UGANDA PROTECTORATE

DEPARTMENT OF AGRICULTURE

MEMOIRS OF THE RESEARCH DIVISION
SERIES 1: SOILS

NUMBER 2

THE SOILS OF THE EASTERN PROVINCE OF UGANDA

A Reconnaissance Survey

by

C.D.Ollier, M.Sc. (Brist.),F.G.S.
and J.F. Harrop, B.Sc. (Leeds)

Kawanda Research Station
P.O. Box 265,
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This memoir is practically and essentially confined to soils. Details of climate, vegetation, crops and agricultural practices, together with information of a general nature on ethnography, history and communications are recorded in the memoirs on Vegetation and Systems of Agriculture. More emphasis is given here to geology and geomorphology as a background. The plain soil map is drawn on the 1:5000,000 scale but the coloured maps will be on the new standard East African grid sheets of 1:250,000. This memoir will form a section of a comprehensive volume on the soils of the Protectorate.

METHODS OF SURVEY

The aims of the survey are to identify the different soils of the province and record their distribution on a map. Field mapping was conducted on a scale of 1:250,000 and the 11,698 square miles of land in the province was covered in just over one year. To achieve this rate of mapping it was necessary to confine most activities to road traverses rather than employ the more time consuming method of grid traverses.

Details of profile morphology and soil distribution were obtained by digging soil inspection pits and augering. Use was also made of any available section that could be examined in road cuttings or murram pits or natural exposures of river channels etc. Information was collected in this manner about conditions of both topsoil and subsoil, and of their relationship to the underlying weathered rock.

The mapping units used in this survey, in most instances, are based on easily recognisable field characteristics and as such do not always correspond to the soil series, associations, etc., which are used in detailed soil surveys in other parts of the world. The map depicts soil units of different kinds, ranging from approximate series to catenas and complexes, but in a wider sense they are all natural land units and can be used as a guide to assessments of soil productivity and land-use.

Cartographic Methods

Base maps used for the survey were the 1:250,000 district sheets. After plotting the field data, interpolation was aided by the use of air photographs and print laydowns. Air photographs enabled a much quicker rate of mapping to be achieved and a more accurate delineation of certain boundaries than would have been possible by field methods alone. In order to produce a map on this scale it has been necessary to ignore the smaller areas of localised soil types and it must be borne in mind that large uniform areas on the map often include minor variations which could only be indicated on a large-scale map. A line drawn on the map to separate two units has in many cases to be chosen rather arbitrarily since in the field the change may merge over an appreciable distance.

Description of Soil Mapping Units

The basis of mapping is the soil profile; this is the sequence of layers or horizons extending down to the parent material from which the soil was formed. In temperate regions the horizons are not, as a rule, so well marked. The range of soils within a mapping unit may give rise to several profiles which are related to the topography. Where this profile topography relationship occurs repeatedly the sequence is referred to as a catena. Other variations in the units may arise from changes in parent rock or patchy distribution of laterite and rock outcrops which do not conform to any regular pattern. In such circumstances it is necessary to describe the unit as a complex. On the other hand, a few of the units display sufficient uniformity of profile morphology to be regarded as soil series, this is especially true of soils developed on alluvium. Soil units may show gradual changes which take place over very great distances and the choice of a boundary in such instances is unavoidably subjective. The separation of the Buruli-Buyaga-Kibara units is an example of the subdivision of such a clinal variation.

Laboratory Investigations

Samples were collected from typical profiles of each mapping unit and sent to Kawanda Research Station for routine mechanical and chemical analyses. This consisted of determinations of silt and clay fractions, exchangeable bases and hydrogen, available phosphorus, organic carbon, nitrogen and pH. The results are given in the appendix.

Standard Terms and Definitions

In the following soil descriptions certain terms are used in a technical manner which will be explained and defined here.

Names

Names of soil units are usually those of the village or township near which the soils were first studied. Some of the more extensive units have been given a county or sub-district name.

Colour

To avoid ambiguity of colour description, use has been made of the Munsell soil colour chart.

Texture

Mechanical analysis separates the soil into three constituent fractions, sand, silt and clay. The relative proportions of these fractions are used to define the soil type. Textural names of the soil survey of the United States are used throughout this memoir.

Fertility

This is distinct from productivity and refers to the content of plant nutrients in the soil which in turn are very closely linked to organic matter status.

Structure

Briefly it may be stated that structure is the ability of the soil to form aggregates and retain them under some form of mechanical disturbance such as cultivation operations and impact of rainfall. The size, shape and permanence of these aggregates has an important bearing on soil productivity. There is a scientific classification of the various structural units which need not be fully discussed here since many of the terms used in this report are more or less self explanatory. Sandy textured soils break down almost to single grains when cultivated and would be described as virtually structureless. Clays tend to crack into hard angular blocks which may be almost indestructible when dry. Soils in the loam class show more varied structure depending on the relative amounts of sand and clay present and also the organic matter content. The latter is of great importance in maintaining structure in the cultivation layer and its depletion due to prolonged cultivation may be one of the most serious causes of loss of productivity. Not only does its destruction mean a loss of plant nutrients but also reduces the capacity of the soils to form aggregates, accept and retain rainfall and permit aeration of the upper soil. In subsoils structural units are less easily discernable and those present are usually weak and incoherent, except for the heavier soils. Many tropical loams are almost structureless in their subsoils but the whole mass may be riddled with small but visible pores and termite and/or ant channels. In the dry state these subsoils are easily broken down to very small grains which are probably aggregates made by termites during the construction of their nests.

GEOLOGY AND GEOMORPHOLOGY

Most of the area of Eastern Province is underlain by rocks of the Basement Complex, which include a variety of granites, migmatites, gneisses, schists and quartzites, and smaller areas of other kinds of strongly folded metamorphic rocks. These rocks are generally well planated, but the quartzite bands often stand up above the surrounding country, having been more resistant to the processes of erosion that have cut away the surrounding rocks. The quartzite ridges and hills usually follow curved outcrops of the intensely folded bands of rock, and the softer rocks weather into 'amphitheatres' between the hills. Other types of metamorphic rock rarely produce ridges, and even the Bugondo hills in Teso are probably largely formed of highly sheared quartzite and not of shale. The granites, too, give rise mostly to flat country, but on the interfluves of valleys there are occasionally outcrops of rock with the 'inselberg' or 'tor' type of hill. Another place where outcrops of tors and exfoliated boulders occur is on the lake shores and along major rivers, where erosion has been to some extent concentrated and the weathering products have been removed, leaving only the resistant cores as tors or pavements.

In south-west Busoga and in very small areas of south Bukedi, and probably in south-east Busoga as well, there are bands of amphibolite which weather easily. The amphibolite is enveloped by broad quartzite bands which stand out as arcuate hills surrounding the amphibolite lowlands.

All the rocks so far described are of pre-Cambrian age and there are no rocks of other age in the area before the Tertiary pre-Elgon volcanics. These are present as volcanic plugs at Tororo, Sukulu and Busuku, and also as some early volcanic layers around the base of Mount Elgon itself. The plugs are not simple lava-filled necks, but of the 'ring complex' type and consist of pyroxenites, carbonatites, phosphate rock and other peculiar rocks. Tororo is a fairly small plug which has been eroded into a single steep sided hill. It is surrounded by a comparatively broad discontinuous pediment on the volcanic rocks. The other plugs give rise to more complex topographic forms. It seems that the rock in the centre of the necks was more erodible than that of the edges, and the pediments breached the ring complexes and coalesced in the middle, leaving a ring of hills on the edges. Sukulu is such a ring of hills.

The other pre-Elgon rocks, and the Bugisu sedimentaries of the same age, cover very small areas and have little effect on the landforms, but they do give some indication of the pre-Elgon land surface. It appears that the land was fairly well dissected with valleys of greater amplitude than those of the present central plain. The pre-Elgon surface has not been studied in any detail.

In Tertiary times there was great volcanic activity, and several mountains in Eastern Uganda were built up, probably over a long period. In Eastern Province these are Napak and associated hills, originally one volcano which has since been eroded, and the Western half of Mount Elgon and neighbouring hills such as Nkokonjeru. Only the outlying Western flanks of Napak come into Eastern Province so this discussion will be limited to Mount Elgon.

The Elgon volcanics consist mainly of agglomerates and tuffs with very much smaller amounts of lava and mud-flow material. Although these volcanics comprise a variety of rock types, bulk chemical compositions have certain features in common: a low silica content and a high percentage of bases; notably Ca and Mg in some rocks and K and Na in others. In the main, the rocks are disposed in horizontal beds which in the lower part of the mountain have been dissected into a series of flat topped, steep-sided benches. There is no evidence to show that any surfaces of the present mountain are original volcano surfaces, but the mountain is still a low cone with a large crater, rimmed by hills. This is in marked contrast to the Napak group which has been dissected into separate hills, constituting only 3% of the original volcano. There are no younger rocks than the Elgon volcanics, except for superficial deposits, and these will best be discussed after an account of the development of the erosion levels and drainage pattern.

Most of the province - that is all except for Mount Elgon and the watershed close to Lake Victoria - consists of a very flat plain. This is part of the 'Africa' pediplain which Lester King (1951) states "is undissected and staggers the imagination in its monotony." Throughout Africa the processes of denudation have tended to form wide flat plains ever since approximately Cretaceous times, at least. When there was rejuvenation of the landscape due to earth movements, a new plain formed at a lower level than the old one, starting at valley bottoms and gradually extending by pedimentation until only small remnants of the old surface were left as the summits of flat topped hills. There are two main surfaces in Eastern Province. The most extensive is the one that merges into the Lake Kyoga flats, and rises to the south and to the east. The flat topped hills that project from this, particularly well seen in south west Busoga, mark the older upper surface. These surfaces have been given different names by different authors, as summarised in Table 1. The flat topped hills of south Busoga peter out to the north through a zone of lower and more rounded hills as described by Pallister (1959) for Mengo district.

The Erosion Levels

Various authors have recognised several peneplains (or pediplains) in Africa, and have used different names and determined different ages for the surfaces. These are shown in Table 1.

Table 1

	WAYLAND (1934)	KING (1951)	DIXEY (1946)	McCONNELL (1955)
UPPER SURFACE	Buganda (Peneplain II)	Gondwana	Mid-Tertiary	Buganda
LOWER SURFACE	Buganda (Peneplain III)	African	End-Tertiary	Tanganyika
				Acholi

To give some idea of the differences in age, and times involved; table 2 gives King's and Dixey's systems against a compressed time scale (million of years).

Table 2

GEOLOGICAL PERIOD	EROSION SURFACE KING	EROSION SURFACE DIXEY	AGE M.Y.
			140
JURASSIC	Gondwana	Jurassic	110
CRETACEOUS	Post Gondwana	Cretaceous	
	African		70
EOCENE		Mid-Tertiary	40
OLIGOCENE		End-Tertiary	30
MIOCENE	Coastal Plain		15
PLIOCENE			5
PLEISTOCENE	Congo	Pleistocene	0

In the east the lowest erosion level above the main plain is a terrace running roughly north-south through Mbale, and crossed by the main road, described here for the first time as the Mbale surface. This surface is preserved in a series of low flat-topped ridges extending westwards to the Bugisu-Bukedi border and is cut off to the east by rising ground along a line running very approximately parallel to, and 2 or 3 miles from, the main road. The ground which rises away from this level is cut by streams into gently sloping ridges, some of which display flattish crests and a correspondence of altitude suggesting a former erosion base level. The most significant of these appears between 4,300 and 4,400 feet but the presence of a lower level to the west and higher levels to the east suggest that they are all part of a pre-volcanic surface rising gradually from west to east and which now underlies part of Buwalasi, part of Nkokonjeru and probably most of the volcanic beds north-west of a line joining Bufumbo to Kyesoweri. Another surface slightly over 6,000 feet in height forms the principal base of the volcano, separated abruptly from the lower surface.

The existence of erosion surfaces on the volcanic rocks of Mount Elgon seems unlikely and would be difficult to distinguish from the structural benches which are produced by differential denudation of the horizontally bedded rocks. A flat-topped feature is often preserved by a capping bed of lava or harder agglomerate after the removal of the relatively soft overlying beds. The steep or vertical sides of the features (risers) are created and maintained by undercutting and breaking away by vertical joints and also spallation or flaking from the faces of the cliffs. Thus many parts of the mountain on the Uganda side are disposed in a series of well defined flat topped mesas. Even in the parts where this is not the case the underlying tendency can usually be seen.

The drainage of Eastern Province must be considered in relation to that of a wider area, and a brief account of its evolution will make its many peculiarities more easily understood. At one time the main drainage of much of Uganda flowed west to the Congo. There were two primary dendritic systems, one along the lines of the present Lake Kyoga and the other across the site of what is now Lake Victoria, and there was a fairly low watershed between the two. This drainage system was probably initiated on the Gondwana (Buganda) surface, and survived until most of the African pediplanation was almost in its present state, and the Gondwana reduced to a small ridge along the divide between the basins. At the time of the upwarping and faulting which formed the western rift valley the downstream ends of these main drainage systems were tilted up, cutting off their outlets to the west. Some of the rivers were reversed, as can be seen on any drainage map of Uganda. With no outlet, the waters within the drainage systems piled up to form lakes - one becoming Lake Victoria and the other Lake Kyoga. It is obvious that, unless evaporation keeps pace with the supply of water, the water level will rise, eventually reaching a point where it overflows over the lowest point on its watershed into another drainage basin. This is exactly what happened. Lake Victoria rose until it reached the lowest point connecting it with another basin, which was near Jinja, and the waters overflowed into Lake Kyoga along the course of the Nile. The lower part of this valley, below Namasagali, is a wide swampy course like the Sezibwa and the other neighbouring rivers, but the upper part was rapidly rejuvenated to form a steep and rocky trench with many falls, such as the Ripon Falls. The Sezibwa and many other valleys, must have approached the cols on the watershed very close in height to the one that the overflow waters actually used, but subsequent erosion has increased the apparent difference.

Lake Kyoga, in turn, found an outlet to the north. The waters over most of the basin continued to flow in the same direction as of old, but the drainage was reversed along the tributary on which Masindi Port now stands. This carried the waters north to the region of Aber in Lango, where another overflow channel took the drainage into another drainage system and eventually into the western rift valley.

From this story we are interested here only in the effects on Lake Kyoga. It must not be supposed that all the events just described took place rapidly. They probably occurred over a long period, interrupted by several earth movements and other adjustments. Lake Kyoga was then deeper and much more extensive, as can be seen from lacustine and shore sediments now far distant from the present site. Old swamp deposits are frequently found in strips and broad stretches at levels above the present swamps. They vary from sands in western Bukedi to black clays in Sebei and eastern Teso. These deposits mark the former extent of Lake Kyoga, although the lake did not necessarily reach the maximum boundary at all places at the same time, and the fact that they do not follow a contour indicates that there must have been subsidiary warping since they were laid down. No doubt some of the old sediments have since been removed by later erosion which further complicates the distribution pattern.

The result of the geological history just outlined is the production at the present day of three main kinds of landscape and soil pattern in Eastern Province. On Mount Elgon itself the volcanic parent material has the greatest influence, but slope is also important, with red soils developing on flattish sites, and dark brown soils on the younger steep sites. On the upper parts of the mountain the effects of low temperature are of great significance, e.g. in humus development. The second region is the south Busoga hills where the relics of the Buganda surface are found (Mwiri unit). Practically all of the Buganda surface has been downgraded a hundred or two feet below its original level but most of south west Busoga is still above the African surface. Two soil catenas (Kabira and Buyaga) form the connecting steps between the two erosion surfaces.

The remainder of Eastern Province is part of the central plain of Uganda and amplitude of relief is small. Interfluves are rounded and there are none of the flat topped hills which distinguish south Busoga. The bottom lands contain widespread deposits of alluvium, which determine the soil type. Waterlogged clays are present in all valleys and are fringed by sandy deposits on lower valley sides.

SOIL FORMING PROCESSES

With the modifications of the land surface described above the processes of erosion and accumulation have given rise to the several soil parent materials. These include river and lake alluvia together with ancient and recent weathering products of igneous and metamorphic rocks. On these, there have been further pedological changes to produce the soils. Some of the processes involved are:-

Biotic Activity

Soil micro-fauna, especially termites, live in the upper part of the solum and are responsible for mixing surface layers. Termites bring up fine material to build their mounds, and the coarser fractions of the weathered rock are left below. The mounds eventually collapse and form a layer of fine material at the ground surface, but new mounds are built and the process continues. This has been going on for a very long time as termites are among the earliest forms of life, and now there is usually a layer, up to three feet thick of uniform, fine grained material with no trace of original rock structure, overlying weathered rock. The coarse material which cannot be moved by termites becomes buried below the worked zone as a result of this process, and accumulates as a line of coarse stones between the re-worked soil and the unmoved weathered rock (cf. Anderson 1957, de Heinzelin, 1955).

The tussocks present in many swamps are due to mounds made by worms, and may be important in the gradual natural conversion of swamps into dry land. (Gunn 1955).

Leaching, Eluviation and Illuviation

Rainfall passes through the profiles and often carries with it fine clay particles (eluviation) and chemicals in solution (leaching) which tend to be redeposited below (illuviation). The clay content of soil horizons almost always increases towards the bottom of the profile. Acid and base radicles which provide the mineral nutrients for plant life tend to be leached into the deep subsoil. This is not shown in the analyses because plants collect and concentrate the bases, which are ultimately returned to the topsoil and consequently the topsoils show the highest concentration of phosphate, bases, etc. Water does not flow only down the profile; it also flows downslope, through the profiles, and carries ions in solution and perhaps some clay with it. Lower slopes just at swamp edges, receive these solutions, and as a consequence tend to be more fertile in some instances, than the upper slopes. Swamps in Eastern and Northern Provinces are the final depository of such material and have a higher base content than most upland soils.

Lateritisation

Laterite (sheet ironstone) and murram (pea or pisolitic ironstone) are chemical deposits consisting largely of iron oxides and kaolin, with a little aluminium oxide, all of varying degrees of hydration. Ferruginous waters continually percolate the soil profile but in horizons with high pH values or high available phosphate the iron may be precipitated. In the dry season soluble iron left behind rapidly becomes insoluble as desiccation proceeds. All these processes may take place in the same profile but the last one is the most important as it is irreversible and eventually may produce deposits of ironstone several feet thick. The first stage is the formation of soft, iron impregnated, kaolinitic pisoliths, more iron is deposited on these in the form of skins which finally become extremely hard murram through the development of films of interlocking crystals of haematite. There is frequently a small hollow in the centre of these pisoliths but not often concentric banding. The murram generally forms a continuous horizon below the ground surface and parallel to it. Prolonged percolation of ferruginous water may actually cement the murram into sheets leaving the vesicular interstices between the pisoliths. Massive non-pisolitic forms of laterite are produced by the bulk ferruginisation of kaolinite in deep subsoils. The product, now called 'plinthite', is soft to very hard and usually contains discontinuous channels of vesicles within which iron hydroxides are deposited in concentric layers to form rigid tubes. The origin of the cavities is not clear, it may be due to soil micro-fauna, tree roots, shrinkage of volume on weathering, leaching and eluviation effects and, in the case of pisolitic laterite, to voids in the packing of the murram. Ferruginous water may also percolate partially weathered rock before this breaks down to kaolinite. The fabric of the rock is then preserved intact once the iron hydroxides have hardened, forming pseudomorphs from pebble size to large boulders, or even extensive crusts of sheet ironstone on the undisturbed country rock. There are many forms of transition between the murram and the vesicular laterite.

The process of lateritization is enhanced on flat sites, and here thicker and more massive laterite is usually found. Well preserved remnants of old erosion surfaces often have a thick laterite cover. Erosion in a later part of the cycle may cause the laterite sheet to outcrop at valley sides. When laterite is exposed to the air it develops a skin of iron hydroxide and becomes much harder than when it is in the ground. This is not, however, the true laterite of Buchanan which is dug as a soft clayey mass and sun dried to form hard bricks.

Creep and Hillwash

Except among the soils of Mount Elgon there is rarely any direct evidence of creep or hillwash in Eastern Province and it seems that most soils are more or less sedentary. Downhill movement of soil must inevitably take place on a small scale, but there are not many signs of it. Around Mount Elgon there are some deep colluvial soils, and elsewhere it is perhaps the gentleness of most slopes which limits the occurrence of drift soils. Some soils appear to have truncated profiles, probably as a result of sheet erosion. Most of the removed material is carried right into the swamps and rivers for there is not usually much accumulation on lower slopes.

Erosion

On very steep relief there is inevitably a tendency for material to be washed downslope during or after heavy rain. The upper part of a soil profile is slowly removed, but the formation of soil below, normally keeps pace, so that there is always a typical profile on the slopes. This is normal geological erosion, not accelerated 'soil erosion' which removes a great deal of soil faster than it can be replenished, and often causes irreparable damage by gullying - fortunately rare in Eastern Province. On slopes mapped as Mwiri, normal erosion is very considerable and the soils never get beyond the stage of skeletal or juvenile. On the terraced slopes of Elgon the flattish 'treads' have mature red soils, but the steep 'risers' have immature brown ones.

Sheet erosion on the plains can alter the profiles considerably by truncation, although eroded phases have not been shown on the map. Such soils have thinner horizons and are shallower to laterite (when this is present) than their uneroded counterparts. At Pingire in Teso for instance the Buruli soils are virtually without topsoil and only about 12" to laterite on average, whereas a typical Buruli soil in Eastern Province is about 36 inches to laterite and has a good topsoil.

Pre-weathering

There is considerable evidence from geomorphology, pedology and mineralogy, that some soils are formed on a strongly weathered parent material that had been formed during a previous cycle of weathering. It is difficult to account for variations in soil profiles and their distribution without believing this theory. Most of the weatherable minerals have been long removed, and the significance of this to a soil study is that bases for plant nutrition cannot be released from the parent material by further weathering. They have all been leached out and no more are available. It is the soils of the red loam type - Buruli, Bukedea, Buyaga, Kabira etc. that show this pre-weathering, and these soils are frequently very low in base content. The evidence for pre-weathering and an account of profile and catenary variations that can be found has been given elsewhere (Ollier, 1959, Ollier and Radwanski, 1959).

Examples of the above processes will now be described. Some of the soil mapping units exhibit all of them, others only one or two. No attempt has been made to classify the soils according to mode of formation because sufficient geo-chemical work has not been done. Genetic classification systems will be discussed in another memoir. In the four provincial and Karamoja District soil memoirs the mapping units have been arranged for convenience according to geomorphological levels.

KEY TO THE SOILS OF THE EASTERN REGION OF UGANDA

	MAPPING UNIT	LOCALITY	DOMINANT SOIL TYPES	PARENT ROCK	PRINCIPAL CASH CROPS	PRODUCTIVITY
			Soils Derived from Volcanic Rocks			
1.	Masaba Series	Summit of Mt.Elgon	Black humose clay loam	Elgon volcanics	None	Nil
2.	Benet Series	Upper forested slopes of Mt.Elgon	Humose red clay loams	Elgon volcanics	Timber	Medium
3.	Sipi Cato	Bugisu and Sebei	Red clay loam, occasionally lateritised	Elgon volcanics moderate relief	Arabica Coffee	High
4.	Choptui Series	North Bugisu, Elgon footslopes	Deep, red clay loam	Elgon colluvium	Cotton, maize	Medium
5.	Bugusega Series	Bugisu and Sebei	Black and brown clay or clay loam	Elgon volcanics strong relief	Arabica Coffee	High - medium
6.	Siroko Series	North Bugisu and around Alekilek	Black clay	Volcanic colluvium	Cotton, maize	High - medium
7.	Napak Series	Akisim flank of Napak	Reddish brown clay	Napak volcanics	None	Nil
8.	Tororo Complex	Tororo, Bukusu and Sukulu	Reddish brown, lateritised clay loam	Pre-Elgon volcanics	Cotton	Medium
			Soils Derived from Mixed Volcanic - Metamorphic Rocks			
9.	Bududa Series	North and Central Bugisu	Red clay loam	Elgon volcanic and B.C. colluvium	Arabica Coffee	High - medium
10.	Sebei Clay	Plains of East Teso and Sebei	Black calcareous clay	Mixed alluvium	Cotton, maize	High to medium
			Soils Derived from Metamorphic Rocks of the Degraded Buganda (Gondwana) Surface			
11.	Bubutu Series	West and South Bugisu	Non-lateritised brown sandy clay loams	B.C. granites	Cotton, Arabica Coffee	Medium
12.	Fubulu Series	Bugisu	Red loam and clay loam usually non-lateritised	B.C. granites and amphibolites	Cotton	Medium
13.	Iwiri Half-catena	Near Jinja, Busoga	Skeletal sands and laterite on relics of Gondwana surface	B.C. quartzite	None	Nil

B.C. = Basement Complex K-A = Karagwe-Ankolean

14. Nakabango Series	Jinja area and South Bukedi	Deep red clay, sometimes lateritised	K-A amphibolite and phyllite	Cotton, sugar Robusta Coffee	High
15. Mbale Complex	Near Mbale on "Mbale surface"	Lateritised red loams	B.C. mica and hornblende schists	Cotton	Medium
16. Serere Catena	Serere and Katata, Teso	Sandy loam to loam, sometimes lateritised	K-A quartz-rich phyllite	Cotton	Medium
17. Metu Complex	Bugondo Hills	Skeletal soils on steep rocky slopes, no laterite	B.C. quartzite	None	Nil
		Soils Derived from Metamorphic Rocks of the African Surface			
18. Kabira Catena	South Busoga	Reddish brown sandy loam on gritty clay loam	B.C. gneisses and granites	Cotton, wood	Medium
19. Buyaga Catena	North Busoga	Deep, red clay loam on laterite	B.C. gneisses and amphibolites	Cotton, Robusta Coffee	Medium
20. Bukedea Series	South-east Teso	Reddish brown clay loam on laterite, often shallow	B.C. gneisses	Cotton	Medium
21. Buruli Catena	Teso, Bukedi, Busoga	Reddish brown sandy loam and loam on laterite, often deep	B.C. gneisses and granites	Cotton	Medium to low
		Soils Derived from Ancient Lake Deposits			
22. Amuria Catena	Teso	Grey or brown sandy loam on laterite, sometimes shallow	B.C. gneisses	Cotton	Low
23. Masimasa Complex of Catenas	Bukedi, Bugisu and Busoga	Grey or brown sandy loams on laterite, usually shallow.	B.C. gneisses	Cotton	Low
24. Usuku Series	North Teso	Deep sands and sandy loam, laterite sometimes present	B.C. gneisses	Cotton Shea butternuts	Low
		Soils Derived from Pleistocene to Recent Alluvia			
25. Lwampanga Series	Bukedi and Busoga Lakeside beaches	Grey to yellowish or reddish brown sands and loams	Pleistocene beach deposits	Cotton	Low
26. Undifferentiated alluvium	All districts	Clays in broad valleys, sandy clays in narrow valleys	Recent swamp and river alluvium	Cotton Cattle	Low Medium

B.C. = Basement Complex K-A = Karagwe-Ankolean

SOILS DERIVED FROM VOLCANIC ROCKS

Mount Elgon Soils

Although the Uganda side of Mount Elgon constitutes only a relatively small part of Eastern Region it is convenient geographical unit by itself and, being formed of a series of volcanic rocks differing in many respects from the rocks underlying the remainder of the region, its associated soils can be considered as a separate group. They differ essentially from others, not only on account of their rather unique parent rock, but also in the fact that they are products of a single weathering cycle and not, as is the case with the majority of soils in the region, derived from pre-weathered material. On this account they are likely to developed elsewhere from material that has already undergone a long period of weathering.

Covering Mount Elgon there is a wide range of soils due, in part, to a diversity of topography and its effect on pedogenic processes. The present form of the mountain with its series of flat topped ridges and steep slopes has produced a sequence of soils that is clearly related to these features. On the steepest slopes, for instance, the soils are black or very dark brown in colour, while on the approximately level sites they are, almost without exception, red clay loams. These two mapping units occupy most of the cultivated parts of the mountain and represent the principal coffee growing areas of Bugisu and Sebei.

Above the upper limits of cultivation there is a broad zone of forest extending up to to an altitude of approximately 10,000 feet. The soils in this zone have been grouped in the Benet unit which consists predominantly of soils resembling in many repeats more humose versions of the Sipi soils. On the highest parts of the mountain in the alpine zone the highly organic soils of the Masaba unit occur.

On the pediments and colluvial deposits at the foot of the mountain soils of the Cheptui and Siroko units are found. The former resembles in some respects the Sipi soils on the higher ground but the latter, although of similar colour to the Bugusege, differs in certain morphological characteristics.

The table overleaf indicates the relative positions of the volcanic soils on the mountain.

Soil Unit	Altitude Distribution	Soil Types
Mesaba	14,000 - 10,000 ft.	Black humose loams
Benet	10,000 - 7,000 ft.	Humose red loams & clay loams
Sipi	7,000 - 5,000 ft.	Red loams & clay loams
Bugusege	7,000 - 4,000 ft	Black clay loams
Cheptui	4,000 - 3,700 ft.	Red loams & clay loams
Siroko	3,700 - 3,600 ft.	Black clays

1.* Mesaba Series

These soils occupy the upper part of the mountain above 10,000 ft. including the summit "crater". The latter does not represent the true crater of the volcano but is a large amphi-theatre, of approximately four miles radius, bounded by a ring of hills. The rim of the crater is breached at intervals by ravines and gaps through which the principal rivers flow. Inside the crater the topography is gently undulating and outside the mountain slopes gradually down to the forest in a series of low ridges. Slopes are locally steepest along the main river courses, the best example being the Suam gap, a ravine cut through the crater wall by the Suam river which drains most of the inner area. The upper reaches of the Wanafwa, Siroko and Simu rivers also run through steep sided valleys, after draining the western side of the crater.

The underlying rock is typical Elgon ash and agglomerate and probably differs little in composition from the rocks towards the base of the mountain.

With regard to climate, no reliable figures are available for the higher parts of the mountain but in all probability the rainfall is far less than supposed. The summit is frequently enveloped in cloud or mist and rain falls mainly in the form of drizzle and very rarely in torrential downpours so characteristic of the lower altitudes. Evaporation is minimised by the almost continuous cloud cover and a condition of almost permanent dampness is thereby maintained. Snow falls occasionally but never persists because day temperatures are nearly always above freezing point. For the same reason overnight frosts are only able to affect the surface inch or two of the soil and thaw out again during the day.

Somewhere between 10,000 and 11,000 feet forest (mainly bamboo) gives way to open alpine moorland. The vegetation forms a dense ground cover and is composed of a large number of plant species.

* Numbers shown on plain map

The soil transition is quite sharp and the red subsoil of the forest disappears on entering the alpine zone. The soils here are characteristically very dark in colour, almost down to the parent rock. Organic matter is usually well humified but only in limited areas near springs and in wet hollows is peat developed. On very gently sloping sites the vegetation is dominated by tussocks of Andropogon amethystinus under which the soil becomes more noticeably peaty. Subsoil colours are duller and less strikingly red than in the forest soils, due probably to the less intense chemical weathering at high altitudes and partly also to the greater amount of humus.

* Profiles 1. (16529-30)

Above Suam, 11,000 feet.

0 - 7" Very dark brown humose loam (10YR:2/2) small sub-angular blocky to crumb structure, friable and porous.

7 - 16" Very dark brown humose loam (10YR:2/2) containing occasional fragments of lava and agglomerate. Weak crumb structure, friable, porous. Overlying rubbly, weathered agglomerate.

This profile represents a shallow phase of the Masaba soils and is entirely coloured by the organic matter. No traces of unhumified plant material are present except for occasional dead root remains. Earthworms were fairly common throughout.

In the crater area at 12,300 feet soil conditions were found to be identical with those of the outer slopes 1,3000 feet below. Deeper profiles, while they show a certain amount of mineral soil in their subsoils, are all essentially similar in the surface 18". It is notable, that in spite of an excessively wet climate, there is very little development of peat and rarely can any gleying be detected in the soils, even on moderately level sites where poor drainage would be expected. Only in wet hollows under a very dark, grassy peat are there any symptoms of slow drainage in the mineral subsoil. On the whole the soil appear to be moderately well drained.

2. Benet Series

These soils occur in the forest belt extending from approximately 7,000 feet to 10,000 feet. Their area is broken up into broad ridges radiating out from the summit of the mountain and, as with other parts of Elgon, the ash and agglomerate beds

* Full analytical data are given in the Appendix for all soil profiles recorded in the text, they are numbered consecutively and ledger numbers of the samples are quoted in brackets for future reference.

give rise to steps on the ridges. These features are, however, less conspicuous than on the lower fringes of the mountain. The soils are developed directly from the ash and agglomerate.

No reliable figures are available for the rainfall in the forest but it is unlikely that the yearly totals increase greatly even on the highest parts of the mountain. It is possible that the maximum for Mount Elgon is attained in the forest as appears to be the case on Kilmanjaro and Ruwenzori. With increasing altitude the climate must approach that of a temperate region. Rainfall will be less seasonal and it is possible it differs more in this respect than totals from areas immediately below the forest.

Owing to the difficulty of access to this very extensive area, examination of the soils is confined to those parts traversed by footpaths and accordingly three lines were sampled up to the alpine zone from Suam, Kaburoron and Bumagabola. Bonet soils are typically brown to reddish brown loams overlying a deep, red, clay loam subsoil. Concretionary material is usually absent although some was seen on a flattish site at about 8,000 feet near Bulambuli and doubtless it is present in very small amounts in other places. Above Endebess on the Kenya side of the mountain at Altitudes of around 9,000 feet several exposures down to 10 - 15 feet were seen, revealing great depth and uniformity of soil profile. Apart from the browner humose surface horizon there were, in some cases at least, 12 feet of red granular clay loam. Similar depths of weathering have been noted on the Uganda side.

The most striking feature of the soils is the build up of organic matter in the top soil with increasing altitude. This is fairly gradual through the forest belt but rises sharply in the bamboo zone, reaching a maximum in the grassy parts of the alpine zone. Under the moister, cooler conditions at higher altitudes earthworms appear and are responsible for the more even distribution of organic matter in the profile. Their activity brings about mixing of the upper horizons which offsets to some extent the acidity developed by the intense leaching. In fact, the pH figures for most of the uplands soils show a decrease downwards which is the reverse of the pH trend in soils below the forest zone. This is more especially the case with soils in the upper parts of the forest where there is greatest earth worm activity; there must be a transitional range of soil fauna paralled with the changes in soil morphological characteristics passing from the lower to the upper reaches of the forest belt. Soils at 8,000 feet therefore will show affinities with the Sipi soils, shallow organic topsoils and occasional concretionary horizons where site conditions promote it while towards the upper limit of the forest, especially where the bamboo becomes more abundant, soil features begin to assume the alpine characteristics.

To demonstrate this transitional sequence pits were sampled at suitable intervals through the forest zone; the traverse from Suam is given below.

<u>Profile 2.</u> (16524-28)

Abwe, Suam. 7,800 feet.

0 - 9"	Dark reddish brown loam (5YR:3/4). Firm sub-angular blocky structure, porous and fissured, moderately high organic matter.
9 - 19"	Dark reddish brown loam to clay loam. Sub-angular blocky, friable and porous. Organic matter moderately low.
19-28"	Dark reddish brown loam to clay loam (2.5YR:3/4). Weak sub-angular blocky, friable, porous.
28-40"	Dark red loam to clay loam (2.5YR:3/6). Soil moderately compact - structure weak, breaking down easily to very small sub-angular blocks, slightly granular.

Organic matter though high at the surface falls off fairly abruptly in the horizons below to a fairly steady low figure. pH values show a similar trend.

<u>Profile 3.</u> (16536-39)

Suam. 8,700 feet.

0 - 12"	Dark reddish brown loam (2.5YR:3/4). Small sub-angular blocky structure - porous.
12 - 24"	Dark red brown loam (2.5YR:3/4). Weak small s.a.b. friable - porous.
24 - 36"	Dark red brown loam (2.5YR:3/4). Incoherent structure breaking down very readily to very small s.a.b. - granular.
36 - 48"	Essentially the same as horizon above. Slightly more compact but very friable down to very small s.a.b.

The organic matter content shows an almost identical trend to profile 2 and similarly with the pH figures, though this soil is definitely more acid. Although the description does not indicate it, there was a tendency for the organic matter to be concentrated at the top of the 0-12" horizon, suggesting a low faunal activity in the surface soil of forest.

<u>Profile 4.</u> (16531-35)

Tunoet, Abwe. 9,700 feet.

0 - 9"	Very dark brown loam (10YR:2/2). Moderately firm sub-angular blocky structure, friable and porous. Occasional earthworms.
9 - 16"	Dark brown loam (7.5YR:3/2). Small s.a.b. loosely held in larger S.A. blocks friable and porous.

16 - 24" Dark red brown loam (5YR:3/4). Weak c.t.b. friable and porous.

24 - 34" Dark red brown loam (5YR:3/4). Structure as above.

34 - 48" Dark red brown loam (5YR:3/4). Structure as above, friable and porous.

The change in organic matter content is very evident in this profile, maintaining a high figure even at a depth of 24", then falling off sharply to a very low percentage below acidity than either of the other soils in the transect. The red subsoil colour, though masked in part by dark humus, is still in the lower parts of the profile and it is not until passing into the alpine zone proper that it disappears almost competely.

3. Sipi Catena

The configuration of Mount Elgon is such that the lower parts and to some extent the mountain as a whole are broken up into broad flat ridges which jut out and succeed each other by fairly abrupt steps, 3 to 4 hundred feet deep. These are always steep and may even take the form of a vertical cliff or riser. It is on the level or nearly level parts of the steps that the red soils are mostly found, but they are occasionally developed on the steeper slopes where down wash accumulates in the embayments of the terrace features, as at Sipi itself. The height of the lowest agglomerate terrace is at approximately 5,000 feet which, therefore, sets the lower limit of these soils. The upper limit is determined by the extent of forest clearance which is usually slightly less than 7,000 feet.

In the main, the soils of Sipi Catena are developed directly from the tuffs and agglomerates of Elgon volcanic rocks. Some colluvial activity is evident and small areas of soil may be found on resorted material in hollows. Slight contamination from Basement Complex rocks occurs in those sites where the volcanic beds are thin or have been subjected to much erosion. The mudflows contain much Basement Complex material and outcrop along the foot of the volcano giving rise to soils stonier and more gritty than the normal types of this mapping unit.

The average rainfalls for the northern parts of the mountain are slightly lower than for areas of equivalent height to the south. The difference is reflected in lusher vegetative growth and greater concentration of cultivation in the southern areas where these soils occur. This is partly coupled with the local effects of the surrounding hills for such areas as Bulucheke. Rainfall at Sipi Mission is 76.8 inches (average of 8 years).

Within this unit are a number of soil types or series arranged on the undulations of the topography in such a way as to approximate to a catena. The soil features suggest that colluviation and soil creep are the chief agents responsible for this distribution. The sequence which is repeated over the area shows shallow loams over laterite on the level crests, deep red loams with included laterite fragments and concretions scattered throughout the lower parts of the profile at the mid slope position and deep usually concretion-free clay loams in the intervening hollows. The laterite is generally compact and frequently becomes cemented into a single layer of sheet ironstone especially where exposed to the atmosphere by erosion of the thin soil cover. It is not confirmed to any particular level and may be found in any part of the red soil area where topographical conditions are suitable for its formation, that is to say, on level or gently sloping sites. It is seldom of any great thickness and can be observed in places as little more than a ferruginous crust bed rock. Below the concretionary horizon there is often a yellowish and red vesicular mass which might at first sight be mistaken for laterite but closer examination reveals it to be weathered rock (in situ) riddled with a network of cavities probably due to solution effects modified and extended by termite activity. This material can, as a rule, be broken up quite readily but often becomes strengthened by a ferruginous deposit lining the cavities.

The concretionary soils, although they occur mainly in the cultivated areas, have been noted in the forest zone above but here again only on gently sloping ground at altitudes up to 8,500 feet. The dominant soil type is a red loam, usually deep and with little variation in the profile beyond a small amount of concretionary material in the lower horizons. They are almost without exception freely drained, despite their rather heavy textures. Structure is moderately well developed especially in the upper parts of the profile. The surface soil has a very stable granular structure which even the impact of heavy rain fails to break down, a feature greatly reducing the erodibility of these soils. In the Balucheka area where the soils occur on steeply sloping ground there are remarkably few signs of erosion even on sites where bunding has not been carried out. Of greater danger on the steep slopes appears to be the risk of landslips. Since the soils are free draining water may collect below and lubricate slip planes which are present in the subsoil, especially where this rests on relatively impermeable bed rock.

On the whole, the red soils are highly leached and, as a consequence, inclined to be acid. The shallower and lighter textured types are noticeably paler and browner in colour and Bracken is more common in the natural vegetation. They are encountered around Kapchorwa and on the high ground between Butandiga and Buginyanya. Clay contents, however, are normally high, so that in spite of low pH values, the soils still show a moderate base content. The lateritic soils are the most depleted but elsewhere conditions are variable. There is a wide range of plant nutrient status where they are associated with soils transitional in sequence to the Bugusege. Colour is a good indication of this relationship and it is reasonable to assume that where they appear as dark red or dark reddish brown close to the Bugusege soils, fertility will be high. Of particular note in this transition is the behaviour of available phosphorus. In the dark soils it is always high but falls to a very low figure in the red soils. Individual red profiles contain more than average contents of this element as, for example, no. 5 sampled near Bumagabula, but this also contains above average amounts of exchangeable bases which suggests that it is transitional in type.

Profile 5 (15718-22)

Above Bumagabula near the crest of a ridge.
Altitude 5,700 feet.

0 - 7"	Dark reddish brown sandy clay (5YR:3/4) with a small sub-angular brocky structure. Much fissured, friable and containing many roots.
7 - 14"	Essentially similar to above except for fewer roots.
14 - 24"	Reddish brown (5YR:4/4) clay structural units slightly larger and more angular than above and less friable.
24 - 36"	Reddish brown (5YR:4/4 to 2.5YR:3/6). Structure as above but more compact.
36 - 50"	Dark red clay (2.5YR:3/6 to 2.5YR:3/4). Angular to sub-angular blocky structure.

Profile 6 is more typical of the red soils with low figures for phosphrus.

Profile 6. (16551-56)

Near Kapchorwa. Almost level crest of a bench feature.
Altitude 6,200 feet.

0 - 12"	Dark reddish brown sandy loam (5YR:3/3) with a moderately firm small sub-angular blocky to crumb structure. Friable much fissured and porous.
12 - 24"	Dark reddish brown sandy loam (5YR:3/3) with a weak sub-angular blocky structure. Fissured and porous.
24 - 36"	Dark reddish brown sandy clay loam (5YR:3/3). Very weak sub-angular structure breaking down to a sloggy power. Porous.
36 - 46"	Narrow layer of rounded concretionary material

and coated rock fragments with a sandy clay matrix. Structureless and moderately compact but not cemented. Porous but very little penetrated by roots.

46 – 56" Mainly fragments of vesicular, rotted volcanic ash and agglomerate with a matrix of dark reddish brown sandy clay loam.

This profile is typical of the shallower soils found on the level or nearly level sites whether benches or flat ridge crests. The upper parts have been much disturbed by termite activity. Phosphorus figures are low. The murram layer is composed chiefly of small rock fragments rounded by weathering and coated with iron oxides. It is seldom cemented but may appear as a massive sheet in those sites where lateral seepage assists enrichment of iron in solution or where a relatively impermeable bed rock prevents a rapid removal of drainage water from subsoil. In the latter case the laterite occurs as a thin vesicular crust cemented to the under-lying rock.

4. Cheptui Series

Immediately below the steep foot slopes of Elgon between the ridge at Butandiga and Cheptui there is a broad tract of red alluvial and colluvial soils mapped as the Cheptui series. Two small areas are to be found at Ngenge and east of Greek River in a similar topographic situation. The soils appear to occur only on those parts of the colluvium or alluvium immediately adjacent to the foothills. Near Salalire they are underlain by spreads of water worn boulders indicating that they occupy an old terrace of the Siroko river. The topography in such a site is naturally flat or nearly so, except where the present river has cut away parts of the terrace. Usually the mapped area slopes gradually away from the foothills at an angle of 1 to 2 degrees with the surface broken up only occasionally by river or stream courses.

Based on a single year's readings the rainfall at Ngenge and Muyembe is about 30" falling off northwards to around 25". The dry season is prolonged from October to the end of February with scattered storms during this period. The wettest months appear to be July and August.

Cheptui series consists of dark red or reddish brown loams and clay loams, on the whole lighter in texture than the black alluvial soils which are associated with them on the lower parts of the pediment slopes. At sections in river cuttings the soils are seen to extend several feet down to a brownish coloured drift containing occasional bands of sand and gravel intercalated with sandy clay. On the Siroko river terrace they overlie beds of gravel boulders composed largely of lavas and Basement Complex rock.

These soils in many respects resemble those of the Sipi unit, being derived from similar material and developed under rather similar topographical conditions. Laterite was not seen in Cheptui profiles, either because of their more recent origin or because of their deeper and free draining nature. Frequently there are very small shot like concretions scattered throughout the profiles but they show no tendency to accumulate in any horizon. They tend to be more noticeable in soils adjacent to the dark brown Siroko soils, and litter the surface where there has been slight water sorting by sheet-wash on bare soil.

Profile 7. (10244-50)

Near Wangutuse, Cheptui.

0 - 6"	Dark reddish brown clay (5YR:3/2) with a moderately firm sub-angular blocky structure with many small fissures. Roots fairly abudant.
6 - 12"	Dark red clay (2.5YR:3/6) structure not so firm as above. Roots few in number.
12 - 24"	Dark red clay (2.5YR:3/3). Weak sub-angular blocky structure.
24 - 36"	Appearance and physical characteristics as above.
36 - 60"	As above.
60 - 72"	Slightly more compact than above, otherwise very similar.

Profile 8 (10277-82)

Between Cheptui and Siroko

0 - 8"	Dark brown silty clay (7.5YR:3/2). Moderately firm granular to sub-angular blocky structure and slightly fissured. Many roots present.
8 - 14"	Dark reddish brown silty clay (5YR:3/3). Moderately firm s.a.b. structure.
14 - 26"	Dark red clay (2.5YR:3/6) . Weak s.a.b. strucutre.
26 - 54"	Dark red clay (2.5 : 3/6). Very weak s.a.b. structure.
54 - 72"	As above with occasional dark manganiferous staining.

5. Bugusege Series

These soils are widely distributed throughout the lower parts of the mountain usually associated with the steep sloping sites linking the bench-like features so characteristic of Elgon. They also occur on the scree slopes banked up against the many vertical agglomerate cliffs conspicuous in the mountain foothills.

Ash and agglomerate are the parent rocks from which Bugusege soils are derived. In a few small areas where erosion of the agglomerates has exposed Basement Complex rocks there may be contamination by non-volcanic material. The mud-flows outcropping along the base of the mountain contain varying amounts of country rock and give rise to soils of a similar mixed origin.

Rainfall in the south and south western parts of the mountain foothills averages between 50 and 70 but falls to between 45 and 40 in the northern and north eastern parts where the dry season is more pronounced. The difference is reflected in the vegetation which is lush to the south and becomes savanna-like around Bukwa in the north east.

Although the dominant soil type is a very dark brown or black clay to clay loam, the mapped area also includes dark reddish brown clay loams representing transitional phases to the Sipi soils. Black soils are more prevalent in the drier parts of the mountain to the north below Bukwa which suggests that the soil colour is related to a leaching factor. On steep slopes the soils would not be subjected to the same leaching as those on the more level sites. Although surface erosion does not seem seriously to affect these soils it is possible that a very gradual removal of surface soil progressing at approximately the same rate as soil formation would tend to maintain them in a relatively immature stage of development. The dark colours are probably due to the initial weathering products of ferromagnesian minerals, common in the volcanic rocks, together with some clay humus complex which is produced under the high base conditions and remains stable up to a critical stage of profile weathering. The high base exchange capacity of the soils suggests a montmorillonitic type of clay which, although retaining a high content of bases, has often become sufficiently desaturated to render the soil acid. Low pH and high base content is a typical feature of these soils and is well demonstrated by a series of samples collected from the site of the proposed coffee research station near Bufumbo. Surface soils ranged in pH from 6.2 to 5.3 (mean 5.6) and in every case there was decrease with depth to values as low as 4.2 at three to four feet, (mean of nine sites 4.5).

Eventually in the weathering cycle a stage must be reached when there is a break down of the clay complex and partial conversion at least, of the montmorillonite to kailinite and further weathering of the ferromagnesian minerals to produce the red colouration by release of iron oxides. Without confirmatory evidence from a clay mineral examination it can only be assumed that during this change from dark brown to red soils there is a concomitant change to a kaolinitic clay since this is the usual development in tropical soils.

Profile 9. (15360-62)

Bumbo at the foot of a steep scarp.
Altitude 5,000 feet.

0 - 9"	Dark brown clay (7.5YR:3/2). Firm sub-angular blocky structure and much fissured.
9 - 15"	Brown to dark brown clay loam (7.5YR:4/2). Structure units larger than above but less firm.
15 - 26"	Very similar to above but with a weaker structure.
26"+	Rotted volcanic agglomerate rubble.

Profile 10. (11834-39)

Busulani

0 - 6"	Dark brown sandy loam (10YR:3/3). Moderately firm small sub-angular blocky to crumb structure.
6 - 12"	Dark brown to brown sandy loam. (7.5YR:4/2). Weak s.a.b.
12 - 18"	Dark brown to brown sandy clay loam (7.5YR:4/4). s.a.b.
18 - 24"	Brown sandy clay loam (7.5YR:4/4). s.a.b.
24 - 36"	Brown sandy clay loam (7.5YR:4/4), weaker structure than above.
36 - 48"	Reddish brown sandy clay loam (5YR:4/4), weak structure.

6. Siroko Series

The red soils of the Cheptui series merge on the lower parts of the pediments extending from the foothills into heavy dark brown or black soils of the Siroko series. The slope is very gentle, generally of the order of one degree, and eventually joining the level ground of the Sebei alluvial plain. Apart from this slope there is little to relieve the monotony of the topography beyong the occasional channel of a river or stream course. Few of the rivers are active and then only during rainstorms, especially those draining the northern parts of the mountain. The soils are developed on alluvium and colluvial material associated with the pediments. The climatic conditions affecting the soils are essentially similar to those for the Cheptui area, viz. a well marked dry season with an annual rainfall of approximately 30" and high average temperatures.

In many respects the soils of Siroko series resemble the black clays extending over the Sebei plain. The have several morphological features in common and similar physical properties, namely a marked tendency to develop extensive cracks as they dry out. Those features are more fully discussed under Sebei soils. The majority of the soils are developed on drift material, either alluvium as at the mouth of the Sircko river where it emerges on the plain or from colluvium as on the pediment slopes. In addition, smaller areas of black clays sedentary on volcanic beds, for example near Ngbagut and probably on parts of the pediment slopes as well, are grouped with this series.

The soils are rich in bases, and free calcium carbonate in the form of nodular concretions is a fairly regular feature. The distribution of the concretions sometimes appears to be concentrated at a certain position in the profile generally between 18" and 24", although they are often distributed sporadically throughout the soil perhaps by mechanical action as the soils shrink and swell with changes of water content. During the dry season the soil at the surface breaks up into small angular blocks which increase in size and become more cubical in shape with depth. At this stage it is extensively fissured and any storm rain drains through rapidly. During more prolonged rain the soil swells, becomes saturated and eventually seals off the fissures so that water movement through the soil is negligible. The mass of the soil is therefore leached only slightly each year and loss of bases is much slower than is the case with the freer draining red soils of the Cheptui series which are devoid of calcareous concretions. In spite of their slow drainage the black clays are seldom flooded because of the gentle surface slope which carries away the excess surface water and directs it to main drainage routes or swamps.

Two typical profiles are described below.

<u>Profile 11.</u> (10109-15)

Near Kaptokoi, Sebei.

0 - 6"	Very dark grey brown (10YR:3/2) granular clay. The horizon is much fissured and deep cracks 1-2" wide at the surface extend down for 3 - 4 feet.
6 - 12"	Colour and texture much as above, structure becoming more blocky.
12 - 24"	Little change except for an angular blocky structure. A few very small $CaCO_3$ concretions present.
24 - 36") 36 - 48")	Both horizons similar to above except for an increase in the number of concretions with depth.
48 - 60"	Dark grey brown (10YR:4/2) clay. Structure more massive than above fissuring less conspicuous. Roots are absent. Concretions attain maximum number in this and succeeding horizon.
60 - 72"	Much as above.

Profile 12. (19202-08)

Alekilek, Teso, south of plug, flat site.

0 – 3"	Very dark grey (10YR:3/1) clay, angular blocky structure.
3 – 6"	Very dark grey (5YR:3/1) clay, angular blocky structure.
6 – 12"	Very dark brown (10YR:2/2) clay, angular blocky structure.
12 – 36"	Very dark grey (7.5YR:3/0) clay, massive structure.
36 – 48"	Very dark grey (2.5YR:3/0) clay, massive structure.
48 – 60"	Very dark grey (7.5YR:3/0) clay, massive structure.
60 – 72"	Very dark grey (2.5YR:3/0) clay, massive structure.

7. Napak Series

On the upper slopes of the Akisim flank of the Napak volcano dark reddish brown clay loam soils are found amongst the rock outcrops. These will be described fully in the memoir on Karamoja soils as the area in Eastern Region (N.W.Teso district) is extremely small.

8. Tororo Complex

Soils of this mapping unit occur in only two small patches in the south east of the Region, one at Bukusu and the other including both Tororo and Sukulu. At Tororo itself there is an abrupt hill (Tororo Rock) surrounded by broad pediment. Sukulu is a ring of several hills with pediments between and all around them. Bukusu is a hill with two peaks, and again a surrounding pediment. The pediments merge into the main plain without noticeable angle. Most of the pediments run down to a valley, but in some places they merge into the erosion levels of Basement Complex rocks. As described in the section on geology, all three areas of pre-Elgon Volcanics contain a variety of rocks, including carbonatites, pyroxenites and phosphate rock. A detailed description of the geology is given by Davies (1947).

All the areas of Tororo soil received about 50 – 60 inches of rain, the southern area probably being wetter than the northern.

There is a catenary variation of soil types from the hilltops down to the valleys. On the steep hills are bare rock and skeletal soils with very patchy distribution. The deepest and best soils occur on the upper part of the pediments. A typical profile is shown overleaf.

Profile 13. (13672-76)

Tororo.	Upper pediment, flat site.
0 - 7"	Reddish brown sandy loam (10R:2/1) with crumb structure.
7 - 15"	Dark reddish brown (2.5YR:2/2) fine sandy clay loam, weak crumb structure.
15 - 28"	Dark reddish brown (2.5YR:2/4) fine sandy clay loam. Structureless to very weak fine crumb.
28 - 60"+	Dark reddish brown (2.5YR:3/4) fine sandy clay loam, structureless.
	Drainage is free throughout the profile.

Away from the hill, on the lower part of the pediment, laterite appears, and there is less depth of soil. A typical profile from a lower middle pediment shows:

Profile 14. (13670-71)

Tororo (1 mile south), flat site.	
0 - 6"	Dark reddish brown (5YR:3/3) fine sandy clay loam. Crumb structure.
6 - 20"	Dark reddish brown (5YR:3/3) fine sandy clay loam. Structureless.
20 - 36"	Dark reddish brown clay with murram pellets.
36" +	Laterite, about 18" thick, some of this nearby is impregnated with secondary calcium carbonate.

Beneath the laterite is pre-Elgon volcanic rock which appears to be little weathered. Often these profiles are exposed in quarries over carbonatite, indicating that they are drift soils, though sedentary ones also occur. Further out from the hill the laterite approaches the surface or shows a thin cover of sandy soil which may be of alluvial or drift origin. In either case soils of this part of the catena are of little use and support only swards of Loudetia kagarensis grass. Beneath the laterite is fresh or little weathered rock. Many of the valleys close to the hills are cut into granite or Basement Complex, so that the lowest topographic units of the complex belong more correctly to the Buruli catena. The soils of the Tororo complex have a very patchy distribution and it has not been possible in this survey to estimate the areas of the different types.

The deep soils usually show a moderately high clay content. Topsoils are well developed with usually a high organic matter content and the extractable phosphorus figure is high or very high. The soils are always on the acid side, even in the profile directly over carbonatite. The base content is not especially high, though probably generally better than that of an average Buruli soil.

The sand fraction of several soils of the Tororo complex has been found to consist of magnetite and apatite in about equal amounts, with other minerals present in very small quantities. The apatite provides the source of abudant phosphate.

SOILS DERIVED FROM MIXED VOLCANIC - METAMORPHIC ROCKS

9. Bududa Series

Soils of this unit occur on the lower colluvial slopes below the Sekululu ring of hills and below Nkokonjeru and in the upper parts of the Siroko valley in Bugisu District. They are derived from mixed colluvial detritus of volcanic and Basement Complex rocks. It is presumed that the summits of the hills near the mountain were at one time covered by a thin layer of volcanic ash and agglomerate. Erosion has since removed it and deposited the drift mixed with varying amounts of granitic material on the lower slopes of the hills. Due to the association of the soils with footslopes in hilly areas rainfall in the areas occupied by these soils is generally higher than average for the Bugisu District. Rainfall ranges between 55 and 60 inches with one main dry season during December, January and February. Average annual mean temperatures are in the region of 70 to 75 degrees F.

In many respects soils of this unit resemble the heavier types of the Sipi series and on a broader scale would have been included with them. They are separated principally on account of the fact that they are predominantly drift soils developed on colluvium and cannot by virtue of their position be derived directly from the underlying rock. On the whole they are deeper than the average Sipi soil and certainly of higher productivity. Several factors contribute to this including an increased rainfall and greater soil depth. Soils on lower parts of colluvial slopes are enriched in bases by lateral drainage from areas above which in certain stages of their development must have been freshly weathering granite and volcanic ash. The total base content of the soils would then be the balance between loss by leaching and replenishment from lateral water drainage. There is usually little evidence in the profile of Basement Complex material except where the soil merge into Bubute on the higher ground but occasionally erratics are seen in the drift on lower slopes. Towards the valley floor where the gradient of the hills eases, the development of laterite in the subsoil becomes more pronounced both as a result of slow subsoil drainage and seepage from above. There is no laterite in the soils on the steep slopes although some concretionary murram may be present, scattered throughout the lower parts of the profile. The soils below Nkokonjeru and Namugabwe between Budadiri and Butema are essentially similar to those in the Buluchoke area.

though perhaps on average deeper, heavier in texture and less lateriticed.

Common to all the soils is the stable granular structure of the topsoils which promotes rapid water penetration and effectively minimises the risk of erosion by surplus run off. As with the Sipi unit there is some risk from landslips and scars from recent slips can still be seen near Bulücheke.

A typical profile appears as follows:-

Profile 15. (15747-52)

Bukigai, elevation 4,600 feet. Slope 15°

0 - 9"	Reddish brown clay loam (5YR:3/4), small sub-angular blocky structure, friable and porous. Many roots and occasional earthworms.
9 - 18"	Reddish brown clay loam (2.5YR:4/4) structure etc. as above. Fewer roots than above, occasional earthworms.
18 - 30"	Dark reddish brown clay loam (2.5YR:3/4) sub-angular blocky structure. Much fissured, friable with several small roots.
30 - 42"	Dark reddish brown clay loam (2.5YR:3/4) sub-angular blocky structure but less coherent than above, otherwise similar.
42 - 66"	Dark reddish brown clay loam (2.5YR:3/4) soil becoming massive with little structure though still fissured.
66" +	Soil continues down to at least 75" without change.

The uniformity of the figures for exchangeable bases throughout the profile is typical of colluvial soils on steep slopes, which also show little differentiation into horizons.

10. Sebei Clay

This soils occupies the large tracts of alluvium extending from north west Sebei into parts of central and south Karamoja and reaching over into north Teso. The alluvium is associated with the Okok, Angare, Lochilimaket rivers which drain the high ground of central Karamoja, Napak, Kadam and the Kelim, Soroko and smaller rivers draining the north and west sides of Elgon. The area of the flats is virtually without relief of any description merging from its outer edges into the swamps and their extensions surrounding Lakes Salisbury, Gedge and Okilitorum. The alluvium is predominantly clay and although very uniform in appearance shows variations in chemical constitution attributable to the difference in geology of the adjacent high ground. The rainfall can only be assessed from figures available at stations close to the alluvial areas. To the west of Kajoro and Katakwi average rainfalls are 38 and 45 respectively, at Kangole and Nabilituk to the east they are 20 and 31, while to the south at Kuyembe and Ngenge the rainfall is 33 and 29 respectively. The figures suggest an average of approximately 30" with slightly more to the west and less to the east. The soil moisture, especially of the swamps bordering the lakes and adjacent to the pediment slopes, will be as much affected by rainfall on the mountain slopes and run off from higher ground as rainfall over the alluvial areas themselves.

Unlike the Siroko soils, Sebei clay lands are subjected to much wetter conditions and seldom, if ever, dry out completely to any great depth, although their surface cracking is definitely more striking. Wide cracks (1-2") taper downwards for 12 to 18 inches, at which depth the clay is compact and dark grey in colour. The subsoils probably remain waterlogged for a considerable part of the year but seldom do they display much gleying. The very dark greyish browns of the topsoils give way abruptly to the dark grey of the subsoil simetimes modified by ochreous mottling.

A typical profile sampled near Lake Okilitorum appeared as follows:-

<u>Profile 16.</u> (15757-61)

North west Kalebai

0 - 12"	Very dark grey clay (2.5Y:3/0). Much fissured hard angular blocky with occasional very small rounded concretions.
12 - 24"	Very dark grey clay (2.5Y:3/0), some rusty staining along root channels. Less fissured than above with large angular blocky structure. Occasional $CaCO_3$ concretions scattered.
24 - 40"	Very dark grey clay (2.4Y:4/0). Occasional closed fissure, massive structure very large angular blocks. Scattered $CaCO_3$ concretions.
40 - 52"	Very dark grey (2.5Y:4/0) clay structure as above with scattered $CaCO_3$ concretions.
52 - 64"	As above.

The width of the cracks is of the order of 1 to 1½ inches and they were open to a depth of 15". Apart from the surface soil the structure is farily massive, becoming more so with depth, and calcium carbonate concretions are scattered throughout the lower parts of the profile without any noticeable tendency to concentrate in any particular horizon. Humus content is low, despite the blackness of the topsoil. The pH value is near neutral at the surface but alkaline below, due to the presence of free calcium carbonate and an appreciable amount of sodium in the exchangeable bases, (up to 9.1 m.e.%). Some exchangeable sodium is present in most of the Sebei soils reaching toxic proportions locally e.g. 20 m.e. in a profile sampled near the Kere river (No.155 Gibb, 1955). Two other profiles sampled in the same area, though they contained smaller amounts of sodium, yielded unusually high amounts of exchangeable magnesium. The pH values of most of the samples from these three profiles were well above 8.0. These soil conditions represent extreme local effects and in the majority of the Sebei soils, although base content is generally high, excessive alkalinity is not typical.

The content of extractable phosphorus is moderate to high in Sebei clay, depending on nearness to the massifs of Elgon and Napak. Analysis shows an increase from just below 100 p.p.m. to well over 1,000 p.p.m. and an accompanying increase in exchangeable bases notably Ca and Mg; Na however is farily low. Soils occurring close to the pediment slopes of the volcanoes display high P and base contents suggesting that these arise from additions of rich material brought down by flood waters from the volcanic uplands.

<u>SOILS DERIVED FROM METAMORPHIC ROCKS OF THE DEGRADED BUGANDA (GONDWANA) SURFACE.</u>

11. <u>Bubutu Series</u>

Between the Mbale surface and the foothills of Nkokonjeru and Elgon the topography is broadly undulating with an occasional tendency to level out into what appear to be remnants of erosion surfaces. This area which lies between 3,800 feet and approximately 4,800 feet is occupied mainly by soils of the Bubutu unit. The upper parts of the hills and their ridges around Bulucheke have been swept clear of volcanic material exposing the Basement Complex rocks; their soils are included here.

Bubutu soils are, in most cases, derived directly from coarse grained gneisses and granites of the Basement Complex. Minor variations which have affected the soil are mylonites near Bulucheke which give rise to fine sandy loams on the hill slopes near Buklasi and the concentration of the quartz veining which determines the size and extent of the stone lines.

The dominant soil type of this unit is a compact gritty clay loam which displays a fairly uniform subsoil colour of reddish brown (5YR:4/4) to yellowish red (5YR:4/6) throughout the mapped area. Most of the soils are developed <u>in situ</u> and relatively little resorting seems to have affected the profiles though there is evidence that grit concentrates in the upper horizons due down-wash of clay. Surface soil textures may therefore be either more gritty or sandy than the soil as a whole, though this is not necessarily always the case. Many of the soils contain a well developed stone line arising from the frequent occurrence of quartz veins in the underlying rock. Below the stoneline shattered remnants of the veins can usually be seen embedded in the weathered mass of the parent rock, more or less in their original positions prior to weathering.

The soils are poorly structured and tend to be very compact in their lower horizons but doubtless the quantity of grit present facilitates drainage.

In the hills immediately to the east of Buluchake the Basement Complex rocks are highly altered by a zone of mylonisation. The soils developed on these rocks are deeper and more stone-free than the normal Bubutu type and occur chiefly on the steep slopes which open out into the main Buluchake valley. Soil textures tend to be heavy where developed from schists and fine sandy from the more quartzose members of this crush zone. On the steepest slopes there is considerable risk of erosion with these light textured soils. On the ridge tops between Ngezi and Ngongore that have been stripped of volcanic residues the soils are similar to the lowland types of this unit but contain greater amounts of organic matter in their surface horizons especially under forest or land recently cleared of forest.

Bubutu soils are not lateritised but occasionally a few irregularly shaped iron cemented concretions are developed in the lower parts of the profile especially on level sites where subsoil drainage might be expected to be slow. Other variations on the modal type depend on the amounts of quartz stone in the upper horizons.

A typical profile from Ngale appears as follows:-

<u>Profile 17.</u> (15384-87)

0 - 9"	Very dark grey sandy loam (10YR:3/1). Small incoherent crumbs when moist, hard compact blocks when dry. Porous and very friable in moist state.
9 - 17"	Dark brown very stony and gritty loam (7.5YR:4/2) structureless compact but not indurated. Friable when dug out. The number of roots falls off rapidly in this horizon.
17 - 38"	Reddish brown gritty clay loam (5YR:4/4), almost without structure compact but slightly fissured. Few roots present.
38 - 60"	Brown gritty clay loam (7.5YR:5/4-5/6). Structure as above. Only very occasional roots.

Exchangeable bases for this soil are higher than average, Ca, Mg and K all being present in adequate amounts. The low organic carbon figure for the surface soil, despite its dark colour, suggests the presence of elemental carbon from grass burning. There is a marked deficiency of available phosphorus.

12. <u>Bubulu Series</u>

These soils occur mainly in the broad vale of the Manafwa and Kufu rivers between Bubulu and Magale, but the mapping unit has been extended as far as the Lwakaka river to include a strip of soil very similar in all respects, though according to the geological map, developed on granite. On either side of the river the ground slopes gently down to the alluvium and the topography is gently undulating. The rocks underlying the area are deeply weathered and consist of Basement Complex members in which there is a predominance of hornblende gneiss, amphibolite and schist.

Typical of the areas close to the foothills of Elgon there is only one marked dry season during the months usually of December, January, February. Yearly average rainfall ranges about 50 inches. Mean annual temperatures are in the neighbourhood of 75°F. range.

In the Kufu valley hornblendic rocks are dominant and elsewhere in the area mapped as Bubulu, they constitute about 50% of the parent rock. Their high content of iron-rich hornblende and other ferro-magnesium minerals tends to make the derived soils very bright red. Since weathering is deep and the topography very gently undulating, soils are correspondingly deep and well developed. It is unlikely that the more nature of the parent rock will contribute greatly to the base status of the present soils on account of the intensive weathering and leaching that they have undergone during their formation. The mining effect of vegetation where the parent amphibolite lies at no great depth may, however, return some cations to the surface soil and thereby improve its base status, but this is likely to be local condition. The fertility of these soils lies more in their depth and favourable physical conditions for root penetration. In addition their situation in a broad valley probably means that they receive some subsoil moisture by lateral seepage.

Laterite is not much in evidence, a feature in which these soils differ from those of the Mbale complex. A profile sampled near Bubulu appeared as follows:-

<u>Profile 18.</u> (15740-45)

0 - 10"	Sandy loam (5YR:2/2). Very friable, porous with a weak crumb structure. Some earthworms were present.
10 - 20"	Stoneless sandy loam (5YR:3/3). Structure as above. Several dark filled channels probably made by earthworms.
20 - 32"	Loam (2.5YR:4/4). Very friable, porous and with little structure. Occasional evidence of earthworms.
32 - 44"	Loam to clay loam (2.5YR:3/6). Porous, slightly fissured and structureless.

44 - 56" Much the same as above except for slight tendency to form weak angular blocks.

56 - 68" Clay loam (2.5YR:3/6). Fissured with a weak angular blocky structure.

The base status is not high but there is some tendency for an increase in depth. Phosphorus is markedly deficient throughout and is very likely deficient in most soils of this unit except for those areas near the alluvium or where they are influenced by colluvial material from volcanic rocks. This particular example has a more sandy topsoil than usual but it is typical in its depth and colour. Bubulu soils are generally loam to clay loam types.

13. Mwiri Half-Catena

These soils occur on the south-west hills, which have flattish crests and steep sides. The flat tops are remnants of the Buganda surface, and the slopes grade down either to the ridges and plateaus of the African surface, or to the swamps and valleys at a still lower level. They always occur on rock which is very resistant to weathering, usually quartzite. This, together with their watershed site, accounts for the survival of the hills, and for the paucity of the soils on them.

On the upper slopes there are exposures of various types of weathered rock, steeply dipping, including a high proportion of quartzite, which are virtually devoid of soil. On the flat hill tops there is weathered sandy rock, which can be seen in all stages of lateritisation from slight staining to massive vesicular laterite with holes often 1" in diameter. Overlying the rock or laterite is a brown sandy soil of very patchy distribution, varying in depth up to about 12". Such soils have poor physical structure, low base status and too rapid a drainage, and are of no use agriculturally.

14. Nakabango Series

The Nakabango soils occupy two areas in south-west Busoga, and a small patch in the Mjanji area of Bukedi. In the Jinja area the topography is made up of arcuate ridges separating 'amphitheatres' and valleys. The highest hills are covered by the Mwiri unit and the lowlands by the Nakabango series. The Simba Falls and Mjanji areas are of varied topography, but mainly uplands between swamp filled valleys. The Nakabango soils occur in areas of Karagwe-Ankolean phyllites and amphibolites, and it is the latter which forms the characteristic parent material of these soils.

The Jinja area is generally fairly wet, with a rainfall of 45 - 50" spread fairly uniformly over most of the year with very little seasonal variation and an average annual mid-day temperature of 79°. The Simba Falls area is very much the same. The Njanji area is hotter, drier and has a more pronounced seasonal variation.

True Nakabango clay, developed on amphibolite, is distinguished by great depth of profile, free drainage, bright red colours, loamy clay texture and fairly high base and phosphate contents. Such soils are regarded as the best in the region, although some of the Elgon soils are more productive on account of higher rainfall. A typical profile is shown below.

Profile 19. (8447-55)

Nakabango, Busoga. Flat site.

0 - 9"	Dark reddish brown (5YR:4/3) clay loam with a markedly stable crumb structure.
9 - 18"	Brownish red (2.5YR:4/3) clay, crumb structured.
18 - 48"	Red (2.5YR:4/6) clay; large, slightly prismatic clod structure with small black pisoliths.
48 - 80"	Similar but weaker structure.

Sub-angular fragments of blue-green amphibolite rock are scattered sporadically through the profile and form a useful confirmatory feature when seen on the surface. The soils are the best structured of all red loams in the Protectorate and stable crumbs extend to about 18 inches. They appear to have a high moisture retaining capacity, but much of this is unavailable to plants, on account of the high clay because of the good structure they do not behave as such, remaining pervious like loam, and there is never any sign of impeded drainage. Clay content may be well over 60%

Phosphate is generally high on Nakabango soils, and base content is also good. The soils are acid and the pH figures are in the 6 - 5 range, the acidity increasing with depth.

There is some variation of soil type within the area lying rock which are too small to separate, and to physiographic changes. In some flat areas very massive laterite is found, which may or may not have a thick soil cover above it. Other areas have soils very like the Buyaga, but again these could not be mapped on the present scale. These variants are not so fertile as the true Nakabango clay.

15. Mbale Complex

The complex of soils which form the Mbale unit has been mapped without exception on the remnants of the 3,800 foot erosion surface which occurs typically betwen Nakaloke and Busiu, with one small isolated patch in Sebei. Similar soils occur on the lower African surface, but there are significant differences between these and most of the Mbale soils. Valleys on basement complex rocks at higher level than the Mbale surface are mapped as the Bubulu mapping unit, and the Mbale unit itself does not include any valley soils.

The complex nature of the Mbale unit is largely a reflection of the underlying geology. A wide variety of metamorphic rocks of the Basement Complex weather to form the soil material. Mica schists are probably the commonest but there are also some very quartzose rocks and basic hornblende schists. Weathering is considerable but generally the regolith does not attain the thickness of the red loams on the African surface, such as Buruli and Bukedea loams. Lateritisation is very variable and gives rise to further mixing of soil types. Some small areas of soil included in this unit are formed on rocks of the Bugisu sedimentary series.

The area has one main dry season in December-January and a must less pronounced one about July. The southern part has a more pronounced bi-modal climate than the northern, and is generally drier. The average annual rainfall at Mbale is about 46" but there is a wide variation from year to year, and in 1957, for example, only 36" were recorded.

A typical profile on mica schist is shown below.

Profile 20. (13356-62)

Near Mbale, 3,800 feet.

0 - 18"	Dark reddish brown loam (5YR:3/3). Moderately hard sub-angular blocky in the dry state. Porous and fissured.
18 - 24"	Dark reddish brown loam (5YR:3/4) structure as above.
24 - 36"	Dark red clay loam (2.5YR:3/6) weak sub-angular blocky, porous.
36 - 48"	Similar to above with many angular quartz fragments (stone line).
48 - 60"	Dark red sandy clay with a few fragments of rotted mica schist. Structureless.
60 - 72"	Dark red sandy clay loam with numerous fragments of rotted mica schist.
72 - 98"	Mainly rotted mica schist in situ.

This may be regarded as one of the best developed examples of the Mbale soils. Elsewhere, it is usual to find massive laterite in the subsoil. Very red colours are rather typical of the Mbale complex and this is especially true of those variants formed on more basic rocks, as for instance below surface which occurs typically betwen Nakaloke and Busiu, with one small isolated patch in Sebei. Similar soils occur on the lower African surface, but there are significant differences between these and most of the Mbale soils. Valleys on basement complex rocks at higher level than the Mbale surface are mapped as the Bubulu mapping unit, and the Mbale unit itself does not include any valley soils.

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The area has one main dry season in December-January and a must less pronounced one about July. The southern part has a more pronounced bi-modal climate than the northern, and is generally drier. The average annual rainfall at Mbale is about 40" but there is a wide variation from year to year, and in 1957, for example, only 33" were recorded.

A typical profile on mica schist is shown below.

<u>Profile 29.</u> (18856-62)

Near Mbale, 3,800 feet.

0 - 18"	Dark reddish brown loam (5YR:3/3). Moderately hard sub-angular blocky in the dry state. Porous and fissured.
18 - 24"	Dark reddish brown loam (5YR:3/4) structure as above.
24 - 36"	Dark red clay loam (2.5YR:3/6) weak sub-angular blocky, porous.
36 - 48"	Similar to above with many angular quartz fragments (stone line).
48 - 60"	Dark red sandy clay with a few fragments of rotted mica schist. Structureless.
60 - 72"	Dark red sandy clay loam with numerous fragments of rotted mica schist.
72 - 96"	Mainly rotted mica schist in situ.

This may be regarded as one of the best developed examples of the Mbale soils. Elsewhere, it is usual to find massive laterite in the subsoil. Very red colours are rather typical of the Mbale complex and this is especially true of those variants formed on more basic rocks, as for instance below

Namagumba on the road to Buwalasi.

Textures range from silty clay loam to sandy clay loam or even loams. Stonelines may or may not be present, depending on the abundance or scarcity of quartz bands in the underlying rocks. Well rounded pea murram is usually present, sometimes as only a few scattered concretions, but more usually as a thick zone merging down into a hard compact cemented mass of laterite.

Topsoils are dark and usually have a weak crumb structure when moist but become hard sub-angular blocky when dry. Subsoils are redder and almost structureless. Dark topsoil colour is probably due to free carbon accumulation from previous grass burnings. The Mbale soils are freely drained, and consequently well leached, which accounts for the low base status. The soils formed on basic rocks are slightly better in this respect than those formed on mica schists or very quartzose rock. There is no addition of bases from the volcanic rocks on higher ground, such as occurs in the Siroko, Bududa and probably Bubulu soils. Most of the area is intensively cultivated and fertility is moderately high, though limited in places by the nearness of murram to the surface, or to the exposure of laterite along the edge of the ridges. In northern Sebei there is a small, uncultivated block of this unit in which the soil profiles have been truncated. There is very little humose topsoil left and the surface is exposed to severe sheet erosion. Conditions here approach those in southern and western Karamoja where the equivalent soil is Opopwa sandy loam.

16. Serere Catena

This soil unit is restricted to two small blocks at Serere and Katete, in Teso District, covering an area of about ten square miles. Both areas of Serere soils have the same topographic features. Each consists of a fairly abrupt hill, below which are long slopes diminishing in angle away from the hill. The slopes are virtually pediments, but are steeper than those in granite areas. The hills consist of shaly rock of the Karagwe-Ankolean System. This is a highly sheared quartzite (quartz-rich phyllite) with subsidiary micaceous material. The high fissility of the rock combined with a deficiency of weatherable minerals gives rise to an unusual soil sequence.

On upper slopes soils are skeletal and appear as greyish brown sand overlying rock fragments. Further downslope a more mature profile occurs, typically as follows:-

Profile 21. (5068-71)

Serere Experiment Station, Teso.

Plateau top near fertility experiment.

0 - 9"	Dark brown (10YR:5/4) sandy loam. Weak crumb structure.
9 - 21"	Brown (7.5YR:5/4) sandy loam. Structureless.
21 - 41"	Brown (7.5YR:5/4) sandy loam and murram pellets. No. structure.
41 - 66"	Reddish yellow (7.5YR:6/6) sandy loam and rock fragments.
66" +	Yellow (10YR:7/6) rock fragments, breaking down into sandy loam.

In flatter sites the murram horizon may develop into a thick laterite, especially along seepage lines. Further away from the hill profile are very much the same, as is shown by Profile 22. Profile 23, further down-slope still, shows laterite near the surface and may be waterlogged in the wet season.

Profile 22. (19844-48)

One mile south of Serere Experiment Station. Mid slope.

0 - 6"	Greyish brown (10YR:5/2) sandy loam. Weak crumb.
6 - 16"	Brown (7.5YR:4/2) sandy loam. Structureless.
16 - 32"	Reddish yellow (7.5YR:6/6) sandy loam and murram pellets.
32 - 50"	Reddish yellow (7.5YR:6/6) rock fragments breaking down into sandy loam.
50" +	Rock.

Profile 23. (8483-87)

Serere Experiment Station. Block 9 near base of slope from plateau.

0 - 12"	Dark greyish brown (7.5YR:4/2) sandy loam, hard single grain structure in situ throughout, but breaks to firm crumbs.
12 - 27"	Yellowish brown (7.5YR:5/6) sandy loam, small clod.
27 - 30"	Dark yellowish brown (7.5YR:4/4) sandy loam, cloddy break. Infil for pisoliths ($\frac{1}{4}$-$\frac{1}{2}$" diameter) which occupy about 70% of the volume.
30" +	Sheet laterite containing quartzite stones up to 8" diameter.

Profile 24 is the basal member of the catena; it is very slow draining and is flooded for several weeks in the wet season.

Profile 24. (11637-42)

Serere Atapar. Flat site.

0 - 6"	Dark grey (10YR:4/1) clayey fine sand with rush encrusted root traces. Small clod structure.
6 - 22"	Very dark grey (10YR:3/1) fine sandy clay, sporadic rush coatings, small cloddy.
22 - 34"	Grey (10YR:5/1) fine sandy clay.
34 - 50"	Pinkish grey (10YR:3/2) clayey fine sand with loose fine sand films.
50 - 68"	Brown (10YR:5/2) clay, diffusely stained with orange (10YR:6/6) and yellowish brown. Fine sand films occur on faces of clods.

Although the Serere soils differ from all others of the region in parent material and other associated features, the general profile morphology, chemical data and the behaviour under cultivation are very similar to soils of much of the rest of Teso district, especially the better soils of the more widespread Amuria series. Mechanical analyses of Serere soils shows that they are heavier than the average Amuria soil, but lighter than the average Buruli. Silt contents are comparatively high and there is an increase in clay down the profile, and topsoils are often identical with those of the Amuria series. Bases, though probably a little better than those of Amuria soils generally, are still very low, and phosphate is usually of the order of 10 p.p.m., which is markedly deficient. Soils are acid, with a pH of 5 - 6 in most places, though in better sites it can be over 6.

17. Metu Complex

Other rocky hills in the region have a different origin from the south Busoga hills, but the soils are essentially similar. They are soilless or carry thin skeletal soils. The Bugondo hills are in this category. They consist of quartzites and subsidiary phyllitic rocks. A thin patchy soil covers the hills, similar to the Mwiri soils, but there are no flat tops and no laterite.

SOILS DERIVED FROM METAMORPHIC ROCKS OF THE AFRICAN SURFACE

Before describing the soils on the plains associated with the African surface it is relevant to mention a feature which is common to all, namely the presence of inselbergs (=island hill). Inselbergs are steep sided granite outcrops varying from a few tens of feet in height to several hundred feet occurring as single, elongated, massive domes. Tors are a much jointed variant of inselbergs. There are a great many inselbergs, tors and smaller rock outcrops through the region but only the larger ones could be shown on the map. The mode of formation of the inselbergs has already been described (Ollier 1959).

Like the Mwiri and Motu soil units the main features of the inselbergs in that they are virtually soilless. The inselbergs do exert some effect on the surrounding soils for these are often slightly enriched with bases from the water draining through joints in the weathering rock. Rotted rock, which forms the parent material of these soils, shows an abrupt junction with the fresh rock of the inselberg. Even in small areas between rock outcrops the parent material is found to be rotted rock from which red loam profiles develop. Such a profile is described below:-

Profile 25. (19317-22)

Ngora, Teso. Between inselbergs in Amuria unit.

0 - 8"	Dark grey (10YR:4/1) sandy loam. Weak crumb.
8 - 15"	Dark reddish grey (5YR:4/2) fine sandy clay loam. Crumb.
15 - 24"	Reddish brown (5YR:4/4) fine sandy clay loam. weak crumb.
24 - 40"	Yellowish red (5YR:5/6) fine sandy clay loam. weak crumb.
40 - 60"	Strong brown (7.5YR:4/4) fine sandy clay. Fragments of weathered rock and some quartz gravel.
60" +	Murram formed in very weathered rock.

Inselbergs are found in all the following soil units but are most common in the Amurie, Buruli and Usuku.

18. Kabira Catena

The Kabira catena occurs in the southern part of Busoga, where the country is remarkably similar to southern Masaka district.

Geologically the setting of this catena is the same as that of the Buruli catena described later (21). The main difference between the two is relief, for the Kabira catena included the main watershed and is less planated than the Buruli. Ridges are broad with round brows but the extreme flatness of the African surface has not been fully developed.

On upper slopes and ridge tops there is often rotted rock to the surface with just a little resorting and eluviation from the topsoil in deeper soils there are developed stonelines and laterite or murram, as in the Buruli sequence. Structure tends to be good, crumb to sub-angular blocky, as a result of the accumulation of organic matter which tends to be higher than in the Buruli soils. Valleys are narrower and not so well aggraded as those of the Buruli catena; swamps and their sandy margin soils are present.

A catenary sequence of typical Kabira profiles is given below.

Profile 26. (7670-73)

South Busoga. Ridge top.

0 - 5"	Dark reddish brown (5YR:3/4) loam, with some murram.
5 - 13"	Reddish brown (2.5YR:4/4) loam, with murram and quartz gravel.
13 - 38"	Dark red (2.5YR:3/6) loam, with murram and gravel.
38 - 48"	Dark red (2.5YR:3/8) coarse gritty loam with murram.

Profile 27. (7661-64)

South Busoga. Mid slope.

0 - 7"	Brown (10YR:4/3) sandy loam
7 - 27"	Yellowish red (5YR:5/6) sandy loam
27 - 43"	Yellowish red (5YR:5/6) sandy loam, more compact than in the horizon above.
43 - 54"	Yellowish red (5YR:5/8) sandy loam with murram pellets.

Profile 28. (7612-18)

South Busoga. Lower slope.

0 - 4"	Dark greyish brown (10YR:4/2) loamy sand.
4 - 11"	Dark yellowish brown (10YR:4/4) loamy sand.
11 - 18"	Brown (7.5YR:4/4) sandy loam with a little grit.
18 - 36"	7.5YR:5/6. Strong brown, sandy loam with grit, more compact than the horizon above.
36 - 48"	Strong brown (7.5YR:5/6) sandy loam with grit, plus murram pellets and quartz stones.
48 - 53"	Massive laterite.

In many respects the analytical data for the Kabira soils are similar to those obtained in the better Buruli soils. Organic carbon is usually fairly high but the figures given in the appendix may be rather lower than average. The pH values for topsoils are almost always over 6, with a marked increase in acidity with depth, due to leaching. Kabira soils are formed directly on rotted rock which is virtually unsorted, and are distinguished by a high content of angular quartz fragments up to ½" diameter. Amounts of bases present are comparatively low because the soils are formed on pre-weathered rock which has no reserves of weatherable minerals to provide plant nutrients.

19. Buyaga Catena

The Buyaga catena is found in Busoga district north of the

Mwiri hills. It is the eastern extremity of an almost continuous belt from western Mubende district. Geomorphologically it is probably part of the African surface, at or near the base level of degradation of the Buganda surface and has not yet reached the extreme flatness of the adjacent Buruli catena. The underlying rocks are granites and gneisses of the Basement Complex with occasional veins of amphibolite. Inselbergs are less frequent here than in Mubende district. Rainfall is between 45 and 55 inches per annum and the natural vegetation is elephant grass and mvule.

The soils are usually deep, consisting of more than 6 feet of uniformly red clay loam containing abundant fine quartz gravel. There is often a district stoneline, below which a semi-indurated mottled horizon of pre-weathered rock usually occurs. Two typical profiles are described below.

<u>Profile 29.</u> (20491-96)

3 miles south of Njeruka, on Kamuli-Jinja road. 3,700 feet.

0 - 9"	Dark reddish brown (2.5YR:3/4-3/2) loam with weak crumb structure and abudant fine quartz gravel.
9 - 18"	Dark red brown with weak sub-angular blocky structure.
18 - 72"	Red clay loam, weak s.a.b. structure.

<u>Profile 30.</u> (20503-07)

3 miles N.E. of Kibinga, Busoga. 3,700 feet.

0 - 3"	Dark reddish grey loam with abadant fine quartz gravel, weak crumb structure. Surface soil may be somewhat eroded.
3 - 9"	Dark red dark brown loam, weak crumbs.
9 - 18"	Dark red loam, weak s.a.b. structure.
18 - 60"	Red loam, weak s.a.b. structure.

The fertility of the Buyaga soils is higher than the neighbouring Buruli in all respects, possibly as a result of the elephant grass mining a subsoil which may be richer in bases from the weathering amphibolite. Agricultural productivity is correspondingly greater and good yields of cotton, coffee and food crops are obtained. A more comprehensive description of this catena will be given in the memoir on the soils of Buganda.

20. <u>Bukedea Series</u>

These soils occupy an area in south east Teso along a strip of relatively high land running from Mbale to Bukedea. Their topographic setting is very like that of the Buruli soils. Gently undulating country along the main Mbale-Bukedea ridge is joined by swamp filled valleys. Towards Kachumbala there are many inselbergs or tors, and this area seems to be almost continuous with the Mbale surface, but rather more eroded.

The parent materials of the Bukedea soil are derived from granites and metamorphic rocks of the Basement Complex which have suffered considerable pre-weathering. But they resemble the Mbale soils rather than the Buruli in that the parent rock structures have not been completely effaced by weathering.

In profile morphology, the soils are very similar to those of the Buruli catena, but tend to be shallower and redder, and often have rather poorly developed topsoils. Typical profiles are shown below.

<u>Profile 31.</u> (19323-33)

Between Kidongole and Kachimbale

0 - 4"	Dark brown (7.5YR:4/2) sandy clay loam with crumb to fine cloddy structure.
4 - 10"	Slightly pale brown (7.5YR:4/3) fine sandy clay loam, same structure.
10 - 20"	Reddish brown (5YR:4/4) fine sandy clay loam, sub-angular blocky structure.
20 - 32"	Yellow red (5YR:4/6) sandy loam, weak s.a.b. structure.
32 - 50"	Reddish brown (5YR:5/4) infill for angular murram up to ½ diameter.
50" +	Sheet vesicular laterite.

<u>Profile 32.</u> (19334-38)

<u>West of Kachumbala</u>

0 - 4"	Dark reddish grey (5YR:4/2) fine sandy loam. Structureless.
4 - 12"	Dark reddish grey (5YR:4/2) fine sandy loam. Weak crumb structure.
12 - 24"	Reddish brown (5YR:4/4) fine sandy clay loam. Very weak crumb to structureless.
24 - 32"	Reddish yellow (5YR:6/6) fine sandy clay loam. Structureless.
32" +	Coarse murram.

Laterite is always present and may be very massive, although unconsolidated murram is perhaps more common. Some of the profiles appear to be truncated, and an average depth of 18 inches to murram is common over most of the area.

The soils are acid, and acidity increases with depth; many pH values are below 5. Base content is very low, and available phosphate is normally deficient. Mechanical analyses show most textures as fine sandy clay loams, very similar to Buruli soils.

21. <u>Buruli Catena</u>

The Buruli catena relief began as a flat plain, part of the African erosion level which was dissected into a series of attenuated ridges or plateaus separate by swamps, with long gentle slopes between crest and valley. Valleys were aggraded and now contain broad swamps. Interfluves may be flat topped or gently rounded. The underlying rocks are pre-Cambrian metamorphic or granitic rocks. Other rock types occur over insignificant areas. The rock has been thoroughly rotted in a previous cycle of weathering and it is the regolith of this rotted rock which is the parent material of the soils. Soils of the Buruli catena occur in all rainfall regions from under 40" to over 60" but the higher the rainfall the more severe is the dry season, so the resulting vegetation and soils are approximately the same.

On the plateaus and ridge tops the soil is a red loam 3 – 4 feet deep over laterite which in turn overlies rotten rock. There seems to be a fairly uniform depth of soil in any one area, thinning out only at the plateau edges. Soil depths are less and hard laterite more frequent in Eastern Region than in North Mengo. Typical profiles are shown below.

<u>Profile 33.</u> (13653-57)

Mulanda, Bukedi. Plateau top.

0 – 4"	Reddish brown (5YR:4/3) fine sandy loam. Crumb structure.
4 – 18"	Reddish brown (5YR:4/3) fine sandy clay loam.
18 – 29"	Yellowish red (5YR:4/6) fine sandy clay loam. Structureless.
29 – 35"	Yellowish red (5YR:4/6) silty clay loam. Structureless.
35" +	Murram.

<u>Profile 34.</u> (19323-27)

Kanyum, Teso. Flat site.

0 – 6"	Reddish brown (5YR:4/3) weak crumb structure.
6 – 12"	Paler reddish brown (5YR:4/6) same structure.
12 – 24"	Yellow red (5YR:4/6) same structure.
24 – 60"	Murram - pisoliths and irregular ferruginised rock fragments.
60 – 120"	Yellow red (5YR:4/6) ferruginised weathered rock and semi-hard to hard murram.

In the wetter areas, a thick topsoil tends to develop and soil structure is improved, becoming fine granular to crumb. In drier areas topsoils are thinner and structure is weaker or absent altogether.

In some areas, notably around Lamino in Bukedi and in the Ningiri area of Teso, the soils are exceptionally red. In all other respects they are like the Buruli soils, and are of the same low standard of fertility, generally, and so have not been mapped separately.

A red profile is described below.

Profile 35. (13658-62)

Lumino, Bukedi. Flat site.

0 - 5"	Dark reddish brown (2.5YR:3/4) fine sandy clay loam. Crumb structure.
5 - 16"	Dark reddish brown (2.5YR:3/4) fine sandy clay. structureless.
16 - 31"	Dusky red (10R:3/4) fine sandy clay loam. Structureless.
31 - 42"	Dark red (10R:3/6) fine sandy clay loam. Structureless.
42" +	Rotten rock.

At the plateau edge there is often an outcrop of sheet laterite, usually very thick, massive and jointed, above which is only a sandy remnant of soil. Below the laterite horizon is amorphous, completely weathered rock, more or less in situ, with the appearance of a red loam or sandy clay loam and is not easily distinguished from other red loams of the catena. Occasionally there are quartz veins traversing this material, indicating that it is in situ, and on granite there is often a good deal of sharply angular quartz of coarse sand grade which is typical of sedentary soils. The amorphous weathered rock may extend down for many tens of feet.

At the junction of weathered rock and the resorted or drift material above there is often an accumulation of pebble-sized quartz fragments forming a stoneline. Below this are found remnants of rock structure and quartz veins which are absent above. Further downslope profiles are much the same, but there may possibly be more drift or hill-creep material. Laterite is usually present in all parts of the catena and forms a continuous sheet below the ground surface and paralled to it, marking the junction of resorted (chiefly by ants and termites), or drift material, and weathered rock in situ.

The valley bottom swamps have been mapped separately from the rest of the catena but the swamp margins have not. These are often mixtures of soil, with sometimes red loams over laterite, sometimes alluvium over laterite, and many other combinations. The broad distribution of sandy deposits along minor valley sides indicate a former wider spread of swamp, lake or river. (c.f. Mazimasa unit).

The analytical data in the appendix are of fairly typical Buruli soils. Most samples fall into the fine sandy clay loam type. In the field the soils give the impression of being heavier and often feel like loams or clay loams. The increase in sand on analysis may be due to aggregation of smaller particles by iron oxides. It is usual for the clay content to increase down the profile, but the amount of silt shows no regular variations. In wetter areas, and in those with good vegetal cover, carbon tends to be fairly high, and is low in dry areas with sparse vegetation. Heavy cultivation or grazing tends to reduce the organic carbon and some of the lowest figures are from the heavily grazed patches of Buruli soil in south east Teso. Such soils are merging into the Bukedea types, which might therefore be regarded as a degraded variant of Buruli. Phosphate content is generally low, and a top-soil figure of 20 or more is exceptional for Buruli soils. The soils are always acid but pH figures over 6 are found in the better soils which seem to be associated with wetter areas and, perhaps, to old kraal sites. In drier areas the pH is lowest but Buruli soils rarely fall below 5.0 in any horizon. Acidity usually increases with depth. Bases are generally low, and there may well be deficiencies of major elements. The same trends are shown as before, and the soils which are poorest in phosphorus and organic carbon will also tend to be of low base status.

Mineralogical analysis of Buruli soils indicates a high degree of weathering and they appear to be formed on pre-weathered parent material. Most of the heavy minerals are ilmenite and secondary limonite, but there is usually a total of about 10% of zircon, tourmaline and rutile. Other minerals such as kyanite, staurolite and hornblende are present only occasionally. The light mineral fraction is virtually all quartz. There are no primary minerals present which release nutrient bases to the soil on weathering, consequently the reserves of soil fertility are low.

SOILS DERIVED FROM ANCIENT LAKE DEPOSITS

22. Amuria Catena

Amuria soils occur on the dessected plain of Teso and relief is nowhere very large. Interfluves are usually rounded, and undulating topography is commonest. Like the Mazimasa unit in the south, the Amuria unit has formed swamp deposits as parent material over most of its area. Most of the country is very flat with only slight relative relief, and is part of an aggraded lake bed. Some included soils, however, though having the same profile morphology, appear to be a variant of the red loams in origin. The underlying rock is Basement Complex gneiss or granite, which outcrops in occasional inselbergs, as at Soroti and Abela.

The soil profiles are in many ways similar to Nasimaca soils but differ in a few respects. The catena consists of gently rounded interfluves seprated by wide valleys, with sandy loam on all parts of the catena except the swamps themselves, though a few small patches of red loam on crests or upper slopes also occur. Laterite is almost invariably present and is frequently very massive. Brown colours prevail, and the soils are generally structureless owing to their high sand contents, and break down easily when dry to single grains.

In the country of Amaric itself many of the profiles are very shallow, and 18 inches to laterite, or even less, is very common. Such a shallow profile with a contrasting deep one from the same locality, is shown below.

<u>Profile 36.</u> (9531-33)

Arapai Farm Institute. Gently undulating relief.

0 - 6"	Dark greyish brown (10YR:3/2) fine sandy loam with very weak crumb structure.
6 - 10"	Dark brown (7.5YR:4/2) loam, weak crumb structure, sporadic pisoliths present.
10 - 18"	Dark brown loam infilling stoneline of crystalline quartz stones up to 2' x 2' x 1', ferruginous pisoliths present $\frac{1}{4}$ - $\frac{1}{2}$" diam.
18" +	Massive orange brown laterite containing both hard and sugary stones of quartzite.

<u>Profile 37.</u> (9533-38)

Arapai Farm Institute. Flattish.

0 - 3"	Dark brown (7.5YR:4/2) fine sandy loam with weak crumb structure, friable.
3 - 6"	Brown (7.5YR:5/2) loam, very hard <u>in situ</u> but breaks into crumbs under pressure.
6 - 12"	Brown (7.5YR:4/2) loam with darker tongues of topsoil: similar structure.
12 - 24"	Dark yellowish brown (10YR:4/3) loam, same structure.
24 - 33"	Dark yellowish brown (10YR:4/4) loam, same structure, with slight speckling of small iron concretions and white quartz grains (1/16").
33 - 55"	Strong brown (10YR:5/6), loam, single grain structure, friable and moist.
55" +	Strong brown and redlish brown hard sheet laterite.

Profile 38 is of intermediate depth.

<u>Profile 38.</u> (19239-42)

7 miles north of Amaric, Teso. Upper slopes.

0 - 6"	Very dark grey brown (10YR:3/2) sand.
6 - 12"	Brown (10YR:4/3) loamy sand.
12 - 24"	Dark yellowish brown (10YR:4/4) loamy sand.

24 - 36"	Brown (10YR:4/3) loamy sand.
36" +	Murram.

In south east Teso the profiles, though usually only about two feet deep, are occasionally very deep, such as the following profile from Kumi.

<u>Profile 39.</u> (19339-43)

Kumi, Teso. Plateau top.

0 - 6"	Dark grey (10YR:4/1) loamy sand. Structureless.
6 - 24"	Dark grey brown (10YR:4/2) loamy sand. Structureless.
24 - 40"	Dark grey brown (10YR:4/2) loamy sand. Structureless. More compact than the horizon above.
40 - 60"	Reddish brown (5YR:5/4) sandy loam. Structureless.
60 - 120"	Yellowish red (5YR:5/6) sandy loam matrix with murram.

In neighbouring Bokolo country of Lango district there are many soils where a sandy loam topsoil overlies reddish brown loam subsoils. These have been mapped as the Bokolo series in Northern Region. The profile given above is merging towards this series and in Kaberamaido county there are one or two small patches which should be mapped as such but they are too small to be mapped on the present scale.

Like the Mazimasa, the Amuria soils contain a large amount of sand but in deep profiles there is an increase in clay downwards. The shallow profiles have the same tendency but it is not so well marked. Organic matter is variable, and depends largely on land use. It is low on the whole, but on land that has not been used for a number of years there is a reasonable accumulation. Soils are invariably acid, usually with a pH of less than 6, and base content is low. Phosphate is generally very deficient, and may be extremely low.

23. <u>Mazimasa Complex of Catenas</u>

This is a very complex mapping unit consisting of several catenas and part catenas, but is characterised by sand and sandy loam soils over a large part of any catena. There are several variations, but most Mazimasa soil is on medium to low topography with a relative relief of less than fifty feet. Gently undulating topography is common and there are very few steep slopes.

The bulk of the Mazimasa soil seems to be associated with a former lake of greater extent than the present Lake Kyoga but overlapping the same site. The old boundaries of this lake are shown in the geomorphology map. It extended along all valleys and laid down a sediment, which was fairly sandy. With recession this has given rise to sand and sandy loam soils, which form the main textural classes of the Mazimasa unit. Evidence for the lacustrine origin of these soils is found in the fact that there is an unbroken sequence from proven swamp soils at the swamp edges, through progressively lighter soils until the highest part of the Mazimasa topography is reached. As the drainage pattern was well developed at the time when the lake attained maximum extent, arms of the lake reached up the valleys so that now the Mazimasa soils also extend up the valleys. In Busoga there is a transition from north to south in the catenary sequence. To the north the Mazimasa soils cover ridge tops and all valley sides. Further south the tops of the watersheds were not covered by the lake and the Mazimasa soils occur only on the mid and lower slopes, while to the south of this only the lower slopes carry Mazimasa soils. Thin strips along valley sides cannot be shown on the present scale, so that only in the areas where the sands occupy the major part of the catena have they been mapped as Mazimasa catena.

Strong eluviation of a normal red earth of the Buruli type may give rise to a sandier soil, differing from a Mazimasa soil only in its colour. These soils will be redder, but they are included in the Mazimasa mapping unit because they are not sufficiently distinct or extensive to be mapped separately. Mazimasa soils occur in the drier areas of Bukedi and neighbouring parts of Busoga and Bugisu. These areas also show a marked seasonal variation.

In the Mazimasa area itself and at Nagongera the soils show the greatest amount of sand. Profiles 40 to 43 are typical examples. The sandy soils are continuous from the swamp margins right to the top of ridges or plateaus between swamps. A catena from ridge top to valley side at Nagongera is given below. Site 1 is on the plateau, site 2 at the turnover, site 3 on the mid slopes and site 4 at the valley side.

<u>Profile 40.</u> (13626-29)

Site I

0 - 5"	Reddish brown (5YR:4/3) sand
5 - 14"	Dark reddish grey (5YR:4/2) sand
14 - 30"	Reddish brown (5YR:4/4) sandy murram
30 - 42"	Loose murram
42" +	Laterite.

Profile 41. (13615-18)

Site 2.

0 – 6"	Brown (7.5YR:5/4) sand
6 – 15"	Brown (7.5YR:5/4) sand
15 – 30"	Light brown (7.5YR:6/4) sand
30" +	Murram

Profile 42. (13619-21)

Site 3.

0 – 4"	Dark reddish grey (5YR:4/2) sand
4 – 23"	Brown (7.5YR:4/2) sand
23" +	Wet sand

Profile 43. (13622-25)

Site 4.

0 – 5"	Dark brown (7.5YR:4/2) sand
5 – 18"	Very dark grey (5YR:3/1) sand
18 – 32"	Dark brown (7.5YR:4/2) sand
32 – 40"	Brown (5YR:5/4) sand

Heavier profiles also occur, such as the one shown below. These have a similar origin and could not be mapped separately without detailed work.

Profile 44. (10637–40)

Iki Iki. Bukedi. Flat site

0 – 6"	Dark brown (7.5YR:4/3) sandy clay loam.
6 – 12"	Dark brown (7.5YR:4/3) sandy clay loam, more compacted than the horizon above.
12 – 18"	Brown (7.5YR:5/4) sandy clay loam.
18 – 28"	Reddish brown (5YR:5/4) sandy clay loam and murram.
28" +	Sheet laterite.

It sometimes happens that the subsoil resembles the red loam of Buruli type. This is more common in Busoga than Bukedi. In the vicinity of Molo in Bukedi where the Mazimasa soils are restricted to a strip along a wide valley, they consist of sands and sandy loams over thick laterite. They are probably of the same age as the rest of the Mazimasa but seem to have originated from valley bottom alluvium. There are a few areas, notably Bugiri in south Busoga, where erosion of the Mazimasa has exposed large expanses of laterite with occasional patches of shallow sand. Such areas as would be expected are of very low productivity.

Typical Mazimasa soils show a high proportion of sand and become a little heavier with depth. Such sandy soils are easily leached and the soils are consequently poor in bases and rather acid. The pH is frequently below 6, though rarely below 5.

Organic matter is also low, though topsoils are often dark, presumably because of carbon left after previous grass burns. Bases are very low, especially bases other than calcium. Despite this low inherent fertility, crop productivity is better on the Mazimasa than the Amuria soils which have a similar origin; this is because they are usually deeper and the dry season is less severe.

24. Usuku Series

The Usuku series constitutes the upper part of a catena. It only occurs in Teso district in a very flat area dissected by swamp filled valleys. The amplitude of relief from ridge to valley is not usually more than 30 feet. There are a few inselbergs with pediments, but these are of very small area and have not been mapped separately. Laterite occurs throughout and where it outcrops it gives rise to a shelf feature on valley sides. It is strongly developed in many places and has formed at the junction of the sands and the underlying rock. The sands appear to be an ancient lacustrine sediment, although it is difficult to account entirely for its distribution. Basement Complex granites and gneisses are occasionally exposed. The basic geomorphic history is as follows:- Laying down of sandy sediments over Basement Complex, with islands formed by protruding inselbergs, slow draining of lake, eluviation and laterite formation, uplift and dissection of the plateau and deposition of new clay soils in the swamps.

Relief is so gentle in many places that it is difficult to decide where a valley ends and ridge begins. In the west, near Katakwi, relief is more marked, and laterite outcrops on valley sides. Apart from this there is virtually no catenary variation, and only a random variation with regard to the depth of laterite. The following profile may be taken as typical of the whole area.

Profile 45. (19217-24)

1 mile S.Katakwi, Teso.

0 – 6"	Dark grey brown (10YR:4/2) sand, single grain structure which persists to the laterite.
6 – 18"	Dark brown (10YR:4/3) sand
18 – 40"	Dark brown (10YR:4/3) sand
40 – 68"	Brown (7.5YR:5/3) sand
68 – 75"	Brown (7.5YR:5/4) sand
75 – 168"	Murram and laterite
168" +	Rotted rock.

The top 2 feet of a profile are nearly homogenous, but below this there may be a gradual change to heavier textures and somewhat warmer colours. These soils gradually merge into the Amuria series by becoming shallower, redder and heavier in texture.

Around rocky outcrops, as at Abela, the Usuku sands are reddish brown in colour but other profile features are more or less the same.

The northernmost patch of Usuku series plotted on the map is rather exceptional. Here are deep sandy soils, grey in colour and frequently mottled as if by poor drainage. The profiles look like valley swamp soils but occur on plateau tops and valleys alike. A typical profile from Obalanga is as follows:-

Profile 46. (19243-49)

Obalanga, Teso. Upper slope.

0 - 6"	Grey (10YR:5/1) sand. Single grain structure.
6 - 12"	Greyish brown (10YR:5/2) sand. Single grain structure.
12 - 24"	Light brownish grey (10YR:6/2) sand. Single grain structure.
24 - 36"	Greyish brown (10YR:5/2) sand. Single grain structure.
36 - 48"	Grey (10YR:6/1) sandy loam, mottled reddish brown (5YR:4/3).
48 - 72"	Light grey (10YR:7/1) sandy clay, mottled reddish brown (5YR:5/4).

Mechanical analysis bears out the simple field observation that Usuku soils are very sandy, and they could be regarded as a deeper and coarser sandy variant of the Amuria soils. Leaching is excessive and results in a low base content. The analytical data for profile 46 shows this extremely well, for all the upper sandy layers have no detectible bases except calcium, which itself is very low: available phosphate is deficient throughout the profile. Acidity does not seem to be very great, and increases with depth.

SOILS DERIVED FROM PLEISTOCENE TO RECENT ALLUVIAL DEPOSITS

25. Lwampanga Series

This mapping unit, which may be regarded as a soil series, is distinguished in areas of lakeside sand in Busoga and Bukedi.

It occurs on wide flats on lake or swamp margins of the Kioga system. In some areas there are many small inselbergs rising abruptly from the flats. There is some slight relief where minor swamps cross the strip of lakeside sands, which may be up to 20 feet between the tops of gentle ridges and valley bottoms.

Much of the parent material of the Lwampanga series is recent lakeside beach sand, but inland it is ancient beach or lake floor sand. There appears to have been fluctuation of lake level causing a succession of spits or bars of sand with rather more clayey material between them, but this detail has been mapped.

Textures are commonly coarse sand, but slightly heavier types such as sandy loam are found. Colour is variable, grey (5YR:5/1) is not uncommon but 7.5YR and 10YR brown and dark brown are more usual. Single grain structure is present in both the coarse sands and the finer textured types.

At the shores of Lake Kyoga the sands are many feet deep, but further inland shallower variants overlie murram and laterite. Laterite is massive but usually only about 1 foot in thickness.

A typical Lwampanga soil is described below.

<u>Profile 47.</u> (13604-06)

Busiba, Bukedi.

0 - 6"	Brown (10YR:5/2) sand, weak crumb structure
6 - 30"	Brown (10YR:5/2) sand, single grain structure
30 - 36"	Light brown (10YR:6/3) sand, single grain structure

Lwampanga soils are very immature and merge gradually into the Masimasa, which occupies slightly higher sites.

Mechanical analyses indicate variations from loose sands to sandy clay loams. There is sometimes an increase of clay with depth, suggesting that the original beach material was a fairly heavy deposit that subsequently lost its clay by mechanical down-wash. The soils on old spits or bars are sandier than those of the hollows. The soils are highly leached resulting in low to very low base contents. Organic matter is fairly low, but considering the physical state of the soils is quite good. The pH is often over 6 and the phosphate content can be quite high.
This is a feature common to lake shores throughout most of Uganda since fish, or the droppings of fish eating birds, crocodiles and hippos have enriched the soils in phosphate. (Chenery, 1954).
The Kigingi sample is from the lake shore and shows high phosphate.

<u>Profile 48.</u> (12771-73)

Kigingi, 5 miles E.N.E. of Kidera, Busoga.

0 - 6"	Dark brown (10YR:4/3) sandy clay loam
6 - 16"	Dark brown (7.5YR:4/4) sandy clay loam
16 - 28"	Brown (7.5YR:5/4) sandy clay loam

26. <u>Undifferentiated Alluvium</u>

Over the period 1954-55 a survey of irrigable land was made by R.E.Gunn for Sir Alexander Gibb and Partners (Africa), irrigation consultants to the Protectorate Government; sixty three profiles were sampled down to 5-6 feet in Eastern Region alone. All except two were clayey throughout the profile and the exceptions, occurring near Namalemba were of the fine sandy clay type.

Sandy clay alluvial soils are, however, much more widely distributed than this and occur in the upper reaches of most river systems, even in broad flats several hundred yards across. The reason why these clays predominate in the Gibb report lies in the fact that only large swamps were investigated. A detailed study of the alluvial soils of the district would probably reveal at least as many distinct soil types as there are vegetation units for poorly drained land. Langdale-Brown (1959) maps 16 kinds of vegetation on land with impeded drainage.

These clays vary in colour from almost black to dark grey, being slightly paler and frequently mottled in the subsoil. Mottling is sometimes only faint or is just confined to rusty stains along lod root traces. An interesting micro-relief of small mounds 15" to 24" high and wide, built by worms, producing a tussock effect are frequently found in Echinochloa pyramidalis swamps such as the Omunyal. Most swamps are flooded during the rainy season but they dry out fairly quickly and are baked hard for many months of the year. During this time they are closely grazed by cattle after the long grass has been burnt. No arable agriculture is practiced except at the fringes and upper reaches where topsoils may be lighter in texture. The papyrus swamps are water-logged if not flooded for most of the year. Some examples of alluvial profiles are given below.

<u>Profile 49.</u> (11332-37)

Agu Bridge, mile 56 on Mbale-Soroti road. Periodically flooded.

0 - 24"	Very dark grey (10YR:3/1) clay, angular blocky structure with large cracks down to 48"
24 - 36"	Similar but with shiny, slip surfaces occurring on cleavage faces.
36 - 48"	Dark grey (10YR:4/1) clay with slight rusty mottling, similar structure; a few small iron concretions present.
48 - 60"	Same colour but compact massive structure; concretions still present.

<u>Profile 50.</u> (11356-61)

Omunyal Swamp, Central Teso. Flat with tussock mounds.

0 - 4"	Very dark grey (10YR:3/1) clay, weak granular structure.
4 - 28"	Very dark grey (7.5YR:3/0) clay, angular blocky structure.
28 - 64"	Same colour weak blocky structure with shiny cleavage faces.

Profile 51. (19261-67)

Okok, N.E. Teso. Flat site.

0 - 24"	Very dark grey (10YR:3/1) clay, blocky structure.
24 - 36"	Dark grey (7.5YR:4/0) clay, massive to cloddy structure.
36 - 48"	Very dark grey (10YR:3/1) clay, massive structure.
48 - 60"	Dark grey (10YR:4/1) clay, same structure.
60 - 72"	Grey (10YR:5/1) clay, same structure.

The high base exchange capacities of these profiles indicates the presence of a montmorillonitic clay mineral. The soils are remarkable in being so acid and yet so rich in base. These bases are not realy indicative of productivity because the major part of them is so firmly bound to the clay mineral as to be not readily available to plants. Acidities as low as pH 3.5 are sometimes found when free sulphuric acid is present. Subsoils may contain exchangeable sodium in amounts which are deleterious to plants but free sodium carbonate has not been found. Free calcium carbonate, however, is very occasionally found as small concretions, chiefly in valley bottom soils of rivers flowing off Mount Elgon which are also phosphate-rich. When calcium carbonate concretions occur in non-volcanic alluvial soils they do not affect the soil reaction to any great extent.it usually remains acid.

The small valleys draining into Lake Victoria contain very variable sandy clays; another wide expanse of sandy clays occurs near the Nile at Mbulamuti. A profile from there which is both very acid and gypseous is described below, others are recorded under the Serere and Mohira catenas.

Profile 52. (9948-54)

Mbulamuti, Busoga. Flat, seasonally ver wet.

0 - 6"	Very dark grey (10YR:3/1) clay loam. Weak crumb structure, grading into
6 - 12"	Grey brown (2.5Y :5/2) clay, cloddy structure.
12 - 24"	Similar but mottled reddish brown
24 - 60"	Grey brown (2.5Y:5/2) clay, mottled reddish brown with small gypsum crystals occurring between 36" and 54"; sub-angular blocky structure.
60 - 72"	Same colour and mottling, fine sandy clay.

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APPENDIX

ANALYTICAL DATA

Methods

Mechanical Analysis

Silt and clay were determined by the hydrometer method of Bouyoucos (1927) as modified by Tyner (1939) using sodium hexa-meta phosphate as the dispersing agent. The figures in the table are for the International fractions.

Clay $< 2\mu$, silt $20 - 2\mu$
sand $20 - 2000\mu$

Exchangeable Bases (Cations)

The exchangeable cations were determined by a rapid method in neutral normal ammonium acetate leachates (Hughes, 1959). The figures in all cases except for sands and sandy loams are about 80% of what is actually present. For sands and sandy loams the more elaborate extraction technique was used and 95% of the exchangeable bases were extracted.

It should be borne in mind that a zero figure for any one cation does not mean that it is entirely absent but that it was not detected by this method.

Exchangeable Hydrogen

This was determined in buffered p-nitrophenol extracts by the method of Schofield (1933)

pH

pH was measured in pastes (about 1:1) by the glass electrode method.

Organic Carbon

The wet combustion method of Walkley and Black (1934) was used but their correction factor of 1:33 was not applied.

Available Phosphate

The well known method of Truog (1930) was used, using buffered N/500 sulphuric acid as the extractant.

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APPENDIX.

ANALYTICAL DATA FOR SOIL PROFILES

Depth Ins.	Mechanical Analysis		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog. P_2O_5 p.p.m	Remarks.
	Silt	Clay	Ca	Mg	K	Na	Mn	Total Bases							
								MASABA							
								Profile I (16529-30)							
Above Suam Sebei		11,000 ft.													
7	3	5	0.8	2.3	0	0	0.15	3.25	18.7	22.0	14.8	5.1	11.31	51	High C & N Leached top soil
16	8	0	5.9	2.0	0.77	0	0.22	9.39	16.2	26.1	37.9	5.2	10.14	n.d.	
								N% 0.889	0-7"	C/N					
								BENET							
								Profile 2 (16524-28)							
Above Suam, Sebei.		7,800 ft.													
9	7	28	10.6	3.0	0.23	0	0.05	13.83	8.9	22.7	60.9	5.8	5.30	3	High C and bases Low P and K
19	2	32	1.3	1.1	<.16	0	0.11	2.5	12.2	14.7	17.0	5.0	1.76	13	
28	0	34	1.8	2.6	<.16	0	0.13	4.53	11.8	16.3	27.8	5.0	1.26	6	
40	1	23	0.8	1.8	<.16	0	0.14	2.80	10.7	13.5	20.7	5.1	1.20	8	
54	3	32	0.8	2.2	<.16	0	0.15	3.30	9.4	12.7	26.0	5.1	1.02	9	
								N% 0.267	0-9"						
								Profile 3 (16536-39)							
Suam, Sebei.		8,700 ft.													
12	9	21	1.1	1.0	0.47	0	0.03	2.60	14.6	17.2	15.1	5.1	5.20	29	High C, low bases
24	7	32	.6	< .6	0.23	0	1.12	<2.95	14.8	17.8	16.6	4.6	1.77	27	
36	5	36	.6	0.7	<.16	0	0.20	<1.84	14.2	16.0	11.5	4.7	1.35	36	
48	5	37	0	0.9	<.16	0	0.11	1.07	13.2	14.3	7.5	4.7	1.04	41	
								N% 0.246	0-12"						

Depth Ins.	Mechanical Analysis Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m	Remarks.
								Profile 4 (16531-35)							
Tuneet (above Suam, Sebei) 9,700 ft.															
9	0	6	[illegible]	5.9	1.84	0	0.08	20.92	14.3	35.2	59.4	6.0	10.83	51	High C, N and bases
16	5	13	7.1	1.7	0.91	0	0.08	9.79	14.4	24.2	40.5	5.5	4.86	10	Low Ca
24	7	13	< 0.8	1.3	1.48	0	0.02	< 3.60	13.8	17.4	20.7	5.5	3.81	14	
34	5	35	< 0.8	1.8	1.25	0	0.02	< 3.87				5.2	1.20	15	
48	7	37	< 0.8	0.6	2.26	0	0.02	< 3.68				5.2	0.60	43	
								N% 0.372 0-9"							
								SIPI							
								Profile 5 (15718-22)							
Bumagelale. 5,700 ft. North Bugisu.															
7	12	42	12.9	3.2	3.98	0	0	20.1	6.4	26.5	75.0	6.0	1.77	920	High P and bases
14	9	44	12.1	2.9	2.68	0	0	17.7	7.8	25.5	69.4	5.9	1.13	870	
24	7	54	9.4	2.4	1.55	0	0	13.4	6.4	19.8	67.7	5.9	0.72	235	
36	5	62	6.9	2.0	1.45	0	0	10.7	6.1	16.8	63.7	6.3	0.60	62	
50	7	64	6.8	2.4	1.64	0	0	10.8	5.9	16.7	64.7	6.3	0.39	64	
								N% 0.237 0-7"							
								Profile 6 (16551-55)							
Kapchorwa, Sebei. 6,200 ft.															
12	7	13	4.3	2.9	0.41	0	0.06	7.67	10.7	18.4	41.7	5.5	2.24	21	Low P and N
24	9	20	3.4	2.5	0.33	0	0.05	6.28	11.3	17.6	35.7	5.5	1.92	9	
36	7	35	3.2	2.2	0.27	0	0.04	5.71	11.0	16.7	34.2	5.6	1.30	12	
40	8	39	1.3	1.5	0	0	<.02	2.8	5.9	8.7	32.3	5.8	0.65	25	
56	11	29	1.5	0.9	<.16	0	<.02	<2.5	n.d.	n.d.	n.d.	5.8	0.62	15	
								N% 0.120 0-12"							

Depth Ins.	Mechanical Analysis Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon	Truog P_2O_5 p.p.m.	Remarks
								CHEPTUI							
							Profile 7	(10244-50)							
Mangatuse, Cheptui.															
6	25	40	13.3	9.4	3.5	0	0.04	26.24	4.8	31.0	84.6	6.4	2.36	510	High P, N and bases
12	17	48	9.8	5.6	2.5	0	0.03	17.83	4.7	22.5	79.2	6.9	1.16	183	
24	11	48	7.2	4.6	1.6	0	<.02	13.6	5.9	19.5	69.7	6.6	0.80	160	
36	14	54	5.5	6.6	2.1	0	<.02	14.2	5.5	19.7	72.9	6.4	0.56	142	
48	13	56	6.5	6.3	2.7	0	<.02	15.5	4.4	19.9	77.9	6.3	0.35	115	
60	18	58	8.8	5.0	2.2	0	0	16.6	3.3	19.9	83.4	6.5	0.30	107	
72	18	56	9.1	5.0	1.7	0	0	15.8	2.0	17.8	88.8	6.7	0.26	53	
								N% 0.289	0-6"						
							Profile 8	(10277-82)							
Between Cheptui and Siroko, North Bugisu.															
8	17	37	12.2	6.3	1.3	0	0.03	19.83	8.2	28.0	70.8	5.8	2.55	650	High P
14	15	39	8.6	6.9	0.6	0	1.04	16.94	8.8	25.7	65.9	5.7	1.77	240	
28	13	50	7.0	4.5	0.6	0	0.02	12.12	7.2	19.3	62.8	5.5	1.20	88	
38	15	40	5.0	5.9	0.9	0	< .02	11.82	6.2	18.0	65.7	5.5	0.71	51	
54	11	60	4.6	5.5	1.2	0	0	10.7	5.7	16.4	65.4	5.7	0.53	69	
72	3	48	1.5	1.7	1.1	0	0	4.3	7.2	11.5	37.4	5.8	0.21	117	
								N% 0.198	0-8"						
								BUGUSEGE							
							Profile 9	(15360-62)							
Bumbo, South Bugisu.															
9	14	39	16.0	3.8	0.78	0	0.07	20.6	9.4	30.0	68.7	5.4	1.92	470	High P
15	10	33	13.3	3.9	0.34	0	0	17.54	6.9	24.4	71.9	5.6	0.66	870	
26	4	29	11.7	2.4	0.33	0	0	14.43	5.6	20.0	72.2	5.7	0.51	940	
								N% 0.248	0-9"						

Depth Ins.	Mechanical Analysis: Silt	Mechanical Analysis: Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil: Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
								Profile 10 (11834-39)							
Buoulеni															
6	2	12	20.5	4.4	0.64	0	0.04	25.58	1.6	27.2	94.0	6.9	1.89	780	
12	6	10	20.0	3.8	0.62	0	0.03	24.45	1.6	26.0	94.0	7.1	1.21	850	High P and Calcium
18	4	24	34.7	4.6	0.80	0	0.16	40.26	4.7	45.0	89.5	6.3	0.72	530	Montmorillonitic
24	10	34	30.7	7.5	1.04	0	0.07	39.31	4.4	43.7	90.0	6.0	0.73	235	clay mineral
36	19	24	30.7	6.3	0.55	0	0.05	37.60	3.7	41.3	91.0	6.0	0.40	173	
48	15	25	22.1	5.9	0.34	0	0.03	28.37	2.8	31.2	90.9	6.2	0.23	131	
								N% 0.149 0-6"							
									SIROKO						
								Profile 11 (10110-16)							
Kaptokoi, Sobei.															
6	9	36	11.3	11.3	2.13	0.3	0.	25.48	3.8	29.3	87.0	6.3	1.76	1620	
12	10	48	11.3	12.0	1.48	< .3	0.	25.08	3.6	28.7	87.4	6.2	1.49	1100	
24	11	50	15.3	14.6	2.18	< .3	0	32.28	2.5	34.8	92.8	6.4	1.23	1020	
36	11	43	13.3	11.3	1.72	0.9	0	27.22	0.9	28.1	96.9	6.9	0.84	1150	Very high P and
48	8	45	16.5	12.6	1.87	2.5	0	33.47	0.1	33.6	99.6	7.2	0.69	910	high bases
60	8	45	18.7	13.2	1.69	1.4	0	34.99	0	35.0	100.0	7.4	0.53	930	
72	9	46	18.7	10.7	1.50	1.3	0	32.20	0	32.20	100.0	7.6	0.27	730	
								N% 0.027 0-6"							
									TESO						
								Profile 12 (10202-08)							
Alekilek, Usuku, Teso.															
3	14	46	27.5	10.1	1.64	0	<.02	39.24	5.1	44.3	88.6	6.1	3.44	1560	
6	10	54	33.6	17.0	1.37	0	0	51.97	3.8	55.8	93.1	6.0	2.83	1260	
12	12	64	36.0	10.7	1.25	0	0	47.95	2.5	48.2	99.5	6.4	1.49	1320	Very high P and bases
24	12	60	35.9	25.8	1.45	1.2	0	57.35	0.2	57.5	99.7	7.0	1.36	1110	Montmorillonitic
36	10	60	35.9	20.0	1.53	1.2	0	57.63	0.2	57.8	99.7	7.2	1.34	1050	clay mineral present
48	8	62	33.6	23.3	1.55	2.8	0.	61.25	0	61.3	100.0	7.2	1.16	1030	
60	6	64	37.3	24.6	1.76	4.1	0	66.25	0	66.3	100.0	7.2	1.13	960	

Depth Ins.	Mechanical Analysis Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
									TORORO						
Tororo, Bukedi.								Profile 13	(13672078						
7	8	16	12.0	2.5	0.87	0	0	16.37	3.2	16.6	82.6	6.8	1.90	3650	
15	6	20	8.6	2.5	0.17	0	0	11.57	4.6	16.2	71.4	6.5	1.33	3850	Very high P
23	2	20	5.8	1.8	<0.16	0	0	< 7.76	5.9	13.6	56.5	5.9	0.84	3900	Some phosphate rich rock
48	6	25	4.6	2.7	<0.16	0	0	< 7.46	5.1	12.6	59.2	5.9	0.37	4100	
60	2	25	4.8	2.6	<0.16	0	0	< 7.56	5.0	12.6	60.0	5.8	0.22	4300	
								N% 0.157	0-7"						
								Profile 14	(13670-71)						
Tororo, Bukedi.															
6	5	23	8.3	2.5	0.26	0	0	11.06	5.7	16.8	65.8	6.0	2.0	41	Normal P
20	8	40	7.4	1.3	0.25	0	0	8.95	6.5	15.5	57.7	5.5	1.35	12	
								N% 0.149	0-6"						
									BUDUDA						
								Profile 15	(15747-52)						
Bukigai, Bugisu.															
9	15	42	5.9	1.1	1.95	0	0	8.95	3.7	12.7	70.5	6.3	1.04	255	
18	15	54	4.3	1.5	1.98	0	0	7.78	3.9	11.7	66.5	6.3	0.36	176	
30	14	54	4.8	1.1	0.69	0	0	6.59	5.1	11.8	55.8	5.9	0.18	138	
42	14	56	4.1	1.1	0.42	0	0	5.62	5.2	10.9	51.6	5.8	0.24	135	High P
54	14	54	3.7	<0.6	0.31	0	0	< 4.61	5.1	9.7	47.5	5.3	0.29	109	
66	14	54	4.3	1.1	0.30	0	0	5.7	4.8	10.5	54.3	5.8	0.90	103	
								N% 0.163	0-9"						
									SEBEI						
								Profile 16	(15757-61)						
Kalebai, Bugisu.															
12	0	60	24.6	18.9	1.08	2.9	0	47.48	2.7	50.2	94.6	6.6	1.13	84	
24	8	68	23.2	20.2	1.51	5.2	0	50.1	0.1	45.5	99.8	7.4	0.77	54	High bases,
40	4	62	16.5	20.8	1.80	6.6	0	45.86	0	45.7	100.0	7.7	0.36	85	Montmorillonitic
52	2	48	16.4	13.9	1.09	9.1	0	40.49	0	40.5	100.0	7.7	0.44	27	clay mineral
64	4	46	14.0	11.8	1.03	7.8	0	34.13	0	34.1	100	7.1	0.11	13	
								N% 0.101	0-12"						

Depth Ins.	Mechanical Analysis Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
									BUBUTU						
Magale, Bugisu.								Profile 17	(15384-87						
9	4	22	2.7	1.1	0.31	0	0.03	4.14	4.7	8.8	47.0	5.5	0.72	7	P deficient
17	2	32	3.7	1.0	0.47	0	0.02	5.19	n.d.	–	–	5.6	0.78	5	
38	0	54	3.2	1.8	0.61	0	0.02	5.63	2.2	7.8	72.2	5.8	0.21	4	
60	6	38	3.0	1.1	0.89	0	0.00	4.99	2.1	7.1	70.3	6.1	0.24	5	
								N% 0.116 0-9"							
									BUBULU						
Bubulu, Bugisu.								Profile 18	(15740-45						
10	9	28	3.5	0.9	<0.16	0	0	<4.56	5.0	9.6	47.5	5.5	0.84	9	P and K deficient
20	6	36	3.4	0.9	<0.16	0	0	<4.46	4.3	8.8	50.7	5.5	0.81	9	
32	2	44	2.5	1.0	0	0	0	3.50	3.5	7.0	50.0	5.5	0.41	13	
44	5	42	<0.8	0.6	0.16	0	0.03	<1.59	5.6	7.2	22.1	5.4	0.30	15	
56	10	42	<0.6	0.6	0.17	0	0.04	<1.61	6.2	7.8	20.6	5.1	0.26	18	
68	3	38	<0.8	0.6	0.17	0	<0.02	<1.59	5.0	6.6	24.1	5.4	0.17	15	
								N% 0.098 0-10"							
									NAKABANGO						
Nakabango, Busoga.								Profile 19	(8447-55)						
6	20	34	11.7	8.1	2.56	0	<0.02	22.38	5.8	28.2	79.4	6.2	4.62	54	
9	15	60	7.6	5.0	0.91	0	0.03	13.54	5.6	19.1	70.9	5.6	2.15	23	
18	6	60	4.1	3.2	0.35	0	<0.02	7.65	3.6	11.3	67.7	5.4	0.78	23	
24	3	64	4.2	3.0	0.19	0	<0.02	7.41	3.8	11.2	66.2	5.4	0.71	25	
36	9	64	2.8	1.5	<0.16	0	0	<4.46	4.0	8.5	52.5	5.5	0.33	37	
48	3	64	2.9	1.5	<0.16	0	0	<4.56	3.1	7.7	59.2	5.5	0.29	25	
60	11	52	2.7	0.6	0.17	0	0	3.47	3.9	7.4	46.9	5.2	0.21	18	
72	6	58	2.9	1.1	<0.16	0	0	<4.16	3.5	7.7	54.0	5.2	0.18	22	
80	11	20	2.9	0.6	<0.16	0	0	<3.66	3.2	6.9	53.0	5.3	0.15	15	
								N% 0.295 0-6"							

Depth Ins.	Mechanical Analysis Silt	Mechanical Analysis Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	MG	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Satur-ation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
								MBALE							
Mbale								Profile 20.		(13356-62)					
12	3	24	3.8	1.5	1.16	0	0.04	6.50	2.1	8.6	75.6	5.3	1.33	41	Low N
24	7	33	0.8	<0.6	0.72	0	0.12	2.24	4.4	6.6	33.9	4.8	0.57	17	
36	5	40	<0.8	<0.6	0.51	0	0.09	<1.99	4.1	6.1	32.6	4.7	0.52	6	
48	3	44	<0.8	<0.6	0.16	0	0.05	<1.65	4.1	5.8	28.4	5.0	0.23	9	Low P and bases
60	5	38	0.8	<0.6	0	0	0.07	<1.47	3.9	5.4	27.2	4.8	0.26	12	
72	11	32	1.2	<0.6	0	0	0.07	<1.87	3.1	5.0	37.4	4.6	0.14	5	
96	9	15	1.1	<0.6	0	0	0.03	<1.73	0.9	2.6	66.5	4.9	0.05	0	
								N% 0.063	0-12"						
								SERERE							
								Profile 21.		(3038-71)					
Serere Experiment Station, Teso.															
9	18	16	2.6	<0.6	<0.16	0	0.15	<3.51	3.3	6.8	51.6	5.6	0.92	5	
21	14	19	1.9	<0.6	<0.16	0	0.07	<2.73	2.6	5.3	51.5	5.4	0.50	3	
26	16	17	1.6	<0.6	<0.16	0	0.05	<2.39	2.5	4.9	48.8	5.5	0.45	3	P deficient
41	16	21	1.4	<0.6	<0.16	0	0.03	<2.49	2.5	5.0	49.8	5.6	0.35	3	
66	12	15	1.6	<0.6	<0.16	0	0.02	<2.38	1.8	4.2	56.7	5.7	0.18	3	Low bases
78	14	15	<0.8	<0.6	<0.16	0	0.02	<1.58	2.2	3.8	41.6	5.7	0.09	3	
								Profile 22		(19344-48)					
I mile S. of Serere Experiment Station, Teso.															
6	18	13	2.0	1.0	0.52	0	0.03	3.55	5.3	8.9	39.9	5.5	1.00	9	
16	14	25	<0.8	<0.6	<0.16	0	<0.01	<1.4	4.8	6.2	22.6	5.0	0.86	2	
32	12	25	<0.8	<0.6	0	0	<0.01	<1.4	5.0	6.4	21.9	4.9	0.38	9	Low N, P and bases
50	18	27	<0.8	<0.6	<0.16	0	<0.01	<1.4	5.5	6.9	20.3	5.2	0.41	10	
50+	18	27	0.8	<0.6	<0.16	0	<0.01	<1.4	4.7	6.1	23.0	5.0	0.32	10	
								N% 0.082	0-6"						

Depth Ins.	Mechanical Analysis Slit	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
								Profile 23 (6483–87)							
Serere Experiment Station, Teso. Block 9															
6	14	23	6.4	1.6	0.62	0	0	8.62	3.1	11.7	73.7	6.5	1.63	11	Low P
12	14	29	5.0	1.1	0.20	0	0	6.30	2.3	9.1	69.2	6.5	0.98	9	
27	11	27	4.3	<0.5	0.19	0	0	<5.10	1.4	6.5	78.5	6.4	0.68	11	
30	16	31	3.5	<0.6	0.16	0	0	<4.26	2.1	6.4	66.6	6.2	0.63	9	
								N% 0.141 0–6"							
								Profile 24 (11637–42)							
Serere Experiment Station, Teso. Swamp.															
6	14	19	7.6	2.0	0.66	0	0.16	10.42	6.8	17.2	60.6	5.9	2.22	66	
22	11	23	9.8	2.9	0.44	0	0.22	13.36	6.8	20.2	66.1	5.8	2.04	96	
34	12	23	9.8	4.0	0.41	0	0.23	14.44	6.2	20.6	70.1	5.8	1.79	58	
50	6	30	8.0	3.3	0.17	0	0.12	11.59	5.3	16.9	68.6	5.6	1.10	28	
62	4	23	2.3	1.3	.16	0	0.04	3.80	2.5	6.3	60.3	5.6	0.28	19	
62+	8	26	4.0	2.8	0.20	0	0.03	7.13	5.4	12.5	57.0	4.7	0.23	17	
								N% 0.177 0–3"							
								INSELBERG PEDIMENT							
								Profile 25 (19317–22)							
Ngore, Teso.															
3	6	16	4.3	1.1	0.27	0	<.02	5.69	2.9	8.6	66.1	5.9	0.70	6	P deficient
15	6	23	3.6	1.1	0.19	0	<.02	4.91	3.2	8.1	60.6	6.1	0.84	3	
24	8	24	2.5	1.5	0.27	0	0	4.27	3.2	7.5	56.9	5.6	0.56	1	
40	6	36	2.8	1.3	0.31	0	<.02	4.43	2.9	7.3	60.7	5.7	0.32	3	
60	6	36	1.3	<.6	0.38	0	<.02	<2.31	3.7	6.0	38.5	5.1	0.26	2	
60+	Murram		–	–	–	–	–	–	–	–	–	–	–	–	
								N% 0.095							

Depth Ins.	Mechanical Analysis Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	MN	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
								KABIRA							
South Busoga Forest Reserve.								Profile 26 (7674–73)							
5	12	30	10.4	3.0	0.69	0	0.03	14.12	1.5	15.6	90.5	6.8	1.92	75	
13	10	33	4.4	1.4	0.84	0	.02	6.66	1.3	8.5	78.3	6.6	0.68	15	
33	12	51	2.3	1.8	1.78	0	0	5.9	2.4	8.3	71.1	6.0	0.35	20	
48	4	69	1.8	0.8	1.98	0	0	4.6	2.7	7.3	63.0	6.0	0.21	13	
								N% 0.264 0–5"							
South Busoga Forest Reserve.								Profile 27 (7661–64)							
7	12	25	3.9	2.6	0.51	0	0.09	7.10	3.4	10.5	67.6	5.8	1.50	13	P deficient
27	12	41	2.7	1.8	0.22	0	0.05	4.77	3.5	8.3	57.5	5.4	0.51	7	
43	n.d.	n.d.	3.4	2.1	0.39	0	0.21	6.10	2.4	8.5	71.8	6.0	0.50	3	
54	n.d.	n.d.	4.1	2.2	0.23	0	0.07	6.60	n.d.	n.d.	–	6.7	0.42	n.d.	
								N% 0.146 0–7"							
South Busoga Forest Reserve.								Profile 25 (7612–18)							
4	6	9	8.0	3.1	0.55	0	0.05	11.70	1.7	13.4	87.3	6.8	1.84	13	P deficient
11	2	11	1.0	0.9	0.33	0	0.04	2.27	1.8	4.1	55.4	5.6	0.86	6	
18	4	23	2.3	0.9	0.22	0	0.03	3.45	2.1	5.6	61.6	5.3	0.36	4	
30	4	33	3.0	0.8	0.17	0	0.03	4.00	2.4	6.4	62.5	5.3	0.30	6	
36	6	33	3.1	1.1	0.20	0	0.03	4.43	2.3	6.7	66.1	5.2	0.30	8	
48	4	33	2.8	1.5	0.11	0	0.03	4.44	2.3	6.7	66.3	5.5	0.27	7	
53	10	23	2.7	1.4	0.09	0	0.01	4.20	2.4	6.6	63.6	6.3	0.24	4	
								N% 0.362 0–4"							

Depth Ins.	Mechanical Analysis		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total Bases							
								BUYAGA							
Njereka, Busoga.								Profile 29 (20491-96							
3	n.d.	n.d.	10.8	3.0	1.33	0	<.02	15.3	1.9	17.0	89.0	6.4	12.75	170	
9	12	37	4.5	1.8	0.31	0	0	7.11	1.6	8.7	81.7	5.9	8.20	23	
18	9	37	2.6	1.4	0.27	0	0	4.27	2.6	6.9	61.9	5.3	5.15	12	
36	3	37	1.6	1.4	<.16	0	0.02	<3.18	2.9	6.1	52.1	5.3	3.85	13	
60	4	49	1.4	2.0	<.16	0	0.02	<3.58	3.1	6.7	53.4	5.2	1.80	7	
72	10	43	1.7	1.4	0	0	0	3.1	3.1	6.2	50.0	5.7	1.65	9	
								N% 0.423 0-3/							
								Profile 30 (20503-07)							
Kibinga, Busoga.															
3	10	41	4.1	2.4	1.16	0	0.08	7.74	4.2	11.9	65.0	6.0	1.70	29	
9	8	42	2.7	1.8	<.16	0	0.04	<4.7	6.4	11.1	42.4	5.0	0.93	7	
18	6	46	1.8	1.4	0.52	0	0.03	3.75	4.4	8.2	45.7	5.0	0.41	7	P deficient
36	6	46	1.6	<.6	0.16	0	0.03	2.39	4.1	6.5	36.8	5.0	0.36	8	
60	4	45	2.2	1.4	0.39	0	0.03	4.02	4.0	8.0	50.3	5.0	0.35	5	
								N% 0.146 0-3"							
								Profile 31 (19828-32)							
Kidongole, Teso.															
4	6	22	1.9	0.9	0.27	0	0.03	3.10	4.2	7.3	42.5	5.4	1.25	25	P deficient
10	6	58	1.8	1.2	<0.16	0	0.03	<3.19	4.8	8.0	≙39.9	5.2	0.94	8	Bases deficient
20	6	42	<0.8	<0.6	<0.16	0	<0.02	<1.58	5.6	7.2	≙21.9	5.0	0.57	5	
32	6	42	<0.8	<0.6	<0.16	0	<0.02	<1.58	5.9	7.5	≙21.1	4.9	0.24	7	
50	2	46	<0.8	<0.6	0.40	0	0.03	1.83	5.6	7.4	24.7	4.7	0.58	13	
								N% 0.139 0-4"							

Depth Ins.	Mechanical Analysis Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
									BUKEDEA						
Kachumbala, Teso.								Profile 32	(19334-38)						
4	6	19	<0.8	<0.6	0.33	0	0.05	<1.78	3.9	≙5.7	≙31.2	5.3	0.90	14	
12	4	26	<0.8	<0.6	0.28	0	0.02	<0.70	5.3	≙7.0	≙24.3	4.8	0.59	4	
22	5	32	<0.8	<0.6	Trace	0	0	<1.4	5.7	≙7.1	≙19.7	4.8	0.48	0	P deficient
32	6	34	<0.8	<0.6	0	0	0	<1.4	5.7	≙7.1	≙19.7	4.9	0.44	7	
32+	8	38	<0.8	<0.6	Trace	0	0	<1.4	5.7	≙7.1	≙19.7	5.1	0.41	4	
								N% 0.065	0-4"						N deficient
									BURULI						
Mulanda, Bukedi.								Profile 33	(13653-57)						
4	5	22	6.9	1.3	1.46	0	0	10.16	1.7	11.9	85.4	6.5	0.83	9	
18	6	24 ?	6.6	<0.6	1.76	0	0	<8.96	0.8	9.8	91.4	6.4	0.78	6	
29	4	0	<0.8	0	<0.16	0	0.02	<0.98	1.3	2.3	42.6	5.3	0.15	10	P deficient
35	7	25	7.5	1.3	1.11	0	0	9.91	1.4	11.3	87.7	6.1	0.46	5	
35+	7	25	8.9	0.9	0.48	0	0	10.28	0.1	10.4	98.8	7.3	0.47	27	
								N% 0.076	0-4"						N deficient
Kanyum, Teso.								Profile 34	(19523-27)						
6	6	19	1.4	<0.6	<.16	0	<.02	2.18	3.2	5.4	40.4	5.2	0.60	3	
12	2	31	1.2	<0.6	<.16	0	<.02	1.98	4.8	6.8	29.1	5.2	0.57	0	P deficient
24	6	35	1.7	0.9	<.16	0	<.02	2.78	5.1	7.9	35.2	5.3	0.65	7	Bases deficient
60	6	41	0.8	<0.6	<.16	0	<.02	1.58	5.2	6.9	22.9	5.4	0.48	24	
60+	8	35	2.7	1.5	0.38	0	0.02	4.60	5.6	10.2	45.1	5.5	0.29	9	
								N% 0.096	0-6"						N deficient
Lumino, Bukedi.								Profile 35	(13658-62)						
5	7	37	5.9	1.1	0.88	0	0	7.88	3.3	11.2	70.2	6.0	1.40	7	P deficient
16	2	23	3.9	1.1	0.28	0	0	5.28	3.5	8.8	60.0	5.9	0.94	5	
31	5	33	2.7	0.7	0	0	0.04	3.44	4.1	7.5	45.9	5.5	0.62	5	
42	8	35	2.1	<.6	0	0	<.02	<2.72	3.6	≙6.3	≙43.2	5.6	0.44	7	
42+	6	40	3.0	0.6	0.44	0	0	3.04	3.0	6.0	50.7	5.6	0.24	12	K ex fresh minerals
								N% 0.075	0-5"						

Depth Ins.	Mechanical Analysis		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total Bases							
AMURIA															
Arapai Farm Institute, Teso.								Profile 36 (9531-33)							
6	3	12	4.1	1.1	0.44	0	0.03	5.67	5.2	8.9	63.7	6.0	1.10	22	
10	3	23	5.6	0.8	0.50	0	0.02	6.92	3.3	10.2	67.8	5.8	0.92	4	P deficient) Leaching impeded by Laterite
18	1	30	4.7	1.2	0.42	0	0.03	6.35	3.7	10.1	62.9	6.0	0.86	0	P deficient)
								N% 0.112 0-6"							
Arapai Farm Institute, Teso.								Profile 37 (9533-38)							
3	7	10	2.0	1.1	0.33	0	0.02	3.51	2.9	6.4	54.8	6.0	0.96	18	
6	9	16	1.3	< .6	0.23	0	0.03	<2.66	4.3	≐7.0	≐38.0	5.3	0.87	3	
12	5	28	1.6	< .6	< .16	0	0.04	<2.40	5.3	≐5.3	≐31.2	5.1	0.78	8	
24	1	36	0.9	0.9	< .16	0	< .02	<1.93	5.1	≐7.1	≐27.9	5.1	0.72	6	P deficient
33	3	36	4.4	0.9	< .16	0	< .02	<5.48	4.3	≐9.8	≐55.9	5.2	0.53	18	
55	5	40	3.9	0.8	< .16	0	< .02	<4.8	4.9	≐9.7	≐49.5	5.5	0.41	6	
								N% 0.102% 0-3"							
7 miles north of Amuria, Teso								Profile 38 (19230-42)							
6	2	21	3.6	< .6	< .16	0	< .02	<4.03	2.6	≐4.3	≐94.9	5.6	0.89	9	
12	2	27	2.8	< .8	0	0	0	<3.4	3.2	≐6.6	≐51.5	5.7	0.83	5	P and K deficient
24	4	35	1.9	1.3	0	0	0	3.2	3.8	7.0	45.7	6.5	0.74	9	
36	n.d.	n.d.	2.0	0.6	0	0	0	2.6	4.0	6.6	39.4	5.3	0.61	0	
								N% 0.079 0-6"							
Kumi, Teso.								Profile 39. (19339-43)							
6	0	6	1.2	<0.6	< .16	0	< .02	<1.93	1.5	≐3.6	≐55.0	5.4	0.36	4	
24	3	3	1.5	<0.6	0.31	0	< .02	<2.43	1.6	≐4.0	≐60.8	5.7	0.45	6	N, P, K deficient
40	4	9	1.4	0.6	< .16	0	0	<2.16	1.3	≐3.5	≐61.7	5.7	0.25	5	
60	2	22	<0.8	0.8	0.40	0	< .02	<2.02	3.2	≐5.2	≐38.8	5.3	0.25	6	
120	6	27	<0.8	<0.6	0.39	0	< .02	<1.79	4.7	≐6.5	≐27.5	5.3	0.25	6	
								N% 0.043 0-6"							Low N

Depth Ins.	Mechanical Analysis		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total Bases							
									MAZIMASA						
								Profile 40	(13626–29)						
Nagongera, Bukedi.		Site 1.													
5	6	0	1.6	< .6	0.28	0	0	<2.48	1.2	≙3.7	67.0	6.8	0.41	45	Mg deficient
14	4	0	1.4	<.6	0.21	0	0	<2.21	1.2	≙3.4	65.0	6.4	0.33	15	throughout
30	8	0	<.8	<.6	0.19	0	0.02	<1.61	2.0	≙3.6	44.7	5.8	0.23	13 }	P deficient
42	8	6	< .8	<.6	0.23	0	0.03	<1.66	2.7	≙4.4	37.7	5.2	0.22	10 }	
								N% 0.036	0–6"						Low N
								Profile 41	(13615–18)						
Nagongera, Bukedi.		Site 2.													
6	6	0	1.1	<.6	0	0	0.02	<1.72	1.3	≙3.0	≙57.3	5.9	0.26	15 }	
15	4	0	<.8	<.6	0	0	0.02	<1.42	1.7	≙3.1	≙45.8	5.8	0.23	5 }	N, P and
30	4	0	<.8	0	0	0	0.02	<0.82	2.0	≙2.8	≙29.3	5.6	0.17	20 }	base deficient
30	4	0	<.8	<.6	0	0	0.02	<1.42	2.2	≙3.6	≙39.4	5.3	0.17	6 }	
								N% 0.036	0–6"						
								Profile 42	(13619–21)						
Nagongera, Bukedi.		Site 3.													
4	4	0	4.4	<.6	0.31	0	0	<5.31	0.5	≙5.8	≙91.6	6.8	0.80	290 }	High P –
23	4	0	4.8	<.6	0.22	0	0	<5.62	0.4	≙6.0	≙93.7	7.2	0.51	82 }	old kraal or boma site
23+	8	0	3.4	<.6	0.20	0	0	<4.20	0.1	≙4.3	≙97.7	7.3	0.38	15 }	
								N% 0.094	0–4"						
								Profile 43	(13622–25)						
Nagongera, Bukedi.		Site 4.													
5	6	0	5.9	<.6	0.35	0	0	<6.85	0.2	≙7.1	≙96.5	8.0	0.50	620 }	High P and pH
13	6	0	4.5	<.6	0.24	0	0	<5.34	0.1	≙5.4	≙98.9	8.2	0.56	130 }	old boma or kraal
32	6	0	2.6	<.6	<.16	0	0	<3.36	0.1	≙3.5	≙96.0	8.2	0.20	37 }	site
40	6	0	2.3	0.9	0	0	0	<3.2	0.5	3.7	86.5	7.8	0.17	24 }	
								N% 0.057	0–5"						

Depth Ins.	Mechanical Analysis Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
								Profile 44 (10637-40)							
Iki-Iki, Bukedi.															
6	9	23	9.6	2.4	0.78	0	0.03	12.96	5.3	18.3	70.8	6.0	1.65	33	Leaching impeded
12	9	23	5.0	2.1	0.33	0	<.02	7.45	4.8	12.3	60.6	6.1	1.46	5	by laterite
18	5	29	3.2	1.9	0.25	0	<.02	5.35	5.0	10.4	51.4	5.9	0.89	1	P deficient
28	-	-	3.0	1.5	0.20	0	<.02	4.72	4.9	9.6	49.2	5.8	0.37	2	
								N% 0.137 0-6"							
									USUKU						
								Profile 45 (10217-21)							
Katakwi, Teso.															
6	4	0	<.8	<.6	<.16	0	<.02	<1.4	0.8	≏ 2.2	≏63.6	6.6	0.43	4	
18	6	0	<.8	<.6	<.16	0	<.02	<1.4	1.3	≏ 2.7	≏51.9	5.8	0.33	1	Bases and
40	3	4	<.8	<.6	<.16	0	<.02	<1.4	1.3	≏ 2.7	≏51.9	5.3	0.24	3	P deficient
63	6	4	<.8	1.7	<.16	0	<.02	<2.5	1.1	≏ 3.6	≏69.4	5.4	0.23	6	
75	8	6	<.8	1.3	<.16	0	<.02	<2.1	1.5	≏ 3.6	≏58.3	5.0	0.21	6	
								N% 0.059 0-6"							N Deficient
								Profile 46 (19243-49)							
Obalanga, Teso.															
6	5	0	<.8	<.6	0	0	0	1.4	1.1	2.5	56.0	5.2	0.28	5	
12	2	6	<.8	<.6	0	0	0	1.4	0.8	2.2	63.6	5.4	0.23	4	
24	2	6	0	<.6	0	0	0	<.6	1.3	1.9	31.6	5.2	0.23	9	N, P and base
36	6	5	0	<.6	0	0	0	<.6	1.4	2.0	30.0	5.0	0.21	9	deficient
48	2	23	<.8	<.6	0	0	0	1.4	2.6	4.0	35.0	4.9	0.29	8	
60	4	32	1.2	1.3	0	0	0	2.5	2.6	5.1	49.0	4.9	0.28	0	
72	6	37	1.9	1.3	0	0	0	3.2	2.6	5.8	55.2	5.2	0.22	2	
								N% 0.040							
									LWAMPANGA						
								Profile 47 (18604-06)							
Busiba, Bukedi.															
6	4	0	<.8	<.6	0	0	0.02	<1.42	1.5	2.9	48.3	6.0	0.32	31	N and base
30	4	0	<.8	0	0	0	0.03	<.83	1.2	2.0	40.0	5.8	0.16	39	deficient
36	6	0	<.8	0	0	0	0.03 N%	<.8 0.037	1.3 0-6"	2.1	38.1	5.6	0.14	20	

	Depth Ins.	Mechanical Analysis Silt	Mechanical Analysis Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total Bases	Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
									Profile 48 (13771-73)							
Xigingi, Busoga.																
	6	5	23	3.4	3.2	1.14	0	0	7.8	2.1	9.9	78.8	6.3	0.93	850	High P due to bird droppings
	16	5	31	2.1	2.7	1.48	0	0	6.3	2.4	8.7	72.4	6.2	0.49	33	
	23	10	31	5.1	3.8	0.94	0	0	9.8	2.7	12.5	78.4	5.9	0.41	66	
									N% 0.09 0-6"							
									UNDIFFERENTIATED ALLUVIUM							
									Profile 49 (11332-37)							
Ago Bridge, Teso.																
	6	11	61	16.4	8.1	0.5	1.8	0.05	28.85	12.1	41.0	70.4	4.9	2.06	105	Montmorillonitic clay mineral present
	12	6	65	18.8	9.3	0.5	2.8	0.0[illegible]	31.42	8.4	39.8	78.9	5.1	1.26	41	
	24	8	67	18.8	8.1	0.3	2.8	0	30.0	6.5	36.5	82.2	5.5	1.08	9	
	36	5	58	22.7	9.3	0.3	3.0	0.02	35.32	3.4	38.7	91.3	5.9	0.76	20	
	43	5	67	22.7	11.8	0.6	3.9	0	39.0	2.0	41.0	95.1	6.4	0.44	11	
	60	7	69	22.7	12.5	0.6	3.8	0	40.6	1.5	42.1	93.4	6.5	0.30	35	
									N% 0.298 0-6"							
									Profile 50 (11356-61)							
Omunyal Swamp, Teso.																
	4	15	46	13.2	4.6	1.1	<.3	0.20	19.40	11.5	30.9	62.8	4.9	4.49	540	High P and C
	16	5	70	15.4	7.2	0.5	0	0.05	23.15	5.3	28.5	81.2	5.7	0.80	10	
	28	2	72	15.0	4.9	0.4	0	0.02	20.32	4.7	25.0	81.3	5.6	0.53	9	
	40	9	73	13.8	4.4	0.3	0	0.02	18.52	9.0	27.5	67.3	5.7	0.44	14	
	52	6	72	18.5	5.2	0.3	<.3	<.02	24.0	4.6	28.6	83.9	5.8	0.48	10	
	64	4	78	15.0	4.4	0.3	0.6	<.02	20.3	4.6	24.9	81.5	5.9	0.39	12	
									N% 0.331 0-4"							

Depth Ins.	Mechanical Analysis		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H	Exch. Capacity m.e.	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total Bases							
								Profile 61 (19261-67)							
Okok Swamp, Teso.															
6	10	58	10.2	9.1	0.39	0.7	0.02	20.41	5.1	25.5	80.0	4.2	1.07	6	Low organic
12	12	55	11.7	10.7	0.38	1.3	0.02	24.10	4.8	28.9	83.4	5.4	1.03	8	carbon
24	12	57	13.4	10.7	0.50	1.3	<.02	25.90	4.5	30.0	86.3	5.4	0.93	4	P deficient
36	14	59	16.4	15.1	0.87	1.7	<.02	34.07	4.1	38.2	89.2	5.5	0.95	4	
48	12	50	20.9	14.8	0.81	2.0	0	38.51	1.9	40.4	95.3	6.1	0.62	4	Montmorillonitic
60	10	59	21.1	13.9	0.81	1.6	0	37.41	1.1	38.5	97.5	6.5	0.50	6	clay mineral
72	14	58	24.6	13.2	0.78	1.8	0	40.38	1.0	41.4	97.5	6.5	0.33	8	
								N% 0.079	0-6"						Low N
								Profile 52 (9948-54)							
Mbalemuti, Busoga.															
6	14	30	11.0	8.2	1.65	<.3	0.05	11.00	n.d.	n.d.	n.d.	5.8	8.90	920	High P and C
12	12	30	6.2	7.2	0.67	<.3	0.05	14.42	"	"	"	5.3	1.40	81	
24	11	48	11.1	10.1	0.81	0.6	0.23	22.24	"	"	"	4.1	0.30	15	
36	14	49	10.7	11.6	0.28	0.8	0.31	23.64	"	"	"	3.3	0.27	8	Free H_2SO_4
48	13	43	8.7	9.4	0.25	1.0	0.84	19.69	"	"	"	3.5	0.18	6	present
60	13	28	10.0	7.4	0.22	0.6	0.24	18.46	"	"	"	3.6	0.14	10	Low P
72	5	30	9.2	7.4	0.16	0.6	0.25	17.61	"	"	"	3.9	0.09	8	
								N% n.d.	0-6"						

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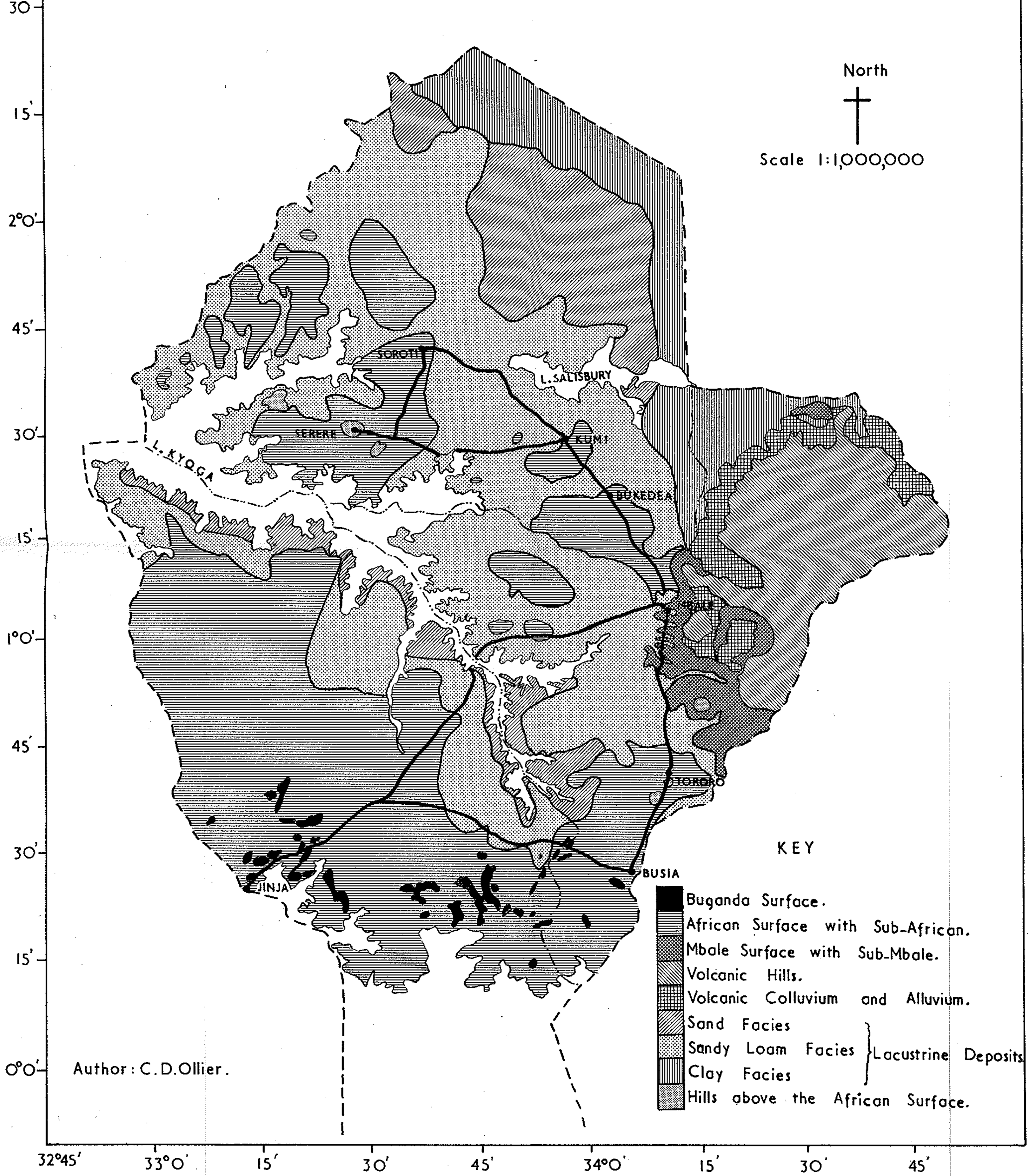
GEOMORPHOLOGY OF EASTERN PROVINCE



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