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REPUBLIC OF KENYA

MINISTRY OF AGRICULTURE

NATIONAL AGRICULTURAL LABORATORIES

KENYA SOIL SURVEY

SOILS OF THE KAPENGURIA AREA

(Quarter Degree Sheet 75)

by

H. F. Gelens, H. C. K. Kinyanjui

and

R. F. van de Weg (editor)

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1976

RECONNAISSANCE SOIL SURVEY REPORT No. R2

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TABLE OF CONTENTS

	PAGE
FOREWORD	iv
SUMMARY AND CONCLUSIONS (BY R. F. VAN DE WEG)	1
1. THE ENVIRONMENT—	
1.1. Location, communications and population (by R. F. van de Weg)	5
1.2. Climate (by H. M. H. Braun)	5
1.2.1. Introduction	5
1.2.2. Relation between altitude and climate	5
1.2.3. Adjusted averages for annual and seasonal rainfall	8
1.2.4. Average annual rainfall and evaporation	8
1.2.5. Seasonal rainfall and evaporation	8
1.2.6. The probability of wet season rainfall deficits	11
1.2.7. Start and finish of the rainy season	11
1.2.8. Rainfall distribution in the rainy season	13
1.2.9. Growing season simulation	13
1.2.10. Rainfall intensity	14
1.3. Geology, geomorphology and hydrology (by R. F. van de Weg)	14
1.3.1. Geology	14
1.3.2. Geomorphology	15
1.3.3. Hydrology	16
1.4. Erosion (by R. F. van de Weg)	18
1.4.1. General	18
1.4.2. Present erosion	19
1.4.3. Erosion hazard	19
1.5. Vegetation (by H.M.H. Braun and H. W. Okwaro)	20
1.5.1. Introduction	20
1.5.2. Methods	20
1.5.3. Description of the vegetation units	20
1.5.4. Relation between altitude, climate, soil and vegetation	22
1.6. Ecological zonification (by H. M. H. Braun)	22
1.7. Present land use (by H. M. H. Braun)	23
1.7.1. Introduction	23
1.7.2. Description of the present land use units	23
1.7.3. Some remarks on crops, range land and forestry	24
2. The survey methods (by R. F. van de Weg and H. C. K Kinyanjui)	25
2.1. Office methods	25
2.2. Field methods	25
2.3. Laboratory methods (by R. A. Leijder)	26
2.4. Cartographic methods	28
3. The Soils	28
3.1. Previous work (by R. F. van de Weg)	28
3.2. General properties of the soils (by W. G. Sombroek)	29
3.3. Description of soil mapping units (by W. Siderius, H. F. Gelens, H. C. K. Kinyanjui and J. J. Vleeshouwer)	29
3.3.1. General	29
3.3.2. Description of the individual soil mapping units	31
3.4. Soil classification, correlation and genesis aspects (by W. G. Sombroek)	64
3.4.1. Introduction	64
3.4.2. The major classification units	64
3.4.3. Soil genesis aspects	68
3.5. Soil fertility aspects (by R. A. Leijder)	72

FOREWORD

The present soil survey is the second in a series "Reconnaissance Soil Surveys" with multi-purpose land evaluation, per topographic map sheet.

The southern part may be taken as an example for the high-potential, low-population areas of the country. It is situated partly at medium altitude (Kitale-Kapenguria area), partly at high altitude (Cherangani hills). The northern part belongs to the medium-potential, low population areas of the country.

It is shown in the report that the soil resources in the southern part are often of moderate to high quality. There is some scope for opening-up of new land, but most of the agricultural development will have to come from the improvement and intensification of the existing types of land use. A good part of the Cherangani hills area is recommended for silviculture rather than for crop production or livestock farming. Because of the steep slopes such farming would lead to rapid diminishing of the organic matter-rich topsoils and to substantial erosion, unless expensive and very strict soil conservation measures are taken.

In the northern half of the area the land resources are poor. Most of the north-eastern part has very steep slopes and shallow soils. Here the maintenance of a protective vegetation cover is recommended, also to safeguard the hydrological potential of the rivers originating in the area.

In the north-western part of the survey area slopes are less and the soils are deeper. The nature of these soils (very low organic matter content, strong surface sealing), the marginal climatic conditions and the present land use (uncontrolled grazing) make this area very susceptible to further deterioration by large-scale erosion. Urgent action is required in this part to avoid irreparable loss of all land.

The report gives an ample description of the methods employed. Part of these methods are liable to be improved upon as more experience is being gathered, and the needs of the users of the map and data become better known. Suggestions to this effect are therefore wholeheartedly invited.

The preparation of the maps and the report is a co-operative effort of most of the staff of the Kenya Soil Survey. This may be already apparent from the names figuring on the various maps and appendices. Substantial contributions to the report writing were given by Messrs. H. M. H. Braun, R. A. Leyder, W. Siderius and R. F. van de Weg.

The co-operation with the service laboratory of the N.A.L. should be mentioned; acknowledgement is due to the Senior Soil Chemists Messrs. W. W. Wapakala/G. Hinga, the Clay Mineralogist Mr. G. Hinga and the Soil Physicist Mr. C. Njihia.

Nairobi, September 1976.

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SUMMARY AND CONCLUSIONS

The area described in this report is situated in the Rift Valley Province of Kenya and is bounded by latitudes 1°00′ and 1°30′ and longitudes 35°00′ and 35°30′. It is approximately 306.000 ha. in extent. The average annual rainfall in the Kapenguria area varies from less than 800 mm. in the northern part (Chepkobeh area) to more than 1400 mm. in the central part. The main rainy season is from April to August and the dry season is from December to February with "transition" seasons from September to November and in March.

Partly based on the climatic study, partly on the vegetation study, the area has been divided into ecological zones I, II cold, II warm, III, IV and V. For details on these zones, *see* map Appendix 2.

Land use varies considerably: in the north-western part there is extensive range, in the south-western part large-scale cultivation and semi-intensive grazing; the higher parts, the Cherangani "hills", are mainly under forest with some extensive grazing and some smallholders farming.

The whole area is occupied by Precambrian rocks of the Basement System, and consists of a wide variety of gneisses and schists. Mountains and hills are prominent in the northern and eastern part of the area, and slopes are in general over 30 per cent. The south-western and north-western parts are made up of gently undulating to undulating uplands. Most of the rivers coming down from the Cherangani hills are perennial.

The general pattern of the soils is shown on the soil map, Appendix 1. They differ strongly in depth, chemical fertility, organic matter content and physical behaviour. The Kitale area has mainly deep soils of good structure (Ferralsols); the Cherangani "hills" area has mainly moderately deep soils of good structure and high organic matter content and variable acidity (mainly Cambisols). The north-western and northern parts have deep to shallow soils which are in general liable to sheet erosion (Luvisols and Acrisols). The mountains and hills of the northern and north-eastern part have shallow to very shallow soils and are often stony and rocky.

Both sheet erosion and gully erosion occur in the area. Fortunately a part of the area is still under forest but everywhere where cutting of the forest or disappearance of the vegetation due to overgrazing exposes the bare soil, erosion is starting at an alarming rate. A *must* for the area is therefore *proper soil conservation practices.*

In the land evaluation part of this study, land suitability ratings for each of the mapping units are given for the following land use alternatives:—

smallholder rainfed mixed farming (intermediate and advanced technology),
large-scale rainfed mixed farming, advanced technology,
small-scale livestock farming, intermediate technology,
extensive range management,
forestry (silviculture),
smallholder irrigation.

All relevant data on each of these land use alternatives are summarized in Table 14 whereas the land evaluation data are presented in tabular form in the land evaluation key, Appendix 3.

Smallholder Rainfed Mixed Farming, Intermediate Technology, Med'um Altitude

Intermediate technology is here defined as that level of technology where certain inputs (fertilizers, mechanization, etc.) are used on a modest scale. For this land utilization type most of the land in ecological zones IIc and III is moderately suitable. For ecological zone IV some stretches of land are indicated as conditionally suitable, on the condition that crops grown are the more drought resistant ones.

Smallholder Rainfed Mixed Farming, Advanced Technology, Medium Altitude

Advanced technology is hereby defined as that type of farming whereby the full range of modern inputs is being used, as recommended through agricultural research. This land use alternative, although hardly existent at present in the area is suited to the conditions prevailing in the ecological zones IIw and III. Most of the land units in these zones are highly to moderately suitable for this land use type. The crops considered here are beside maize, the high yielding, high labour and capital intensive cash crops as coffee, tea, pyrethrum and potatoes (soil and climate requirements for these crops are summarized in Table 15). Most of the area outside the above-mentioned zones is unsuitable for this land utilization type.

Large-Scale Rainfed Mixed Farming, Advanced Technology, Medium Altitude

This land use alternative is at present already being practised in most of the Kitale (Trans-Nzoia) area, which belongs to ecological zone III. The large-scale mixed farming is practised at a relatively high, but locally strongly varying, level of technology. Management standards are declining at present. Fragmentation of the large-scale farms, and illegal settlement of non-registered partners actually takes place to the detriment of the viability of these farms. Rehabilitation of these farms would therefore also mean that these practices of fragmentation and illegal settlement must be brought to a halt. Most of the land in zone III is highly to moderately suitable for this kind of land use; most of the rest of the survey area however is unsuitable for this kind of land use.

Small-Scale Livestock Farming, Intermediate Technology, High Altitude

This land utilization type is suited to the ecological conditions in the region of ecological zone IIc. In this area crops require a very long growing season, it is therefore that livestock enterprising is the most suitable activity to be developed in these areas. Much care should be taken to avoid overgrazing. Part of the land units in zone II are moderately to marginally suitable for this land use alternative.

Extensive Range Management

This land use alternative has been considered for the ecological zones IV and V. As rangeland is never likely to be very productive either in terms of shillings or in employment situation per ha., it should be appreciated that only those areas which offer little scope for arable farming should be allocated to extensive range management. Most of the grazing in this area at present is done in the traditional pastoral way. However, it is assumed that group ranches (or even individual ranching with communal facilities) will become the major vehicle for the implementation of adequate range management.

Two suitability ratings are given in the report: a current one and a potential one. Most of the area is suffering at the moment from serious overgrazing. This and other constraints contribute to the fact that most of the area at present is only marginally or submarginally suitable for range. The potential suitability rating (implying "major improvement" such as bush clearing, watering facilities, etc.) shows however, that quite some land can be of moderate or high suitability. If however no action is taken and the present overgrazing will continue, it will ultimately lead to a complete destruction of these grazing grounds.

Much thought should be given to subsistence growing of sorghum and millet in the relatively "better" parts of the range area although this area is only marginal for crop growing.

Smallholder Irrigation

Most of the land in the Kapenguria area is not suitable for irrigated agriculture. For smallholder irrigation some small stretches of land along some of the rivers are suitable, provided that sufficient water can be taken from these streams. Only some land units near Kongelai, in the Wei-Wei valley and near Ortoum can be considered for smallholder irrigation development.

Silviculture (forestry)

In the Cherangani "hills" a substantial area is covered with indigenous forest. Almost all of the forest in ecological zone IIw and part of the forest in zone IIc are in principle suitable for exploitation. In considering however the possibilities for forest exploitation it should be realized that, apart from their timber potential, the indigenous forests have a very important function in the protection of the water catchments. Most of the forest reserves should be, therefore, kept intact, in spite of the increasing land hunger due to population growth. This however does not mean that the possibility of establishing and exploiting exotic softwood plantations in part of the protected forest area should be excluded, although the utmost care should be taken to preserve the water conserving functions.

The suitability classification is divided into two: the first one gives a suitability rating of the *present forest value* so it takes into account only those areas which at present are under forest; the second one gives for the whole area a suitability classification indicating the potential suitability for *plantation forest*. Most of the land units in ecological zones IIc, IIw and III and some land units in zone IV are highly to moderately suitable for plantation forest. In establishing these fuel wood and building pole plantations, the different ecological conditions should be taken into account as far as species to be planted and expected production are concerned.

Protective Vegetation

For that land where certain land qualities are so adverse (very shallow soils and/or very steep slopes) that it is unsuitable for any type of arable farming, range or silviculture, it is strongly advised that it should be set aside for protection (*protective vegetation*). In fact it concerns those areas which should be protected to avoid serious erosion which may have both local and downstream effects. It should be stressed that it concerns large stretches of land, amounting to around 140.000 ha. *which is nearly* 50 *per cent of the total surveyed area.* This does not mean that no use at all could be made of this area. Some additional but strictly controlled grazing could be practised in part of this land and the protected forests may serve a dual purpose of protection against erosion and the production of timber, fuel and poles provided that the utmost care is taken and that replanting takes place.

The highest part of the Cherangani "hills" is unique from a point of view of vegetation and beauty of the scenery. It is therefore strongly recommended to set this area aside as a *National Park* (cf. the Aberdares National Park).

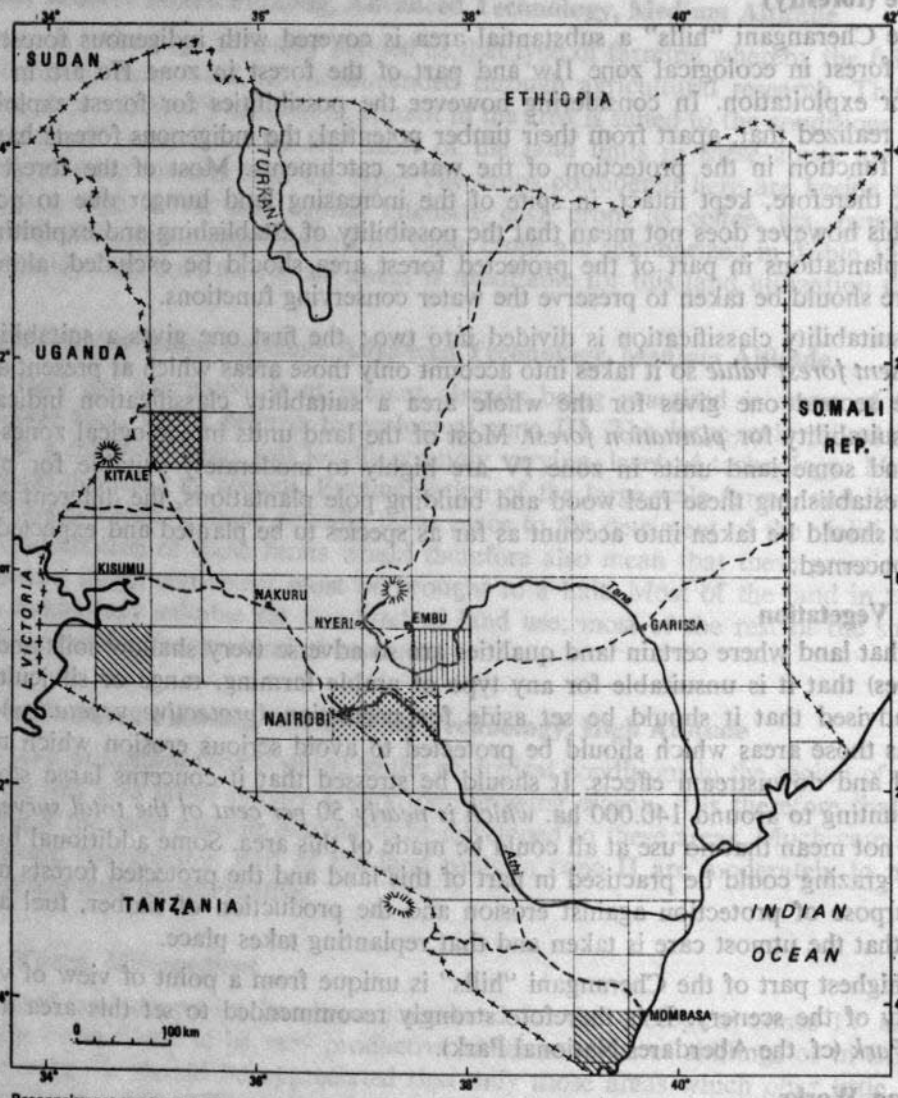
Engineering Works

A separate "Soil Engineering map" (Appendix 10) has been prepared, by combining various soil mapping units into major soil groups with significant differences in engineering properties. This map has been prepared in co-operation with the Materials Branch of the Ministry of Works, and is intended for those interested only in the engineering properties of the soils.

Recommended Land Use

As this study is mainly confined to the natural resources aspects, and the selection of the most promising land use alternatives should be left to the planners, only some recommendations are given (*see* Figure 15).

Large-scale mixed farming and/or smallholder mixed farming with advanced technology seems to be the recommended land use for the south-western corner of the area. In the north-western part the recommended land use is *extensive range*. Current suitability for range is however dominantly marginal or even submarginal; improvements will be required in this case. In the Cherangani "hills" large stretches of land are at present covered with indigenous forest. Because of its importance in the protection of water catchments it is strongly urged that most of this *forest* should be kept *intact and protected*. However, *exploitation of the forest* does not need to be excluded providing the water conserving function of the forests is preserved. The area which at present is already under grass in the Cherangani "hills", can be recommended for *small-scale livestock enterprises*. The steep and mountainous areas in the northern and north-eastern part of the surveyed area should be *protected* as much as possible to avoid accelerated erosion. It is recommended to set apart the highest level of the Cherangani "hills" as a *nature reserve* (National Park).



Reconnaissance survey program

- this map sheet
- report published
- sheet under preparation
- surveyed by D.O.S. (1963)
- to be mapped on 1:100 000
- to be mapped on 1:250 000
- international boundary
- river
- town
- road
- mountain

Fig. 1 Location map

1.—THE ENVIRONMENT

1.1. Location, Communications and Population

The Kapenguria area is situated in the Rift Valley Province and covers parts of the West-Pokot, Trans Nzoia and Elgeyo Marakwet districts. The area lies in the south-western quadrant of degree sheet No. 26 and is bounded by the 35°00′ and 35°30′ east longitudes and the 1°00′ and 1°30′ north latitudes. It is approximately 306.000 ha. in extent (*see* Fig. 1).

The elevation of the area ranges from just over 11000 ft. (3350m.) in the eastern part of the Cherangani "hills" to 3000 ft. (910m.) in the north-western part of the area. A map on scale 1:250.000 shows the altitudes for the whole surveyed area (Appendix 4, Map B).

The area is administered from three different centres. The West-Pokot District which covers the northern and central part of the sheet has Kapenguria as its district headquarters. The south-western corner of the map belongs to the Trans Nzoia District with Kitale as headquarters; the south-eastern corner is part of Elgeyo Marakwet District with Tambach as administrative centre (outside the surveyed area). Communications are poor in general. All-weather roads (murram) are Kitale-Makutano-Kapenguria, Makutano-Kongelai and many of the roads in the south-western corner of the area around Kitale. Other murram roads are Makutano-Ortum-Sigor and the "Cherangani highway". These latter roads may be, however, impassable after heavy rain. The rest of the area is accessible only by Land-Rover or on foot. The Kitale branch of the railway terminates at Kitale.

Fig. 2 supplies the demographic data. It gives the population density per administrative location based on the Kenya Population census, 1969. The highest density (apart from the towns of Kitale and Kapenguria) is found in the south-west corner. The rest of the area is rather sparsely populated. All the country north of Kapenguria is occupied by the "Pokot" tribe while the southern Cherangani hills is occupied by the "Marakwet" tribe which is an allied tribe of the "Pokot". The Trans Nzoia part of the area is at present not inhabited by indigenous tribes, although having formerly been a grazing ground of the "Masai". One can now find members of all tribes in that district.

1.2. Climate

1.2.1. Introduction

The agricultural potential of an area depends, apart from soil resources, largely on the prevailing climatic conditions, particularly the annual and seasonal balance between rainfall and evaporation.

In the previous survey report (Kindaruma) these climatic conditions were studied (Braun, 1975a) for a large area surrounding the survey area, partly because there were only a few rainfall stations in the survey area. The present climatic study is confined to the Kapenguria survey area proper because there are enough rainfall stations in that area, (Fig. 3) while there are only a few to the North and East of the survey area.

1.2.2. Relation Between Altitude and Climate

Altitude affects rainfall, temperature and evaporation and consequently also the vegetation (Trapnell and Griffiths, 1960). Both altitude and vegetation have been used as a guide drawing isohyet or iso-probability lines in the following sections. First, some information is given for the relation between altitude and temperature.

Griffiths (1969) gives the following equations for the average annual maximum and minimum temperature in East Africa in relation to altitude:

$t_{max} = 33.9 - 0.55$ A and t_{min} $24.4 - 0.7$ A (t is temperature in centigrade, A is altitude in 100 m.) and Trapnell and Griffiths (1960) give an equation for the average annual temperature in Kenya:

$$t_{max + min/2} = 30.2 - 0.66 \text{ A}$$

Fig. 2 Population density per location based on: Kenya Population Census, 1969

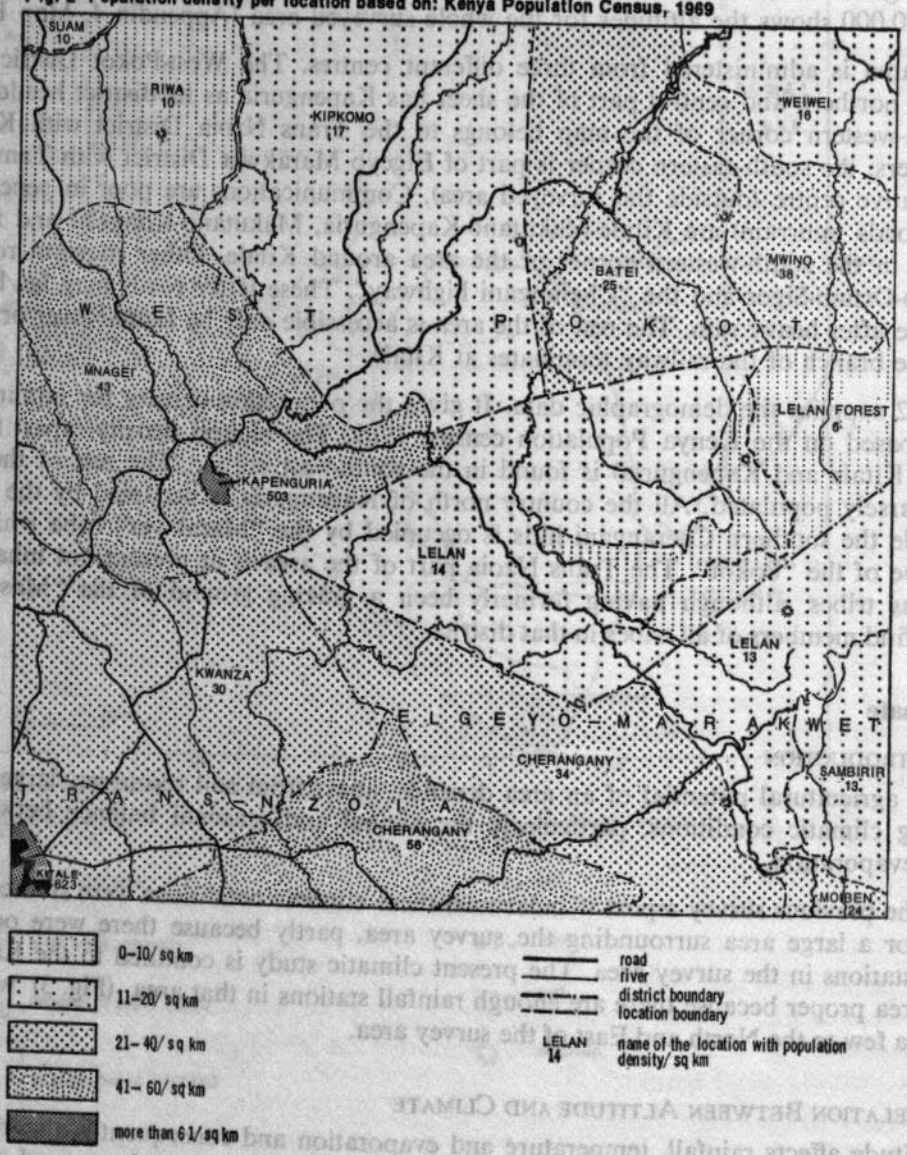


Fig. 4 Average annual rainfall

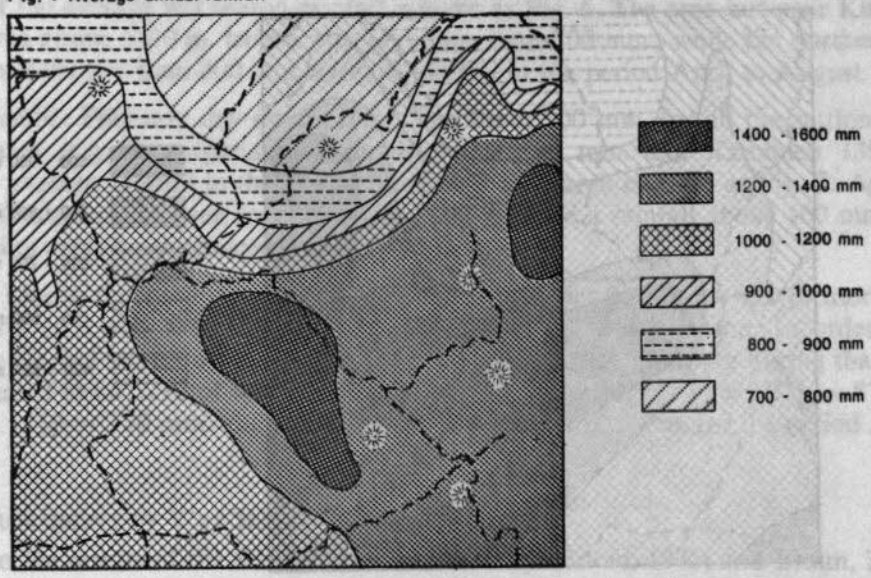


Fig.5 Average annual potential evaporation (Eo)

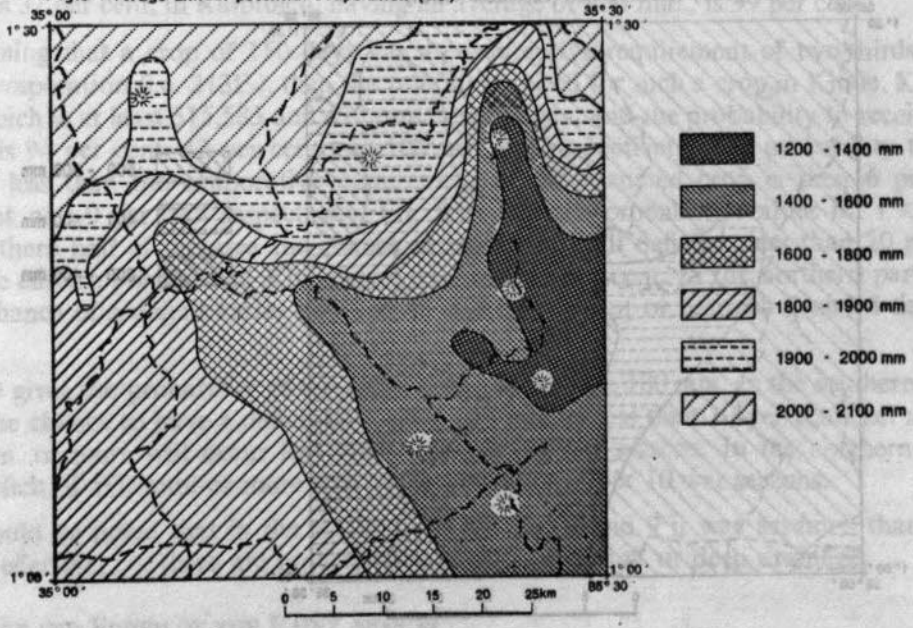


Fig.6 Average wet season rainfall (April–August)

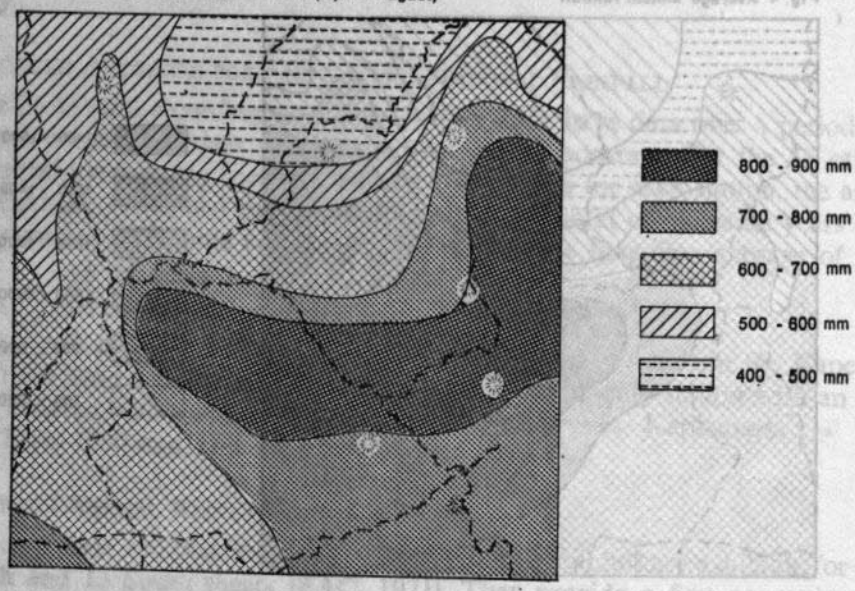
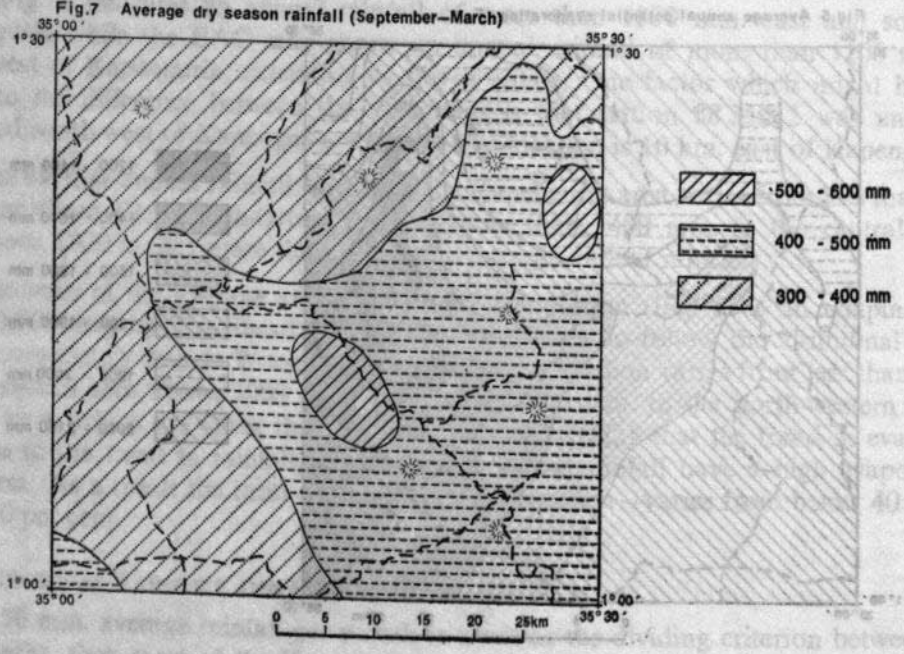


Fig.7 Average dry season rainfall (September–March)



and 5 months for the other stations. The months of April, May, July and August have the highest monthly rainfall at all stations and the period April-August accounts for 65 per cent of the annual rainfall. The year can thus be divided in.—

(i) the rainy season from April to August

(ii) the dry season from December to February

(iii) transition seasons from September to November and March.

A map of the average wet season rainfall is given as Fig. 6. The area just near Kitale and roughly the area above 2100 m. have a rainfall higher than 700 mm., while the northern areas below 1500 m. have less than 600 mm. average rainfall in the period April to August.

The December-February dry season rainfall is about 100 mm. for all the stations in the Kapenguria area (e.g. Kapenguria 80 mm., Kongelai 100 mm. and Kaibibich 139 mm.). A map of the average rainfall in the period September to March is given as Fig. 7. Again the area around Kitale and the area roughly above 2100 m. have a rainfall above 400 mm. while all the remaining areas have between 300 and 400 mm.

The wet season potential evaporation is 125-150 mm. per month for the greater part of the Kapenguria area and it is 150-175 mm. per month in the dry season. In order not to underestimate the wet season evaporative demand the potential evaporation during that period has been assumed to be 5/12 of the annual value, e.g. for Kongelai 5/12 x 2100 = 875 mm., Kitale 5/12 x 1850 = 770 mm. and Kaibibich 5/12 x 1500 = 625 mm. for the period April to August.

1.2.6. The Probability of Wet Season Rainfall Deficits

Similar to the results of the Kindaruma climate study (Braun, 1975; and Braun, in prep.) it was found that the probability of a specific rainfall during the April-August wet season (or the September-March dry season) is related to the average seasonal rainfall of that location. Thus the probability to obtain at least 600 mm. of rain during the period April-August in Kitale, having an average of 740 mm., is 82 per cent; in Kongelai, having an average of 560 mm., is 32 per cent; in Kaibibich, having an average of 950 mm., is 99 per cent.

Assuming that a crop of 150 days has a consumptive requirement of two-thirds of the potential evaporation (i.e. $2/3E_0$), then the rainfall required for such a crop in Kitale, Kongelai and Kaibibich is at least 515,585 and 420 mm. respectively, and the probability to receive such a rainfall is 94 per cent, 42 per cent and 100 per cent respectively. The probability that the rainfall is less than the evaporative requirement of the assumed crop is then 6 per cent, 58 per cent, and 0 per cent respectively. Fig. 8 depicts the probability values for $r < 2/3E_0$. In the southern half of the area the chance to have a rainfall deficit is less than 20 per cent and for the eastern portion and Kitale even less than 10 per cent. In the northern part of the area the chance of a deficit varies between 40 and 80 per cent or between 2 and 4 times per 5 years.

Fig. 9 gives the probability of a rainfall deficit of at least 100 mm. In the southern part of the area the chance to have a deficit of at least 100 mm. is less than 10 per cent, i.e. a deficit of 100 mm. or more will occur less than once per 10 wet seasons. In the northern area a rainfall deficit of 100 mm. or more will occur 2 to 6 times per 10 wet seasons.

It should be noted that in the calculations for Fig. 8 and 9 it was assumed that all the rainfall is effective, i.e. there are no water losses through runoff or deep drainage.

1.2.7. Start and Finish of the Rainy Season

For 7 stations near Kitale, Lawes (1969) worked out the 50 per cent and 80 per cent rainfall probabilities for overlapping periods of 20 days. If one defines the rainy season as starting when there is at least 20 mm./10 days (40 mm./20 days) then his data indicate that there is 85 per cent probability to have more than 40 mm. of rain in the 20 day period starting April 1st, and there is 45 per cent probability to have more than 40 mm. in the 20 day period starting March 10th. The probability that these periods are followed by a non-overlapping 20-day period with at least 60 mm. is 70 per cent and 30 per cent respectively.

Fig.8 The probability (P, in %) that the rainfall in the wet season is smaller than two-thirds of the potential evaporation: Pr< 2/3 Eo

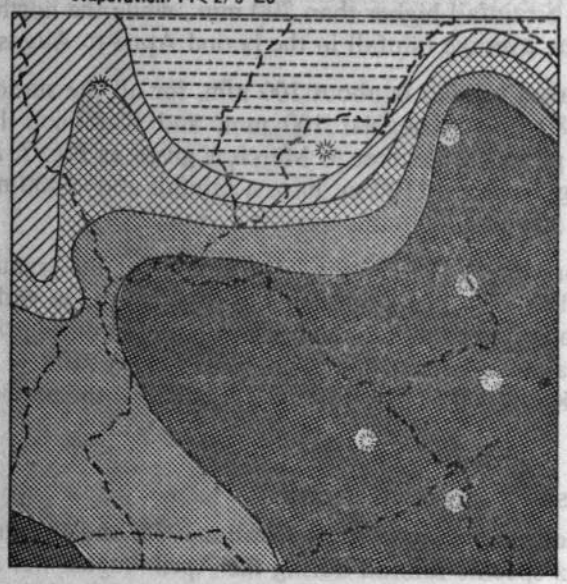
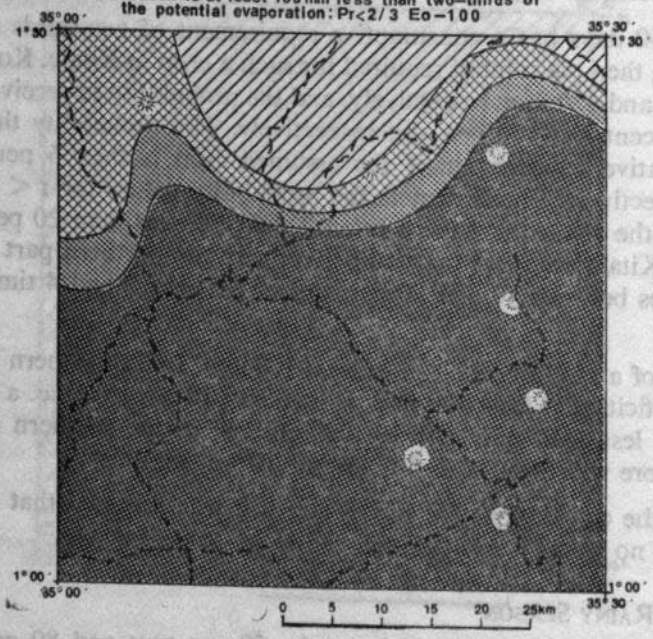


Fig.9 The probability (P, in %) that the rainfall in the wet season is at least 100 mm less than two-thirds of the potential evaporation: Pr<2/3 Eo−100



If the end of the rains is defined as having less than 80 mm./20 days then there is 70 to 90 per cent probability to have less than 80 mm. in all the periods between September 1st and December 1st; before September and after December these probabilities are less than 50 per cent and more than 95 per cent respectively.

Another approach to this problem is to look at the actual rainfall per 10 day period which are published (EAMD, 1974b) for 2 stations in the Kitale area. If the above definitions of start and finish of the rains are applied to the actual data, one encounters the problem of what to do with dry periods. From the data it appears that 20 mm. of rain per 10 days can occur as early as January, but is then often followed by extensive dry periods. From the second 10-day period of March onwards these dry periods do not seem to occur. Thus the first rain of more than 20 mm./10 days after the 10th of March initiates a proper rainy season. Similarly the end of the rains is taken when there are two consecutive 10-day periods with less than 40 mm./10 days after September 1st.

Of the seven years available for Kitale the start and end of the rains was:

1966	2nd 10-day period of March	— 1st 10-day period September	
1967	3rd	March — 2nd	,,
1968	1st	April — 1st	,,
1969	2nd	March — 3rd	,,
1970	3rd	March — 2nd	,,
1971	1st	April — 1st	,,
1972	2nd	April — 2nd	,,

1.2.8. Rainfall Distribution in the Rainy Season

For 12 rainy seasons of 180 days, counted from the first 10-day period with more than 20 mm., the distribution of rain was 16 per cent in the first 30 days, 22 per cent in the second 30 days and 16 per cent, 16 per cent, 16 per cent and 14 per cent in the third, fourth, fifth and sixth periods of 30 days. This is a very regular distribution, if one compares for instance with the data for Eastern Province (Braun, 1975) where 50 per cent of the 90 day rainfall comes in the first 22 days.

1.2.9. Growing Season Simulation

For assessing the length of the growing season a comparison of the actual rainfall and an assumed evapotranspiration for a period of 180 days, needing 524 mm. in total, was carried out for soil moisture storage capacities of 25 mm. and 100 mm. for in total 12 seasons, in the Kitale and Eldoret area.

Though the 180-day rainfall varied between 797 and 1208 mm. (i.e. considerably more than required for evapotranspiration), the low moisture storage capacity of 25 mm. results in temporary deficits in 11 out of 12 seasons. For a soil moisture storage capacity of 100 mm. there were no deficits in any of the 12 seasons.

In order to get some indications on the effect of the rainfall distribution on seasonal moisture deficits in the drier areas, the monthly rainfall of Kongelai, Kapenguria, Sebit, Chepareria and Sigor over the years 1959, 1960, 1963 through 1972 was compared with an evaporative demand of 524 mm. over 6 months (48 + 76 + 104 + 120 + 108 + 68 mm.). Out of the total of 51 seasons, 15 (29 per cent) had a rainfall which was less than the evaporative demand. With a soil moisture storage capacity of 150 mm. 17 (33%) seasons had a deficit,

,, ,, ,, ,,	100 mm. 21 (41 %)	,,	,,
,, ,, ,, ,,	50 mm. 32 (63 %)	,,	,,
,, ,, ,, ,,	25 mm. 41 (80 %)	,,	,,

It is as clear as for the Eastern Province that shallow soils augment the risk of seasonal crop water deficits tremendously. From the same rainfall data as above an estimate of the length

of the growing period was made for an evaporative demand of 524 mm. and soil moisture storage capacities of 50 and 150 mm. The results are:

Rainfall	Soil Moisture Storage Capacity	
	50 mm.	150 mm.
300 mm.	75 days growing period	90 days growing period
400 mm.	120 days growing period	140 days growing period
424 mm.	130 days growing period	150 days growing period
500 mm.	155 days growing period	170 days growing period
524 mm.	160 days growing period	172 days growing period
600 mm.	170 days growing period	180 days growing period

Now we can return to Figs. 8 and 9. Though the calculations above were made for a period of 6 months they can serve to reinterprete Figs. 8 and 9. A $Pr < 2/3E_0$ of 10 per cent in Fig. 8 means that for a soil moisture storage capacity (s.c.) of 50 mm., the length of the growing season is 20 days too short once per 10 seasons, and for an s.c. of 150 mm., 8 days too short once per 10 seasons. Similarly a $Pr < 2/3E_0 - 100$ in Fig. 9 of 40 per cent, means that for a soil moisture storage capacity of 50 mm. the length of the growing season is less than 130 days 4 times per 10 seasons and for 150 mm. s.c. less than 150 days 4 times per 10 seasons.

These data indicate that the northern part of the Kapenguria area is not suitable for the growing of slow maturing crops like hybrid maize. From a climatic point of view this northern part seems better suited for quick maturing and/or drought resistant crops or varieties. Provided there is a good soil, the possibilities for quick maturing crops seem in general better than in large parts of Eastern Province.

1.2.10. Rainfall Intensity

Some data on rainfall intensity which might be applicable to the appropriate altitudes in the Kapenguria area is given in the two tables below.

Table 1—Rainfall Intensities (in mm./h.) Likely to be Exceeded once per Two Years and once per Fifty Years for Durations of 15 min., 30 min., 60 min., 3 hours, 6 Hours and 24 Hours (After Taylor and Lawes, 1971)

	Duration						Duration					
	15	30 min.	60	3h.	6h.	24h.	15	30 min.	60	3h.	6h.	24h.
Kisumu 1150 m.	120	92	51	21	11	3	200	152	83	36	20	6
Kabete 1800 m.	60	44	31	14	8	3	120	86	70	28	16	5
Kitale 1880 m.	84	60	40	15	8	3	152	100	67	26	14	4
Equator 2760 m.	68	48	30	14	8	2	116	82	52	22	13	4
	Once per 2 years						Once per 50 years					

Table 2—The Number of Times per Year that a Rainfall Intensity of 25 mm./h is Exceeded for Durations of 15 Minutes, 30 Minutes and 60 Minutes

	15 min.	30 min.	60 min.
Kisumu 1150 m.	53	28	10
Kabete 1800 m.	41	12	3
Kitale 1880 m.	42	20	5
Equator 2760 m.	33	15	2

1.3. Geology, Geomorphology and Hydrology

1.3.1. Geology

The area was geologically surveyed in 1951-1952. The map and report were published in 1956 (Miller, 1956). For details on the geology, the reader should refer to that report. For

the purpose of this report and to clarify the relationship between geology and soil formation a simplified and adapted geological map has been prepared from Miller's publication (*see* Appendix 4, Map A).

The whole area is occupied by Precambrian rocks of the Basement System. The Basement System here consists of a wide variety of gneisses and schists. These rocks have been formed by regional metamorphism of sedimentary rocks ranging from sandstones, sandy shales, shales to limestones. A gradation is therefore recognizable from silica-rich rocks (quartzites), through more fine-grained rocks like biotite gneisses, and hornblende gneisses (rocks rich in ferromagnesian minerals) to pure calcareous rocks like crystalline limestones.

Biotite gneisses and hornblende gneisses occupy most of the area (*see* Map A). The quartz-muscovite gneisses and muscovite-quartzites are responsible for the continuous "ridge" stretching north-west—south-east through the area. The pure quartzites occur mainly as narrow bands, lying in the plane of the foliation whose axis is N.N.W.—S.S.E.. Crystalline limestones are found in the north-eastern corner around Ortum village, forming numerous "lenses". The granitoid gneisses have been formed by granitization of the pre-existing rock, in this case gneisses. These granitoid gneisses have a great resistance to erosion and they form the bulk of the highest parts of the Cherangani "hills". Acid and basic intrusive rocks have invaded the metamorphic rocks; they include granite and gabbro but occupy only a small area north-east of Ortum.

1.3.2. Geomorphology

The area can be divided into six major physiographic units* (*see* Map C, geomorphology, Appendix 4):

(*a*) mountains and hills
(*b*) major and minor scarps
(*c*) footslopes
(*d*) uplands; several erosion surfaces at various levels
(*e*) piedmont plains
(*f*) river terraces and floodplains

(*a*) and (*b*) The mountains, hills and scarps are prominent in the northern and eastern part of the area. Ridges are steep-sided with slopes ranging from 16 to 30 per cent in general in the hilly parts and slopes in general over 30 per cent in the mountainous parts. Especially in the north-eastern part, valleys are V-shaped and deeply incised. Miller (1956) discusses the origin of the Cherangani "hills". He concludes that the "hills" are an old resistant mountain upon and around which traces of six erosion cycles can be found.

(*c*) The footslopes are those sloping areas (3-8 per cent) where debris carried by slope wash are accumulating or have been recently accumulated from adjacent mountains and major scarps.

(*d*) The erosion surface levels are clearly recognizable in the area. Six major ones have been distinguished. Miller (1956) discusses at length the age of these surfaces and correlates them with surfaces found elsewhere in East Africa. Age indications given below are based on his work. From some of these erosion surfaces or peneplains only remnants are recognizable at present as they have gone through various erosion cycles in the past. The relatively younger ones as the Kitale and Kunyao levels however are better preserved and their original peneplain character is still discernible. The highest surface (Sondang level) is developed chiefly on granitoid gneisses and granite and the Cherangani-Sekerr range owes its elevation to the preservation of an old peneplain upon resistant rock. The Kapsait level (approximately 300 m. lower) is preserved in the "lower Cherangani hills". It is a rolling landscape with smooth rounded ridges. These upper two original surfaces must have been formed in pre-Cretaceous times. The next lower surface (Kapenguria level) is separated from the former one by a well

**See* also "Definitions of standard land forms", internal report KSS/S328/JK/RFW.

defined step (major scarp, the Kaibibich escarpment). It is a rolling area with smooth rounded ridges and a clear dendritic drainage pattern; this level is supposed to be a remnant of the Cretaceous peneplain.

The Kitale level, separated from the Kapenguria one by the Kapcherop escarpment is less dissected and forms a broad, gently undulating to undulating landscape interspersed by widely spaced valleys often with flat swampy valley bottoms. The next lower surface (Kunyao level) is rather well preserved and consists of low, flat to gently undulating, rounded interfluves and a rather dense dendritic drainage system. It is the continuation of the main Uganda erosion surface and is probably part of the sub-Miocene peneplain which stretched over great parts of Kenya and East Africa.

The erosion surface near Sigor (Wei-Wei level) is probably part of the end-Tertiary or main peneplain of North-Eastern Province.

(*e*) In the extreme north-eastern section of the area a small part of piedmont plain is found, a gently sloping plain extending along the Eastern side of the Cherangani "hills" and formed by the lateral coalescence of a series of separate but confluent fans.

(*f*) River terraces and floodplains formed of recent and subrecent alluvial material are found along some of the rivers.

Ellerbeck (1952) stated that the Cherangani "hills" were covered in Pleistocene time by an ice-sheet and claimed the existence of drumlins, terminal moraines and hanging valleys. Miller (1956) however gives evidence against any glaciation and also during the soil survey no evidence was found of any glaciation in the past.

Two borings were made in the sixties in a swamp at the top end of a valley at 2900 m. in the Kaisungurr area. Pollen diagrams made of the core samples reveal information on the paleo-climatology and paleo-vegetation over the last 16.000 years (Coetzee, 1967).

The area surveyed is covered by the "Land system atlas of Western Kenya", (Scott *et al.*, 1971). At the beginning of the soil survey this atlas was a valuable tool in getting an overall view of the "landscapes" in the area. Seven land systems are recognized and described in terms of climate, geology, landscape, soils, vegetation, slope and altitude. The land systems are subdivided into land facets which are described according to form, soil material, hydrology and land cover. The description is illustrated with a block diagram and with a stereo-triplet representative for that particular land system.

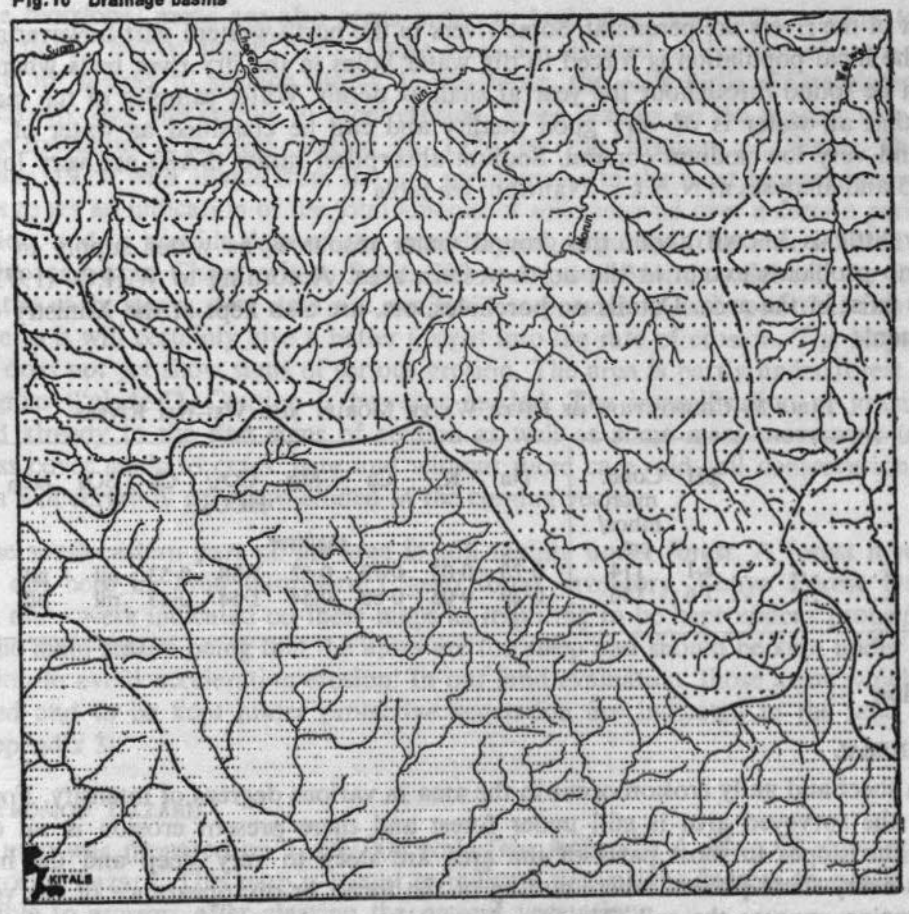
1.3.3. Hydrology

The area can be divided into a northern half and a southern half with respect to the main water catchments (Fig. 10). The southern half lies in the Lake Victoria drainage area; the rivers flow via the Nzoia river into Lake Victoria. The streams are well graded. The northern half lies in the Lake Turkana (Lake Rudolf) drainage area. Rivers like Suam, Morun (with tributaries Iun and Wei-Wei) all belong to the Turkwel catchment area which discharges into Lake Turkana. Here most of the rivers are deeply incised with steeply graded beds and narrow valleys.

From 1973-1975, a reconnaissance survey, the objective of which was to gain information on the hydrological regimes of the River Turkwel and its tributaries, was carried out by Tollenaar (1975) for the catchment areas of the River Turkwel. New river gauging stations were opened and the network of meteorological stations was extended. The report deals mainly with the River Turkwel proper but includes valuable data on water resources in the surveyed area*.

*All information on water resources is filed in the Ministry of Water Development, Hydrology Section, Nairobi.

Fig.10 Drainage basins



lake Rudolf drainage basin

lake Victoria drainage basin

major water divide

minor water divide

Stream flow data have been collected for 15-20 years in the upper reaches of the Turkwel catchment. At present river gauging stations exist in Kongelai (Suam river), Marich pass (Morun river) and Tamkal valley (Wei-Wei river). Base flow studies reveal that in Kongelai RGS (= River Gauging Station) about 65 per cent of the catchment area contributes water only in the wet seasons (poor soil infiltration capacities resulting in high run-off). The RGS of the Morun river in the Marich pass shows that the Iun subcatchment (61 per cent of the Morun catchment) is responsible for high flashy floods due to low permeability and low retention by vegetation, resulting in a high surface runoff, without contributing substantial water in the dry season. The other subcatchment is the area of the Cherangani "hills" (39 per cent of the Morun catchment). This area is responsible for the long lasting flow in the Morun in the dry season, and supplies water from ground-water storage all year through to the Morun and Wei-Wei with lowest values in the dry season of approximately 1000 l/sec. The RGS in Sigor (Wei-Wei river) shows also relatively high base flows.

Most of the rivers are perennial. Some rivers in the north-western part however are seasonal and the local population is forced to dig water holes in the dry river beds where usually water can be found throughout the year at shallow depth. Water samples of the main rivers indicate that all water is of very good quality and can be classified as water of very low salinity and very low sodium content. Sodium absorption ratios (SAR) are very low (Tollenaar, 1975 and analyses at N.A.L.—Nairobi); *see* table 3.

Very little is known about the ground water resources as water supply in this area presents no problems except in the north-western area. According to W.H.O. (1973) only 8 boreholes exist in the area. Details on boreholes, etc. are also kept at the Ministry of Water Development.

TABLE 3—COMPOSITION OF RIVER WATER MORUN AND WEI-WEI RIVERS

	pH	Cond. micro mhos/cm.	Na	K	Ca	Mg	CO_3/HCO_3	Cl	SO_4	NO_3	SAR
			me/liter								
Morun	8·1	114	0·28	0·03	0·78	0·52	1·38	0·53	nil	nil	0·35
Wei-Wei	7·6	136	0·29	0·05	0·80	0·54	1·54	0·43	nil	nil	0·28

1.4. Erosion

1.4.1. GENERAL

Both sheet and gully erosion occur in the area in various degrees of intensity. Fortunately a part of the surveyed area is still under forest and there present erosion is nil or small. However the slopes in most parts of the area are steep to very steep and the hazard of erosion is everywhere present where cutting of the forest or disappearance of the vegetation by overgrazing exposes the soil. The ever increasing opening up and clearing of more and more land in particular in Mnagei Location (Kapenguria area) and the Kapcherop escarpment poses a serious risk. A pre-requisite must therefore be proper soil conservation practices. At present some soil conservation work is undertaken by the Soil Conservation Service under the aegis of the Special Rural Development Programme of Kapenguria. Terracing of some of the slopes in the Kapenguria area is or has been undertaken. The SRDP encourages also the afforestation of some of the steeper slopes in some of the recently cleared areas, especially along minor water courses, to avoid excessive washing down of soil. However, the menace of accelerating soil erosion is everywhere present. One of the most serious hazards of the indiscriminate cutting down of forest is the removal by sheet erosion of the relatively rich topsoil of the land formerly under forest. Overgrazing is another menace to the land. Especially in the northern part of the surveyed area, overgrazing is the main cause of the alarming state of both sheet and gully erosion. Strict grazing control, enclosures, etc. will certainly control and even stop erosion as is clearly demonstrated in the Riwa group range near Kongelai and in the Ministry of Agriculture holding ground near Chepareria where vegetation is protected and where the speed of recovery of the vegetation is encouraging.

1.4.2. Present Erosion

The area already severely eroded is the north-western part of the sheet. Serious overgrazing, in particular by goats is here the main cause of erosion. Deep soils are only found on the rather small interfluves. Very shallow soils are found in the gullies which slowly deplete the soil cover of the whole area. The only possible means to save this area from total destruction and the "point of no return" is a ban on grazing for a certain period of time followed by a very strict grazing control with a reduced number of livestock. Other areas where erosion is imminent are the mountainous and hilly lands of the northern part of the sheet, the area around Kapenguria and the escarpment area between the Kitale uplands and the Kapenguria uplands. These are for the major part under natural vegetation but the opening up threatens the land and on many places erosion has started already. Soil conservation measures must be taken *urgently* to avoid permanent, irreparable damage.

The footslopes areas are also areas prone to both sheet and gully erosion (cf. the soil mapping units: FGrce and FGrcE). These areas are situated at the foot of steep slopes and are therefore subject to surface runoff. Furthermore, the soils (little differentiated Luvisols) are inherently very susceptible to sheet erosion. Some studies on the present rate of erosion on these footslopes area were started in 1974 by the Ministry of Water Development (Tollenaar, 1975) with advice from the soil surveyors as to the most representative sites. The aim was to get an indication of the total amount of soil removed over a certain period of time by erosion, and to provide data on the growth-speed of gullies. The area selected is situated along the road from Chepareria to Sebit, 500 m. beyond Morobus School. As this study is still in the early stages, few data are available at present. It is hoped that this study will continue as it will certainly give a better insight into the rate of erosion. The Kapsait area at present does not yet show signs of serious erosion. The area is partly under forest and partly under grass ("glades"). Caution is however needed. The intensification of grazing here is reflected already in the first signs of erosion as well as some mass movement (*see* photo); the grass cover tends to crack here and without more care and soil conservation measures, the area will certainly get more eroded in the coming years.

The south-eastern part of the area is still mainly under forest. A forest inventory was carried out here in 1966 (Northern Elgeyo forest inventory, Kenya Forest Department). Certain areas were indicated on these maps as requiring to be kept under "protective vegetation", the main reason being that the areas are too steep and should be kept under permanent protection to avoid accelerating erosion. In our land evaluation, those areas which are to be protected and to be kept under protective vegetation are indicated in the land evaluation key (Appendix 3).

1.4.3. Erosion Hazard

A map was prepared on 1:250.000 scale (*see* Appendix 4, Map G) showing sheet and gully erosion hazard. This map is meant to indicate the various degrees to which the land is susceptible to erosion, after clearing the present vegetation.

This map was prepared taking into account.—

1. susceptibility to erosion of the topsoil and the subsoil
2. slope class percentage
3. climate/ecological zone.

For rating the susceptibility to erosion of the topsoil use was made of an empirical combination of data on:

(*a*) organic matter percentage
(*b*) structure stability (flocculation index)
(*c*) silt/clay ratio
(*d*) bulk density
(*e*) topsoil structure (field data)
(*f*) infiltration rates.

For rating the susceptibility to erosion of the subsoil (important for gully erosion) the following criteria were selected.—

(*a*) structure stability of the B-horizon

(*b*) field structure of the B-horizon.

The following rating for topsoil susceptibility to erosion was found for the soil classification units.—

erosion hazard	*soil classification units*
nil to slight	soils with umbric and mollic topsoils
slight	Ferralsols
moderate	(non-humic) Cambisols and Ferral-Acrisol intergrades
severe	Luvisols, Acrisols with little textural differentiation between topsoil and subsoil.

The final rating for soil erosion hazard according to soil mapping units can be found in Appendix 9 at the end of this report.

1.5. Vegetation

1.5.1. Introduction

The vegetation is one of the land resources and therefore it is necessary to study and map the vegetation in connection with the soil survey in order to obtain one of the basic data required for the land evaluation. As the vegetation is moreover a useful indicator of climatic conditions (Trapnell and Griffiths, 1960; Pratt, Greenway and Gwynne, 1966) and because climatic data are scarce, there is even more reason to study the distribution of vegetation types.

1.5.2. Methods

The vegetation mapped (Appendix 4F) is the actual vegetation extrapolated to areas which are under cultivation. The field survey was carried out after interpretation of aerial photographs. The vegetation of representative parts was described on sample areas of one hectare approximately. This consisted of making a checklist of the trees, shrubs, herbs and grasses present at each sample site, estimating their cover and indicating the dominant and subdominant species among the trees, shrubs, herbs and grasses.

In the preparation of the map, use has been made of the 1:250.000 vegetation map by Trapnell *et al.* (1966) which covers the southern half of the sheet and particularly of the 1:25.000 Northern Elgeyo Forest Inventory Map (Kenya Forest Department, 1966) which covers the south-eastern part of the sheet. In the legend the dominant species in each vegetation unit are mentioned. In the next section a somewhat more comprehensive description of the units is given.

1.5.3. Description of the Vegetation Units

Moorland and montane shrubland.—the tree heather Erica arborea is the dominant shrub; Andropogon mannii is the dominant grass with Andropogon longipes and Festuca abyssinica as co-dominants; many herbs are generally present. Grass productivity is low. This unit occurs in the high eastern part of the sheet.

Montane grassland.—the dominant grass is Pennisetum schimperi, with Digitaria scalarum, Pennisetum clandestinum and Eragrostis schweinfurthii as co-dominants; in places where the soil is very humic, the dominant grass is Pennisetum clandestinum which is locally overtaken by the unpalatable grass Eleusine jaegeri. The herb

cover varies. The productivity is moderate to fairly low; it can be improved considerably by digging out the Pennisetum schimperi or Eleusine jaegeri tussocks and planting Pennisetum clandestinum. This unit occurs in the south-eastern part of the sheet.

Wooded bamboo thicket.—the bamboo Arundinaria alpina is the dominant shrub; Hagenia abyssinica, Faurea saligna, Afrocrania volkensii and Hypericum sp. are the most common trees; the bamboo is extensively cut for making hedges in the montane grassland. This unit occurs as single units and also in a complex with the previous and next unit in the eastern part of the sheet.

Sclerophyll forest.—Juniperus procera is the dominant tree with Prunus africana and Olea hochstetteri as co-dominants; this unit occurs as single unit in the south-east corner of the sheet and it forms part of three complexes which cover a large section in the eastern part of the sheet.

Moist forest.—the dominant and co-dominant trees are Macaranga kilimandscharica, Podocarpus milanjianus and P. gracilior, Syzigium guineense, Olea africana and O. hochstetteri and Dombeya goetzenii with Hagenia abyssinica, Neoboutonia macrocalyx and Teclea nobilis as common trees. This unit covers an area in the central part of the sheet stretching out to the south-east.

Undifferentiated forest.—the dominant trees are Cassipourea malosana, Albizia gummifera, and Syzigium guineense in the area around Kapenguria but the composition in other areas is undifferentiated. This unit only occurs in a complex with the next unit, to which it is adjacent.

Cleared forest or forest glades.—most of the area is cleared; the remaining or secondary trees are Acacia abyssinica and A. lahai, Croton megalocarpus and Faurea speciosa; the grass cover is variable, often heavily infested with weeds; the grass productivity is moderate but could be increased if weeds were taken out. This unit occurs in the central part of the southern half of the sheet.

Moist Combretum woodland.—the dominant trees are Combretum molle, Terminalia mollis, Faurea speciosa, Combretum binderianum and Erythrina abyssinica; the dominant grasses are Hyparrhenia filipendula and Loudetia sp.; many areas in this unit are cleared for cultivation; grass leys are a common feature; the grassland productivity is moderate to high though the botanical composition is not ideal. This unit occurs in the south-western part of the sheet.

Vlei grassland.—this unit occurs north and east of Kitale. Its composition has not been observed; moderate to high productivity is presumed.

Combretum-Euphorbia woodland.—the dominant trees and shrubs are Combretum molle, Combretum binderianum, Acacia hockii and Euphorbia candelabrum; the grass cover is low through overgrazing; the dominants are Eragrostis superba and Chloris pycnothrix; productivity is low to moderate; it could be increased substantially by destocking and temporary resting of the vegetation. This unit occurs in an area around Chepareria in the central-northern section of the sheet.

Dry Combretum woodland.—the dominant trees and shrubs are Combretum binderianum, Acacia nilotica, Terminalia brownii, Acacia hockii, and Albizia amara; the grass cover is very low, dominated by annuals like Tragus berteronianus and Aristida keniensis; the productivity is low. This unit occurs on a small area in the north-western part of the sheet.

Acacia woodland.—rather variable in composition; Acacia tortilis, Balanites aegyptiaca and Acacia elatior are the commonest dominants; the grass cover is very variable; its productivity low to moderate. This unit occurs in several riparian areas in the northern part of the sheet.

Croton bushland.—the dominant shrubs and trees are Croton dichogamus, Acacia brevispica, Terminalia brownii, Acacia hockii and Heeria reticulata; the grass cover is very low, dominated by annuals and its productivity is very low. This unit covers some areas in the central-northern part.

Acacia nilotica bushland.—the dominant shrub or small tree is Acacia nilotica with Acacia brevispica, Acacia hockii, Albizia amara, Balanites aegyptiaca, Acacia senegal and Dichrostachys cinerea as subdominants; the grass cover is very low dominated by annuals such as Chloris pycnothrix; its productivity is very low destocking and resting is urgently required. This unit occurs in the north-central and north-western part of the sheet.

Acacia seyal bushland.—the dominant shrub or tree is Acacia seyal; the grass cover is moderate with Enteropogon macrostachyus, Chloris roxburghiana and Panicum maximum as the dominants; the productivity is moderate. This unit covers a very small area in the north-eastern corner of the sheet.

Euphorbia bushland.—the dominant shrub is Euphorbia tirucalli with Acacia brevispica and Acacia mellifera as subdominants; the grass cover is fairly low with Enteropogon macrostachyus as dominant; the productivity is fairly low. This unit covers a very small area in the north-eastern corner of the sheet.

Acacia reficiens bushland.—the dominant shrub is Acacia reficiens with Acacia mellifera as co-dominant; the grass cover is low to very low, dominated by annuals; and the productivity very low. This unit covers a very small area in the north-eastern corner of the sheet.

Complexes.—for the complexes the reader is referred to the composing single units. The slope complex is a transition zone which in its upper part resembles the higher altitude vegetations (e.g. sclerophyll forest) while in its lower parts it is similar to the medium altitude vegetations (e.g. Acacia nilotica bushland).

1.5.4. Relation Between Altitude, Climate, Soil and Vegetation

A comparison of the altitude, soil and vegetation maps of Appendix 4 with a climatic map like Fig. 8 reveals that some boundaries have a similar position in all these maps. Altitude governs temperature, evaporation and to a large extent rainfall too. The soil development depends largely on climate and the vegetation depends mainly on climate and soil. Thus the vegetation can provide an indication of the ecological conditions; this was recognized long ago (e.g. Edwards, 1956).

1.6. Ecological Zonification

The concept of ecological zonification on the basis of vegetation is well accepted in Kenya (Edwards, 1956, Pratt/Greenway/Gwynne, 1966). Later publications (Atlas of Kenya, 1970 pp. 28-29) are based on vegetation and climate or on climate and soil (Woodhead, 1970). The ecological zone boundaries drawn on Appendix 2 are based on the annual ratio of rainfall and potential evaporation, vegetation and temperature. The ratio r/Eo was calculated first and as the transitions between vegetation types seemed to occur at similar ratio values of those established in the Kindaruma area (Braun, 1975a), the ratio values 38 per cent, 53 per cent and 67 per cent were retained here as the boundary values of the ecological zones V-IV IV-III and III-II respectively (*see* also the table in the legend of Appendix 2).

Ecological zone II has been divided in II-warm and II-cold approximately along the 2400 m. (8000 ft.) contour, keeping the moist forest types in II-warm and the sclerophyll types in zone II-cold. Zone I is the area above the 3000 m. (10000 ft.) contour. Some of the characteristics of the ecological zones are given in the table on Appendix 2, some further climatological statistics, partly derived from chapter 1.2 and partly from unpublished material (Braun, in prep.) are given in Table 4.

TABLE 4.—CLIMATIC CHARACTERISTICS OF THE ECOLOGICAL ZONES IN THE KAPENGURIA AREA

	I	II Cold	II Warm	III	IV	V
Average annual rainfall (r)	1200–1400	1200–1400	1200–1600	1000–1200	750–1000	700–800 mm.
Average annual evaporation (Eo)	1200–1400	1400–1600	1600–1800	1800–1900	1900–2100	>2100 mm.
Ratio r/Eo	>85	>67	>67	53–67	38–53	<38%
Average annual max. temp.	<16	16–20	20–24	21–24	23–29	>29°C
Average annual min. temp.	<4	4–8	8–12	9–12	11–17	>17°C
Average annual temp.	<10	10–14	14–18	15–18	17–23	>23°C
Absolute min. temp.	<–4	–4–0	0–4	1–4	3–9	>9°C
Altitude	>3000	2400–3000	1850–2400	1750–2200	1150–2000	1100–1150 mm.
Average rainfall April–August	800–900	700–900	700–1000	600–750	450–600	450–500 mm.
Average rainfall April–September	900–1000	800–1000	800–1100	700–850	500–650	500–550 mm.
Average rainfall September–March	400–500	400–500	450–600	350–450	300–400	250–300 mm.
Average rainfall October–March	300–400	300–400	350–500	250–350	200–300	200–250 mm.
Average rainfall December–February	100	100	100	100	100	50
April–August rainfall to be exceeded 9 out of 10 seasons	620	520	520	430	300	300 mm.
April—September rainfall to be exceeded 9 out of 10 seasons	720	620	620	520	340	340 mm.
October–March rainfall to be exceeded 9 out of 10 seasons	150	150	200	110	70	70 mm.
December–February rainfall to be exceeded 9 out of 10 seasons	20	20	20	20	20	0 mm.
*Pgs<120 days 50 mm. storage	0	0	0	0–1	3–23	13–23%
150 mm. storage	0	0	0	0	1–12	6–12%
*Pgs<150 days 50 mm. storage	0–1	0–1	0–1	1–7	14–60	43–60%
150 mm. storage	0	0	0	0–2	6–35	22–35%

*Pgs<120 days=the probability that the growing season is less than 120 days, assuming an evapotranspiration of 524mm.for 180 days.

1.7. Present Land use

1.7.1. INTRODUCTION

The purpose of the inventory mapping of climate, soil and vegetation is to assess what can be done with the land. The land suitability classification (Chapter 4) will treat aspects of possible land use. The assessment of possible land use partly depends on what kind of land use is going on at this moment. Therefore a brief description and mapping of present land use seems worthwhile.

1.7.2. DESCRIPTION OF PRESENT LAND USE UNITS

The present land use map (Map E, Appendix 4) is based on aerial photo interpretation and field observations, the former mainly for drawing boundaries, the latter for describing the type of land use. The four major types of land use are.—

extensive grazing

semi-intensive grazing

cultivation and grazing

forestry/watershed protection.

Some further details of the major types and units are given below.—

Extensive grazing.—No fencing or other improvements; low productivity of vegetation; low stock densities.

Extensive grazing on gently undulating uplands:—

cattle, sheep and goats; local breeds; very low productivity due to severe overgrazing and shallow soils; in north-western part.

Ditto on hilly and mountainous land:—

goats, sheep and cattle; local breeds; low to locally very low productivity due to poor accessability and locally severe overgrazing; in northern part of the surveyed area.

Ditto on moorland.—

hair sheep and cattle, imported and local breeds; low productivity due to low temperatures; in eastern part of the sheet.

Semi-intensive grazing.—some fencing and other improvements; moderate to high productivity of vegetation; moderate stock densities.

Semi-intensive grazing on vlei grasslands.—

cattle, mostly improved breeds, moderate productivity; in south-western part of the sheet; recently large parts of this unit have been ploughed up and are used now for maize growing.

Ditto on forest glades with some smallholders cultivation near homesteads.—

cattle, sheep, goats, mostly local breeds; moderate to low productivity due to poor accessability and soil truncation (loss of humic topsoil); in complexes in eastern and central part of sheet.

Ditto on montane grasslands with smallholders cultivation near homesteads.—

cattle and hair sheep, local and improved breeds; moderate productivity; in south-eastern part of the sheet.

Cultivation and grazing.—the amount of terrain occupied by cultivation is mostly less than that used for grazing, though the cultivation is much more important than in the previous units.

Smallholders cultivation in extensive range areas.—

small areas; few improvements; low productivity due to low standard of land management; maize is by far the most common crop; scattered over the northern part of the sheet (only a small part of the indicated areas are actually cultivated).

Large-scale cultivation and semi-intensive grazing.—

large areas; use of machinery, fertilizers and improved seeds; beef and dairy cattle — improved breeds; maize is main crop; grass leys in rotation with maize; in south-western part of the area.

Smallholders cultivation and semi-intensive grazing.—

small areas, often on steep slopes; improved varieties of seeds are used, generally no machinery or fertilizers; cattle, sheep and goats, mostly unimproved breeds; maize is the main crop in area around Kapenguria and Kapcherop.

Smallholders cultivation and semi-intensive grazing on mountains.—

small areas, improved varieties of seeds used, no machinery or fertilizers; sheep and goats, local breeds; maize is main crop; in bench and saddle areas of mountains in north-eastern part of the sheet.

Forestry or watershed protection.—many areas are grazetted forests, but very little forestry (silviculture) takes place; some areas are specifically intended for watershed protection (protective vegetation); cutting without replanting seems a rather common practice; the sub-units are based on tree composition. They occur in the central and south-eastern part of the sheet.

1.7.3. Some Remarks on Crops, Rangeland and Forestry

Maize is by far the most important cash and/or subsistence crop grown. Beans take second place in subsistence farming while sunflower takes second place as cash crop. For crops such as coffee, tea, potatoes, very small acreages are occupied at present. Rangeland covers nearly half of the total surveyed area. Due to poor management most of the rangeland is overgrazed and now subject to erosion.

Forests of various composition (including some relatively small areas with plantations of Eucalyptus near Kitale and Pinus near Kapenguria) cover a substantial part of the whole surveyed area. Parts of these forests are gradually cut down to provide land for crop cultivation. Only some official cutting (logging) takes place.

For further and more detailed information on the subject of land use, specifically the economic aspects and potential land use the reader is referred to the consultancy report of de Jong (1976) prepared in connection with the reconnaissance survey of Kapenguria.

2.—THE SURVEY METHODS

2.1. Office Methods

As a first step in the reconnaissance soil survey the available aerial photographs, topographic and geological maps together with all the existing information about the area were collected and studied. The area is covered by topographic maps at scale 1:50.000 in four sheets numbered 75/1, 75/2, 75/3 and 75/4, published respectively in 1968, 1962, 1969 and 1961 (Survey of Kenya). Sheet 75/1 has form lines (V.I. 500 ft.); sheet 75/3 has contour lines (V.I. 20 m.); the other two sheets have only some spot heights indicating important landmarks.

All aerial photographs were acquired from the Survey of Kenya. Most prints are of good quality. The whole area is covered by aerial photographs at a scale of approximately 1:55.000 except for a small part of sheet 75/4 (Kiptaberr area) which has only a coverage of 1:25.000 aerial photographs. The following large-scale photography is in addition available within the sheet: West Pokot (area between Makutano and Kongelai) at scale 1:12.500 and a good part of the Cherangani hills at scale 1:25.000. The photographs at scale 1:55.000 used in this soil survey were flown in 1967. This implies that some of the detail shown on the photos is out of date; in particular the areas around Kitale and Kapenguria are affected due to important changes in land use since 1967.

Prior to the field work all photographs were studied stereoscopically and a preliminary photo interpretation map with a legend was prepared. Photo interpretation proved to be of great assistance in this area, especially because part of the area is either difficult to traverse by Land-Rover or is accessible only on foot. During the field work all observations and boundaries, noticed in the field, were plotted directly on aerial photographs and on the topographic field maps. After the field work all data (boundaries, profile pits/augerholes) were transferred to a "final field map" at scale 1:50.000. Transfer of boundaries from aerial photographs to the topographical base map was done either by hand or with the aid of a Sketchmaster. After completion and thorough checking of the "final field map", boundaries and symbols were transferred to translucent 1:50.000 copies of the topographic sheets. These copies were handed over to the draughtsman (*see* 2.4).

2.2. Field Methods

The actual field work was carried out between September 1973 and February 1975. Three survey teams (two soil survey teams and one team carrying out the vegetation survey, infiltration measurements and sampling for soil physical data) each consisting of two to three surveyors supported by technical assistants, labourers and drivers carried out the survey. Field stations were established for longer or shorter time in Makutano, Ortum, Sigor, Kaibibich and Kapcherop. Routine soil augerings were made with Edelman or Riverside auger type to a depth in general of 120 cm. (if depth of bedrock allowed) at spots selected in relation to the photo interpretation map.

The sites were indicated both on the topographical maps and on the aerial photographs. Land and soil properties were recorded on the standard soil profile description forms, following the standards applied by the Kenya Soil Survey. All these filled-in forms are kept in the data storage of the KSS at Nairobi. From all representative soil mapping units, sites were selected where profile pits were dug. The pits were 150-180 cm. deep if depth permitted. Each soil horizon was sampled for chemical analysis in the laboratory, in addition composite samples from 0-30 cm. were taken at each site to be analysed according to the "Mehlich method" (Mehlich *et al.*, 1962) for available nutrients. From selected profiles undisturbed samples for bulk density and pF determination were collected with specially made rings and also samples for the preparation of thin sections. The thin sections were made to study in detail micromorphological features in particular the presence of clay cutans. A total of 550 augerings were described; 76 profile pits (including a few roadcuts) were described and fully sampled. For their location *see* Appendix 4 Map H. Infiltration measurements were carried out at some 22 sites using 4″-diameter rings with a falling head of 12 cm. water (*see* 3.6.1.1.). Although depth of water infiltrated was recorded after 15 sec. 30, 1 min. 2, 4, 8, 18,

18, 30, 60, 90, 120, 180 and 240 min., the main parameter used for interpretation is the time needed for the infiltration of 100 mm. water. The variation between replicates was often rather large and therefore the medium time needed for the infiltration of 100 mm. water seemed a more appropriate value than the arithmetic average for characterizing a site. A "dry run" and one or more "wet runs" were carried out, in some cases both in the wet and dry seasons. A simple method of "irrigation" which avoids the soil disturbance caused by the cylinders was tried out at a few sites. The method consists of "irrigating" one square meter of soil with water running through a hosepipe from a jerrycan on the bonnet of a car. The waterflow is regulated in such a way that just no runoff occurs. The infiltration rate is measured after 2, 4, 8, 16, 30 minutes. Both dry and wet runs were carried out.

2.3. Laboratory Methods

2.3.1. 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 2 mm. sieve.
Texture (hydrometer):	No chemical treatments to remove cementing agents; shaking overnight with sodiumhexametaphosphate/sodium carbonate in an end-over-end shaker at 40 r.p.m. Measurement of silt+clay (0–50μ) and clay (0–2μ) with a hydrometer, ASTM 152H, after 40 seconds and 2 hours respectively. Sand fraction (50–2000μ) obtained by difference (Day, 1956).
Dispersed clay:	As above for clay, but omitting the dispersing agent during shaking.
Flocculation index computed through the formula:	$100\left(1-\frac{\text{dispersed clay}}{\text{total clay}}\right)$
pH and electrical conductivity:	Determined in a 1:1 soil-water suspension. For soils with an EC> 1·2 mmho's/cm. at 25°C, a saturation extract is prepared for pH and EC measurement.
pH–KCl:	pH measurement in a 1:1 soil–N KCl suspension.
$CaCO_3$%:	Gravimetric determination of loss of carbon dioxide (Richards, 1954).
C%:	Walkley and Black method (Black, 1965, pp. 1375/6), on A-horizons only.
N%:	Semi-micro Kjeldahl method (Black, 1965, pp. 1374/5), on A–horizons only.
Exchangeable cations:	Leaching of the soil with N ammonium acetate of pH 7·0. Determination of Na, K and Ca by EEL flamephotometer, with addition of Lanthanum chloride for the last element. Colorimetric determination of Mg with Thiazol yellow reagent (Mehlich *et al.*, 1962).
Cation exchange capacity:	Following the leaching for exchangeable cations, the same soil is washed with 90% ethyl-alcohol and then with acidified 1N sodium chloride. The last leachate is collected. CEC is determined by determination of ammonia through semi-micro steam distillation and titration with 0·01 potassium di-iodate (Houba and van Schouwenburg, 1971).
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 ration with 0·1N HCl/0·025N H_2SO_4. Determination of Ca, K, Na by EEL flamephotometer, after an anion resin treatment for Ca. For Mg the same procedure as for exchangeable Mg. For P, the Vanadomolybdophosphoric yellow method is followed. Mn is measured colorimetrically using phospheric acid-potassiumperiodate for colour development (Mehlich *et al.*, 1962).

2.3.2. Additional Analysis for Soil Samples of Representative Profiles

Texture "USDA": .. .. Chemical pretreatment with hydrogen peroxide and hydrochloric acid, the latter at the rate of 10me/100 g. of soil plus the amount required to neutralize the $CaCO_3$ if present. Leaching with water and after removal of excess electrolyte, shaking overnight with dispersing agent (*see* texture: hydrometer). Determination of the sand fractions employs sieves of 47–105–250–500–2000μ. Determination of the clay fraction (0–2μ) by pipette based on Stoke's law. The silt fraction (2–50μ) is obtained by substraction of the clay fraction from the sum of sand fractions plus the organic matter plus the $CaCO_3$%.

Bulk Density: .. .. Determination of the oven dry (105°C) weight of a soil core of known volume (Richards, 1954).

Particle Density: .. .. Method 39 (Richards, 1954).

Porosity: .. .. Method 40 (Richards, 1954).

pF Curve: .. .. Determination of moisture percentages at the following pF values: 2·3–2·7–3·7–4·2, using standard moisture extraction equipment as provided by Soil Moisture Co., Santa Barbara, Calif., U.S.A. for pF 3·7 and 4·2. For the lower pF values a sand/kaolin box was used, employing suction at the desired level.

Alternatively, soils are wetted in the field and left overnight to reach "field capacity" conditions, after which a sample was taken for moisture determination.

Clay mineralogy: .. .. The fraction 0–2μ is separated after pretreatments with hydrogen peroxide, hydrochloric acid and sodium dithionite (the latter two only if necessary) and dispersion with sodium hexametaphosphate/sodium carbonate. X-ray diffraction analysis is carried out on samples, saturated with Mg and K, using standard clay minerals for semi-quantitative estimation. Peak area ratios, rather than peak height ratios are considered. Techniques involving solvation with ethylene glycol and heating to 500°C are employed as well.

Apparatus: Philips direct recording X-ray diffractometer, using copper K∝r radiations. (Theisen *et al.*, 1962 and Theisen *et al.*, 1964).

SiO_2/Al_2O_3 and SiO_2/R_2O_3 ratios: .. Determined on the clay fraction following the procedure of Bernas, 1968, involving a low temperature digestion with aqua regia and hydrogen fluoride in a sealed container (modification employed in this laboratory is to leave the sample standing overnight in a polypropylene, non-flexible bottle in an oven at 90°C). After cooling of the digest to room temperature, boric acid solution is added. The mixture (which is non-corrosive for a few hours) is transferred to a 100 ml. volumetric flask, made up to volume with water and stored in plastic container. Si, Al and Fe are determined with the Pye-Unicam atomic absorption spectrometer, employing N_2O/acetylene mixture for the first two elements and acetylene/air mixture for Fe.

"Total analysis" for the appraisal of nutrient reserve: All topsoil samples (0–30 cm.) were analysed for total P, K, Ca, Mg, after digestion of the soil with a 1:1 mixture of nitric acid and sulphuric acid and dropwise additions of hydrogen peroxide until perfectly clear extracts were obtained. Determination of P by molybdenum blue/ascorbic acid method. Ca and Mg by atomic absorption-spectrometry, and K by EEL flamephotometer.

Primary minerals analysis: .. .. .. The soil sample was treated with 30% H_2O_2 to remove organic matter. The sand fraction (50–250μ) was obtained by the sedimentation method and sieving according to Milner (1962). The material, coating the sand grains, was removed by gently boiling with water, but in some cases (if ferruginous material was present) 1:1 hydrochloric acid was used. The light and heavyminerals were together mounted with canada balsam on microscopic slides and examined, using a petrographic microscope.

2.4. Cartographic Methods

For the area surveyed, a base map as required at a scale of 1 : 100.000 was not available. To overcome this problem use was made of four adjoining 1 : 50.000 sheets as supplied by the Survey of Kenya (sheet 75/1 up to /4), which together cover the same area. Each of these sheets was simplified by deleting all unwanted details. Subsequently, each sheet underwent a photographic reduction to the final 1 : 100.000 scale after which the four sheets were joined together as a film positive. New elements, not featuring on the original 1 : 50.000 sheets, such as recently constructed main roads, schools, etc. were added. This additional information was collected during the field work and is presented under the responsibility of the KSS.

The soil map (Appendix 1) was printed in subsequent steps, using six plates. Each plate was used to print one different colour. The colours employed were black, solid blue, yellow, red and blue. One black plate was for all topographic details, soil boundaries, symbols and the legend and the solid blue one was for the rivers. Two additional black plates were required: one to provide additional information on symbols for mountains, hills, depth classes, etc. (Appendix 1); the other one for the information on the ecological zones (Appendix 2). The colours of the different soil units are combinations of the three basic colours namely yellow, red and blue in different intensities.

All cartographic work was done in the drawing rooms of the Kenya Soil Survey except for the colour separation which was done at the Soil Survey Institute at Wageningen, the Netherlands. After preparation of all seven plates a proofprint was copied on paper using the "Cromalin" proofset. The map was finally printed by Kenya Litho, Nairobi, on an offset printing press.

3.—THE SOILS

3.1. Previous Work

In 1959 a 1 : 3.000.000 soil map of Kenya by H. G. Gethin Jones and R. M. Scott was published in the first edition of the atlas of Kenya (Survey of Kenya). According to this map five major groupings of soil are recognized in the survey area: vlei soils, red friable clays, alpine meadow (peat) soils, light yellowish brown sandy loams with laterite horizon, and shallow stony soils. The "Land system atlas of Western Kenya" (Scott *et al.*, 1971) gives some soil information in its description of land systems and land facets.

Three studies (Theisen, 1966; Kantor, 1971 and 1974) deal with mineralogical and chemical studies on tropical soils, some of them situated in the Cherangani area. Besides the fact that these studies are rather academic, only a rough indication is given of the location of the analysed soils (the spots are not plotted on a map) which renders the results of the studies rather useless as the exact location of the sampled soils cannot be traced.

Some soil data exist on areas next to the surveyed sheet. In 1971 a detailed survey was carried out of the Kitale National Agricultural Research Station (Michieka and Oswaggo, 1971) at scale 1 : 10.000. This station is situated about three kilometres south-west of Kitale town, just outside the survey area. It gives detailed information on the soils of the station and includes many analytical data.

The soils of Kitale station can be broadly divided in two groups: the well drained ones (mapping units 1 up to 8 of the 1971 report) and the imperfectly to poorly drained ones (mapping units 9 up to 12). Most of the well drained ones are comparable to the soils of unit U4Ub of this report. The differences between the various units distinguished in the 1971 detailed survey are mainly based on slight textural differences especially of the topsoil and slight colour differences. Only unit 7 which is red is comparable to the soil described in this report as U4Ur. The poorly drained soil units (units 9 up to 12) all have impeded drainage during at least a part of the year. They would mainly fall in unit VC of the reconnaissance survey. Unit 12 covers the valley bottoms of the shallow valleys dissecting the area, the units 9, 10 and 11 cover small areas and are situated at the transition from the shallow valleys

to the well drained areas. Maybe unit 9 could be correlated with unit Vgc of the reconnaissance survey. Soil units 1, 2 and 4 are the dominant soils of the station; they are only slightly different from each other. The "Top" station has only soils of the units 2 and 4; the "Grassland" station has as dominant soils the units 1, 2, 4 and 6; the shallow valleys have soils of unit 12.

Two site evaluations were carried out recently in areas east and north-east of this map sheet. The first one (Bonarius and Njoroge, 1975) deals with a preliminary evaluation of the irrigation suitability of the land along the Wei-Wei, Morun and Samakitok rivers north-east of Sigor village. The scale of the preliminary soil map is 1:60.000. The second one (Siderius, 1975) is an exploratory soil survey (scale 1:100.000) of the upper Kerio valley and covers the valley up to Lomut Village which is near Sigor.*

3.2. General Properties of the Soils

The soils of the area are predominantly well drained. They differ however strongly in depth, chemical fertility, organic matter content and physical behaviour. Four major soil regions can be clearly distinguished.—

(i) the Kitale uplands

(ii) the Cherangani "hills"

(iii) the uplands, footslopes and piedmont plains of the northern part

(iv) the mountains and hills of the north and north-eastern part.

The Kitale area.—has mainly deep soils of good structure, fair organic matter content and fair acidity. The soils can be easily worked but are a little liable to surface sealing and erosion.

The Cherangani "hills" area.—has mainly moderately deep soils of good structure, high organic matter content, but variable acidity. The soils can be easily worked but the slopes are often quite steep. Those around Kapenguria town are moreover rather liable to surface sealing and erosion, where the protecting humic topsoil is absent or liable to diminish substantially under intensive cultivation.

The uplands, footslopes and piedmont plains of the north.—have mainly deep soils that have however a very low organic matter content. The acidity varies. The soils are rather difficult to work and are very liable to surface sealing and erosion, the latter one because of the sparse vegetation cover as induced by a relatively dry climate and serious overgrazing.

The mountains and hills of the north-eastern half.—have shallow to very shallow, often stony or rocky soils of low organic matter content. The very steep slopes preclude their use for arable farming.

For the survey area as a whole, few experimental data exist concerning soil fertility. However, an interpretation of the chemical soil data is given in 3.5.

Nowhere in the survey area is there any substantial occurrence of petroplinthite (laterite/murram) in or below the soils. Also petrocalcic horizons (kunkar) are virtually absent.

3.3. Description of Soil Mapping Units

3.3.1. General

The highest level of soil mapping units differentiation is formed by the physiography, followed by the geology (parent material). On lowest level the soils within the various units are described according to drainage, depth, colour, consistence and texture. The descriptions relate to the characteristics of the subsoil (usually the B-horizon) unless otherwise indicated. A code system is used to identify the map units; the following abbreviations apply.

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*Recently a site evaluation was carried out in the whole of the Trans Nzoia District (Siderius and Njeru, 1976; site evaluation Kenya Soil Survey No. 28).

Physiography:

M = Mountains and Major Scarps (high relief intensity, slopes in general over 16 per cent)

H = Hills and Minor Scarps (low relief intensity, slopes in general over 16 per cent)

F = Footslopes (at the foot of mountains and hills, slopes predominantly 3-8 per cent)

U = Uplands (dissected peneplains at various levels, slope percentages variable)

U1 = Sondang level (altitude about 3200 m., rolling to hilly)

U2 = Kapsait level (altitude about 2900 m., rolling to hilly)

U3 = Kapenguria level (altitude about 2300 m., rolling to hilly)

U4 = Kitale level (altitude about 1900 m., (gently) undulating)

U5 = Kunyao level (altitude about 1350 m., flat to gently undulating, dissected by wide erosion valleys)

U6 = Wei-Wei level (altitude about 1050 m., gently undulating)

U7 = Undifferentiated levels (various altitudes and macro-relief)

Y = Piedmont plains (long slopes, in general less than 4 per cent)

A = River Terraces and Floodplains

V = Minor Valleys and Bottomlands.

Geology

U = undifferentiated Basement System rocks

G = quartzites and various gneisses

B = biotite gneisses

F = hornblende gneisses (rich in ferromagnesian minerals)

Q = granitoid gneisses

C = calc-silicate granulites

L = crystalline limestones.

No separate symbol is given for soils developed on "various parent materials".

When two or more soils occur in an unsystematic pattern, and could not be separated at the scale of the survey, a capital "C" is added after the geological symbol (= complex). A catenary sequence is however also indicated with a "C"; it is described accordingly. The following symbols are used for the coding of soils at the lowest level:

h = 20-40 cm. acid humic topsoil

<u>h</u> = 40-60 cm. acid very humic topsoil

r = red

b = brown

g = mottled (gleyed)

y = young (cambic B-horizon)

c = compact

e = sheet plus moderate gully-erosion

E = sheet plus severe gully-erosion

p = moderately deep (50-80 cm.)

P = shallow (25-50 cm.)

<u>P</u> = very shallow (0-25 cm.)

o = acid peat and muck.

In addition the slope class of each mapping unit is represented by the symbols:

A: 0-2 per cent slope — flat to very gently undulating

B: 2-5 per cent slope — gently undulating

C: 5-8 per cent slope — undulating

D: 8-16 per cent slope — rolling

E: 16-30 per cent slope — hilly.

The terminology of the legend of the soil map follows closely the outline and definitions as given by the USDA (Soil Survey Manual, 1961 supplement) and the FAO "Guidelines for Soil Profile Description".

Colour indications are based on the Munsell colour chart and are for moist condition, unless stated otherwise.

3.3.2. Description of the Individual Soil Mapping Units

M—Mountains and Major Scarps

MG—Soils developed on various gneisses and quartzites

***Map Unit* MGh**

Surface area.—20,780 ha.

Parent material.—various gneisses (predominantly biotite gneisses and quartz-muscovite gneisses) with muscovite-quartzites and quartzites.

Relief.—mountainous with slopes from 20-60 per cent; irregular meso-relief, slope length varying from 100-1000 m.

Vegetation and/or Land use.—sclerophyll forest and wooded bamboo thicket, some moist forest, commercially planted Pinus species have replaced original vegetation in places; also some forest areas are cleared for rainfed arable farming or grazing.

Soils.—predominantly deep, occasionally moderately deep, well drained, permeable, medium textured soils with well developed horizonation. A 20-40 cm. thick humic A-horizon, in places up to 60 cm. thick, overlies an altered B-horizon; the C-horizon is commonly reached from 100-150 cm.

Colour.—the A-horizon varies between black (10YR 2/1) and dark greyish brown (10YR 3/2); 10YR 2/2 is common, occasionally 5YR 2/2 occurs; dry values are one unit higher than the moist ones but have the same chroma; colour of the B-horizon is higher in value and chroma; 5YR 3/3 (dark reddish brown) is common with (dark) brown colours in the 7.5 and 10YR hue, 3-5 values and 2-4 chromas.

Texture.—the epipedon is commonly a sandy loam to sandy clay loam; usually the texture becomes somewhat heavier in the subsoil giving rise to (sandy) clay loam; the clay percentage increases irregularly with depth and then decreases in the deeper subsoil horizons (BC and C); the silt/clay ratio is from 0.2-1.2 in the A and varies from 0.3-0.5 in the B.

Structure.—the topsoil is moderate, fine to medium subangular blocky changing to porous massive with depth; occasionally weak coarse (sub-) angular blocky structure is apparent in the B2.

Consistence.—dry: slightly hard to hard
moist: friable
wet: slightly sticky and (slightly) plastic.

Weatherable primary minerals.—there is a high (30-80 per cent) percentage of these minerals in the B-horizons; muscovite is dominant, followed by biotite and oligoclase.

Clay minerals.—kaolinite in varying degree of crystallization is the dominant clay mineral, followed by subordinate amounts of illite.

Cation Exchange Cap. and acidity.—the CEC* (by NH_4 OAc at pH 7.0) is generally less than 10 me. per cent; occasionally from 10-15 me. per cent; calcium is the dominant cation of the exchange complex followed by magnesium; exchangeable sodium is very low; the sum of cations is commonly below 5 me. per cent. The pH-H_2O varies from 5.2-6.4 indicating strongly to slightly acid conditions; the pH-KCl is on average 1.3 unit lower than the pH-H_2O.

Organic C per cent in the A.—the percentage varies from 1.2-5.7 per cent C and decrease gradually with depth; average value for A11 and A12 horizons is 2.7 per cent C.

Base Saturation per cent.—(calculated at pH 7.0) this value usually decreases with depth; it varies from 53-93 per cent in the A11 and A12 horizons and between 32 and 53 per cent in the B2.

Diagnostic horizons.—a mollic A-horizon overlying a cambic B.

Remarks.—Low erosion hazard as long as the slopes are protected by forest or adapted cultivation practices. Variable erosion and accumulation of topsoil material at the lower slopes at unprotected sites. Considerable animal soil activity as testified by worm channels, termite mounds and burrows. About 60 per cent of the unit falls within ecological zone IIc. Profile 75/1-326 is a representative soil (*see* App. 6).

Map Unit MG

Surface area.—36.100 ha.

Parent material.—various gneisses (predominantly biotite gneisses and quartz-muscovite gneisses) with muscovite-quartzite and quartzites.

Relief.—mountainous relief with slopes from 15-55 per cent; irregular meso-relief due to rock outcrops; slope length varying between 100-1000 m.

Vegetation and/or Land use.—open bushland or bushed grassland is common; main species are Terminalia, Combretum and Acacia spp.; grass cover is sparse; rainfed arable farming is rare but extensive grazing is fairly common mainly of goats and sheep.

Soils.—are well drained, very shallow to shallow, of varying textures and little profile development; rocks and stones are common; truncated profiles occur, average depth of A-horizon is 18 cm.

Colour.—the topsoil is (very) dark greyish brown (10YR 3/2-4/2) occasionally in the 7.5YR hue; dry colours have usually 1 unit higher value; with depth, the chroma increases and (dark) brown colours (10YR 4/3-3/3, sometimes in the 7.5YR hue) are common.

Texture.—the A-horizon is a sandy loam occasionally loamy sand; with depth, the clay percentage may increase resulting in sandy clay loam textures, in places sandy clay.

Structure.—porous massive in places with a tendency to weak, coarse sub-angular blocky.

Consistence.—slightly hard when dry; friable when moist and non to slightly sticky and non to slightly plastic when wet.

Weatherable primary minerals.—many muscovites.

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*If not otherwise stated, CEC—soil is meant.

Diagnostic horizons.—an ochric A is recognized and occasionally an Umbric A. The B-horizon, if developed, has cambic properties.

Inclusions.—some patches of moderately deep and even deep soils may occur.

Remarks.—Soils of this unit experience a high erosion hazard due to steep slopes, the rather open vegetation and mode of rainfall. Accelerated erosion is caused by overgrazing and cropping without the application of proper soil conservation practices. It is not unlikely that because of the above circumstances this unit expands in relation to map unit MGh.

Approximately 75 per cent of the unit appears in ecological zone III-IV.

MQ Soils developed mainly on granitoid gneisses.

Map Unit MQh

Surface area.—11.850 ha.

Parent material.—granitoid gneisses; main constituents: SiO_2 and oligoclase.

Relief.—mountainous with slopes from 15-60 per cent; irregular meso-relief due to rock outcrops; slope length varies from 100-1000 m.; in places flatter areas are encountered.

Vegetation and/or Land use.—wooded bamboo thicket and some sclerophyll forest with montane grassland, extensive grazing occurs.

Soils.—well drained, moderately deep to deep, medium textured soils with fair profile development and dark coloured A, rich in organic matter.

Colour.—of the A-horizon is black (10YR 2/1-2/2); the B-horizons are commonly brown (7.5YR 3/4-4/3), sometimes yellowish red (5YR 4/6).

Texture.—the topsoil horizon has a sandy loam to sandy clay loam texture; the clay percentage increases with depth giving rise to sandy clay loam and occasionally clay texture; there is a fair amount of silt resulting in high silt/clay ratios (0.4-1.3).

Structure.—the upper part of the A has a strong, very fine to fine subangular blocky structure; the grade decreases with depth but the size increases (weak medium to coarse subangular blocky); the B-horizon is porous massive.

Consistence.—in the A-horizon is friable when moist; slightly sticky and slightly plastic when wet; in the B-horizon firm when moist and sticky and plastic when wet.

Weatherable primary minerals.—abundant muscovite is present throughout.

Clay minerals.—well crystallized kaolinite is dominant followed by vermiculite with spacings of respectively 7.16 Å and 14.24 Å.

Cation Exchange Cap. and pH.—The CEC decreases regularly with depth from 33 me. per cent in the A to 11 me. per cent in the B; calcium is the dominant cation of the exchange complex followed by magnesium, the sum of cations varies between 4.6 in the top and 1.3 in the subsoil.

The pH water varies from 5.4-4.9, indicating strongly acid soil conditions. The pH-KC1 is 0.5-1.0 unit lower than the pH-H_2O.

Organic C per cent in the A.—this percentage is about 6 in the A11; 4.5 per cent in the A12 and 5.6 in the AB; it drops sharply to 1.68 in the B2 (70-100 cm.).

Base saturation per cent.—the value changes irregularly with depth and varies from 12-15 per cent throughout.

Diagnostic horizons.—umbric A over a cambic B.

Inclusions.—Shallow soils and rock outcrops.

Remarks.—in spite of its occurrence in steeply sloping terrain, little erosion is observed.

Inclusions of soil of unit $\frac{\text{UlQh}}{\text{p}}$

This whole map unit falls in ecological zone IIc.

Profile 75/2-383 gives full analytical data and description, *see* App. 6.

MF Soils developed on gneisses rich in ferromagnesian minerals

Map Unit MFry

Surface area.—8.800 ha.

Parent material.—mainly hornblende gneisses, which are rich in ferromagnesian minerals, as well as calcium and sodium-aluminium silicates.

Relief.—very steep slopes from 20-45 per cent; with a varying meso-relief.

Vegetation and/or Land use.—montane grassland alternating with sclerophyll forest and bamboo forest; patches on lower slopes may be cleared and cultivated for maize.

Soils.—well drained, predominantly deep, medium textured soils with fair profile development.

Colour.—the surface has commonly a dark reddish brown colour (5YR 2/2-3/2) occasionally in the 7.5YR hue. With depth, value and chroma increase to dark reddish brown or yellowish red, sometimes dark red (5YR 3/4, 4/6, 2.5YR 3/6).

Texture.—sandy clay loam and clay loam textures are evident in the subsoil, which are overlain by a sandy loam to sandy clay loam topsoil. Clayey textures occur occasionally in the deep subsoil.

Consistence.—the soil material is friable when moist.

Weatherable primary minerals.—the occurrence of muscovite is common throughout the soil.

Clay minerals.—vermiculite is regarded the dominant clay mineral.

Diagnostic horizons.—an ochric A-horizon over a cambic B is recognized.

Inclusions.—a moderate deep phase of this unit is included as well as rocky and stony areas within this map unit.

Remarks.—this unit is confined to ecological zone IIc.

Map Unit MFC (Soil complex)

Surface area.—23.200 ha.

Parent material.—gneisses rich in ferromagnesian minerals (hornblende) and (Ca-Na) Al-silicates.

Relief.—very steep slopes (20-80 per cent) with occasionally flatter areas; irregular short (100 m.) slopes are commonly associated with rock outcrops.

Vegetation and/or Land use.—the original vegetation is referred to as wooded bushland, main species are Acacia tortilis, A. seyal, Balanites and Albizia. Undergrowth of grasses and herbs is fair, extensive grazing of mainly cattle and goats is practised in open areas; in places the vegetation has been cleared to make way for rainfed arable farming in spite of steep topography.

Soils.—this unit consists of a complex of well drained soils; they are either (very) shallow or deep; the former ones are commonly rocky and stony. An A-B-C horizon designation is recognized on the deeper ones.

Colour.—the epipedon has a dark (reddish) brown colour (5YR 3/2-3/4, 7.5YR 2/2), dry colours are normally one unit higher in value.

With depth value and chroma increase, giving rise to dark red (2.5YR 3/6) to reddish brown (5YR 4/3-4/4) colours in the B-horizon.

Texture.—the A-horizon has a sandy clay loam texture; the clay percentage (14-26 per cent) varies irregularly with depth; sandy clay loams are most common in the B, but some sandy loams throughout do occur. The silt percentage varies from 12-26 per cent; corresponding silt/clay ratios are around 1.0.

Structure.—is weak to moderate, medium and coarse subangular blocky.

Consistence.—of the soil material is slightly hard when dry, friable to occasionally firm when moist and slightly sticky and slightly plastic when wet.

Primary weatherable minerals.—muscovite commonly occurs throughout the soil.

Clay minerals.—the dominant clay mineral is vermiculite.

Cation Exchange Cap. and acidity.—the CEC varies from 14.4-22.6 me. per cent (at pH 8.2 by Na OAc) and from 8.8-14 me. per cent (at pH 7.0 by NH_4 OAc), calcium is the dominant cation followed by magnesium; the sodium percentage is equal or higher than the potassium percentage; pH-water values indicate slightly acid to moderately alkaline conditions, ranging from 6.3-8.3; the pH KCl is 0.5-1.7 units lower.

Organic C per cent in the A.—this is variable as indicated by the range 0.2-1.5 per cent in the topsoil; the C per cent normally decreases with depth (0.2-0.4 per cent C) in the B.

Base saturation per cent.—this value is more than 50 per cent at pH 8.2 as well as at pH 7.0 and varies from 67-100 per cent; base saturation usually increases irregularly with depth.

Diagnostic horizons.—an ochric A overlying a cambic B is commonly recognized or just an ochric A-horizon.

Inclusions.—(1) deeper soils are usually encountered in areas east of the Cherangani Mountains,

(2) soils with a humic topsoil are found on the upper slopes,

(3) brown (7.5YR 4/4) soils do occur in pockets and are probably derived from locally exposed biotite gneisses.

Remarks.—stonelines occur at varying depth; this mapping unit falls into Ecological Zone III-IV. Sheet and/or gully erosion has exposed the bedrock in many places, especially on steeper sloping land; colluvial material at the lower slopes is thus common. Calcium carbonate concretions (±1 per cent) may be present in some soils.

For full soil description and analyses *see* Appendix 6, profile 75/2-520, for a soil with a cambic B-horizon.

H — Hills and Minor Scarps

HG — Soils developed on various gneisses and quartzites

Map Unit HGh1

Surface area.—4.220 ha.

Parent material.—various quartzites and gneisses contributing a high amount of quartz and little weatherable minerals.

Relief.—commonly slopes from 20-30 per cent; occasionally 50 per cent with slope length 200-500 m.; irregular meso-relief.

Vegetation and/or Land use.—the original mixed, sclerophyll and moist forest vegetation has degraded to bushed grassland in many places. Undergrowth of grasses and herbs is sparse. In some places commercially planted Pinus spp. plantations have replaced the original vegetation. Extensive grazing does occur on grassy areas. In places tea and maize is cultivated.

Soils.—these are similar to the ones described under mapping unit MQh

Diagnostic horizons.—an umbric A overlying a cambic B.

Remarks.—approximately 55 per cent of this unit falls into Ecological Zone IIc and 45 per cent in Ecological Zone IIw.

Map Unit HGh2

Surface area.—5.100 ha.

Parent material.—dominantly biotite gneisses and quartzites, the latter grading into muscovite-quartzites.

Relief.—slopes vary from 10-40 per cent but are usually about 20 per cent; convex and straight slopes are common with a length of 100-500 m. The majority of this unit is confined to the steep and well defined escarpment between Kiptaberr forest and the Kapenguria — Kitale upland levels. The meso-relief is irregular.

Vegetation and/or Land use.—the natural forest of Acacia and broad-leaved spp. characteristic for this unit is often cleared for cultivation of maize. Fallow patches have good coverage of grasses and herbs, and are utilized for grazing, mainly by cattle and goats.

Soils.—well drained, deep, fine textured soils with a high organic matter content in the topsoil; horizonation is well defined, structural development is moderate to weak.

Colour.—of the A-horizon is black (10YR 2/1-2/2) or very dark greyish brown (10YR 3/2), occasionally dark reddish brown (5YR 3/2). With depth, the colour becomes redder and lighter and dark reddish brown (5YR 3/4) and brown (7.5YR 4/4) colours are common in the B. Sometimes dark reddish brown to dark red in the 2.5YR hue is encountered.

Texture.—the topsoil has a sandy loam to clay loam texture; there is often a clear increase of clay with depth giving rise to clay; few to common, moderate clay skins are observed in the B2. The silt percentage varies from 12-30 per cent; average 20 per cent. Corresponding silt/clay ratios vary between 0.71 in the A and 0.22 in the B2.

Structure.—in the topsoil moderate, medium to coarse subangular blocky breaking into moderate, fine and very fine crumby; the structure in the subsoil is weak, coarse to very coarse, angular blocky to porous massive.

Consistence.—of the A-horizon is friable to very friable when moist and non to slightly sticky and non plastic to plastic when wet; the B-horizon is commonly friable when moist and slightly sticky and plastic when wet.

Weatherable primary minerals.—variable but in many soils abundant, particularly micas.

Clay minerals.—kaolinite constitutes about 60 per cent of the clay minerals and illite about 40 per cent, both are moderately well crystallized.

Cation Exchange Cap. and pH.—the CEC (at pH 7.0) is around 35 me. per cent in the A-horizon and decreases to below 30 in the B. The pH-H_2O decreases regularly with depth from 5.7 in the A11 to 5.3 in the B 22 indicating strongly acid conditions. The pH-KCl is 0.9-1.4 unit lower.

Organic C per cent in the A.—this is high (4.5 per cent) in the top 40 cm., below this depth it decreases sharply to 1.5 per cent C. The per cent nitrogen is about 0.5 in the A.

Base Saturation per cent.—this value averages 66 per cent in the A and drops to 25 per cent in the B2-horizon.

Diagnostic criteria.—a mollic A is recognized overlying an argillic or cambic B.

Inclusions.—moderately deep and shallow phases of the described soil.

Remarks.—this unit falls into Ecological Zone IIw. Profile 75/3-55 supplies full description and analytical data of a soil with a mollic horizon overlying an argillic B. *See* Appendix 6.

Map Unit HG

Surface area.—2.780 ha.

Parent material.—various gneisses and quartzites.

Relief.—slopes commonly about 20 per cent and 200-500 m. long; meso-relief irregular, partly caused by bedrock exposures.

Vegetation and/or Land use.— Croton bushland, in some areas utilized as pasture.

Soils.—are similar to those of unit MG, apart from a slightly brown topsoil colour (7.5YR 4/4, 5YR 3/3) in addition to a gravelly sandy clay loam texture; soils are very shallow in general.

Diagnostic horizons.—rock is often encountered within 10 cm. of the surface; no other horizon than an ochric A is recognized.

Remarks.—this unit falls in Ecological Zone IV.

Map Unit HGC1

Surface area.—2.270 ha.

Parent material.—various gneisses and quartzites; quartz and K-feldspar commonly dominant; but biotite, hornblende and muscovite are present also.

Relief.—slope gradients vary from 16-30 per cent, commonly 20-25 per cent; slopes are slightly convex varying from 200-1000 m. length; occasionally irregular meso-relief.

Vegetation and/or Land use.—undifferentiated forest and forest glades; grassland is used for extensive grazing; few small areas under maize cultivation.

Soils.—Catenary sequence of well drained soils: very shallow, coarse textured on high topography; deep, medium to fine textured on lower slopes and in bottomlands. Increase of organic matter in the A-horizon of soils in low topographic position.

Colour.—brown to dark brown in the 7.5YR and 10YR hue's (7.5YR 3/2, 10YR 3/2, 2/2); with depth, values usually increase with 1 or 2 units but chroma may be the same.

Texture.—sandy loams to sandy clay loams occur in the subsoil; considerable amounts of coarse rock fragments and gravel can be present throughout the soils.

Diagnostic horizons.—an ochric A-horizon of varying thickness in the upper terrains; with umbric A-horizons overlying argillic B in the lower part of the sequence.

Remarks.—soils of this unit are comparable to those of unit U3GC2, to which is also referred for a representative profile description. The map unit occurs in Ecological Zone IIw.

Map Unit HGC2

Surface area.—6.570 ha.

Parent material.—various gneisses and quartzites of the Basement System.

Relief.—hilly; straight to slightly convex slopes up to 300 m. long.

Vegetation and/or Land use.—montane grassland and sclerophyll forest; grassland is used for extensive grazing of cattle and sheep, crop cultivation locally on less steep parts; small shambas.

Soils.—occur as a complex; soil properties vary greatly over short distances in depth, texture, colour and thickness of humic A-horizon (if present), all soils are well drained however. On the higher areas of this map unit, soils are similar to the ones described under map unit $\frac{\text{U2Gh1}}{\text{p}}$. Those terrains covered by forest have soils comparable to those of map units U3Gh or $\frac{\text{U2Gh2}}{\text{p}}$. Soils of open areas of lower topography tend to be similar to $\frac{\text{U3Gby}}{\text{p}}$ soils, as described in the $\frac{\text{U3Gby}}{\text{p}}$ — U3Gh association.

Remarks.—inclusions of Lithosols and stony/rocky areas do occur. This map unit occurs in Ecological Zone IIc.

HL — Soils developed on crystalline limestones and hornblende gneisses

Map Unit HLC

Surface area.—830 ha.

Parent material.—rich in calcium, magnesium, iron and aluminium.

Relief.—varying slopes from 6-35 per cent; on the whole very hilly with straight to convex slopes of 100-400 m., somewhat irregular meso-relief.

Vegetation and/or Land use.—Croton bushland and bushed grassland with various Acacia species; sparse undergrowth of herbs and grasses.

Soils.—this unit is a complex consisting of well drained coarse to medium textured soils of varying depth. Shallow soils are usually encountered upslope, moderately deep soils are found on top of the ridges and the uppermost parts of the slopes, while deep soils occur at the lower flatter parts of the slopes and in the valley bottom. Profile development is weak to moderate. The soils are moderately permeable and have an ABC morphology.

Colour.—in the A-horizon varies from 2.5YR 3/2, 5YR 3/2 to 10YR 3/2, but is most commonly a dark (greyish) brown; with depth value and chroma increase one unit and dark reddish brown colours occur (5YR, 2.5YR 3/4), occasionally dark brown.

Texture.—of the topsoil is normally a gravelly sandy clay loam; the percentage of clay remains virtually constant with depth, but the amount of coarse fragments decreases. Sandy clay loam textures dominate throughout. The percentage silt varies from 10-18 per cent; corresponding silt/clay ratios are from 0.4-0.8.

Structure.—in the A-horizon moderate, fine to medium subangular blocky; in the B-horizon weak fine medium (sub-) angular blocky structure.

Consistence.—slightly hard when dry, friable when moist and slightly sticky and slightly plastic when wet.

Weatherable primary minerals.—muscovite is common throughout.

Clay minerals.—dominant are montmorillonite and vermiculite.

Cation Exchange Cap. and pH.—the CEC at pH 8.0 varies from 17-22 me. per cent, it is fairly constant throughout the soils.

Calcium is by far the dominant exchangeable cation, followed by magnesium, exchangeable Na is equal or supersedes K.

The sum of cations varies from 17-21. The pH water varies from 7.3-8.6 indicating neutral to moderately alkaline soil conditions.

Organic C per cent in the A.— varies from 0.7-1.3 per cent C.

Base Saturation per cent.—at pH 8.2 is commonly 100 per cent.

Diagnostic criteria.—mollic A over a cambic B, or an ochric A only.

Remarks.—This unit occurs in Ecological Zone III-IV. For a profile description of a soil with a mollic A, *see* Appendix 6, profile 75/2-505.

F — Footslopes

FG — Soils developed on colluvium predominantly derived from various gneisses

Map Unit FGrc

Surface area.—2.500 ha.

Parent material.—colluvium, fairly rich in ferromagnesian minerals.

Relief.—undulating topography with slopes from 5-8 per cent, 100-500 m. long and regular to somewhat convex; the terrain occurring at the base of mountains and hills may have occasionally somewhat steeper slopes (12 per cent).

In places termite mounds of 2-2½ m. in diameter, 1 m. high and 50-100 m. apart, are observed.

Vegetation and/or Land use.—the natural vegetation of mainly Combretum-Euphorbia woodland has been cleared in most of the area, to give way to rainfed arable crop production of maize and millet. The grass cover in fallow land is absent to poor, partly because of overgrazing by cattle, sheep and goats.

Soils.—well drained, deep, medium to fine textured soils with an A-B-C profile morphology and with a tendency to moderate strong surface sealing, inducing strong runoff and subsequent erosion.

Colour.—of the A-horizon dominantly dark (reddish) brown (7.5YR 3/2, 5YR 3/2); the B-horizon commonly (dark) reddish brown in the 5YR hue; occasionally yellowish red (7.5YR 4/6).

Texture.—fairly homogeneous throughout and mainly sandy clay loam to clay. The topsoil may be somewhat coarser partly caused by admixture of coarser material. Clay transportation is evident from moderate to strong common clay skins, partly confirmed by micromorphological analyses (*see* Appendix 8).

The silt percentage varies from 14-18 per cent; silt/clay ratios are from 0.4-0.8; gravel may be encountered in the subsoil.

Structure.—weak to strong, medium to coarse, (sub-) angular blocky, with depth often intergrading to porous massive.

Consistence.—hard to very hard when dry, firm to friable when moist and sticky and plastic when wet.

Weatherable primary minerals.—many (> 20 per cent), muscovite and biotite.

Clay minerals.—a combination of illite and kaolinite is common.

Cation Exchange Cap. and pH.—the CEC varies considerably and was found at pH 8.2 to be in the order of 10 me. per cent and at pH 7.0 around 33 me. per cent. Calcium and magnesium are the dominant cations, potassium is fairly high in the topsoil but decreases with depth; the sodium exchange percentage is low. Sum of cations varies from 7-10 to 28-30. The pH-water increases with depth with values from pH 6.8-8.0 (neutral to mildly alkaline). The pH-KCl is 0.9-1.5 unit lower than pH-H_2O.

Organic C per cent in the A.—is about 0.8 per cent and decreases with depth.

Base Saturation per cent.—varies from 79-100 per cent and increases with depth.

Diagnostic horizons.—an orthic A overlying an argillic B, in some places a cambic B.

Remarks.—There is marked animal activity in most of these soils as seen in channels, pores, burrows and termite mounds. The soils are very suceptible to erosion. Most of this map unit falls in Ecological Zone IV. Detailed description and analytical data are presented in Appendix 6, profile 75/2-515, for a soil with an argillic B.

Map Unit FGrce

Surface area.—10.920 ha.

Parent material.—as for FGrc.

Relief.—gently undulating to rolling with slopes from 2-16 per cent, undulating topography dominates; slopes are straight to convex, ranging from 100-1500 m.; meso-relief is induced by steeply incised gullies.

Vegetation and/or Land use.—Combretum-Euphorbia woodland and some Acacia nilotica bushland; undergrowth of grasses and/or herbs is sparse to absent; bare surface soil is a common sight. Bush cutting and overgrazing has led to depletion of the vegetation in many areas.

Soils.—are similar to those of map unit FGrc, apart from sheet erosion and moderate gully erosion which has led to the removal of the A-horizon and occasionally the B-horizon. Surface sealing is moderate and an overwash of coarse soil material is common.

Colour.—of the A-horizon may vary from the described one because of profile truncation or because of new epipedon forming processes. Dark reddish brown colours in the 5YR and 2.5YR hue may thus be encountered. The colour of the B may in addition be red to dark red in the 2.5YR hue.

Texture.—in most soils an increase of clay with depth is observed, caused by clay translocation as is evident by clay skins. Sandy clay loam textures are common, but some clayey profiles occur also. In some soils there is little textural differentiation, they usually have a sandy loam texture. The contrast of this texture with that of the "A" horizon is caused by admixture of coarser material as well as by flushing out of the finer soil particles by erosion. Sandy loams prevail.

Structure.—as for FGrc

Consistence.—when dry commonly hard but sometimes soft or very hard; when moist the soils are mainly friable, occasionally firm; when wet the material is (slightly) sticky to (slightly) plastic.

Weatherable primary minerals.—abundant (about 50 per cent); mainly muscovite and biotite.

Clay minerals.—kaolinite is commonly the dominant clay material, followed by illite; small quantities of vermiculite may occur in the B-horizon.

Cation Exchange Cap. and acidity (pH).—the CEC at pH 7.0 is lower than described for FGrc and varies from 4-15 me. per cent, it usually increases with depth. Calcium and magnesium are the dominant cations, followed by K and Na. The sum of cations is low and varies from 2-10 me. per cent. The pH-water is around 6.9, the pH-KC1 is 1-1.5 unit lower (medium acid).

Organic C per cent in the A.—this value is about 0.4 per cent.

Base Saturation per cent.—varies from 60-90 per cent.

Diagnostic Horizons.—an ochric A overlying an argillic B or a cambic B.

Remarks.—The topographic position of the soils at the foot of hills and mountains, the subdued relief, the surface sealing and weak structural development combined with destruction of the vegetation cover has led to soil erosion in many parts. A little more than 90 per cent of this map unit falls in Ecological Zone IV, the remaining part in Zone III-IV. A detailed profile description is given in Appendix 6, profile No. 75/1-107.

Map Unit FGrcE

Surface area.—2.290 ha.

Parent material.—as for FGrc

Relief.—is undulating (5-8 per cent); the meso-relief is very irregular because of the presence of many deep gullies; often 2-5 m. deep and up to 10 m. wide.

Vegetation and/or Land use.—open woodland vegetation of mainly Combretum and a completely bare soil surface due to erosion, that even makes extensive grazing impossible.

Soils.—the original soils as described under FGrc and FGrce have been subject to severe erosion, causing profile truncation of the A and B horizons, often exposing the bedrock. Only in small areas some "natural" soils remain.

Remarks.—this map unit falls in Ecological Zone IV.

Map Unit FGby

Surface area.—1.410 ha.

Parent material.—various gneisses with muscovite and biotite as major constituents.

Relief.—undulating topography (5-8 per cent) dominates but flatter terrain occurs also; uniform, occasionally convex slopes from 100-400 m. long. Regular meso-relief.

Vegetation and/or Land use.—Acacia woodland (A. tortilis, A. elatior) in many places cleared in this unit for cultivation; rainfed and/or smallholders irrigation is practised; main crops are maize, millet, sorghum, cassava, groundnuts, bananas and pawpaw. Fallow land is used for extensive grazing.

Soils.—well drained, deep of varying textures; horizonation is sometimes caused by sedimentological processes rather than by pedogenesis. Profile development is varied but recent, ranging from A-B-C to A-C profiles.

Colour.—the A-horizon varies considerably from reddish brown (5YR 4/4) to very dark greyish brown (10YR 3/2); occasionally black (N2.5/) colours are encounted. Most common are however dark brown to dark greyish brown colours in the 7.5YR and 10YR hue. Colours in the subsoil tend to be browner and may range from dark red (2.5YR 3/6) to dark yellowish brown (10YR 4/4); often dark, reddish brown (5YR 3/3-3/4).

Texture.—vertical as well as lateral textural changes are marked over short distances, sandy loams and sandy clay loams seem dominant. Silt and clay percentages change irregularly with depth. The silt/clay ratio varies from 0.3-1.10.

Structure.—weak, fine to medium subangular blocky structure is common; there is usually little to no structural development in the subsoil.

Consistence.—varies from loose to very hard when dry; is commonly firm when moist and non to slightly sticky and plastic when wet.

Weatherable primary minerals.—many (> 20 per cent), mainly muscovite.

Clay minerals.—some illite is present in addition to a high percentage of amorphous material in the clay fraction.

Cation Exchange Cap. and pH.—the CEC, obtained at pH 7.0, varies considerably, is however below 20 me. per cent and changes irregularly in the profile. The pH-water is 7.0 (+ or - 0.4)—(neutral).

Organic C per cent in the A.—is high (average 1.4) but drops sharply in the subsoil horizon.

Base Saturation per cent.—varies from 70-100 per cent; often above 80 per cent.

Diagnostic Horizons.—ochric A over cambic B.

Inclusions.—Soils of unit FGbys, mainly close to the mountains; poorly drained areas close to the Wei-Wei river.

Remarks.—Some soils may be calcareous; about 60 per cent of this unit falls into Ecological Zone IV; the remaining 40 per cent in zone III-IV; *see* profile 75/2-536 in Appendix 6 for a detailed description with analytical data.

Map Unit FGbys

Surface area.—480 ha.

Parent material.—as for FGby

Relief.—gently undulating to rolling; convex slopes of about 200 m.; irregular meso-relief due to gullies (5 m. deep, 15 m. wide).

Vegetation and/or Land use.—as for FGby — with some bushland; sparse plant population; used for extensive grazing.

Soils.—similar to those described under — FGby — but gravelly and/or stony, in places bouldery.

Remarks.—the whole of this unit belongs to Ecological Zone IV; description and analytical data are under profile No. 75/2-523, Appendix 6.

U — Uplands

U1 — Sondang Level (altitude about 3200 m.)

U1Q — Soils developed on granitoid gneisses

Map Unit $\frac{\text{U1Qh}}{\text{p}}$

Surface area.—7.250 ha.

Parent material.—Granitoid gneisses; main constituents SiO_2, orthoclase, microcline and biotite.

Relief.—rolling to hilly; commonly from 16-35 per cent; slopes irregular and from 100-500 m. long.

Vegetation and/or Land use.—Moorland and montane shrubland (Erica arborea) with some sclerophyll forest and bamboo thicket; some grazing by goats and sheep. Scattered potato cultivation.

Soils.—of this unit are foremost characterized by a very humic topsoil of about 50 cm. thick and loamy texture; this A-horizon may rest conformably on the B or rests directly on gravel, stones or rock; soils are medium textured in the subsoil; horizonation is abrupt to gradual.

Colour.—the A-horizon commonly very dark brown (10YR 2/2), occasionally very dark grey (10YR 3/1); in the B-horizon brown to dark brown (7.5YR 4/3-3/3).

Texture.—(sandy) loam in the A, occasionally gravelly, underlain by a clay loam B.

Structure.—of the A-horizon strong, fine to medium crumb in the upper part; changing to weak, coarse subangular blocky in the lower part; the B-horizon is porous, massive.

Diagnostic horizons.—umbric A overlying a cambic B.

Inclusions.—stony and rocky areas, and Lithosols.

Remarks.—the map unit as a whole occurs in Ecological Zone I.

U2 — Kapsait Level (altitude about 2900 m.)

U2G—Soils developed at various gneisses and quartzites

Map Unit U2Gry

Surface area.—3.970 ha.

Parent material.—various gneisses, including muscovite gneiss; major constituents quartz, orthoclase, microcline, muscovite, biotite and hornblende.

Relief.—rolling to hilly (12-30 per cent slope); slope length 100-500 m.; irregular meso-relief.

Vegetation and/or Land use.—mainly montane grassland utilized as grazing grounds for cattle and (wool) sheep; this vegetation alternates with patches of forest and cultivation. The acreage of cultivated land is increasing, main crops are potatoes, pyrethrum and, despite the high altitude, maize.

Soils.—are well drained, deep, permeable of medium to fine texture with an A-B-C horizon sequence; gradual boundary transitions and moderate structural development.

Colour.—of the A-horizon dark reddish brown (5YR 3/2); of the B-horizon commonly dark reddish brown in the 5YR and 2.5YR hue; occasionally dark red (2.5YR 3/6).

Texture.—of the A varies from sandy loam-sandy clay loam-clay; — of the B is sandy clay loam-(sandy) clay. The percentage silt is fairly high; silt/clay ratio ranges from 0.4-0.6; gravel may be present.

Structure.—moderate, medium to coarse (sub-) angular blocky.

Consistence.—hard when dry, firm when moist, (slightly) sticky and (slightly) plastic when wet.

Weatherable primary minerals.—common muscovite and biotite.

Clay minerals.—Illite is the dominant clay mineral.

Cation Exchange Cap. and acidity (pH).—CEC soil at pH 7.0 decreases regularly with depth from 24 in the top to 8.1 in the B3, calcium and magnesium are dominant; the pH-water ranges between 4.9 and 5.4; the pH-KC1 is 0.5-1.2 unit lower than pH-H_2O (strongly acid).

Organic C per cent in the A.—average about 3 per cent in the top 35 cm., decreasing with depth.

Base saturation per cent.—at pH 8.2 varies from 28-37 per cent.

Diagnostic horizons.—ochric A over cambic B.

Remarks.—in many places an overstocking has led to erosion, usually initiated on the upper parts of the slopes and developing into gullies. The unit occurs in Ecological Zone IIc; *see* profile 75/4-629 for a detailed profile description and analytical data, in Appendix 6.

Map Unit $\frac{\text{U2Gh1}}{\text{p}}$

Surface area.—7.800 ha.

Parent material.—as for U2Gry.

Relief.—rolling to hilly (16-35 per cent slope gradient), irregular meso-relief; slope length 200-500 m.

Vegetation and/or Land use.—montane grassland with scattered trees; extensive grazing by cattle, sheep and goats is the main land use; cultivation is scattered and on a small scale, potatoes and pyrethrum are the main crops, maize is occasionally grown.

Soils.—are varied; dominant soil is well drained, very deep to deep, coarse to medium textured, with A-B-C profile morphology, clear to gradual horizonation and moderate to weak structural development; a clear organic A-horizon is common.

Colour.—of the A very dark brown (10YR 2/2) but 3/2-2/2 colours in the 7.5YR and 5YR hue's do occur also; of the B-horizon, dark reddish brown (5YR 3/4) to yellowish red (5YR 4/6).

Texture.—sandy loam in the A; with clay percentage increasing with depth giving rise to (sandy) clay (loam) textures in the B; the silt percentage may be high, causing silt/clay ratio's of up to 2.3.

Structure.—moderate to weak, coarse (sub-) angular blocky.

Consistence.—very friable to firm when moist, (slightly) sticky and (slightly) plastic when wet.

Weatherable primary minerals.—common to many, mainly muscovite.

Cation Exchange Cap. and acidity (pH).—the CEC at pH 7.0 varies from 20-30 me. per cent in the A and decreases in the B; sum of cations is very low: 3.5 in the A11 to 0.9 in the B; pH-water varies from 5.1-5.4 (strongly acid).

Organic C per cent in the A.—5.8 per cent in the A11 to 4.5 per cent in the AB (25-45 cm.).

Base Saturation per cent.—low (8-12 per cent).

Diagnostic horizons.—umbric A over cambic B.

Inclusions.—(1) Soils with A-horizons that are less or not developed, on the upper parts of the convex slopes,

(2) soils with cumulic A-horizons in the valley bottoms (up to 50 cm. of organic A, often mucky) are poorly drained and commonly black in colour,

(3) very shallow and/or rocky soils in some areas.

Remarks.—rill erosion starting between terracettes formed by cattle on the upper part of the slopes commonly develops into gully erosion. This map unit falls into Ecological zone IIc. Profile 75/4-378 is representative for the majority of soils in this unit, for detailed description and analytical data, *see* Appendix 6.

Map Unit $\frac{\text{U2Gh2}}{\text{p}}$

Surface area.—1.180 ha.

Parent material.—various gneisses and quartzites of the Basement system.

Relief.—rolling to hilly topography.

Vegetation and/or Land use.—moist forest in some areas cleared for cultivation.

Soils.—well drained, moderately deep to deep; predominantly dark reddish brown, friable, sandy clay loam to clay; with an acid humic topsoil of at least 30 cm. thick.

Diagnostic horizons.—umbric A overlying a cambic B.

Remarks.—this map unit occurs also in a complex with unit $\frac{\text{U2Gh1}}{\text{p}}$.

It usually occurs under forest on the steeper slopes. The unit falls in Ecological Zone IIc.

Map Unit $\frac{\text{U2Gh1}}{\text{p}}$ — $\frac{\text{U2Gh2}}{\text{p}}$

Surface area.—6.940 ha.

Parent material.—as for $\frac{\text{U2Gh1}}{\text{p}}$ and $\frac{\text{U2Gh2}}{\text{p}}$.

Relief.—rolling to hilly, D and E slopes.

Vegetation.—Montane grassland and sclerophyll forest.

Soils.—complex of units $\frac{\text{U2Gh1}}{\text{p}}$ $\frac{\text{U2Gh2}}{\text{p}}$;

the latter commonly associated with forest vegetation, the former with grassland.

Remarks.—this unit occurs in Ecological Zone IIc. Profile 75/4-384 is representative for the $\frac{U2Gh2}{p}$ part of this complex.

For a detailed description and analytical data, *see* Appendix 6.

U3—Kapenguria Level (altitude about 2300 m.)

U3G — Soils developed of various gneisses and quartzites.

Map Unit U3Gh

Surface area.—20.500 ha.

Parent material.—various gneisses, predominantly biotite gneiss, also quartzites with variable percentage of biotite.

Relief.—rolling (slope class D) with inclusions of steeper slopes, average slope gradient 13 per cent. Long, convex slopes are common.

Vegetation and/or Land use.—moist montane forest (indigenous) and exotic pine plantations, occasionally cleared for maize cultivation.

Soils.—well drained, deep, brown, friable, fine textured soils with a characteristic humic topsoil of more than 30 cm. thick.

Colour.—A-horizon: very dark grey (10YR 3/1) to black (10YR 2/1) and/or very dark brown (10YR 2/2) to dark reddish brown (5YR 3/2); B-horizon: dark reddish brown (5YR 3/3, 3/4; 2.5YR 3/4), sometimes reddish brown (5YR 4/4) or dark red (2.5YR 3/6) or yellowish red (5YR 4/6).

Texture.—sandy clay loam in the A-horizon to clay in the B; silt percentage varies from 14-20 in the A and upper B; silt/clay ratio's 0.3-0.6; stoniness may be encountered in the soils.

Structure.—moderate to strong, fine to medium crumb; changing to weak and moderate, medium and coarse (sub-) angular blocky in the B-horizon.

Consistence.—hard to very hard when dry, friable when moist, sticky and plastic when wet.

Weatherable primary minerals.—many, mainly biotite and muscovite.

Clay minerals.—dominantly kaolinite, subordinate amounts of illite.

Cation Exchange Cap. and acidity.—the CEC at pH 7.0 is usually decreasing from 35-40 me. per cent in the A11 to around 10 me. per cent in the B2; calcium is dominant on the exchange complex followed by magnesium; the pH-water decreases from 5.9 to below 4.5 (very strongly to extremely acid).

Organic C per cent in the A.—around 6 per cent, dropping considerably in the B2.

Base Saturation per cent.—above 50 per cent in the A1 but below 50 per cent in the subsoil horizons.

Diagnostic horizons.—an umbric A-horizon overlying an argillic or cambic B.

Inclusions.—Soils with a thinner A-horizon are included, as well as soils with cumulo-humic A-horizons of more than 1 m. thick, the latter normally confined to the lower parts of the slopes and the valley bottoms.

Remarks.—the occurrence of clay skins in the B-horizon is variable. The map unit occurs in Ecological Zone IIw; profile 75/3-61 is representative, for a detailed description and analytical data, *see* Appendix 6.

Map Unit U3GC1

Surface area.—1.640 ha.

Parent material.—various gneisses with varying amounts of quartz, and considerable percentages of micas, biotite and hornblende.

Relief.—rolling topography, commonly 10-11 per cent slope; on interfluves 5 per cent slopes are normal; convex (500 m.) long slopes are common.

Vegetation and/or Land use.—the original (Acacia) forest has been cleared in many areas to give way to arable land and pasture.

Soils.—The dominant member of this catena is a well drained, deep, dark red, friable clay, with A-B-C- profile morphology, distinct to clear horizonation and weak structural development. The upper members of the catena have none or a thin A-horizon, the lower members have an acid humic topsoil increasing in thickness downslope; the B-horizon is basically the same throughout the catena.

Colour.—the A-horizon is dark (reddish) brown in the 5YR, 7.5YR or 10YR hue; the B-horizon has a characteristic (2.5YR 3/6) dark red colour.

Texture.—the A-horizon is a sandy clay loam; the B-horizon has commonly a clay texture. The percentage silt is low resulting in low silt/clay ratios from 0.3 in the A to 0.1 in the B22.

Structure.—weak, coarse angular blocky to porous massive.

Consistence.—hard to very hard when dry, friable when moist, sticky and plastic when wet.

Weatherable primary minerals.—common muscovite.

Clay minerals.—well crystallized kaolinite is dominant, with traces of illite.

Cation Exchange Cap. and acidity.—the CEC soil at pH 7.0 is from 5-8 me. per cent, potassium (K) is the dominant exchangeable cation; the sum of cations is very low (1.4-3.1 me. per cent); the soil pH varies from 5.3-5.8 (medium acid); lowest values usually encountered in the subsoil.

Organic C per cent in the A.—around 1.3 decreasing with depth.

Base Saturation per cent.—at pH 7.0 is normally below 50 per cent and decreases sharply in the subsoil.

Diagnostic horizons.—an orthic sometimes umbric A overlying a argillic B with ferralic properties.

Inclusions.—(1) soils with a more brownish colour similar to that of soils in unit U3GC2 are included, these soils are also somewhat coarser in texture,

(2) at the lower part of the slopes and in the valley bottoms soils with cumulic-humic A-horizons of 1 m. and more thick are included.

Remarks.—Profile 75/3-62 is representative for the dominant soils of this unit which falls in Ecological Zone IIw. For a full description of this profile, with analytical data *see* Appendix 6.

Map Unit U3GC2

Surface area.—8.320 ha.

Parent material.—various gneisses, presumably dominantly biotite gneisses and quartz-biotite gneisses ranging to quartzites with varying amount of biotite.

Relief.—mainly rolling (D slope) in some parts hilly (E slope), long convex slopes are common.

Vegetation and/or Land use.—the original forest vegetation has been cleared in most of the area and the land is put to mixed farming; indigenous trees (mainly Acacia spp.) are only observed along the streams of the dendritic drainage pattern.

Soils.—the dominant soil of the catena is well drained, deep to moderately deep, (reddish) brown and of medium texture; horizonation is gradual and A-B-C profile morphology is common. The higher members of the catena situated at or near the crest of the interfluves have commonly a thin, weakly developed A-horizon and are often moderately deep soils; going downslope the A-horizon develops into a deep, acid humic A, which may come to great thickness in the valley bottoms and lower slope areas. The B-horizon remains virtually the same throughout.

Colour.—of the A is very dark greyish brown (10YR 3/2), occasionally black (10YR 2/1) or brown (10YR 3/3); — of the B-horizon varies from dark yellowish brown (10YR 4/4) to brown (7.5YR 4/4) to dark reddish brown in the 5YR and 2.5YR hue and is sometimes yellowish red (5YR 4/6).

Texture.—of the A-horizon sandy clay loam, clay percentage usually increases somewhat with depth but remains in the SCL texture class; occasionally sandy clay may be encountered. The silt percentage varies from 10-16 per cent; corresponding silt/clay ratios are commonly from 0.4-0.8; gravel may be encountered in the deep subsoil.

Structure.—weak, coarse to very coarse angular blocky with a tendency to massive.

Consistence.—(slightly) hard when dry, friable when moist, (slightly) sticky and plastic when wet.

Weatherable primary minerals.—many, mainly muscovite and biotite.

Clay minerals.—well crystallized kaolinite is dominant followed by well crystallized illite; occasionally traces of vermiculite and gibbsite.

Cation Exchange Cap. and acidity.—the CEC soil is fairly high in the A but decreases sharply in the B2 with values varying from 4-10 me. per cent; calcium and magnesium are the dominant cations; sum of cations ranges between 1-10; the pH-H_2O varies from 5.1-6.3 (strongly to slightly acid).

Organic C per cent in the A.—is on average 2 per cent; range.—0.8-3.0.

Base Saturation per cent.—is variable and ranges from 30-70 per cent throughout the soil.

Diagnostic horizons.—orthic or umbric A overlying an argillic B, often with ferralic properties.

Remarks.—This map unit occurs in Ecological Zone IIw. Clay cutans are weak and thin but common in the B2; profile 75/3-53 is representative as a Ferral-humic Acrisol of the catena; for a detailed description and analysical data *see* Appendix 6.

Map Unit $\frac{\text{U3Gby}}{\text{p}}$ — U3Gh

Surface area.—7.820 ha.

Parent material.—various gneisses and quartzites of the Basement System; possibly including some calc-silicate granulites.

Relief.—rolling, usually 15 per cent slopes but particularly to the top of the interfluves only up to 5 per cent slopes; convex slopes of 100-300 m. long are common.

Vegetation and/or Land use.—moist forest, alternating with large areas of open grassland (glades); the latter are used for grazing; parts of the indigenous forest are being cleared for crop production.

Soils.—The soils of this unit are described as an association of:

1. on the upper slopes, well drained, moderately deep to deep, dark reddish brown to yellowish red, friable clay loam to clay; and

2. on the lower slopes, soils of map unit U3Gh.

The characteristics of unit $\frac{\text{U3Gby}}{\text{p}}$ are given below:

Colour.—the A-horizon is dark brown (7.5YR 3/2) or dark reddish brown (5YR 3/3),—of the B-horizon dark reddish brown (5YR 3/3-3/4), occasionally yellowish red (5YR 4/6) or dark red (2.5YR 3/6).

Texture.—sandy clay loam to clay in the A-horizon; clay in the B2 (40-55 per cent clay); the percentage silt varies from 8-24 per cent, soil clay ratios are from 0.2-0.9; gravel may be encountered in the subsoil.

Structure.—moderate to weak, coarse to very coarse subangular with a tendency to porous massive in the subsoil.

Consistence.—friable to firm when moist, slightly sticky and plastic when wet.

Weatherable primary minerals.—many, muscovite and orthoclase.

Clay minerals.—moderately well crystallized kaolinite is the dominant clay mineral.

Cation Exchange Cap. and acidity.—The CEC at pH 7.0 is commonly below 14 me. per cent; calcium and magnesium are dominant on the exchange complex; sum of cations is low (from 1-7 me. per cent in the B). The pH-water is around 5.0 (varies from 4.0-5.5); (very) strongly acid, the pH-KCl is 0.7-1.1 unit lower.

Organic C per cent in the A.—is high (average 3.3, range 2.3-4.1).

Base Saturation per cent.—is below 50 per cent throughout and often below 25 per cent in the B-horizon.

Diagnostic horizons.—an ochric or umbric A overlying a cambic B; occasionally with a tendency to an argillic B.

Remarks.—The unit as a whole occurs in Ecological Zone IIw. Soils of unit U3Gh are usually encountered in the valleys and the lower part of the slopes, while soils of unit $\frac{\text{U3Gby}}{\text{p}}$ occur on the crests and upper slopes.

Profile 75/4-391 is representative for a soil in the latter one; for a detailed description with analytical data, *see* Appendix 6.

U4—Kitale Level (about 1900 m. alt.)

U4U—Soils developed on undifferentiated Basement System Rocks

Map Unit U4Ur

Surface area.—30.980 ha.

Parent material.—fairly rich in quartz and potassium feldspars with varying amounts of ferromagnesian minerals.

Relief.—generally gently undulating (2-5 per cent) to undulating (5-8 per cent) terrain with occasionally flatter or steeper parts; long (up to 500 m.) slopes, commonly straight to convex; regular meso-relief.

Vegetation and/or Land use.—the original vegetation of (mainly Acacia spp.) forest has been altered to extensive pastures, while maize cultivation is practised frequently.

Soils.—are predominantly well drained, very deep, strongly weathered, red (-dish) clays with gradual horizonation and A-B-C horizon sequence and very friable to friable consistence.

Colour.—most of the A-horizon is commonly a very dusky red (2.5YR 3/2) but dark reddish brown colours in the 2.5YR and 5YR hue do occur also; with depth chromas become higher in the same hue and often with the same value; thus a dark red colour (2.5YR 3/6) is common in the B, sometimes yellowish red (5YR 4/6).

Texture.—clay to sandy clay in the A-horizon (range 40-60 per cent clay; average 53 per cent); the B-horizon has exclusively a clay texture (range 52-72 per cent; average 60 per cent clay). The silt percentage is low, varying from 4-20 per cent. Silt/clay ratios range from 0.07-0.66.

Structure.—in the topsoil weak to moderate, fine to medium subangular blocky; with depth structure development decreases and porous massive is common.

Consistence.—slightly hard to hard when dry; friable when moist and sticky and plastic when wet.

Weatherable primary minerals.—dominantly biotite and muscovite in varying amounts but usually common (8-20 per cent).

Clay minerals.—kaolinite is the dominant clay mineral; crystallinity varies; illite occurs in subordinate amounts.

Cation Exchange Cap. and acidity.—the CEC at pH 7.0 varies from 7-14 me. per cent; the sum of exchangeable cations is low (commonly from 4-10 me. per cent), calcium is dominant, followed by Mg although occasionally Mg is higher; exchangeable Na is low to very low.

The pH-H_2O varies from 4.9-6.1 indicating very strongly to medium acid conditions. The pH-KC1 is 0.4-0.9 unit lower.

Organic C per cent in the A.—varies from 1.1-4.1 per cent C; average 2.1 per cent C.

Base Saturation per cent.—39-73 per cent in the A; 20-69 per cent in the B; mean 48 per cent.

Diagnostic horizons.—ochric to umbric B overlying an oxic B.

Remarks.—This map unit falls in Ecological Zone III; for soil description and analytical data, *see* profile No. 75/3-2, Appendix 6.

Map Unit U4Ub

Surface area.—5.860 ha.

Parent material.—as for U4Ur.

Relief.—gently undulating to undulating topography prevails (2-8 per cent), occasionally rolling (8-16 per cent slope); convex slopes of 100-800 m. long are dominant; meso-relief is regular; termite mounds may cause irregular micro-relief.

Vegetation and/or Land use.—moist Combretum woodland and glades; often altered to productive pasture utilized for intensive grazing. Some areas are under maize cultivation, occasionally sunflower.

Soils.—are mainly well drained, deep to very deep, permeable, moderately weathered clays with gradual to diffuse horizonation and A-B-C horizon sequence.

Colour.—in the A horizon dark reddish brown (5YR 3/3-3/4) or dark brown (7.5YR 3/2). The chroma increases in the subsoil giving rise to dominantly yellowish red (5YR 4/6-4/8) colours in the B2-horizon, occasionally also dark reddish brown (5YR 3/4).

Texture.—in the A-horizon sandy clay, occasionally sandy clay loam; texture of the B-horizon is clay throughout (range 52-60 per cent; 54 per cent mean). The silt percentage is low, range 2-18 per cent, silt/clay ratios range between 0.1-0.5.

Structure.—in the topsoil weak, fine to medium subangular blocky, tending to become porous massive with depth.

Consistence.—hard when dry, friable to firm when moist and sticky and plastic when wet.

Weatherable primary minerals.—are many (> 20 per cent) mainly biotite and muscovite

Clay minerals.—kaolinite and illite occur, both poorly crystallized.

Cation Exchange Cap. and acidity.—the CEC value ranges from 6-10 me. per cent; sum of cations is low: 2-7 me. per cent; Ca and Mg are dominant. The pH-water ranges from 5.4-6.1 (strongly to medium acid). The pH-KC1 is 0.7-1.0 unit lower; the values change irregularly with depth.

Organic C per cent in the A.—varies from 1.3-1.6 per cent C; average 1.5 per cent.

Base Saturation per cent.—at pH 7.0 is from 41-51 per cent in the A (average 48 per cent) and ranges from 40-68 per cent in the B2.

Diagnostic horizons.—umbric to ochric A overlying an oxic B.

Inclusions.—small areas of moderately deep soils.

Remarks.—this map unit falls into Ecological Zone III; profile 75/3-18 is representative for this unit, for a full description and analytical data *see* Appendix 6.

U5 — Kunyao Level (alt. about 1350 *m.)*

U5F—Soils developed on gneisses rich in ferromagnesian minerals

Map Unit $\frac{\text{U5Frc}}{\text{p}}$

Surface area.—6.650 ha.

Parent material.—gneisses rich in ferromagnesian minerals, mainly hornblende, and biotite; the former may take up 34 per cent.

Relief.—the major part of the land has flat to gently undulating topography (slopes up to 5 per cent); slightly convex to straight slopes from 500-1000 m. are common; termite mounds may cause irregular meso-relief (height 1 m., 5 m. diameter, 100 m. apart).

Vegetation and/or Land use.—Acacia nilotica bushland with Albizia and Commiphora spp.; fair grass cover. Most of this land is utilized for extensive grazing.

Soils.—well drained, moderately deep to deep, fine textured with weak structural development and gradual horizonation.

Colour.—the A-horizon is commonly dark brown (7.5YR 3/2) or dark reddish brown (5YR 3/2-3/5); colours of the B-horizon are redder in the 5YR and 2.5YR hue, thus (dark) reddish brown (5YR 3/4-4/3-4/4) or 2.5YR 3/4 and dark red (2.5YR 3/6).

Texture.—the A-horizon is usually a sandy loam, occasionally sandy clay loam or loamy sand; with depth the clay percentage increases giving rise to (sandy) clay texture, sometimes with gravels. Clay per cent in the B2 is around 40 per cent; the silt percentage varies from 8-15 per cent; silt/clay ratio is from 0.2-0.7. There is little evidence for clay illuviation in thin sections, although field observations may support an argillic horizon concept. Stonelines occur in these soils; if exposed on the surface 3-10 cm. large quartz stones are common.

Structure.—weak, coarse subangular blocky in some occasions, but tend to be massive in most cases.

Consistence.—hard when dry; friable to firm when moist and (slightly) sticky to slightly plastic when wet.

Weatherable primary minerals.—up to 7 per cent, mainly biotite and muscovite.

Clay minerals.—illite constitutes about 50-55 per cent of the clay fraction, followed by kaolinite (±40 per cent), some montmorillonite may be present.

Cation Exchange Cap. and acidity.—the CEC at pH 7.0 is below 16 me. per cent and ranges from 15.4-16.0 (average 13.0 me. per cent); it varies irregularly with depth; the pH usually increases with depth from 5.5/6.0 to 6.1/7.6, indicating medium acid to neutral soil conditions; magnesium and calcium are the dominant cations followed by K, sodium is very low.

Oorganic C per cent in the A—varies from 0.32-1.18 per cent C (average 0.62 per cent).

Base Saturation per cent.—varies from 50-100 per cent in the B; average for the A-horizon 66 per cent and for the B22 74 per cent.

Diagnostic horizons.—ochric A over argillic B.

Inclusions.—shallow soils of the same unit and black, cracking clay soils.

Remarks.—This unit falls in Ecological Zone IV. Profile No. 75/1-104 is representative; for full description and analytical data, *see* Appendix 6.

U5B—Soils developed on biotite gneisses

Map Unit $\frac{\text{U5Bbc1}}{\text{p}}$

Surface area.—1.780 ha.

Parent material.—dominant are biotite gneisses; a volumetric model of the constituents reads as follows: oligoclase ($NAlSi_3O8$) . . . 40 per cent; quartz (SiO_2) . . . 35 per cent; biotite (K_2 $(MgFe)_6$ Si_6 Al_2) . . . 10 per cent.

Relief.—flat to very gently undulating (0-2 per cent); termite mounds (1-2 m. high; 100-200 m. apart) may cause irregular meso-relief.

Vegetation and/or Land use.—open bushland of mainly Acacia spp. (A. nilotica) with fair to sparse grass cover; extensive grazing is common.

Soils.—well drained, moderately deep to deep, fine textured soils overlying stonelines, petroplinthite (murram) or rock. Structural development is weak, horizonation is gradual (A-B-C profile morphology).

Colour.—the A-horizon is dark brown (7.5YR 3/2); the B-horizon is brown (7.5YR 4/4) to reddish brown (5YR 4/4).

Texture.—the A-horizon is sandy loam, occasionally loamy sand overlying a (sandy) clay (loam). Quartz stonelines are encountered at varying depth. The presence of these causes varying stoniness in the soil and on the surface. Petroplinthite or rock is commonly found underlying the soil material.

Consistence.—hard when dry; firm to friable when moist and slightly sticky and slightly plastic when wet.

Weatherable primary minerals.—common, mainly biotite.

Clay minerals.—kaolinite, some illite and occasionally intergrades.

Diagnostic horizons.—ochric A over argillic B.

Inclusions.—shallow and stony soils, and soils with soft plinthite transitional to R-horizon; occasionally horizons with secondary lime enrichment occurs.

Remarks.—this unit falls in Ecological Zone IV.

Map Unit U5Bbc 2

Surface area.—2.480 ha.

Parent material.—as for $\frac{\text{U5Bbc1}}{\text{p}}$.

Relief.—flat to gently undulating (up to 5 per cent); slightly convex to straight slopes of 100-500 m. are common; regular meso-relief; occasional scattered termite mounds.

Vegetation and/or Land use.—Acacia nilotica bushland and some dry Combretum woodland; poor to fair grass cover; most of this land is utilized for extensive grazing.

Soils.—well drained to moderately well drained, deep to very deep, fine textured soils with varying structural development and gradual horizonation.

Colour.—the A-horizon is dark brown (7.5YR 3/2) or very dark greyish brown (10YR 3/2); the dominant colour in the B is brown (10YR or 7.5YR hue) or a reddish brown in the 5YR hue; red mottles may be encountered from 70 cm. onwards.

Texture.—the A-horizon is sandy loam, occasionally sandy clay loam or loamy sand; with depth the texture becomes finer and sandy clay is common in the B2. In some cases clay skins are observed in the field supporting an argillic horizon idea. An absolute increase in clay from B1-B2 of 10-16 per cent is common; silt percentage varies from 6-16 per cent silt/clay ratios are from 0.2-0.9.

Structure.—weak to moderate, coarse to very coarse (sub-) angular blocky; occasionally massive.

Consistence.—slightly hard to hard when dry; firm to friable when moist and (slightly) sticky to slightly plastic when wet.

Weatherable primary minerals.—few (up to 7 per cent), mainly biotite, some muscovite.

Clay minerals.—(moderately) well crystallized illite followed by kaolinite (resp. about 55 and 45 per cent).

Cation Exchange Cap. and acidity.—the CEC at pH 7.0 varies from 5-14 me. per cent; normally increasing with depth; lowest average in the B2 is 10 me. per cent; magnesium and calcium are the dominant cations; exchangeable K is low and Na very low; the pH commonly increases with depth from 5.0-7.7 (medium acid to mildly alkaline). The sum of cations ranges from 2-8 me. per cent.

Organic C per cent in the A.—varies from 0.62-0.84 (average 0.71 per cent C).

Base Saturation per cent.—in the A-horizon ranges from 49-59 per cent (average 54 per cent) and varies in the B2 from 32-51 per cent.

Diagnostic horizons.—ochric A over argillic B.

Inclusions.—shallow, stony soils; at the foot of the mountains and along the Kaiboni river, soils with heavy clay at depth often separated by plinthite are included.

Remarks.—sheet and rill erosion has caused the destruction of the epipedon. This unit falls in Ecological Zone IV; profile 75/1-57 is representative for this unit, for a full description and analytical data, *see* Appendix 6.

U5G — Soils developed on various gneisses

Map Unit — U5GC

Surface area.—15.320 ha.

Parent material.—various gneisses.

Relief.—gently undulating to rolling topography (2-16 per cent); the former, west of Kaiboni river, the latter, east and west of the line Chepareria—Chepkobeh.

Vegetation and/or Land use.—Acacia nilotica bushland; varying bush and grass cover, in many areas bare soil surface; most of this land is utilized for extensive grazing.

Soils.—mostly truncated and of varying depth, depending on the erosion intensity.

In 30-50 per cent of the area soils are moderately deep; in 35-75 per cent of the area soils are shallow and in 15-25 per cent of the area soils are very shallow.

Drainage is (moderately) well; surface sealing is common.

Colour.—dark brown (7.5YR 3/2) or very dark greyish brown (10YR 3/2) often becoming brown (in the 7.5YR and 10YR hue) with depth.

Texture.—sandy clay loams common, but loamy sands and clays occur; concretions of lime and Fe + Mg may be found in addition to mainly quartzitic gravel.

Structure.—is weak to absent.

Consistence.—hard when dry; firm when moist; slightly sticky to non-plastic when wet.

Diagnostic horizons.—ochric A over cambic B.

Inclusions.—at the foot of slopes some deeper soils may be found; due to the overbearing influence of erosional processes in this map unit, the soils pattern is complex and occurs mainly in erosional valleys commonly ± 500 m. wide and 5-15 m. deep.

Remarks.—this unit falls in Ecological Zone IV.

U6—Wei-Wei Level (alt. about 1050 m.)

U6G — Soils developed on various gneisses and quartzites

Map Unit $\frac{\text{U6Gbc}}{\text{p}}$

Surface area.—460 ha.

Parent material.—rich in silica, low in base metal cations.

Relief.—gently undulating (2-5 per cent slopes); irregular meso-relief due to the presence of many gullies, which are up to 5 m. deep and up to 15 m. wide.

Vegetation and/or Land use.—Acacia reficiens bushland, utilized for grazing.

Soils.—well drained to moderately well drained, moderately deep to deep, fine textured; with gradual horizonation and A-B-C profile morphology.

Colour.—the A-horizon is dark reddish brown (5YR 3/3) to dark brown (7.5YR 3/2); yellowish red (5YR 4/6) colour in the B-horizon is common.

Texture.—the topsoil has a sandy clay loam texture while in the B-horizons clay textures are common; occasionally gravelly sandy clay at the transition to the bedrock; stonelines may occur.

Structure.—weakly developed to massive.

Consistence.—slightly hard when dry, friable when moist and slightly sticky and slightly plastic when wet.

Weatherable primary minerals.—common, mainly hornblende and muscovite.

Clay minerals.—kaolinite and illite are anticipated in about equal amounts.

Cation Exchange Cap. and acidity.—the CEC at pH 7.0 varies from 8-10 me. per cent; Ca and Mg are dominant; the sum of cations varies from 5.2-7.5; the pH indicates slightly acid to neutral conditions (5.7-6.9); the pH KC1 is 0.9-1.0 unit lower.

Organic C per cent in the A.—0.44 per cent C (on one sample); decreases with depth.

Base Saturation per cent.—varies from 52-85 per cent.

Diagnostic horizons.—ochric A over cambic B.

Inclusions.—small areas of deep and shallow soils and rock outcrops.

Remarks.— this unit falls into Ecological Zone IV; a representative profile 75/2-540; is described in Appendix 6, a Cambisol with ferralic diagnostic properties.

U7 — Undifferentiated Levels

U7B — Soils developed on predominantly biotite gneisses

Map Unit $\frac{\text{U7Bbc}}{\text{p}}$

Surface area.—9.880 ha.

Parent material.—mainly biotite gneisses, composed out of 40 per cent oligoclase, 35 per cent quartz and 10 per cent biotite.

Relief.—varying topography, ranging from gently undulating to hilly; most of the unit occurs in rolling to hilly terrain (8-30 per cent); convex slopes common, length from 50 m. up to 500 m.

Vegetation and/or Land use.—grassland, utilized for extensive grazing.

Soils.—well drained, moderately deep to deep brownish soils, medium to fine textured with an A-B-C profile morphology, gradual to diffuse horizonation and weak to no structure development.

Colour.—the A-horizon is very dark greyish brown (10YR 3/2) or dark brown (7.5YR 3/2); but black (10YR 2/1) or brown (7.5YR 4/4 or 10YR 4/3) colours do occur also; the B-horizon is brown (7.5YR 4/4) or dark yellowish brown (10YR 4/4); occasionally dark reddish brown (5YR 3/3-3/4).

Texture.—light sandy clay loam in the A-horizon gradually changing to a heavy sandy clay loam with depth, (clay skins common in the B2), around 35 per cent clay in the B2.

Structure.—usually massive, sometimes weak, coarse subangular blocky.

Consistence.—hard to very hard when dry, (very) friable when moist, and (slightly) sticky and (slightly) plastic when wet.

Weatherable primary minerals.—many; biotite and muscovite.

Clay minerals.—kaolinite is dominant, illite is subordinate and vermiculite and gibbsite occur as traces.

Cation Exchange Cap. and acidity.—the CEC at pH 7.0 ranges from 7-14 me. per cent in the B; calcium and magnesium are dominant; sum of cations is low (from 5-8 me. per cent). The pH-H_2O varies from 5.2-6.2 (medium to slightly acid); the pH KC1 is 0.5-1.2 unit lower.

Organic C per cent in the A.—ranges from 0.9-2.2 per cent C.

Base Saturation per cent.—is below 50 per cent in the topsoil, but more than 50 per cent in the B2.

Diagnostic horizons.—ochric A over argillic B.

Remarks.—slight sheet erosion is observed on cultivated areas; about 60 per cent of this unit falls in Ecological Zone III, 30 per cent in Ecological Zone III-IV and the remaining in Zone IIw. Profile 75/1-60 is representative for this unit, for profile description and analytical data, *see* Appendix 6.

Map Unit $\frac{\text{U7Bbc}}{\text{P}}$

Surface area.—1.280 ha.

Parent material.—rich in quartz, Na-Al silicates and some biotite which constitutes constitutes of K (Mg, Fe) Al silicate.

Relief.—common rolling topography (10-16 per cent slopes), occasionally hilly; irregular meso-relief.

Vegetation and/or Land use.—(wooded) bushland of Acacia spp. and Albizia; fair to good grass cover; land is utilized for grazing.

Soils.—well drained, shallow to moderately deep, sandy clay; often gravelly and/or rocky.

Color.—the A-horizon is very dark greyish brown (10YR 3/2) and the B horizon is (dark) brown to dark yellowish brown (7.5YR 4/4-10YR 4/4).

Texture.—sandy (clay) loam overlying a sandy clay.

Consistence.—hard when dry, firm when moist.

Diagnostic horizons.—ochric A over cambic B.

Remarks—this unit falls in Ecological Zone IV.

Map Unit $\frac{U7Bb}{P} - \frac{U7Bbc}{p}$

Surface area: 520ha.

Parent Material.—as for $\frac{U7Bbc}{p}$.

Relief.—undulating to rolling topography (5-16 per cent); slightly convex to straight slopes of up to 400 m.; irregular meso-relief due to termite mounds (1 m. high, 1-2 m. in diam., and 75-100 m. apart).

Vegetation and/or Land use.—Undifferentiated bushland with fair grass cover, almost exclusively utilized for grazing.

Soils.—a complex consisting of

1. soils of Unit $\frac{U7Bbc}{p}$ and
2. well drained, very shallow to shallow, brownish, stony and rocky, sandy loam to sandy clay.

Profile development on the whole is not very marked, while structural development is weak to absent.

Colour.—the A-horizon is brown to dark brown (7.5YR 3/3) or brown (7.5YR 4/4).

Texture.—varies considerably from sandy loam to sandy clay; seems however predominantly a sandy clay loam; shallow soils are coarser in texture than deeper ones and also contain a large amount of coarse fragments of rock.

Consistence.—(slightly) hard when dry, friable when moist and slightly sticky and slightly plastic when wet.

Cation Exchange Cap. and acidity.—the CEC at pH 7.0 is from 13-15 me. per cent in the B, sum of cations is from 5-8 me. per cent; Ca and Mg are dominant.

Organic C per cent in the A.—high (2.23 per cent), but decreases sharply with depth.

Base Saturation per cent.—varies between 38 per cent in the A1 and 57 per cent in the B2.

Diagnostic horizons.—ochric or umbric A over a cambic B.

Remarks.—This unit falls in Ecological Zone IV; the moderately deep phase is described in profile 75/2-488, *see* for description and analytical data, Appendix 6.

U7F—Soil developed on gneisses rich in ferromagnesian minerals

Map Unit $\frac{U7Fr}{P}$

Surface area.—1.190 ha.

Parent material.—gneisses rich in hornblende and biotite supplying the bulk of the ferromagnesian minerals.

Relief.—undulating to rolling topography (slope gradient from 5-16 per cent), 100-600 m. long, convex to straight slopes; with commonly irregular meso-relief.

Vegetation and/or Land use.—Combretum-Euphorbia woodland and Croton bushland with varying amount of surface cover; ranging from bare ground to fair grass growth.

Soils.—have been and are subject to severe erosion, resulting in numerous truncated soils of shallow to very shallow depth, bedrock exposures and considerable amount of coarse fragments on the soil.

Colour.—usually brown (7.5YR 4/4) or reddish brown (5YR 4/4) in the "A" and the B.

Texture.—the texture in the "A" is commonly a sandy loam to loamy sand with varying amounts of coarse fragments. In the subsoil sandy clay texture is common.

Consistence.—(slightly) hard when dry, firm to friable when moist.

Diagnostic horizons.—an ochric A only.

Remarks.—these soils are similar to those in map unit MG and HG, over large areas the C-horizon is thick (up to 150 cm.); this map unit falls in Ecological Zone IV.

Map Unit $\frac{\text{U7Fr}}{\text{P}}$ — $\frac{\text{U7Frc}}{\text{p}}$

Surface area.—2.660 ha.

Parent material.—as for the previous unit.

Relief.—undulating to rolling (5-16 per cent).

Vegetation and/or Land use.—as for previous unit.

Soils.—are similar to those of unit $\frac{\text{U7Fr}}{\text{P}}$, but the moderately deep phase may occur. These soils are slightly stony and non-rocky and have a reddish (5YR 4/3) or dark red (2.5YR 3/6) colour, a sandy clay to clay texture and a firm consistence when moist. Much mica is encountered, while the structure is moderate to weak, medium subangular blocky; few, thin clay cutans may be encountered in the B2.

Diagnostic horizons.—ochric A over cambic B or argillic B or an ochric A only.

Inclusions.—patches of deep soils mainly in the valley bottoms.

Remarks.—approximately 20 per cent of this unit occurs in Ecological Zone III-IV, the remaining part falls into Zone IV.

Y — Piedmont Plains

YG — Soils developed on alluvium predominantly derived from various gneisses.

Map Unit — YGbc1

Surface area.—2.490 ha.

Parent material.—alluvium derived from various gneisses.

Relief.—flat to gently undulating (up to 5 per cent slope); straight to slightly convex slopes of up to 400 m. are common; regular meso-relief.

Vegetation and/or Land use.—Acacia seyal bushland and Acacia woodland with about 30 per cent ground coverage of herbs and grasses; extensive grazing is practised, while occasionally maize and/or millet are cultivated.

Soils.—well drained, deep fairly compact, sandy clay to clay with gradual horizonation and A-B-C profile morphology.

Colour.—the A-horizon is a dark reddish
(10YR 3/3); dry colours usually o
tend to be slightly higher in chrom
(5YR 3/4).

Texture.—the epipedon texture is varia
with depth a sandy clay texture is c
occur also. The silt percentage is
ratios are usually from 0.2-0.5; c
support an argillic horizon concept.

Structure.—strong, coarse (sub-) angula
structure; massive occurs also.

Consistence.—hard to very hard when
sticky and plastic when wet.

Weatherable primary minerals.—common,

Clay minerals.—moderately well crystallized
amounts of kaolinite; occasionally interst
and vermiculite type occur; sometimes
amorphous material.

Cation Exchange Cap. and acidity.—the C
per cent; and differs considerably from
and Mg are the dominant exchangeable
in the subsoil; the sum of cations is fro
7.0, but may be somewhat lower in the A

Organic C per cent in the A.—varies from 0
the percentage sharply decreases with de

Base Saturation per cent.—at pH 7.0 is arou
to 75-95 per cent in the B2.

Diagnostic horizons.—ochric A over argillic

Inclusions.—in the north-eastern part close to

Remarks.—this unit occurs in Ecological Zo
for this map unit, for a detailed descrip
6. This Luvisol has some vertic propertie

Map Unit YGbc2

Surface area.—200 ha.

Parent material.—as for YGbc1.

Relief.—flat to very gently undulating (up to 2 pe
slightly convex).

Vegetation and/or Land use.—Acacia seyal

Soils.—well drained to moderately well drai
in the subsoils; slightly to moderately alk

Colour.—in the A-horizon dark brow
brown (10YR 3/3) or dark reddish

Texture.—clay throughout (52-56 per ce

Structure.—strong coarse angular bloc
latter determined by cracks up to

brown (5YR 3/2-3/3) to dark brown
value unit higher; colours in the B
and are usually dark reddish brown

le (loams, sandy clay loams, clays);
nmon, but sandy clay loams or clays
ariable (4-40 per cent silt); silt/clay
y skins observed in the field may

blocky with a tendency to prismatic

y, firm to very firm when moist and

ainly muscovite and biotite.

lite is dominant, followed by varying
tified minerals of the montmorillonite
the clay fraction consists largely of

C at pH 7.0 varies from 6-24 me.
one sampled profile to the other. Ca
tions, exchangeable Na may exceed K
3-23 me. per cent; the pH is around

-1.0 per cent; average 0.7 per cent C;
h.

d 50 per cent in the A and increases

he Wei-Wei river, soils of Unit $\frac{\text{U6Gbc}}{\text{p}}$

IV; profile 75/2-539 is representative
on and analytical data, *see* Appendix

cent slope; regular slopes, occasionally

ushland utilized for extensive grazing.

d, deep, fine textured with carbonates
line.

(10YR 3/3), in the B-horizon dark
rown (5YR 3/3).

); silt/clay ratio: 0.2.

y with a tendency to prismatic; the
5 cm. wide at a depth of 40 cm.

Consistence.—hard to very hard when dry; very firm when moist and sticky and plastic when wet.

Weatherable primary minerals.—traces of muscovite.

Clay minerals.—kaolinite and illite with vermiculite are anticipated.

Cation Exchange Cap. and acidity.—the CEC in the A may be 17 me. per cent increasing to 22 me. per cent in the C; the pH-water increases with depth from neutral (pH 6.8) to strongly alkaline (pH 8.5). Ca, Mg are the dominant exchangeable cations, followed by Na. The ESP is 5.7-8.8 within 100 cm. depth. The sum of cations varies from 23-30 me. per cent.

Organic C per cent in the A.—0.7 per cent decreasing to 0.2 per cent C with depth.

Base saturation per cent.—high throughout (89-100 per cent).

Diagnostic horizons.—ochric A over vertic B.

Remarks.—the occurrence of slickensides is common; this map unit occurs in Ecological Zone V. For a description of a representative profile with analytical data, *see* Appendix 6; profile No. 75/2-542.

A — River Terraces and Flood-Plains

Soils developed on sub-recent and recent alluvial deposits

Map Unit Agc

Surface area.—1.620 ha.

Parent material.—clayey alluvial sediments.

Relief.—on low terrace with flat to very gently undulating topography with irregular microrelief (humps of 30/40 cm.).

Vegetation and/or Land use.—vlei grassland, along streams occasional riverine forest; most of this area is utilized for grazing; lower lands may experience occasional flooding.

Soils.—moderately well to poorly drained, very deep, mottled, fine textured soils with an A_1-A_2-B-C profile development; stratification of the soil material due to sedimentological processes may be evident in the deep subsoil.

Colour.—topsoils usually have dark (reddish) brown colours; with depth reddish brown colours occur, commonly with distinct reddish brown mottles.

Texture.—the very topsoil may be peaty and coarse textured but from 40-100 cm. usually a clay layer is found, resulting in strongly contrasting textures.

Weatherable primary minerals.—are varied in nature as well as in quantity.

Cation Exchange Cap. and acidity.—the pH is strongly acid in the top but normally increases with depth to neutral; the soils are non-calcareous, non-saline and non-alkali; CEC at pH 7.0 is below 24 me. per cent.

Diagnostic horizons.—ochric A overlying a thin albic E, over argillic B.

Remarks.—Soils of this unit are "comparable" to those of unit Vgc. This unit occurs in Ecological Zone III, profile 75/3-5 is representative for this unit, for detailed description and analytical data, *see* Appendix 6.

Map Unit AC

Surface area.—4.270 ha.

Parent material.—alluvial deposits with varying textures, generally medium and fine.

Relief.—commonly flat to almost flat but undulating and occasionally rolling topography occur also.

Vegetation and/or Land use.—Acacia woodland with some Balanites; utilized for grazing and some cultivation of maize.

Soils.—form a complex of stratified and homogeneous soil materials of varying texures, colours, drainage conditions and physiographic positions.

Along the *Kaiboni* river, the *Chesera* river and the *Kenyonga* river three clearly defined terraces occur.

The *highest* terrace is 10.15 m. above the present river bed and covers the largest acreage. The topography is undulating, in places rolling due to the presence of many gullies and valleys. The soils of this terrace consist of mainly well drained, very deep, dark reddish brown (5YR 3/3), micaceous, sandy clay loam to sandy clay. The subsoil contains in many places sandy or gravelly layers and may be slightly calcareous. Obsidian artefacts may be present on this terrace along the Kaiboni river.

The *middle* terrace occurs 4-6 m. above the present river bed and is 100-200 m. wide. The topography is flat to very gently undulating. The soils on this terrace show distinct stratification, individual strata varying in texture from sand to sandy clay. Most soils are well drained, very deep and consist of medium to coarse loamy sand, with finer textured layers interlayering.

Along the Suam river, the largest acreage is taken by the middle terrace (about 90 per cent) of the sub-recent alluvial deposits. The soils are moderately well drained, very deep, very dark brown (10YR 2/2), non-calcareous, non-micaceous and of clay texture. If associated with soils of map unit U5GC, well drained, very deep, sandy soils are encountered.

The *lowest* terrace occurs 1-2 m. above the present river bed and covers only small areas. The soils are well drained, deep, and consist mainly of very micaceous, medium and coarse sand and loamy sand, in places interlayered with sandy clay deposits.

No clear terraces could be recognized in the alluvial deposits of the Wei-Wei, the Morun River and near Sebit.

The topography varies with the absence or presence of erosion gullies. The soils are mainly well drained and very deep. Fine to medium sandy loam to sandy clay is common, alternating with medium to coarse sandy strata, mica is common throughout.

In a river valley west of Chepareria, alluvial soils commonly have a very dark (10YR 2/1) topsoil of sandy loam texture underlain by reddish brown sandy loam to sandy clay (loam). Mica is common throughout the soil.

A generalized picture of the alluvial soils with regard to some of their physical and physical and chemical properties reads as follows:

Colour.—commonly in the 10YR hue with a value between 2 and 5 and chroma from 1-4, occasionally brown or redder colours occur.

Texture.—much variation due to geological processes rather than pedogenesis; clay percentages were found to range from 10-58 per cent clay; also the silt percentage of the soil material appears to fluctuate considerably.

Structure.—(sub-) angular to prismatic structure may be present in the finer textured soils; the coarser soil material tends to be structureless on the whole.

Consistence.—ranges from loose to very hard when dry; very friable to very firm when moist and non-sticky to sticky and non-plastic to plastic when wet.

Weatherable primary minerals.—muscovite is common to abundant in many alluvial soils.

Cation Exchange Cap. and acidity.—the pH-H_2O ranges from 5.9-8.0 but generally is around 6.5-7.5 (neutral). The CEC at pH 7.0 varies from 10-28 me. per cent. Calcium and magnesium are dominant, followed by potassium and sodium.

Organic C per cent in the A.—the value ranges from 0.7-2.6; average over the top 20 cm.: 1.4 per cent C.

Base saturation per cent.—is above 50 throughout and varies from 57-100 per cent in the A11 with an average of 81 per cent in the top 100 cm.

Diagnostic horizon.—ochric or mollic A over subsoils of varying nature.

Remarks.—about 85 per cent of this unit occurs in Ecological Zone IV; the remaining part in Ecological Zone III-IV; profile 75/1-507 is representative for a majority of soils, for a detailed description with analytical data *see* Appendix 6.

V—Minor Valleys and Bottomlands

Soils developed on various parent materials

Map Unit Vgc

Surface area.—1.650 ha.

Parent material.—clayey alluvial deposits.

Relief.—flat to very gently undulating topography (0-5 per cent) prevails; commonly 1-2 per cent slopes. Termite mounds are common (0.5-1 m. high, 1-2 m. in diameter; 10-60 m. apart); most of these areas are subject to ponding during rains and thereafter.

Vegetation and/or Land use.—vlei grassland of mainly Hyperhenia, Sporobolus and Sorghum; occasionally mixed with Acacia shrub; mainly used for grazing. On the higher, drier areas, some cultivation is practised.

Soils.—imperfectly to poorly drained, very deep, mottled, fine textured, in places calcareous and alkali in the subsoil.

Colour.—a very dark grey (10YR 3/1) colour is common in the topsoil; occasionally 7.5YR or 5YR hue. With depth the value increases with 2 units or more but the chroma remains the same or increases with 1 unit. (Dark) greyish brown (10YR 5/2-4/2) is common. Yellowish red to reddish brown mottles are common from 14 cm. onwards.

Texture.—of the top 20 cm. varies from sandy clay loam to clay (32-48 per cent); with depth textures become finer and sandy clay or clay is common (40-64 per cent clay); the percentage silt is variable (2-20 per cent); average for the whole soil: 12 per cent. Silt/clay ratios vary accordingly.

Structure.—moderate to strong, medium to coarse (sub-) angular blocky in the topsoil, changing to massive or prism-like or platy structures in the subsoil; slickensides and pressure faces may be present in vertic soil material.

Consistence.—very hard when dry; very firm to very friable when moist and slightly sticky to very sticky and slightly plastic to very plastic when wet.

Weatherable primary minerals.—common to many; mainly muscovite and biotite.

Clay minerals.—well crystallized montmorillonite as well as very well crystallized kaolinite depending on the source of the parent material; some illite may be present too.

Cation Exchange Cap. and acidity.—the CEC is variable and may be below 16 me. per cent but also from 35-45 me. per cent; calcium and magnesium are dominant exchangeable cations; ESP values may be as high as 14 in some soils; the pH-H_2O usually increases with depth from acid conditions to moderately alkaline.

Organic C per cent in the A.—varies from 1.6-2.2 per cent C; average 1.8 per cent C.

Base Saturation.—approximately 55 per cent in the A; normally increasing with depth to values from 80-100 per cent.

Diagnostic horizons.—ochric-mollic A overlying a gleyed horizon, often cambic.

Remarks.—about 80 per cent of this unit falls in Ecological Zone III, the remaining part occurs in Zone IIw. Profile 75/3-3 is described fully in Appendix 6.

Map Unit Vo.

Surface area.—620 ha.

Parent material.—various colluvia from the Basement System.

Relief.—local depressional areas, mainly encountered on the high levels of the Cherangani Hills.

Vegetation and/or Land use.—moorland and montane shrubland; used for extensive grazing of livestock.

Soils.—very poorly drained, deep, acid peat and/or muck; in places over peaty or mucky clay.

Colour.—the deep organic A is black (10YR 2/1) in colour; underlying clay may be very dark grey (10YR 3/1) or olive brown (2.5Y 4/4) to black (N2.5).

Texture.—clay.

Organic matter per cent.—varies from 0.3-2.1 from 0-50 cm.; average 1.05 per cent.

Diagnostic horizon.—histic H-horizon.

Remarks.—this unit occurs on the Kapsait and Sondang levels of the Cherangani Hills; it is confined to small depressions varying in size from 1 to 20 ha. The majority of this unit occurs in Ecological Zone IIc.

Map Unit VC

Surface area.—10.150 ha.

Parent material.—mainly colluvium-alluvium derived from Basement System rocks.

Relief.—varies from almost flat valley bottom to rolling terrain.

Vegetation and/or Land use.—vlei grassland and cultivated areas; maize cultivation is on the increase, but bananas, sugarcane and napier grass are also cultivated.

Soils.—form an association ranging from peat to very poorly drained, deep mottled gley soils often with a humic epipedon. Soils of this unit occur on the Kitale level along minor river valleys with or without flowing water. On the valley bottom, soils are usually peat with very poorly drained, deep, mottled, very dark grey (10YR 3/1) to dark greyish brown (10YR 4/1-4/2) clay. On the valley sides these soils are associated with units U4Ur and U4Ub, the latter commonly having a 20-40 cm. thick humic topsoil in the transitional zone.

Some of the variations in physical and chemical properties are given below:

Colour.—black to very dark grey (10YR 2/-3/1) but also dark (reddish) brown (7.5YR 3/2, 5YR 3/2-3/3) colours occur; in the subsoil dark grey in the 10YR and 7.5YR hue is common, but dark reddish brown colour (5YR 3/3, 3/4), occasionally in the 2.5YR hue, is observed also. Yellowish red to dark red mottles may occur from 25 cm. onwards.

Texture.—usually clay throughout (up to 72 per cent).

Structure.—weak to moderate, fine to medium prismatic, crumb and platy structures are reported; in addition to massive.

Consistence.—firm when moist, sticky and plastic when wet.

Weatherable primary minerals.—common to many, mainly muscovite.

Cation Exchange Cap. and acidity.—the CEC at pH 7.0 in one soil was found to be around 35 me. per cent throughout; Ca and Mg are dominant; the pH-H_2O was 5.2 (strongly acid) in the A, increasing to 6.3 (slightly acid) in the B3.

Organic C per cent in the A.—may be as high as 6.0 per cent C.

Base Saturation per cent.—varies from 65-88 per cent.

Diagnostic horizons.—mollic A over cambic B or oxic B.

Remarks.—this map unit occurs in Ecological Zone III. Profile 75/3-11 is representative for valley bottom soils, that have a mollic A overlying a gleyed B horizon, for a detailed description with analytical data *see* Appendix 6.

3.4. Soil Classification, Correlation and Genesis Aspects

3.4.1. Introduction

For the accommodation of the soils encountered in the survey area into an internationally recognized framework of classification, the FAO-UNESCO legend for the Soil-Map-of-the-World Project was applied as a system of reference (*see* the Kindaruma report, ref. van de Weg and Mbuvi, 1975, for further considerations on this choice of reference system). 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 Kapenguria area the following major classification units are recognized: *Ferralsols, Acrisols, Luvisols, Phaeozems, Kastanozems, Planosols, Vertisols, Gleysols, Histosols,* and *Regosols and Lithosols*. This sequence reflects partly a trend in profile development, i.e. old to young or chemically poor to rich. The following short description of these soils should be read together with Appendix 5, "Soil profile characteristics significant for soil classification", in which also a classification according to the U.S. "Soil Taxonomy" system is given (Soil Survey Staff, 1975). For a comprehensive description of all soils in the FAO/UNESCO legend, and the definition of the diagnostic horizons involved reference is made to Dudal, 1974.

3.4.2 The Major Classification Units

(*a*) *Ferralsols*

These are very strongly weathered and leached soils with a low chemical fertility (*see* 3.5) but relatively good physical properties. They have ABC sequence of horizons with an ochric or mollic A-horizon and a gradual transition to a B-horizon. The CEC-clay* of the latter is less than 16 me. per 100 gram/clay, the silicate clay minerals are predominantly of the kaolinitic type and the silt/clay ratio† is normally about 0.2 or less. Subangular blocky to porous massive structures are common and the structure stability is high.

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* CEC-NH_4OAc at pH 7, calculated on the clay percentage after subtraction of the activity of the organic matter. The latter was assumed to be 3.5 me. CEC per 1 per cent C. In case the percentage C of the B-horizon was not determined, it was assumed to be 0.5 per cent.

† All laboratory data relating to silt and clay percentages concern their determination with the "hydrometer" method (*see* 2.3), which has only limited pre-treatment to dissolve cementing agents. For the more weathered soils, therefore, the total clay percentage may be slightly higher—and the silt content lower—than indicated. The actual degree of difference between "hydrometer" clay and "total" clay can be compared from the laboratory analysis data of representative profiles as given in Appendix 6.

There is little textural differentiation in the profile, there are no signs of clay illuviation and the content of weatherable minerals is low. In the survey area two subunits occur, the *rhodic* (dark red) ones and the *orthic* ("brown") ones. For the rhodic ones many profiles were described and analysed (soil mapping unit U4Ur). They fit the official definition of an oxic B-horizon fairly well, except for the primary mineral content which — judging from 1 profile only — is still quite high. The orthic ones as distinguished in the field (soil mapping unit U4Ub), have turned out to be less clearly ferralitic in their clay mineralogy and structure stability a.o., a phenomenon also observed in the Kindaruma area.

(*b*) *Acrisols*

These are strongly weathered and strongly leached soils with 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 50 per cent. An argillic B-horizon is characterized by signs of clay illuviation from the A-horizon. For a full discussion on the characteristics of the argillic horizon, and the limited merit of the base saturation criterion *see* the Kindaruma report (loc. cit.)

In the survey area one regular subunit has been identified, the *orthic* one, i.e. the "brown" one or the type without any of the specific features characteristic for the other subunits. The textural differentiation in the soils concerned (soil mapping unit U5Bbc2) is however not so strong that one can speak of a "sandy" topsoil. Related to this is a relatively strong surface sealing.

There are also *humic* Acrisols in the survey area (i.e. having an umbric topsoil, relatively rich in acid organic matter) but they tend towards the (ferralic) Cambisols as indicated by their high silt percentage and relatively high percentage of weatherable primary minerals (soil mapping unit U3Gh). In striking contrast to the situation in the Kindaruma area there are only few soils that can be said to be intergrading between Acrisols and Ferralsols (low CEC-clay, few of the characteristics of an argillic B, but relatively compact and liable to sealing). Only soil mapping units U3GC1 and U3GC2 are considered to be intergrades: *Ferral-chromic / orthic / humic Acrisols*.

(*c*) *Luvisols*

These are moderately weathered mineral soils with ABC sequence of horizons. An ochric or umbric A-horizon overlies an argillic B-horizon that has consistently a base saturation above 50 per cent. Several subunits are found in the survey area, e.g. the *orthic* and the *chromic* ones. In both cases the textural differentiation is however not strong as encountered, i.e. there is no "sandy topsoil" with accompanying easy infiltration / low susceptibility to sealing. The *orthic* (brown) ones, soil mapping unit U7Bbc, are the "normal" Luvisols, i.e. those without any of the specific features characteristic for other subunits. The *chromic* (red) ones, soil mapping units U5Frc and FGrcE, have a reddish colour, hues being redder than 5YR*.

A special subdivision, *Verti-chromic Luvisols* was devised for those chromic ones that are quite rich chemically, as shown in the field by some vertic properties like prismatic structures, some slickensides and some cracking (soil mapping unit YGbcl).

(*d*) *Cambisols*

These are "young" and little weathered soils. They have an A(B)C sequence of horizons, but the B-horizon has not developed into a recognizable argillic one. There are many weatherable primary minerals in this horizon, the structure is subangular blocky or weakly coherent massive, the consistence often friable and the horizon transitions are gradual. Cambisols are frequent in Kapenguria area. The following subunits were encountered: *dystric, eutric*

* The FAO legend gives in fact a hue redder than 7.5YR, or 7.5YR with chroma more than 4. For Kenyan circumstances this seems however impractical.

(*cumulo*) *humic* and *chromic*.

The *humic* ones (soil mapping units HGh1, UlGh, U2Gh1) have an "umbric" A-horizon, i.e. a horizon which is relatively high in organic matter of acid character. When thick (more than 25 cm.) this horizon may even directly overlie the C-horizon. In fact, in some cases (soil mapping unit: U2Gh2) the A-horizon is so deep and outspokenly rich in organic matter that the prefix *cumulo* was added. The *dystric* Cambisols (soil mapping units U2Gry, part of U3Gby + U3Gh) have no "umbric" A-horizon but have a base saturation of less than 50 per cent in at least some part of the B-horizon. The *chromic* Cambisols and *eutric* Cambisols have no "umbric" A-horizon but a base saturation consistently above 50 per cent in the B-horizon. The chromic ones (soil mapping unit MFry, part of MFC) are reddish, i.e. with a hue redder than 5YR*; the eutric ones (soil mapping units FGby and FGbys) non-reddish.

Besides the Cambisols there are several soils in the area that are intergrading to Luvisols, Acrisols and even Ferralsols. The *chromic Luvisols to Cambisols* (soil mapping unit FGrc) are about intermediate between chromic Cambisol and chromic Luvisol, having a tendency to the development of an argillic B together with high base saturation and relatively high CEC. The *humic Acrisols to Cambisols* (soil mapping unit U3Gh) have an "umbric" A-horizon combined with a tendency to the development of an argillic B that has however low base saturation and low CEC. The *ferralic Cambisols* (soil mapping unit U6Gbc) are intergrading to *Ferralsols*, having a particularly low CEC, but still an appreciable amount of weatherable primary minerals. There is substantial profile development but structural development in the B-horizon is weak and clay skins are absent. Apparently this horizon has largely passed the stage of argillic†.

(*e*) *Phaeozems* (prairie soils)

These are relatively rich soils with a "mollic" A-horizon, i.e. a dark topsoil that is relatively high in organic matter and non-acid (base saturation clearly above 50 per cent). They usually have an ABC sequence of horizons.

The Phaeozems proper in the survey area are *luvic*, i.e. they have also an argillic B-horizon (soil mapping unit HGh2).

There are also soils (soil mapping unit MGh) that have a dark topsoil with a base saturation little or not above 50 per cent, while the CEC-clay is relatively low and an argillic horizon is lacking. These have been classified as *haplic Phaeozems to humic Cambisols*.

(*f*) *Kastanozems* (chestnut soils)

These are relatively rich soils with a less dark topsoil than the Phaeozems which is, however, still relatively rich in non-acid organic matter. They moreover have a concentration of free lime (or gypsum) below the topsoil. Only one soil unit of this kind was found in the the area, (part of soil mapping unit HLC). It was provisionally named *haplic* because of the absence of either a properly calcic, gypsic or argillic horizon below the topsoil.

(*g*) *Planosols*

These are imperfectly drained soils with a pronounced and abrupt transition between a relatively light textured topsoil, part of which is whitish ("albic" or E-horizon), and a heavy textured, compact and hard B-horizon. In the survey area these soils are of limited occurrence, and the three sampled soil profiles happen to be hardly representative either because their horizon sequence is disturbed by plowing or because they occur at the edge of the soil mapping unit. They are put with the *eutric* subunit, because the base saturation in the B-horizon is consistently above the 50 per cent.

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* *see* footnote under Luvisols.

† According to the FAO legend also part of the dystric Cambisols of the area might be put in the ferralic ones, but they do not have substantial textural differentiation, hence it seems that they have not yet reached the stage of argillic.

(h) *Vertisols*

These are imperfectly drained, dark, cracking clay soils lacking distinct horizons in their profile. This is related to a process of churning (self-mulching) due to their capacity to expand and contract with changes in moisture content. Clay minerals are of the montmorillonite type. In the survey area these soils only occur in the extreme north-eastern part (soil mapping unit YGbc2). They were classified as *chromic*, because of the relatively high chroma of the moist subsoil (more than 1.5).

(i) *Gleysols*

These are poorly drained mineral soils, without clear textural differentiation. Hydromorphic properties should occur within 50 cm. of the surface: periodic or permanent saturation by groundwater, reflected in dominant greyish hues, or prominent mottling. Any B-horizon should be weakly developed (cambic rather than argillic). Dependig on the base saturation in the upper 20-50 cm., *eutric* (more than 50 per cent base saturation) and *dystric* (less than 50 per cent base saturation) subunits are concerned. Soil mapping unit Vgc has Gleysols that are intermediate between the two. In the soil mapping unit VC a component occurs that combines a high base saturation in the topsoil with dark colours due to relatively high percentage of organic matter. This component therefore belongs to the *mollic* subunit.

Note.—The "vlei soils" of the early East African soil classification ref. Gethin-Jones and Scott, 1959, in Atlas of Kenya (Survey of Kenya, 1970), and Morgan, 1969, comprise probably both Gleysols and Planosols.

(j) *Histosols* (Bog soils)

These are poorly drained organic soils, i.e. soils with a thick topsoil that contains a high percentage of organic matter (more than 20-30 per cent, depending on the clay percentage). This H-horizon should be at least 40 cm. thick. In the survey area such soils are found in the minor valleys and bottomlands of the Cherangani "hills" (soil mapping unit Vo) as well as in part of those near Kitale (part of soil mapping unit VC). Both are *dystric* ones, i.e. they have a base saturation below 50 per cent (pH less than 5.5) in at least part of the soil between 20 and 50 cm. depth.

(k) *Fluvisols*

These are young mineral soils on recent and subrecent alluvial deposits. They have no horizon differentiation due to soil forming processes but show stratification due to sedimentary deposition. They have irregularly decreasing organic matter content (or an organic matter content that remains above 0.35 per cent to a depth of 125 cm.); receive fresh sedimentary material at regular intervals, or have unripe sulphidic material within 125 cm. The soils usually contain many weatherable minerals. The Fluvisols in the survey area (soil mapping unit AC) belong to the *eutric* subunit, having a base saturation above 50 per cent, while predominantly not calcareous.

(l) *Regosols and Lithosols*

These are shallow soils with AC or AR sequence of horizons. The topsoil is not rich in organic matter ("ochric" A) and there is no B-horizon of any kind. The Regosols have directly below the A-horizon weathering rock material that is unconsolidated, i.e. penetrable for roots and moisture, while the Lithosols should have continuous coherent and hard rock within 10 cm. of the surface*. In the survey area most of the shallow soils of either kind have a low base saturation (less than 50 per cent) and belong therefore to the *dystric* subunit (soil mapping unit MG and HG). A few, developed on ferromagnesian rich rocks, have however definitely high base saturation percentages and are therefore *eutric* (soil mapping unit U7Fr and part of U7Fr + U7Frc).

* 20-30 cm. may be more convenient for Kenyan conditions.

3.4.3. Soil Genesis Aspects

For better understanding of the pattern of soils in the survey area some obvious trends in soil genesis are summarized, in relation to soil forming factors. This may also be of use at future reconnaissance surveys in surrounding areas, and contribute to the understanding of soil genesis in the country at large. The schematic cross-sections of Figs. 11-14 may illustrate some of the remarks.

(a) Influence of climate

The influence of the differences in climate is clearly the most pronounced of the soil forming factors in the area. The relation between soil formation and the large differences in altitude, with associated different temperature regimes and amounts of rainfall, is illustrated on cross-section C-D for the southern part of the area. From relatively low (6.000 ft.) to high (11.000 ft.) there is a clear trend in diminishing degree of weathering (Ferralsols-Acrisols-Luvisols-luvic Phaeozems-Cambisols), while the organic matter content of the *topsoil* gradually increases, unless slopes are very steep. The soils at the Kitale level are medium acid (pH 5.0 to 6.1; rhodic Ferralsols), those on the high levels are strongly acid (pH 5.0-5.5, humic Cambisols), but those at intermediate levels are slightly acid to moderately alkaline (orthic Luvisols and luvic Phaeozems), pH 5.6-8. It would appear that the climatic conditions at about 7.000 feet give the most fertile soils. The north-western part of the survey area, where rainfall is limited and altitudes are lower, with corresponding higher temperatures, has mainly Acrisols and Luvisols with topsoils of low to very low organic matter content.

(b) Influence of parent material

The influence of parent materials can be read from the subheadings of the legend of the soil map (Appendix 1). In the present survey area, the influence of parent material is overshadowed by climatic and physiographic influences but within the mapping units of the mountains and hills several good examples of the influence of parent rock can be demonstrated. One of these is the occurrence of strikingly dark and rich soils developed on crystalline limestone and hornblende gneisses (*Kastanozems* of soil mapping unit HLC); the sharp and straight boundary between soil mapping unit MG (*dystric Litho/Regosols*) and soil mapping unit MFC (*eutric Regosols and chromic Cambisols*) in the north-eastern part of the area is related to a change from granitoid gneisses and biotite gneisses to the "richer" hornblende gneisses.

(c) Influence of geomorphology and age

The influence of land forms is most clear in the relatively dry northern part of the area (cf. cross-section A-B, Fig. 11), where mountains, footslopes, piedmont plains, uplands and recently dissected/eroded uplands have each their own soil or soil complex. Contrary to what at first sight might be expected, there is no relationship between the age of the various planation surfaces in the southern part of the area (dating from pre-Cretaceous for the highest surface to end-Tertiary for the lowest surface according to Miller, 1956) and the degree of soil development. This is due to the fact that practically nowhere these surfaces have been left intact. Their *present* topography (undulating to rolling or even hilly) is likely to have been finally modelled in (early) Pleistocene times, hence also the formation of the *present-day* soils must have been started everywhere in those times. The low CEC-clay (12-18 me.) of many of the soils of the higher levels (U1, U2 and U3) may however point to some pre-weathering of the parent materials in earlier times.

Fine examples of the influence of the position on individual slopes can be found on most of the levels in the southern half of the area. This holds particularly for the Kapenguria mapping units U3GC1 and U3GC2, where regular catenary sequences—of Milne's "first" class category, i.e. with identical parent material—were established (cf. cross-section E, Fig. 13).

(d) Influence of drainage conditions

Most of the soils in the area are well drained. Poor drainage conditions have however been of dominating influence on the soil development in the minor valleys and bottomlands

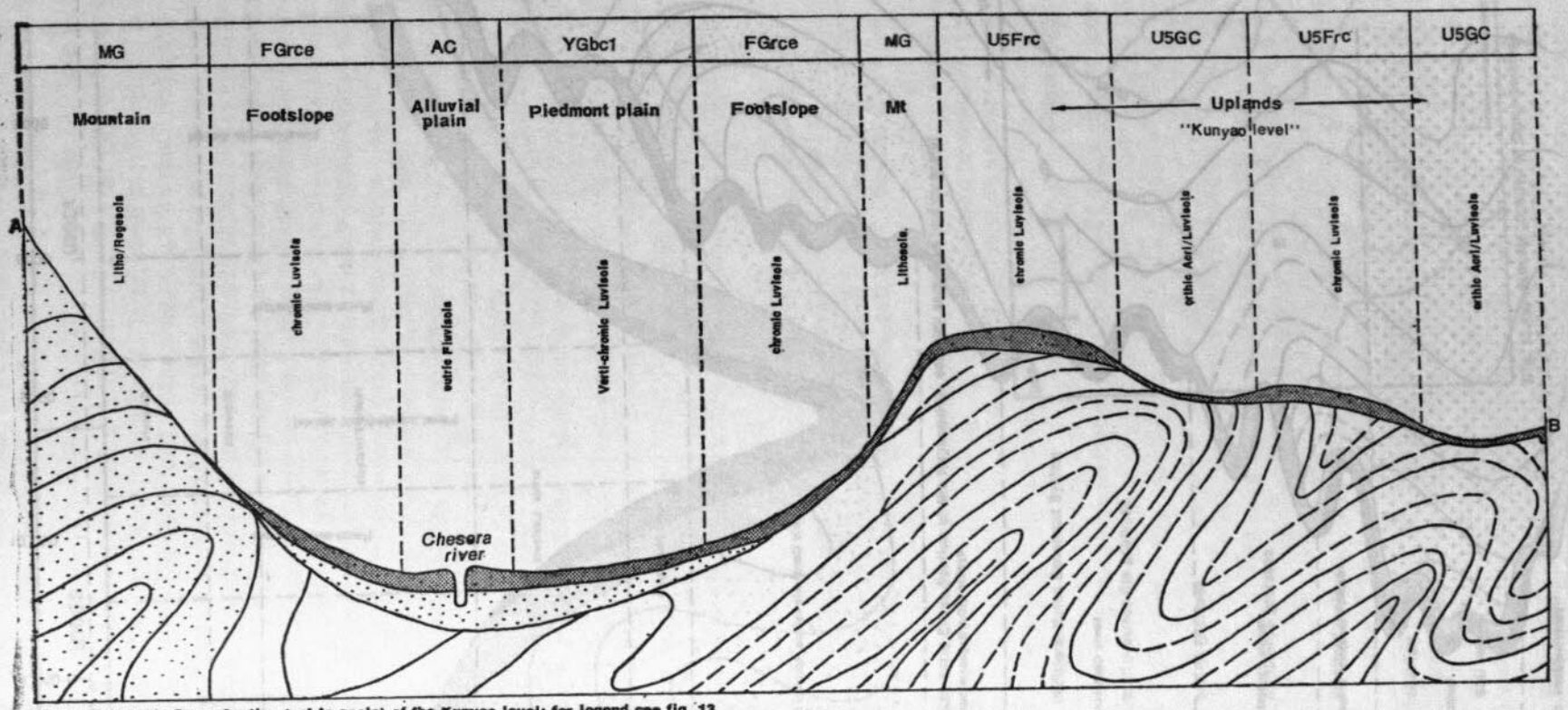


Fig. 11 Schematic Cross-Section (not to scale) of the Kunyao level; for legend see fig. 13

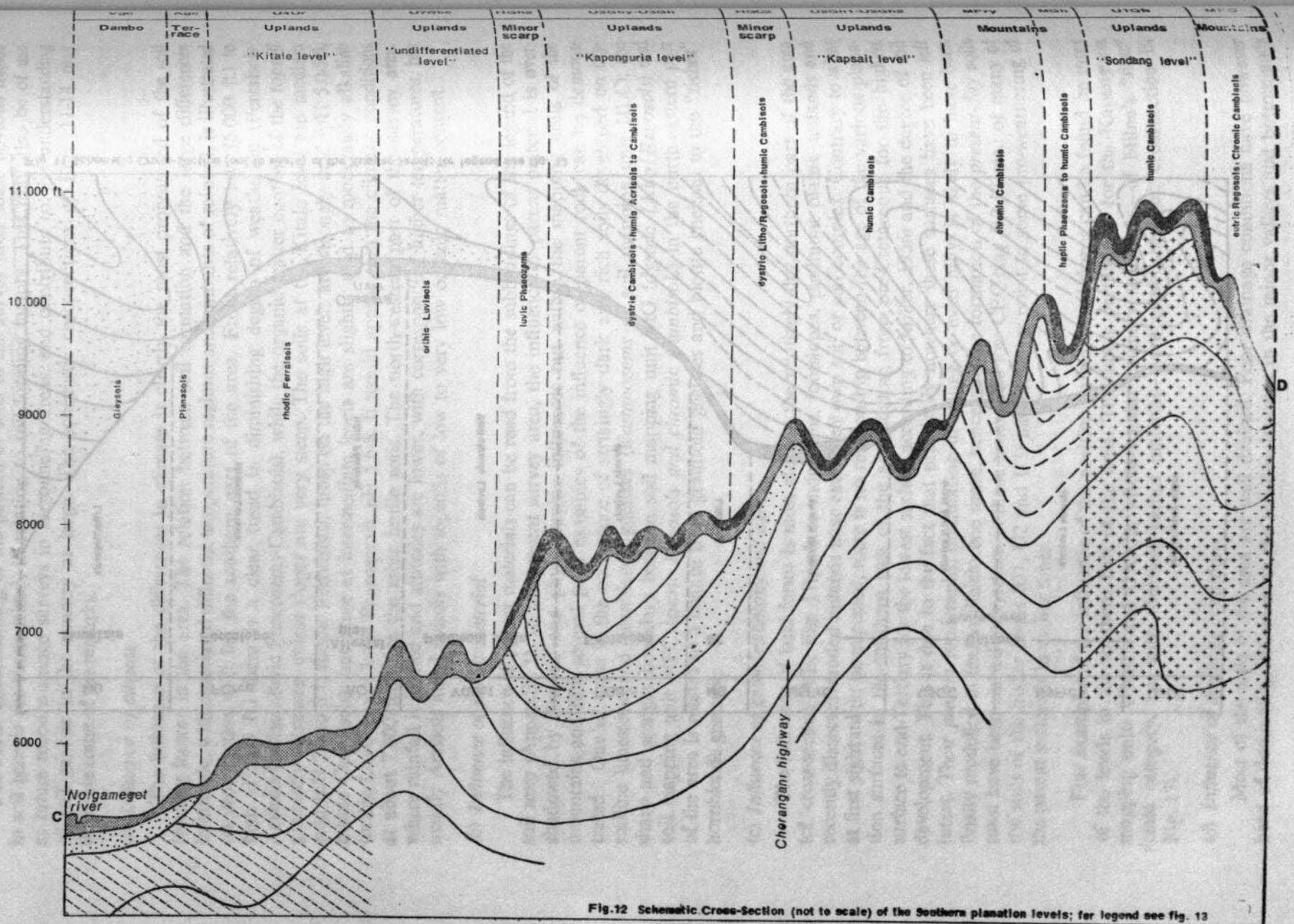


Fig.12 Schematic Cross-Section (not to scale) of the Southern planation levels; for legend see fig. 13

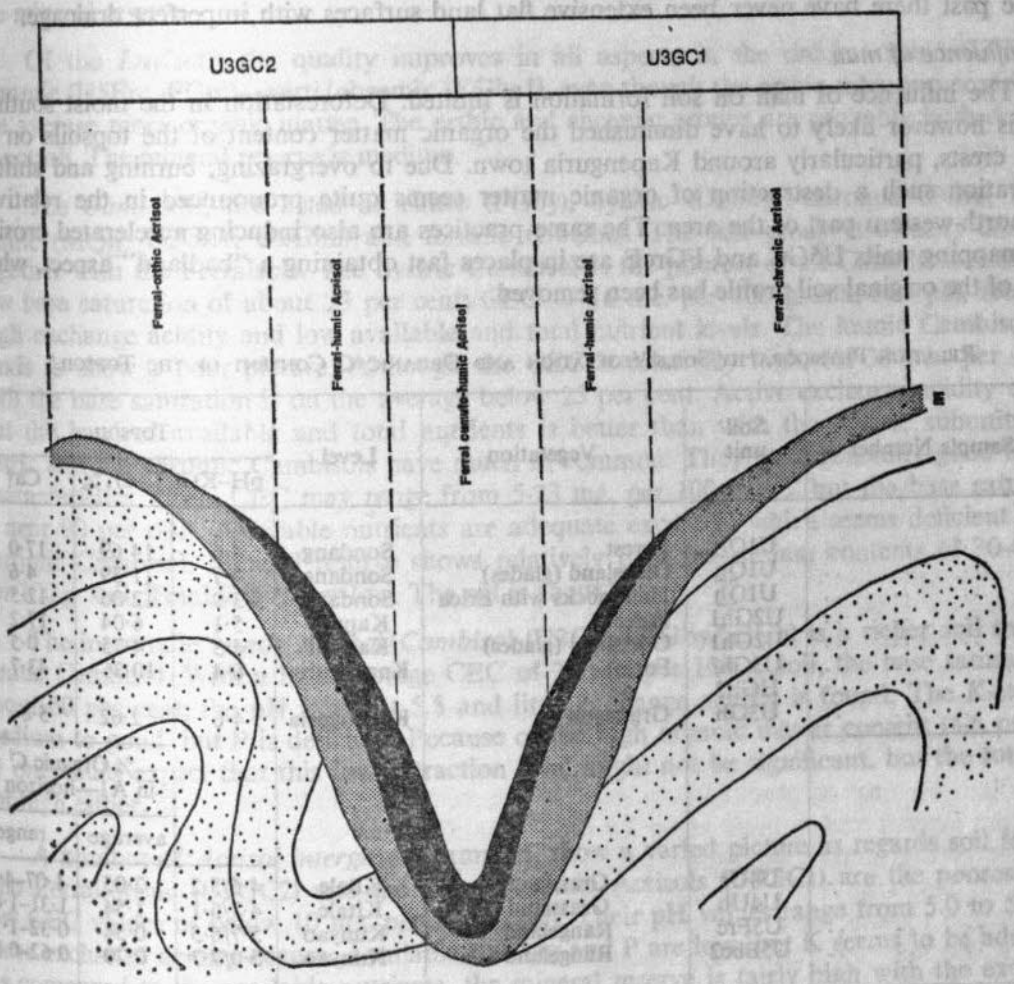


Fig.13 Schematic Cross-Section of the Kapenguria catenary sequence (not to scale)

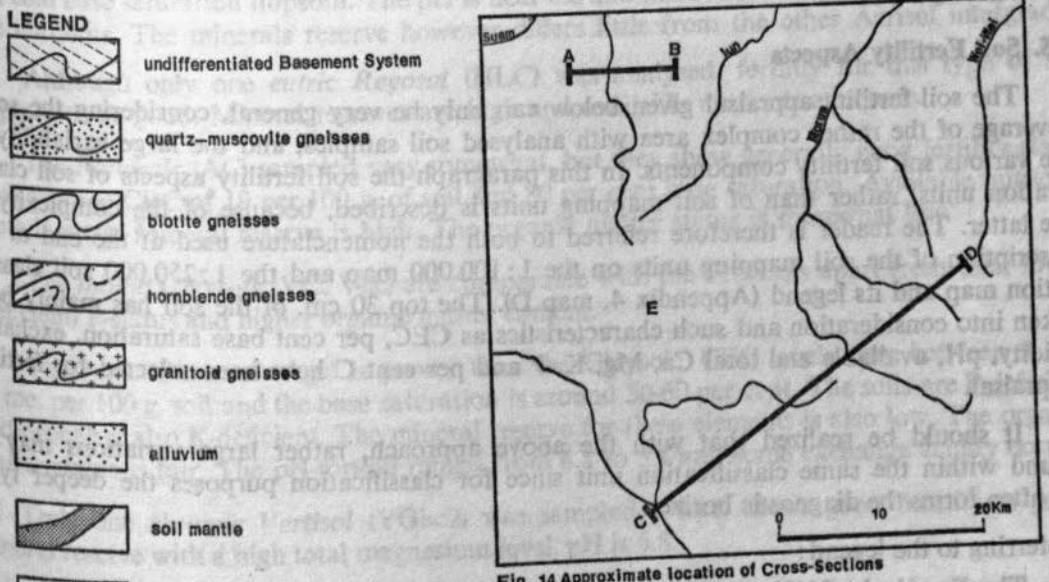


Fig. 14 Approximate location of Cross-Sections

(dambos), especially in the south-western part of the sheet (Planosols, Gleysols and Histosols). The virtual absence of petroplinthite ("laterite" — "murram") suggests that also in the past there have never been extensive flat land surfaces with imperfect drainage.

(*e*) *Influence of man*

The influence of man on soil formation is limited. Deforestation in the moist southern half is however likely to have diminished the organic matter content of the topsoils on the ridge crests, particularly around Kapenguria town. Due to overgrazing, burning and shifting cultivation such a destruction of organic matter seems quite pronounced in the relatively dry north-western part of the area. The same practices are also inducing accelerated erosion; soil mapping units U5GC and FGrcE are in places fast obtaining a "badland" aspect, where most of the original soil profile has been removed.

RELATION PHYSIOGRAPHY/SOILS/VEGETATION AND ORGANIC C CONTENT OF THE TOPSOIL*

Sample Number	Soil unit	Vegetation	Level	Topsoil		
				pH–KCl	C–el. %	Ca†
382b	U1Qh	Forest	Sondang	4·6	14·69	17·0
382a	U1Qh	Grassland (glades)	Sondang	4·7	11·39	4·6
382c	U1Qh	Hummocks with Erica	Sondang	3·9	12·06	12·5
385	U2Gh1	Forest	Kapsait	5·1	6·04	17·2
384	U2Gh1	Grassland (glades)	Kapsait	4·3	4·75	0·5
Y	U3Gh/ HGh2	Forest	Kapenguria	6·4	10·36	43·7
X	U3Gh	Grassland	Kapenguria	4·6	2·62	5·8
					% Organic C in A1—horizon	
					average	range
—	U4Ur	Grassland	Kitale	4·5/5·2	2·05	1·07–4·05
—	U4Ub	Grassland	Kitale	4·7/5·1	1·54	1·31–1·68
—	U5Frc	Rangeland	Kunyao	5·7/6·5	0·54	0·32–1·18
—	U5Bbc2	Rangeland	Kunyao	5·0/7·7	0·70	0·62–0·84

*Analysis by "Bedrijfslaboratorium voor grond-en gewasonderzoek Oosterbeek, the Netherlands". The data were received after the manuscript was finalised.

†in meq/100 gr. soil.

3.5. Soil Fertility Aspects

The soil fertility appraisal given below can only be very general, considering the scant coverage of the rather complex area with analysed soil samples, and the large variability of the various soil fertility components. In this paragraph the soil fertility aspects of soil classification units, rather than of soil mapping units is described, because of the complexity of the latter. The reader is therefore referred to both the nomenclature used at the end of the description of the soil mapping units on the 1:100.000 map and the 1:250.000 soil classification map and its legend (Appendix 4, map D). The top 30 cm. of the soil has mainly been taken into consideration and such characteristics as CEC, per cent base saturation, exchange acidity, pH, available and total Ca, Mg, K, P and per cent C have been selected for fertility appraisal.

It should be realized that with the above approach, rather large variations may be found within the same classification unit since for classification purposes the deeper lying B_2 often forms the diagnostic horizon.

Referring to the legend:

The *Ferralsols*, (U4Ur, U4Ub) together with the orthic Acrisols (U5Bbc2) and the ferralic Cambisols (U6Gbc) are chemically the poorest soils, with low CEC-soil, base saturation and available nutrients as a whole. Surprisingly the K-status of the Ferralsols is relatively good

in comparison with many other soils. The organic matter status is also rather favourable. Some soils of this group are rather acid and need liming. P-status is mostly low and so is the mineral reserve.

Of the *Luvisols*, the quality improves in all aspects in the order: orthic (U7Bbc)—chromic (U5Frc, FGrc)—verti/chromic (YGbc1), even though the orthic subgroup contains on the average more organic matter. The orthic and chromic groups are probably both deficient in potash. The mineral reserve is medium.

The *Cambisols*, are listed as eutric (FGby), dystric (U2Gry), chromic (FGrc, MFC), humic (MQh, U2Gh1, U2Gh2) and ferralic (U6Gbc). The last group is already discussed together with the Ferralsols. The dystric Cambisol is the poorest of all Cambisols exhibiting low base saturation of about 23 per cent; CEC = 16 me. per 100 g. soil, low pH, relatively high exchange acidity and low available and total nutrient levels. The humic Cambisol also tends to show a poor picture. Although the CEC is relatively high, (13-33 me. per 100 g. soil) the base saturation is on the average below 25 per cent. Active exchange acidity occurs, but the level of available and total nutrients is better than with the dystric subunits. The eutric and the chromic Cambisols have much in common. They have generally good fertility characteristics. Their CEC may range from 5-23 me. per 100 g. soil but the base saturation is near 90 per cent. Available nutrients are adequate except K which seems deficient in the chromic Cambisol. Mineral reserve shows relatively high magnesium contents of 30-40 me. per 100 g. soil. Total P is rather low. The pH is about 7.

The intergrade *humic Acrisol/Cambisol* (U3Gh, U3Gby-U3Gh) is a richer soil than the humic Cambisol. With a high average CEC of 29 me. per 100 g. soil, the base saturation is about 60 per cent; the pH is about 5.5 and little exchange acidity is found. The K-status is medium to good, but P is deficient. Because of the high organic matter content (4-6 per cent C) one could expect that this low extraction level might not be significant, but the total P is not high either.

A number of *Acrisol intergrades* sampled, show a varied picture as regards soil fertility. The Ferral-orthic (U3GC2) and the Ferral-chromic Acrisols (U3GC1) are the poorest, with low CEC values of below 10 me. per 100 g. soil. Their pH values range from 5.0 to 5.5 and some exchange acidity occurs. Available Ca, Mg and P are low, but K seems to be adequate. As compared to the available nutrients, the mineral reserve is fairly high with the exception of P, which is low. The Ferral-humic Acrisols (U3GC2, U3GC1) are much richer than the Acrisols described before. CEC's are in the range of 15-20 me. per 100 g. soil with 60-70 per cent base saturation (topsoil). The pH is near 6.0 and there is an adequate supply of available nutrients. The minerals reserve however differs little from the other Acrisol intergrades.

Although only one *eutric Regosol* (HLC) was analysed, fertility for this type of soil appears to be good. Mineral reserves are high and available nutrients adequate.

The *Fluvisols* (AC) sampled vary somewhat, but they show generally good fertility status with average CEC of 19 per 100 g. of soil and 80 per cent base saturation. Available nutrients are adequate. Mineral reserve is high. The organic matter status is somewhat low.

The *mollic Gleysols* (VC, Vgc) are comparable with the Fluvisols apart from their lower (deficient) P-status and higher organic matter content.

The *eutric Planosol* (Agc) is poorer than the Gleysol: CEC levels vary between 9 and 26 me. per 100 g. soil and the base saturation is around 50-60 per cent. The soils are P deficient and probably also K-deficient. The mineral reserve for these elements is also low. The organic matter status is fair. The pH-topsoil ranges from 4.8 to 5.4 and some exchange acidity occurs.

Only one *chromic Vertisol* (YGbc2) was sampled, which shows good fertility, a good mineral reserve with a high total magnesium level. pH is 6.8.

The *haplic Phaeozem* (MGh) shows a low P availability. It is otherwise a fertile soil with a CEC of near 20 me. per 100 g. soil; 70 per cent base saturation and a medium to good mineral reserve, except for P, which is low. pH is near 6.0.

The *haplic Kastanozem* (HLC) is a fertile soil, with a high CEC (20 me. per 100 g. soil), near 100 per cent base saturation and a pH of 7.5. Although the organic matter status is fairly low, available nutrients are adequate and the mineral reserve is medium to high.

For the survey area as a whole, few experimental data exist concerning soil fertility and the interpretation of the chemical soil data given above should be taken with due caution. Future greenhouse pot-testing and field fertilizing trials, for different crops, on the now identified major soils is expected to yield more substantive data, which then can be translated into recommendations to the farmers in the area.

Of the Ferralsols, which occupy the major part of the Kitale area, much work has been done by the National Agricultural Research Station, Kitale, particularly on maize. The standard fertilizer recommendation for non-hybrid maize indicate requirements of up to 100 kg. N/ha. and 50 kg. or more P_2O_5 kg./ha. Special attention is drawn to a potential sulphur deficiency.

3.6. Soil Physical Aspects

3.6.1. Permeability: Infiltration, Percolation and Hydraulic Conductivity

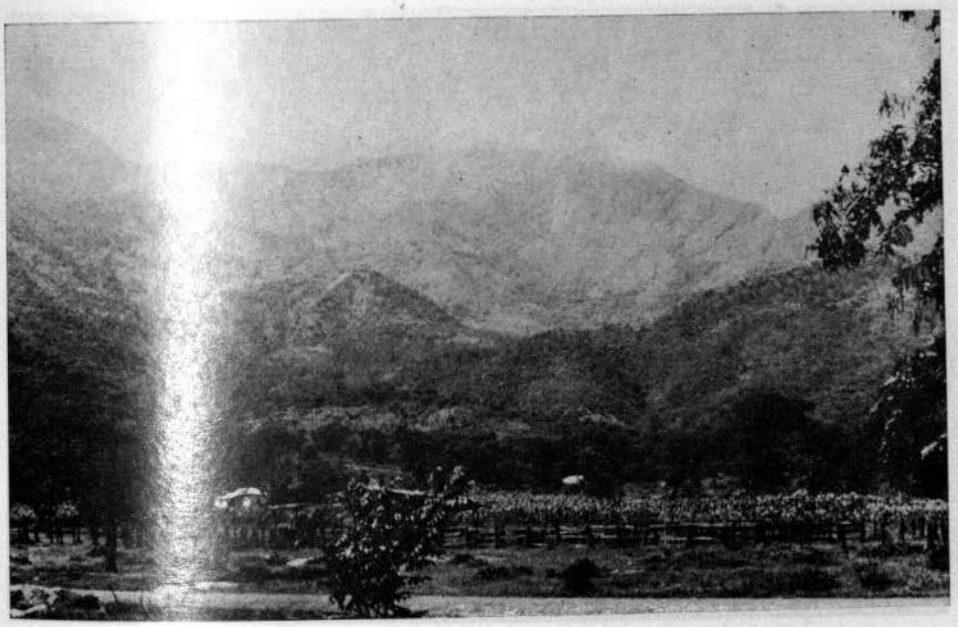
3.6.1.1. Infiltration is the movement of rain or irrigation water into the soil; percolation is the rate of water movement through the unsaturated soil; and hydraulic conductivity is the movement of water through the saturated soil, i.e. below groundwater level. For evaluating the likelihood of runoff and the suitability for irrigation of soil types both the infiltration and percolation characteristics are important, while the hydraulic conductivity is of special importance for drainage purposes, often in connection with the removal of saline groundwater in irrigation schemes.

When the rate of precipitation exceeds the rate of infiltration, water starts running along the surface and erosion could be the result. If water infiltrates but for some reason does not percolate, then the topsoil gets saturated and finally inundation and runoff can be the result. Similarly, if the hydraulic conductivity is low and insufficient drains are made in an irrigation scheme, then the groundwater level rises gradually and in case the groundwater is saline, the soil could turn saline through evaporation of the groundwater.

The measurement of infiltration can be done by "flooding" or by rainfall simulation The former is more appropriate in irrigation research while for runoff considerations rainfall simulation would be the best. Flooding in rings is a relatively easy procedure to measure infiltration and therefore rings were used by the KSS. A major disadvantage of the rings is that they have to be hammered into the soil particularly when the soil is dry and this causes an alteration of the original soil structure and porosity. Therefore in the later stages of the Kapenguria survey a simple method of rainfall simulation was used for comparison with the ring infiltration.

Though only carried out on 4 sites, the data indicate that the infiltration rate obtained by ring infiltration is up 7 times higher than the rate obtained by rainfall simulation. Thus the results of the ring infiltration have a relative value only. Instead of infiltration it is probably better to consider the results of cylinder infiltrations as percolation of the layer just below the soil surface (from about 10 cm. onwards).

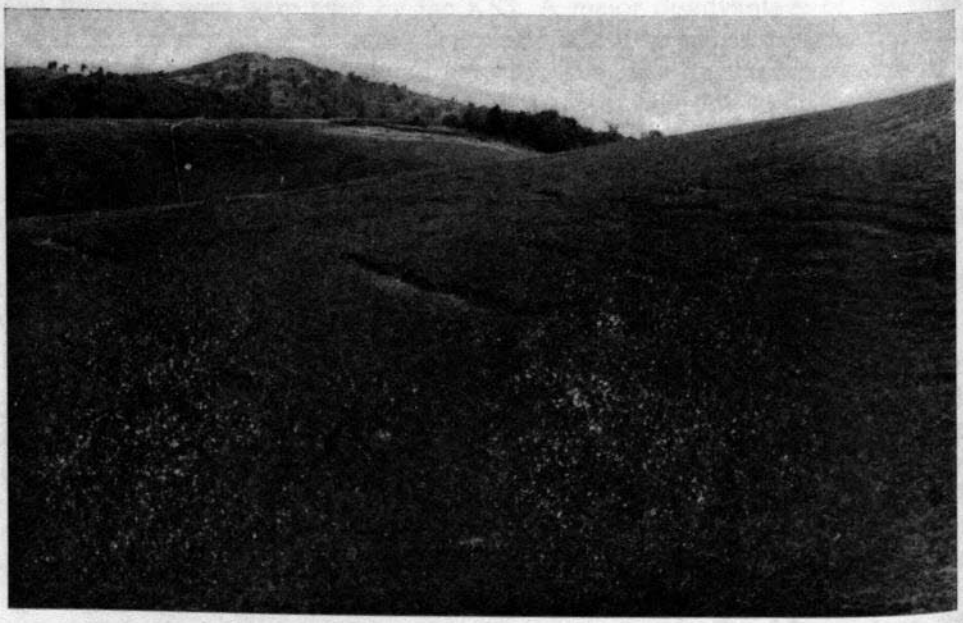
Apart from some 13 measurements in the topsoil, about 7 measurements of ring infiltration were carried out in the subsurface at about 30 cm. depth, to see if the percolation rate is adequate. Measurements of hydraulic conductivity were not carried out: they are rather complicated in the field and it was not thought worthwhile to take subsoil samples to the laboratory as a matter of routine, also in view of the small acreage suitable for irrigation development. One characteristic of the infiltration rate is that it decreases with time. When the soil is dry at the start of the experiment, the infiltration rate will drop very quickly in the beginning and somewhat less later on. With a wet soil the initial drop in infiltration rate will be less pronounced but it will decrease gradually. After a long time,



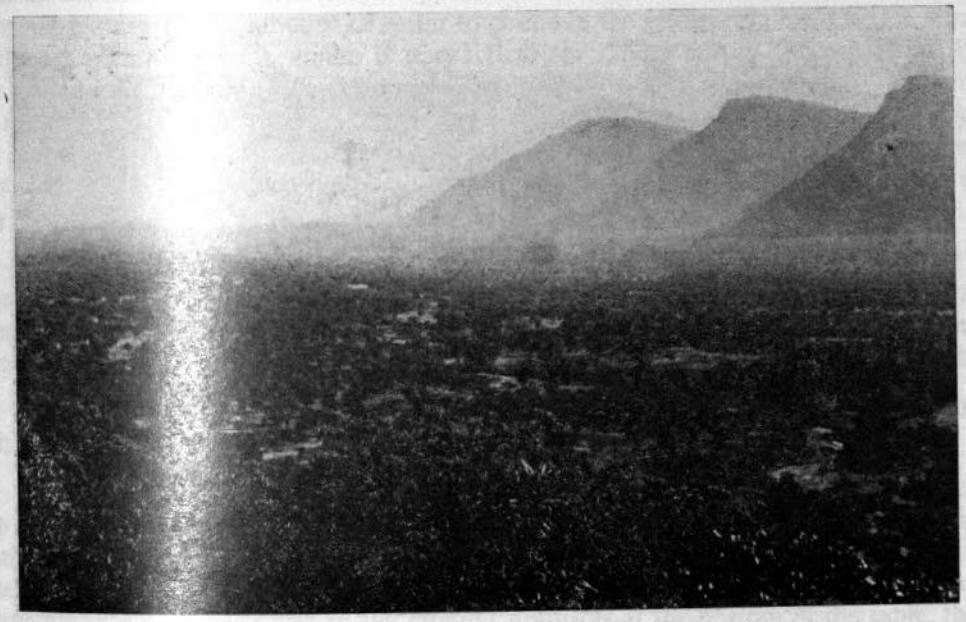
View from Ortum to east. Mountains (Cherangani "hills") with dominantly shallow, stony/rocky soils of unit MFC

Kapsait level near Kapsangar. Rolling area but top levels are more or less the same. In general moderately deep, humus-rich soils. Land use mainly livestock farming

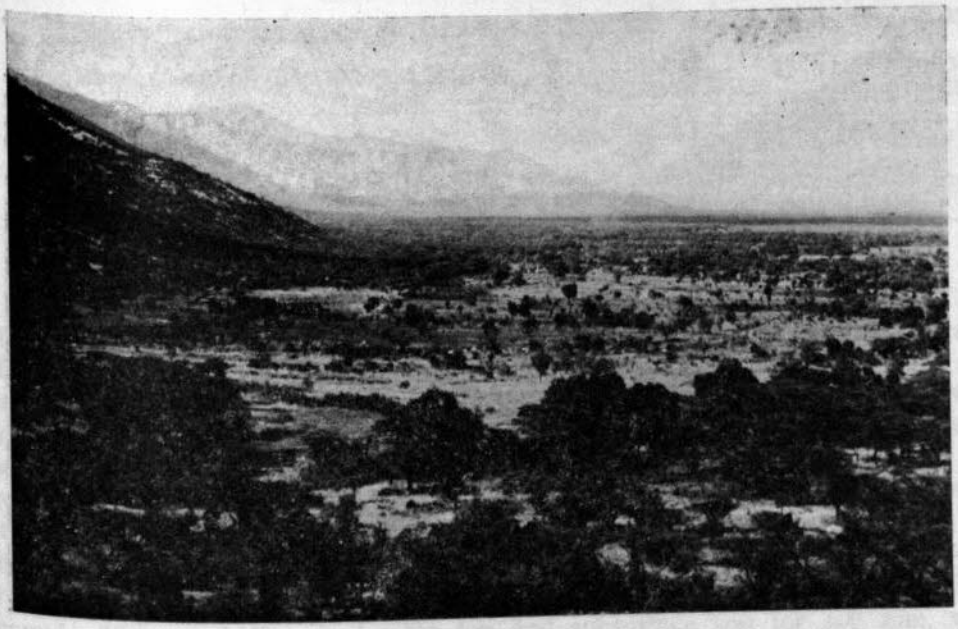
Kapsait level near Morun river. Moderately deep to deep soils of unit U2Gh1. Note beginning of erosion along cattle tracks



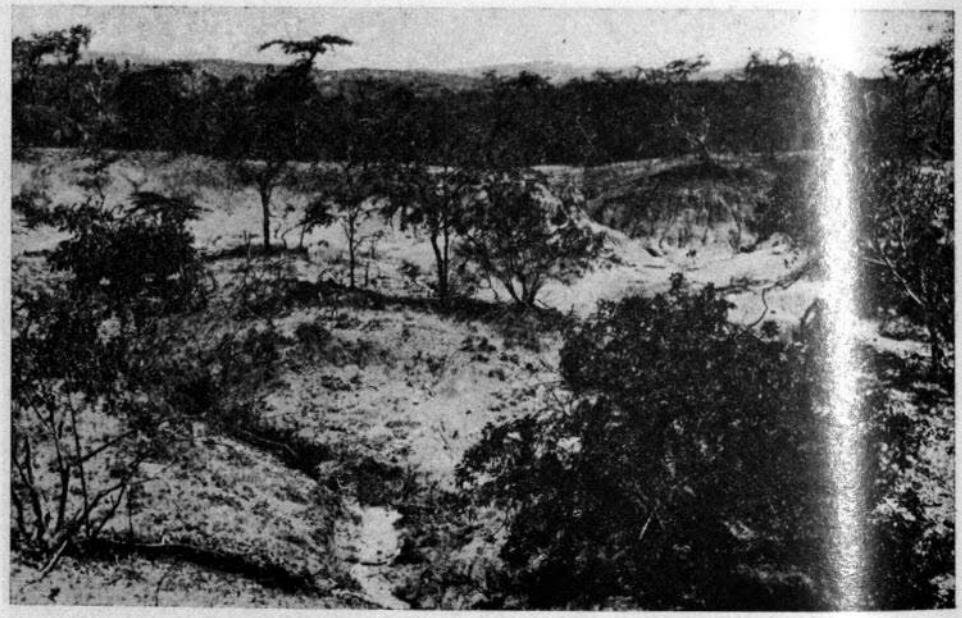
Near Kapsait School—Cherangani highway. Soils deep and humus-rich, unit U2Gh1. Note terracettes: slumped soil masses due to trampling by cattle



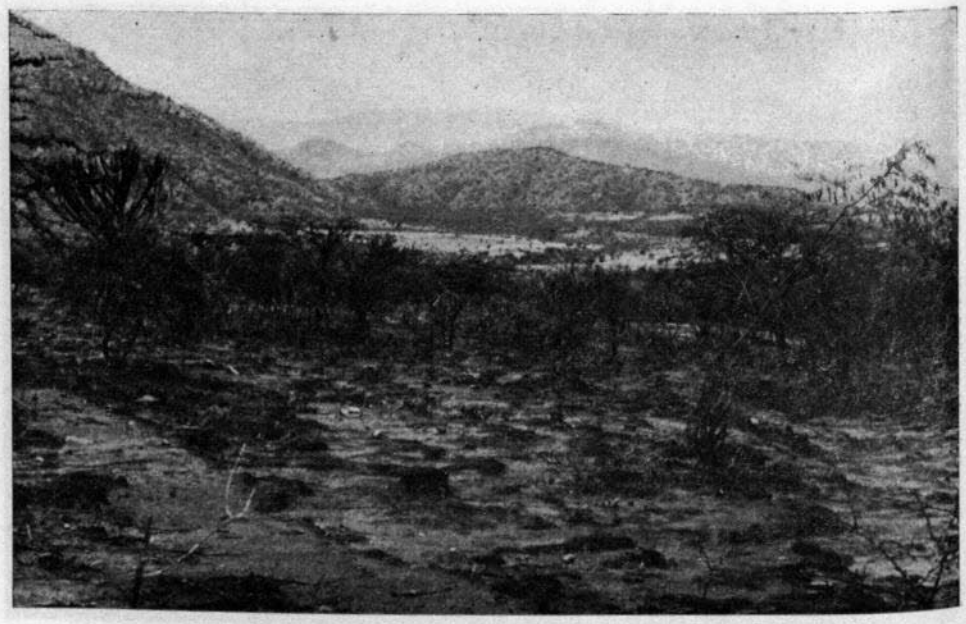
View from Miembur over Kunyao level and Gobut range. Note fault-line. At right-hand side note footslope area. At foreground incision of Kaiboni River



View from Sigor to North. At the left Cherangani-Sekerr range. Note piedmont plain, sloping very gradually to east



Typical view in Kunyao level area. Strongly eroded, strongly overgrazed land



Near Morobus school. Footslope area with strong sheet-erosion. Soils of unit FGrce. Note absence of A-horizon

the infiltration rate seems to approach a constant value. The infiltration rate after 4 hours is often assumed to be a reasonable approximation of the constant infiltration rate. It would however require a large amount of water to continue the infiltration for 4 hours, when dealing with very permeable soils, which is unpractical for a field survey. Therefore the KSS opted for the measurement of the time needed for the infiltration of 100 mm. water as a measure of infiltration rate. After an initial dry run, a wet run was carried out, occasionally followed by a second wet run on the following day. Some measurement were done in the wet season but most in dry season (September 1973-March 1974). For only one profile, both a wet and dry season measurements were carried out.

The calculation of the average time needed for the infiltration of 100 mm. of water per site has been done by taking the average time of the 3, 4 or 5 results around the median. Very often some strange values are obtained on any site and by taking the average of the data near the median, it is avoided that one aberrant value alters the average substantially.

The results for the dry run of the top soil and the subsurface soil are summarized per soil classification unit in Table 5.

Noteworthy is the low infiltration (long time!) of the Ferral-Acrisol Intergrades which is the "non-humic" component of soil unit U3GC1 around Kapenguria. The Luvisols are very variable as far as the texture of the topsoil is concerned and this is reflected in the infiltration results. The Luvisols (clayey type) are considerably slower than the Luvisols (sandy type). Attention should be paid also to the humic Cambisols at the bottom of the table; the "humic" horizon has by far the highest infiltration rate of all the groups while the "non-humic" subsurface soil is comparable in infiltration to the Luvisols-clayey type and the Ferralsols.

TABLE 5—SUMMARY OF DRY RUN INFILTRATION; TIME IN MINUTES NEEDED FOR THE INFILTRATION OF 100 MM. WATER (4 INCH CYLINDERS WITH ± 12 CM. HYDRAULIC HEAD AT THE START)

	Topsoil		Subsurface Soil	
Ferralsols (profiles 2,6,18,21)	M_{54}	53	M_{30}	78
*Acrisols (57,101,513)	M_{41}	55	M_{23}	23
Ferral–Acrisol Intergrades (52,B1)	M_{26}	354	M_{14}	251
*Luvisols (clayey types) (58,60,515)	M_{38}	135	M_{21}	104
*Luvisols (sandy types) (498,512,514,538)	M_{57}	43	M_{25}	25
Humic Cambisols (B3,63,326,384,385,388)	M_{92}	17	humic (384,388) M_{16}	20
			non humic (63,385) M_{22}	108

*texturally little differentiated.

In the previous survey area, Kindaruma, it was found (Braun, 1975b) that the infiltration in the topsoil was slower than in the subsurface except for Luvisols with pronounced textural differentiation. In the Kapenguria area the same tendency that the subsurface soil has a faster infiltration rate than the topsoil is observed in all soil types except the Ferralsols and humic Cambisols. Particularly the "non-humic" subsurface soil of the humic Cambisols is considerably slower than the topsoil. Omitted in Table 5 is the measurement for a Fluvisol (profile 106) in the alluvial valley near Kongelai. This infiltration measurement was carried out in the wet season and the clay stuck so much to the cylinders that the soil inside the cylinders probably got compressed with a resulting very low infiltration rate of 540 minutes for 100 mm. water in the topsoil. In a Vertisol (profile 542) probably something similar occurred: 304 and 1455 minutes for top and subsurface soil for 100 mm. water. The extremely high infiltration rates of the cracked Gleysol (profile 3) are omitted also.

3.6.1.2. Difference Between Ring Infiltration and Rainfall Simulation

As indicated above only on a few sites both ring infiltration and rainfall simulation were carried out. The result, including two sites without ring infiltration, are given in Table 6. It is seen that the $t_{100\ mm.}$—infiltration rate is higher than the rainfall simulation rate.

Table 6—Comparison Between ring Infiltration and Rainfall Simulation

Profile	$t_{100\ mm.}$	$t_{100\ mm.}$ rate	Rainfall simulation rate
512	44 minutes	136 mm./hour	20 mm./hour
513	58 minutes	103 mm./hour	17 mm./hour
514	40 minutes	150 mm./hour	52 mm./hour
539	—	—	90 mm./hour
540	—	—	53 mm./hour
542	304 minutes	20 mm./hour	16 mm./hour

The data in Table 6 are too few to derive a correlation and therefore the data which at present are available from the ongoing reconnaissance soil survey in Kwale have been used also to derive a correlation between ring infiltration and rainfall simulation. From 22 sites the correlation coefficient between the reciprocal value of $t_{100\ mm.}$ and the simulation rate is 0.87. From the graph the following relationship appears:

Table 7—Correlation Ring Infiltration—Rainfall Simulation

t 100 mm. (rate)		Rainfall simulation rate
6 min.	(1000 mm./hour)	150 mm./hour
10 min.	600 mm./hour	120 mm./hour
15 min.	400 mm./hour	80 mm./hour
20 min.	300 mm./hour	60 mm./hour
30 min.	200 mm./hour	40 mm./hour
60 min.	100 mm./hour	20 mm./hour
100 min.	60 mm./hour	12 mm./hour
250 min.	24 mm./hour	6 mm./hour
500 min.	12 mm./hour	4 mm./hour
1000 min.	6 mm./hour	3 mm./hour

Between a $t_{100\ mm.}$ of 10 and 100 the rainfall simulation rate is one fifth of the rate measured with ring infiltration. With longer times (i.e. slower rates) the ratio between the two rates decreases to $\frac{1}{2}$ at 1000 minutes and probably becomes one for extremely slow rates.

Assuming that the relationship given in Table 7 is valid for the data collected with ring infiltration in the Kapenguria area, then the data of Table 5 can be recalculated and the dry infiltration rate would then be as given in Table 8.

Table 8—Summary of Dry Run Infiltration (by Rainfall Simulation, *see* Explanation in Text)

	Topsoil	*Subsurface Soil*	
Ferralsols	23	16	mm./hour
*Acrisols	22	55	"
Ferral-Acrisols Intergrades ..	5	6	"
*Luvisols (clayey types) ..	9	12	"
*Luvisols (sandy types) ..	28	48	"
Humic Cambisols	70	60 (humic)	"
		11 (non-humic)	mm./hour

* texturally little differentiated.

The data of Table 8 can be compared with the data given in Tables 6 and 7 of chapter 1.2.10. The comparison shows that on all soil types except the humic Cambisols the infiltration rate is very frequently exceeded by the rainfall rate.

3.6.1.3. The Relation Between Dry Run and Wet Run

On 25 sites, topsoil wet run values were obtained immediately after the dry run ring infiltration was completed. The time needed for the infiltration of 100 mm. water in the wet run appeared well correlated ($r = 0.93$) with the dry run. For 21 sites where subsurface dry and wet runs were carried out, a linear correlation coefficient of 0.89 was obtained. For the sample of 46 dry and wet runs the linear correlation coefficient is 0.89 and the following equation was found:

$$t_{wet} = 1.8\, t_{dry} + 14$$

The time needed for the wet run is approximately twice the time needed for the dry run. Thus the infiltration rate during the wet run is half of the infiltration rate during the dry run. On 16 sites, a wet run was followed by another wet run on the day after the dry and wet run were carried out. The relation between the two wet runs is curvilinear and the derived equation is approximately:

$$t_{wet\ II} = 0.0049\, t^2_{wet\ I} + 0.67\, t_{wet\ I} - 5.4$$

Wet run time	*Wet run next day time*
20 minutes/100 mm.	10 minutes/100 mm.
40 minutes/100 mm.	30 minutes/100 mm.
80 minutes/100 mm.	80 minutes/100 mm.
120 minutes/100 mm.	145 minutes/100 mm.
180 minutes/100 mm.	275 minutes/100 mm.
240 minutes/100 mm.	440 minutes/100 mm.

On soils having a wet run infiltration time of less than 80 minutes the wet run on the next day is faster and for a wet run infiltration of more than 80 mm. the wet run on the next day is slower, in both cases proportionally more, the further away from the value of 80 minutes. This is understandable because in soils with a rapid infiltration, the water is evacuated through the large pores and a state of equilibrium is reached in a few hours. In the soils with a low infiltration rate the water moves through small pores and a state of equilibrium is not reached within 24 hours.

3.6.1.4. Comparison of Wet and Dry Season Infiltration

Only for one site, data were collected both in the dry and in the wet season. Profile 2, a rhodic Ferralsol, had a dry run time of 85 minutes and a wet run time of 142 minutes per 100 mm. water in the dry season, while the wet-season "dry" run time was 153 minutes, i.e. the wet-season dry run is similar to the dry-season wet run. This is in agreement with what could be expected on the basis of the previous paragraph.

3.6.1.5. The Effects of Soil Management on the Infiltration Rate

A comparison between the infiltration on rangeland and on adjacent cultivated land was carried out on 6 sites. The median infiltration times are given in Table 9.

Table 9—The Median Infiltration Time for 100 mm. Water on Rangeland and Adjacent Cultivated Land

	Rangeland	*Cultivated*
Profile 2 Ferralsol	85	3
21 Ferralsol	29	6
18 Ferralsol	68	12
57 Acrisol	88	47
B Ferral–Acrisol Intergrade	336	143

It is clear from the table that the tillage practices have increased the infiltration rate; the effect on the Ferralsols is much more pronounced than on the other two soil types. This was also found in the Kindaruma survey and it appears moreover that the effect of tillage on Ferralsols is long-lasting while on Acrisols and Ferral-Acrisol Intergrades the improvement of infiltration through tillage is of short duration. These soils reseal relatively quickly and have to be reworked regularly to maintain a reasonable infiltration rate.

3.6.1.6. The Effect of Forest Clearing on the Infiltration Rate

Near profile 326, a humic Cambisol, the infiltration was measured under the natural forest cover and on an adjacent area where the forest had been cleared. The median infiltration for 100 mm. water was 9 minutes and 27 minutes respectively, i.e. a 3-fold decrease.

Summarizing the infiltration section, it can be stated that the data obtained with 4-inch rings are a gross over-estimation of the infiltration as it occurs when a simple method of rainfall simulation is applied. There is, however, a good correlation between both methods which enables a translation of the ring infiltration data into "true" infiltration values. On all soil types except the humic Cambisols the dry run infiltration is frequently exceeded by the rate of rainfall. The infiltration rate during the wet run decreases to 50 per cent of its dry run value. When a second wet run is carried out on the next day, its infiltration rate will be still slower for wet run values of more than 80 minutes or dry "true infiltration" rates of less than 30 mm./hour. The wet-season infiltration rates are slower than the dry-season rates. It is expected that the slower the dry-season rate, the more the infiltration rate is reduced in the wet-season. The infiltration rate under rangeland condition is, probably because of compaction, considerably lower than that on cultivated sites, particularly on Ferralsols.

3.6.2. Bulk Density and Porosity

Bulk density is the weight of the soil per unit of volume. Porosity is the portion of the soil not taken up by the solid phase. The bulk density was determined on a composite sample of 5 times 100 cm^3 soil which had been wetted the previous day. The porosity can be calculated when the particle density is known. For the Kapenguria area the particle density was estimated at 2.60 for non-organic horizons and 2.30 for organic horizons. The bulk density and porosity data for the Kapenguria area are given in Table 10. A low bulk density and consequently a high porosity is considered a desirable characteristic of a soil, particularly if the size distribution of the pores is such that a substantial part of the pores is filled with air. A high bulk density might indicate a very compact soil which is difficult to penetrate for plant roots.

None of the bulk densities is very high, nor is the porosity for any of the soil groups very low. The water content at field capacity of all the soils is considerably less than the total porosity and consequently in none of the soils there is a risk of oxygen deficiency.

Table 10—Bulk Densities and Porosities

	Bulk Density Range	Bulk Density Average	Porosity Per cent	Per cent Clay	Field Capacity Percent Water
Red Ferralsols..	1·0–1·2	1·11	57	62	32
Brown Ferralsols	1·2–1·3	1·22	53	52	28
Ferral–Acrisol Intergrades	1·3–1·5	1·42	45	30	19
Acrisols	1·3–1·5	1·42	45	30	19
Luvisols	1·3–1·6	1·40	46	top 25	17
				sub 40	23
Fluvisol	1·1–1·2	1·13	57	50	27
Eutric Cambisols	1·3–1·5	1·46	44	20	15
Dystric Cambisols	1·2	1·18	55	48	26
Humic Cambisols					
Humic Topsoil	0·8–1·3	0·98	57	—	37
Non-humic Subsoil	1·0–1·5	1·18	55	50	27
Vertisol..	1·3–1·5	1·42	45	30	19

3.6.3. Moisture Retention and Available Moisture

For growth and survival, plants depend on the moisture they can extract from the soil. Soils retain moisture from infiltrated rain or irrigation water against the force of gravity; the amount retained is called the field capacity (FC) which can be expressed as a

weight or a volume percentage. Near field capacity the water is loosely bound to the soil and plants can extract this water easily but the force with which water is held in the soil, increases with a decreasing moisture content and it becomes increasingly difficult for the plant to extract water from the soil. There does not however have to be a definite limit above which water is so tightly bound to the soil that it cannot be taken up by plants; for practical purposes it is generally accepted that permanent wilting, mostly called permanent wilting point (WP), occurs when the forces with which the water is held in the soil exceed 15 atmospheres (FAO/UNESCO, 1973; Russell, 1973). The binding forces of the soil-water are often expressed as pF-values, being the logarithm of the binding force in cm. water (e.g. 15 atm. = 15,000 cm.; log 15,000 = 4.2). Field capacity coincides with binding forces equivalent to tensions of 0.1 to 0.33 atm., or pF 2.0 to 2.5, depending on the texture of the soil and other factors (FAO/UNESCO, 1973, Hillel, 1971). The KSS uses 0.2 atm. (pF 2.3) for field capacity and pF 3.7 for the upper limit of uninhibited growth.

In the Kapenguria area some 23 profiles were sampled for moisture retention characteristics. Undisturbed ring samples were taken for direct field capacity determination or pF 2.3 and 2.7 determination, after moistening the soil on the day prior to sampling. Disturbed samples were taken for the pF 3.7 and 4.2 determinations. Of a total of 60 samples (from which 10 with a high organic matter content were excluded) a good correlation was found between the water content at F.C. or pF 2.3 and the clay content (r = 0.87) and between the water content at pF 3.7 and the clay content (r = 0.88). The following regression equations were calculated:

Vol. per cent water at F.C. or pF 2.3 = 0.41 × per cent clay + 6.5

Vol. per cent water at pF 3.7 = 0.29 × per cent clay + 2.6

From these equations one can derive the following equation for the amount of water held in the soil between field capacity (pF 2.3) and pF 3.7, also called the *productive available moisture* (PAM):

PAM = 0.12 × per cent clay + 3.9 (in vol. per cent water or mm. water per 10 cm. soil)

Available moisture (AM) which is the difference between Field Capacity and pF 4.2 is an average 1.2 vol. per cent higher than PAM.

From the 10 samples with an organic carbon content above 1 per cent, it has roughly been estimated that each percentage organic carbon increases the field capacity with 3.4 per cent and the moisture content at pF 3.7 with 2.3 per cent. Thus the PAM-value should increase with 1.1 per cent for each per cent carbon above 1 per cent.

For a soil horizon with 40 per cent clay and 4 per cent carbon the PAM-value is $40 \times 0.12 + 3.9 + (4-1) \times 1.1 = 12$ per cent.

For the soil textural classes the PAM-values are given in Table 11.

TABLE 11—PRODUCTIVE AVAILABLE MOISTURE FOR TEXTURAL CLASSES

Textural Class	*Per cent Clay*	*PAM (pF 2·3–3·7; in Vol Per cent or mm. per 10 cm.)*	
Sand and loamy sand ..	0–15	5	(3·9–5·7)
Sandy loam	15–20	6	(5·7–6·3)
Sandy clay loam	20–35	7	(6·3–8.1)
Sandy clay	35–55	9	(8·1–10·5)
Clay	55–85	12	(10·5–14·1)

Because there is *so much variation in texture within the soil mapping units* and *also within the classification units* it does not seem appropriate to give *averages* as was done for the Kindaruma area.

The total productive available moisture (TPAM) depends on soil depth, texture and organic matter content. In Table 12 the TPAM-values are given for different soil depths and textures.

It depends on the depths and density of the rooting system if the available water in the soil can readily be taken up by the plants.

TABLE 12—TOTAL PRODUCTIVE AVAILABLE MOISTURE (TPAM IN MM. WATER) FOR DIFFERENT SOIL DEPTHS AND TEXTURES

Depth/Texture	*LS*	*SL*	*SCL*	*SC*	*C*
20 cm. (very shallow)	10	12	14	18	24
40 cm. (shallow)	20	24	28	36	48
60 cm. (mod. deep)	30	36	42	54	72
100 cm. (deep)	50	60	70	90	120
140 cm. (very deep)	70	84	98	126	168
180 cm. (extr. deep)	90	108	126	171	216

Note: if there is 20, 40, 60 cm. "humic" topsoil then add 5, 10, 15 mm.; if there is 20, 40, 60 cm. "very humic" topsoil add 10, 20, 30 mm. respectively.

If it is assumed that the actual take-up of water from the soil is related to the volume of the roots and if the relative root amounts for crops A, B and C are:

	*A**	*B*	*C*
100%	0–20 cm.	0–40 cm.	0–80 cm.
75	20–30	40–60	80–150
50	30–40	60–80	150–180
25	40–60	80–120	
10	60–80	120–150	
5	80–100	150–180	

then it can be calculated that the *total productive readily available moisture* (TPRAM) for the crops A, B and C on a sandy clay loam profile is:—

A	*B*	*C*
100×14=14	100%×28=28	100×56=56
75×7 =5·3	75%×14=10·5	75×49=36·7
50×7 =3·5	50%×14=7	50×21=10·5
25×14=3·5	25%×28=7	
10×14=1·4	10%×21=2	103·2 mm
5×14=0·7	5%×21=1	
28·7 mm.	58·5 mm.	

The TPAM of the soil profile is 126 mm. (Table 12). If the evaporative demand is 5 mm. per day then the three crops remain productive in the absence of rain for 6, 11 and 21 days respectively. These calculations show the importance which should be attributed to soil depth but also to the influence of the kind of crop and its rooting depth. Shallow-rooted crops have much higher risk to be affected by temporary droughts than deep-rooted crops.

3.6.4. SURFACE SEALING, RUNOFF AND EROSION

It has already been noted that the precipitation rate in the survey area often will exceed the rate of infiltration. Moreover, when the soil is not protected by vegetation from the direct impact of rain, then on many soils a sealed layer is formed which reduces the infiltration rate. Consequently a larger proportion of the rainfall will disappear as runoff. With less water penetrating the soil, the plants growing on it will produce less and wilt earlier. This

*A, B, C for example: potatoes, maize, sunflower respectively.

surface-sealing is very common in many parts of the area designated as ecological zone IV, as a result of overgrazing (*see* Appendix 2). In times of rain there is a tremendous runoff in these areas resulting in severe erosion, very irregular flow in the rivers and very little vegetation growth, which soon after the rains wilts. For most of the year this area makes a very dry impression (locally the people speak of the "desert") though the average annual rainfall is probably in the order of 800 or 900 mm. It is thought that most of the "desert" is caused by overgrazing though it should be admitted that the soils are much more sealing-prone than for instance the Ferralsols in the Kitale area. Through somewhat higher sealing, less rainfall, higher evaporation and maybe other factors, the ecological balance in the northern areas is much easier disturbed than in the more favourable Kitale area. Local results of protection against grazing indicate that the rehabilitation of these northern areas is possible. The major problem to achieve rehabilitation will be to convince the people that destocking is necessary but even if the farmer is convinced, he might be unable to destock because he does not have alternative means of feeding his family.

3.7. Land Management Aspects

3.7.1. Introduction

The aim of land management should be to obtain a maximum profit from the land, without jeoparadizing the continued existence of the soil, vegetation and water resources. In many places of the Kapenguria area the status of land management is so poor, that the profits from the land are very low, while the vegetation, soil and water resources are declining. This is particularly noticeable in the drier areas: ecozones III-IV, IV and V. Deplorable land use practices can also be seen in the area between Kapenguria and Kapcherop where forests are felled indiscriminately on slopes which are too steep for cultivation and mostly without any soil conservation practices. Some examples of what can be achieved with proper land management can be found in Pereira (1973).

3.7.2. Soil Tillage

Tillage of the soil is done for removing the weeds, for creating a proper seedbed and for improving the structure, aeration and infiltrability of the soil. The tillage operation can be done with a jembe (hoe) or with machinery like ploughs, cultivators and harrows. In the previous chapter it has been shown that the infiltration rate on cultivated sites is considerably higher than the infiltration on adjacent rangeland sites. On some soil types the effect of tillage on infiltration is long-lasting (e.g. the rhodic Ferralsols, mapping unit U4 Ur) while on other soils resealing seems to occur rather quickly (e.g. the orthic Acrisols, mapping unit U5Bbc2). To avoid water loss through runoff the latter soils should be worked frequently in the growing season. Land preparation generally has to be carried out in the dry season, partly because the major crop (maize) has a pronounced time-of-planting effect (Allan, 1972, Law and Cooper, 1974), partly because in the rainy season the soil is too wet anyway for successful tillage. In the dry season the soil will often be too dry for effective tillage. However, the dry season in all areas has on average more than 300 mm. of rainfall and generally there will be a period during the dry season that the soil has the right moisture content for successful tillage.

3.7.3. Soil Conservation

Soil erosion occurs in each of the ecological zones but this phenomenon is particularly noticeable in the ecozones III-IV and IV, mostly as a result of overgrazing. As has been suggested in 3.6.4. a destocking of the areas affected is necessary to stop further soil deterioration. In some of the areas in zones IIc, IIw and III, erosion occurs through overgrazing or cattle tracks but generally the cause is cultivation without sufficient or any control measures on relatively steep slopes. If such steep slopes are to be used for cultivation then a lot more attention should be paid to soil conservation practices like terracing, strip-cropping, mulching, for a review of which the reader is referred to Hudson (1971), USDA, (1954), Schwab *et al.*, (1966) or other handbooks treating the principles and engineering aspects of soil conservation.

3.7.4. Water Management and Conservation

When the rate of precipitation exceeds the rate of infiltration then the excess water is lost as surface runoff. Sometimes this runoff results in local redistribution of water (e.g. water runs off from deforested slopes but infiltrates at the lower parts of the slope which are still under forest) but generally the runoff water disappears through rivers. Particularly in areas which are not favoured with abundant rainfall these water losses can have a pronounced effect on crop or range production. Evidently such water losses should, if possible, be avoided. The creation of a proper vegetation cover is generally the most effective way of increasing the infiltration rate, particularly on rangeland. For cropland, ploughing, mulching and other techniques like terracing can help to increase the infiltration and/or to reduce the loss of water through runoff.

In the northern part of the Kapenguria area (i.e. ecological Zone IV) there is a moderate to fairly high probability that the rainfall in the wet-season is less than two-thirds of the potential evaporation which is the assumed amount of water required for the proper growth of a 5 months' crop (*see* Fig. 8). If 100 mm. of water could be stored in the soil during the dry season, then the risk of a water deficit is fairly low to moderate (*see* Fig. 9), i.e. 20 per cent less than without water storage. As the average dry-season rainfall is more than 300 mm. the probability to get at least 200 mm. is 80 per cent or more. Assuming that out of 200 mm. of rainfall at least 100 mm. can be stored, then in 4 years out of 5 it is possible to reduce the probability of a water deficit by about 20 per cent. The probability of a deficit is then still 20 to 60 per cent which is too high for any agricultural enterprise. Other measures, among them crop selection are necessary to reduce the chance of water deficits.

3.7.5. Crop Selection and Management

In the previous section it was shown that for the northern part of the area the probability of a water deficit for an assumed 5 months' crop is still 20 to 60 per cent, even if 100 mm. of water is stored in the soil at the beginning of the growing season. For a 3 months' growing period no maps have been made but examples will be given for Kongelai and Sigor, *see* Table 13.

Table 13—Rainfall and Evaporation Data Kongelai and Sigor

Kongelai	*April–August*	*April–June*	*June–August*
Average Rainfall	560 mm.	308	359
Average Evaporation (Eo)	875 mm.	525	525
2/3Eo	585 mm.	350	350
Pr<2/3Eo	50%	70%	52%
Pr<2/3Eo–100	32%	35%	20% (with 100 mm. storage)

Sigor	*April–August*	*April–June*	*June–August*
Average Rainfall	518	336	243
Average Evaporation (Eo)	875	525	525
2/3Eo	585	350	350
Pr<2/3Eo	72%	65%	86%
Pr<2/3Eo–100	48%	30%	54% (with 100 mm. storage)

The comparison of the 5 months' and 3 months' growing seasons shows that in Kongelai the 3 months' period June to August has the lowest probability of a deficit, while in Sigor the period April-June has the lowest probability of a deficit. The table also shows that the effect of 100 mm. moisture storage is more important than the effect of the reduction in length of the growing period. Note also that the effect of 100 mm. storage is approximately 35 per cent for the 3 months' growing periods and approximately 25 per cent for the 5 months' growing period.

The deficit probabilities of 20 and 30 per cent for Kongelai and Sigor could still be considered too high. One way of bringing the deficit probabilities further down is by giving the plants a wider spacing, but this can only be effective if the rooting covers all the area between plants.

If weeds are allowed to compete for water and nutrients with the crop then the positive effects of water conservation and crop selection will be reduced or can be nullified altogether.

3.7.6. Range Management

The resources available for grazing should determine the number of grazing animals to be kept on the rangeland. If the stocking rate is too high for the available resources, then the range will show a decrease in plant density and plant production. When the stock density is kept constant then it is obvious that the range will deteriorate further and further. Finally the stock numbers have to come down because there is not enough for the animals to eat. In this stage vegetation and soil are very vulnerable and deterioration to "badland" can happen in a few years. Many parts of ecological zone IV are in this stage. Destocking is urgently necessary to save whatever is remaining. It is thought that destocking can partly be achieved if the stock owners are given an alternative food supply. It has been shown in 3.7.4. and 3.7.5 that crops can be grown in the drier areas provided water conservation is carried out and a proper crop is chosen. The introduction of arable cropping together with destocking seems the only possible way to prevent large tracts from becoming "badlands" in the next few years. *See* also 4.3 and 4.7.

4.—INTERPRETATION OF SURVEY DATA

4.1. Methods of Land Evaluation

A soil survey provides the fundamental information about soil and land characteristics. The information may be used for a variety of practical purposes such as various types of agriculture, range, wildlife, etc. They all involve interpretation of data. Land is classified to show its relative value for a certain kind of land use. Different methods are used to classify the land for different purposes. The method of land evaluation for this survey area follows similar lines as the one used for the Kindaruma area. A comprehensive account of the origin and details of the procedure is contained in the report "Soils of the Kindaruma Area" (van de Weg and Mbuvi, *eds*, 1975).

Basic in this approach is that land evaluation is meaningful only in relation to clearly defined land uses and therefore relevant land use possibilities: *Land use alternatives* (land utilization types) should be identified at an early stage in the land evaluation procedure. The identification of relevant forms of land use requires considerable agro-economic insight and the full attention of a specialist for the collection and subsequent comprehensive definition of all relevant land use alternatives. A consultant, Ir. C. de Jong was called in by the Kenya Soil Survey. His report on the "Land use alternatives in high potential areas of medium to high altitude (Kapenguria)", which is the result of discussions and interviews with a great number of persons whose field of work is connected with the development of the area, and the study of literature, has been published as a separate publication by the Kenya Soil Survey (de Jong, 1976).

Each land use alternative is defined by use of some specific factors that need to be accounted for as having a marked influence on the performance of the land and which therefore are an integral part of the relevant definition of a land use alternative.

These factors are.—

- produce,
- capital intensity,
- labour intensity,
- farm power,
- farm size,
- land tenure,
- incomes, and
- price structure.

The land use alternatives considered relevant to the Kapenguria area are the following:

Smallholder rainfed mixed farming, intermediate technology, medium altitude.
Smallholder rainfed mixed farming, advanced technology, medium altitude.
Large-scale rainfed mixed farming, advanced technology, medium altitude.
Small-scale livestock farming, intermediate technology, high altitude.
Extensive range management (combined with bee-keeping and subsistence crop growing).
Forestry.
Smalholder irrigation.

For elaboration of each of these land use alternatives the reader is referred to be con-report; Table 14 summarizes all relevant data on each of the land use alternatives concerned (de Jong, 1976).

Two kinds of interpretative classification have been used as follows.—

Current suitability classification.—
An appraisal of the suitability for a specific use in the present condition or with "modest" modification.

Potential suitability classification.—
An appraisal of the suitability for a specific use when it is known or assumed that *major* improvements will have been effected where necessary.

The distinction between the two classifications indicate to the user whether and in what manner land improvement or land conservation measures, as can be implemented at the relevant land use alternative, have been taken into account in assessing the suitability. In this context a "major improvement" is a substantial capital investment in land improvement (as opposed to recurrent) that will result in a major and reasonably permanent change in the characteristics of that land. For most of the land use alternatives the current suitability classification has been considered. The potential one has been considered relevant only for some of the land use alternatives. Details of the major improvements which have to be effected to "reach" the potential suitability are outlined in subchapters 4.3 to 4.11.

Three orders of land suitability have been defined: (FAO, 1972, 1973 and 1975)

Order 1: Suitable land—
Land on which sustained use (continuing use, without deterioration of the land) for the defined purpose in the defined manner is expected to yield benefits that will justify required recurrent inputs without unacceptable risk to land resources on the site or in adjacent areas.

Order 2: Conditionally suitable land—
Land which, in general, is unsuitable for sustained use in the defined manner but which would only be suitable *under specific conditions of management.*

Order 3: Unsuitable land—
Land having characteristics which appear to preclude its sustained use for the defined purpose or which would create production, upkeep and/or conservation problems requiring a level of recurrent inputs unacceptable at the moment.

In Order 1 and 2, three classes have been distinguished as follows:—

Class 1.1 highly suitable	2.1 conditionally highly suitable
Class 1.2 moderately suitable	2.2 conditionally moderately suitable
Class 1.3 marginally suitable*	2.3 conditionally marginally suitable.

Within each classification (current and potential) tracts of land are evaluated *separately* for *each* relevant land use alternative. Each *potential* suitability classification has to be based on the assumption that specific "major improvements" have to be effected. The following rather broad classification of "input" requirements has been used. It gives some broad qualitative standards.

* in the suitability rating for range, class 1.3 has been subdivided in 1.3.1: marginally suitable and 1.3.2: submarginally suitable.

Input	Technical difficulty	Cost
A: low	low, may require some technical advisory services to the farmer	low, usually borne by farmer with occasional credit facilities.
B: moderate	moderate, requires important advisory services to the farmer	moderate, borne by the farmer/group of farmers with short-term credit facilities.
C: high	high, needs to be entrusted to specialists both for planning and execution; special equipment needed.	high, requires government funds or long-term credit facilities.
D: very high	as for C	very high.

The evaluation data for the Kapenguria map are presented in tabular form (Appendix 3). Given the number of land use alternatives for which the evaluation had to be made, the cost of map production prohibited the "ideal" situation of having a colour-printed suitability map for each land use alternative. This problem was solved by presenting in addition to the coloured soil map, a non-coloured soil map on which the ecological information is superimposed as an overprint (Appendix 2), together with a Key for Land Evaluation (Appendix 3). The key will enable the user to colour the map by hand according to the suitability for a particular land use alternative he is interested in. Uncoloured copies of the map are available on request from the Kenya Soil Survey, National Agricultural Laboratories, Nairobi. In Appendix 3 the top row shows the respective land use alternatives for which an evaluation was made. Each land use alternative serves as the subject matter of separate evaluations. Each evaluation as such has been considered independently and without reference to the desirability of other relevant uses of the same land. The first vertical column gives the soil units which occur under various slope classes and different ecological zones (*see* chapter 1.5). In parallel *horizontal* columns the suitability class of each "mapping unit" (being a combination of soil, slope class and ecological zone) for each land use alternative is shown. For some land use alternatives both current and potential suitability are given. In that case also the level of input required is then indicated. It should be noted that a suitability class (1.1, 1.3, etc.) indicating a certain degree of suitability may *not* have the same economic significance when applied to different land use alternatives.

4.2. Diagnostic Procedures and Criteria

In many existing systems of land evaluation, single or minor land characteristics, such as texture, drainage, are used as a basis for diagnosis and for establishing suitability class-determining specifications. But only if the expression of a land characteristic is extreme (e.g. very steep slope, very shallow soil) it is likely to influence suitability independently. The majority of characteristics must therefore be considered jointly with, or in relation to other characteristics. Therefore single characteristics are grouped into a combination called a *land quality*. A major land quality can be used as a largely independent diagnostic criterion reflecting limitations to land suitability. It can be rated and quantified; and suitability class limits can be specified using the rated criteria. For the evaluation of the soil and land resources in the Kapenguria area the following land qualities were the criteria used.—

(*a*) climate, i.e. ecological zone
(*b*) soil moisture storage capacity
(*c*) chemical soil fertility
(*d*) possibilities for the use of agricultural implements
(*e*) resistance to erosion
(*f*) hindrance by vegetation
(*g*) presence of overgrazing
(*h*) depth of soil (foothold)
(*i*) presence/hazard of waterlogging.

TABLE—14—QUANTIFIABLE FACTORS FOR THE VARIOUS LAND UTILIZATION TYPES

Land Utilization Type	Produce	Capital Intensity Sh./acre	Labour intensity man-equivalent/ 1,000 acres	Farm power	Level of technical know-how	Farm size acres/house-hold	Land tenure	Farm income value added/ acre	Price structure
I Small-holder rain-fed mixed farming, intermediate technology, medium altitude	Maize, pulses, sunflower, Zebu beef cattle and a few dairy cattle	*Investment:* 300–400 Sh./acre (excl. land and buildings) *Recurrent costs:** 100 Sh./acre	Rather high 100 to 140	Only land preparation mechanized (tractor)	Low to moderate	Average: 20 to 25 acres (30% crops, 70% livestock)	Non-adjudicated land is frequently leased to "outsiders", this might lead to serious problems in future	Average: 200 Sh./ acre (as long as shifting cultivation can be practised in maize growing)	Transport costs are high, which leads to low farm gate prices
II Small-holder rain-fed mixed farming, advanced technology, medium altitude	Maize, English potatoes, pyrethrum, tea, coffee, dairy and beef cattle (graded), wool sheep	*Investment:* 500 to 600 Sh./ acre (excl. land and buildings) *Recurrent costs:** 250 Sh./acre	High: approx. 160	Only land preparation for crop growing is mechanized (tractor)	Moderate to high	Average: 15 acres (30% crops, 70% livestock)	—do—	Average 300 Sh./ acre	Low farmgate prices, because of high transport costs,
III Rain-fed large-scale mixed farming, advanced technology, medium altitude	Maize, seed maize, sunflower, wheat, dairy and beef cattle (graded cattle)	*Investment:* 500 to 700 Sh./ acre (incl. land and buildings) *Recurrent costs:** 300 to 350 Sh./ acre	Rather low: approx. 40	Highly mechanized (tractor)	High	Average: 1,000 acres (20 to 25% crops, 75 to 80% livestock)	In principle no problem, however, illegal splitting up of large-scale farms is presently becoming serious	Average: 100 Sh. /acre (75% for the labour force, 25% for the management)	Especially the price of seed maize is presently much to low in comparison with the price of commercial maize

*excluding family labour; 1 acre = 0.4 ha.; 100 Sh./acre = 250 Sh./ha.;100 maneq./1000 acre = 250 maneq./1000 ha..

TABLE 14—QUANTIFIABLE FACTORS FOR THE VARIOUS LAND UTILIZATION TYPES—(*Contd.*)

Land Utilization Type	Produce	Capital Intensity Sh./acre	Labour intensity man-equivalent/ 1,000 acres	Farm power	Level of technical know-how	Farm size acres/household	Land tenure	Farm income value added/ acre	Price structure
IV Small-scale livestock farming, intermediate technology, high altitude	Beef, mutton, wool	*Investment*: 200 to 300 Sh./acre (excl. land and buildings) *Recurrent costs*:* 100 Sh./acre	low: 10 to 15	Completely hand-operated	Moderate	40 to 50	Land not yet adjudicated	Average: 100 Sh./acre (80% of livestock, 20% of subsistence crops)	Beef is generally priced too low
V Extensive range management (combined with beekeeping and subsistence crop growing)	Beef, mutton, goat meat, honey, sorghum, millet, maize	*Investment*: <100 Sh./acre (incl. dams, boreholes and dips) *Recurrent costs*:* 5 Sh./acre	Very low 5 to 10	Completely hand-operated	Low to moderate (basically a departure from the traditional way of live)	Approx 150	Communal grazing on communally owned range-lands with privately owned herds (group ranching)	Average: 15 Sh./acre (including income from honey and subsistence crops)	—do—
VI Forestry	Timber, poles and fuel wood	*Investment*: rather high* *Recurrent costs*: rather high	Moderate (if labour of related industries is included)	Partly mechanized, partly hand operated	High	Approx. 10,000 acres per saw-mill	Government gazetted areas	Depending on "royalties"	—
VII Small-holder irrigation	Food crops such as maize, sorghum, rice; cash crops such as vegetables, tobacco, cotton	*Investment*: 1,000 Sh./acre (excl. land and buildings; incl. pumps, etc.) *Recurrent costs*:* 250 to 500 Sh./acre.	Very high: 200 to 500	Land preparation tractorized, for the rest handwork	Rather high	Approx. 4	Land adjudication required	1,000 to 5,000 Sh./acre (depending on choice of crops)	—

*Excluding family labour

For the rating of the land qualities proposals have been prepared at KSS but as they are still tentative it was decided not to include the full details in this report. Mimeographed copies can nevertheless be obtained at request from the Kenya Soil Survey (stencil S269, new edition S472). In this rating system the land qualities are classified into five grades, ranging from 1 (very high) to 5 (very low). For an account of the single characteristics used in the rating of the land qualities see the above-mentioned stencil and the report on the Kindaruma soils (op. cit.). For the rating of the land qualities of each of the mapping units in the Kapenguria area *see* Appendix 7 at the back of this report.

The next step is the establishment of specifications for the diagnostic criteria (= the land qualities) that will define the suitability class levels for each land use alternative separately. This is the most difficult step in the land evaluation procedure as this determines the final suitability evaluation. In fact this is a multidisciplinary exercise and requires also the participation of the expected users of the land evaluation.

After the establishment of the specifications, the *current* suitability evaluation of "each mapping unit" for each land use alternative was carried out, by comparison of the land qualities of that particular "mapping unit" with the specifications prepared for each land use alternative ("conversion tables"). Before arriving at the *potential* suitability evaluation, following the same procedure as for the current one, an identification and appraisal of the desirable "major improvements" was made.

4.3. Land Suitability for Smallholder Rainfed Mixed Farming, Intermediate Technology, Medium Altitude

—for an elaborate account of these land use alternatives, *see* the report of de Jong, 1976

	altitude	*ecological zone*
—very high altitude	3000 m.	I
—high altitude	2400 — 3000 m.	IIc
—medium altitude	1800 — 2400 m.	IIw + III

Intermediate technology is defined here (Luning, 1973) somewhat loosely as that level of technology where certain inputs (fertilizers, insecticides, mechanized land preparation, etc.) are used on a modest scale. This land use alternative is mostly practised at present in the areas around Kapenguria (Mnagei Location). The most important crop grown is maize, next to this crop, pulses and sunflower are grown. Livestock enterprises are also of importance in this mixed farming type. Investments are for the greater part confined to machinery and farm equipment. The source of farm power in the Mnagei area is mainly the tractor, whilst in other areas it is still the traditional jembe. Animal power is virtually not employed. As regards recurrent inputs seeds and fertilizers are the major items. At present, most of the reasonable high yields in the Kapenguria area are obtained without the use of any significant amount of fertilizer, but this happens only on recently cleared forest land, so that farmers still benefit from the high initial fertility of these soils. However, in the near future rather high levels of fertilizer application will be needed to maintain the present yield levels.

The major limiting land qualities are "soil moisture storage capacity" (soil depth); slope of which aspect is taken care of in two land qualities: "possibilities for the use of agricultural implements" and "resistance to erosion"; "chemical soil fertility", and in ecological zone IV and V also lack of rainfall.

This land use alternative has been taken into account for the ecological zones IIw, III, IV and V. However, for zone IV and V the evaluation has been indicated in the form of *conditionally suitable*, on the *condition* that crops grown in these zones are the more drought resistant ones like sorghum and millet, as these zones are not suitable for growing maize, pulses, etc.

For the suitability rating *see* Appendix 3 (in folder). Only the *current* suitability rating is given, assuming that forest/bush clearing (land preparation) is included in the definition of this land use alternative. The potential suitability is not relevant here as no "major improvements" are involved for this type of land use.

4.4. Land Suitability for Smallholder Rainfed Mixed Farming, Advanced Technology, Medium Altitude.

Advanced technology is here defined as that type of farming whereby the full range of modern inputs is being used, as recommended through agricultural research. This land use alternative, although hardly existent at present is suited to the conditions prevailing in the areas of ecological zones IIw. and III. As in the course of time agriculture in the area will have to be intensified, the farmers will be compelled to adopt modern technology because of the increasing pressure on the land. A prerequisite for this development however is that the land resources will be protected against the devastating effects of soil erosion by effective soil (and water) conservation.

The crops considered here are beside maize, the high yielding, high labour and capital intensive cash crops such as coffee, tea, and pyrethrum. Soil and climate requirements for these crops are summarized in Table 15. Capital intensity is high, and is estimated to be around K.Sh. 500 per acre (de Jong, 1976). This amount does not include the establishment costs of the perennial crops which can be estimated at K.Sh. 900 per acre for coffee, K.Sh. 1,200 per acre for tea, and K.Sh. 1,000 per acre for pyrethrum (opus cit.). The source of farm power is generally the tractor. As regards recurrent inputs seeds, fertilizers, herbicides, etc. are the major items. The major limiting land qualities are "soil moisture storage capacity" (soil depth a.o.) and slope. This land use alternative has been taken into account for the ecological zones IIw, III and III-IV.

For the suitability rating *see* Appendix 3. Only the *current* suitability classification is given here, assuming that forest/bush clearing is included in the definition of the land use alternative. The *potential* classification is not relevant here as no "major improvements" are involved in this type of land use.

TABLE 15.—SOIL AND CLIMATE REQUREMENTS FOR SELECTED CROPS

POTATOES

Altitude.—higher than 1800 m. but lower than 2900 m.; occasionally found between 1800 m.

Temperature.—16°-19°C.

Rainfall.—250 mm. rain/month for at least 3½ months.

Soils.—free draining; heavy soils difficult for rooting and harvesting; good supply of nutrients needed (NPK).

COFFEE

Altitude.—higher than 1400 m. Mt. Elgon up to 2100 m.

Temperature.—15°-22°C.

Rainfall.—optimal around 1800 mm./year, but with 1000 mm./year still possible (addit. irr.); rainfall must be well distributed.

Soils.—pH 5.3 up till 6.0/6.5; free draining soils; good water retention; not too heavy soils; depth pref. more than 180 cm.; high nutrient status.

PYRETHRUM

Altitude.—more than 2000 m., up to 2500 m.

Temperature.—<16°C.

Rainfall.—optimal around 1800 mm./year, but with 1000 mm./year still possible with additional irrigation; rainfall must be well distributed.

Frost.—mild frost is no problem.

Soils.—pH more than 5.6; good structured soils; well drained, fairly rich soils.

TEA

Altitude.—1500-2200 m.

Rainfall.—minimum around 1400 mm./year; optimal 1500-1750 mm./year, well distributed.

TABLE 15.—SOIL AND CLIMATE REQUREMENTS FOR SELECTED CROPS—(*Cont.*)

Temperature.—optimal 21°-16°C; lowest temperature 12°C.

Soils.—pH from 4.0-6.0; optimal 5.4-5.6; depth preferably more than 180 cm.; well drained; good water retaining capacity.

MAIZE

Altitude.—less than 2400 m.

Temperature.—light frost kills.

Rainfall.—more than 300 mm./growing season.

Soils.—well drained, fairly rich soils

Source.—East African Crops, by Acland, 1971.

4.5. Land Suitability for Large-Scale Rainfed Mixed Farming, Advanced Technology, Medium Altitude

This land use alternative is at present already being practised in most of the Kitale (Trans-Nzoia) area, which belongs to ecological Zone III. Large stretches of land are a prerogative and the land quality "possibilities for the use of agricultural implements" is an important factor, as this farm type is highly mechanized. The large-scale mixed farming is practised at a relatively high, but locally strongly varying, level of technology. The large-scale farms have still an important role to play in the production of hybrid maize seed and wheat and breeding stock to smallholders, as well as ensuring adequate food surpluses for the urban population and for possible "famine areas". This land utilization type calls for a high level of management. However due to the new fashion of group ownership of large-scale farms, management standards are declining generally. Fragmentation of the large-scale farms, and illegal settlement of non-registered partners actually takes place to the detriment of the viability of these farms. Rehabilitation of these farms would therefore also mean that these practices of fragmentation and illegal settlement must be brought to a halt.

The most important crops currently grown in the large-scale farming area are commercial maize, seed maize, wheat (the latter only in the areas W. of Kitale) and sunflower; furthermore large stretches are under grass and are used for dairy and beef cattle. The capital intensity is very high namely some K.Sh. 500-700 per acre. Investment covers land, farm buildings, farm machinery and livestock. Recurrent cost cover fertilizers, harbicides, etc. Labour intensity is low. The source of farm power is exclusively the tractor. Farm sizes are in the order of 1,000 acres. Limiting factors are in places: slope (reflected in the land quality "possibilities for the use of agricultural implements") and soil depth (reflected in "soil moisture storage capacity").

This land use alternative has been considered and evaluated for the ecological zones IIw, III, IV and V. For the latter two zones this land utilization type is however only feasible under the condition that "dry-farming" techniques and drought-resistant crops are feasible and are applied. The zones IV and V are too dry to consider this land use alternative with the farming system as practised in the Kitale/Trans-Nzoia area. For the suitability classification *see* Appendix 3. For the Kitale area, only the *current* suitability classification is considered as no "major improvements" are needed. For the areas considered as *conditionally* suitable, only the *potential* suitability classification is given, as a "major improvement" is a prerequisite. Input requirement levels here are estimated (de Jong, pers. comm.) at levels B to C (*see* 4.1) and may be in the order of K.Sh. 1,000 to 1,500 per hectare covering items as buying of land, machinery, buildings, fencing and grading of the land.

4.6. Land Suitability for Small-Scale Livestock Farming, Intermediate Technology, High Altitude

This land utilization type is well suited to the ecological conditions in the region of ecological zones IIc and lower parts of I. In these areas crops require a very long growing season, also the condition of the roads and the distance to the nearest market centres

prevent profitable cash crop growing. Moreover the topography of the area is such that only small parts may be suitable for crop growing. Grasses however thrive under the prevailing conditions. It is therefore obvious that livestock enterprising is the most suitable activity to be developed in these areas. Beef cattle and wool sheep seem to be the obvious choices. Beside the livestock enterprises some crops such as potatoes and some vegetables could be grown for the livestock farmer's own subsistence. Capital intensity is low to moderate depending on whether sheep or beef cattle are kept, most of the investment refers to livestock. The major limiting factor is slope (land quality: "resistance to erosion") and also accessability of the area. Much care should be taken to avoid overgrazing. The area does not at present show signs of overgrazing. However, along cattle tracks one can see the beginning of soil erosion in the form of terracettes (*see* photograph).

For the suitability classification *see* Appendix 3. This land use alternative has been considered only in ecological zone IIc and I. Also, only the *current* suitability classification has been taken into account, as no "major improvements" are involved.

4.7. Land Suitability for Extensive Range Management

This land use alternative has been considered for ecological zones III-IV, IV and V. This land use alternative can be described as an organization of livestock keeping where a group of farmers pool their animals (group ranching). However most of the grazing in this area is at present done in the traditional pastoral way, except for the area south of Kongelai where the Riwa group ranch has existed for some time. Rangeland is never likely to be very productive either in terms of shillings or in employment per ha. It should be appreciated therefore that only those areas which offer little scope for arable farming should be allocated to extensive range management (*see* also von Kaufmann, 1976). Therefore this land use alternative will have a future only in areas where certain land qualities, in this case particulary climate ("ecological zone") and slope ("resistance to erosion") are so adverse that arable farming is not to be recommended.

A prerequisite for this type of land use is the availability of drinking water and controlled grazing; stock numbers should be brought in line with the land carrying capacity. The necessary "destocking" of the areas is currently stimulated through an extensive livestock marketing programme in the area. If these measures fail, the present overgrazing will continue and will ultimately lead to a complete destruction of the grazing grounds.

As stated clearly by de Jong (1976) much thought should be given to subsistence growing of sorghum and millet which are rather drought-resistant. In relation to this, the reader is referred to section 4.3 and Appendix 3, where the areas with some possibilities for smallholder rainfed arable farming have been indicated as *conditionally* suitable. Bee-keeping should be encouraged as this can be an additional source of income.

For the suitability classification *see* Appendix 3. Both the *current* and the *potential* suitability classification are presented. "Major improvements" concern water facilities (dams, boreholes), dips, stock handling facilities, fencing and last but not least initial bush clearing. Recurrent costs however concern maintenance of watering places, prevention of bush regrowth, etc. The required input level has been estimated (de Jong, personal communication) at the level B and will be in the range of K.Sh. 50-200 per ha. Land qualities such as "availability of drinking water", "nutritional value of grazing land", etc. are difficult to quantify and information is scant for the present survey area. They are therefore not taken into account here; in the present approach only the land qualities mentioned in section 4.2. are considered.

4.8. Land Suitability for Smallholder Irrigation

Smallholder irrigation projects are defined as those schemes where project management is limited to a minimum and where the freedom to cultivate is large. In this area the potential for the development of such schemes is very limited, mainly due to lack of suitable land. Only some areas near Kongelai, in the Wei-Wei valley and near Ortum can be taken

into consideration. Only for those few areas where it may be feasible to supply some irrigation water, a suitability classification is given. Crops which can be grown are mainly food crops, but some cash crops especially vegetables could be considered; in most cases however lack of sufficient market demand within economic reach of the schemes will be a strongly limiting factor. However in the minor-irrigation schemes emphasis is on food crop production since the major aim of the Minor Irrigation Development Programme is to improve the livelihood of the drought-stricken farmers and pastoralists, while it simultaneously reduces the burden of Kenya Government famine relief. Investment costs vary considerably from place to place depending on topography, soil type, availability of water, etc. Total investment costs are roughly K.Sh. 700 to 900 per acre (de Jong, 1976), when pumping is needed even higher. They concern costs for land levelling, primary canals, pumps and others. Recurrent costs are in the order of K.Sh. 250 to 500 per annum depending on the cost of pumping and water. The level of technology required is rather high especially when vegetables are grown.

For the *potential* suitability classification *see* Appendix 3.

4.9. Land Suitability for Silviculture (Forestry)

In the Kapenguria soil survey area 20 to 25 per cent of the gross area is covered with indigenous forest. The area under plantation forest is negligible. All the forest lands are in the highlands (ecological zone IIc and IIw). Almost all of the forest in zone IIw and some 40 per cent of the forest in zone IIc is in principle suitable for exploitation. Because of lack of data concerning the forest reserves it is impossible to give any clear idea about the possible yields of the various sub-areas, about the investments needed to open up the area, or about the total exploitation costs. In view of the remote location of the areas, however, it may be assumed that exploitation costs would be relatively high. In considering the possibilities for forest exploitation it should be realized that, apart from their timber potential, the indigenous forests have a number of other functions such as the protection of water catchment areas (*see* subsection 4.10). Most of the forest reserves should be kept intact, in spite of the increasing land hunger due to population growth. This however does not mean that the possibility of establishing and exploiting exotic softwood plantations in part of the protected forest area should be excluded, although the utmost care should be taken to preserve the water conserving function. It is very well conceivable that in this way the Kapenguria area could play an important role in the supply of wood, for which there is an increasing market, at home as well as abroad.

In the areas of ecological zone III and IV fuel wood and building pole plantations are viable enterprises. The urban domestic market for charcoal is also growing rapidly. To meet this growing demand for fuel wood and building poles the Government will have to promote and support the establishment of these plantations wherever possible.

The suitability classification as presented in Appendix 3 is divided into two. The first one gives a suitability rating of the *present forest value*. So it takes into account only those areas which at present are under forest, mainly in ecological zone IIc and IIw. This rating is based only on a rather superficial interpretation of the forest inventory maps prepared in 1966 (Kenya Forest Department). The classification therefore only serves as a rather broad qualitative indication. The second classification, *after inputs*, indicating the suitability for plantation forest has been given for the whole area. Here an attempt has been made to give a suitability classification of the land for forestry (silviculture). As stated before fuel wood and building pole plantations could be established near villages and larger population centres. In establishing these plantations, the different climatological conditions should be taken into account, as far as species to be planted and expected production are concerned. However, very little is known at present on this subject, it is however clear that most of the planting should be done with exotic softwood. Most land qualities, mentioned in subsection 4.2. including "foothold" (depth of soil) have been taken into account in this *potential* suitability classification. Soils which are shallow (less than 50 cm. over hard rock) and stony, are considered to be unsuitable. Input requirements are rather high, mainly depending on the present infrastructure and may vary from B to D (*see* subsection 4.1).

Some of the forest areas may be classified as purely *protective* in which all clear felling should be avoided in order to protect the slopes against erosion and to safeguard the water supply to villages and towns, *see* section 4.10.

4.10. Land Suitability for Protection/Nature Reserve

As indicated in Appendix 3 certain areas should be set aside for protection (*protective vegetation*). In fact it concerns those areas which should be protected to avoid serious erosion which may have both local and downstream effects. Beside the protection of water catchment areas other important functions of the indigenous forest reserves are the provision of dry weather grazing for livestock and possibly, the provision of a basis for tourist development. It should be stressed that it concerns large stretches of land at present forested or under bush. The following percentages of land in the survey area are as *protective vegetation* indicated in the land evaluation:

in zone IIc	43720 ha. or 66 per cent of that zone
in zone IIw	32830 ha. or 65 per cent of that zone
in zone III-IV	53170 ha. or 89 per cent of that zone
in zone IV	10870 ha. or 17 per cent of that zone

this amounts to 141.130 ha. out of 305.900 ha. which is around 46 *per cent of the total surveyed area.*

As stated before this protection does not mean that no use at all could be made of that land. Some additional but controlled grazing could be practised in part of that land and, as mentioned in a previous section, the forests may serve a dual purpose of protection against erosion and the production of timber, fuel and poles, provided replanting takes place.

For some stretches of land it is indicated in Appendix 3 that an alternative could be *nature reserve*. The higher parts of the Cherangani Hills, although not blessed with a spectacular abundance of game, are unique from a point of view of vegetation and beauty of the scenery (cf. the Aberdares National Park). It should be seriously considered to set apart these areas as a national park.

4.11. Land Suitability for the Collection of Natural Products

This deals with the collection of honey and charcoal. Both aspects have been dealt with in consultancy reports (Luning, 1973 and de Jong, 1976). These land uses are genuinely "residual" ones and it is felt that no separate suitability classification should be attempted as they are practised by the people in the area together with other land uses. They can be an additional source of income especially where smallholder farming, extensive range or silviculture are practised.

4.12. Land Suitability for Engineering Purposes

At the advice of the staff of the Materials Branch (Ministry of Works) it was decided to prepare a separate "Soil Engineering map". It is derived from the reconnaissance soil map by combining various soil mapping units into major soil groups with significant differences in engineering properties. In addition to the soil information supplied by the reconnaissance soil map, also plasticity data (analysis carried out in the laboratories of the Materials Branch) were incorporated. The grouping of soil units was carried out by the staff of the Materials Branch in co-operation with the Kenya Soil Survey.

The "Soil Engineering map" is presented in black and white as a separate appendix (No. 10) to the report, but is included only in a limited number of copies. The map is however available at request from he Kenya Soil Survey offices in Nairobi. In the map legend, the soil groups are described and also classified according to the following two engineering soil classification systems:

1. U.S.C.S. Classification (the unified Soil Classification System which is the extended Casagrande classification system)
2. A.A.S.H.O. classification (the "American Association of State Highway Officials" system)

It should be stressed that this map is intended for those interested in the engineering properties of the soils, but it should not directly be used for final designs of roads and building foundations; for the latter, several separate engineering suitability maps could be prepared, on the basis of the soil engineering map as presented.

5.—RECOMMENDED LAND USE

The suitability of the various land tracts for the different land use alternatives (*see* Appendix 3 to this report) shows the range of uses for which each tract of land may to a varying degree be suited. It should be reiterated that an interpretative class indicating a certain degree of suitability (highly suitable, moderately suitable, etc.) may *not* have the same economic significance when applied to different land use alternatives.

So far, no judgement has been passed on the desirability of one land use alternative versus another. This study is mainly confined to the natural resources aspects. *The selection of the most promising land use alternative should be left to the planners.* Various socio-economic and political factors like labour policy are also playing a role in this selection procedure and these latter factors are beyond the scope of the present study. The reader is also referred to de Jong's report (1976) in which an economic evaluation is given of the various land use alternatives taken into account. However, certain recommendations are given below as to what obviously seem to be the most promising land use for broad sections of the survey area (*see* Fig. 15).

In the *South-Western corner* of the area (ecological zone III) most of the land is highly to moderately suitable for both large-scale rainfed mixed farming and smallholder rainfed mixed farming both with advanced technology.

In the *North-Western part* of the area (ecological zone IV) possibilities for arable farming are very limited. Part of this area is however *potentially* moderately suitable for extensive range management. Co-operative and/or group ranching with known and feasible management techniques should be stimulated together with stringent grazing control. If these measures fail and the present overgrazing will continue, it will lead to a complete destruction of the grazing grounds.

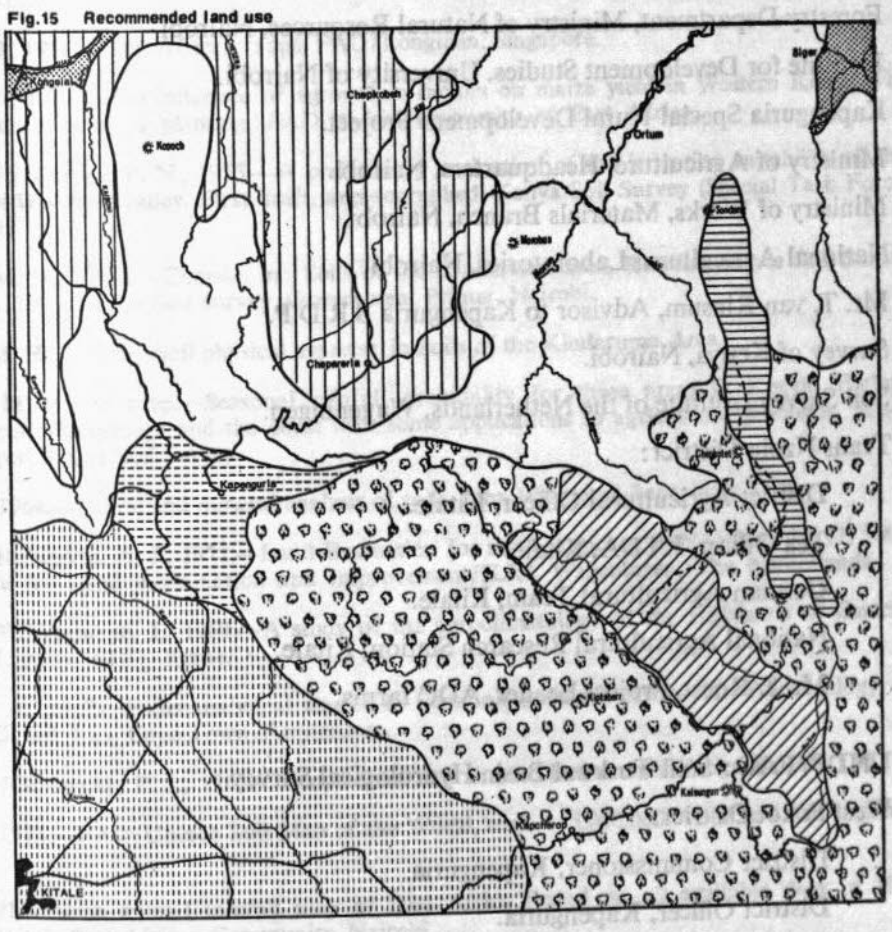
In the *Cherangani highlands* large stretches of land are covered with indigenous forest. Because of its importance in the protection of water catchments almost all of the indigenous forest is gazetted as protective forest reserve and it is strongly urged that most of this forest should be kept intact, in spite of the increasing land hunger due to population growth. This however does not mean that exploitation in part of the protected forest area should be excluded although the utmost care should be taken to preserve the water conserving function.

In part of the *higher altitude areas* which at present are already mainly under grass (part of ecological zone IIc) livestock enterprising seems to be the most suitable activity to be developed. Dairy as well as beef cattle and wool sheep could be kept but sheep too would be profitable.

In the steep and *mountainous areas North of Kapenguria and in the north-eastern corner* (ecological zone III-IV) the present vegetation should be protected as much as possible to avoid accelerated erosion. Any indiscriminate clearing of the vegetation within these catchment areas would inevitably result in serious erosion.

The highest parts of the Cherangani hills are unique from a point of view of vegetation and beauty of the scenery. It should be seriously considered to set apart these areas as a national park.

Fig.15 Recommended land use



large scale mixed farming/ smallholders mixed farming, advanced technology

smallholders mixed farming, intermediate technology

small scale livestock farming

extensive range management

smallholders irrigation

silviculture

protection of natural vegetation with in places silviculture/controlled grazing

nature reserve

0 10 20km

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6. Institute for Development Studies, University of Nairobi.
7. Kapenguria Special Rural Development Project.
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    Tea Officer, KTDA, Kitale.

    German Agricultural Team, Kitale.

    National Agricultural Research Station, Kitale.

    Mr. J. Roest, Project Leader, ADC farms.

15. UNDP/FAO: Staff Turkwel Basin Hydrological Survey.
16. West Pokot District:

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    District Officer, Kapenguria.

    District Agricultural Officer, Kapenguria.

    District Crops Officer, Kapenguria.

    District Range Officer, Kapenguria.

    District Forest Officer, Kapenguria.

    Chief, Lelan Location, Kaibibich.

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APPENDIX 6:

Detailed descriptions of representative soils and analytical data.

Map Unit	*Profile No.*
MGh	326
MQh	383
MFC	520
HGh2	55
HLC	505
FGrc	515
FGrce	107
FGby	536
FGbys	523
U2Gry	629
U2Gh1	378
p	
U2Gh1–U2Gh2	384
p	
U3Gh	61
U3GC1	62
U3GC2	53
U3Gby	391
p	
U4Ur	2
U4Ub	18
U5Frc	104
p	
U5Bbc2	57
U6Gbc	540
p	
U7Bbc	60
p	
U7Bb–U7Bbc	488
P p	
YGbc1	539
YGbc2	542
Agc	5
AC	507
Vgc	3
VC	11

LABORATORY DATA SHEET—SOIL PROFILE NO. 75/1—326

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	3575	3576	3577	3578	3579
Horizon	A11	A12	AB	B	C
Depth in cm.	0–15	15–60	60–100	100–120	120–170
Moisture % air dry soil					
Gravel %	—	9	51	16	39
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	62	60	68	72	76
Silt % 50–2 μ	18	18	8	8	8
Clay % 2–0 μ	20	22	24	20	16
Texture class	SL/SCL	SCL	SCL	SL/SCL	SL
Dispersed clay %	16	16	12	8	8
Flocculation index	20	20	50	60	50
Soil-liquid 1:1 susp:					
pH–H_2O	5·6	5·9	6·0	6·1	6·0
pH–KCl	4·5	4·5	4·5	4·1	4·4
EC in mmho's/cm.	0·06	0·03	0·02	0·02	0·01
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4 \cdot 2H_2O$%					
C%	2·41	2·18	1·31		
N%	0·19	0·16	0·11		
C/N	12·7	13·6	11·9		
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4 OAc, pH 7·0) me%	8·0	8·3	5·4	3·8	3·4
Exch. Ca me%	2·4	2·8	1·7	0·8	0·4
Exch. Mg me%	1·3	1·2	0·7	0·4	0·4
Exch. K me%	0·6	0·2	0·3	0·1	0·2
Exch. Na me%	0	0·2	0·2	0·1	0
Sum of cations me%	4·3	4·4	2·9	1·4	1·0
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	54	53	54	37	29
E.S.P. at pH 8·2					
Exch. acidity me%	0·3				
Miscellaneous:					
Silt/Clay Ratio	0·9	0·82	0·33	0·4	0·5

Special analyses: Area Kapenguria

Depth in cm.	0–15	15–60	60–100	100–120	120–170
Texture U.S.D.A.:					
Sand % 2.0 –1.0 mm.					
1.0–0·5 mm.					
0·5–0.25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
total sand %					
Silt % 50–20 μ					
20–2 μ					
total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3				1·7	
SiO_2/R_2O_3				1·5	
Fe_2O_3%				4·9	
X-ray Report:					
B	Predominantly well crystallized kaolinite				
Fertility aspects:					
Available Ca me% ..	2·0				
Available Mg me%	1·1				
Available K me%	0·4				
Available Na me%	0				
Available Mn me%	0·30				
Available P ppm	23				
Total Ca me%	5·4				
Total Mg me%	4·8				
Total K me%	3·3				
Total P ppm	120				

Map Unit MGh: Profile 326

Date of observation:	1st May, 1974, beginning of the rains.
Observation and location:	75/1–326, E390, N40·5; along the Cherangani highway 1 km. SE off turnoff to Chepareria.
Soil classification:	Haplic Phaeozem.
Ecological zone:	IIc.
Geological formation:	Predominantly biotite gneisses from the basement system.
Local petrography:	Biotite gneiss.
Physiography:	Mountainous; altitude about 7,800 ft.
Relief—macro:	Mountainous (38% slope); slopes 200–500 m. long.
Relief—micro:	Irregular.
Vegetation/Land use:	Forest plantation of mainly pinus spp.; good ground cover of herbs and grasses.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	38%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Well drained.

A11	0—15 cm.	Very dark greyish brown (10YR 3/2 dry), very dark brown (10YR 2/2 moist), sandy loam; moderate, fine to medium subangular blocky, breaking into fine granular elements in the top 5 cm.; slightly hard when dry, friable when moist, slightly sticky and non plastic when wet; many fine pores; abundant fine and very fine roots; gradual smooth boundary; (Sample 75/1–326a)
A12	15—60 cm.	Very dark greyish brown (10YR 3.5/2 dry), very dark brown (10YR 2.5/2 moist), slightly gravelly sandy clay loam; weak, very coarse subangular blocky to massive; consistence as A11; many very fine and common fine pores; occasional humus coatings; smooth gradual boundary; (Sample 75/1–326b)
AB	60–100 cm.	Very dark brown to brown (10YR 2.5/2–4/3 moist), very gravelly sandy clay loam; porous massive; consistence as A12; common very fine pores; common, very fine and fine roots; common, moderate humus coatings; smooth gradual boundary; (Sample 75/1–326c)
B	100–120 cm.	Pale brown (10YR 6/3 dry), brown (10YR 4/3 moist), gravelly sandy loam; porous massive; hard when dry, friable when moist, slightly sticky and non plastic when wet; many very fine and fine pores; common fine roots; smooth gradual boundary; (Sample 75/1–326d)
C	120–170 cm.	Very pale brown (10YR 7/3 dry), brown (10YR 5/3 moist), very gravelly sandy loam; rock structure is evident in many places; a mixture of weathered rock and soil material is common.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—383

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	9398	9399	9400	9401
Horizon	A11	A12	AB	B2
Depth in cm.	0–20	20–45	45–70	70–100
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	54	48	54	40
Silt % 50–2 μ	26	26	26	18
Clay % 2–0 μ	20	26	20	42
Texture class	SCL	SCL	SCL	C
Dispersed clay %	6	4	4	4
Flocculation index	70	85	80	90
Soil-liquid 1:1 susp:				
pH-H_2O	5·3	5·4	4·9	5·2
pH–KCl	4·3	4·7	4·4	4·3
EC in mmho's/cm.	0·08	0·04	0·08	0·03
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$%				
$CaSO_4.2H_2O$ %				
C%	5·91	4·53	5·62	1·68
N%	0·93			
C/N	6·6			
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	33·2	29·6	25·2	10·9
Exch. Ca me%	2·6	3·0	1·7	0·4
Exch. Mg me%	1·2	0·7	1·0	0·2
Exch. K me%	0·6	0·4	0·5	0·3
Exch. Na me%	0·2	0·2	0·2	0·4
Sum of cations me%	4·6	4.3	3·4	1.3
Base Sat. % at pH 8·2				
Base Sat. % at pH 7.0	14	15	13	12
E.S.P. at pH 8·2				
Exch. acidity me%	1·5			
Miscellaneous:				
Silt/Clay Ratio	1·3	1·0	1·3	0·43

Special analyses: Area Kapengaria

Depth in cm.	0–20	20–45	45–70	70–100
Texture U.S.D.A.:				
Sand % 2·0–1·0 cm.				
1·0–0·5 mm.				
0·5–0·25 mm.				
0·25–0·1 mm.				
0·1–0·05 mm.				
Total sand %				
Silt % 50–20 μ				
20–2 μ				
Total silt %				
Clay % 2–0 μ				
Texture class				
Bulk density				
Particle density				
Porosity				
Moisture % w/v at:				
pF 2·0				
pF 2·3				
pF 2·7				
pF 3·7				
pF 4·2				
Clay mineralogy:				
SiO_2/Al_2O_3				2·6
SiO_2/R_2O_3				2·1
Fe_2O_3%				11·2
X-ray report:				
B2	The components of the clay fraction are very well crystallized kaolinite and vermiculite with spacings of resp. 7·16Å and 14·24Å.			
Fertility aspects:				
Available Ca me%	2·4			
Available Mg me%	0·8			
Available K me%	0·34			
Available Na me%	0·15			
Available Mn me%	0·56			
Avaliable P ppm	46			
Total Ca me%	6·0			
Total Mg me%	4·0			
Total K me%	4·0			
Total P ppm	740			

Map Unit MQh: Profile 383

Date of observation:	2nd November, 1974.
Observation/location:	75/2–383, E69.7, N42.1, about 4 km. North of Chepkotet.
Soil classification:	Humic Cambisol.
Ecological zone:	IIc.
Geological formation:	Granitoid gneisses.
Local petrography:	Granitoid gneisses.
Physiography:	Mountains.
Relief—macro:	Middle position of slope (gradient 35%).
Relief—micro:	Smooth.
Vegetation/land use:	Moorland, close to montane shrubland.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	35%.
Salinity/alkalinity:	Nil.
Drainage class:	Well drained.

A11	0—20 cm.	Black (10YR 2/1 moist), sandy loam; strong, very fine and fine subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many fine and very fine roots; gradual smooth boundary; (Sample 75/2–383a)
A12	20—45 cm.	Very dark brown (10YR 2/2 moist), sandy clay loam; weak coarse and very coarse subangular blocky; consistence as A11; common very fine and fine roots; diffuse smooth boundary; (Sample 75/2–383b)
AB	47—70 cm.	Dark brown (10YR 3/3 moist), sandy clay loam; massive; firm when moist, sticky and plastic when wet; many fine and medium pores; few fine and very fine roots; diffuse smooth boundary; (Sample 75/2–383c)
B2	70—100 cm.	Dark brown (7.5YR 3/2 moist), clay; massive; consistence as AB.

LABORATORY DATA SHEET—SOIL PROFILE No. 7[illegible]/2—520

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	9329	9330	9331		
Horizon	A1	AB	B2		
Depth in cm.	0–35	35–72	72–142+		
Moisture % air dry soil					
Gravel %		24			
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	60	58	64		
Silt % 50–2 μ	20	16	12		
Clay % 2–0 μ	20	26	24		
Texture class	SL/SCL	SCL	SCL		
Dispersed clay %	6	20	12		
Flocculation index	70	23	14		
Soil-liquid 1:1 susp:					
pH–H_2O	6·3	6·5	6·8		
pH–KCl	5·4	5·2	5·5		
EC in mmho's/cm.	0·13	0·11	0·04		
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	1·50	0·56	0·26		
N%	0·15				
C/N	10·0				
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	14·0	10·8	10·2		
Exch. Ca me%	6·3	4·8	6·4		
Exch. Mg me%	4·8	3·3	2·5		
Exch. K me%	0·3	0·2	0·2		
Exch. Na me%	0·1	0·3	0·3		
Sum of cations me%	11·5	8·6	9·4		
Base Sat. % at pH 8.2					
Base Sat. % at pH 7·0	82	80	92		
E.S.P. at pH 8·2					
Exch. acidity me%	—				
Miscellaneous:					
Silt/Clay Ratio	1·00	0·62	0·86		

Special Analyses: Area Kapenguria

Depth in cm.	0–35				
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3%					
X-ray report:					
Fertility aspects:					
Available Ca me%	4·2				
Available Mg me%	3·2				
Available K me%	0·14				
Available Na me%	0·04				
Available Mn me%	0·18				
Available P ppm	24				
Total Ca me%	7·8				
Total Mg me%	7·2				
Total K me%	2·1				
Total P ppm	52				

Map Unit MFC: Profile 520

Date of observation:	28th October, 1974.
Observation/location:	75/2–520, E.74.8, N.54.0, West Pokot.
Soil classification:	Chromic Cambisol.
Ecological zone:	III+IV.
Geological formation:	Predominantly biotite gneisses of the basement system.
Local petrography:	Biotite gneisses with lenticulars of hornblende gneiss.
Physiography:	Mountainous.
Relief—macro:	Convex slopes of 100–150 m.
Relief—micro:	Irregular.
Vegetation/land use	Grassland, close to acacia woodland.
Erosion:	Nil.
Surface stoniness:	Slightly stony.
Slope gradient:	45%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Well drained.

A1	0—35 cm.	Dark reddish brown (5YR 2.5/2 moist), sandy loam; weak, fine to medium subangular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; common fine and medium, few coarse pores; many fine, medium and coarse roots; clear smooth boundary; (Sample 75/2–520a)
AB	35—72 cm.	Reddish brown (5YR 4/4 dry, 5YR 4/3 moist) gravelly sandy clay loam; moderate medium and coarse subangular blocky; consistence as A1; many fine to coarse pores; many fine and medium, few coarse roots; diffuse, smooth boundary; (Sample 75/2–520b)
B2	72—142 cm.+	Yellowish red (5YR 4/6 dry), dark red (2.5YR 3/6 moist), sandy clay loam; structure and consistence as AB; many pores; few roots; common mica. (Sample 75/2–520c)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—55

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /73	8836	8837	8838	8839	8840
Horizon	A11	A12	B1	B21	B22
Depth in cm.	0–11	11–40	40–70	70–110	110–170
Moisture % air dry soil					
Gravel %					
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	36	28	36	33	24
Silt % 50–2 μ	24	30	12	12	20
Clay % 2–0 μ	40	42	52	55	56
Texture class	CL/C	C	C	C	C
Dispersed clay %	11	19	23	25	27
Flocculation index	73	55	56	55	52
Soil-liquid susp:					
pH–H_2O	5·7	5·7	5·6	5·4	5·3
pH–KCl	4·6	4·6	4·2	4·1	3·9
EC in mmho's/cm.	0·13	0·12	0·07	0·05	0·05
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$ %					
$CaSO_4.2H_2O$ %					
C%	4·55	4·52	1·52		
N%	0·52	0·42	0·19		
C/N	8·8	10·8	8		
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4 OAc, pH 7·0) me%	35·2	36·0	28·6	24·6	22·1
Exch. Ca me%	14·2	14·0	4·9	2·8	2·0
Exch. Mg me%	8·3	7·8	4·0	2·7	2·7
Exch. K me%	1·1	1·0	0·7	0·6	0·3
Exch. Na me%	0·3	0·4	0·4	0·6	0·1
Sum of cations me%	23·9	23·2	10·0	6·7	5·1
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	68	64	35	27	23
E.S.P. at pH 8·2					
Exch. acidity me%	0·3		1·1		
Miscellaneous:					
Silt/Clay Ratio	0·60	0·71	0·23	0·22	0·36

Special analyses: Area Kapenguria

Depth in cm.	0–11	11–40	40–70	70–110	110–170
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.		0·4	0·9	0·7	1·1
1·0–0·5 mm.		2·1	3·6	0·3	3·6
0·5–0·25 mm.		7·3	7·4	6·7	6·5
0·25–0·1 mm.		6·8	8·1	7·3	7·2
0·1–0·05 mm.		2·9	3·0	2·6	2·4
Total sand %		19·5	23·0	17·5	20·8
Silt % 50–20 μ					
20–2 μ					
Total silt %		34·3	11·9	15·6	12·7
Clay % 2–0 μ		46·2	65·1	66·9	66·5
Texture class		C	C	C	C
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3			2·6	2·5	
SiO_2/R_2O_3			2·2	2·2	
Fe_2O_3 %			16·7	14·3	
X-ray report:					
B21, B22	The composition is approx. 60% illite and 40% kaolinite, both moderately well crystallized.				
Fertility aspects:					
Available Ca me%	13·2				
Available Mg me%	7·5				
Available K me%	0·65				
Available Na me%	0·14				
Available Mn me%	0·95				
Available P ppm	22				
Total Ca me%	19·8				
Total Mg me%	17·6				
Total K me%	7·1				
Total P ppm	180				

Map Unit HGh2: Profile 55

Date of observation:	9th October, 1973.
Observation/location:	75/3–55, E.38.5, N.30.2, East of St. Christopher Centre.
Soil classification:	Luvic Phaeozem.
Ecological zone:	IIw.
Geological formation:	Undifferentiated basement system.
Local petrography:	Gneisses rich in SiO2 and K–feldspars.
Physiography:	Rolling to hilly uplands of altitude 2050 m.
Relief—macro:	Rolling; on saddle-like position;
Relief—micro:	Irregular bumps up to 30 cm.
Vegetation/land use:	Partly cleared acacia forest, with 100% ground cover.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	14%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Well drained.

A11	0—11 cm.	Black (10YR 2/1 moist) clay loam; moderate fine and very fine subangular blocky, breaking down into moderate fine crumb; friable when moist, non sticky and plastic when wet; abundant very fine and fine roots; gradual wavy boundary; (Sample 73/3–55a)
A12	11—40 cm.	Black (10YR 2/1 moist) clay; moderate; very fine crumb; very friable when moist, slightly sticky and plastic when wet; abundant very fine and fine roots; gradual wavy boundary; (Sample 75/3–55b)
B1	40—70 cm.	Dark reddish brown (5YR 3/2 moist) clay; weak coarse to very coarse angular blocky; consistence as A12; many micro pores; common fine and very fine roots; distinct smooth boundary; (Sample 75/3–55c)
B21	70—110 cm.	Dusky red (2.5YR 3/2 moist) clay; porous massive; friable when moist, non sticky and plastic when wet; thin few clay skins; common very fine and fine roots; some signs of krotovinas; smooth gradual boundary; (Sample 75/3–55d)
B22	110—170 cm.	Dark reddish brown (2.5YR 3/4 moist) clay; moderate coarse to very coarse angular blocky; firm to friable when moist, slightly sticky and plastic when wet; many micro and common fine pores; moderate common clay skins; (Sample 75/3–55e)
B23	170—250 cm.+	Dark red (2.5YR 3/6 moist) clay; (no sample) (by auger).

Remark: The A11 and A12 are rich in organic matter.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—505

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	8274	8275	8276	8277
Horizon	Ap	AB	B21	B22
Depth in cm.	0–30	30–70	70–100	100–130+
Moisture % air dry soil				
Gravel %				
Texture Hydrometer:				
Sand % 2·0–0·05 mm.	64	62	64	68
Silt % 50-2 μ	10	14	12	10
Clay % 2–0 μ	26	24	24	22
Texture class	SCL	SCL	SCL	SCL
Dispersed clay %	10	16	14	16
Flocculation index	62	33	42	27
Soil-liquid 1:1 susp:				
pH–H_2O	8·3	8·4	8·1	7·8
pH–KCl	7·0	7·2	7·2	7·0
EC in mmho's/cm.	0·18	0·19	0·23	0·32
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$ %	0·8	1·1	2·1	1·4
$CaSO_4.2H_2O$ %				
C%	0·91	0·71		
N%	0·10	0·05		
C/N	9·1	14·2		
CEC (NaOAc, pH 8·2) me%	19·3	20·0	21·2	20·2
CEC (NH_4OAc, pH 7·0) me%				
Exch. Ca me%	13·2	13·6	14·1	13·4
Exch. Mg me%	4·9	5·2	6·0	5·7
Exch. K me%	0·5	0·5	0·4	0·3
Exch. Na me%	0·7	0·7	0·7	0·8
Sum of cations me%	19·3	20·0	21·2	20·2
Base Sat. % at pH 8·2	100	100	100	100
Base Sat. % at pH 7·0				
E.S.P. at pH 8·2				
Exch. acidity me%	—			
Miscellaneous:				
Silt/clay Ratio	0·38	0·58	0·5	0·45

Special analyses: Area Kapenguria

Depth in cm.	0–30	30–70	70–100	100–130+
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.	0·8	1·1	1·0	1·2
1·0–0·5 mm.	2·4	1·6	1·1	1·4
0·5–0·25 mm.	13·7	14·3	15·2	13·3
0·25–0·1 mm.	34·8	35·0	35·5	36·5
0·1–0·05 mm.	13·6	11·6	10·6	9·8
Total sand %	65·3	63·6	63·2	62·2
Silt % 50–20 μ				
20–2 μ				
Total silt %	10·4	13·3	11·6	13·8
Clay % 2–0 μ	24·3	23·1	25·2	24·0
Texture class	SCL	SCL	SCL	SCL
Bulk density				
Particle density				
Porosity				
Moisture % w/v at:				
pF 2·0				
pF 2·3				
pF 2·7				
pF 3·7				
pF 4·2				
Clay mineralogy:				
SiO_2/Al_2O_3				2·7
SiO_2/R_2O_3				2·5
Fe_2O_3 %				5·7
X-ray report:				
B21, B22	The only clay mineral present is of an [illegible] defined 2:1 type of 14·4 Å of which a par[illegible] expands to 16·98 Å. Heat treatment produ[illegible] a single intensified peak at 10·04 Å.			
Fertility aspects:				
Available Ca me%	10·6			
Available Mg me%	4·2			
Available K me%	0·54			
Available Na me%	0·15			
Available Mn me%	0·58			
Available P ppm	244			
Total Ca me%	31·0			
Total Mg me%	34·0			
Total K me%	8·0			
Total P ppm	620			

Map Unit HLC: Profile 505

Date of observation:	26th September, 1974.
Observation/location:	75/2–505, E.60.8, N.56.0, West Pokot District.
Soil classification:	Haplic Kastanozem.
Ecological zone:	III+IV.
Geological formation:	Predominantly hornblende gneisses of the basement system.
Local petrography:	Hornblende gneisses (rich in ferromagnesian minerals and calcium and magnesium).
Physiography:	Lower slopes of hill complex, elevation 5000 ft.
Relief—macro:	Convex slope of 300 m.
Relief—micro:	Common termite mounds; 2–2½ m. high, 1–5 m. in diameter and 50–100 m. apart.
Vegetation/land use:	Fallow after cultivation, presently grasses and herbs; originally Croton bushland.
Erosion:	Nil.
Surface stoniness:	About 1%.
Slope gradient:	10%.
Salinity/alkalinity:	Nil.
Surface sealing:	5–7 mm., moderate.
Drainage class:	Well drained.

Ap	0—30 cm.	Dark brown (10YR 3/3 dry), very dark greyish brown (10YR 3/2 moist) sandy clay loam; weak to moderate, fine to medium subangular blocky; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; very few, fine and medium pores; many very fine, common fine roots; common micas; matrix material is slightly calcareous; clear smooth boundary; (Sample 75/2–505a)
AB	30—70 cm.	Dark brown (10YR 3/3 dry) and very dark greyish brown (10YR 3/2 moist) sandy clay loam; moderate, fine and medium (sub-) angular blocky; slightly hard when dry, friable when moist, slightly sticky and plastic when wet; many fine, common very fine roots; soft mycelium occupies about 20% of the soil matrix causing strong reaction with HCl; micas common; clear smooth boundary; (Sample 75/2–505b)
B21	70—100 cm.	Brown (10YR 4/3 dry), dark brown (10YR 3/3 moist) sandy clay loam; weak to moderate, fine to medium (sub-) angular blocky; soft to slightly hard when dry; friable when moist, slightly sticky and slightly plastic when wet; many very fine and common fine pores; common fine, few medium roots; soft mycelium takes up 3–5% of the soil; occasionally somewhat rounded gravel (3–20 mm. in diam.) is encountered; gradual smooth boundary; (Sample 75/2–505c)
B22	100—130 cm.+	Dark brown (7.5YR 3/2 dry and moist) sandy clay loam; weak, fine and medium subangular blocky with a tendency to massive structure; consistence as B21; many fine and very few medium pores; common fine, few medium roots; common mica; (Sample 75/2–505d)

Remark: The whole soil is slightly magnetic.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—515

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	8292	8293	8394		
Horizon	Ap	B21	B22		
Depth in cm.	0–20	20–65	65–80+		
Moisture % air dry soil					
Gravel %					
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	44	34	32		
Silt % 50–2 μ	16	14	18		
Clay % 2–0 μ	40	52	50		
Texture class	C	C	C		
Dispersed clay %	22	30	26		
Flocculation index	45	42	48		
Soil-liquid 1:1 susp:					
pH–H_2O	7·1	7·2	7·8		
pH–KCl	6·2	6·1	6·9		
EC in mmho's/cm.	0·20	0·28	0·34		
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$ %	0	tr.	1·1		
$CaSO_4.2H_2O$ %					
C %	0·80	0·44			
N %	0·11	0·06			
C/N	7·3	7·3			
CEC (NaOAc, pH 8·2) me %			36·6		
CEC (NH_4OAc, pH 7·0) me %	30	35·2	33·6		
Exch. Ca me %	16·8	20·6	23·4		
Exch. Mg me %	7·9	9·4	9·3		
Exch. K me %	2·4	0·8	0·8		
Exch. Na me %	1·0	1·8	2·1		
Sum of cations me %	28·1	32·6	35·6		
Base Sat. % at pH 8·2			97		
Base Sat. % at pH 7·0	94	93	100+		
E.S.P. at pH 8·2			5·7		
Exch. acidity me %	—				
Miscellaneous:					
Silt/Clay Ratio	0·4	0·26	0·36		

Special analyses: Area Kapenguria

Depth in cm.	0–20	20–65	65–80+		
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3 %					
X-ray report:					
Fertility aspects:					
Available Ca me %	12.6				
Available Mg me %	6·6				
Available K me %	1·26				
Available Na me %	0·16				
Available Mn me %	0·64				
Available P ppm	27				
Total Ca me %	22·0				
Total Mg me %	14·0				
Total K me %	9·6				
Total P ppm	140				

Map Unit FGrc: Profile 515

Date of observation:	26th September, 1974.
Observation/location:	75/2–515; E.62.7, N.59.6; North East of Ortum.
Soil classification:	Chromic Luvisol.
Ecological zone:	IV.
Geological formation:	Predominantly hornblende gneisses from the basement system.
Local petrography:	Colluvium derived from hornblende gneisses.
Physiography:	Footslopes.
Relief—macro:	Undulating; convex slopes of ±400 m.; gradient 7%.
Relief—micro:	Common termite mounds, 1 m. high, 2–2½ m., in diameter and 50–100 m. apart.
Vegetation/land use:	Fallow after irrigated cultivation; presently fair cover of herbs and grasses; originally Croton bushland.
Erosion:	Some water erosion in places with little vegetation.
Surface stoniness:	Nil.
Slope gradient:	7%.
Salinity/alkalinity:	Nil.
Surface sealing:	Strong (30 mm.); common fine cracks 3–5 mm. wide.
Drainage class:	Well drained.

Ap	0—20 cm.	Dark reddish brown (5YR 3/4 dry and moist) clay; strong medium and coarse (sub-) angular blocky; very hard when dry, very firm when moist, sticky and plastic when wet; common to many fine and medium pores, common coarse pores; many fine and medium roots; common mica; clear smooth boundary; (Sample 75/2–515a)
B21	20—65 cm.	Dark reddish brown (5YR 3/2 dry and moist) clay; strong, medium and coarse angular blocky; consistence as Ap; few fine and medium pores; common fine and medium roots; thick, many clay cutans and pressure faces; common mica; gradual smooth boundary; (Sample 75/2–515b)
B22	65—80 cm.+	Dark reddish brown (5YR 3/4 dry and moist) clay; structure and consistence as B21; common fine and medium pores; common fine and medium roots; moderate to strong clay skins; pressure faces are common; mica as in B21; (Sample 75/2—515c)

Remark: The soil material is slightly magnetic.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/1—107

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	3566	3567	3568	3569
Horizon	A1	B1	B21	B22
Depth in cm.	0–18	18–45	45–100	100–180+
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	80	76	66	62
Silt % 50–2 μ	8	8	6	8
Clay % 2–0 μ	12	16	28	30
Texture class	SL	SL	SCL	SCL
Dispersed clay %	4	8	12	14
Flocculation index	67	50	57	53
Soil-liquid 1:1 susp:				
pH–H_2O	6·1	5·7	6·2	6·5
pH–KCl	4·8	4·2	4·5	4·8
EC in mmho's/cm.	0·05	0·04	0·06	0·05
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$%				
$CaSO_4.2H_2O$%				
C%	0·44	0·35		
N%	0·04	0·04		
C/N	11·0	8·7		
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	4·2	7·0	8·8	8·6
Exch. Ca me%	1·2	2·2	2·3	2·6
Exch. Mg me%	1·4	1·8	2·4	2·4
Exch. K me%	0·3	0·2	0·2	0·2
Exch. Na me%	0	0	0·1	0·2
Sum of cations me%	2·9	4·2	5·0	5·4
Base Sat. % at pH 8·2				
Base Sat. % at pH 7·0	69	60	57	63
E.S.P. at pH 8·2				
Exch. acidity me%	—			
Miscellaneous:				
Silt/clay Ratio	0·67	0·5	0·21	0·27

Special analyses: Area Kapenguria

Depth in cm.	0–18	18–45	45–100	100–180+
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.				
1·0–0·5 mm.				
0·5–0·25 mm.				
0·25–0·1 mm.				
0·1–0·05 mm.				
Total sand %				
Silt % 50–20 μ				
20–2 μ				
Total silt %				
Clay % 2–0 μ				
Texture class				
Bulk density				
Particle density				
Porosity				
Moisture % w/v at:				
pF 2·0				
pF 2·3				
pF 2·7				
pF 3·7				
pF 4·2				
Clay mineralogy:				
SiO_2/Al_2O_3				2·3
SiO_2/R_2O_3				1·7
Fe_2O_3%				13·2
X-ray report:				
B1, B22	Illite (mica) is predominant, but with substantial admixture of kaolinite. The illite appears to have been derived directly from mica, as shown by enhanced peak intensity upon K–saturation.			
Fertility aspects:				
Available Ca me%	1·0			
Available Mg me%	0·8			
Available K me%	0·22			
Available Na me%	tr.			
Available Mn me%	0·34			
Available P ppm	45			
Total Ca me%	5·6			
Total Mg me%	4·8			
Total K me%	2·9			
Total P pmm	160			

Map Unit FGrce: Profile 107

Date of observation:	26th April, 1974.
Observation/location:	75/1–107; E.28.3, N.49.5; 1 km. S.E. of Mtembur.
Soil classification:	Chromic Luvisol.
Ecological zone:	IV.
Geological formation:	Predominantly biotite gneisses of the basement complex.
Local petrography:	Gneisses relatively rich in biotite with much oligoclase.
Physiography:	Footslopes, altitude 5500 ft.
Relief—macro:	Gently undulating terrain (gradient 5%).
Relief—micro:	Irregular because of 1 m. deep gullies and termite mounds (2 m. high, 6–7 m. diam., 50 m. apart).
Vegetation/Land use:	Acacia nilotica bushland with no undergrowth.
Erosion:	Moderate to severe rill and gully erosion.
Surface stoniness:	Nil.
Slope gradient:	5%.
Salinity/alkalinity:	Nil.
Surface sealing:	Moderate to strong (3–7 mm.); commonly with sand overwash.
Drainage class:	Well drained.

A1	0—18 cm.	Dark brown (7.5YR 4/2 dry), very dark brown (7.5YR 2/2 moist) loamy sand; massive; slightly hard when dry, very friable when moist; non sticky and non plastic when wet; few fine pores; few very fine and medium roots; smooth gradual boundary; (Sample 75/1–107a)
B1	18—45 cm.	Dark reddish grey (5YR 4/2 dry) and dark reddish brown (5YR 3/2 moist) sandy loam; massive; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many micro and very fine pores; few fine roots; diffuse smooth boundary; (Sample 75/1–107b)
B21	45—100 cm.	Reddish brown (5YR 4/4 dry), dark reddish brown (5YR 3/4 moist) sandy clay loam; massive; very hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many micro pores; few fine roots; diffuse smooth boundary; (Sample 75/1–107c)
B22	100—180 cm.+	Dark red (2.5YR 3/6 dry and moist) sandy clay loam; massive; hard when dry, friable when moist, sticky and plastic when wet; many micro and common (very) fine pores; (Sample 75/1–107d)

Remark: Dark minerals occur from 50 cm. onwards (probably biotite and green hornblende).

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—536

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /75	9338	9339	9340		
Horizon	Ap	(B)	B3		
Depth in cm.	0–30	30–110	110–130+		
Moisture % air dry soil					
Gravel %					
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	48	46	50		
Silt % 50–2 μ	24	18	20		
Clay % 2–0 μ	28	36	30		
Texture class	SCL	SC/SCL	SCL		
Dispersed clay %	10	10	20		
Flocculation index	64	72	33		
Soil-liquid 1:1 susp:					
pH–H_2O	7·0	7·2	6·9		
pH–KCl	6·0	5·8	5·5		
EC in mmho's/mm.	0·14	0·11	0·10		
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	1·41	0·62	0·62		
N%	0·13				
C/N	10·8				
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	18·2	18·0	16·6		
Exch. Ca me%	10·0	10·8	10·1		
Exch. Mg me%	5·5	4·9	3·4		
Exch. K me%	0·9	0·4	0·7		
Exch. Na me%	0·9	0·8	0·7		
Sum of cations me%	17·3	16·9	14·9		
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	95	94	90		
E.S.P. at pH 8·2					
Exch. acidity me%	—				
Miscellaneous:					
Silt/Clay Ratio	0·86	0·50	0·67		

Special analyses: Area Kapenguria

Depth in cm.	0–30	30–110			
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3		2·3			
SiO_2/R_2O_3		1·8			
Fe_2O_3%		11·6			
X-ray report:					
(B)	A mixture of Illite and Kaolinite at abo equal proportions.				
Fertility aspects:					
Available Ca me%	6·8				
Available Mg me%	2·8				
Available K me%	0·36				
Available Na me%	0·12				
Available Mn me%	0·50				
Available P ppm	122				
Total Ca me%	22·0				
Total Mg me%	12.0				
Total K me%	8·4				
Total P ppm	300				

Map Unit FGby: Profile 536

Date of observation:	1st November, 1974.
Observation/location:	75/2–536; E.74.7, N.60.1; West Pokot District.
Soil classification:	Eutric Cambisol
Ecological zone:	IV.
Geological formation:	Undifferentiated basement system.
Local petrography:	Colluvium, main components quartz and K–feldspar.
Physiography:	Footslopes.
Relief—macro:	Gently undulating terrain, gradient 3%.
Relief—micro:	Plow ridges.
Vegetation/land use:	Acacia woodland, presently under rainfed cassava cultivation.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	3%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Well drained.

Ap	0—30 cm.	Brown (10YR 5/3 dry), black (7.5YR N2.5/0 moist) sandy clay loam; weak fine and medium subangular blocky with a tendency to massive; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many fine and medium pores; common medium, few fine roots; common to many micas; smooth diffuse boundary; (Sample 75/2–536a)
(B)	30—110 cm.	Dark brown (7.5YR 3/2 moist) sandy clay loam; structure and consistence as Ap; pores and roots also like Ap; abundant mica; clear smooth boundary; (Sample 75/2–536b)
B3	110—130 cm.+	Dark brown (7.5YR 3/2 moist) sandy clay loam; massive to weak, fine and medium subangular blocky; friable when moist, sticky and plastic when wet; many fine and medium pores. (Sample 75/2–536c)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—523

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /75	9332	9333	9334		
Horizon	A1	B21	B22		
Depth in cm.	0–20	20–50	50–100+		
Moisture % air dry soil					
Gravel %	40		5		
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	56	48	50		
Silt % 50–2 μ	10	12	12		
Clay % 2–0 μ	34	40	38		
Texture class	SCL	SC	SC		
Dispersed clay %	22	12	8		
Flocculation index	35	70	79		
Soil-liquid 1:1 susp:					
pH–H_2O	7·1	7·8	8·3		
pH–KCl	6·2	6·4	7·1		
EC in mmho's/cm.	0·20	0·22	0·35		
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	1·06	0·38	0·11		
N%	0·12				
C/N	8·8				
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	17·3	17·1	17·0		
Exch. Ca me%	10·0	10·7	11·1		
Exch. Mg me%	4·2	4·9	4·7		
Exch. K me%	0·9	0·8	0·5		
Exch. Na me%	0·1	0·5	0·7		
Sum of cations me%	15·2	16·8	17·0		
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	88	98	100		
E.S.P. at pH 8·2					
Exch. acidity me%		—			
Miscellaneous:					
Silt/Clay Ratio	0·29	0·30	0·32		

Special analyses: Area Kapenguria

Depth in cm.	0–20	20–50	50–100+		
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3%					
X-ray report:					
Fertility aspects:					
Available Ca me%	4·0				
Available Mg me%	3·4				
Available K me%	0·32				
Available Na me%	0·05				
Available Mn me%	0·40				
Available P ppm	124				
Total Ca me%	12·0				
Total Mg me%	15·2				
Total K me%	4·8				
Total P ppm	140				

Map Unit FGbys: Profile 523

Date of observation:	29th October, 1974.
Observation/location:	75/2–523, E.75.7 N.60.6.
Soil classification:	Eutric Cambisol.
Ecological zone:	IV.
Geological formation:	Predominantly biotite gneisses from the basement system.
Local petrography:	Colluvium from biotite gneisses with lenses of hornblende gneiss.
Physiography:	Footslopes.
Relief—macro:	Undulating terrain; convex slopes (200 m.), gradient 5%.
Relief—micro:	Irregular due to termite mounds (1–2 m. high, 3–4 m., diam.).
Vegetation/land use:	Acacia reficiens bushland to acacia woodland, much bare ground.
Erosion:	Nil.
Surface stoniness:	Stony.
Slope gradient:	5%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Well drained.

A1	0—20 cm.	Dark reddish brown (2.5YR 3/4 dry and moist) gravelly sandy clay loam; strong, medium and coarse angular blocky; slightly hard when dry, firm when moist, sticky and plastic when wet; few fine and coarse pores, many fine, common medium and a few coarse roots; common mica and hornblende; smooth clear boundary; (Sample 75/2–523a)
B21	20—50 cm.	Dark red (2.5YR 3/6 dry), dark reddish brown (2.5YR 3/4 moist) sandy clay; strong coarse angular blocky; slightly hard to hard when dry, firm when moist, sticky and plastic when wet; common medium, few coarse pores, roots as the A-horizon; few thin clay skins; common mica and hornblende; smooth distinct boundary; (Sample 75/2–523b)
B22	50—100 cm.+	Red (2.5YR 4/6 dry), dark red (2.5YR 3/6 moist) slightly gravelly sandy clay; structure, consistence, pores and cutans like B21; common fine, few medium roots; common soft $CaCO_3$ accumulations; common mica and hornblende; (Sample 75/2–523c)

Remark: Stone lines are common in these soils in addition to quartz gravel on the soil surface.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/4—629

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /75	1153	1154	1155	1156
Horizon	A11	A12	B21	B3
Depth in cm.	0–12	12–33	33–78	97–120+
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	36	38	28	24
Silt % 50–2 μ	22	16	24	28
Clay % 2–0 μ	42	46	48	48
Texture class	C	C	C	C
Dispersed clay %	18	26	34	28
Flocculation index	57	43	29	42
Soil-liquid 1:1 susp:				
pH–H_2O	4·9	4·8	5·0	5·4
pH–KCl	4·3	4·3	4·1	4·2
EC in mmho's/cm.	0·30	0·12	0·09	0·03
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$%				
$CaSO_4 \cdot 2H_2O$%				
C%	3·58	2·71	1·59	0·56
N%	0·29			
C/N	12·3			
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	24·1	22·0	14·2	8·1
Exch. Ca me%	3·2	2·8	1·8	1·4
Exch. Mg me%	2·4	2·0	1·4	1·1
Exch. K me%	1·0	0·7	0·2	0·2
Exch. Na me%	0·1	0·2	0·5	0·3
Sum of cations me%	6·7	5·7	3·9	3·0
Base Sat. % at pH 8·2				
Base Sat. at pH 7·0	28	26	27	37
E.S.P. at pH 8·2				
Exch. acidity me%	1·4			
Miscellaneous:				
Silt/Clay Ratio	0·52	0·35	0·50	0·58

Special analyses: Area Kapenguria

Depth in cm.	0–12	12–33	33–78	97–120+
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.				
1·0–0·5 mm.				
0·5–0·25 mm.				
0·25–0·1 mm.				
0·1–0·05 mm.				
Total sand %				
Silt % 50–20 μ				
20–2 μ				
Total silt %				
Clay % 2–0 μ				
Texture class				
Bulk density				
Particle density				
Porosity				
Moisture % w/v at:				
pF 2·0				
pF 2·3				
pF 2·7				
pF 3·7				
pF 4·2				
Clay mineralogy:				
SiO_2/Al_2O_3				
SiO_2/R_2O_3				
Fe_2O_3%				
X-ray report:				
Fertility aspects:				
Available Ca me%	2·6			
Available Mg me%	2·3			
Available K me%	0·20			
Available Na me%	0·04			
Available Mn me%	0·64			
Available P ppm	16			
Total Ca me%				
Total Mg me%				
Total K me%				
Total P ppm				

Map Unit U2Gry: Profile 629

Date of observation:	12th February, 1975.
Observation/location:	75/4–629; E.70.1, N.13.4; 3 km. from Kaisungur towards Kimnai.
Soil classification:	Dystric Cambisol.
Ecological zone:	II.
Geological formation:	Quartzite, muscovite–quartzite and quartz–muscovite gneisses.
Local petrography:	Quartzite and some muscovite–quartzite.
Physiography:	Upland, Kapsait level (about 2900 m.).
Relief—macro:	Rolling (15% slope); length 200–500 m.; concave slope.
Relief—micro:	Irregular surface.
Vegetation/land use:	Montane grassland; used for grazing; Occasionally cultivation of maize on small plots.
Erosion:	Some rill erosion along cattle tracks.
Surface stoniness:	Nil.
Slope gradient:	15%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Well drained.

A11	0—12 cm.	Dark reddish brown (5YR 3/2 dry) and (5YR 2.5/2 moist) clay; strong, coarse and very coarse granular structure; very hard when dry, firm when moist, sticky and plastic when wet; clear smooth boundary; (Sample 74/4–629a)
A12	12—33 cm.	Dark reddish brown (5YR 3/2 dry) and moist (5YR 2.5/2) clay; moderate medium subangular blocky breaking down into very fine granules; hard when dry, firm when moist, sticky and plastic when wet; clear smooth boundary; (Sample 74/4–629b)
B21	33—78 cm.	Dark reddish brown (5YR 3/4 dry, 5YR 3/3 moist) clay; moderate, medium and coarse angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; common micro and few fine pores; abrupt and irregular boundary; (Sample 74/4–629c
B22	78—97 cm.	Stone line, consisting of quartz gravel and manganese concretions; abrup irregular boundary;
B3	97—120 cm.+	Yellowish red (5YR 4/6 moist) clay; massive; friable when moist, sticky and plastic when wet; many primary minerals. (Sample 74/4–629d)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/4—378

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	9394	9395	9396	9397
Horizon	A11	A12	B21	B22
Depth in cm.	0–10	10–25	25–45	45–85
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	68	54	40	30
Silt % 50–2 μ	20	32	34	22
Clay % 2–0 μ	12	14	26	48
Texture class	SL	SL	L	C
Dispersed clay %	4	4	4	6
Flocculation index	67	71	85	88
Soil–liquid 1:1 susp:				
pH–H_2O	5·1	5·2	5·4	5·4
pH–KCl	4·3	4·4	4·6	4·1
EC in mmho's/cm.	0·08	0·05	0·05	0·03
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$ %				
$CaSO_4 \cdot 2H_2O$ %				
C%	5·83	5·62	4·50	1·29
N%	0·73			
C/N	7·9			
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	28·4	25·3	20·0	11·5
Exch. Ca me%	1·6	1·0	1·0	0·4
Exch. Mg me%	0·8	0·6	0·4	0·3
Exch. K me%	0·7	0·4	0·3	0·1
Exch. Na me%	0·4	0·3	0·2	0·1
Sum of cations me%	3·5	2·3	1·9	0·9
Base Sat. % at pH 8·2				
Base Sat. % at pH 7·0	12	9	10	8
E.S.P. at pH 8·2				
Exch. acidity me%	1·9	1·4		
Miscellaneous:				
Silt/Clay Ratio	1·67	2·29	1·31	0·46

Special analyses: Area Kapenguria

Depth in cm.	0–10	10–25	25–45	45–85
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.				
1·0–0·5 mm.				
0·5–0·25 mm.				
0·25–0·1 mm.				
0·1–0·05 mm.				
Total sand %				
Silt % 50–20 μ				
20–2 μ				
Total silt %				
Clay % 2–0 μ				
Texture class				
Bulk density				
Particle density				
Porosity				
Moisture % w/v at:				
pF 2·0				
pF 2·3				
pF 2·7				
pF 3·7				
pF 4·2				
Clay mineralogy:				
SiO_2/Al_2O_3				
SiO_2/R_2O_3				
Fe_2O_3 %				
X-ray report:				
Fertility aspects:				
Available Ca me%	1·2			
Available Mg me%	0·5			
Available K me%	0·44			
Available Na me%	0·18			
Available Mn me%	0·40			
Available P ppm	118			
Total Ca me%	7·0			
Total Mg me%	2·6			
Total K me%	4·4			
Total P ppm	360			

Map Unit $\frac{\text{U2Gh1}}{\text{p}}$: Profile 378

Date of observation:	2nd November, 1974.
Observation/location:	75/4–378; E.65.9, N.31.6.; about 1.5 km. S.W. of Kapsangar.
Soil classification:	Humic Cambisol.
Ecological zone:	IIc.
Geological formation:	Predominantly biotite gneisses of the basement system.
Local petrography:	Biotite gneisses.
Physiography:	Uplands, Kapsait level (about 2900 m).
Relief—macro:	Rolling (15%), slopes 200–400 m. long.
Relief—micro:	Irregular, 50 cm. high humps.
Vegetation/land use:	Montane grassland, used for grazing.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	15%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	(Moderately) well drained.

A11	0—10 cm.	Very dark brown (10YR 2/2 moist) sandy loam; moderate, medium crumb; very friable when moist, slightly sticky and slightly plastic when wet; abundant very fine and fine roots; clear smooth boundary; (Sample 75/4–378a)
A12	10—25 cm.	Very dark brown (10YR 2/2 moist) sandy loam; moderate fine and medium subangular blocky structure; firm when moist, slightly sticky and slightly plastic when wet; clear smooth boundary; (Sample 75/4–378b)
B21	25–45 cm.	Dark brown (7.5YR 3/2 moist) loam; weak coarse angular blocky; firm when moist; slightly sticky and plastic when wet; common very fine pores; gradual smooth boundary; (Sample 75/4–378c)
B22	45—85 cm.	Yellowish red (5YR 4/6 moist) clay; weak coarse angular blocky; friable when moist, sticky and plastic when wet; many very fine and fine pores; gradual smooth boundary; (Sample 75/4–378d)
C	85—100 cm.	Semi-weathered rock.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/4—384

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	10592	10593	10594	10595
Horizon	A1	B1	B2	B3
Depth in cm.	0–25	25–45	45–65	65–85
Moisture % air dry soil				
Gravel %				20
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	30	30	28	36
Silt % 50–2 μ	14	14	8	24
Clay % 2–0 μ	56	56	64	40
Texture class	C	C	C	C
Dispersed clay %	4	4	4	6
Flocculation index	93	93	94	85
Soil-liquid 1:1 susp:				
pH–H_2O	4·8	4·4	4·8	4·9
pH–KCl	4·0	4·2	4·2	4·2
EC in mmho's/cm.	0·04	0·05	0·02	0·02
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$ %				
$CaSO_4.2H_2O$ %				
C%	3·87	2·29	0·74	0·62
N%	0·29			
C/N				
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	19·2	15·8	8·3	5·2
Exch. Ca me%	0·4	0·4	0·4	0·2
Exch. Mg me%	0·8	0·8	0·3	0·1
Exch. K me%	0·4	0·3	0·1	0·1
Exch. Na me%	0·2	0·2	0·1	0
Sum of cations	1·8	1·7	0·9	0·4
Base Sat. % at pH 8·2				
Base Sat. % at pH 7·0	9	11	11	8
E.S.P. at pH 8·2				
Exch. acidity me %	4·2			
Miscellaneous:				
Silt/Clay Ratio	0·25	0·25	0·13	0·6

Special analyses: Area Kapenguria

Depth in cm.	0–25	25–45	45–65	65–85
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.				
1·0–0·5 mm.				
0·5–0·25 mm.				
0·25–0·1 mm.				
0·1–0·05 mm.				
Total sand %				
Silt % 50–20 μ				
20–2 μ				
Total silt %				
Clay % 2–0 μ				
Texture class				
Bulk density				
Particle density				
Porosity				
Moisture % w/v at:				
pF 2·0				
pF 2·3				
pF 2·7				
pF 3·7				
pF 4·2				
Clay mineralogy:				
SiO_2/Al_2O_3			1·8	
SiO_2/R_2O_3			1·3	
Fe_2O_3 %			14·1	
X-ray report:				
B2	Predominantly a very well crystallized kaolinite, spacing 7·19 Å, with about 10% illite.			
Fertility aspects:				
Available Ca me%	0·2			
Available Mg me%	0·3			
Available K me%	0·18			
Available Na me%	0·07			
Available Mn me%	0·48			
Available P ppm	13			
Total Ca me%	5.5			
Total Mg me%	3·0			
Total K me%	4·8			
Total P ppm	240			

Map Unit $\frac{\text{U2Gh1}}{\text{p}}$—$\frac{\text{U2Gh2}}{\text{p}}$: Profile 384

Date of observation:	27th November, 1974.
Observation/location:	75/4–384; E.61.2, N.28.3; 1 km. E. of Kapsait School.
Soil classification:	Humic Cambisol.
Ecological zone:	IIc
Geological formation:	Quartzite, muscovite–quartzite and quartz–muscovite gneisses of the basement system.
Local petrography:	Quartz–muscovite gneiss.
Physiography:	Uplands, Kapsait level (about 2900 m.).
Relief—macro:	Hilly, 18% slope gradient on moderate part of long (200–300 m.) convex slope.
Relief—micro:	Slightly hummocky.
Vegetation/land use:	Montane grassland used for extensive grazing.
Erosion:	Slight sheet and rill erosion nearby.
Surface stoniness:	Nil.
Slope gradient:	18%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Moderately well drained.

A1	0—25 cm.	Dark brown (7.5YR 3/2 moist) clay; moderate fine to medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many micro pores; abundant very fine and fine roots; gradual smooth boundary; (Sample 75/4–384a)
B1	25—45 cm.	Dark reddish brown (5YR 3/3 moist) clay; weak medium and coarse subangular blocky; friable when moist, slightly sticky and plastic when wet; many micro and very fine pores; few medium roots; much mica; gradual smooth boundary; (Sample 75/4–384b)
B2	45—65 cm.	Dark reddish brown (5YR 3/4 moist) clay; weak coarse to very coarse subangular blocky; very friable when moist, sticky and plastic when wet; pores as in B1; common mica; gradual smooth boundary; (Sample 75/4–384c)
B3	65—85 cm.	Brown (7.5YR 4/4) gravelly clay; many, fine faint yellowish brown mottles; massive; clear smooth boundary; (Sample 75/4–384d)
C	85—100 cm.+	Weathered rock with quartz gravel and manganese concretions.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—61

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	3526	3527	3528	3529	3530	3531
Horizon	A11	A12	A13	B1	B21	B22
Depth in cm.	0–18	18–55	55–80	80–100	100–135	135-160+
Moisture % air dry soil						
Gravel %						
Texture-Hydrometer:						
Sand % 2·0–0·05 mm.	52	40	38	34	36	36
Silt % 50–2 μ	15	16	14	14	8	4
Clay % 2–0 μ	32	44	48	52	56	60
Texture class	SCL	C	C	C	C	C
Dispersed clay %	16	12	12	20	28	34
Flocculation index ..	50	73	75	58	50	43
Soil-liquid 1:1 susp:						
pH–H_2O	5·8	5·4	5·2	4·5	4·4	4·3
pH–KCl	4·8	4·2	4·1	3·9	3·8	3·9
EC in mmho's/cm.	0·21	0·05	0·04	0·09	0·06	0·07
Saturation extract:						
pH						
EC						
Saturation %						
$CaCO_3$%						
$CaSO_4 \cdot 2H_2O$%						
C%	6·00	5·77	3·80	2·35		
N%	0·71	0·37	0·28	0·18		
C/N	8·5	15·6	13·6	13·1		
CEC (NaOAc, pH 8·2) me%						
CEC (NH_4OAc, pH 7·0) me%	34·4	30·0	14·0	11·3	7·2	5·2
Exch. Ca me%	17·2	5·6	2·8	1·6	0·9	0·4
Exch. Mg me%	6·5	2·2	1·5	1·0	0·6	0·3
Exch. K me%	0·5	0·4	0·3	0·2	0·2	0·2
Exch. Na me%	tr.	tr.	0	0	0	0
Sum of cations me%	24·2	8·2	4·6	2·8	1·7	0·9
Base Sat. % at pH 8·2						
Base Sat. % at pH 7·0	70	27	33	25	24	17
E.S.P. at pH 8·2						
Exch. acidity me%	—	—	2·5	3·6	3·7	3·4
Miscellaneous:						
Silt/Clay Ratio	0·47	0·36	0·29	0·27	0·14	0.07

Special analyses: **Area Kapenguria**

Depth in cm.	0–18	18–55	55–80	80–100	100-135
Texture U.S.D.A.:					
Sand % 2.0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3%					
X-ray report:					
B21, B22	Predominantly kaolinite, which is better crystallized in B22 horizon; about 10% illite is detected, spacings 7·18Å and 10·04Å.				
Fertility aspects:					
Available Ca me%	13·5				
Available Mg me%	5·6				
Available K me%	0·16				
Available Na me%	tr.				
Available Mn me%	0·42				
Available P ppm	16				
Total Ca me%	20·5				
Total Mg me%	9·4				
Total K me%	2·5				
Total P ppm	95				

Map Unit U3Gh: Profile 61

Date of observation:	25th April, 1974.
Observation/location:	75/3–61; E.38.0, N.34.0; 4 km. S.E. of Kapenguria.
Soil classification:	humic Acri/Cambisol.
Ecological zone:	IIw.
Geological formation:	Predominantly biotite gneisses.
Local petrography:	Biotite gneisses.
Physiography:	Uplands, Kapenguria level (about 2120 m.).
Relief—macro:	Rolling (14% slope); site on upper part of long (500–1000 m.) convex slope.
Relief—micro:	Nil.
Vegetation/land use:	Fallow land after maize; originally undifferentiated forest and cleared forests (glades).
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	14%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Well drained.

A11	0—18 cm.	Very dark grey (7.5YR 3/1 dry), black (7.5YR 2/1 moist) sandy clay loam; weak fine and medium subangular blocky, breaking into moderate, very fine and fine crumb; soft when dry, very friable when moist, slightly sticky and plastic when wet; many micro pores; abundant, very fine and fine roots; much mica; smooth clear boundary; (Sample 75/3–61a)
A12	18–55 cm.	Dark reddish brown (5YR 2.5/2 moist) clay; weak, very coarse angular blocky; friable when moist, sticky and plastic when wet; many micro pores; many very fine and fine, and common medium roots; much mica; smooth gradual boundary; (Sample 75/3–61b)
A13	55—80 cm.	Dark reddish brown (5YR 2.5/2 moist) clay; moderate fine to coarse (sub-) angular blocky; many micro and very fine pores; very friable when moist, slightly sticky and plastic when wet; roots and mica as A12; smooth gradual boundary; (Sample 75/3–61c)
B1	80—100 cm.	Dark reddish brown (5YR 3/3 moist) clay; weak, medium and coarse angular blocky; friable when moist, sticky and plastic when wet; many micro; common very fine pores; roots and mica as A13; smooth gradual boundary; (Sample 75/3–61d)
B21	100—135 cm.	Yellowish red (5YR 4/6 dry) and dark reddish brown (5YR 3/4 moist) clay; moderate coarse angular blocky; slightly hard when dry; very friable when moist, sticky and plastic when wet; many micro and very fine pores; common thin clay cutans; much mica and quartz; smooth clear boundary; (Sample 75/3–61e)
B22	135–160 cm.+	Red (2.5YR 4/6 dry), dark red (2.5YR 3/6 moist) clay; weak medium and coarse angular blocky; slightly hard when dry, very friable when moist, sticky and plastic when wet; many micro pores; many moderate clay skins. (Sample 75/3–61f)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—62

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	3532	3533	3534	3535	3536
Horizon	A1	B1	B21	B22	B23
Depth in cm.	0–8	8–27	27–65	65–100	100–150
Moisture % air dry soil					
Gravel %					
Texture–Hydrometer:					
Sand % 2·0–0·05 mm.	56	46	44	34	38
Silt % 50–2 μ	10	12	8	12	6
Clay % 2–0 μ	34	42	48	54	56
Texture class	SCL	C	C	C	C
Dispersed clay %	20	22	24	6	6
Flocculation index	41	48	50	89	89
Soil-liquid 1:1 susp:					
pH–H_2O	5·6	5·4	5·8	5·2	5·3
pH–KCl	4·5	4·4	4·4	4·3	4·3
EC in mmho's/cm.	0·08	0·08	0·05	0·04	0·02
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	1·31	0·80			
N%	0·15	0·09			
C/N	8·7	9·0			
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	6·4	5·4	4·8	5·8	5·9
Exch. Ca me%	0·8	0·8	0·6	0·4	0·4
Exch. Mg me%	1·0	0·8	0·8	0·7	0·8
Exch. K me%	1·2	1·0	1·2	0·6	0·2
Exch. Na me%	0·1	tr.	tr.	tr.	tr.
Sum of cations me%	3·1	2·6	2·6	1·7	1·4
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	48	48	54	32	24
E.S.P. at pH 8·2					
Exch. acidity me%	—	0·5	—	0·7	0·7
Miscellaneous:					
Silt/Clay Ratio	0·29	0·29	0·17	0·21	0·11

Special analyses: Area Kapenguria

Depth in cm.	0–8	8–27	27–65	65–100	100–150
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3			1·2	1·1	
SiO_2/R_2O_3			1·0	1·0	
Fe_2O_3%			14·9	16·9	
X-ray report:					
B1, B21, B22	Kaolinite is predominant, which is well crystallized, with spacing of 7·13 Å. Traces of illite present throughout the profile.				
Fertility aspects:					
Available Ca me%	0·8				
Available Mg me%	1·0				
Available K me%	0·58				
Available Na me%	tr.				
Available Mn me%	0·12				
Available P ppm	12				
Total Ca me%	5·0				
Total Mg me%	15·0				
Total K me%	4·2				
Total P ppm	80				

Map Unit U3GC1: Profile 62

Date of observation:	25th April, 1974.
Observation/location:	75/3–62; E.33.9; N.31.8; 1 km. East of Morkwijit.
Soil classification:	Ferral–chromic Acrisol.
Ecological zone:	IIw.
Geological formation:	Undifferentiated basement system.
Local petrography:	Unknown.
Physiography:	Uplands; Kapenguria level; altitude 1920 m.
Relief—macro:	Undulating terrain; site on upper part of long (750 m.) convex slope, gradient 7%.
Relief—micro:	Common termite mounds, 50 cm. high, 2 m. diam. 10 m. apart.
Vegetation/land use:	Undifferentiated forest and cleared forest or glades; extensive grazing is common.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	7%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Well drained.

A1	0—8 cm.	Dark reddish brown (5YR 3/4 dry and 5YR 3/3 moist) sandy clay loam; moderate fine to coarse subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; many micro, common very fine and few medium pores; many very fine and fine roots; smooth clear boundary; (Sample 75/3–62a)
B1	8—27 cm.	Yellowish red (5YR 4/6 dry), and dark reddish brown (5YR 3/4 moist) clay; massive; very hard when dry; friable, when moist, sticky and plastic when wet; common micro, few very fine pores; common very fine roots; many thin clay skins; smooth diffuse boundary; (Sample 75/3–62b)
B21	27—65 cm.	Red (2.5YR 4/6 dry), dark red (2.5YR 3/6 moist) clay; weak, coarse to very coarse angular blocky; hard when dry, friable when moist, sticky and plastic when wet; many micro, few medium and common very fine pores; common thin clay cutans; few very fine roots; smooth diffuse boundary; (Sample 75/3–62c)
B22/B23	65—150 cm.	Red (2.5YR 4/6 dry) and dark red (2.5YR 3/6 moist) clay; major structural elements are very large, weak prisms with a tendency to be massive; very hard when dry, friable when moist, sticky and plastic when wet; many micro, common very fine pores; few thin clay skins; very few fine roots; (Samples 65–100 cm. and 100–150 cm. resp.–62d and 62e).

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—53

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /73	8832	8833	8834	8835
Horizon	A1	B1	B21	B22
Depth in cm.	0–20	20–45	45–70	70–150
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	52	54	38	34
Silt % 50–2 μ	14	14	10	12
Clay % 2–0 μ	34	32	52	54
Texture class	SCL	SCL	C	C
Dispersed clay %	15	19	29	7
Flocculation index	56	41	44	87
Soil-liquid 1:1 susp:				
pH–H_2O	5·7	5·5	5·7	5·9
pH–KC1	4·6	4·3	4·4	4·8
EC in mmho's/cm.	0·11	0·07	0·04	0·04
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$%				
$CaSO_4 \cdot 2H_2O$%				
C%	3·0	1·6		
N%	0·30	0·16		
C/N	9·8	9·8		
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	17·5	10·3	8·0	8·2
Exch. Ca me%	6·5	2·7	1·8	2·2
Exch. Mg me%	3·1	1·3	1·8	2·6
Exch. K me%	1·0	0·9	0·8	0·5
Exch. Na me%	0·1	tr.	0·7	0·9
Sum of cations me%	10·7	4·9	5·1	6·2
Base Sat. % at pH 8·2				
Base Sat. % at pH 7·0	61	48	64	76
E.S.P. at pH 8·2				
Exch. acidity me%	—	0·4		
Miscellaneous:				
Silt/Clay Ratio	0·41	0·44	0·19	0·22

Special analyses: Area Kapenguri

Depth in cm.	0–20	20–45	45–70	70–150
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.	0·6	0·9	1·1	1·2
1·0–0·5 mm.	10·1	9·9	8·2	7·4
0·5–0·25 mm.	22·8	22·3	14·5	12·3
0·25–0·1 mm.	13·8	15·0	10·6	10·7
0·1–0·05 mm.	1·3	1·7	3·2	3·3
Total sand %	48·6	49·8	37·6	34·9
Silt % 50–20 μ				
20–2 μ				
Total silt %	19·0	16·9	13·3	14·6
Clay % 2–0 μ	32·4	33·3	49·1	50·5
Texture class	SCL	SCL	C	C
Bulk density	1·30	1·35	1·41	
Particle density	2·6	2·6	2·6	
Porosity	0·5	0·48	0·46	
Moisture % w/v at:				
pF 2·0				
pF 2·3	22·0	18·3	26·0	
pF 2·7	18·6	15·0	22·4	
pF 3·7	8·9	9·3	11·7	
pF 4·2	7·4	8·0	10·0	
Clay mineralogy:				
SiO_2/Al_2O_3			1·8	1·8
SiO_2/R_2O_3			1·3	1·3
Fe_2O_3%			17·2	16·9
X-ray report:				
B21, B22	Well crystallized kaolinite (7·19Å) is predominant, but there are substantial quantities of illite as well, which is less well defined.			
Fertility aspects:				
Available Ca me%	5·6			
Available Mg me%	2·4			
Available K me%	0·72			
Available Na me%	0·04			
Available Mn me%	0·67			
Available P ppm	10			
Total Ca me%	8·1			
Total Mg me%	9·0			
Total K me%	4·9			
Total P ppm	75			

Map Unit U3GC2: Profile 53

Date of observation:	8th October, 1973.
Observation/location:	75/3–53; E.34.2, N.33.6; about 3 km. S.S.W. of Kapenguria.
Soil classification:	Ferral–humic Acrisol.
Ecological zone:	IIw.
Geological formation:	Predominantly biotite gneisses.
Local petrography:	Presumably biotite gneiss.
Physiography:	Uplands, Kapenguria level; 1920 m. altitude.
Relief—macro:	Rolling (15% slope); site on lower part of convex slope.
Relief—micro:	Nil.
Vegetation/land use:	Undifferentiated forest and cleared forest or glades; mixed farming.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	15%.
Surface sealing:	Nil.
Drainage class:	Well drained:

A1	0—20 cm.	Very dark brown (10YR 2/2 moist) sandy clay loam; weak, medium to coarse subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many micro pores; many fine and medium roots; gradual smooth boundary; (Sample 75/3–53a)
B1	20—45 cm.	Dark reddish brown (5YR 3/3 moist) sandy clay loam; weak coarse to very coarse subangular blocky; friable when moist, sticky and plastic when wet; many micro and common very fine pores; common medium and few coarse roots; diffuse smooth boundary; (Sample 75/3–53b)
B21	45—70 cm.	Dark reddish brown (2.5YR 3/4 moist) clay; porous massive; friable when moist, sticky and plastic when wet; pores and roots as B1; common moderate clay skins; diffuse smooth boundary; (Sample 75/3–53c)
B22	70—150 cm.	Dark red (2.5YR 3/6 moist) clay; porous massive; consistence and roots as B21; moderate to strong common clay skins. (Sample 75/3–53d)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/4—391

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	10621	10622	10623		
Horizon	A1	B1	B2		
Depth in cm.	0–20	20–45	45–80		
Moisture % air dry soil					
Gravel %					
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	48	40	40		
Silt % 50–2 μ	14	16	10		
Clay % 2–0 μ	38	44	50		
Texture class	SC	C	C		
Dispersed clay %	12	14	22		
Flocculation index	68	68	56		
Soil-liquid 1:1 susp:					
pH–H_2O	4·8	4·8	4·8		
pH–KCl	3·9	4·0	4·0		
EC in mmho's/cm.	0·05	0·03	0·02		
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	3·0	2·03	1·32		
N%	0·22				
C/N	13·6				
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	14·2	11·6	10·0		
Exch. Ca me%	1·2	0·9	0·7		
Exch. Mg me%	1·0	0·7	0·2		
Exch. K me%	0·3	0·2	0·2		
Exch. Na me%	0·2	0·3	0·1		
Sum of cations me%	2·7	2·1	1.2		
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	19	18	12		
E.S.P. at pH 8·2					
Exch. acidity me%	3·3				
Miscellaneous:					
Silt/Clay Ratio	0·37	0·36	0·2		

Special analyses: Area Kapenguria

Depth in cm.	0–20	20–45	45–80		
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3			1·9		
SiO_2/R_2O_3			1·3		
Fe_2O_3%			6·3		
X-ray report:					
B2	A moderately well crystallized kaolinite is the sole component of the clay fraction. Spacing 7·19Å				
Fertility aspects:					
Available Ca me%	0·6				
Available Mg me%	0·6				
Available K me%	0·10				
Available Na me%	0·08				
Available Mn me%	0·32				
Available P ppm	12				
Total Ca me%	5·0				
Total Mg me%	3·0				
Total K me%	5·8				
Total P ppm	100				

Map Unit $\frac{\text{U3Gby}}{\text{p}}$: Profile 391

Date of observation :	28th November, 1974.
Observation/location:	75/4–391; E.56.6, N.28.5; 3.5 km. West of Kapsait School.
Soil classification;	Dystric Cambisol.
Ecological zone:	IIw.
Geological formation:	Predominantly biotite gneisses of the basement system.
Local petrography:	Biotite gneisses.
Physiography:	Uplands, Kapenguria level
Relief—macro:	Rolling to hilly terrain; site on a convex slope of 200–300 m. length and a slope gradient of 18%.
Relief—micro:	Nil.
Vegetation/land use:	Undifferentiated forest and cleared forest or glades; land used for extensive grazing.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	18%.
Surface sealing:	Nil.
Drainage class:	Well drained.

A1	0—20 cm.	Dark reddish brown (5YR 3/3 moist) sandy clay; moderate fine and medium subangular blocky; friable when moist, slightly sticky and slightly plastic when wet; many micro pores; many very fine and fine roots; gradual smooth boundary; (Sample 75/4–391a)
B1	20—45 cm.	Dark reddish brown (5YR 3/4 moist) clay; very weak coarse subangular blocky; friable when moist; slightly sticky and plastic when wet; many micro pores; common fine and very fine roots; diffuse smooth boundary; (Sample 75/4–391b)
B2	45—80 cm.	Yellowish red (5YR 4/6 moist) clay; porous massive; consistence as B1; many micro and common very fine pores; common very fine and fine roots; many primary minerals, mainly mica; clear smooth boundary; (Sample 75/4–391c)
B3	80—95 cm.	Stone line, consisting of fine quartz gravel and (weathered) rock fragments and some soil material; clear wavy boundary;
C	95—105 cm.+	Reddish coloured semi-weathered rock.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—2

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /73	8819	8820	8821	8822
Horizon	A	B1	B21	B22
Depth in cm.	0–18	18–43	43–113	113-174+
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	30	26	24	24
Silt % 50–2 μ	10	12	12	8
Clay % 2–0 μ	60	62	64	68
Texture class	C	C	C	C
Dispersed clay %	19	27	7	5
Flocculation index	68	56	89	93
Soil-liquid 1:1 susp:				
pH–H_2O	5·4	5·5	5·7	5·9
pH–KCl	4·3	4·4	4·6	4·9
EC in mmho's/cm.	0·08	0·04	0·02	0·02
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$%				
$CaSO_4.2H_2O$%				
C%	1·07	1·07		
N%	0·14	0·08		
C/N	7·6	13·4		
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	9·2	9·4	8·4	8·3
Exch. Ca me%	1·8	1·6	1·5	1·4
Exch. Mg me%	1·8	1·7	2·0	1·7
Exch. K me%	1·0	0·6	0·5	0·5
Exch. Na me%	0	0·2	0	0·6
Sum of cations me%	4·6	4·1	4·0	4·2
Base Sat. % at pH 8·2				
Base Sat. % at pH 7·0	50	44	48	51
E.S.P. at pH 8·2				
Exch. acidity me%	0·4			
Miscellaneous:				
Silt/Clay Ratio	0·17	0·19	0·19	0·12

Special analyses: Area Kapeng

Depth in cm.	0–18	18–43	43–113	113-174+
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.	0·4	0·5	0·5	0·5
1·0–0·5 mm.	3·8	3·7	3·7	2·5
0·5–0·25 mm.	11·3	9·9	7·8	6·0
0·25–0·1 mm.	9·0	8·1	7·4	7·7
0·1–0·05 mm.	0·1	0·3	0·2	1·8
Total sand %	24·6	22·5	19·6	18·5
Silt % 50–20 μ				
20–2 μ				
Total silt %	15·8	13·0	12·3	11·7
Clay % 2–0 μ	59·6	64·5	68·1	69·8
Texture class	C	C	C	C
Bulk density	1·19		1·15	1·11
Particle density	2·6		2·6	2·6
Porosity	0·54		0·56	0·57
Moisture % w/v at:				
pF 2·0				
pF 2·3	30·5		32·4	34·5
pF 2·7	24·3		26·9	29·6
pF 3·7	18·8		20·9	23·3
pF 4·2	17·3		20·6	21·5
Clay mineralogy:				
SiO_2/Al_2O_3			1·7	1·6
SiO_2/R_2O_3			1·3	1·2
Fe_2O_3%			16·5	19·2
X-ray report:				
B21, B22	The sole mineral present is kaolinite, spe 7·19Å. The peak is of low intensity.			
Fertility aspects:				
Available Ca me%	1·2			
Available Mg me%	1·4			
Available K me%	0·54			
Available Na me%	0·04			
Available Mn me%	0·80			
Available P ppm	12			
Total Ca me%	8·0			
Total Mg me%	6·4			
Total K me%	3·3			
Total P ppm	200			

Map Unit U4Ur: Profile 2

Date of observation:	6th October, 1973.
Observation/location:	75/3–2; E.26.1, N.30.1; along Kitale–Kapenguria Road.
Soil classification:	Rhodic Ferralsol.
Ecological zone:	III.
Geological formation:	Undifferentiated basement system rocks.
Local petrography:	Gneisses rich in quartz and potassium feldspars.
Physiography:	Upland, Kitale level.
Relief—macro:	Gently undulating; convex slopes (gradient 2%).
Relief—micro:	Regular, apart from some termite mounds.
Vegetation/land use:	Grassland; originally moist Combretum woodland.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	2%.
Salinity/alkalinity:	Nil.
Surface sealing:	Thin; slight cracking of soil surface.
Drainage class:	Well drained.

A1	0—18 cm.	Dark reddish brown (2.5YR 3/4 dry), dusky red (2.5YR 3/2 moist) clay; moderate fine and medium subangular blocky; slightly hard when dry; friable when moist, sticky and plastic when wet; common very fine pores; many fine roots; smooth clear boundary; (Sample 75/3–2a)
B1	18—43 cm.	Dark red (2.5YR 3/6 dry), dark reddish brown (2.5YR 3/4 moist) clay; structure and consistence as A; few very fine, common micro pores; many very fine roots; gradual smooth boundary; (Sample 75/3–2b)
B21	43—113 cm.	Dark red (10R 3/6 dry), dusky red (10R 3/4 moist) clay; weak (very) fine subangular blocky; friable when moist; sticky and plastic when wet; few to common very fine pores; few very fine roots; smooth diffuse boundary; (Sample 75/3–2c)
B22	113—174 cm.+	Dusky red (10R 3/4 moist) clay; structure and consistence and pores like B21; few thin clay skins in the lower part of the horizon. (Sample 75/3–2d)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—18

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	3586	3587	3588	3589
Horizon	A1	B1	B21	B22
Depth in cm.	0–22	22–33	33–69	69–193+
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	52	48	40	34
Silt % 50–2 μ	8	8	8	18
Clay % 2–0 μ	40	44	52	60
Texture class	SC	C	C	C
Dispersed clay %	16	20	24	16
Flocculation index	60	55	54	73
Soil-liquid 1:1 susp:				
pH–H_2O	5·7	5·6	5·8	6·1
pH–KCl	4·7	4·7	4·8	5·3
EC in mmho's/cm.	0·07	0·08	0·04	0·03
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$ %				
$CaSO_4.2H_2O$ %				
C%	1·68	1·39		
N%	0·16	0·10		
C/N	10·5	13·9		
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	10·1	9·8	8·6	10·2
Exch. Ca me%	3·2	3·0	3·2	3·6
Exch. Mg me%	1·4	1·4	1·3	2·5
Exch. K me%	0·4	0·4	0·3	0·5
Exch. Na me%	0·1	0·3	0·3	0·3
Sum of cations me%	5·1	5·1	5·1	6·9
Base Sat. % at pH 8·2				
Base Sat. % at pH 7·0	51	52	59	68
E.S.P. at pH 8·2				
Exch. acidity me%	—			
Miscellaneous:				
Silt/Clay Ratio	0·20	0·18	0·15	0·3

Special analyses: Area Kapengu

Depth in cm.	0–22	22–33	33–69	69–193+
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.				
1·0–0·5 mm.				
0·5–0·25 mm.				
0·25–0·1 mm.				
0·1–0·05 mm.				
Total sand %				
Silt % 50–20 μ				
20–2 μ				
Total silt %				
Clay % 2–0 μ				
Texture class				
Bulk density		1·26	1·23	1·18
Particle density		2·6	2·6	2·6
Porosity		0·52	0·53	0·55
Moisture % w/v at:				
pF 2·0				
pF 2·3		24·0	26·0	28·0
pF 2·7		19·1	20·5	23·4
pF 3·7		15·4	17·3	18·5
pF 4·2		14·1	16·3	17·6
Clay mineralogy:				
SiO_2/Al_2O_3			2·4	2·4
SiO_2/R_2O_3			2·2	2·1
Fe_2O_3 %			9·6	12·5

X-ray report:

B21, B22 — Kaolinite and illite, both very poorly crystallized are present, of which the latter shows a better peak after heat treatment.

Fertility aspects:	
Available Ca me%	2·2
Available Mg me%	1·4
Available K me%	0·24
Available Na me%	0·10
Available Mn me%	0·64
Available P ppm	7
Total Ca me%	5·0
Total Mg me%	6·8
Total K me%	2·7
Total P ppm	96

Map Unit U4Ub: Profile 18

Date of observation:	1st April, 1974.
Observation/location:	75/3–18; E.24.6, N.27.8; 1 km. S.E. of Knights Corner.
Soil classification:	Orthic/humic Ferralsol.
Ecological zone:	III.
Geological formation:	Undifferentiated basement system rocks.
Local petrography:	Gneisses rich in quartz and potassium feldspars.
Physiography:	Upland, Kitale level.
Relief—macro:	Rolling, concave slope of 800 m.; gradient 4%.
Relief—micro:	Some ant hills.
Vegetation/land use:	Grassland; originally moist Combretum woodland.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	10%.
Salinity/alkalinity:	Nil.
Surface sealing:	Weak, few fine cracks on soil surface.
Drainage class:	Well drained.

A1	0—22 cm.	Dark reddish brown (5YR 3/2 moist) sandy clay; weak, fine to medium subangular blocky; firm when moist, sticky when wet; common fine and medium pores; many fine and medium, few coarse roots; clear smooth boundary; (Sample 75/3–18a)
B1	22—33 cm.	Dark reddish brown (5YR 3/3 moist) clay; weak to moderate, fine to medium angular blocky; firm when moist, sticky when wet; few fine and medium pores; common fine, few medium roots; gradual smooth boundary; (Sample 75/3–18b)
B21	33—69 cm.	Dark reddish brown (5YR 3/4 moist) clay; moderate, fine to medium angular blocky; firm when moist, sticky when wet; few fine pores; common fine roots; few insect channels; diffuse smooth boundary: (Sample 75/3–18c)
B22	69—193 cm.+	Yellowish red (5YR 4/6 moist) clay; weak, fine to medium subangular blocky; friable when moist, sticky when wet; few very fine pores; few fine roots; (Sample 75/3–18d)

Remark: Pockets of charcoal occur occasionally in the A1 and B1 horizons.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/1—104

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	3555	3556	3557	3558	3559
Horizon	A1	B1	B21	B22	B23
Depth in cm.	0–10	10–25	25–80	80–95	95–160+
Moisture % air dry soil					
Gravel %				47	6
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	66	56	52	58	48
Silt % 50–2 μ	14	8	8	4	12
Clay % 2–0 μ	20	36	40	38	40
Texture class	SCL/SL	SC	SC	SC	SC
Dispersed clay %	6	16	22	24	26
Flocculation index	70	56	45	37	35
Soil-liquid 1:1 susp:					
pH–H_2O	5·9	5·5	6·0	6·4	6·3
pH–KCl	4·9	4·8	4·7	5·0	5·1
EC in mmho's/cm.	0·22	0·37	0·05	0·05	0·11
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4 \cdot 2H_2O$%					
C%	0·35				
N%	0·07				
C/N	5·0				
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	7·2	10·4	12·3	11·8	11·6
Exch. Ca me%	2·5	2·6	3·4	3·2	3·4
Exch. Mg me%	1·0	2·4	2·5	3·7	3·2
Exch. K me%	0·7	0·4	0·2	0·3	0·3
Exch. Na me%	0	0	0	0·1	0·1
Sum of cations me%	4·2	5·4	6·1	7·4	7·0
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	58	52	50	63	60
E.S.P. at pH 8·2					
Exch. acidity me%	—	0·1			
Miscellaneous:					
Silt/Clay Ratio	0·70	0·22	0·2	0·11	0·3

Special analyses: Area Kapenguria

Depth in cm.	0–10	10–25	25–80	80–95	95–160+
Texture U.S.D.A.:					
Sand % 2·0–1·0 cm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3			2·4	2·3	2·3
SiO_2/R_2O_3			1·9	1·8	1·8
Fe_2O_3%			11·2	18·6	17·6
X-ray report:					
B21, B22, B23	Moderately well crystallized, consisting of about 45% kaolinite and 53% illite. Trace of a 14 Å, 2:1 non-exp. type of clay minera				
Fertility aspects:					
Available Ca me%	1·5	1·8			
Available Mg me%	0·6	1·4			
Available K me%	0·43	0·22			
Available Na me%	tr.	tr.			
Available Mn me%	0·31	0·40			
Available P ppm	150	164			
Total Ca me%	3·2				
Total Mg me%	3·3				
Total K me%	2·8				
Total P ppm	250				

Map Unit $\frac{\text{U5Frc}}{\text{p}}$: Profile 104

Date of observation:	30th April, 1974.
Observation/location:	75/1–104; E.41.0, N.55.7; 5½ km. N.N.W. of holding ground.
Soil classification:	Chromic Luvisol.
Ecological zone:	IV.
Geological formation:	Predominantly hornblende gneisses of the basement system.
Local petrography:	Gneisses rich in Fe+Mg as well as in Ca and Na.
Physiography:	Upland, Kunyao level, 5200 ft.
Relief—macro:	Gently undulating: 100–300 m. slopes; gradient 4%.
Relief—micro:	Termite mounds 1 m. high, 5 m. diameter, 100 m. apart.
Vegetation/land use:	Acacia nilotica bushland, more than 90% bare soil.
Erosion:	Moderate sheet erosion.
Surface stoniness:	Nil.
Slope gradient:	4%.
Salinity/alkalinity:	Nil.
Surface sealing:	Strong and continuous (3–5 mm.); sand wash common.
Drainage class:	Well drained.

A1	0—10 cm.	Reddish brown (5YR 4/3 dry), dark reddish brown (5YR 3/3 moist) sandy loam; massive; very hard when dry, friable when moist, non sticky and non plastic when wet; many micro pores; common very fine and fine roots; many dark minerals; smooth clear boundary; (Sample 75/1–104a)
B1	10—25 cm.	Yellowish red (5YR 4/6 dry), dark reddish brown (5YR 3/4 moist) sandy clay loam; massive with occasionally weak subangular blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many micro, few fine and medium pores; common very fine and fine roots; common thin clay cutans; smooth diffuse boundary; (Sample 75/1–104b)
B21	25—80 cm.	Red (2.5YR 4/6 dry) dark red (2.5YR 3/6 moist) sandy clay; weak, very coarse prismatic structure; hard when dry, friable when moist, slightly sticky and plastic when wet; many micro and few fine pores; very few fine roots; common thin clay cutans; wavy abrupt boundary; (Sample 75/1–104c)
B22	80—95 cm.	Very gravelly sandy clay; structureless; gravel consists of quartz and semi-weathered rock fragments, mainly feldspars; wavy gradual boundary; (Sample 75/1–104d)
B23	95—160 cm.+	Yellowish red (5YR 4/6 dry and 5YR 3/6 moist) slightly gravelly sandy clay; massive with occasionally, tendency to weak subangular blocky; hard when dry, friable when moist, sticky and plastic when wet; many micro and common fine pores; common thin clay cutans. (Sample 75/1–104e)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—57

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /73	8847	8848	8849	8850
Horizon	A1	B1	B21	B22
Depth in cm.	0–20	20–45	45–95	95–125
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	70	64	56	50
Silt % 50–2 μ	14	12	16	14
Clay % 2–0 μ	16	24	28	36
Texture class	SL	SCL	SCL	SC
Dispersed clay %	11	15	23	23
Flocculation index	31	37	17	36
Soil-liquid 1:1 susp:				
pH–H_2O	5·8	5·5	6·0	7·2
pH–KCl	4·6	4·2	4·7	5·9
EC in mmho's/cm.	0·08	0·06	0·09	0·18
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$ %				
$CaSO_4.2H_2O$ %				
C%	0·84			
N%	0·09			
C/N	9·3			
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	8·7	10·2	10·6	11·8
Exch. Ca me%	1·4	1·6	2·4	3·2
Exch. Mg me%	1·7	1·2	1·7	2·6
Exch. K me%	1·5	0·9	1·2	2·0
Exch. Na me%	0	0	0.1	0.2
Sum of cations me%	4·6	3·7	5·4	8·0
Base Sat. % at pH 8·2				
Base Sat. % at pH 7·0	53	36	51	68
E.S.P. at pH 8·2				
Exch. acidity me%	—			
Miscellaneous:				
Silt/Clay Ratio	0·88	0·5	0·57	0·39

Special analyses: Area Kapenguria

Depth in cm.	0–20	20–45	45–95	95–125
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.				
1·0–0·5 mm.				
0·5–0·25 mm.				
0·25–0·1 mm.				
0·1–0·05 mm.				
Total sand %				
Silt % 50–20 μ				
20–2 μ				
Total silt %				
Clay % 2–0 μ				
Texture class				
Bulk density	1·51	1·53	1·54	
Particle density	2·6	2·6	2·6	
Porosity	0·42	0·40	0·40	
Moisture % w/v at:				
pF 2·0				
pF 2·3	13·2	15·5	20·1	
pF 2·7	10·3	12·1	14·6	
pF 3·7	6·0	8·2	11·3	
pF 4·2	5·1	7·4	10·1	
Clay mineralogy:				
SiO_2/Al_2O_3			2·6	2·4
SiO_2/R_2O_3			2·2	2·0
Fe_2O_3 %			16·2	16·0
X-ray report:				
B21, B22	Illite and kaolinite, both well crystallized are present in about equal amounts, although kaolinite is increasing with depth.			
Fertility aspects:				
Available Ca me%	1·2			
Available Mg me%	0·9			
Available K me%	0·34			
Available Na me%	tr.			
Available Mn me%	0·20			
Available P ppm	78			
Total Ca me%	7·0			
Total Mg me%	13·6			
Total K me%	4·2			
Total P ppm	80			

Map Unit U5Bbc2: Profile 57

Date of observation:	10th October, 1973.
Observation/location:	75/1–57; E.45.5, N.47.5; 2½ km. from junction at Chepareria.
Soil classification:	Orthic Acrisol.
Ecological zone:	IV.
Geological formation:	Predominantly hornblende gneisses of the basement system.
Local petrography:	Gneisses rich in ferromagnesian minerals and calcium and sodium.
Physiography:	Upland, Kunyao level, 5500 ft.
Relief—macro:	Gently undulating on middle slope of interfluve.
Relief—micro:	Termite mounds 1 m. high, 4–5 m. diameter; 50 m. apart.
Vegetation/land use:	Combretum–Euphorbia woodland.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	3%.
Salinity/alkalinity:	Nil.
Surface sealing:	3–5 mm., moderate to strong.
Drainage class:	Well drained.

A1	0—20 cm.	Brown (7.5YR 4/2 dry), dark brown (7.5YR 3/2 moist) sandy loam; weak medium to coarse subangular blocky; friable when moist, sticky and slightly plastic when wet; many micro and common very fine pores; many fine and very fine roots; clear smooth boundary; (Sample 75/1–57a)
B1	20—45 cm.	Reddish brown (5YR 4/4 dry), dark reddish brown (5YR 3/3 moist) sandy clay loam; weak, coarse and very coarse angular blocky; friable when moist, slightly sticky and plastic when wet; many micro, common very fine and few fine pores; few very fine roots; few thin clay skins, many primary minerals; diffuse smooth boundary; (Sample 75/1–57b)
B21	45—95 cm.	Yellowish red (5YR 4/6 moist) sandy clay loam; weak, coarse angular blocky; friable when moist, sticky and plastic when wet; roots and pores as B1; common, thin clay skins; diffuse smooth boundary; (Sample 75/1–57c)
B22	95—125 cm.	Yellowish red (5YR 4/6 moist) sandy clay; porous massive; very friable when moist, sticky and very plastic when wet; clear smooth boundary; (Sample 75/1–57d)
C	125 cm.+	Mixture of quartz gravel and petroplinthite fragments with dark red clay; hard rock at 140 cm.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—540

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /75	9346	9347	9348		
Horizon	A1	B2	B3		
Depth in cm.	0–25	25–60	60–85		
Moisture % air dry soil					
Gravel %			47		
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	66	30	38		
Silt % 50–2 μ	8	22	14		
Clay % 2–0 μ	26	48	48		
Texture class	SCL	C	C		
Dispersed clay %	16	28	26		
Flocculation index	38	42	46		
Soil liquid 1:1 susp:					
pH–H_2O	6·9	5·7	6·1		
pH–KCl	5·8	4·6	5·1		
EC in mmho's/cm.	0·10	0·12	0·25		
Saturation extracts:					
pH					
EC					
Saturation %					
$CaCO_3$ %					
$CaSO_4.2H_2O$ %					
C%	0·44	0·35	0·29		
N%	0·05				
C/N	8·8				
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	8·8	10·0	9·5		
Exch. Ca me%	4·2	2·5	3·3		
Exch. Mg me%	2·3	2·0	2·7		
Exch. K me%	0·9	0·5	0·5		
Exch. Na me%	0·1	0·2	0·2		
Sum of cations me%	7·5	5·2	6·4		
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	85	52	67		
E.S.P. at pH 8·2					
Exch. acidity me%	—				
Miscellaneous:					
Silt/Clay Ratio	0·31	0·46	0·29		

Special analyses: Area Kapenguria

Depth in cm.	0–25	25–60	60–85		
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3 %					
X-ray report:					
Fertility aspects:					
Available Ca me%	2·6				
Available Mg me%	1·9				
Available K me%	0·79				
Available Na me%	0·15				
Available Mn me%	0·33				
Available P ppm	41				
Total Ca me%	6·3				
Total Mg me%	4·8				
Total K me%	4·9				
Total P ppm	52				

Map Unit $\frac{\text{U6Gbc}}{\text{p}}$: Profile 540

Date of observation:	1st November, 1974.
Observation/location:	75/2–540; E.78.8, N.62.5.
Soil classification:	Ferralic Cambisol.
Ecological zone:	IV.
Geological formation:	Undifferentiated basement system rocks.
Local petrography:	Gneisses rich in quartz and K-feldspars.
Physiography:	Upland, Wei-Wei level.
Relief—macro:	Very gently undulating (2% slope); convex terrain.
Relief—micro:	Irregular because of rock outcrops and gullies.
Vegetation/land use:	Acacia reficiens bushland; appr. 75% bare ground.
Erosion:	Moderate gully erosion.
Surface stoniness:	Nil.
Slope gradient:	2%.
Salinity/alkalinity:	Nil.
Surface sealing:	5–8 mm.; strong.
Drainage class:	Well drained.

A1	0—25 cm.	Brown (7·5YR 5/4 dry), dark reddish brown (5YR 3/3 moist), sandy clay loam; moderate, fine and medium subangular blocky; slightly hard when dry; friable when moist, non sticky and non plastic when wet; few (very) fine, common medium pores; gradual smooth boundary; (Sample 75/2–540a)
B2	25—60 cm.	Yellowish red (5YR 5/6 dry), dark red (2.5YR 3/6 moist) clay; moderate, fine and medium subangular blocky; slightly hard when dry; friable when moist, slightly sticky and slightly plastic when wet; pores as A1; clear smooth boundary; (Sample 75/2–540b)
B3	60—85 cm.	Yellowish red (5YR 5/6 dry and 4/6 moist) gravelly clay; moderate fine subangular blocky; consistence as B2; common manganese concretions (5–10 mm. in diameter); (Sample 75/2–540c)
C	85 cm.+	Weathered parent material with quartz stones.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/1—60

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	2009	2010	2011	2012
Horizon	A1	B1	B21	B22
Depth in cm.	0–15	15–35	35–70	70–105
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	55	49	53	53
Silt % 50–2 μ	24	22	14	10
Clay % 2–0 μ	21	29	29	37
Texture class	SCL/SL	SCL	SCL	SC
Dispersed clay%	15	15	17	21
Flocculation index	29	48	41	43
Soil-liquid 1:1 susp:				
pH–H_2O	5·4	5·4	5·8	6·2
pH–KCl	4·2	4·2	5·3	4·6
EC in mmho's/cm.	0·08	0·06	0·06	0·06
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$%				
$CaSO_4.2H_2O$%				
C%	0·94	0·94		
N%	0·10	0·08		
C/N	9·4	11·7		
CEC (NaOAc, pH 8·2) me%				
CEC (NH_4OAc, pH 7·0) me%	5·6	7·6	7·2	8·3
Exch. Ca me%	1·2	1·8	2·6	2·8
Exch. Mg me%	1·3	1·6	2·4	2·6
Exch. K me%	0·2	0·2	0·2	0·3
Exch. Na me%	0	0·1	0·2	0·4
Sum of cations me%	2·7	3·7	5·4	6·1
Base Sat. % at pH 8·2				
Base Sat. % at pH 7·0	48	49	75	73
E.S.P. at pH 8·2				
Exch. acidity me%	—			
Miscellaneous:				
Silt/Clay Ratio	1·14	0·76	0·48	0·27

Special analyses: Area Kapenguria

Depth in cm.	0–15	15–35	35–70	70–105
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.	1·8	1·6	1·9	3·1
1·0–0·5 mm.	10·2	10·1	7·6	9·1
0·5–0·25 mm.	26·6	18·6	17·4	16·2
0·25–0·1 mm.	24·0	20·8	20·0	18·0
0·1–0·05 mm.	5·1	7·2	4·8	5·1
Total sand %	67·7	58·3	51·7	45·5
Silt % 50–20 μ				
20–2 μ				
Total silt %	9·0	10·2	16·1	16·0
Clay % 2–0 μ	23·3	31·5	32·2	38·5
Texture class	SCL	SCL	SCL	SC
Bulk density		1·54	1·50	1·53
Particle density		2·6	2·6	2·6
Porosity		0·40	0·40	0·40
Moisture % w/v at:				
pF 2·0				
pF 2·3		16·1	17·3	23·3
pF 2·7		13·3	14·1	19·6
pF 3·7		8·9	9·3	11·7
pF 4·2		7·4	8·0	10·0
Clay mineralogy:				
SiO_2/Al_2O_3			2·0	2·2
SiO_2/R_2O_3			1·8	1·9
Fe_2O_3%			7·1	6·8

X-ray report:

B21, B22 — Kaolinite (7·17Å) is dominant, although appreciable quantities of illite material (10–14·24A) are present, which is perhaps altering into vermiculite. Traces of gibbsite.

Fertility aspects:	
Available Ca me%	0·8
Available Mg me%	1·1
Available K me%	0·26
Available Na me%	0·09
Available Mn me%	0·12
Available P ppm	5
Total Ca me%	3·2
Total Mg me%	3·6
Total K me%	2·9
Total P ppm	60

Map Unit $\frac{\text{U7Bbc}}{\text{p}}$: Profile 60

Date of observation:	29th November, 1973.
Observation/location:	75/1–60; E.29.5, N.39.8; about 3 km. S.W. of Kisiaunet.
Soil classification:	Orthic Luvisol.
Ecological zone:	III.
Geological formation:	Predominantly biotite gneisses of the basement system.
Local petrography:	Presumably biotite gneisses.
Physiography:	Uplands; altitute 6500 ft.
Relief—macro:	Undulating to rolling; site on upper part of a convex slope, length 100 m.; slope gradient 6%.
Relief—micro :	Few termite mounds, 10–20 m. apart.
Vegetation/land use:	Cleared forest or glades; used for extensive grazing.
Surface stoniness:	Nil.
Slope gradient.:	6%.
Salinity/alkalinity:	Nil.
Surface sealing:	3–5 mm.; strong.
Drainage class:	Well drained.

A1	0—15 cm.	Greyish brown (10YR 5/2 dry), very dark greyish brown (10YR 3/2 moist) sandy loam; moderate, fine and medium subangular blocky; hard when dry, friable when moist, slightly sticky and slightly plastic when wet; many micro and common fine pores; many fine and medium roots; clear smooth boundary; (Sample 75/1–60a)
B1	15—35 cm.	Brown (10YR 5/3 dry), dark brown (10YR 3/3 moist) sandy clay loam; massive; hard when dry, very friable when moist, slightly sticky and slightly plastic when wet; many micro pores; few fine roots; many biotite and mica; gradual smooth boundary; (Sample 75/1–60b)
B21	35—70 cm.	Yellowish brown (10YR 5/4 dry), dark yellowish brown (10YR 4/4 moist) sandy clay loam; massive; consistence, pores and roots as B1; few thick clay skins; many dark minerals; distinct smooth boundary; (Sample 75/1–60c)
B22	70—105 cm.	Light yellowish brown (10YR 6/4 dry), brown (7.5YR 4/4 moist) sandy clay; coarse angular blocky with a tendency to massive; very hard when dry; friable when moist, sticky and plastic when wet; many micro, common very fine pores; common clay skins, mainly bridges; many dark minerals; abrupt boundary; (Sample 75/1–60d)
B31	105—115 cm.	Stone line consisting of quartz stones, micaceous rock fragments and hornblende gneiss.
B32	115—145 cm.	Mixture of soil material and semi-weathered rock.
C	145—170 cm.+	Semi-weathered rock.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—488

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	8260	8261	8262		
Horizon	A1	B2	B3		
Depth in cm.	0–25	25–40	40–60		
Moisture % air dry soil					
Gravel %					
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	60	62	62		
Silt % 50–2 μ	14	18	14		
Clay % 2–0 μ	26	20	24		
Texture class	SCL	SCL/SL	SCL		
Dispersed clay %	10	12	16		
Flocculation index	62	40	33		
Soil-liquid 1:1 susp:					
pH–H_2O	8·3	8·4	8·5		
pH–KCl	6·9	7·2	7·1		
EC in mmho's/cm.	0·21	0·23	0·47		
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%	3·1	2·0	2·8		
$CaSO_4.2H_2O$%					
C%	0·71				
N%	0·06				
C/N	11·8				
CEC (NaOAc, pH 8·2) me%	19·2	17·4	19·6		
CEC (NH_4OAc, pH 7·0) me%					
Exch. Ca me%	14·1	10·0	10·8		
Exch. Mg me%	4·0	5·8	6·3		
Exch. K me%	0·5	0·4	0·3		
Exch. Na me%	0·6	1·2	2·2		
Sum of cations me%	19·2	17·4	19·6		
Base Sat. % at pH 8·2	100	100	100		
Base Sat. at % pH 7·0					
E.S.P. at pH 8·2		6·8	11·2		
Exch. acidity me%	—				
Miscellaneous:					
Silt/Clay Ratio	0·54	0·9	0·58		

Special analyses: Area Kapenguria

Depth in cm.	0–25	25–40	40–60		
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3%					
X-ray report:					
Fertility aspects:					
Available Ca me%	11·8				
Available Mg me%	3·7				
Available K me%	0·26				
Available Na me%	0·24				
Available Mn me%	0·56				
Available P ppm	184				
Total Ca me%	16·0				
Total Mg me%	22·0				
Total K me%	9·6				
Total P ppm	580				

Map Unit $\frac{\text{U7Bb}}{\text{P}}$—$\frac{\text{U7Bbc}}{\text{p}}$: Profile 488

Date of observation:	18th September, 1974.
Observation/location:	75/2–488; E.57.2, N. 57.3
Soil classification:	Eutric Cambisol.
Ecological zone:	IV.
Geological formation:	Predominantly biotite gneisses from the basement system.
Local petrography:	Gneisses rich in oligoclase, quartz and biotite
Physiography:	Undifferentiated level in uplands; altitude 1550 m.
Relief—macro:	Rolling (9% slope) middle part of convex slope; length 400 m.
Relief—micro:	Irregular, common termite mounds.
Vegetation/land use:	Acacia nilotica bushland.
Erosion:	Very slight water erosion.
Surface stoniness:	15–20%.
Slope gradient:	9%.
Salinity/alkalinity:	Slightly sodic in the subsoil.
Surface sealing:	About 5 mm.; weak.
Drainage class:	Well drained.

A1 0—25 cm. Brown (7.5YR 4/4 dry and moist) sandy clay loam; moderate, fine and medium subangular blocky; hard when dry, firm when moist, slightly sticky and non plastic when wet; common fine and medium, few coarse pores; many fine, common medium, few coarse roots; much mica; clear wavy boundary;

(Sample 75/2–488a)

B2 25—40 cm. Dark reddish brown (5YR 3/3 dry), dark brown (7.5YR 3/2 moist) sandy clay loam; moderate, fine and medium subangular blocky; hard when dry, firm when moist, slightly sticky and slightly plastic when wet; common fine and coarse, few medium pores; roots as A1; common mycelium of $CaCO_3$; much mica; abrupt irregular boundary;

(Sample 75/2–488b)

B3 40—60 cm. Brown (7.5YR dry, 4/4 moist) sandy clay loam; structure as B2; hard when dry, firm when moist, sticky and plastic when wet; common fine and medium pores; much mycelium of $CaCO_3$; much mica; with depth the horizon has many aspects of weathered rock.

(Sample 75/2–488c)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—539

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /75	9343	9344	9345		
Horizon	Ap	B2	C		
Depth in cm.	0–30	30–85	85–120+		
Moisture % air dry soil					
Gravel %					
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	40	40	46		
Silt % 50–2 μ	18	14	10		
Clay % 2–0 μ	42	46	44		
Texture class	C	SC	SC		
Dispersed clay %	34	36	38		
Flocculation index	19	22	14		
Soil-liquid 1:1 susp:					
pH–H_2O	7·0	7·0	7·0		
pH–KCl	5·8	5·6	5·7		
EC in mmho's/cm.	0·18	0·23	0·33		
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	0·97	0·26	0·16		
N%	0·12				
C/N	8·1				
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	23·4	22·2	21·5		
Exch. Ca me%	13·6	15·2	13·6		
Exch. Mg me%	8·0	5·1	5·0		
Exch. K me%	0·7	0·2	0·3		
Exch. Na me%	0·3	0·8	1·2		
Sum of cations me%	22·6	21·3	20·1		
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	97	96	93		
E.S.P. at pH 8·2					
Exch. acidity me%	—				
Miscellaneous:					
Silt/Clay Ratio	0·43	0·30	0·23		

Special analyses: Area Kapenguria

Depth in cm.	0–30	30–85	85–120+		
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0 μ					
Texture Class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3		2·2	2·3		
SiO_2/R_2O_3		1·7	1·7		
Fe_2O_3%		8·1	5·0		
X-ray report:					
B2, C	The clay fraction consists of kaolinite and illite; the former is predominant. Both are well crystallized.				
Fertility aspects:					
Available Ca me%	8·8				
Available Mg me%	3·8				
Available K me%	1·20				
Available Na me%	0·18				
Available Mn me%	0·61				
Available P ppm	147				
Total Ca me%	15·0				
Total Mg me%	10·6				
Total K me%	10·8				
Total P ppm	340				

Map Unit YGbc1: Profile 539

Date of observation:	1st November, 1974.
Observation/location	75/2–539; E.76.3; N.64.1; 2.5 km. S.W. of Sigor.
Soil classification:	Verti-chromic Luvisol.
Ecological zone:	IV.
Geological formation:	Predominantly biotite gneiss of the basement system.
Local petrography:	Alluvium with heterogeneous composition.
Physiography:	Piedmont plain; altitude 4400 ft.
Relief—macro:	Almost level (1% slope).
Relief—micro:	None.
Vegetation/land use:	Acacia seyal bushland, 70% bare soil surface.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	1%.
Salinity/alkalinity:	Nil.
Surface sealing:	0. 5 cm. continuous weak; sand wash on soil surface.
Drainage class:	Well drained.

Ap	0—30 cm.	Dark brown (7.5YR 3/2 dry), dark reddish brown (5YR 3/2 moist) clay; strong, medium subangular blocky; firm when moist, sticky and plastic when wet, common fine and medium pores; common fine coarse roots; few common mica; smooth gradual boundary; (Sample 75/2–539a)
B2	30—85 cm.	Dark reddish brown (5YR 3/4 dry and 5YR 3/3 moist) sandy clay; strong, medium coarse angular blocky to prismatic; very hard when dry, firm when moist, sticky and plastic when wet; few fine and medium pores; few roots; common mica; smooth gradual boundary; (Sample 75/2–539b)
C	85—120 cm.+	Dark reddish brown (5YR 3/4 dry and 5YR 3/3 moist) clay; common, medium faint dark reddish brown (5YR 3/2) mottles; massive; very hard when dry; firm when moist, sticky and plastic when wet; few (very) fine pores; very few fine roots; soil material becomes very hard (compact) with depth. (Sample 75/2–539c)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—542

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /75	9351	9352	9353		
Horizon	A1	B	C		
Depth in cm.	0–20	20–75	75–120+		
Moisture % air dry soil					
Gravel %					
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	36	32	36		
Silt % 50–2 μ	12	12	12		
Clay % 2–0 μ	52	56	56		
Texture class	C	C	C		
Dispersed clay %	34	16	28		
Flocculation index	35	71	50		
Soil-liquid 1:1 susp:					
pH–H_2O	6·8	8·3	8·5		
pH–KCl	5·6	6·8	7·1		
EC in mmho's/cm.	0·35	0·50	0·70		
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	0·65	0·44	0·24		
N%	0·08				
C/N	8·1				
CEC (NaOAc, pH 8·2) me%	26·2	26·4	29·5		
CEC (NH_4OAc, pH 7·0) me%					
Exch. Ca me%	16·8	19·4	22·2		
Exch. Mg me%	5·5	5·0	4·3		
Exch. K me%	0·7	0·5	0·4		
Exch. Na me%	0·2	1·5	2·6		
Sum of cations me%	23·2	26·3	29·5		
Base Sat. % at pH 8·2	89	100	100		
Base Sat % at pH 7·0					
E.S.P. at pH 8·2	—	5·7	8·8		
Exch. acidity me%					
Miscellaneous:					
Silt/Clay Ratio	0·23	0·21	0·21		

Special analyses: Area Kapenguria

Depth in cm.	0–20	20–75	75–120+		
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.					
1·0–0·5 mm.					
0·5–0·25 mm.					
0·25–0·1 mm.					
0·1–0·05 mm.					
Total sand %					
Silt % 50–20 μ					
20–2 μ					
Total silt %					
Clay % 2–0μ					
Texture class					
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3		2·7			
SiO_2/R_2O_3		2·1			
Fe_2O_3%		6·8			
X-ray report:					
B	Predominantly illite; traces of poorly crystallized kaolin. The situation may be described by the sequence: Mica→illite→2:1 type of material (Montmorillonite/Vermiculite).				
Fertility aspects:					
Available Ca me%	11·8				
Available Mg me%	5·0				
Available K me%	0·77				
Available Na me%	0·26				
Available Mn me%	0·54				
Available P ppm	27				
Total Ca me%	16·0				
Total Mg me%	32·8				
Total K me%	4·0				
Total P ppm	100				

Map Unit YGbc2: Profile 542

Date of observation:	2nd November, 1974.
Observation/location:	75/2–542; E.76.5, N.65.5
Soil classification:	Chromic Vertisol.
Ecological zone:	V.
Geological formation:	Undifferentiated basement system rock.
Local petrography:	Alluvium derived from various gneisses.
Physiography:	Piedmont plain; altitude 910 m.
Relief—macro:	Flat (1% slope).
Relief—micro:	Some termite mounds, 200 m. apart.
Vegetation/land use:	Acacia seyal bushland; 80% bare ground.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	1%.
Salinity/alkalinity:	Slightly sodic within 100 cm.
Surface sealing:	Weak (2–4 mm.), locally cracks 5 cm. wide at the top, depth 40 cm.
Drainage class:	Moderately well drained.

A1	0—20 cm.	Dark brown (10YR 3/3 dry, dry and moist) clay; strong, coarse prismatic structure, breaking down into angular blocky; hard when dry, firm when moist, sticky and plastic when wet; few medium pores; few fine and medium, and very few coarse roots; gradual smooth boundary; (Sample 75/2–542a)
B	20—75 cm.	Very dark greyish brown (10YR 3/2 dry), dark brown (10YR 3/3 moist) clay; structure as for the A-horizon hard when dry, very fine when moist, sticky and plastic when wet; very few fine and few medium roots; commom moderate pressure faces, common vertical cracks up to 0·5 cm. wide; clear smooth boundary; (Sample 75/2–542b)
C	75—120 cm.+	Dark brown (10YR 3/3 dry and moist) clay; strong, medium and coarse prisms breaking down into angular blocky; consistence as in B; few thin slickensides; common $CaCO_3$ concretions (2–15 mm. in diameter), the size and amount of $CaCO_3$ concretions increases with depth. (Sample 75/2–542c)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—5

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	2029	2030	2031	2032	2033
Horizon	A1p	(A2+B)p	B21g	B22g	B3g
Depth in cm.	0–18	18–49	49–68	68–138	138–177+
Moisture % air dry soil					
Gravel %	5	20			
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	56	42	40	40	36
Silt % 50–2 μ	12	10	8	10	12
Clay % 2–0 μ	32	48	52	50	52
Texture class	SCL	C	C	SC	C
Dispersed clay %	20	35	33	31	39
Flocculation index	38	27	37	38	25
Soil-liquid 1:1 susp:					
pH–H_2O	5·6	5·3	6·0	6·4	7·1
pH–KCl	4·3	4·2	4·7	5·4	5·9
EC in mmho's/cm.	0·05	0·13	0·10	0·30	0·32
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	1·60				
N%	0·16				
C/N	10·0				
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	9·6	14·4	15·2	15·0	15·4
Exch. Ca me%	2·2	5·2	6·5	8·2	9·2
Exch. Mg me%	2·0	1·3	3·5	4·6	5·0
Exch. K me%	0·3	0·3	0·4	0·5	0·6
Exch. Na me%	0·1	0·2	0·3	0·3	0·4
Sum of cations me%	4·6	7·0	10·7	13·6	15·2
Base Sat. % at pH 8·2					
Base Sat. % at pH 7·0	48	49	70	91	99
E.S.P. at pH 8·2					
Exch. acidity me%	—				
Miscellaneous:					
Silt/Clay Ratio	0·38	0·21	0·15	0·2	0·23

Special analyses: Area Kapengur

Depth in cm.	0–18	18–49	49–68	68–138	138–177
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.	10·3	8·5	6·4	2·8	0·9
1·0–0·5 mm.	11·0	8·5	7·4	4·6	2·8
0·5–0·25 mm.	20·6	12·8	10·2	10·7	12·2
0·25–0·1 mm.	12·2	8·2	9·0	11·5	15·4
0·1–0·05 mm.	3·3	2·4	2·0	1·0	4·8
Total sand %	57·4	40·4	35·3	30·6	36·1
Silt % 50–20 μ					
20–2 μ					
Total silt %	12·6	8·0	11·4	15·4	11·0
Clay % 2–0 μ	30·0	51·6	53·3	54·0	52·9
Texture class	SCL	C	C	C	C
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3%					
X-ray report:					
Fertility aspects:					
Available Ca me%	1·8				
Available Mg me%	2·0				
Available K me%	0·12				
Available Na me%	0·04				
Available Mn me%	0·48				
Available P ppm	8				
Total Ca me%	7·0				
Total Mg me%	4·0				
Total K me%	5·4				
Total P ppm	96				

Map Unit Agc: Profile 5

Date of observation:	8th October, 1975.
Observation/location:	75/3–5; E.24.1, N.21.5; 1.5 km. North of McGall's Bridge.
Soil classification:	(Ploughed) eutric Planosol.
Ecological zone:	III.
Geological formation:	Undifferentiated basement system rocks.
Local petrography:	Alluvium rich in quartz and K-feldspar.
Physiography:	Alluvial terrace 5 m. above "vlei" level.
Relief—macro:	Flat to very gently undulating (0–2% slope).
Relief—micro:	Numerous termite mounds.
Vegetation/land use:	Vlei grassland.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	1%.
Salinity/alkalinity:	Nil.
Surface sealing:	Weak.
Drainage class:	Poorly drained.

A1p	0—18 cm.	Dark grey (5YR 4/1 dry), very dark grey (5YR 3/1 moist) slightly gravelly sandy clay loam; moderate, fine and medium clods; slightly hard when dry, firm when moist, sticky and plastic when wet; few pores; common fine roots; clear wavy to irregular boundary; (Sample 75/3–5a)
(A2+B)p	18—49 cm.	Dark brown (7.5YR 3/2 dry, 4/2 moist) gravelly clay with common, distinct reddish brown mottles; moderate, fine and medium subangular blocky; very hard when dry, friable when moist, sticky and plastic when wet; few pores; common fine and very fine roots; common iron and manganese concretions; distinct smooth boundary; (Sample 75/3–5b)
B21g	49—68 cm.	Brown (10YR 5/3 dry and moist) clay with many, medium and coarse, distinct and prominent reddish brown and yellowish red mottles; moderate to strong, fine to medium prisms; few pores; few fine roots; very hard when dry, very firm when moist, very sticky when wet; few concretions; distinct smooth boundary; (Sample 75/3–5c)
B22g	68—138 cm.	Brown (10YR 4/3 moist) clay with many coarse, prominent yellowish brown mottles; strong, medium to very coarse prisms; extremely hard when dry, extremely firm when moist, very sticky when wet; many strong slickensides; few concretions; gradual smooth boundary; (Sample 75/3–5d)
B3g	138—177 cm.+	Greyish brown (10YR 5/2 moist) clay; structure, mottles, slickensides and consistence as B22g; common iron and manganese concretions. (Sample 75/3–5e)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/2—507

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	8278	8279	8280	8281	8282
Horizon	Ap	C1	C2	C3	C4
Depth in cm.	0–20	20–50	50–70	70–105	105–140
Moisture % air dry soil					
Gravel %					9
Texture-Hydrometer:					
Sand % 2·0–0·05 mm.	68	86	78	74	78
Silt % 50–2 μ	12	4	10	6	10
Clay % 2–0 μ	20	10	12	20	12
Texture class	SL/SCL	S	SL	SL/SCL	SL
Dispersed clay %	14	8	8	10	8
Flocculation index	30	20	33	50	33
Soil-liquid 1:1 susp:					
pH–H_2O	7·9	8·0	7·9	7·6	7·6
pH–KCl	7·2	7·3	7·2	7·0	6·8
EC in mmho's/cm.	0·18	0·08	0·10	0·11	0·07
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$ %	41	tr.	0	0	0
$CaSO_4 \cdot 2H_2O$ %					
C%	0·66				
N%	0·07				
C/N	9·4				
CEC (NaOAc, pH 8·2) me%	17·6	5·0	7·4	13·0	7·0
CEC (NH_4OAc, pH 7·0) me%					
Exch. Ca me%	14·1	2·3	4·4	9·6	4·8
Exch. Mg me%	2·6	1·7	1·9	2·7	1·2
Exch. K me%	0·4	0·3	0·3	0·3	0·3
Exch. Na me%	0·5	0·5	0·6	0·4	0·4
Sum of cations me%	17·6	4·8	7·2	13·0	6·7
Base Sat. % at pH 8·2	100	96	97	100	96
Base Sat. % at pH 7·0					
E.S.P. at pH 8·2					
Exch. acidity me%	—				
Miscellaneous:					
Silt/Clay Ratio	0·6	0·4	0·83	0·3	0·83

Special analyses: Area Kapengur

Depth in cm.	0–20	20–50	50–70	70–105	105–14
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.	1·6	1·3	2·7	1·6	6·3
1·0–0·5 mm.	7·0	8·1	9·5	6·2	14·8
0·5–0·25 mm.	24·2	33·9	31·8	21·4	24·2
0·25–0·1 mm.	25·4	34·4	31·9	30·5	22·8
0·1–0·05 mm.	4·8	6·3	8·5	12·1	9·9
Total sand %	63·0	85·0	84·4	71·8	78·0
Silt % 50–20 μ					
20–2 μ					
Total silt %	15·8	4·8	3·7	4·9	9·3
Clay % 2–0 μ	21·2	10·2	11·9	23·3	12·7
Texture class	SCL	S	SL	SCL	SL
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralgy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3 %					
X-ray report:					
Fertility aspects:					
Available Ca me%	10·4				
Available Mg me%	2·2				
Available K me%	0·24				
Available Na me%	0·08				
Available Mn me%	0·48				
Available P ppm	238				
Total Ca me%	17·0				
Total Mg me%	7·0				
Total K me%	4·4				
Total P ppm	800				

Map Unit AC: Profile 507

Date of observation:	25th September, 1974.
Observation/location:	75/2–507; E.60.8, N.54.0.
Soil classification:	Eutric Fluvisol.
Ecological zone.:	IV.
Geological formation:	Predominantly biotite gneisses of the basement system.
Local petrography:	Alluvium rich in mica's and hornblende.
Physiography:	Alluvial terrace; altitude 1550 m.
Relief—macro:	Flat.
Relief—micro:	Some termite mounds.
Vegetation/land use:	Acacia woodland.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	0%.
Salinity/alkalinity:	Nil.
Surface sealing:	Moderate (5–10 mm.)
Drainage class:	Well drained:

Ap	0—20 cm.	Brown (7.5YR 4/4 dry), dark reddish brown (5YR 2·5 2/2 moist) sandy clay loam, moderate, medium and coarse subangular blocky; slightly hard when dry, slightly sticky and slightly plastic when wet; many fine and common medium roots; common micas and hornblende; the soil material is magnetic; and effervesces strongly with HC1; clear smooth boundary; (Sample 75/2–507a)
C1	20—50 cm.	Dark brown (10YR 3/3 dry), very dark greyish brown (10YR 3/2 moist) loamy sand; structureless, single grained; loose when dry, non sticky and non plastic when wet; many fine and common medium roots; abrupt smooth boundary; (Sample 75/2–507b)
C2	50—70 cm.	Very dark greyish brown (10YR 3/2 moist) sandy loam; structureless; loose when dry, non sticky and non plastic when wet; roots as C1; abrupt smooth boundary; (Sample 75/2–507c)
C3	70—105 cm.	Very dark greyish brown (10YR 3/2 moist) sandy clay loam; structure and consistence as C2; many very fine and common fine roots; abrupt smooth boundary; (Sample 75/2—507d)
C4	105—140 cm.	Dark yellowish brown (10YR 4/4 moist) sandy loam; structureless; loose when dry, non sticky and non plastic when wet; many very fine and common fine roots; abrupt smooth boundary; (Sample 75/2–507e)
C5	140 cm.+	Brownish sand.

Remark: The soil is moist to 200 cm. and dry below that depth.

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—3

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /73	8823	8824	8825	8826
Horizon	A1	B21g	B22g	B3g
Depth in cm.	0–14	14–106	106–143	143–166+
Moisture % air dry soil				
Gravel %				
Texture-Hydrometer:				
Sand % 2·0–0·05 mm.	36	32	32	30
Silt % 50–2 μ	20	8	8	10
Clay % 2–0 μ	44	60	60	60
Texture class	C	C	C	C
Dispersed clay %	23	39	39	41
Flocculation index	48	35	35	32
Soil-liquid 1:1 susp:				
pH–H_2O	5·4	6·8	8·0	8·0
pH–KC1	4·3	5·1	6·4	6·5
EC in mmho's/cm.	0·17	0·15	0·35	0·40
Saturation extract:				
pH				
EC				
Saturation %				
$CaCO_3$%				
$CaSO_4 \cdot 2H_2O$%				
C%	2·13			
N%	0·17			
C/N	12·5			
CEC (NaOAc, pH 8·2) me%	35·2	44·0	42·3	40·4
CEC (NH_4OAc, pH 7·0) me%	33·1	42·2		
Exch. Ca me%	9·0	12·4	14·4	16·2
Exch. Mg me%	7·4	11·7	14·0	14·4
Exch. K me%	1·2	1·0	1·4	1·3
Exch. Na me%	1·0	2·5	5·4	5·5
Sum of cations me%	18·6	27·6	35·2	37·4
Base Sat. % at pH 8·2	53	62	84	94
Base Sat. % at pH 7·0	56	66		
E.S.P. at pH 8·2		5·6	12·8	13·8
Exch. acidity me%	0·3			
Miscellaneous:				
Silt/Clay Ratio	0·45	0·13	0·13	0·17

Special analyses: Area Kapenguria

Depth in cm.	0–14	14–106	106–143	143–166+
Texture U.S.D.A.:				
Sand % 2·0–1·0 mm.	0·9	1·0	1·4	1·7
1·0–0·5 mm.	1·7	1·1	1·8	2·3
0·5–0·25 mm.	8·3	7·0	5·5	4·9
0·25–0·1 mm.	15·2	10·0	8·8	9·5
0·1–0·05 mm.	3·1	0·9	0·9	0·6
Total sand %	29·2	20·0	17·6	19·0
Silt % 50–20 μ				
20–2 μ				
Total silt %	23·1	15·6	17·1	15·6
Clay % 2–0 μ	47·7	64·4	65·3	65·4
Texture class	C	C	C	C
Bulk density				
Particle density				
Porosity				
Moisture % w/v at:				
pF 2·0				
pF 2·3				
pF 2·7				
pF 3·7				
pF 4·2				
Clay mineralogy:				
$SiO_2/A1_2O_3$			3·0	2·8
SiO_2/R_2O_3			2·2	2·2
Fe_2O_3%			16·0	16·2
X-ray report:				
B21, B22	Predominantly montmorillonite, expanding from 15·22–18·02Å and very well crystallized. Traces of kaolinite.			
Fertility aspects:				
Available Ca me%	7·6			
Available Mg me%	6·0			
Available K me%	0·38			
Available Na me%	0·26			
Available Mn me%	1·14			
Available P ppm	12			
Total Ca me%	11·0			
Total Mg me%	8·6			
Total K me%	3·5			
Total P ppm	52			

lap Unit Vgc: Profile 3

ate of observation:	6th October, 1973.
bservation/location:	75/3–3; E.23.3, N.21.1; 200 m. N.E. of McGall's Bridge
oil classification:	Eutric/dystric Gleysol.
cological zone:	III.
eological formation:	Undifferentiated basement system rocks.
ocal petrography:	Alluvium.
hysiography:	Bottomlands.
elief—macro:	Almost flat, with slight slope towards the river.
elief—micro:	Occasional termite mounds.
egetation/land use:	Vleigrassland.
rosion:	Nil.
urface stoniness:	Nil.
lope gradient:	0%.
alinity/alkalinity:	Slightly sodic.
urface sealing:	Thick crust with distinct crack pattern.
rainage class:	Poorly drained.

A1	0—14 cm.	Dark grey (10YR 4/1 dry), very dark grey (10YR 3/1 moist) clay; strong, coarse prismatic structure; very hard when dry, very firm when moist and sticky when wet; few thin pressure faces; few pores, many fine roots; occasionally medium and coarse; round quartz stones; gradual smooth boundary; (Sample 75/3–3a)
B21g	14–106 cm.	Dark grey (10YR 4/1 dry and moist) clay with common, yellowish brown (10YR 5/8) mottles; strong, coarse angular blocky: very hard when dry, very firm when moist, sticky when wet; few micro pores; few fine roots; many moderate and strong pressure faces; few, fine and medium $CaCO_3$ and Mg concretions; gradual smooth boundary; (Sample 75/3–3b)
B22g	106—143 cm.	Dark grey (10YR 4/1 moist) clay with distinct fine and medium yellowish brown (10YR 5/8) mottles; strong, very coarse prisms, breaking down into strong coarse and medium angular blocky; consistence as B21g; many strong slickensides; very few, very fine roots; few, fine and medium $CaCO_3$ and Mg concretions; gradual, smooth boundary; (Sample 75/3–3c)
B3g	143—166 cm.+	Dark greyish brown (10YR 4/2 moist) clay with many distinct and prominent medium strong brown (7.5YR 5/6) mottles; moderate coarse prisms; very firm when moist, very sticky and very plastic when wet; many slickensides; concretions as B22g. (Sample 75/3–3d)

LABORATORY DATA SHEET—SOIL PROFILE No. 75/3—11

KENYA SOIL SURVEY

Routine analyses:

Laboratory No. /74	2059	2060	2061	2062	
Horizon	A1g	B21g	B22g	B3g	
Depth in cm.	0–8	8–32	32–80	80–115+	
Moisture % air dry soil					
Gravel %					
Texture-Hydrometer					
Sand % 2·0–0·05 mm.	24	16	18	16	
Silt % 50–2 μ	28	16	16	19	
Clay % 2–0 μ	48	68	66	72	
Texture class	C	C	C	C	
Dispersed clay %	28	48	44	62	
Flocculation index	42	29	33	14	
Soil-liquid 1:1 susp:					
pH–H_2O	5·2	5·2	5·7	6·3	
pH–KCl	4·5	4·3	4·5	5·2	
EC in mmho's/cm.	0·35	0·20	0·10	0·08	
Saturation extract:					
pH					
EC					
Saturation %					
$CaCO_3$%					
$CaSO_4.2H_2O$%					
C%	6·02	2·23			
N%	0·65	0·35			
C/N	9·3	6·3			
CEC (NaOAc, pH 8·2) me%					
CEC (NH_4OAc, pH 7·0) me%	35·2	35·3	34·8	35·6	
Exch. Ca me%	13·2	11·0	10·9	14·2	
Exch. Mg me%	9·6	10·6	12·0	15·1	
Exch. K me%	1·3	0·5	0·5	0·5	
Exch. Na me%	1·1	0·7	0·7	1·4	
Sum of cations me%	25·2	22·8	24·1	31·2	
Base Sat % at pH 8·2					
Base Sat. % at pH 7·0	72	65	69	88	
E.S.P. at pH 8·2	—	—	—	—	
Exch. acidity me%	0·7	0·9			
Miscellaneous:					
Silt/Clay Ratio	0·48	0·24	0·24	0·26	

Special analyses: **Area Kapenguria**

Depth in cm.	0–8	8–32	32–80	80–115+	
Texture U.S.D.A.:					
Sand % 2·0–1·0 mm.	0·1	0·1	0·1	1·2	
1·0–0·5 mm.	0·2	0·2	0·6	1·9	
0·5–0·25 mm.	0·3	0·5	1·1	1·7	
0·25–0·1 mm.	0·4	0·8	1·8	1·3	
0·1–0·05 mm.	0·3	0·8	0·6	1·0	
Total sand %	1·3	2·4	4·2	7·1	
Silt % 50–20 μ					
20–2 μ					
Total silt %	35·8	22·3	19·6	20·8	
Clay % 2–0 μ	62·9	73·3	76·2	72·1	
Texture class	C	C	C	C	
Bulk density					
Particle density					
Porosity					
Moisture % w/v at:					
pF 2·0					
pF 2·3					
pF 2·7					
pF 3·7					
pF 4·2					
Clay mineralogy:					
SiO_2/Al_2O_3					
SiO_2/R_2O_3					
Fe_2O_3%					
X-ray report:					
Fertility aspects:					
Available Ca me%	12·3				
Available Mg me%	6·8				
Available K me%	0·54				
Available Na me%	0·70				
Available Mn me%	1·25				
Available P ppm	24				
Total Ca me%	18·0				
Total Mg me%	7·6				
Total K me%	5·8				
Total P ppm	560				

Map Unit VC: Profile 11

Date of observation:	29th November, 1973.
Observation/location:	75/3–11; E.28.4, N.17.2; at bridge of Koitobos river.
Soil classification:	Mollic Gleysol.
Ecological zone:	III.
Geological formation:	Undifferentiated basement system rocks.
Local petrography:	Alluvium.
Physiography:	Valley, bottomland.
Relief—macro:	Depressional area, flat.
Relief—micro:	Nil.
Vegetation/land use:	Vleigrassland.
Erosion:	Nil.
Surface stoniness:	Nil.
Slope gradient:	0%.
Salinity/alkalinity:	Nil.
Surface sealing:	Nil.
Drainage class:	Poorly drained.

A1g	0—8 cm.	Black (10YR 2.5/1 moist) clay with many medium and coarse, distinct red (2.5YR 4/6) mottles; massive; firm when moist, sticky when wet; few fine pores; common roots; diffuse smooth boundary; (Sample 75/3–11a)
B21g	8—32 cm.	Very dark grey (10YR 3/1 moist) clay with many fine and medium, distinct, yellowish red (5YR 5/6) mottles; moderate, fine to medium prisms; firm when moist, sticky when wet; many moderate to thick pressure faces; few fine pores; few, fine and medium roots; smooth gradual boundary; (Sample 75/3–11b)
B22g	32—80 cm.	Very dark grey (7.5YR 3/0 moist) clay with many, medium distinct, yellowish red (5YR 5/6) mottles; weak to moderate, coarse prisms; firm when moist, sticky when wet; pressure faces as B21g; very few fine pores; smooth gradual boundary; (Sample 75/3–11c)
B3g	80—115 cm.+	Dark grey (7.5YR 4.0) clay with many, medium faint and distinct yellowish red mottles; moderate coarse prisms; firm when moist, sticky when wet; many strong pressure faces. (Sample 75/3–11d)

APPENDIX 7

Heavy and light mineral analyses from selected pits (50–250 μ sand fraction).

Heavy minerals:

Pit + map unit	326	613	107	514	384	61	53	391	2	18	58	57	60	3
mineral	MGh	MGh	FGrce	FGrce	U2Gh1	U3Gh	U3GC2	U3Gby	U4Ur	U4Ub	U5Frc	U5Bbc2	U7Bbc	VGc
Opaque	7	—	3	—	6	13	3	3	2	5	1	2	1	3
Zircon	—	2	—	9	1	10	—	2	10	—	—	—	32	—
Garnet	—	—	2	—	—	—	6	—	2	2	—	—	3	—
Rutile	—	—	—	—	—	2	—	—	—	—	—	—	—	—
Titanite	—	—	—	—	—	—	—	—	—	—	—	2	—	2
Staurolite	6	2	12	1	—	8	—	4	—	—	2	—	—	—
Kyanite	56	30	50	15	98	80	68	90	58	96	80	84	18	68
Epidote	14	12	—	17	—	—	20	2	—	—	—	6	8	10
Zoisite	—	—	2	1	—	—	—	—	—	—	—	—	—	—
Gr. hornblende ..	12	54	34	57	1	—	6	—	30	2	18	6	39	12
Augite	—	—	—	—	—	—	—	—	—	—	—	—	—	4
Sillimanite	2	—	—	—	—	—	—	2	—	—	—	—	—	—
Mineral reserve including *light minerals*	31	81	57	48	39	49	22	40	41	56	7	6	46	41
Biotite	††	—	†††	—	††	††††	†††	—	†††	†††	††	††††	††††	†††
Muscovite	†††	††††	††††	††††	††††	†††	††††	†††	††††	†††	††††	††	†††	††††
Oligoclase ..	—	††	†	—	—	††	†	†††	††	†	—	†	††	††

The percentage of weatherable minerals may be indicated as follows:

Not present	: —	
Trace	: 1	tr.
Very few	: 1–3	†
Few	: 4–7	††
Common	: 8–20	†††
Many	: >20	††††

Analyses by W. Siderius.

Micromorphology

A total of 11 mammouth thin sections from seven profiles were prepared and analysed by STIBOKA, Wageningen, Holland. Initial information was provided in a letter by Dr. Bisdom (August, 1975) but further elaborations were made by Siderius. For clarification of the terminology one is advised to consult Brewer (1964). In general the micromorphological data support the field descriptions, especially with regard to the surface sealing and to a certain extent the occurrence of cutans. The micromorphological information deviates however on the presence of the soil fauna and the beneficial effects of it, in that it recognizes these activities most clearly in all thin sections as burrows. This is not in agreement with most of the field descriptions, in which animal activity is hardly recognized. Apart from the effect of homogenization caused by the soil fauna, the animals also induce crumb structures in soil material that otherwise would be more dense or structureless. This improves the aeration and permeability of the soils considerably.

Pointing to the continued process of soil formation is the presence of "weathering" cutans especially clear in slide 3357 (Ferralsol) while "stress" cutans are present in most soil materials indicating *in situ* modifications of plasma due to differential forces such as shearing. The occurrence of microcutans is limited to sections from a Cambisol and a Luvisol (Slides 3363 and 3353 respectively).

The order of description follows the sequence in the legend.

Pit: 514

Unit: FGrce

Slide: 3357

Horizon: AB

Soil classification: chromic Luvisol

Depth: 100-110 cm.

Field description of the soil material:

Dark brown (10YR 3/3) moist, brown (10YR 3/4) dry, sandy clay with common fine prominent dark reddish brown (5YR 2.5/2) mottles; strong coarse angular blocky to massive (?) structure: few coarse, many fine and medium pores; very hard dry; firm moist and sticky and plastic wet; 7 per cent Mn concretions; moderate few clay skins.

Micromorphology

CUTANS

(1) moderate weathering cutans

(2) few stress cutans

(3) few papules

ANIMAL ACTIVITY

(1) few aggrotubules

(2) few isotubules

(3) little crumb structure

(4) moderate dense structure

NODULES

(1) many Fe nodules

(2) few Fe-Mn nodules

(3) few rock fragments

REMARKS

A large variety of weathering minerals in and outside iron nodules. Considerable reorganization of iron inside nodules.

Interpretation:

Considerable evidence for *in situ* modification of plasma in addition to continuous weathering of the soil material. Little evidence for plasma deposition (e.g. argillic horizon). Restricted animal activity resulting in limited crumb structure and homogenization.

The movement of iron compounds has led to nodule formation. The majority of "Mn-concretions" as described in the field appear to be Fe nodules.

On the whole the correlation between macro and micro-morphology is good.

Pit: 384

Unit: $\frac{\text{U2Gh1}}{\text{p}}$ — $\frac{\text{U2Gh2}}{\text{p}}$

Slide: 3363

Soil classification: humic Cambisol

Horizon: B2

Depth: 50-60 cm.

Field description of the soil material:

Dark reddish brown (5YR 3/4) moist, clay; weak coarse and very coarse subangular blocky; very friable moist, sticky and plastic wet; many micro and very fine pores; common mica.

Micromorphology

CUTANS

(1) few micro cutans

(2) few weathering cutans

(3) few stress cutans

(4) few papules

ANIMAL ACTIVITY

(1) common aggrotubules

(2) few isotubules

(3) few striotubules

(4) little crumb structure

(5) moderate dense structure

NODULES

(1) few Fe

(2) few Fe + Mn

(3) few rock fragments

Interpretation:

The features are well in line with the cambic B designation. The common aggrotubules point to considerable animal activity that is not reported on in the field description. It nevertheless contributes to the structural development.

Pit: 61

Unit: U3Gh

Slide: 3355

Horizon: B1

Soil classification: humic Acri/Cambisol

Depth: 80-90 cm.

Field description of the soil material:

Dark reddish brown (5YR 3/3) moist, clay; weak medium and coarse angular blocky; friable moist, sticky and plastic wet; many micro, common very fine pores; many very fine and fine common medium roots; much mica.

Micromorphology

CUTANS

nil

ANIMAL ACTIVITY

(1) many aggrotubules

(2) much crumb structure

(3) little dense structure

NODULES

(1) moderate Fe

(2) few rock fragments

Same Pit

Horizon: B22

Slide: 3356

Depth: 140-150 cm.

Field description of the soil material

Red (2.5YR 4/6) dry, dark red (2.5YR 3/6) moist, clay; weak medium and coarse angular blocky; slightly hard dry, very friable moist, sticky and plastic wet; many micro pores; many moderate clay skins.

Micromorphology

CUTANS

(1) moderate argillans

(2) few stress cutans

(3) few papules

ANIMAL ACTIVITY

(1) moderate aggrotubules

(2) moderate isotubules

(3) moderate crumb structure

(4) moderate dense structure

NODULES

(1) few Fe

(2) few rock fragments

Interpretation:

The occurrence of argillans in the deep subsoil agrees with the field observations. However remaining data do not support the Bt idea. As the development is towards such an horizon, the classification as Acri/Cambisol reflects the intergrading character of the soil. There is considerable animal activity in the soil, which gives rise to fair structural development. The micropedological visible peds seem to be better developed than those macroscopic visible. The difference in the presence of the Fe nodules is not supported by the field observations.

Pit: 2

Unit: U4Ur

Horizon: B21

Slide: 3358

Soil classification: rhodic Ferralsol

Depth: 40-50 cm.

Field description of the soil material:

Dusky red (10R 3/4) moist, dark red (10R 3/6) dry, clay; weak fine to very fine subangular blocky; few micro and very fine pores; friable moist, sticky and plastic wet, pH 5.6.

Micromorphology

CUTANS

(1) moderate stress cutans

(2) few papules

ANIMAL ACTIVITY

(1) moderate aggrotubules

(2) few isotubules

(3) few striotubules

(4) moderate crumb structure

(5) moderate dense structure

NODULES

(1) few Fe nodules

(2) few rock fragments

Same pit

Horizon: B22

Slide: 3359

Depth: 120-130 cm.

Field description of the soil material:

Dusky red (10R 3/4) moist, clay; weak fine to very fine subangular blocky; thin few clay skins; few micro and very fine pores; friable moist, sticky and plastic wet; pH 5.5.

Micromorphology

CUTANS

(1) few argillans

(2) many stress cutans

(3) moderate papules

ANIMAL ACTIVITY

(1) moderate aggrotubules

(2) few isotubules

(3) few striotubules

(4) moderate dense structure

(5) moderate crumb structure

NODULES

(1) few Fe nodules

(2) few rock fragments

Interpretation:

In the B21 the absence of evidence for clay translocation is supported by the micromorphological data; stress cutans point to local deformation of plasma. The moderate animal activity has resulted in moderate crumb structure in some parts. Macro observations indicate weak structural development. The presence of Fe concretions could not be verified in the field. With depth there is a marked increase in local clay deformation but there is little evidence for actual clay transportation (i.e. argillic horizon). Animal activity remains moderate, resulting in weak structures. The red soil colour points to iron movement in an aerated environment, that occasionally was favourable for the genesis of small Fe nodules.

Pit: 18

Unit: U4Ub

Horizon: B22

Depth: 70-80 cm.

Slide: 3360

Soil classification: orthic/humic Ferralsol

Field description of the soil material:

Yellowish red (5YR 4/6) moist, clay; weak fine to medium subangular blocky; few very fine and fine pores; friable moist, sticky wet. In the topsoil horizons pockets of charcoal occur, it may have mingled with subsoil material through cracks.

Micromorphology

CUTANS

(1) few argillans

(2) many stress cutans

(3) few papules

NODULES

(1) moderate Fe nodules

(2) few Fe-Mn nodules

(3) few rock fragments

ANIMAL ACTIVITY

(1) moderate aggrotubules

(2) few isotubules

(3) moderate crumb structure

(4) moderate dense structure

REMARKS

Isotubule filled with darker material probably derived from an overlying horizon, which consists of clayey material with iron and organic matter.

Interpretation:

Internal forces have caused the *in situ* modification of plasma (clay) into what is described as stress cutans. There is little evidence for the deposition or diffusion of plasma, which agrees with the field observations. The continuous weathering of the soil material is witnessed in the presence of a few papules. Animal activity is moderated corresponding with weak fine and medium macro structural development. The presence of Fe nodules was not verified in the field, yet indicates the movement and subsequent concentration of Fe compounds.

Pit: 58

Unit: $\frac{\text{U5Frc}}{\text{p}}$

Horizon: A1?

Depth: 0-10 cm.

Slide: 3361

Soil classification: chromic Luvisol

Field description of the soil material:

Dark brown (7.5YR 3/2) moist and dark reddish grey (5YR 4/2) dry, sandy clay loam; structureless; many micro and common fine pores; hard dry, firm moist, slightly sticky and slightly plastic wet; pH 6.0. Very weak surface sealing of 2-3 mm.

Micromorphology

CUTANS

(1) many argillans

(2) few stress cutans

(3) few papules

(4) much surface sealing

ANIMAL ACTIVITY

(1) few aggrotubules

(2) few isotubules

(3) little crumb structure

(4) moderate dense structure

NODULES

(1) few Fe nodules

(2) few rock fragments

REMARKS

An outspoken and very irregular thin surface sealing with some rock fragments. The sealing is predominantly dense with locally a very thin crumb layer near the surface. Some argillans are present in the sealing itself. They are numerous beneath the surface sealing.

Same pit

Horizon: B22 Slide: 3362

Depth: 60-70 cm.

Field description of the soil material:

Dark reddish brown (2.5YR 3/4) moist, dark red (2.5YR 3/6) dry, clay; weak coarse angular blocky; common thin clay skins; many micro and common very fine pores; slightly hard dry, friable moist, slightly sticky and plastic wet; pH 6.0; few fine (2-3 mm.) Mn concretions.

Micromorphology

CUTANS

(1) few argillans

(2) few weathering cutans

(3) moderate stress cutans

(4) moderate papules

ANIMAL ACTIVITY

(1) moderate aggrotubules

(2) few isotubules

(3) little crumb structure

(4) moderate dense structure

NODULES

(1) few Fe nodules

(2) few rock fragments

REMARK

Less argillans than in the A1, but more stress cutans and papules.

Interpretation:

The upper part of the epipedon shows distinct sealing to a much larger degree than is reported from the field observations. In addition, the presence of argillans indicates the deposition of plasma. Structural development is poor and corresponding with little animal activity.

With depth the amount of stress cutans increases, but the amount of argillans decreases. *In situ* weathering of the soil material is evident, while also structural development is more pronounced. There is little evidence for the presence of an argillic horizon while the "Mn concretions" from the field description appear to be mainly Fe nodules.

It is not impossible that this is a truncated profile, in which part of the B is now subject to epipedon formation. This implies that the described A1 is in fact a B1, which also would help to explain the presence of argillans in the topsoil.

Pit: 60

Unit: U7Bbc

Slide: 3353

Horizon: A1

Soil classification: orthic Luvisol

Depth: 0-15 cm.

Field description of the soil material:

Greyish brown (10YR 5/2) dry and very dark greyish brown (10YR 3/2) moist, sandy loam; moderate fine and medium subangular blocky; hard dry, friable moist, slightly sticky and slightly plastic wet; many micro, common fine pores; many fine and medium roots; pH 5.6. Strong surface sealing (3-5 mm. thick).

Micromorphology

CUTANS

(1) few argillians
(2) few micro cutans
(3) few stress cutans
(4) few papules
(5) moderate surface sealing

ANIMAL ACTIVITY

(1) few aggrotubules
(2) common isotubules
(3) few striotubules
(4) little crumb structure
(5) moderate dense structure

NODULES

(1) few Fe
(2) few rock fragments

REMARK

Surface sealing occurs (0.2—0.5 cm. thick) in various layers.

Same pit:

Horizon: B21

Slide: 3354

Depth: 60-70 cm.

Field description of the soil material:

Yellowish brown (10YR 5/4) dry, dark yellowish brown (10YR 4/4) moist, sandy clay loam; massive; hard dry, very friable moist, slightly sticky and slightly plastic wet; many micro pores; few fine roots; few thick clay skins; many dark minerals; pH 6.0.

CUTANS

(1) few argillans
(2) few micro cutans
(3) few stress cutans
(4) few papules
(5) few zones with laminated fabric

ANIMAL ACTIVITY

(1) few aggrotubules
(2) common isotubules
(3) few striotubules
(4) little crumb structure
(5) moderate dense structure

NODULES

(1) few Fe
(2) few rock fragments

REMARK

Large quantities of weathered micas, especially biotite.

Interpretation:

The feature of the surface sealing is supported by the micromorphological data, the remaining part of the A1 has weak rather than moderate structural development. Surface sealing is expressed as various layers. Animal activity as measured in the occurrence of faecal pellets is limited. With depth there does not seem to be a significant increase in the amount of argillans and other cutanic features. This may be due to the fact that the possibility of profile truncation is not excluded.

APPENDIX 9

RATING OF LAND QUALITIES OF THE "MAPPING UNITS"

"Mapping Unit"	Ecological Zone	Soil Moisture Storage Capacity	Chemical Soil Fertility	Possibilities of the use of Agricultural Implements	Resistance to Erosion	Hindrance by Vegetation	Presence/ Hazard Waterlogging	Presence of Overgrazing	Depth ("Foothold")
U1Qh/p–DE..	I	3	4–5?	2–4	2	3	1	2	3
Vo/BC ..	I	3	4–5?	2–3	1	3	5	2	2
MGh	IIc	2–3	5?	4	4	n.r.	1	2	2–3
MG	IIc	4–5	5	5	4	1	1	2	4–5
MQh	IIc	2–3	3	4–5	3	1	1	2	2–3
MFry.. ..	IIc	3	4–5?	4–5	4	1	1	2	2
HGh1 ..	IIc	2–3	1–2	4	3	1	1	2	2–3
HGC2 ..	IIc	2–5	4–5?	5	4?	1	1	2	2–5
U2Gry/DE ..	IIc	3	5	3	3	1	1	2	1–2
U2Gh1/p–D	IIc	2–3	4	2–3	2	1	1	2	2–3
U2GH1/p–E..	IIc	2–3	4	3–4	3	1	1	2	2–3
U2Gh2/p–DE	IIc	2–3	4	2–3	2	1	1	2	2–3
U2Gh1/p–DE–U2Gh2/p–DE	IIc	2–3	4–5	2–4	2	1	1	2	2–3
U2Gh1/p–E–U2Gh2/p–E	IIc	2–3	4–5	3–4	3	1	1	2	2–3
Vo	IIc	3	5?	2–3	1	1	5	2	2
MGh	IIw	2–3	5?	4	4	1	1	3	2–3
MG	IIw	4–5	5	5	4	1	1	3	4–5
HGh1 ..	IIw	2–3	1–2	4	3	1	1	2	2–3
HGh2 ..	IIw	2–3	1–2	4–5	4	1	1	2	1–2
HGC1 ..	IIw	2–5	4–5?	5	4?	1	1	3	2–5
U3Gh/D ..	IIw	2	3–4	2	2	n.r.	1	2	2
U3GC1/D ..	IIw	2–3	3–5	2	3?	1	1	3	1–2
U3GC2/D ..	IIw	2–3	3–5	2	3?	2	1	3	2–3
U3GC2/DE ..	IIw	2–3	3–5	2	3	2	1	3	2–3
U3Gby/p–D–U3Gh/D ..	IIw	2–3	5	2	2	1	1	2	2–3
U7Bbc/p–DE	IIw	3–4	3–4	3–4	4	1	1	2	3–4
Vgc/AB ..	IIw	2	3	2	1	1	3–4	2	1
U3GC1/D ..	III	2–3	3–5	2	3?	1	1	3	1–2
U4Ur/B ..	III	1	4	1	1	1	1	2	1
U4Ur/C ..	III	1	4	1	2	1	1	2	1
U4Ur/D ..	III	1	4	2	2	1	1	2	1
U4Ub/B ..	III	2–3	5	1	2	1	1	2	1–2
U4Ub/C ..	III	2–3	5	1	2	1	1	2	1–2
U4Ub/D ..	III	2–3	5	2	3	1	1	2	1–2
U7Bbc/p–B ..	III	3–4	3–4	1	3	1	1	2	2–3
U7Bbc/p–CD	III	3–4	3–4	1–2	4	1	1	2	2–3
U7Bbc/p–D ..	III	3–4	3–4	2	4	1	1	3	2–3
U7Bbc/p–E ..	III	3–4	3–4	4	4	1	1	3	2–3
Agc/AB ..	III	3	4–5	2	1	1	2–4	2	1
Vgc/AB ..	III	2	3	2	1	1	3–4	2	1
VC/AC ..	III	2–3	1?	1–3	1	1	5	2	1–2
VC/AD ..	III	2–3	1?	1–3	1	1	5	2	1–2
MGh	III–IV	2–3	5?	4	4	2	1	3	2–3
MG	III–IV	4–5	5	5	5	2	1	3	4–5
MFry ..	III–IV	3	4–5?	4–5	5	2	1	3	2
MFC	III–IV	3–4	4	5	5	5	1	3	3–4
HLC ..	III–IV	3–5	2	5	4	2	1	3	2–5
FGrc/BC ..	III–IV	3	2	1	4?	2	1	3	1–2
FGrc/CD ..	III IV	3	2	1–2	4	2	1	3	1–2
FGrce/CD ..	III–IV	3	4	1–2	4	2	1	3	1–2
FGrce/D ..	III–IV	3	4	2	4	2	1	3	1–2
FGby/C ..	III–IV	3	2–3	1	3	2	1	3	1–2
U5Frc/p–C ..	III–IV	3	4–5	1	4?	2	1	3	2–3
U7Bbc/p–CD	III–IV	3–4	3–4	1–2	4	2	1	3	2–3
U7Bbc/P–DE	III–IV	3–4	3–4	3–4	5	2	1	3	3–4
U7Fr/P–CD–U7Frc/p–CD	III–IV	3–4	4–5?	2–4	4	2	1	3	3–5
AC/BC ..	III–IV	3–4	2	1	1	2	1–5	3	1–3?
AC/AD ..	III–IV	3–4	2	1–2	1	2	1–5	3	1–3?

RATING OF LAND QUALITIES OF THE "MAPPING UNITS"

"Mapping Unit"	Ecological Zone	Soil Moisture Storage Capacity	Chemical Soil Fertility	Possibilities of the use of Agricultural Implements	Resistance to Erosion	Hindrance by Vegetation	Presence/ Hazard Waterlogging	Presence of Overgrazing	Depth ("Foothold")
MG	IV	4–5	5?	5	5	3	1	4	4–5
HG	IV	4–5	5?	5	5	3	1	4	4–5
FGrc/C ..	IV	3	2	1	4	3	1	4	1–2
FGrce/BC ..	IV	3	4	1	4	3	1	4	1–2
FGrce/C ..	IV	3	4	1	4	3	1	4	1–2
FGrce/CD ..	IV	3	4	1–2	4	3	1	4	1–2
FGrce/D ..	IV	3	4	2	4	3	1	4	1–2
FGrcE/BC ..	IV	3	4	1	4	3	1	4	1–2
FGrcE/C ..	IV	3	4	1	4	3	1	4	1–2
FGrcE/CD ..	IV	3	4	1–2	4	3	1	4	1–2
FGby/AB ..	IV	3	2–3	1	2	3	1	4	1–2
FGby/BC ..	IV	3	2–3	1	3	3	1	4	1–2
FGby/CD ..	IV	3	2–3	1–2	3	3	1	4	1–2
FGbys/BC ..	IV	3–4	3	3	3	3	1	4	1–3
FGbys/CD ..	IV	3–4	3	3–4	4	3	1	4	1–3
U5Frc/p–AB ..	IV	3	4–5	3	3	3	1	4	2–3
U5Bbc1/p–A ..	IV	3	5	1	3	3	1	4	2–3
U5Bbc2/A ..	IV	2–3	5	1	3	3	1	4	1–2
U5Bbc2/AB ..	IV	2–3	5	1	3	3	1	4	1–2
U5Bbc2/B ..	IV	2–3	5	1	4	3	1	4	1–2
U5Bbc2/BC ..	IV	2–3	5	1	4	3	1	4	1–2
U5GC/BC ..	IV	3–4	5	2–3	4	3	1–3	4	3–4
U5GC/CD ..	IV	3–4	5	2–4	4	3	1–3	4	3–4
U6Gbc/p—B ..	IV	3	4	1	3	3	1–2	4	2–3
U7Fr/P–CD ..	IV	4	4–5	3–4	4	3	1	4	4–5
U7Bb/P̄–CD–U7B̄bc/p–CD	IV	3–5	3–4	3–4	4	3	1	4	3–5
U7Bb/P–D–U7B̄bc/p–D	IV	3–5	3–4	4	4	3	1	4	3–5
U7Fr/P–CD–U7F̄rc/p–CD	IV	3–4	4–5	2–4	4	3	1	4	3–5
U7Fr/P–D–U7F̄rc/p–D	IV	3–4	4–5	3–4	4	3	1	4	3–5
YGbc1/A ..	IV	3–4	3	2	3	3	1	4	2
YGbc1/AB ..	IV	3–4	3	2	3	3	1	4	2
AC/A.. ..	IV	3–4	2	1	1	3	1–5	3	1–3
AC/BC ..	IV	3–4	2	1	2	3	1–5	4?	1–3
AC/AC ..	IV	3–4	2	1	2	3	1–5	4?	1–3
AC/AD ..	IV	3–4	2	1–2	2	3	1–5	4?	1–3
YGbc2/A ..	V	3	3	2	2	3	1–2	4–5	1–2

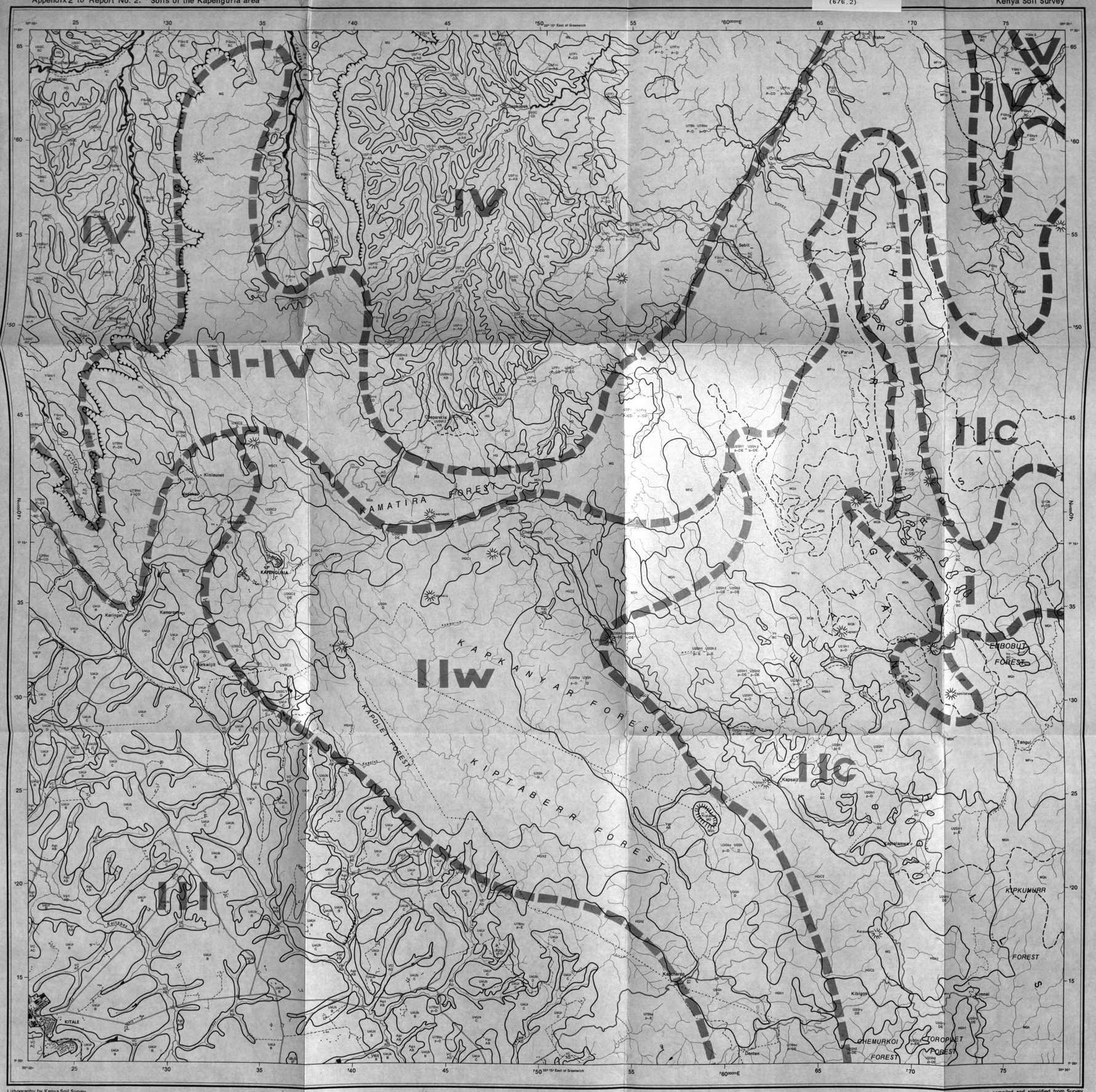
MAP SHEET 75

Appendix 2 to Report No. 2: "Soils of the Kapenguria area"

RECONNAISSANCE SOIL MAP OF THE KAPENGURIA AREA

WOSSAC: 14835
631.471
(676.2)

Ministry of Agriculture
Kenya Soil Survey



Lithography by Kenya Soil Survey
Printed by Kenya Litho, Nairobi

SCALE 1:100,000

METRES 1000 500 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 KILOMETRES

Base map compiled and simplified from Survey of Kenya topographical maps scale 1:50,000

LEGEND

MOUNTAINS AND MAJOR SCARPS (high relief intensity, slopes in general over 16%)

MG Soils developed on various gneisses and quartzites

MGh — well drained, moderately deep to deep, dark reddish brown to brown, friable, sandy loam to clay loam, with 20 to 40 cm humic topsoil (haplic PHAEOZEMS to humic CAMBISOLS)

MG — well drained, very shallow to shallow, brownish to reddish, rocky and stony, gravelly to very gravelly, sandy loam to sandy clay loam (dystric LITHO/REGOSOLS)

MQ Soils developed on mainly granitoid gneisses

MQh — well drained, moderately deep to deep, reddish brown to brown, friable, sandy clay loam to clay loam, with 40–60 cm acid very humic topsoil; in places stony and rocky (humic CAMBISOLS)

MF Soils developed on gneisses rich in ferromagnesian minerals

MFry — well drained, predominantly deep, dark reddish brown to yellowish red or dark red, friable, sandy clay loam to clay loam; in places stony and rocky (chromic CAMBISOLS)

MFC — complex of well drained soils, ranging from shallow, stony and rocky, to moderately deep, non-stony and slightly rocky, dark brown to dark red, friable to firm (compact), sandy loam to sandy clay (eutric REGOSOLS + chromic CAMBISOLS)

HILLS AND MINOR SCARPS (low relief intensity, slopes in general over 16%)

HG Soils developed on various gneisses and quartzites

HGh1 — well drained, moderately deep to deep, dark reddish brown, friable, sandy clay loam to clay, with 25 to 60 cm acid humic topsoil (humic CAMBISOLS)

HGh2 — well drained, deep, brown to dark reddish brown, friable, sandy clay loam to clay, with 25 to 60 cm acid humic topsoil; in places moderately deep or shallow and rocky (luvic PHAEOZEMS)

HG — well drained, very shallow to shallow, brownish to reddish, rocky, stony, sandy loam to sandy clay loam (dystric LITHO/REGOSOLS)

HGC1 — catenary sequence of well drained soils, ranging from very shallow, brownish, stony, sandy loam on ridges, to deep, brown to reddish brown, friable to firm (compact), sandy clay loam to clay, with increasing thickness of acid humic topsoil down the valley slopes (dystric LITHO/REGOSOLS + humic ACRISOLS)

HGC2 — complex of well drained soils, ranging from very shallow, stony and rocky, to deep, friable, sandy clay loam to clay, with or without thick acid humic topsoil (dystric LITHO/REGOSOLS + humic CAMBISOLS)

HL Soils developed on crystalline limestones and hornblende gneisses

HLC — complex of well drained soils, ranging from very shallow, stony and rocky, to deep, non-stony and non-rocky, dark reddish brown to dark brown, friable, calcareous to non-calcareous, sandy loam to clay (eutric REGOSOLS + haplic KASTANOZEMS)

FOOTSLOPES (at the foot of mountains and hills, slopes predominantly 3–8%)

FG Soils developed on colluvium predominantly derived from various gneisses

FGrc — well drained, deep, dark reddish brown to reddish brown or red, firm, sandy loam to sandy clay often with stone lines (chromic LUVISOLS to CAMBISOLS)

FGrc4 — like FGrc, but with sheet erosion and moderate gully erosion (chromic LUVISOLS)

FGrcE — like FGrc, but with sheet erosion and severe gully erosion (chromic LUVISOLS)

FGby — well drained, deep, dark reddish brown to brown, friable, loamy sand to clay; in places stratified (eutric CAMBISOLS)

FGbys — like FGby, but gravelly and stony and in places bouldery (eutric CAMBISOLS)

UPLANDS (dissected peneplains at various levels, slope percentages variable)

SONDANG LEVEL (altitude about 3200m, rolling to hilly)

U1Q Soils developed on granitoid gneisses

U1Qh p — predominantly well drained, 40 to 50cm thick, black to very dark brown, acid very humic topsoil, either directly over rock or over dark brown, friable, sandy clay loam to clay loam (humic CAMBISOLS)

KAPSAIT LEVEL (altitude about 2900m, rolling to hilly)

U2G Soils developed on various gneisses and quartzites

U2Gry — well drained, deep, dusky red to dark reddish brown, friable, sandy clay loam to clay (dystric CAMBISOLS)

U2Gh1 p — well drained, in places moderately well drained, moderately deep to deep, dark reddish brown to yellowish red, friable, sandy clay loam to clay, with 20 to 30 cm acid humic topsoil; in the hilly parts often eroded and in places shallow and rocky (humic CAMBISOLS)

U2Gh2 p — well drained, moderately deep to deep, predominantly dark reddish brown, friable, sandy clay loam to clay, with more than 30 cm acid humic topsoil (eutric + humic CAMBISOLS)

U2Gh1–U2Gh2 p — complex consisting of soils of units U2Gh1 p and of units U2Gh2 p

KAPENGURIA LEVEL (altitude about 2300m, rolling to hilly)

U3G Soils developed on various gneisses and quartzites

U3Gh — well drained, predominantly deep, dark reddish brown to dark brown, friable, sandy clay loam to clay, with more than 30 cm acid humic topsoil (humic ACRISOLS to CAMBISOLS)

U3GC1 — catenary sequence of well drained, deep, red to dark red, friable clay; on the crests truncated or with only a thin topsoil, downslope with acid humic topsoil of increasing thickness (FERRALS chromic ACRISOLS + FERRALS + humic ACRISOLS)

U3GC2 — catenary sequence like U3GC1, but with moderately deep to deep, brown to reddish brown, friable to firm (compact) sandy clay loam to clay loam underlying the topsoil (FERRALS orthic ACRISOLS + FERRALS humic ACRISOLS)

U3Gby–U3Gh p — association consisting of
– well drained, moderately deep to deep, dark reddish brown to yellowish red, friable, clay loam to clay, on upper slopes
– well drained, predominantly deep and dark reddish brown to dark brown, friable, sandy clay loam to clay, with in general more than 30cm acid humic topsoil, on lower slopes (dystric CAMBISOLS + humic ACRISOLS to CAMBISOLS)

KITALE LEVEL (altitude about 1900m, gently undulating to undulating)

U4U Soils developed on undifferentiated Basement System rocks

U4Ur — well drained, very deep, red to dark red, very friable to friable clay (rhodic FERRALSOLS)

U4Uh — well drained, deep to very deep, dark reddish brown to yellowish red, friable clay (orthic to humic FERRALSOLS)

KUNYAO LEVEL (altitude about 1350m, flat to gently undulating, dissected by wide erosion valleys)

U5F Soils developed on gneisses rich in ferromagnesian minerals

U5Fry p — well drained, moderately deep to deep, dark reddish brown to dark red, friable to firm (compact), sandy clay to clay; in many places with stone lines (chromic LUVISOLS)

U5B Soils developed on biotite gneisses

U5Bhc1 p — well drained, moderately deep to deep, reddish brown to brown, firm, sandy clay; in many places with stone lines, over petroplinthite (murram) and / or rock (orthic to plinthic ACRISOLS)

U5Bhc2 — well drained to moderately well drained, deep to very deep, dark reddish brown, firm, sandy loam to sandy clay (orthic ACRISOLS)

U5G Soils developed on various gneisses

U5GC — complex of soils ranging from moderately to severely eroded, well drained to imperfectly drained, shallow, rocky and stony, to moderately deep, non-rocky and non-stony, dark yellowish brown to dark red, firm, sandy loam to clay (orthic ACRISOLS/LUVISOLS and others)

WEI–WEI LEVEL (altitude about 1050m, gently undulating)

U6G Soils developed on various gneisses and quartzites

U6Ghc p — well drained to moderately well drained, moderately deep to deep, dark brown to dark red, firm, sandy clay, with stone lines (ferralic CAMBISOLS)

UNDIFFERENTIATED LEVELS (various altitudes, various macro-relief)

U7B Soils developed on predominantly biotite gneisses

U7Bhc p — well drained, moderately deep to deep, brown to dark yellowish brown, firm, sandy clay loam (orthic LUVISOLS)

U7Bhc p — like U7Bbc p but shallow to moderately deep and rocky (orthic LUVISOLS)

U7Bb–U7Bbc p — complex consisting of
– well drained, very shallow to shallow, brownish, stony and rocky, sandy loam to sandy clay
– soils of unit U7Bbc p (eutric CAMBISOLS + orthic LUVISOLS)

U7F Soils developed on gneisses rich in ferromagnesian minerals

U7Fr p — well drained, very shallow to shallow, reddish, stony and rocky, sandy clay to clay (eutric REGOSOLS)

U7Fr–U7Frc p — complex consisting of
– soils of unit U7Fr p and
– well drained, moderately deep, dark reddish brown to dark red, firm, fairly stony and non-rocky, sandy clay to clay (eutric REGOSOLS + chromic LUVISOLS)

PIEDMONT PLAINS (long slopes, in general less than 4%)

YG Soils developed on alluvium predominantly derived from various gneisses

YGhc1 — well drained, deep, dark brown to dark reddish brown, friable to firm (compact), sandy clay to clay (VERTI-chromic LUVISOLS)

YGhc2 — well drained to moderately well drained, deep, dark brown, very firm clay; moderately calcareous in deeper subsoil (chromic VERTISOLS)

RIVER TERRACES AND FLOODPLAINS

Soils developed on subrecent and recent alluvial deposits

Agh — moderately well to poorly drained, very deep, mottled, dark greyish brown to brown, firm, sandy clay to clay; on low terrace (eutric PLANOSOLS)

AC — complex of stratified and non-stratified soils of various textures, colours and drainage conditions; on floodplains and on terraces of various levels (eutric FLUVISOLS)

MINOR VALLEYS AND BOTTOMLANDS

Soils developed on various parent materials

Vgr — imperfectly to poorly drained, very deep, mottled, dark grey to greyish brown, firm, sandy clay to clay; in places calcareous in subsoil (eutric to dystric GLEYSOLS)

Vo — very poorly drained, deep, acid peat and/or muck; in places over very dark greyish brown to dark olive grey, soft, peaty or mucky clay (dystric HISTOSOLS)

VC — association of soils ranging from peat and very poorly drained, deep, mottled, very dark grey to dark greyish brown clay on the flat valley bottom, to soils of units U4Ur and U4Uh, but with 20 to 40 cm acid humic topsoil, on the valley sides (dystric HISTOSOLS + mollic GLEYSOLS + humic FERRALSOLS)

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

KEY TO SLOPE CLASSES

slope %	slope class symbol	name of macrorelief
0-2	A	flat to very gently undulating
2-5	B	gently undulating
5-8	C	undulating
8-16	D	rolling
16-30	E	hilly

KEY TO DEPTH CLASSES*

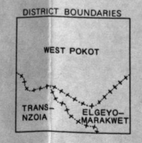
thickness soil in cm	symbol# over rock	over petro plinthite	over sec. limestone	name
0–25	P			very shallow
25–50	P			shallow
50–80	P			moderately deep
more than 80				deep to very deep

* *not indicated for mountains and hills*

\# *if a complex of depth classes occurs in one unit, only the symbol of the shallowest depth class is indicated*

KEY

- U6Fr p AB — soil mapping symbol; slope class symbol; depth class symbol
- soil boundary
- soil boundary (uncertain)
- slope class boundary
- ecological zone boundary
- 1 sq cm = 100 ha
- all weather road
- track
- district boundary
- building
- school
- bridge
- dam
- river
- mountain or hill top
- scarp



ECOLOGICAL ZONES

ZONE	average annual rainfall r/m mm	average annual evaporation E0/a mm	ratio r/Eo in mm	altitude in m	vegetation	average annual temperature in °C	occurrence of frost
I	1200–1400	1200–1400	85–120	3000–3350	moorland or bamboo	6–9	common
IIc cold	1200–1400	1400–1600	75–100	2400–3000	cedar forest or bamboo	9–13	occasional
IIw warm	1200–1600	1600–1800	67–100	1850–2400	moist forest	13–17	very rare
III	1000–1200	1800–1900	53–66	1750–2200	moist savanna	15–18	absent
IV	700–1000	1900–2100	38–52	1150–2000	dry savanna	16–22	absent
V	700–800	2100–2200	33–37	1100–1150	dry bushland	22–23	absent

INDEX TO ADJOINING SHEETS

62	63	
75	76	UGANDA
89	90	

Soil survey 1973–1974

survey ..... H.M.H. Braun, H.F. Gelens, J.M. Kibe, H.C.K. Kinyanjui, J.P. Mbuvi, D.O. Michieka, F.N. Muchena, G.Ngari, H.W.Okwaro, O.Oewaggo, R.Rachilo, J.J.Vleeshouwer, R.F.van de Weg, S.M.Wokabi

soil correlation ..... W. Siderius, W.G.Sombroek

map compilation ..... H.F. Gelens, H.C.K. Kinyanjui

map correlation ..... J.J.Vleeshouwer

cartography ..... D.M.Olullo, C.N.Muchemi

Appendix 3 to Report No. 2: "Soils of the Kapenguria area"

LAND EVALUATION KEY

Ministry of Agriculture
Kenya Soil Survey

LAND USE ALTERNATIVES

mapping unit	smallholders rainfed mixed farming, med. alt. 1) intermediate technology	smallholders rainfed mixed farming, med. alt. 1) advanced technology	large scale mixed farming, med. alt.	small scale livestock farming, intermediate technology, high alt.	extensive range	forestry 5)	smallholders irrigation	other alternatives	area in hectares
Ecological zone I									
U1Qh p–DE	– 2)	–	–	1.3	–	3 / – / 3	–	nature reserve	7.250
Vo BC	–	–	–	3	–	– / – / 3	–	nature reserve	180
								total	7.430
Ecological zone IIc									
MGh	–	–	–	3	–	1.1-1.2 / D / 1.1	–	protective vegetation	16.630
MG	–	–	–	3	–	3 / – / 3	–	protective vegetation	270
MQh	–	–	–	3	–	1.3 / D / 1.3	–	protective vegetation	11.850
MFry	–	–	–	3	–	3 / – / (1.3)	–	protective vegetation	8.400
HGh1	–	–	–	1.3	–	1.1 / D / 1.1	–		2.390
HGC2	–	–	–	1.3	–	(1.2) 3) / D / 1.1	–	protective vegetation	6.570
U2Gry DE	–	–	–	1.2	–	– / C / 1.1	–		3.970
U2Gh1 p–D	–	–	–	1.2	–	1.3 / C / 1.3	–		4.840
U2Gh1 p–E	–	–	–	1.2	–	1.3 / C / 1.3	–		2.970
U2Gh2 p–DE	–	–	–	1.2	–	1.1 / C / 1.2	–		1.180
U2Gh1_U2Gh2 p–DE p–DE	–	–	–	1.2	–	1.3 / C / 1.3	–		4.070
U2Gh1_U2Gh2 p–E p–E	–	–	–	1.2	–	1.3 / C / 1.3	–		2.400
Vo BC	–	–	–	3	–	– / – / 3	–		440
								total	65.980
Ecological zone IIw									
MGh	3	3	3	–	–	1.1-1.2 / D / 1.2	–	protective vegetation	1.920
MG	3	3	3	–	–	3 / – / 3	–	protective vegetation	40
HGh1	3	1.3	3	–	–	1.1 / D / 1.1	–		1.950
HGh2	3	1.3	3	–	–	(1.2) / D / 1.1	–		5.100
HGC1	3	3	3	–	–	(1.2) / D / 1.1	–	protective vegetation	2.270
U3Gh D	1.2	1.2	3	–	–	1.1 / C / 1.1	–	protective vegetation	20.800
U3GC1 D	1.2	1.2	3	–	–	(1.2) / C / 1.1	–		1.640
U3GC2 D	1.2	1.2	3	–	–	(1.2) / C / 1.1	–		6.980
U3GC2 DE	1.2	1.3	3	–	–	(1.2) / C / 1.1	–		1.340
U3Gby_U3Gh p–D D	1.2	1.2	3	–	–	1.2 / C / 1.2	–	protective vegetation	7.800
U7Bbc p–DE	3	3	3	–	–	– / C / 1.3	–		700
Vgc AB	1.3	3	3	–	–	– / – / 3	–		300
								total	50.840
Ecological zone III									
U3GC1 D	1.2	1.2	3	–	–	– / B / 1.1	–		100
U4Ur B	1.2	1.1	1.1	–	–	– / B / 1.1	–		16.200
U4Ur C	1.2	1.1	1.2	–	–	– / B / 1.1	–		14.600
U4Ur D	1.2	1.2	1.3	–	–	– / B / 1.1	–		160
U4Ub B	1.2	1.1	1.2	–	–	– / B / 1.2	–		2.830
U4Ub C	1.2	1.1	1.2	–	–	– / B / 1.2	–		2.700
U4Ub D	1.2	1.2	1.3	–	–	– / B / 1.2	–		360
U7Bbc p–B	1.3	3	1.3	–	–	– / B / 1.3	–		180
U7Bbc p–CD	1.3	3	3	–	–	– / B / 1.3	–		520
U7Bbc p–D	1.3	3	3	–	–	– / B / 1.3	–		460
U7Bbc p–E	3	3	3	–	–	– / C / 1.3	–		5.900
Agc AB	1.3	1.3	1.3	–	–	– / B / 1.3	–		1.620
Vgc AB	1.3	1.3	1.3	–	–	– / B / 3	–		1.350
VC AC	1.3	1.3	1.3	–	–	– / – / (1.3)	–		850
VC AD	1.3	1.3	1.3	–	–	– / – / (1.3)	–		9.300
								total	57.130

LAND USE ALTERNATIVES

mapping unit	smallholders rainfed mixed farming med. alt. 1) intermediate technology 4)	smallholders rainfed mixed farming med. alt. 1) advanced technology	large scale mixed farming med. alt. 7)	small scale livestock farming, intermediate technology high alt.	extensive range	forestry 5)	smallholders irrigation	other alternatives	area in hectares
Ecological zone III–IV									
MGh	3	3	3	–	1.3.2 / B / 1.3.1	(1.2) / D / 1.3	–	protective vegetation 6)	2.230
MG	3	3	3	–	1.3.2 / – / 1.3.2	3 / – / 3	–	protective vegetation 6)	27.380
MFry	3	3	3	–	1.3.2 / B / 1.3.1	3 / D / (1.3)	–	protective vegetation 6)	400
MFC	3	3	3	–	1.3.2 / B / 1.3.1	3 / D / (1.3)	–	protective vegetation 6)	23.700
HLC	3	3	3	–	1.3.2 / B / 1.3.1	3 / C / 1.3	–		830
FGrc BC	1.2	1.3	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		400
FGrc CD	1.3	1.3	3	–	1.3.1 / B / 1.2	– / B / 1.2	–		200
FGrce CD	3	3	3	–	1.3.1 / B / 1.2	– / B / 1.2	–		400
FGrce D	3	3	3	–	1.3.1 / B / 1.2	– / B / 1.2	–		70
FGby C	1.3	1.3	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		600
U5Frc p–C	1.3	3	3	–	1.3.1 / B / 1.2	– / B / 1.3	–		100
U7Bbc p–CD	1.3	3	3	–	1.3.1 / B / 1.2	– / B / 1.3	–		2.100
U7Bbc P–DE	3	3	3	–	1.3.2 / B / 1.3.1	– / – / 3	–		1.300
U7Fr_U7Frc P–CD p–CD	3	3	3	–	1.3.2 / B / 1.3.1	– / B / 1.3	–		450
AC BC	1.3	3	– / B / 2.3	–	1.3.1 / B / 1.1	– / A / 1.1	–		100
AC AD	1.3	3	– / B / 2.3	–	1.3.1 / B / 1.1	– / A / 1.1	–		60
								total	60.320
Ecological zone IV									
MG	3	–	3	–	1.3.2 / – / 1.3.2	3 / – / 3	–	protective vegetation	8.100
HG	3	–	3	–	1.3.2 / – / 1.3.2	3 / – / 3	–	protective vegetation	2.770
FGrc C	2.3 4)	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		2.000
FGrce BC	3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		5.400
FGrce C	3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		4.300
FGrce CD	3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		800
FGrce D	3	–	3	–	1.3.1 / B / 1.2	– / B / 1.2	–		300
FGrcE BC	3	–	3	–	1.3.2 / B / 1.3.1	– / B / 1.2	–		1.400
FGrcE C	3	–	3	–	1.3.2 / B / 1.3.1	– / B / 1.2	–		800
FGrcE CD	3	–	3	–	1.3.2 / B / 1.3.1	– / B / 1.2	–		100
FGby AB	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	3 / C / 1.2-1.3		330
FGby BC	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	3 / C / 1.3		150
FGby CD	3	–	3	–	1.3.1 / B / 1.2	– / B / 1.2	–		330
FGbys BC	2.3	–	3	–	1.3.1 / B / 1.2	– / B / 1.3	–		450
FGbys CD	3	–	3	–	1.3.1 / B / 1.2	– / B / 1.3	–		50
U5Frc p–AB	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.3	–		6.450
U5Bbc1 p–A	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.3	–		1.800
U5Bbc2 A	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		700
U5Bbc2 AB	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		930
U5Bbc2 B	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		80
U5Bbc2 BC	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.2	– / B / 1.2	–		340
U5GC BC	3	–	3	–	1.3.2 / B / 1.3.1	– / – / 3	–		5.400
U5GC CD	3	–	3	–	1.3.2 / B / 1.3.1	– / – / 3	–		10.100
U6Gbc p–B	2.3	–	3	–	1.3.2 / B / 1.3.1	– / B / 1.2	–		460
U7Fr P–CD	3	–	3	–	1.3.2 / B / 1.3.1	– / – / 3	–		1.200
U7Bb_U7Bbc P–CD p–CD	3	–	3	–	1.3 / B / 1.3.1	– / – / 3	–		300
U7Bb_U7Bbc P–D p–D	3	–	3	–	1.3.2 / B / 1.3.1	– / – / 3	–		200
U7Fr_U7Frc P–CD p–CD	3	–	3	–	1.3.2 / B / 1.3.1	– / – / 3	–		2.030
U7Fr_U7Frc P–D p–D	3	–	3	–	1.3.2 / B / 1.3.1	– / – / 3	–		200
YGbc1 A	2.2	–	– / B / 2.2	–	1.3.1 / B / 1.2	– / B / 1.2	3 / C / 1.2		1.800
YGbc1 AB	2.2	–	– / B / 2.2	–	1.3.1 / B / 1.1	– / B / 1.2	3 / C / 1.2		700
AC A	2.2	–	– / B / 2.3	–	1.3.1 / B / 1.1	– / A / 1.1	3 / C / 1.2		1.700

LAND USE ALTERNATIVES

mapping units	smallholders rainfed mixed farming med. alt. 1) intermediate technology	smallholders rainfed mixed farming med. alt. 1) advanced technology	large scale mixed farming med. alt. 7)	small scale livestock farming, intermediate technology high alt.	extensive range	forestry 5)	smallholders irrigation	other alternatives	area in hectares
AC BC	2.2	–	– / B / 2.3	–	1.3.1 / B / 1.1	– / A / 1.1	3 / C / 1.2		180
AC AC	2.2	–	– / B / 2.3	–	1.3.1 / B / 1.1	– / A / 1.1	–		1.080
AC AD	2.3	–	– / B / 2.3	–	1.3.1 / B / 1.1	– / A / 1.1	–		650
								total	63.580
Ecological zone V									
YGbc2 A	2.3	–	– / C / 2.3	–	1.3.2 / B / 1.3.1	– / – / 3	3 / C / 1.2-1.3		200
								total	200
								urban areas	420
								Grand total	305.900

Notes and explanation

1) current suitability after clearing
2) –(indicated in boxes): not applicable
3) ( ) : in places only
4) if conditionally suitable (class 2): assuming that crops cultivated are sorghum, millet, and maize
5) first figure indicates present forest value; second figure indicates potential for plantation forest
6) with limited use for grazing
7) if conditionally suitable (class 2); assuming that advanced technology, including dry farming methods, is applied

The following "land qualities" have been used in assessing the suitability of the land:
- climate
- soil moisture storage capacity
- chemical soil fertility
- possibilities for the use of agricultural implements
- resistance to erosion
- hindrance by vegetation
- presence/ hazard of waterlogging
- presence of overgrazing
- depth of soil ("foothold")

explanation of land suitability symbols :

class	suitability	suggested colour
1.1	highly suitable	dark green
1.2	moderately suitable	medium green
1.3	marginally suitable	light green
for range: 1.3.1 = marginally suitable; 1.3.2 = submarginally suitable		
2.2	conditionally moderately suitable	orange/yellow
2.3	conditionally marginally suitable	orange
3	unsuitable	red

current suitability class — 1.3 / B / 1.2 — potential suitability class

required major improvement/ capital input

Input levels
A low
B moderate
C high
D very high

land use alternatives in relation to ecological zones

land use alternatives / ecological zone	smallholders rainfed mixed farming: intermediate technology	smallholders rainfed mixed farming: advanced* technology	large scale mixed farming, advanced technology	small scale livestock farming, intermediate technology	extensive range	forestry: current	forestry: potential	smallholders irrigation	protective vegetation
I				x		x	x		x
IIc		in places		x		x	x		some units
IIw	x	x	x			x	x		some units
III	x	x	x				x		
III–IV	x	x	x		x		x		some units
IV	x(cond.)**		x(cond.)		x		x	some units	some units
V	x(cond.)		x(cond.)		x		x	x	

If no "x" is indicated, then the land use alternative is not applicable for that particular ecological zone; see description of land use alternatives in accompanying report

*for specification of altitude/ rainfall requirements of individual crops; see report.

**(cond.): conditionally

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This key to be used in conjunction with appendix 2

Prepared by R.F. Van de Weg, F. N. Muchena, H.M.H. Braun, H.C.K. Kinyanjui
Cartography by C. M. Muchemi April 1976
Printed by Government Printer, Nairobi

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Appendix 5 to Report No. 2
"Soils of the Kapenguria area"

SOIL PROFILE CHARACTERISTICS SIGNIFICANT FOR SOIL CLASSIFICATION

Ministry of Agriculture
Kenya Soil Survey

Soil classification according to FAO-UNESCO (1974)							Colour in A1										B2-Horizon																	Soil classification according to "Soil Taxonomy" USDA (1976)
main unit	subunit	mapping unit (s)	number of profiles analysed	CEC soil A1&A3 at pH 7.0	organic C % in A1	thickness A1 in cm	dry	moist	description moist	base saturation % A1+A3 at pH 7.0	clay % A1+A3	silt/clay ratio A1+A3	transition A to B horizon	clay ratio B/A	clay %	silt/clay ratio	consistence (moist)	structure	flocculation index	clay cutans field	clay cutans lab.	base saturation % at pH 7.0	bulk density	porosity	CEC clay at pH 7.0	weatherable primary minerals	Clay minerals: kaolinite	Clay minerals: illite	Clay minerals: montmorillonite	Clay minerals: vermiculite	SiO_2/Al_2O_3	Fe_2O_3%	colour dry	colour moist	colour description (moist)	
FERRALSOLS	Rhodic	U4Ur	10	13.6	2.05	26	2.5YR 3/4	2.5YR 3/2	dusky red	55	51	0.2	g-d	1.3	63	0.19	friable	sb-pm	70	f 1	– –	54	1.1	57%	13.9	++	xx g	x m			1.7	15.4		2.5YR 3/6	dark red	Typic Haplustox
	Orthic	U4Ub	3	8.9	1.54	23		5YR 3/2	dark red. brown	48	38	0.3	g	1.3	55	0.20	friable	sb	58	–	–	52	1.2	53%	11.3	++	x p	x p			2.4	11.1		5YR 3/4	dark red. brown	Typic Eutrustox
ACRISOLS	Orthic	U5Bbc2	3	7.0	0.71	20	7.5YR 4-5/2	7.5YR 3/2	dark brown	54	21	0.5	d s	1.9	39	0.29	firm	m	36	f 1	– –	59 2)	1.4	45%	24.3	+++	x g	xx g			2.4	12.0		7.5YR 4/4 5YR 4/6	brown-yellow. red	Typic Haplustalf
	Ferral-Orthic/Chromic	U3GC1	3	5.8	1.05	22	10YR 5/3	10YR 3/2	very dark greyish brown	40	24	0.7	v	1.4	38	0.41	friable to firm (comp.)	sb-m	54	–	–	33	1.4	45%	12.5	++++	xx g	x			1.5	14.4		10YR 4/4-2.5YR 3/6	dark yellow. brown-dark red	"Oxic" Rhodustult
	Ferral-Humic	U3GC2	2	16.2	3.29	18	10YR 3/2	10YR 2/2	very dark brown	65	32	0.4	g	1.3	41	0.24	friable to firm (comp.)	sb-m	69	c 2	– –	63 2)	1.4	45%	16.8	++++	xx g	x m			1.8	17.1		5YR 3/4 2.5YR 3/6	dark red. brown-dark red	Oxic/"Sombri" Paleustalf
LUVISOLS	Orthic	U7Bbc/p	3	12.1	1.59	19	7.5YR 4/4 10YR 5/2	7.5YR 3/3 10YR 3/3	dark brown	43	21	0.9	g	1.7	27	0.42	friable to firm	sb	40	f	c	57	1.5	44%	26.0	++++	xx g	x m		tr	2.1	6.9		5YR 4/6	yellow. red	Typic Paleustalf
	Chromic	U5Frc/p FGrce/E	5	7.4	0.54	15	7.5YR4/2-4/4	7.5YR 3/2	dark brown	69	17	0.6	g s	2.0	34	0.30	friable	pm	32	c 2	c 2	74	1.4	46%	38.8	++++	x m	xx g	x m		2.3	11.6	5YR 4/6	5YR 4/4	red. brown	Udic Rhodustalf
	Verti-Chromic	YGBc1	4	12.7	0.60	30	10YR 4/2 5YR 3/3	10YR 3/3 5YR 3/4	dark brown	79	28	0.7	g s	1.4	38	0.34	firm	pr-(s)ab	25	c 2	c 2	89	1.3	49%	38.0	++++	x	xx m		tr	2.5	8.2	10YR 4/2 5YR 3/4	10YR 3/3 5YR 3/3	dark brown-dark red. brown	"Vertic" Paleustalf
CAMBISOLS	Eutric	FGby(s)	4	12.9	1.11	24	10YR 5/3	5YR 3/4-10YR 3/2	dark red. brown	86	23	0.7	g-d s	1.3	29	0.47	friable	sb	54	f 1	–	89	1.5	44%	50.1	+++	xx p	xx m			–	–	5YR 4/4	2.5YR 3/6 5YR 3/4	dark red-dark red. brown	Typic Ustropept
	Dystric	U3Gby/p U2Gry	3	17.3	2.90	24	5YR 3/3-2	5YR 2-3/2	dark red. brown	23	43	0.4	v	1.1	46	0.36	friable	sb	62	–	–	17	1.2	55%	16.7	+++	xx m				–	–		5YR 3/4-4/6	dark red. brown-yellow. red	Ustic Humitropept
	Humic (Cumulo)	U2Gh1.2/p MQh	6	17.8	4.13	47	10YR 2/2	10YR 2/1	black	24	39	0.7	g s	1.5	47	0.55	friable	(s)ab	80	–	–	16	1.0	57%	11.6	++++	xx g		tr		–	–		5YR 3/4	dark red. brown	Ustic Humitropept
	Humic-Acri	U3Gh	4	22.9	4.29	41	7.5-10YR 3/1	10YR 3/1	very dark grey	50	39	0.5	g s	1.3	49	0.26	friable	sb	60	–	c	32	1.3	49%	13.9	++++	xx m		tr		2.4	11.7		5YR 3/4	dark red. brown	Ustic Humitropept
	Chromic	MFC	4	15.3	0.76	38	5YR 4/3	5YR 4/2-3	dark red. brown	90	21	0.8	g-c s	1.0	22	1.04	friable	sb	34	–	–	91	1.3	49%	47.6	–		–			–	–	2.5YR 4/6 5YR 3/4	2.5YR 3/6 5YR 3/3	dark red-dark redd. brown	Typic Ustropept
	Chromic-Luvi	FGrc	4	15.2	0.68	18	7.5YR 4/4	7.5YR 3/2	dark brown	82	27	0.5	g-c s	1.4	36	0.39	firm	sb	35	c 2	c 2	78	1.4	46%	42.8	+++	x m	x m			2.3	9.2	5YR 4/4 2.5YR 4/6	5YR 3/4 2.5YR 3/6	dark red. brown-dark red	Rhodic Paleustalf
PHAEOZEMS	Haplic 1)	MGh	3	11.9	2.33	49	10YR3-4/2	10YR 2/2-1	very dark brown-black	67	22	0.8	g-c s	1.0	27	0.42	friable	pm	49	–	–	41	–	–	20.1	++++	xx p	x p			2.1	7.1	7.5YR 5/4	5YR 3/3 7.5YR 3/3	dark red. brown-dark brown	Oxic Dystropept
	Luvic	HGh2	1	35.6	4.53	40		10YR 2/1	black	66	15	0.6	d s	1.4	56	0.29	friable	sb-pm	54	f-c	–	25	–	–	38.5	+++	x m	xx m			2.6	14.3		5YR 3/4	dark red. brown	Ustic Humitropept
KASTANOZEMS	Haplic	HLC	2	20.3	1.10	21	10YR 3/3	7.5YR 3/2	dark brown	100	24	0.5	c s	1.0	23	0.54	friable	sb	40	–	–	100	–	–	79.0	–					2.7	5.7	5YR 3/4	5YR 3/3	dark red. brown	Typic Ustropept
VERTISOLS	Chromic	YGbc2	1	26.3	0.65	20	10YR 4/4	10YR 3/3	dark brown	89	54	0.2	g	n.a.	–	–	(v) firm	pr-(s)ab	–	–	–	–	1.4	45%	–	–	x p	xx g			–	–		10YR 3/3	dark brown	Udic Chromustert
GLEYSOLS	Eutric Dystric Mollic	Agc Vgc VC	3	26.9	3.15	12	5-10YR 4/1	10YR 4-2/1	very dark grey to black	58	43	0.4	c	1.1	55	0.19	firm	m-pr	33	f-c	–	63	–	–	37.8	++++		xx			2.9	16.1		10YR 5/2 10YR 3-5/1	grey brown-grey	Tropoquent
FLUVISOLS	Eutric	AC	3	19.0	1.36	17	7.5YR 4/4	10YR 2-5/1-4	dark grey brown	70	15	0.6	c s	1.2	31	0.46	friable	v	47	f	–	76	1.1	57%	37.9	–	x p	xx m			–	–		10YR2-5/1-4	grey-brown	Typic Ustifluvent

Notes

weatherable minerals, micromorphological analyses, clay mineral analyses and total analyses (SiO_2, Al_2O_3, Fe_2O_3) usually of one profile only

n.a. not applicable
v variable
– not determined

1) transitional to Humic Cambisol
2) occasionally the B1 horizon has 50% or less base saturation

explanation of abbreviations

transition A to B
- c clear
- g gradual
- d diffuse
- s smooth

structure B
- pr prismatic
- m massive
- pm porous massive
- ab angular blocky
- sb subangular blocky

clay cutans
- f few
- c common
- 1 weak/thin
- 2 moderate

flocculation index

$$fi = 100 \times \left(1 - \frac{\text{natural clay}}{\text{total clay}}\right)$$

weatherable primary minerals
- tr trace
- + very few (1-3)
- ++ few (4-7)
- +++ common (8-20)
- ++++ many (more than 20)

Clay minerals
- tr trace
- x subordinate (10-40%)
- xx dominant (more than 50%)

degree of crystallization of clay minerals
- g good
- m moderate
- p poor

Prepared by : W. Siderius and W. G. Sombroek

Cartography by : C. N. Muchemi Jan. 1977

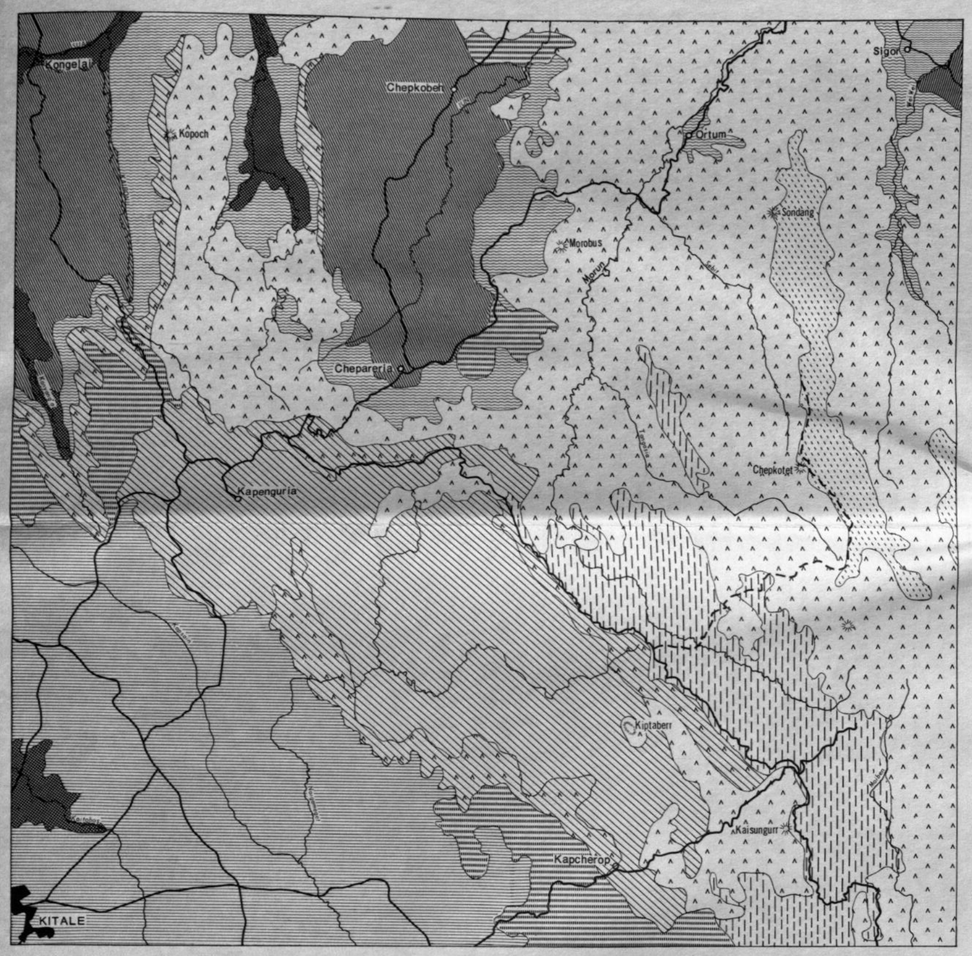
Printed by : Government Printers, Nairobi

Drawing No. 76048

WOSSAC: 19835
631.471
(676.2)

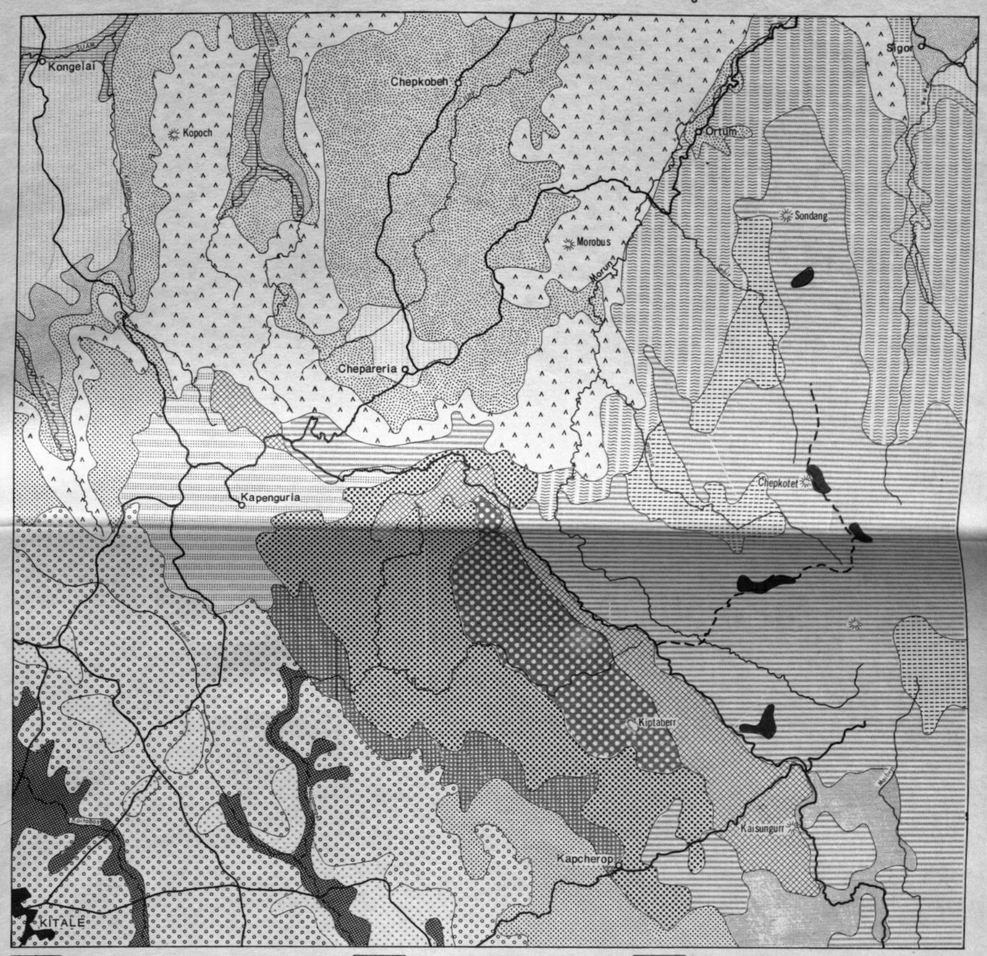
Ministry of Agriculture
Kenya Soil Survey

C GEOMORPHOLOGY



- mountains and hills
- major and minor scarps
- footslopes
- Sondang erosion surface, rolling to hilly appr. alt. 3200m
- Kapsait erosion surface, rolling to hilly appr. alt. 2900m
- Kapenguria erosion surface, rolling to hilly appr. alt. 2300m
- Kitale erosion surface, gently undulating to undulating appr. alt. 1900m
- Kunyao erosion surface, flat to gently undulating appr. alt. 1350m
- Wei-Wei erosion surface, gently undulating appr. alt. 1050m
- undifferentiated erosion surfaces
- piedmont plains
- river terraces and floodplains

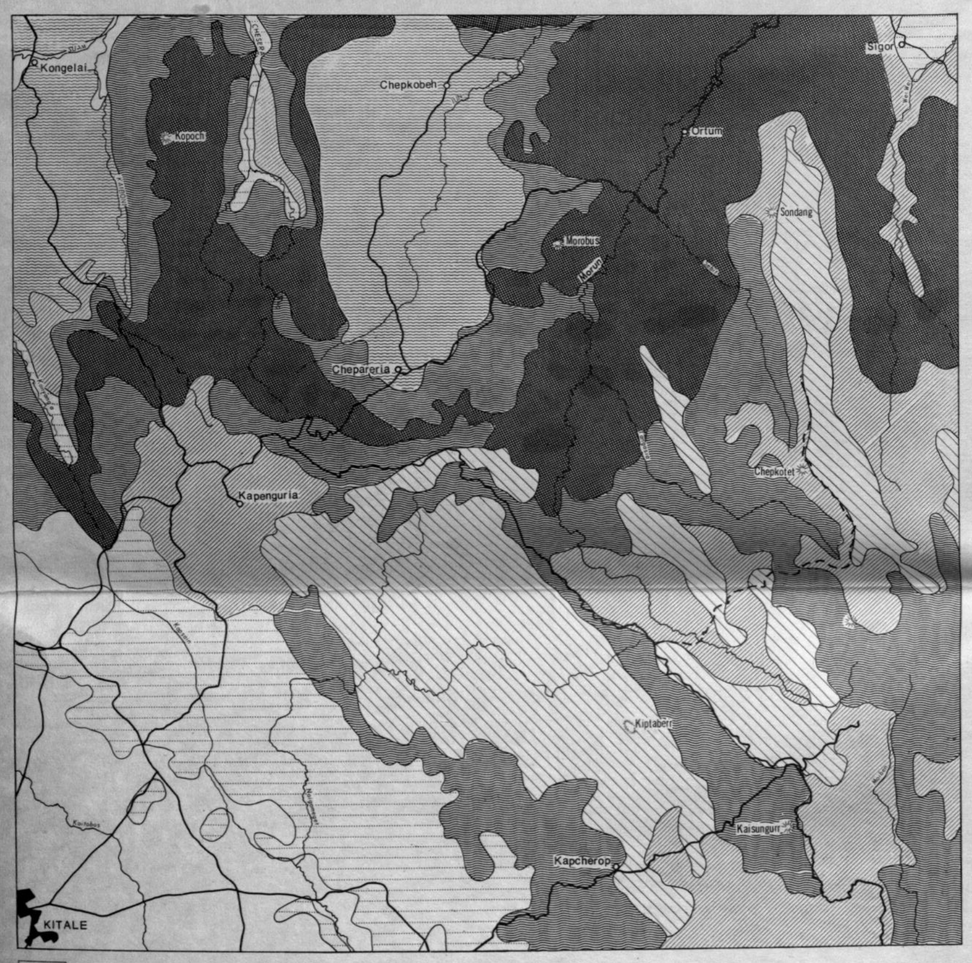
D SOILS (GENERALIZED) classified according to "FAO-UNESCO Soil Map of the World", vol. 1, legend



- rhodic Ferralsols
- orthic Ferralsols
- orthic, chromic and humic Acrisols–Ferralsols intergrades
- orthic Acrisols* (+ferralic Cambisols)
- orthic Luvisols*
- chromic Luvisols*
- vertic Luvisols
- luvic Phaeozems
- humic Acrisols–Cambisols intergrades
- dystric Cambisols
- eutric Cambisols
- chromic Cambisols
- humic Cambisols
- dystric Lithosols/Regosols
- Fluvisols
- Gleysols - Planosols
- Histosols
- eutric Regosols and chromic Cambisols
- dystric Lithosols/Regosols and humic Cambisols
- humic Acrisols–Cambisols intergrades and dystric Cambisols

* :texturally little differentiated

G SHEET AND GULLY EROSION HAZARD (AFTER CLEARING)



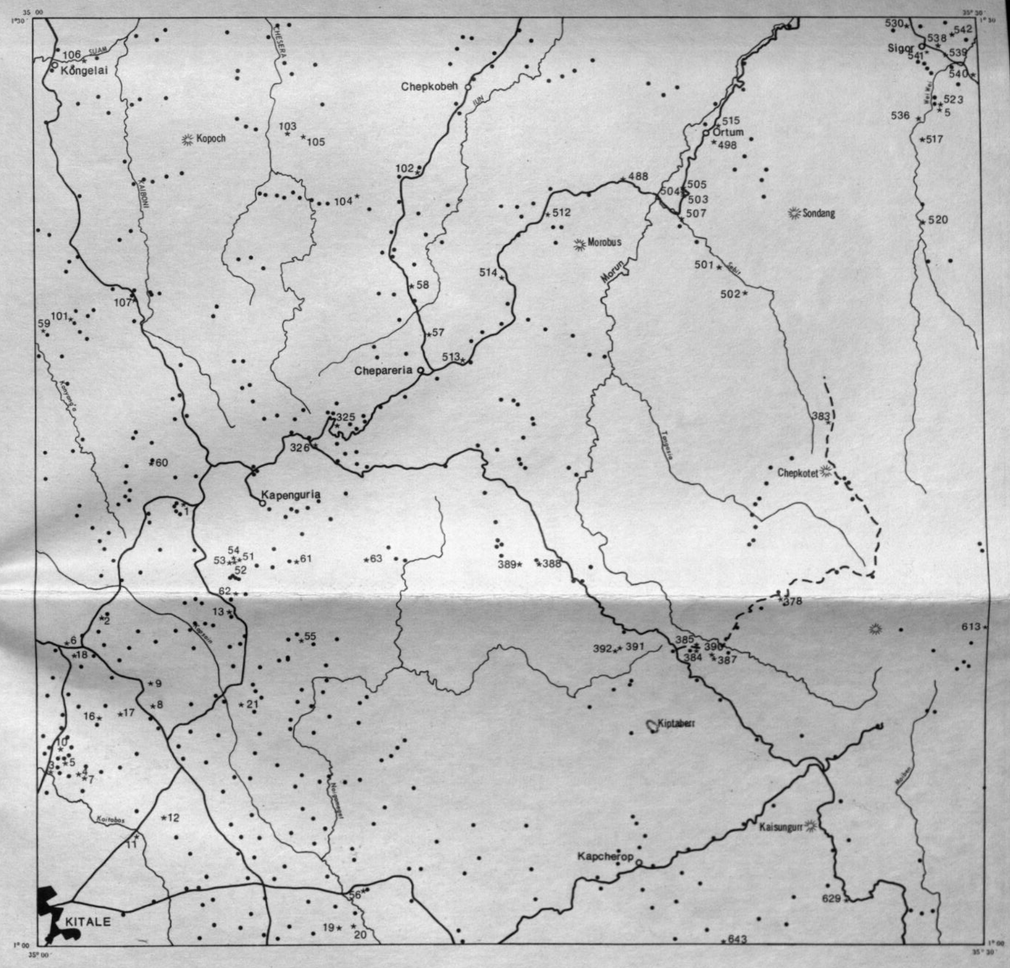
- none to slight
- slight
- moderate
- moderate to severe
- moderate and severe*
- severe
- very severe

*interfluves: moderate hazard
valleys : severe hazard

Scale 1:250 000

5 km 2,5 0 5 10 15 km

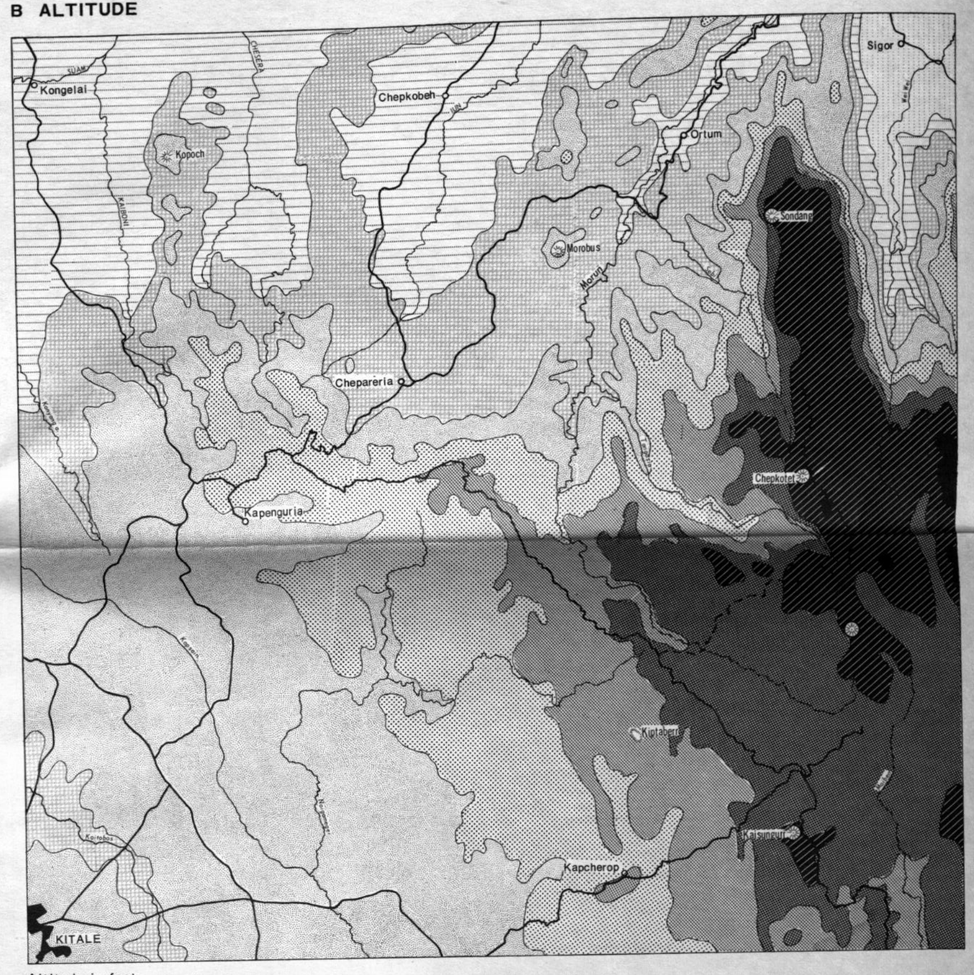
H LOCATION OF PROFILE PITS AND OTHER OBSERVATIONS



*325 profile pit (with number)
augering or roadcut

compilation of maps:	A, B, C, H	H.F.Geleas, H.C.K. Kinyanjui
compilation of maps:	E, F	H.M.H.Braun, H.W.Okewo
compilation of map:	D	W.G.Sombroek, W.Siderius
compilation of map:	G	W.G.Sombroek, R.F.van de Weg, F.N.Muchena
map correlation:		J.J.Vleeshouwer, R.F.van de Weg
cartography:		D.M.Olulo, C.N.Mucheeni, P.Maingi
printed by		Printpak, Nairobi

B ALTITUDE



Altitude in feet – metres

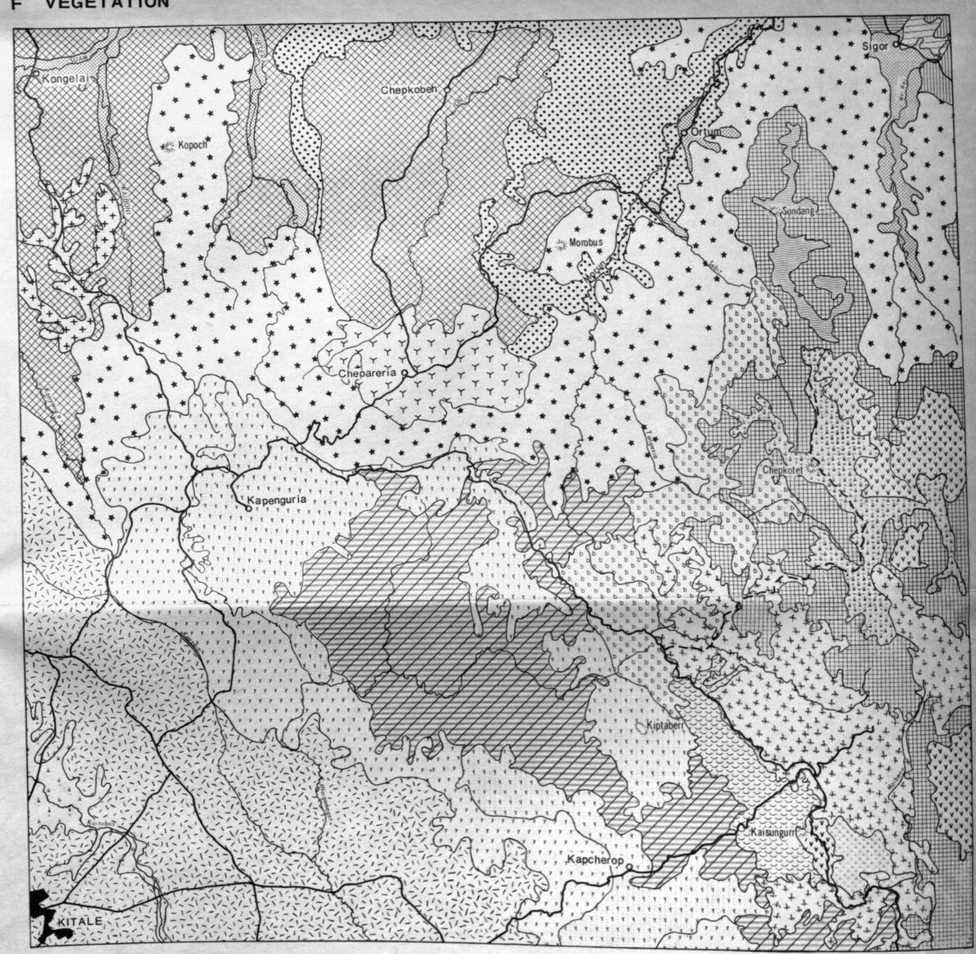
	3000-4000	910–1220
	4000-5000	1220–1520
	5000-6000	1520–1830
	6000-7000	1830–2130
	7000-8000	2130–2440
	8000-9000	2440–2740
	9000-10000	2740–3050
	10000-11000	3050–3350
	more than 11000	more than 3350

tensive grazing
ve grazing

rest, used
for forestry
ex)
try or

ades and forestry
and bamboo
intensive grazing
rection of

F VEGETATION



- **moorland and montane shrubland**; Erica arborea, Compositae
- **montane grassland**; Pennisetum schimperi, Pennisetum clandestinum, Digitaria scalarum
- **wooded bamboo thicket**: Arundinaria alpina, Faurea saligna, Hagenia abyssinica
- **sclerophyll forest**; Juniperus procera
- **moist forest**; Macaranga kilimandscharica, Podocarpus milanjianus, Syzygium guineense
- **undifferentiated forest** (only in complex)
- **cleared forest or forest glades**; Acacia lahai, Acacia abyssinica, Digitaria scalarum
- **moist Combretum woodland**; Combretum molle, Faurea speciosa, Terminalia mollis
- **vlei grassland**; undifferentiated
- **Combretum–Euphorbia woodland**: Combretum molle, Combretum collinum, Euphorbia candelabrum
- **dry Combretum woodland**; Terminalia brownii Combretum molle, Acacia nilotica
- **Acacia woodland**; Acacia tortilis, Acacia elatior
- **Croton bushland**; Croton dichogamus, Acacia hockii, Terminalia brownii
- **Acacia nilotica bushland**: Acacia nilotica, Acacia senegal, Acacia brevispica
- **Acacia seyal bushland**; Acacia seyal
- **Euphorbia bushland**: Euphorbia tirucalli Acacia mellifera, Acacia tortilis
- **Acacia reficiens bushland**: Acacia reficiens. Euphorbia tirucalli, Acacia mellifera

complexes

- **montane grassland and moorland or montane shrubland**
- **montane grassland, wooded bamboo thicket and sclerophyll forest**
- **montane grassland and sclerophyll forest**
- **sclerophyll forest and wooded bamboo thicket**
- **undifferentiated forest and cleared forest or forest glades**
- **slope complex**: undifferentiated