical soil fertility	Resistance to erosion	hazard/ presence of water logging	Possibility of mechanisation	Nutritional value of vegetation	Presence of overgrazing	Treadibility ※	Hindrance by vegetation	Suitability class for livestock farming	Limitations
11. Bp	zone III	3	2	2	3	3	0	3	3	2	1.2 Moderately suitable	- moderate soil moisture storage capacity - moderate workability - moderate hazard of waterlogging - moderate treadibility
12. WCE	zone III	4	2	5	1	4	4	5	-	4	2. Unsuitable	- low soil moisture storage capacity - very slight resistance to erosion - very poor workability, high hindrance by vegetation - very severe overgrazing, poor grass cover

※ No suitable rating system has been developed yet.

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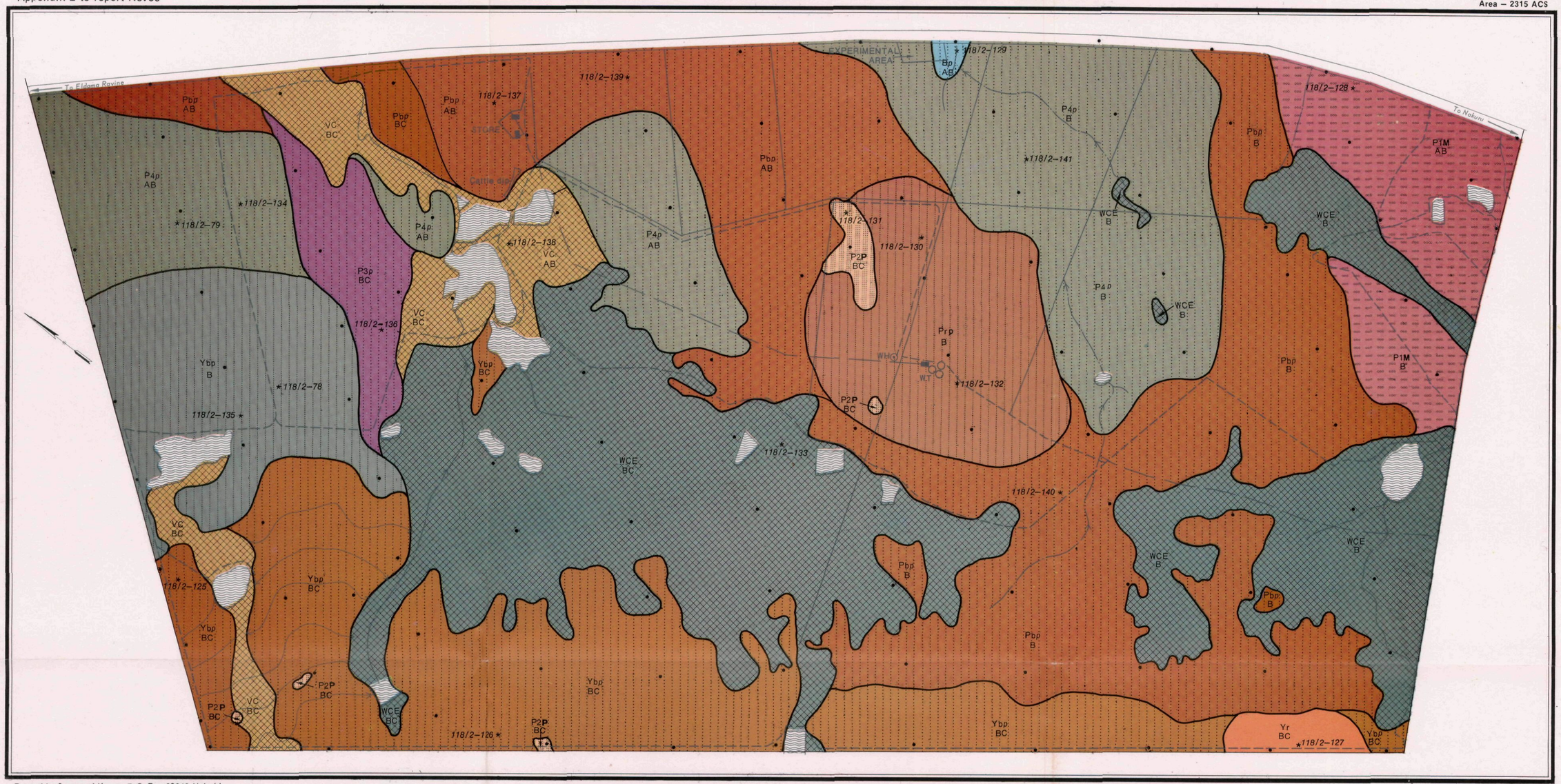
Appendix 2 to report No. S9

SEMI–DETAILED SOIL MAP OF KELELWA FARM (NAKURU DISTRICT)

L.R. No. 487/26/4
Area – 2315 ACS



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LEGEND

Y PIEDMONT PLAINS (slopes 2 – 6%)

Yr — well drained, very deep, dark reddish brown, friable clay (chromic* ACRISOLS)

Ybp — well drained, deep, dark brown to dark yellowish brown, firm, sandy clay to clay (eutric CAMBISOLS and orthic LUVISOLS)

Ybp — moderately well drained, moderately deep to deep, dark brown to yellowish brown, firm (compact), non–calcareous to strongly calcareous, sandy clay loam to clay, overlying pyroclastic gravel cemented by calcium carbonate; in places shallow over petroplinthite (murram) (vertic LUVISOLS and eutric CAMBISOLS)

P VOLCANIC PLAINS (slopes less than 6%)

Pbp — well drained, deep, dark brown to yellowish brown, firm, sandy clay loam to clay (orthic LUVISOLS)

Prp — well drained, moderately deep to deep, dark reddish brown to yellowish red, friable clay, over pisoplinthite (chromic LUVISOLS and eutric CAMBISOLS, pisoferric phase)

P1M — well drained, very shallow to moderately deep, dark yellowish brown to yellowish brown, friable, sandy clay loam to sandy clay, over petroplinthite or pyroclastic rocks (dystric CAMBISOLS, petroferric phase and LITHOSOLS)

P2P — well drained, very shallow to moderately deep, dark red–dish brown to strong brown, firm, rocky, bouldery and stony, sandy clay loam to clay loam (eutric CAMBISOLS, partly lithic phase and LITHOSOLS)

P3p — well drained to moderately well drained, deep, dark yellowish brown to greyish brown, friable to firm, clay loam to clay; with many calcium carbornate concretions on the surface (mollic ANDOSOLS)

P4p — moderately well drained, deep, dark yellowish brown to greyish brown, firm (compact), clay loam to clay (vertic LUVISOLS, orthic LUVISOLS and eutric CAMBISOLS)

MINOR VALLEYS (slopes 2–3%)

VC — complex of well drained to moderately well drained, shallow to deep, dark yellowish red to very dark greyish brown, friable to firm, gravelly, clay loam to clay (levelled areas) (eutric CAMBISOLS)

B BOTTOMLANDS (slopes 0–2%)

Bp — imperfectly drained to poorly drained, deep, dark brown to very dark greyish brown, mottled, firm to very firm, clay loam to clay (plinthic GLEYSOLS)

W BADLANDS

WCE — complex of well drained to moderately well drained, very shallow to deep, yellowish brown to dark yellowish brown, firm (compact), clay loam to sandy clay; with severe gully and sheet erosion

The names between parentheses reflect the scientific soil classification according to the FAO/UNESCO legend for their "Soil Map of the World"; prefixes marked with * are tentative terms, awaiting international agreement on nomenclature

SCALE 1:10,000

0 100 200 500 1000m

KEY TO SLOPE CLASSES

slope %	slope class symbol+	name of the macrorelief
0-2	A	flat to very gently undulating
2-5	B	gently undulating
5-8	C	undulating

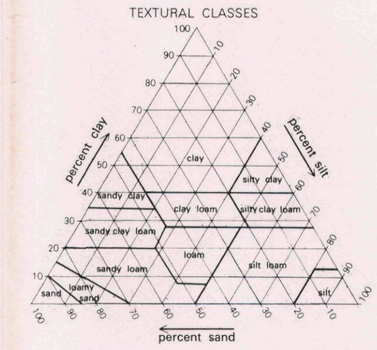
KEY TO DEPTH CLASSES

thickness soil in cm	symbol+ over rock	symbol+ over murram	name
0-25	P	M	very shallow
25-50			shallow
50-80	p		moderately deep
80-120	p		deep
more than 120			very deep

+ if a complex of depth classes occurs within one unit, only the symbol of the shallowest depth class is indicated

All soils are developed on pyroclastic rocks and sediments derived from pyroclastic rocks. The descriptions denote the characteristics of the subsoil (usually the B–horizon) above 100cm depth. Where the topsoil and/or the deeper subsoil differ(s) from this subsoil by two or more textural classes, they are also described

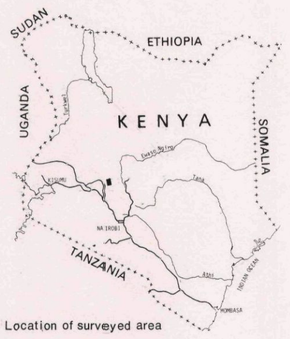
TEXTURAL CLASSES



Soil Survey and Map Preparation

soil survey	D.O. Michieka, H. Onyono and T. Wachira.
soil correlation	D.O. Michieka
map compilation	D.O. Michieka
map correlation	B.J. A. van der Pouw
cartography	D.M.Olulo, L. Mikisi

Base map compiled from the topo map scale 1:5,000 of the soil conservation section of the Land and Farm Management Division of the Ministry of Agriculture, Nakuru



■ Location of surveyed area

KEY

soil mapping symbol	fence
Pbp B depth class symbol / slope class symbol	terrace
soil boundary	pipe line
slope class boundary	drainage line
main road	water tank (WT)
farm road	dam
building	water hole (WH)
	augerhole
	profile pit with number (118/2–127)

Drawing No. 81009