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KENYA SOIL SURVEY

The soils of Karamoja District-northern province of Uganda

by

J.G.Wilson 1959

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NORTHERN PROVINCE OF UGANDA

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THE SOILS OF KARAMOJA DISTRICT
NORTHERN PROVINCE OF UGANDA

by J.G. Wilson

GENERAL DESCRIPTION OF THE DISTRICT

Karamoja District, including Karasuk, occupies about 13,000 square miles* of the eastern side of the Northern Province of Uganda. It is bounded in the north by the Sudan Republic and to the east by Kenya Colony. Much of the area is a wide, very flat plain at about 3,700 feet above sea level which is an extension of the main plain of central and northern Uganda. The district is, however, not entirely featureless as several mountain masses up to 10,000 feet in height and hill ranges, besides isolated hills from 6,000 to 9,000 feet, arise from the surface and thus break the monotony. The mountain masses may be isolated as in the case of the four volcanoes, Toror, Moroto, Napak and Kadam, or may be part of ranges such as the Chemorongit and Labwor hills. The eastern border is terminated sharply along the whole of its length by a steep scarp commonly known as the Turkana escarpment.

The scenery overall is that of a semi-arid country with large areas of Acacia bushland and thicket and little actual ground cover. Erosion phenomena are widespread over all the drier parts of the district. A further marked feature, typical of semi-arid areas, is the frequent occurrence of ephemeral streams and rivers.

Karamoja is sparsely populated by a primitive group of tribes, the Karamojong and, to a much lesser degree, the Suk. In adaptation to their semi-arid habitat these people are largely pastoral but they do practise some cultivation. Cattle are kept in very large numbers and are the mainstay to the life of the community. But there is an ever increasing tendency to cultivate cereal foods.

AIMS AND METHODS

The purpose of the soil survey is to depict on a map the different kinds of soil occurring in the district, either as types, series or topographic associations (catenas) or complexes of these units. Because there is such a very close correlation between soil and vegetation it was also convenient to map the latter at the same time with very little extra effort.

The soil survey, concurrently with a vegetation survey was

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* The exact area has never been computed as the boundaries have not yet been surveyed.

commenced at the end of 1955. They were initially and finally conducted from a base in the district headquarters at Moroto with an intervening period of 18 months spent at various temporary field stations. Mapping of the different soil units has been carried out by interpretation of the aerial photographs of the district which has enabled a detailed and accurate map to be produced. Boundaries of the different soil units were usually very easily seen through the stereoscope on the aerial photographs and could be delineated accurately by known correlations with topography. The information was transferred by free hand directly on to the 1:50,000 Preliminary Plot Sheets prepared by the Directorate of Colonial Surveys. These sheets contained the check points for the photos and most topographic features and practically all waterways, from wide rivers to small streams. The 1:50,000 soil maps constructed in this way were then photographically reduced to 1:250,000 and the reduction transferred to the basic East African 1:250,000 grid charts. Coloured maps on this scale will eventually be printed, but for the time being a black and white map on the scale of 1:500,000 will accompany this memoir, so as not to delay distribution.

Extensive field work was carried out in conjunction with the aerial photograph interpretation and numerous check traverses were made along the roads of the district. Since roads were few and far between, large areas have had to be examined on foot traverses, distances of up to 30 miles being covered in a single day. During these activities, 147* soil profiles were sampled and several hundreds were described in detail from pits freshly dug, murram pits, river banks, gullies etc.

A great deal of information on the geological, topographical, climatic and vegetative relationships with soil has been obtained. Information has also been collected on land-use and on such phenomena as erosion. It is hoped that the soil map and the subsidiary maps on erosion, erosion surfaces, present and potential land-use will serve as a basis for future planning and development of the district.

CLIMATE

The greater part of Karamoja is semi-arid, the least arid parts being on the western and north-western borders of the district. Rainfall is episodic in occurrence, alternating with a prolonged severe dry season. Limits range between a probable 15 inches per annum in the driest parts to 35 inches on the western boundary. Somewhat more rainfall occurs on the higher mountains. There is considerable variation from year to year in the total annual rainfall

* 131 of these were analysed.

and in its distribution. However, the general pattern is one of commencement of the rains in April and cessation in September. The period of effective plant growth is only from April to the end of August, because intense drought extends from November to the end of March. The months of September and October are generally transitional from humid and cool to hot and dry.

The relative incidence of rainfall is the most important factor affecting plant growth, the drier eastern areas where the range is from 15 to 25 inches can only support a subsistence agriculture. Areas with a somewhat higher rainfall could support a wider based agriculture with the cultivation of some economic crops. Where rainfall is in excess of 35 inches per annum such as the higher mountains, suitable parts could support a perennial crop agriculture. The period of incidence of effective rainfall on the higher mountains is generally longer than on the plains. Slight and scattered showers during the dry season are not a factor of much importance to agriculture on the plains but on the mountains they may be important. Effects of "dry season rain" on grass growth are negligible in the short-grass areas but they are of importance in the long-grass areas.

Temperatures in the district are as high as 96°F in the shade during the dry season and over 90°F is generally prevalent during the months of January, February and March. Temperatures in the rainy season do not often exceed 85°F in the shade. Temperatures often fall at night to below 60°F.

The humidity, or the lack of it, is another important factor affecting plant growth in Karamoja during the dry season. When it falls very low and is coupled with hot dusty winds and the absence of rain it brings about rapid desiccation of growing crops and grass. In the short-grass areas at the end of the rainy period a 3-4 week drought completely transforms green grass into a dead, tinder-dry condition.

<u>GEOLOGY</u>

Like Eastern Province and the rest of Northern Province, Karamoja is underlain by pre-Cambrian metamorphic rocks of the Basement Complex. These were originally laid down under water as sediments which were later metamorphosed by heat, pressure and solution effects to gneisses, schists and quartzites. The process was roughly as follows:-

Into the early sedimentary rocks came numerous, massive acid or slightly basic granitic intrusions: these intrusions were injected in a molten state and appeared as massive batholiths, altering the rocks through which they had passed by contact along the planes of stratification, joints and surfaces. Weathering and removal of the softer country rocks leaves behind these harder, more erosion resistant, plutonic rocks. After long continued erosion processes the larger intrusions stand out from the surrounding plain as residual hill ranges, e.g. the Labwor hills. Plutonic rocks where exposed show very marked jointing, the joints often occurring at right angles to each other. Weathering and subsequent erosion of these rocks leave the hardest members standing out as castle-like tors or kopjes, with large cuboidal rocks perched one on top of the other, e.g. around Loyoro.

At a much later date, during the Tertiary period, a few widely scattered large scale extrusions of volcanic material took place. The period of vulcanicity occurred on a land surface, the relics of which remain to-day several hundred feet above the level of the plain, e.g. the sub-volcanic surface of Moroto mountain. Four immense single-cone volcanoes were created by the ejection of basic magmatic material. The volcanoes were built up by repeated lava flows which may still be discerned as parallel beds. Large amounts of ash were also ejected, much of which became consolidated to form tuffs.

Little segregation of valuable minerals has taken place in the Basement Complex except in the eastern part of the district, including Karasuk; a little has also occurred in or adjacent to the plutonic rocks (Fleuty, 1959). So far no mineral deposit of economic importance has been found. During the course of the soil survey a number of interesting, small deposits were revealed in Karasuk/ and around Moroto. The minerals were beryl, cuprite, columbite, corundum, garnet, graphite, haematite, ilmenite, kyanite, limestone (crystalline), magnesite, magnetite, talc, tantalite and zircon.

Dating of rock formations and erosion surfaces is very difficult in Africa because of the rarity of fossils. The writer was fortunate in discovering no less than seven sites of mammalian fossils. Four were in the vicinity of Napak and three at the foot of Moroto mountain. All had been buried by volcanic material and later re-exposed by erosion. A third fossil location, of minor importance, has been found in the bed of the Apule river. Among the fossils found at Napak were the complete skulls of an early hyrax, the teeth of an early elephant and various bones and teeth belonging to other animals including proconsul, the precursor of the higher apes. At the foot of Moroto Mountain well-preserved teeth of a possibly hitherto unknown species of prehistoric elephant were recently disclosed, also numerous bone fragments belonging to elephants, bovids and various other animals and reptiles.

These findings are of major importance as they will enable vertebrate palaeontologists to estimate more accurately the age of the volcanic mountains of Karamoja and the minimum age of the land surface over which they erupted. Bishop (1958), who later examined the Napak sites in detail, is of the opinion that the age of the fossils is early Miocene. This means that the land surface (African surface) on which the animals roamed must have been at least of the same age, which is much older than many geologists considered possible.

GEOMORPHOLOGY

The Karamoja Plain

The most striking features of this district are the vastness of the major erosion surface, known as the Karamoja plain, the abruptness of the mountains which emerge from it and the broad sandy beds of fast rising rivers. The Karamoja plain is considered part of the "African Surface"; it is of end-Tertiary age and is described by L.C. King (1951) as a pedeplain. By this is meant a plain of low relief composed of many interlocking, concave pediments, being derived from a less mature state, by gradual erosion of outstanding features. The plain extends as far east as the Suam-Kyoga watershed and north from there along the Turkana escarpment well into Dodoth county, where it is limited by the Dopeth-Kapeta watershed. It then extends southwards and passes slightly to the east of the Labwor hills and finally curves round south and west of this hill. The greatest degree of flatness is attained on the western borders of the district; in the south-west near Lake Opeta the Karamoja plain stands at a level of about 3,400 feet. Proceeding northwards from Lake Opeta along the district border, it rises slightly to about 3,550 feet at the Okok river on the Teso border. Proceeding eastwards and south of Kadam mountain, the plain is upwarped to 4,550 feet elevation on the Suam-Kyoga watershed. Between Kadam and Moroto the plain is bordered by a long ridge which is a continuation of the Suam-Kyoga watershed, at the base of the ridge at Kakumongole it is about 3,900ft. above sea level (Trendall, 1959). Continuing northwards, it appears to breach the ridge, and continues into the base of Moroto mountain near Lokitonyala, as a headward extended valley system of the Manimani river, rising as high as 4,550 feet. North of Moroto mountain it follows the perimeter of the Turkana escarpment up to the base of the Nagosi hills and the extended Koten-Ibok chain, rising above Kaabong to an elevation of over 5,000 feet; then by gradual pedimentation it drops to the Kapeta-Dopeth watershed at an elevation of from 4,500 to 4,000 feet.

The Karamoja plain shows an immense expanse of a very low concave-pedimented surface from its base level, up to about the 4,000 foot level. Above this level the topography becomes more rolling, in direct relationship with increase in altitude, the eastern and northern extremities having more numerous, smaller pediments with deeper valleys than the central and western parts. The drainage system of the plain is most complex along the eastern and northern margins where it is composed of frequent rapidly grading streams of mature profile. Some youthful characters are exhibited such as steep valleys only where the surface rises at its perimeter, sometimes to as much as 5,000 feet. Equilibrium between downcutting, deposition and flow (grade) is fairly rapidly attained and resultant coalescence to form a few major tributaries takes place. This is accompanied by considerable deposition of alluvial material, on either side of the river banks, the deposits extending for as much as 2 miles in width. Such development is typified by the coalescence of the Apule, Lumeno, Matheniko and Masupu rivers, which join up with the Manimani system to form the Lochomon; the Lochomon being a large, sluggish river forming multi-cross braided channels with considerable lateral spread as it reaches a level of about 3,700 feet. The middle reaches of the large rivers tend to meander considerably with the occasional development of "ox-bows". The present day flood channels of the larger rivers form trenches in the older alluvium up to 100 yards wide and 20 feet deep. These are lined with coarse, water-bearing sand several yards thick. All travellers in Karamoja sooner or later have to contend with these sand beds as they are extremely troublesome to cross when unconsolidated.

Apart from the major plain there are relics of four more, probably older erosion surfaces, and three much younger, more or less intact plains. The younger surfaces will be described first. These are the Kunyao plain (Trendall, 1959), the Chapeth-Kapeta plain and the Kidepo plain. The last two which are described here for the first time are very much younger than the others but their exact correlation has not been worked out.

In the south east of Karamoja lying between the Chemorongit hills and the Turkwell-Nile watershed ridge and south of Moroto mountain, a relatively young erosion surface has been cut by the Kanyangaring and Kunyao rivers. This erosion surface has been mentioned by Trendall (1959). The surface in outline is relatively elongated and narrow, stretching in a rough north-south direction. The northern end reaches an elevation of over 5,000 feet and gradually grades down to a base level of approximately 3,600 feet at the junction of the Suam and Kunyao rivers, over a distance of approximately 40 miles. This surface exhibits the phenomenon of a sub-mature to mature state overall, with the development of fairly steep-sided valleys in the northern end, where the drainage systems are rapidly aggrading streams. A slow levelling is apparent as one proceeds southwards, but a grading-cum-downcutting effect is still exhibited by the Kanyangareng at Amudat with adjacent steep valley sides and the exposure of quite a lot of bare rock by the reduction of the soil mantle. Where the Kanyangareng forms the Kunyao the surface levels out considerably and pediments have, to some extent, coalesced into larger and flatter units. Some minor development of alluvial deposits has also taken place. Around Kacheliba and Karameri a few residual hills and inselbergs stick out, the inselbergs at Kacheliba being a small cluster of very steep-sided granite kopjes. The rocks of the Karameri ridge are metamorphic in origin and consist of a micaccous quartzite which contains the chromium mica fuchsite.

In the north east of Karamoja a relatively minor erosion surface has been cut by the Chapeth and Kapeta rivers which are tributaries of the Pager river in Acholi. This surface extends from an elevation of about 3,450 feet at the Karamoja border up to about 5,000 feet, being initially flat and well planod, but becoming more rugged and more dissected as elevation increases. There is no pronounced scarp between this surface and the main Karamoja ("African") surface, only a low ridge separates the two. There is a pronounced scarp, however, where the surface meets the bases of Morongole, Lotim and Lwala mountains. The rivers exhibit very similar phenomena to those of the main Karamoja plain. Grade is achieved rapidly in the upper reaches of the tributaries with the development of thick sand and stone choked beds. The rivers Lakalas, Kapeta and Kanapedi coalesce into a single braided channel in which there are considerable deposits of fine-grained material and occasionally development of semi-swamp conditions.

A further minor surface has been cut by the Kidepo river system in the form of a Y, by the two rivers, the Kidepo and Narus. An erosion surface sloping gradually westwards has been cut by the headward advance of the two river systems into the higher ground to the east. This surface on the Sudan border is at about 3,700 feet at its lowest point with extended valley perimeters rising to between 4,000 and 5,000 feet; on these perimeters fairly deep, relatively steep-sided secondary valleys have been cut by the consequent and subsequent streams.

The Pre-African Surfaces

In addition to the volcanoes rising from the Karamoja plain there are many smaller protrusions which are relics of other land surfaces, now existing as sharp ridges and inselbergs. In a few cases the ancient surfaces may be discerned in flat-topped hills of about the same elevation. These ancient surfaces are the base levels of former erosion cycles; they are depicted in the geomorphological map. Davies (1948) recognized four surfaces as follows:-

i. A mid-Tertiary surface represented by a fairly level sub-volcanic surface standing between 4,900 and 5,000 feet under Moroto, Kadam, Napak and Toror mountains.

ii. A narrow relict surface at the base of the Chemorongi hills stretching as a clearly defined plateau from Lokitonyala down to Amadat.

iii. A 6,000 foot erosion surface of Cretaceous age exemplified on Mount Zulia and summit levels of Magosi hills which is the Gondwana surface of L.C. King and others.

iv. A 10,000 foot plain represented by the summit levels of the Chemorongit hills and possibly the summit of Mount Morongole.

These four surfaces will now be considered in turn.

i. The mid-Tertiary or sub-volcanic surface under the main volcanic mountains is the lowest relict surface in Karamoja, standing above the plain at a level of 4,900 - 5,100 feet as it exists under Moroto mountain. However, little of this surface extends beyond the protective mantle of the overlying volcanic rock and it is relatively unimportant. The mid-Tertiary surface may extend, however, as relicts right up the Turkana escarpment and through the Magosi hills northwards as a rough line as far as Nakwamovu. Probably contemporary with the sub-volcanic surface is the ridge (now traversed by the new Mbale-Moroto road) along the Kyoga-Turkwell watershed with a long north-south strike and a summit level of slightly over 5,000 feet extending under Kadam, which would indicate a relict surface comparable with the mid-Tertiary 5,000-foot surface. To the west of this ridge a number of inselbergs have been isolated by the advance of the Karamoja plain which ends abruptly in places as a steep scarp. The eastern perimeter of the ridge is not so well defined, as it merges more gently into the surrounding landscape.

ii. This narrow surface is extremely dissected and is only revealed by the concordance of summits of 5,500 feet, a few of which are flat topped. It is impossible, at present, to correlate them with other surfaces in the Protectorate.

iii. It is extremely difficult to distinguish between relics of the mid-Tertiary surface and the Gondwana surface, due to the reduction of land features to steep-sided inselbergs and residual hills. However, it is possible to compare the relative pediment levels, and the relative summit levels with that of the surrounding Karamoja plain.

The Magosi hills and the Koten to Nakwamoru range have many features in common, the main hills such as Moruangome, Sogolimen and Ibok arise from pediments of about 5,000 feet to summits varying between 5,300 and slightly over 6,000 feet. Two further chains of residual hills and inselbergs are clearly defined running in a north-south direction. The first chain runs from Lading southwards through Loyapong and Nakawach to Theau with summits ranging from 6,288 to 4,770 feet. The second chain, roughly parallel to the first, arises at Lokwakut at 6,048 feet, extending through a chain of inselbergs and elevated land to Maru at 4,703 feet.

These chains, if followed from their southern limits, will be seen to join a much larger and more intact land surface at over 5,000 feet with many concordant summit hills at an elevation close to 6,000 feet. The evidence provided by these higher features suggests that there was once a much more extensive surface with a probable level at about 6,000 feet.

Dixey (1948) mentions Mount Zulia, one of the summits of the area, as having a pronounced plateau top at a little above 6,000 feet. There are also a number of other fairly flat-topped summits or near summit levels scattered over the area, notably Lemej, Lomil, Lokineng, Katorosa and many others. The bases of Morongole, Lotim and Lwala mountains all stand at about a 6,000-foot level.

The dissection of this area of high land is in itself significant, as it is the meeting place of one major (the Karamoja plain) and two minor erosion surfaces all terminating in this area, with the production of immature land forms and numerous inselbergs. In fact the three surfaces rise considerably in their upper reaches as they approach their terminals. In places a pronounced erosion scarp exists between the ancient and the more recent surfaces as exemplified near Kalapata and around Lemej.

It is also significant that there exist numerous large and small elevated land forms close to the main northern mass which appear to have been isolated by the advance of the different erosion surfaces. One such large mass is the Lokilokaka-Lonyili ridge lying mainly in the Sudan with a well-defined plateau surface slightly over 6,000 feet. The extension of the ridge is clearly extended southwards through Kaleri to Nyangea, Kaleri having a well defined 6,000-foot plateau and much of the extended ridge being over 5,500 feet.

The pattern of dissection of the once extensive surface appears to be cut by a one-cycle erosion phase reducing the original surface, without intermediate levels, to the present day surface. The drainage pattern over all the elevated area follows faithfully a structural line pattern as determined by faulting in the underlying rock. At the same time, the advance of the intruding new land surfaces also follows the main structural lines. The north-south directional flow of the Lakalas, Koputh and Loyoro systems with an east-west tributary pattern demonstrate this. They also show a one-cycle dissection of the 6,000-foot surface to the existing lower surface.

There is evidence to show that the 6,000-foot surface existed at one time at least as far south as Loyoro, as the summit levels of residual hills show. South of Loyoro there is also evidence of another ancient land surface in the numerous inselbergs which occur there, but the evidence of a 6,000-foot level is not so marked.

The Labwor hills to the south and east of the northern mass are a further extended chain of inselbergs. They resemble in many ways the Magosi hills in structure, altitude and direction. The summit levels of the Labwor chain vary between 5,000 and 6,000 feet, the pediments going down to about 4,000 feet. It is difficult to postulate which erosion surface affected the summits of the Labwor hills. There may be evidence of two distinct surfaces as the summit levels vary between 5,000 feet and slightly over 6,000 feet.

iv. Further signs of an even older surface may be seen above the ancient 6,000-foot surface. These are the three main mountains of Morungole, 9,022 feet; Lwala, 8,057 feet; and Lotim, 7,621 feet. They would appear to be relics of the 10,000-foot surface as exemplified by the Chemorongit hills.

The Volcanoes

Dominating southern and central Karamoja are four Tertiary volcanic massifs. These are Toror mountain, 6,382 feet; Moroto mountain, 10,116 feet; the Napak cluster, 8,322 feet; and Kadam mountain, 10,067 feet. All are said to be of a single cone, radial type.

Toror stands on a prevolcanic pedestal of Basement Complex rocks at an elevation of about 5,000 feet. Today it is a very dissected mass, about 5 miles long. The dissection pattern is that of valley reduction and scarp retreat to a steeply sloping hill. An upright neck of rock stands out close to the summit which may be part of the original cone.

Moroto mountain, the most easterly of the major volcanoes, also rests on a Basement Complex surface which varies in altitude from about 4,600 to 5,000 feet. Moroto measures in a north-south direction approximately 15 miles and somewhat less in an east-west direction. As it stands today, it is a roughly circular, much dissected shell, of what must once have been a much larger cone but no trace of the crater remains. It is apparent that dissection has followed a differential pattern. The perimeter from near Nakiloro, proceeding west around to the residual hill of Sogolimen, exhibits a number of very steep-sided, truncated spurs, with terminal and lateral scarps arranged radially, the terminal scarp faces being 200 to 300 feet above the level of the pediment. These scarps are cut vertically or near vertically down through the volcanic and pre-volcanic rocks, as one face, or occasionally with a differential scarp. The upper volcanic rock is cut slightly further back than the lower basement rock, producing a slight stepped effect. Between the spurs extending well back into the mountain are fairly wide U-shaped valleys becoming V-shaped in their upper reaches. The perimeter of Moroto mountain from Sogolimen on the Kitale road around in an easterly direction, consists of somewhat elongated, radially arranged, rounded spurs which enter the pediment surface with a gentle terminal scarp or no scarp at all. The valleys between the spurs are again U-shaped at their mouths but rapidly become narrow with convex walls. The extreme eastern side, bordering the Turkana escarpment, shows marked truncation, and the development of a very steep scarp face from about 4,800 feet, with significant valley formation. The uneven pattern of the basal perimeter can well be explained by differences in altitude of the surrounding pediment and plain. On the north and west sides the terminal scarps end at an elevation of about 4,500 to 4,600 feet where the pediment begins, the pediment itself being gently lowered to the plain level. On the south side, the pediment level extends up to, or almost up to, the top of the pre-volcanic surface at a level of about 5,000 feet and as a result erosion inducement has been slower. On the Turkana or eastern side, the retreat of the Turkana escarpment to a base level of about 3,000 feet has had the effect of producing a very steep, high scarp face with valleys playing little or no part in the retreating process.

The overall dissection of the mountain still follows a radial or consequent pattern with the development of deep valleys, very steep in their upper reaches. The advanced stage of denudation of the mass into a number of isolated buttes (as in Kadam and Napak) has not been reached. The present radial drainage is augmented by subsequent streams near the centre which have cut laterally back and isolated the lava flows into massive outward-facing benches and obliterated the original central neck or cone structure. Dissection of the neck and cone structures may have been hastened by the incision of the Nakiloro consequent river which has cut back well into the centre of the mountain, where it splits into three main tributaries which have rapidly lowered the floor level and induced valley widening. As a result, a central amphitheatre has been produced within knife-edge ridges extending in an arc back against the summit plateaux of Sokdek and Sogolimen. The valley heads have induced very steep scarp faces against these summit plateaux. It would appear that these entrant valleys and their parent streams have played a major part in the removal of much of the central part of the mountain. The summit benches of Sokdek (10,116 feet) and Sogolimen (9,628 feet) end in very abrupt scarps inclined towards the centre, suggestive of a crater-wall collapse, but outer slopes from the summits are gentle.

The development of soil on Moroto mountain has to a certain extent been influenced by the dissection pattern. The soils on the steeper-sided spurs of the north and west sides are skeletal or immature, with much exposed rock. The soils on the southern side, on the more rounded spurs, are deeper but with a boulder mantle.

Napak mountain has been well described by B. C. King (1949), according to whom, it is an extremely dissected, former circular, volcanic cone of approximately 12 miles radius. Today only a few remnants of the former volcano exist, and King estimates that 97 per cent. of the original volcano has been removed by erosion. The residual buttes are clustered in a rough circle with steep scarp faces exposed inwards. He estimated the height of the original volcano to have been in the neighbourhood of 14,000 feet above sea level. Now a small central plug, Lokupoi, is the only remaining relic of the central vent. It is surrounded by the four buttes of which Kodiakori-Napak is the largest, measuring 8,322 feet. King also states that up-doming has occurred.

Much discussion has taken place about the size of Napak compared with the other volcanoes in Karamoja. It was considered at one time to be older, due to its advanced dissection, compared with the others. However, the vertebrate fossils found during the soil survey have shown that Napak is possibly the same age as Moroto.

There has been a significant development of soils on the plateaux of Napak and on Kodiakori butte, influenced it would appear by rainfall, as extensive natural forest exists. The soil on the other masses tends to be shallower and in parts skeletal. Napak, like the other Tertiary volcanoes, stands on a pre-volcanic surface varying in height between 3,600 and 5,000 feet.

The remaining large volcanic massif is Kadam, which is the most extensive of the four. It rests on a pedestal of Basement Complex rocks. Trendall (1959) records a very varying contact height of the volcanic base and the pre-volcanic surface ranging from 4,550 feet at Katabok to as high as 5,500 feet between Komakatak and Katabok. He states that the variation in height cannot be attributed to up-doming as in the case of Napak. Kadam as it stands shows little evidence of a former round, single-cone structure, except on the southern side, where a radial consequent pattern of drainage is clearly evident. The rest of the mountain shows very extensive dissection, with the removal of an immense volume on the north side, producing a concave outline. The removal of a great deal of the northern face may be connected with the collapse of the central dome structure with consequent faulting. The exposure of a number of subsidiary vents has also taken place and King (1949)

mentions a connection between areas of faulting and the appearance of subsidiary vents. Collapse of the central dome structure and subsequent removal of debris by erosion might well explain the existence of the two widely separated, outward inclined, summit plateaux of Tebtho and Obda, at respective altitudes of 10,067 and 10,050 feet.

The outline of Kadam shows a differential dissection pattern, which may well be attributed to the relative rates of erosion, induced by a differing elevation of the surrounding land surface, in relation to the perimeter of the mountain. Kadam is roughly astride the Kyoga-Turkwell watershed with the land surface on the Kyoga side of the watershed being lower than that on the Turkwell side. The south and east side shows a roughly circular outline, with radial consequent drainage and wide, deep valleys between steep, sloping spurs. The west side by comparison displays very severe erosion of spurs to razor-back ridges; the north side exhibits a concave depressed outline with extreme truncation of the spurs, coalescence of valleys and scarp retreat to a massive, near perpendicular scarp face.

The soil pattern on Kadam has been greatly influenced by the dissection pattern. On the south side on the gently sloping spurs there is some development of a red-brown clay which is stone and boulder covered. The valley floors carry a deep mantle of a humose alluvium. From about 6,500 feet upwards humose red clay is found, particularly under forest.

Numerous smaller volcanic vents and plugs arise out of the plain; they are generally not large enough to influence the rainfall, and, therefore, soil development to any extent. They are often steep sided with thin stony soils of no agricultural value. Koten is probably the largest of these, measuring 5,558 feet above sea level.

ARCHAEOLOGY

Karamoja district bears witness to former extensive occupation by very primitive, stone age people. In this connection a considerable number of finds of stone artefacts were made during soil survey activities. It appears from the accumulated material on various sites that the early peoples belonged to the Stillbay cultural period with occasional evidence of Sangoan influence.

The numerous sites are scattered through the district, often near to permanent water and on the pediments of granite tors. The area around Moroto township has proved to be a particularly rich location for artefacts. They are beautifully fashioned out of various stones such as chert, chalcedony, obsidian, quartz, talc schist, magnesite, etc. Burins, scrapers, arrowheads, lance heads, backed blades, bored stones and many pottery fragments have been found.

These cultural remains indicate an ancient settlement by stone age people possibly as early as 200,000 years ago. They also exhibit a gradation into the Magosian culture (Wayland & Burkitt, 1932) which is of comparatively recent times - 5,000 to 7,000 years ago. Unfortunately, despite the existence of numerous rock shelters in the district, no rock paintings were revealed.

SOIL-FORMING PROCESSES

Twenty-four soil units have been mapped in Karamoja of which nineteen are distinct series or types. There are four complexes and a unit for undifferentiated alluvium.

The genesis of soils in Karamoja has been affected by many factors such as climate, elevation, type of parent rock, vegetative cover, topography, aggradation and erosion processes. Man has also had a considerable influence, chiefly in so far as the loss of soils through his use or misuse of the vegetative cover.

It is well established that East African soils have been subjected to many cycles of climatic change but it appears that the present regime in Karamoja has left an indelible mark on the soils. It may well be that the climatic cycles did not reach the greater part of Karamoja district and that the present climate has been more or less constant since Tertiary times.

It is abundantly clear that the soils of Karamoja can be partly correlated with the average rainfall range in the area in which they occur. The smaller the annual amount of rainfall, the smaller the amount of water penetrating the parent rock, consequently the slower the rate of weathering. Comparative rates of weathering are not only affected by rainfall but also by other conditions such as maximum and minimum temperatures and degree of aridity. Mechanical weathering of rock may occur to a considerable extent by sharp temperature changes or by alternate wetting and drying of exposed rocks. In this way granite inselbergs and large exposed scarp faces are made to exfoliate and coarse detritus is built up at the bases of large rock masses. This process is markedly prevalent in the drier eastern areas of the district and on the Turkana escarpment. Mechanical weathering coupled with a low rainfall regime in the neighbourhood of 15 to 20 inches produces shallow, coarse sandy or gritty soils. Such soils occur all over the dry, extreme eastern area of the district and are mapped as the Kunyao Series. These sandy loams are generally very truncated without the development of humose topsoils and the solum is not more than two feet deep overlying brashy semi-rotted rock.

The prevalence of relatively high temperatures and the alternating sequence of rain followed by desiccating winds, with an annual precipitation of rainfall of a range from 20 to 30 inches, tend to produce sandy clay loams of the Panyangara Series. More advanced weathering of the parent rock results in a greater amount of clay being formed. However, there is still an appreciable amount of sand derived from resistant rocks and a reddish-brown sandy-clay loam is produced.

A thin stone line of angular quartzite just above the rotted rock is often found in these soils (cf. Ollier, 1959). Lateritization is confined to soft murram and weakly cemented rotted rock.

Soil genesis in Karamoja is also associated with macro- and micro-topographic conditions and the interaction of those conditions with the climatic regime. Where the topography is relatively immature and irregular, small hill ranges are produced which do not influence the rainfall to any extent, consequently a brashy surface of rough, unsorted rock debris is produced. Along the Turkana escarpment for example due to very steep slopes and a probable rainfall of between 10 and 20 inches there is a shallow, very stony surface, with little or no soil. Occasionally, the stonemantle protects a shallow soil underneath, in other cases the stony surface lies directly on rough, partly weathered rock.

In places where the hill features are large enough to exert a definite influence on the rainfall within an estimated 20 to 35-inch range soils of greater depth are produced. The rainfall is high enough to bring about a considerable degree of rock weathering and to promote the growth of a fairly thick vegetative cover. Consequently, an accumulation of soil on hill slopes takes place. The soils associated with such conditions are the red clay loams of the Lokitanyala Series which are of very wide distribution from the Chemorongit hills to the Timu forest. Furthermore, there appear to be definite altitude limits between 4,500 and 6,500 feet in which they occur.

Altitude, rainfall, topography and state of the underlying rock are factors which combine to produce a soil unit of widespread occurrence in the north of Karamoja. This is the Kalapata Series, a well structured deep reddish-brown sandy-clay loam which occurs between elevations of 4,500 to 7,000 feet. The rainfall regime would appear to be in the range of 30 to 40 inches. The soil itself has developed directly from the underlying weathered rock, so that the profile merges gradually into the fresh rock.

The influence of altitude at elevations over 7,000 feet on rainfall precipitation is very marked on all the higher mountains in Karamoja. The increased rainfall induces luxuriant forest vegetation. In turn the combination of altitude, rainfall and vegetation type combine together to produce surface litter and deep humose topsoils. This humose topsoil allows easy absorption of rainfall and passage into the soil, at the same time providing humic acids which hasten breakdown of mineral matter. The combination of abundant water entering the soil with the addition of humic acids results in a very complete and possibly accelerated weathering process which produces a deep profile of red clay on volcanic mountains; where derived from igneous and metamorphic rocks the soil appears to be more orange coloured.

The influence of topography itself regardless of climatic conditions on soil genesis and depth can frequently be seen where the topographic features induce rapid erosion of the soil from adjacent areas. Erosion will take place despite the vegetative cover, the end result being the almost complete removal of the solum exposing bare rock and a brashy stonemantle. This effect can be seen in many areas such as Amudat, Lokitanyala, the Timu forest, etc.

The nature of the underlying rock may largely determine the genesis of the soil. The softer metamorphic rocks tend to rot quickly and produce deep soils. On the other hand, the harder rocks such as fine-grained granites and gneisses tend to weather slowly and, depending on their mode of occurrence, different soils may be produced. On steep granite faces in the Labwor hills a very shallow brashy soil is formed which accumulates if the vegetative cover is maintained. When massive, horizontally bedded, impervious granite or gneiss bodies occur, mottled clay soils with sandy surface layers may be created due to conditions of impeded drainage.

Basic volcanic rocks weather in a particular spheroidal pattern and give rise to clays and clay loams of a chocolate-brown colour often of considerable depth.

The most widespread soils of Karamoja are those of the Sebei Series frequently referred to as "black cotton" soils. These occupy all the low-lying land, apart from trenches and levees of present-day rivers. They are of alluvial and colluvial origin and undoubtedly contain much base-rich material from the volcanic hills. Low rainfall and high base content would favour production and maintenance of the clay mineral montmorillonite. Erosion from the uplands below which the alluvium was deposited would contribute hill-wash which can be seen in many places as a lighter top soil and very frequent angular quartzite stones up to 3" in diameter. The dark colour of the Sebei profile is due to the clay-organic matter complex but the very dark top soil colour could be caused by free carbon from grass fires. The content of organic carbon, is low being seldom more than 1.0 per cent and usually about 0.6 per cent.

More recent alluvium occurs at the lowest levels leaving the older darker soils on the gently sloping pediments. Sometimes the red weathered Basement Complex ridges have been eroded almost flat and merge very gradually into the black clays.

Several undifferentiated soil series are formed on the more recent alluvial deposits. The size and kind of these deposits depend greatly on the topography of the surrounding country which influences

The climatic regime also determines the periodicity of flow of the rivers. A number of alluvial soils often of great depth occur on the margins of all the major rivers and of many minor ones. The initial deposits on rivers arising in immature topography tend to be narrow and of coarse material. As the river attains grade the deposits tend to be finer and more widely spread because the coalescence of river systems into single units on very mature levelled land allows of a wider deposition. The periodic flow of practically all the rivers of Karamoja induced by the semi-arid climatic regime has also a great influence on the volume and kind of material transported and its deposition.

The influence of termites on the genesis of soil in Karamoja must also be taken into account. The species of termite appear to vary quite a lot from east to west, the small mound-building termites being most prevalent in the western part of the district where climatic conditions tend to support a perennial grass savanna. In the eastern part of the district, other less conspicuous termites tend to become dominant under the drier climatic conditions and Acacia bushland. Termites devour a great deal of dead vegetative matter such as dry grass which would otherwise enrich the topsoil with humifiable material; the soils of eastern Karamoja being notably humus deficient. Termites also contribute to the removal of vegetative cover and, therefore, to soil erosion.

The effect of man on the genesis of soils in Karamoja must also be considered. Man may have existed in Karamoja for at least 200,000 years, a sufficient period of time for him to exert a considerable influence on the development of soils. The primitive stone-age tribes by their artefacts show that they were hunters who depended on game for their survival. Ring firing may well have been one of their methods of hunting which over a long period of time would promote a grass savanna. The grass savanna in turn would allow of the build-up of a soil protected from undue erosion. There is abundant evidence to show that forty years ago much of Karamoja was such a grass savanna.

Changes in land-use as exemplified today, by extensive and continued overgrazing, have altered the ground cover to that of a short-tree savanna or bushland over large areas. This offers little protection from sheet erosion and, as a result, the soils exhibit marked signs of truncation.

The influence of fire on natural forest areas as found on the higher mountain elevations is apparent. In modern times much forest has been destroyed and is still being destroyed by the indiscriminate use of fire. This has led to a change from forest to grass and much loss of soil on steep ridges and slopes. It has also resulted in the reduction of the humose topsoil of these mountain soils.

TABLE I

KEY TO THE SOILS OF KARAMOJA DISTRICT
NORTHERN PROVINCE OF UGANDA

MAPPING UNIT	LOCALITY	DOMINANT SOIL TYPES	PARENT ROCK	LAND USE	PRODUCTIVITY
		Soils Derived from Volcanic Rocks			
1. Kadam Series	Mt. Kadam 8,500-10,000 ft.	Peaty loam on orange loam	Volcanic	Rough grazing	Low
2. Moroto Series	Mts. Moroto, Napak, Kadam, 7,000-10,000 ft.	Brown loam on orange-red clay loam or sandy clay	Volcanic	Rough grazing	Low
3. Nadiket Complex	Basal slopes Moroto & E. Kadam Mts. 5,000-7,000 ft.	Brown clay to reddish clay loam under stone mantles	Volcanic	Limited food crops	Low
4. Katabok Series	Basal slopes Kadam Mt. 5,000-7,000 ft.	Reddish brown clay to sandy clay	Volcanic	Limited food crops	Low
5. Napak Series	Mt. Napak, 4,500-5,000 ft.	Dark brown on reddish brown clay	Volcanic	Limited food crops	Medium
6. Lolikek Series	Kadam pediments 4,000-5,000 ft.	Dark brown on yellowish brown clay to sandy clay	Volcanic	Grazing	Low
7. Namalu Series	Lower valleys of volcanoes	Brown loams	Alluvium	Food crops	Medium-high
		Soils Derived from Mixed Volcanic-Metamorphic Rocks			
8. Toror Complex	Toror Mountain	Stony loam on reddish brown clay	Volcanic on Basement Complex	Rough grazing and browsing	Low
9. Apedet Clay	Base of Napak and Kadam Mts. 4,000-4,500 ft.	Grey brown clay, mottled yellowish in subsoil, murram	Volcanic colluvium	Grazing	Low
		Montane Soils Derived from Igneous and Metamorphic Rocks			
10. Morongole Series	Chemorongit, Morongole, Zulia hills	Black to dark grey brown/sandy clay loam, yellow mottled subsoil	Pre-Cambrian granites & gneisses	Rough grazing	Low
		Soils Derived from Metamorphic Rocks of the Pre-Volcanic (Gondwana ?) Surface			
11. Lokitanyala Series	Eastern foothills	Reddish brown on red sandy clay loam to sandy clay	Basement Complex	Food crops, wet season grazing	Low
12. Kalapata Series	Dodoth, N.E. of Loyoro	Stony reddish brown sandy loam on stony clay	Basement Complex	Food crops, wet season grazing	Low
13. Lokapel Complex	Kyoga-Turkwell watershed	Red and black clays, sandy loam, mottled sandy clay loam	Basement Complex	Rough grazing	Low

MAPPING UNIT	LOCALITY	DOMINANT SOIL TYPES	PARENT ROCK	LAND USE	PRODUCTIVITY
14. Metu Complex	Eastern and Western hills	Rocky sands	Basement Complex	Rough browsing	Low
		Soils Derived from Metamorphic Rocks of the African Surface (Karamoja Plain)			
15. Pajule Series	Labwor hill pediments	Eroded, laterite red clay to sandy clay loam	Basement Complex	Food crops, cotton, grazing	Medium-low
		Soils Derived from Metamorphic Rocks of the Degraded African Surface (Karamoja Plain)			
16. Opopwa Series	Teso, Acholi border	Brown sandy clay loam on orange sandy clay, laterite present	Basement Complex	Food crops, wet season grazing	Low
17. Panyangara Series	East and west uplands	Brown to red sandy clay loam on orange mottled grey clay	Basement Complex	Food crops, wet season grazing	Low
18. Lorengikipi Catena	East central lowlands	Brown sandy loam on grey clay mottled red and black	Basement Complex	Dry season grazing	Low
19. Lomerimong Series	East and west uplands	Grey sandy clay loam with orange brown stony subsoil	Basement Complex	Rough wet season grazing	Low
20. Katikekile Series	Widely scattered	Stones and boulders on red and black clays and orange loams	Basement Complex	Rough browsing	Nil
		Soils Derived from Ancient Lake Deposits on the Degraded African Surface (Karamoja Plain)			
21. Amuria Series	Labwor hills and northwards	Grey sandy loam on yellowish brown loam, laterite	Basement Complex	Good grazing	Medium
22. Sebei Series	Central Karamoja plain	Black calcareous clays to clay loams	Ancient alluvium and colluvium	Food crops, dry season grazing	Medium
		Soils Derived from Rocks of Post-African Surfaces			
23. Kunyao Series	Eastern foothills, base of Turkana escarpment	Reddish brown sandy loam	Basement Complex	Rough grazing and browsing	Low
24. Kidepo Series	Kidepo plain near Sudan border	Grey clay to sandy clay loam, mottled yellowish brown below, calcareous	Sub-recent alluvium	Grazing	Low
		Soils Derived from Pleistocene to Recent Alluvia			
25. Loyoro Series	Banks of larger rivers	Brown sandy to sandy clay loam	Recent Alluvium	Food crops	Medium
26. Undifferentiated Alluvium	Banks of smaller rivers	Black to grey clay loam, acid to slightly calcareous	Recent Alluvium	Food crops, dry season grazing	Medium

SOILS DERIVED FROM VOLCANIC ROCKS

1. Kadam Series

The extent of this soil series is very restricted - it occurs only between 8,500 and 10,000 feet on Kadam mountain. Depths of soil vary between as little as 6 inches to as much as 5 feet. They have deep peaty of fibrous topsoils grading down to a brown or yellow-brown to yellow-red clay subsoil. The drainage is often impeded by massive unrotted rock. Typical profiles are given below:-

Profile 1 (21016-18)

Kadam Mountain, 8,500 feet.

0 - 13"	Very dark grey (10YR:3/1) peaty loam with occasional to frequent rounded stones. Handling consistency soft, crumby.
13 - 24"	Dark greyish-brown (10YR:4/2) loam, granular structure; handling consistency plastic. Frequent stones present.
24 - 60"	Brownish-yellow (10YR:6/6) stony loam grading down to mottled, rotted rock. Stones present up to 6 inches in diameter, crumby structure. Handling consistency soft and cohesive.

Profile 2 (21014-15)

Kadam Mountain, 9,600 feet, near Oboa summit.

0 - 7"	Dark brown (7.5YR:4/4) peaty loam. Consistency stiff fibrous to cloddy. Very occasional stones present.
7 - 28"	Dark brown (7.5YR:4/4) clay, granular structure, soft consistency.

As would be expected, the most outstanding features of the analytical data* are the high organic carbon and nitrogen figures due to low temperatures slowing down the microbiological processes of decomposition. Bases are moderate to very low and available phosphorus is very low. Reactions vary from strongly to slightly acid.

Vegetation is characteristically Erica arborea heather thicket with occasional Protea abyssinica and open tufted grass. Bare exposed rock has a light succulent flora.

The agricultural potential of these soils is almost nil due to their very high acidity, drying winds and inaccessibility.

2. Moroto Series

This series occurs on Moroto, Kadam and Napak mountains generally at an elevation of over 7,000 feet, extending up to 10,000 feet on Moroto mountain. But on Kadam its range may be from about 6,000 to 9,000 feet. The probable rainfall regime lies between 40 and 50 inches per annum. The soils are characterized by loose surface litter when occurring under forest overlying 14 to 25 inches of a dark humose loam. Under grass, the humose topsoil is noticeably shallower and of a stiffer texture. Below this is a reddish, granular clay extending usually 3 or 4 feet and occasionally to as much as 10 or 12 feet below the surface. Murram, but not laterite, has been infrequently found in these soils. The soil profile becomes mottled through differential weathering as it extends into the underlying rotted rock. These soils are indicated in the aerial photographs by a distinctive large stipple pattern of a very pale colour, easily distinguished from adjacent soils. Two profiles are given verleaf:-

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* See appendix for full details.

Profile 3 (20579-82)

Near forest camp, Moroto Mountain.

Altitude 8,000 feet, in grassland.

0 - 7"	Dark reddish-brown (5YR:3/3) clay loam, sub-angular blocky to granular structure.
7 - 14"	Dark red (2.5YR:3/6) clay loam, sub-angular blocky to granular structure, slightly cloddy and plastic when wet.
14 - 35"	Red (2.5YR:4/6) as before with frequent very small black murram pellets.
35 - 70"	Dark red (2.5YR:3/6) clay loam, sub-angular blocky to granular with frequent murram pellets. Very compacted and stiff.

Profile 4 (20019-22)

Kadam Mountain, in forest at 7,500 feet.

3 - 0"	Black (5YR:2/1) free, loose surface leaf litter.
0 - 25"	Dark brown (7.5YR:3/2) loam, soft granular or free crumby structure. Occasional stones present from 1 to 9 inches in diameter.
25 - 45"	Reddish-yellow (2.5YR:6/8) mottled with very dark grey (2.5YR:3/0); but granular compact structure. Handling consistency soft and crumby. Occasional rotted stone present.
45 - 72"	Reddish-yellow and red mottled, brashy, sandy clay; soft, crumby structure. Mixture of clay and rotted rock.

The effects of high altitude are again reflected in the organic-matter status, especially in soils under forest. Bases are comparatively high but available phosphorus is still low, reactions vary from strongly acid to slightly acid.

The vegetative cover is often forest of many species including Teclea nobilis, Juniperus procera, Podocarpus gracilior, Albizia grandibacteata, Dombeya goetzenii, Olea chrysophylla etc. Where fire has destroyed the forest a light wooded grassland of Protea abyssinica, Fauroa saligna and Olea chrysophylla is usually dominant with a Bromus spp., Cymbopogon sp., etc. grassland.

Moroto soils have to a limited extent been cultivated by the mountain tribe, the Tepeth, in the past. Forest legislation, however, forbids cultivation at present. It would appear from the natural vegetation that these soils could be extensively used for perennial crops such as arabica coffee, particularly on Kadam and Napak.

3. Nadiket Complex

Nadiket clays occur in a climatic regime of 30 to 35 inches rainfall per annum at an altitude range from 4,500 to 7,000 feet. The eastern side of Kadam mountain and the basal slopes of Moroto mountain have a similar climate as indicated by both the vegetation and soils. A brown clay in certain localities has developed from the spheroidally weathering underlying volcanic rock. The profile varies in depth from 1 or 2 to 15 feet, being remarkably uniform, with little or no horizon development. These brown clays are frequently subject to considerable erosion, thus producing a somewhat truncated profile under a protective stone-mantle. The occurrence of such stone-mantled brown clays is widespread on the southern slopes of Moroto mountain. A typical profile is given below:-

Profile 5 (18531-4)

0 - 12"	Dark brown (7.5YR:4/2) silt loam with a hard crumb structure.
12 - 72"	Very dark brown (10YR:2/2) clay loam with sub-angular blocky structure.
72 - 144"	Dark brown (7.5YR:4/2) clay loam as above with occasional $CaCO_3$ nodules present.
144 - 180"	Reddish-brown (5YR:5/4) clay loam with darker brown mottlings, compact massive structure.

The vegetative cover is strongly influenced by climate and is very variable. Around the base of Moroto mountain the soils are often covered by a Euphorbia candelabrum - Acacia brevispica - A. seyal thicket with numerous shrubs and xerophytes and a very mixed grass layer. There also appears to some extent an Acacia mellifera - A. brevispica - A. seyal - Euphorbia stapfii thicket community on the drier phases of this soil. A Combretum spp. - Terminalia brownii - Acacia seyal community with Hyparrhenia spp. develops on the lower slopes of Moroto mountain.

Where the angle of the slope is more pronounced, such as on valley flanks and ridges, shallower soil develops of a red-brown to brown colour. The profile rarely extends beyond a depth of 4 feet, usually about 2 feet with little or no horizon development apart from a humose topsoil. Numerous stones and sometimes boulders are present, usually exhibiting spheroidal weathering. The following is a typical profile:-

Profile 6 (20608-11)

South side of Moroto Mountain, altitude 5,800 feet.

3 - 0"	Very dark grey (10YR:3/1) clay, abundant stones, linear, oblong up to 2 inches in length.
0 - 13"	Very dark brown (10YR:2/2) clay, crumb structured, becoming slightly more cohesive with increasing depth, few stones.
13 - 24"	Dark reddish-brown (5YR:3/3) clay, fewer and smaller stones. Soft but more cohesive consistency.
24 - 38"	Reddish-brown (5YR:5/4) clay, containing numerous very weathered oblong stones up to 6 inches in length.

Lower altitude and higher temperatures are responsible for the low organic-matter status of Nadiket soils. They are notably very rich in bases and available phosphate which together with pH increase in depth. Lime concretions are present in the deep subsoil. The stony soils of this unit are more leached and may be deficient in available phosphorus.

The depth of the soil on the valley flanks is often influenced by the vegetative cover which is a mixed Combretum - Terminalia spp. wooded savanna with trees such as Cussonia sp. and Dombeya sp. The grass layer contains Hyparrhenia rufa, H. filipendula, H. lintonii, Sehima nervosum, Cymbopogon spp. etc. Where the soil is very shallow and large exposures of bare rock occur, the vegetative cover becomes very xerophytic with Aloe spp., Aeolanthus spp., Sarcostemma viminale, etc.

Nadiket soils are only used for agriculture to a limited extent, sorghum being the main crop grown. A little maize and finger millet are also grown on them.

4. Katabok Series

The soils of Kadam mountain are somewhat different from those of Moroto except on the western side of the mountain. Again climatic influence has played a considerable part in the development of the soils, Kadam enjoying a slightly wetter overall climatic regime than Moroto. The basal areas of Kadam and the lower slopes have developed a reddish-brown sandy clay of good structure. This soil is somewhat truncated in places but in other places it shows a profile of several feet. Apart from the humose topsoil there is no differentiation into horizons, the soil ranges from sandy clay to clay. Scattered through it are frequently rotting volcanic rock particles and occasional ferruginous pellets. The parent material of the soil is composed of a brashy, mottled, rotted rock layer and there is no development of laterite. A typical profile is given below:-

Profile 7 (21867-9)

Mbale-Moroto road, 3 miles east of Namalu Camp.

0 - 13"	Dark brown (7.5YR:4/2) sandy clay with occasional semi-rotted volcanic stones, blocky structure in situ, granular when fractured.
13 - 40"	Brown (7.5YR:4/2) mottled reddish-yellow (7.5YR:7/6) sandy clay with very frequent semi-rotted stones, massive blocky structure, brittle consistency.
40 - 58"	Brown (7.5YR:4/4) mottled reddish-yellow (7.5YR:7/6) gravelly clay, frequent semi-rotted stones and ferruginized fragments of rotted rock, brittle consistency.
58" +	Rotting volcanic rock (not sampled).

The mottling in this profile is due to differential weathering and not to impeded drainage.

Katabok sandy clay is well supplied with all plant nutrients which again tend to increase with depth. But this is due as much to the presence of fresh minerals in the subsoil as to the dry climate.

Vegetative cover is variable but *Combretum* spp., *Lannea* spp., *Terminalia velutina*, *Butyrospermum parkii*, *Strychnos* spp., *Stereospermum kunthianum* and *Faurea* spp. are usually present as a savanna woodland. The grass layer includes *Hyparrhenia* spp., *Themeda triandra*, *Andropogon gayanus* var. *squamulatus*, *Panicum maximum* etc.

The nature of the soil is greatly influenced by topography on the western side of Kadam. On the steep slopes it tends to be shallow or stony in pockets between rock outcrops. Vegetation on the stony phases is xerophytic with *Euphorbia* spp., *Aloe* spp., *Aeolanthus* spp. dominant.

Agriculturally, the soils seem to be fertile as good crops of sorghum, finger millet, sweet potatoes, cassava, maize and groundnuts are grown around the Namalu area.

5. Napak Series

On Napak the soils are slightly different from those of Moroto and Kadam mountains. The relative slopes of the basal pediment have been of considerable influence in soil development. There are two members of this series - the deep, reddish clay loam and its stony or stone-mantle phases. On the steeper slopes a surface stone and boulder-mantled brown to red-brown clay loam has developed around the base of all the buttes to a lesser or greater extent. Angular or rounded stones and boulders cover a soil profile of 1 to 4 feet which merges into spheroidally weathered rock. On the more gentle slopes and in pockets between boulders a deeper red-brown clay loam is found. This soil extends from 2 to 5 feet or more with a slight humose surface development. Its consistency is usually hard, compact and cloddy when dry but soft and cohesive when wet. A good crumb structure is apparent and the soil is quite porous. Murram may occur but no sheet laterite. The altitude range is from about 4,000 to over 6,000 feet. A deep phase of this series is described below:-

Profile 8 (19209-16)

Alekilek, one mile N.W. of the plug, upper flat ridge crest.

0 - 3"	Dark grey (5YR:4/1) clay, crumb structured.
3 - 6"	Dark reddish-grey (5YR:4/2) clay, crumby.
6 - 12"	Dark brown (7.5YR:3/2) clay, sub-angular blocky structure.
12 - 30"	Dark brown (7.5YR:3/2) clay, massive structure, very hard consistency.
30 - 72"	Dark reddish-brown (5YR:3/3-2) clay, massive structure *in situ*, blocky to sub-angular blocky when dug out.

Napak soils reflect the influence of a fairly high rainfall by being strongly acid in the top 30 inches, becoming medium acid below. They are very rich in bases particularly magnesium and potassium as would be expected from their volcanic origin. The clay complex is saturated only to 74 per cent. in the topsoil rising to 87 per cent. in the subsoil. In this respect Napak soils are very similar to those of the Bugusegi Series of Mount Elgon in which montmorillonite has been determined by X-ray analysis.

Vegetative cover of the Napak soils reflects a rainfall regime of between 30 and 45 inches with the development of a mixed *Combretum* spp., *Terminalia velutina*, *Ficus* spp., *Strychnos* sp., *Dombeya* sp., etc., savanna woodland with a grass layer including *Hyparrhenia* spp., *Themeda triandra*, *Panicum maximum*, *Schima nervosum*, *Heteropogon contortus*.

Cultivation of the Napak soils has not been observed but it is likely that a wide range of crops could be grown. However, due to the steep slopes, terracing and other such soil conservation measures would have to be practised.

6. Lolekek Series

The Lolekek mapping unit is essentially an orange-red, sandy-clay loam to clay developed from volcanic rock, particularly in the neighbourhood of Kadam mountain. The depth of soil is very variable, close to the mountain there may be two or three feet of topsoil grading down to murram and rotted volcanic rock. Further out in the plains towards Lolekek the profile generally appears to be very truncated with between 6 inches and 2 feet of soil overlying massive sheet laterite.

The topsoil is of varying depth from 3 to 12 inches, porous, soft and easily penetrated by a mattock and of a coarse, granular structure. Mineral subsoil may be almost non-existent, being masked by the humus in shallow profiles, or it may extend to 2 or 3 feet. It is a clay, generally hard and compact when dry but becoming soft and cohesive when wetted. Little or no coarse sand fraction is present but often there are scattered, small rounded, black-cored murram pellets present in varying amounts. The murram layer may be only 2 or 3 inches thick, or as much as 2 or 3 feet. The murram pellets are loosely or compactly mixed with soil. Murram usually overlies either massive sheet laterite 3 to 6 feet in depth or ferruginized rotted rock. The laterite is composed of cemented round or irregular murram pellets of ¼ to ½ inch in diameter with a glossy surface. In cross-section they are reddish or orange-brown skinned, sometimes yellow-brown inside, with a jet black or blue-black core. The rotted rock where it occurs usually marks a sharp change from the overlying murram. It consists of platy oblong rock fragments to irregular shaped rock fragments up to 2 or 3 inches in length. The surface of the fragments is dark brown to reddish-brown, usually shiny with a black core in the centre of the chip; the original rock structure is still recognizable. The solum is porous and free draining, and easily penetrated by plant roots.

Air photo diagnosis is the same as for the Opopwa Series from which the Lolekek clay loams are distinguished only by ground observations. The following are typical profiles:-

Profile 9 (14597-600)

8 miles along Namalu-Lolekek road.

0 - 12"	Dark brown (7.5YR:3/2) clay, single-grain structure.
12 - 18"	Dark brown (7.5YR:4/2) clay, sub-angular blocky structure.
18 - 30"	Strong brown (7.5YR:5/8) clay with crumb structure.
30 - 52"	Strong brown clay mottled dark grey (7.5YR:5/8 and 2.5Y:4/0) massive hard cemented rock.

Profile 10 (21068-71)

0 - 3"	Dark brown (7.5YR:3/2) sandy-clay loam, single-grain structure, friable.
3 - 13"	Dark reddish-brown (5YR:3/3) sandy clay with single-grain structure.
13 - 50"	Yellow-red (5YR:5/8) loamy gravel; massive, platy structure.
50 - 60"	Yellow-red (5YR:5/6) stony loam, massive structure.

Lolekek soils vary from sandy-clay loam to clay in texture. Bases are high but decrease with depth owing to the high rainfall around the foot of Kadam mountain. Available phosphorus is moderate to low; organic carbon and nitrogen are normal. Reactions range from medium to slightly acid.

The vegetative cover of these soils is usually a *Hyparrhenia - Themeda* grass mixture with occasional scattered trees such as *Acacia sieberiana*. The soils are little used for cultivation but produce quite reasonable grazing.

7. Namalu Series

The streams and rivers issuing from the major volcanic mountains have all deposited alluvium. The initial deposits tend to be fairly narrowly confined to the floors of many of the valleys and flutings of mountain sides. They are often very deep and, where not altered by former or present cultivation, the vegetation cover is a fairly thick forest, from which a deep humose topsoil builds up. Only isolated occurrences of such forest-covered deposits remain, usually well up towards a valley head. It is more usual to find the cover altered by man to a grass savanna or a bushland with only a narrow riparian forest fringe, e.g., the Lia river.

The alluvium varies a great deal in texture, depth, colour and stoniness. It has been laid down by periodic or flash floods with long intervening dry periods. Wide fans are produced in and at the mouths of valleys. However, occasional permanent streams may flow throughout the dry season which complicates the genesis of the soil. Where the water table is high, biological activity is stimulated and a rich organic soil is developed. A typical profile is given below:-

<u>Profile 11</u> (12049-53)

Namalu Irrigation Scheme

0 - 6"	Dark brown (10YR:3/3) friable, crumby loam, with occasional murram pellets and very occasional small stones. Plastic on pressure.
6 - 12"	Dark brown (10YR:3/3) as above.
12 - 18"	Dark brown (10YR:3/3) as above with very occasional murram pellets.
18 - 30"	Dark brown (10YR:3/3) as above but more plastic.
30 - 48"	Dark brown mottled pink (7.5YR:3/2 and 7.5YR:7/4) friable, crumby loam with frequent large murram pellets. Very porous.

A further profile which was not sampled is given below to illustrate a different type of volcanic alluvium in this case with Acacia woodland close to the stream bed, the vegetative cover of the deposit away from the stream bed being sparse thornbush with succulent plants. This illustrates the importance of water available to the plant in the utilization of these potentially productive soils.

Moroto - Soroti road, 1.5 miles from Moroto. Profile on river bank.

0 - 19"	Dark red-brown, soft cloddy clay with occasional small rounded stones.
19 - 28"	Dark brown, gravel layer of small rounded stones mixed with soil.
28 - 40"	Dark brown, clay with a loose granular structure.
40 - 160"	Yellow-brown mottled, mixed gravelly clay with round stones, getting larger with depth and showing signs of weathering.

These alluvial loams and clays are the most fertile in the district; they are very rich in both bases and available phosphorus and in reaction they range from medium acid to neutral. Nitrogen and organic carbon contents are normal but in order to make the most of the other plant nutrients and the abundant supply of subsoil moisture, liberal dressings of sulphate of ammonia should be given to crops, especially in the irrigated areas.

Until very recently the only cultivation of these soils was the Agricultural Department's experimental plot by the Namalu river. Here vegetables of all kinds were very successfully grown and sugar cane, citrus and pawpaws flourished. Cotton has been grown without irrigation.

The soils with the greatest agricultural potential are those dissected by permanent streams or with a high water table. The Namalu area is probably the best example and here irrigation has been carried out but the crop productivity without irrigation could still be high because of a naturally high water table and high inherent fertility.

SOILS DERIVED FROM MIXED VOLCANIC-METAMORPHIC ROCKS

8. Toror Complex

While not a major mapping unit, the Toror Complex is, nevertheless, different from the other volcanic units. Included here are soils derived from the pre-volcanic Basement Complex surface which are quite distinct yet form part of a unit with Toror as a whole. The soils at the base of Toror are also different from the basement soils occurring at lower elevations.

Toror mountain is characterized by a fairly steep pediment from the surrounding plains, which extends into the base of the mountain. The mountain rises abruptly from the pediment with very steep slopes.

On the pediment a much gullied, eroded stone-mantle of a red clay loam exists. Profiles appear to be very similar to those of Lokitanyala clay loam, but they have been markedly truncated and are now only 4 or 5 feet deep. At the base of the mountain on the extreme edge of the pediment and extending some distance up slope is a Basement Complex residual stone-mantle. This stone-mantle has very little soil and is composed mainly of stones over rotted rock. The reduction of the solum to this stage is not, however, complete and eroding pockets of soil are to be found interspersed with the stone-mantle. A gradual replacement of the Basement Complex stones by volcanic stones takes place on the initial slopes of the mountain. The volcanic stone-mantle is composed of angular to rounded gravel and stones with occasional boulders. Underneath this is a sandy-clay loam of grey-brown to red-brown colour grading to a red-brown clay with frequent stones and small, rotted rock fragments. The depth of this soil under the stone-mantle is very variable but 2 to 3 feet of solum are present.

It would appear that Toror receives less rainfall per annum than the other three volcanic mountains. However, it does receive more than the surrounding plains. The summit vegetation indicates a rainfall of about 30 to 35 inches per annum.

The vegetation of Toror mountain reflects the changes from soil to stone-mantle and from Basement Complex to volcanic stones. The vegetation of the pediment soil is an association of Lannea humilis, Acacia brevispica, A. senegal, Dichrostachys glomerata, Albizia amara var. sericocephala etc. The Basement Complex stone-mantle carries a scattered tree cover of Acacia hockii, Heeria reticulata, Terminalia brownii, Lannea triphylla etc. The volcanic stone mantle carries an Acacia seyal, wooded savanna cover with occasional Combretum spp.

No cultivation has been seen on Toror itself, the stony nature of the soil precluding this. On the pediment good crops of sorghum and, to a lesser extent, finger millet are grown. According to Jie tradition, the mountain was formerly occupied by the Labwor tribe, who cultivated extensively on and around it.

9. Apedet Clay

This soil type occurs mainly in the areas west of Kadam mountain and around Napak mountain. It is found in catenary association between Lolekek loam and Sebei clay. The soil is a granular clay which becomes very stiff and hard when dry but does not crack. When wet it becomes soft and cohesive but not sticky. A further characteristic is the presence of numerous small, red-cored murram pellets throughout the profile. The climatic range of the soil is from about 30 to 40 inches of rainfall per annum. The aerial photograph pattern is not easily distinguished from that of the black clay series apart from a slight stipple effect. It has not been possible to separate it to any extent from the black clays of the Sebei Series. Two typical profiles are as follows:-

Profile 12 (14585-9)

5½ miles up Namalu road from the Suam river.

0 - 12"	Dark grey-brown (2.5Y:4/2) clay, loose crumby structure with occasional murram pellets present.
12 - 24"	Dark grey-brown (2.5Y:4/2) as above.
24 - 40"	Dark grey-brown (2.5Y:4/2) clay, hard and compact, breaking into nutty fragments. More frequent murram pellets.
40 - 61"	Very dark grey-brown (2.5Y:3/2) mottled reddish-yellow (7.5YR:6/6) clay, massive and hard. Numerous murram pellets.
61 - 68"	Greyish-brown (2.5Y:5/2) and light yellowish-brown (10YR:6/4).

Profile 13 (14607-10)

5 miles from Namalu towards Lolekek hill.

0 - 12"	Dark grey-brown (2.5Y:4/2) clay. Massive single-grain structure *in situ* but breaks down to small crumbs.
12 - 30"	Greyish-brown (2.5Y:5/2) clay as above with frequent, rounded murram pellets and occasional $CaCO_3$ concretions.
30 - 54"	Greyish-brown (2.5Y:5/2) clay; hard cloddy structure with more frequent $CaCO_3$ concretions and murram pellets.
54 - 62"	Light brown-grey (2.5Y:6/2) mottled light olive brown (2.5Y:5/4) clay as above.

Apedet clay is very rich in bases, probably due to the presence of a montmorillonitic clay mineral; organic carbon, nitrogen and available phosphorus are normal. Severe dry season desiccation is indicated by the tendency for bases to increase with depth. Reactions vary in the same way from slightly acid to moderately alkaline. This soil should respond very well to nitrogenous fertilizers applied in the wet season.

The vegetative cover is usually good, consisting of mixed *Combretum* spp., *Lannea schimperi* tree savanna with a grass layer of *Hyparrhenia rufa*, *H. filipendula*, *H. dissoluta*, *Setaria sphacelata*, *Themeda triandra* etc.

The cultivation of this soil has not been observed.

MONTANE SOILS DERIVED FROM IGNEOUS AND METAMORPHIC ROCKS

10. Morongole Series

This series occurs in the Chemorongit Hills and on the higher mountains in the north-east of the district, including Morongole and Zulia. Its range is generally from about 7,000 feet upwards under a vegetative cover of forest or grassland. The soil when under forest shows a leaf litter on the surface and a deep humose layer but under grass the humose layer is not so marked. A deep sandy-clay loam develops below the humose layer, in appearance and texture being very similar to the Moroto Series but is darker and not so red. Laterite in this series has not been met with but murram may be present to some extent.

The aerial photograph pattern is very similar to that of the montane volcanic clays, being of a large pallid stipple pattern. Profiles 14 and 15 may be considered typical of forest and grassland respectively.

Profile 14 (21267-9)

Mount Morongole, 8,500 feet. Forest.

0 - 7"	Black (10YR:2/1) single-grain, sandy-clay loam. Soft, friable consistency.
7 - 22"	Very dark grey (10YR:3/1) sandy-clay loam. Cloddy structure.
22 - 46"	Light red (2.5YR:6/8) sandy clay. Cloddy structure when dry, compact, cohesive and massive when wet.

Profile 15 (21271-3)

Mount Morongole, 8,500 feet. Grassland.

0 - 15"	Very dark grey (10YR:3/1) fibrous sandy loam, good crumb structure.
15 - 27"	Very dark greyish-brown (10YR:3/2) sandy-clay loam, single-grain structure. Cohesive to crumby consistency. Occasional quartz stone and granite fragment.
27 - 42"	Dark greyish-brown (10YR:4/2) mottled yellow (10YR:7/6) sandy-clay loam with a cloddy structure and occasional ferruginous pellets.

Morongole sandy-clay loam varies in fertility in direct proportion to organic-carbon content which in turn depends on whether the soil is under forest or grassland. Available phosphorus is remarkably high in the forest soils. There is no tendency for bases to increase with depth which confirms the remark made below about rainfall.

The vegetation of these soils appears to be the same as for their volcanic counterpart, i.e. forest or Olea - Protea - Faurea light wooded grassland, indicative of a 40 to 50 inches rainfall.

Morongole soils are, as far as is known, not cultivated but it is probable that they are of fairly high productivity and it is likely that permanent crops such as coffee could be grown.

SOILS OF THE PRE-VOLCANIC SURFACE

11. Lokitanyala Series

The distribution of this series is mainly in the east of Karamoja on high ground. Its occurrence is fairly widespread at an elevation of 4,500 to 7,000 feet. The rainfall range in which it occurs is probably from 25 to 35 inches. The profile itself is often deep with very little or no differentiation. The more skeletal phases may show some admixture with rock fragments. Murram in the lowest horizons is met with occasionally. A typical profile will extend to 7 or 8 feet of a deep, sandy clay with a massive to blocky structure over a slightly rotted rock layer. Occasionally the soil overlies a dense grey clay layer as at the base of Moroto mountain. In turn the red, sandy clay itself may be overlain by black clay of the Sebei Series.

The aerial photograph pattern is that of a very fine, close-grained stipple. Two typical profiles are presented overleaf:-

Profile 16 (12038-43)

6 miles from Lokitanyala

0 - 6"	Reddish-brown (5YR:4/4) sandy-clay loam with occasional large sand grains and feldspar fragments: columnar structure.
6 - 36"	Dark red (2.5YR:3/6) as before.
36 - 48"	Dark red (2.5YR:3/6) as before but with more frequent feldspar fragments, more compact.
48 - 60"	Dark red (2.5YR:3/6) massive stone-soil mixture with frequent angular quartz stones slightly red stained and frequent clear feldspar fragments.

Profile 17 (16036-9)

Loro Village

0 - 9"	Yellow-red (5YR:4/8) sandy clay, compact and structureless.
9 - 36"	Red (2.5YR:4/8) sandy clay, structureless, loose and free with soft consistency.
36 - 54"	Red (2.5YR:4/8) as above.
54 - 66"	Yellow-red (5YR:4/6) blocky, sandy clay with occasional rounded murram pellets and large sand grains.

Lokitanyala soils are well endowed with bases which increase with depth. They are the best example of what looks like a typical "red earth" in the Milnean sense which has had its base status modified by a drier climate than the one in which it was originally developed. Organic carbon and nitrogen are low and also the C/N ratio is remarkably so, possibly on account of termite activity. Available phosphorus is normal. Reactions vary from medium acid in the topsoil to neutral in the subsoil.

Undisturbed, Lokitanyala soils support a pronounced thicket community of Acacia brevispica, Euphorbia candelabrum, Coleus sp. and other xerophytes with a fair grass cover. In areas where the rainfall is slightly higher A. brevispica with Albizia amara var. serioicephala and Terminalia brownii occur.

Cultivation is not widely practised on these soils but sorghum and finger millet and even cassava can be grown in areas of favourable rainfall.

12. Kalapata Series

This series is mainly distributed in Dodoth county north and east of Loyoro. It occurs at elevations of over 4,500 feet up to at least 6,500 feet, and develops from what appears to be deeply weathered rock in undulating topography. The soil profile frequently shows a stone line of quartzite and granitic fragments near the surface or somewhat below. This stone line suggests that the main profile has developed under fairly stable conditions after the deflation of the original soil down to the level of the present stone line. The soil mantle above the present stone line could easily accumulate by simple hill creep. There is some development of a humose topsoil but overall there is little or no horizon development. The bottom layers of the soil merge into a coarse, granular, soft, loose, rotted rock, pale or brown stained. There is great variation in depth of solum - from 4 to 9 feet, depending on the topography. The rainfall regime is between 30 and 40 inches per annum.

The aerial photograph pattern is one of a fine-grained stipple, difficult to distinguish from a Lokitanyala red clay loam pattern. Two typical profiles are shown below:-

Profile 18 (21035-8)

8 miles north of Kaabong, 5,000 feet.

0 - 7"	Dark reddish-brown (5YR:3/3) sandy-clay loam with single-grain structure. Handling consistency compact and cohesive; mineral particles present.
7 - 18"	Dark reddish-brown (2.5YR:3/4) gritty to sandy-clay loam with occasional very small stones and large mineral particles present. Single-grain structure.
18 - 42"	Red (2.5YR:5/6) sandy-clay loam with prismatic, blocky structure. Occasional small stones and more frequent mineral particles present.
42 - 62"	Reddish-yellow (7.5YR:6/6) coarse sandy loam and rotted rock. Structureless grading into rotted rock. Slightly brown stained. Soft, loose consistency.

Profile 19 (21282-4)

1 mile north of Kalapata camp, 5,200 feet.

0 - 12"	Reddish-brown (5YR:4/3) sandy loam. Soft, friable texture, with very occasional rock fragments present; angular blocky structure.
12 - 16"	Light reddish-brown (5YR:6/4) sandy-clay loam, stoneline of mixed rotted granite fragments and angular quartz stones. Slightly compacted.
16 - 72"	Reddish-brown (5YR:4/4) sandy-clay loam and rotted rock fragments of ¼ to ½ inch in diameter with tongues of rotted rock extending into the profile. Consistency loose, soft and granular.

Kalapata soils contain a normal amount of bases, rather irregularly distributed in the profile but pH values tend to increase with depth. Organic carbon and nitrogen figures are normal but available phosphorus is variable from high to very low. The reaction range is only from slightly acid to neutral.

The vegetative cover is distinctive, being usually *Acacia hockii* and odd *Combretum gueinzii*, *Acacia gerrardii*, *Commiphora pilosa* etc. occurring as a light-wooded grassland with few herbs or shrubs. The grass layer includes *Hyparrhenia* spp., *Themeda triandra*, *Eragrostis superba*, etc. Quite useful stock keep is produced but there is a tendency for overgrazing and erosion to take place.

These soils are not widely cultivated but where they are, sorghum and bulrush millet are often grown; sesame, finger millet and cassava are also grown in favourable climatic areas.

13. Lokapel Complex

At least nine different soil series occur in a very complex pattern on the watershed ridge dividing the Kyoga-Turkwell drainage systems at elevations of 4,000 to over 5,000 feet. To a certain extent traces of stone mantle also occur. The topography of the ridge varies from gently to steeply rolling to almost vertical scarp

faces. This variation naturally leads to differences in erosion rates and, therefore, truncation of the different soils. The components of Lokapel Complex are as follows:-

(i) Generally the highest member is a red, sandy-clay loam similar in every respect to those of the Lokitanyala Series which is found around the base of granite-gneiss outcrops and on ridge tops, occupying most of the land surface over 5,000 feet. The soil is usually sheet eroded to a degree depending on the vegetative cover and in parts is severely gully eroded. Overall the profile depth varies between 2 and 8 feet. Occasionally murram is found in the lower horizons but generally the soil grades into semi-rotted rock.

(ii) Small patches of Kunyao red sandy loam which occur usually at elevations between 4,000 and 4,500 feet. These are very truncated and often gully eroded with only a skeletal cover of soil over a quartz stone line.

(iii) Brown to reddish-brown, sandy-clay loam with a mottled grey-brown to yellowish-brown, compact clay subsoil. This subsoil is widespread, occurring generally between 4,000 and 4,500 feet on valley flanks and ridge tops. It is a shallow, brown, sandy-clay loam or sometimes sandy loam of fairly loose consistency, becoming compact with depth, and is only 6 inches to 3 feet in depth. There is often a slight concentration of round, concretionary murram pellets, sometimes sand encrusted, in the last 12 inches of the profile with a noticeable increase in compaction. Quartz stones may or may not be present, with or without murram pellets in a definite stone line. The quartz stones are usually sharp and angular, clean or slightly stained with iron and up to 2 x 2 x 3 inches in dimensions. Below the stone line a hard compact clay horizon exists of a greyish-brown to a yellowish-brown colour, studded with numerous to occasional black murram pellets and frequently mottled with red and black spots. Rare $CaCO_3$ concretions are to be found mixed with the clay which itself effervesces readily with acid. This horizon extends for 2 to 3 feet and merges into rotted rock at the base. There is usually a fair amount of sand distributed throughout the profile.

(iv) Sandy alluvial soils and sandy clay alluvial soils associated with all the streams dissecting the watershed. These are, in all ways, comparable with recent alluvial soils elsewhere in Karamoja, consisting of a numerous layered profile of up to 15 feet in depth and up to $\frac{3}{4}$ mile in width. Artefacts are sometimes to be found.

(v) Distributed fairly widely are tracts of residual stone mantle, these often occur at valley heads and on the flanks of immature streams which are still rapidly downcutting. Large expanses of stone mantles are found on the steeper western scarp where the ridge descends rapidly to the level of the Karamoja plain. The stone mantles are generally residual, mixed with brashy rock material overlying semi-rotted rock, but in places fresh rock. Many areas of transition stone mantle are developing from the eroding soil mantle by accelerated erosion and are scattered all the way along the ridge from Moruita to Lorengedwat.

(vi) Between Moruita and Kakomongole there are extensive occurrences of a soil with a profile depth of 4 or 5 feet to 20 feet. This has a yellow-brown to olive or grey brown, sandy-loam topsoil on mottled, very compact subsoil of sandy clay or sandy-clay loam. The mottles are roughly circular, pale red in colour and up to 1/3 inch in diameter. There

may also be present small rounded, sand-encrusted concretions, reddish in cross-section, which are probably indurated mottles, often concentrated as a band at the base of this first horizon. Occasional angular, sharp quartz stones up to 3 or 4 inches in diameter may be present as a thin or scattered line.

At about 4 or 5 feet there is a change to a more frequently mottled layer 2 to 3 feet thick grading into a very hard, dense, non-cracking greyish-yellow to grey-brown, sandy clay extending to 12 feet from the surface. A basal layer of quartzite and other rock fragments may be present overlying a further mottled yellow-brown clay layer containing reddish, sandy, iron concretions. Finally brashy, yellow-stained, rotted gneiss is reached.

(vii) A soil in all ways similar to the Opopwa clay loam series is occasionally present towards the Moruita-Kakomongole end of the watershed.

(viii) Sebei calcareous black clay constitutes the lowest member of the complex.

(ix) Small occurrences of Panyangara sandy-clay loams are also found towards the northern end of the watershed.

Three profiles of the Lokapel unit are described below:-

<u>Profile 20</u> (16961-3)

Lokapel Complex, series (i)
Typical red clay loam.
Water Catchment Experiment.

0 - 6"	Red (2.5YR:4/6) sandy to fine sandy-clay loam, structureless *in situ*; hard consistency.
6 - 19"	Reddish-brown (2.5YR:4/4) fine sandy-clay loam, structureless. Very occasional quartz stones present. Hard lumpy handling consistency.
19 - 49"	Reddish-brown (5YR:4/4) gravelly loam of mixed, small murram pellets, fine sandy loam and rotted rock fragments. Very occasional smooth quartz stones present. Hard, brittle handling consistency.

<u>Profile 21</u> (12792-7)

Lokapel Complex, series (iii)
Typical profile of brown, sandy-clay loam - grey-brown clay
Kalomeo enclosure.

0 - 4"	Brown (7.5YR:5/4) sand, sub-angular blocky structure. Loose, soft consistency.
4 - 10"	Brown (7.5YR:5/4) sandy loam as before, very loose and soft.
10 - 23"	Reddish-brown (2.5YR:4/4) sandy-clay loam, compact massive structure. Hard and brittle consistency.
23 - 39"	Dark greyish-brown (10YR:4/2) sandy-clay loam, angular blocky structure, hard compact consistency.
39 - 46"	Yellowish-brown (10YR:5/4) sandy-clay loam as above but mottled and very occasional small quartz stones present.
46 - 58"	Quartzite stone line with angular sharp stones.

Profile 22 (13450-4)

Lokapel Complex, series (vi)
Grey-yellow-brown clay from Kakomongole.

0 - 5"	Dark greyish-brown (10YR:4/2) loose sand, structureless.
5 - 17"	Brown (10YR:5/3) sand, sub-angular blocky structure. More compact than previous.
17 - 27"	Light yellowish-brown (10YR:6/4) sand, sub-angular blocky structure. Hard, brittle consistency.
27 - 50"	Light yellowish-brown (10YR:6/4) loamy sand mottled pink (5YR:7/4) sub-angular blocky structure with occasional murram pellets.
50 - 70"	Light grey (10YR:7/2) sandy-clay loam mottled pink (5YR:7/4), massive, in situ; frequent murram pellets.

The data for series (i) reveals somewhat more leaching than the true Lokitanyala profiles but alkalinity still increases with depth. Available phosphate is very low. With regard to the soils of series (iii) considerable down-washing of the clay fraction has occurred but base saturation increases also with depth reflecting wet conditions prior to the present dry one. Nitrogen and organic carbon are very low; available phosphorus also tends to be low. The sandy soils of series (vi) show considerable through leaching as would be expected. They are very low in all plant nutrients, particularly in nitrogen, magnesium and phosphorus.

The vegetative cover of the Lokapel Complex varies enormously according to soil type and rainfall. Towards the southern end there is a mixed Combretum spp., Heeria reticulata, Acacia hockii, occasional Acacia gerrardii savanna woodland with a Hyparrhenia - Themeda grass cover. On sheet- and gully-eroded phases Acacia mellifera, Acacia brevispica and xerophytes tend to invade at the expense of the broader leaved tree elements.

There is a gradual change in vegetation as one proceeds northwards along the watershed, the northern end reflecting a drier regime together with more erosion because of sparser cover. Acacia mellifera, A. brevispica, Euphorbia candelabrum, [illegible] chalybea, Lannea humilis and Acacia senegal are constituents of a bushland-cum-thicket cover at the northern end with only a few surviving perennial and annual grasses, plus many spiny herbs and shrubs.

Soils of the complex are hardly cultivated apart from the alluvial members. Steep topography and the truncated nature of many of the soils preclude any agricultural development on a large scale.

14. Metu Complex

This unit is not a soil series in itself but is a name applied to the physical and topographic state of much mountainous and hill country, most of which has no soil at all. Included here are the isolated inselberg groups such as the Labwor Hills, the Magosi Hill, those around Loyoro etc. The inselbergs present, on the whole, massive, bare rock faces with often boulder-strewn pediments. There is little or no soil development on the steep slopes though there may be some accumulation on the pediments. Even where there is some soil the rocky nature of the topography disallows cultivation. Slopes where the vegetative cover is reasonably protective have fairly deep soils, but the removal of this cover by cultivation would seriously expose the soils to erosion. The Turkana escarpment is a further example of this unit as it is an almost continual scarp face with very steep slopes, narrow U-shaped valleys and in places, fairly deep chasms.

Profile 22 ([illegible])

Bokagel Complex, Series (v)
Grey-yellow-brown clay from Korbecolpile.

0 - 5" Dark greyish-brown 10YR(4/3) [illegible] structureless.

5 - 17" Brown (10YR 5/3) [illegible] structure. [illegible]

17 - 27" Light yel [illegible] angular [illegible] consistency.

27 - 50" Light [illegible] structure [illegible]

50 - 70" Light grey [illegible] pink (5YR 7/4), [illegible] surface pellets.

The data for series (v) reveal [illegible] true lokkomypla profiles [illegible] Available phosphate is very low. [illegible] considerable down-washing of the clay [illegible] saturation increases [illegible] the present dry one. Nitrogen and organic carbon [illegible] phosphorus also seems to be low. [illegible] siderable through leaching as would be expected. [illegible] plant nutrients, particularly in nitrogen, phosphorus [illegible]

The vegetative cover of the Bokagel Complex varies according to soil type and rainfall. [illegible] a mixed Cymbopogon spp., Hewila [illegible] Korcardii savanna associated with a [illegible] short- and gully-eroded phases Acacia [illegible], Acacia [illegible] xerophytes tend to invade at the expense of the broader leaved [illegible] elements.

There is a gradual change in vegetation as one proceeds northwards along the watershed, the northern end reflecting a drier regime together with more erosion because of sparser cover. Acacia [illegible], [illegible] Euphorbia [illegible] constituents of a [illegible] and Acacia [illegible] are few surviving perennial and annual grasses, [illegible] and shrubs.

Soils of the complex and [illegible] members. Steep topography and the [illegible] preclude any agricultural development [illegible] of the soils [illegible]

14. [illegible]

[illegible] is the [illegible] of [illegible]

[illegible] cultivation. [illegible] have fairly [illegible] seriously expose the soils to erosion. The [illegible] is a further example of this unit as it is an [illegible] steep slopes, narrow drainage [illegible] channels.

Little or no soil accumulation takes place, as the forces of erosion are acting as quickly as the forces of creation. The end result of this process is the exposure of bare rock sides but more common is the widespread development of a brashy stone-mantle on rotted rock or a stone-mantle over a shallow soil profile of 6 to 12 inches.

Steep slopes and hills are easily identified from aerial photographs and the delineation of this mapping unit is a simple matter.

While totally unsuited for cultivation the steep slopes have often a varied and useful browse cover of shrubs and small trees varying from Acacia misera and Boswellia elegans to Ximenia americana, Sterculia rhynchocarpa, Cussonia sp., Acacia hockii, etc.

SOILS OF THE KARAMOJA PLAIN (AFRICAN SURFACE)

15. Pajule Series

This series has a distribution on the western side of the district commencing near the Labwor Hills and extending northwards in catenary or complex association with Series 16, 18, 21 and 22. Pajule Series is often the uppermost member of the catena. The soil occurs at elevations between 3,800 and 5,000 feet in a probable rainfall regime of from 30 to 40 inches per annum. Apart from the major occurrences, occasional minor ones crop up over a wide area. Pajule red loams are found on very flat, mature pediments of the African surface but they also occur around inselbergs such as the Labwor Hills. Commonly these soils exhibit signs of extreme truncation with only 3 to 12 inches of topsoil overlying murram or sheet laterite. Deeper profiles often with murram but not laterite occur around the bases of inselbergs, resembling the Lokitanyala red clays. The sheet laterite appears to be rotted rock lateritized in situ.

The aerial photograph pattern is a fine dense stipple, easily separated from adjacent soil patterns. A typical profile is shown below:-

Profile 23 (16080-2)

3½ miles from Iriri on Nabilatuk road.

0 - 9"	Dark reddish-grey (5YR:4/2) massive compact clay. Crumbly loose consistency.
9 - 30"	Reddish-brown (2.5YR:4/4) sub-angular blocky clay, massive in situ. Soft loose friable texture.
30 - 54"	Reddish-yellow (7.5YR:7/6) clay mottled dark grey (7.5YR:4/0). Massive soft, loose rotted rock and soil. Rock fragments soft in texture, with black cores. Occasional murram pellets present.

The above profile occurs in the neighbourhood of Napak mountain where the deposits occur on the Basement Complex rocks of what was the pre-volcanic surface.

A truncated profile is described below:-

Profile 24 (20594-5)

18.3 miles from Kotido on Labwor road.

0 - 14"	Yellow-red (5YR:5/6). Massive, sandy-clay loam (in situ), compact at first them becoming very soft. Handling consistency soft, loose, friable.
14 - 59"	Light red (2.5YR:6/8) sandy-clay loam. Massive, soft, loose murram gravel with occasional angular rounded quartz stones present.

A variation of the above profile shows 2 to 4 feet of mixed murram pellets of about ¼-inch diameter and quartz rock fragments in a compacted layer. Beneath this is a massive lateritized rock layer about 3 to 5 feet in depth.

The analytical data for Pajule soils reflect the transition from through-leaching to base-accumulating conditions. Profiles showing both of the characteristics can be found in the area. Contents of bases and nitrogen are usually adequate but available phosphorus is low. Reactions vary according to distance from the volcanoes - the nearer the more alkaline.

The vegetative cover is often savanna woodland consisting of Combretum gueinzii, C. binderanum, C. ghasalense and Heeria reticulata. Eroded tracts are very frequent and on these the vegetation is often a mixture of odd trees like Terminalia brownii and Acacia brevispica, Fagara chalybea etc. There is also a marked tendency for xerophytic plants such as Sanseveria spp. to invade the eroded phases of the soil. The grazing value of the soils, where well preserved, appears to be good with a Hyparrhenia - Themeda etc. dominant.

Pajule Series in Karamoja is not widely used for cultivation outside of Labwor, but in this area a variety of crops are grown. Among the crops are cassava, cotton, sesame, finger millet, groundnuts and sorghum. Sorghum is probably the most important crop.

16. Opopwa Series

The Opopwa Series occurs all along the Teso and Acholi borders eastwards into Karamoja for some distance. This appears to be in direct relationship with higher rainfall limits. It is usually found on ridge tops and valley flanks on smooth pedimented land.

The profile of these soils is often very truncated with only 6 or 7 inches overlying murram but occasionally 2 or 3 feet may be present. The topsoil is of a fine, granular sandy-clay loam to sandy clay which sets very hard when dry, becoming soft, but not sticky, when wetted. A humose horizon may be present but is more frequently not. A loose murram layer, mixed with soil usually occurs below the topsoil, with often a brief scattering of rounded, brown-stained quartzite stones. Below the murram layer there is either sheet laterite or a semi-indurated, ferruginous, rotted-rock layer. Occasionally a mixture of both are present but it is generally found that the laterite layer shows a vesicular structure of cemented, smooth, round glossy pellets, reddish-brown in colour with dark grey or black cores. Narrow quartz stonelines may be observed traversing the profile.

The underlying rotted rock layer is composed of flattish platy fragments with black cores and a yellow-brown skin, the fragments are about 2 or 3 inches and are bedded horizontally. This layer merges into underlying gneiss or granite rotting into large platy sections. The combined murram-laterite-ferruginous rock fragment horizons may extend for 6 or 7 feet. Two typical profiles are given below:-

Profile 25 (133396-400)

2 miles north of Nabilatakuk.

0 - 3"	Brown (7.5YR:5/4) loamy sand. Loose crumby structure.
3 - 9"	Reddish-brown (5YR:4/4) sandy-clay loam, structure friable crumbs but massive in situ.
9 - 26"	Yellow-red (5YR:5/6) sandy-clay loam, blocky structure.
26 - 38"	Yellow-red (5YR:5/6) gravelly, sandy-clay loam and murram with occasional quartzite stones, structureless.
38 - 63"	Reddish-yellow (7.5YR:6/6) sandy-clay loam, mottled grey (7.5YR:5/0) massive sheet ironstone with numerous rounded quartzite stones up to 5" in diameter.

Profile 26 (16062-5)

Near Opopwa.

0 - 15"	Dark greyish-brown (7.5YR:4/2) sandy clay, hard compact angular blocky structure.
15 - 37"	Dark yellowish-brown (10YR:4/4) sandy clay with occasional smooth quartz stone and pea murram pellets.
37 - 50"	Yellow-brown (10YR:7/4) sandy clay mottled grey (2.5Y:6/0) massive compact, slightly cemented pea murram layer with occasional quartzite stones.
50 - 90"	Yellow (10YR:8/6) sandy clay, mottled very dark grey (2.5Y:3/0) massive, vesicular sheet ironstone containing occasional quartzite stones.

Severe desiccation is again reflected in the data for the Opopwa Series both in the two profiles recorded above and twelve others that were analysed. Base contents are low to moderate and nitrogen and available phosphorus vary directly with the organic-matter status. Topsoils are often strongly acid in reaction but this decreases to only slightly acid in the subsoil.

Natural vegetation is usually a light wooded grassland or scattered tree grassland: Acacia sieberiana or Combretum guienzi - C. ghasalense over Hyparrhenia - Themeda swards.

Opopwa soil is rarely cultivated but will produce reasonable crops of finger millet and sorghum. Its grass ground-cover forms quite good wet-season grazing.

17. Panyangara Series

Panyangara Series has a very wide distribution in Karamoja, which can be linked to rainfall. It occurs in the central and eastern parts of the district in a rainfall regime of 20 to 30 inches per annum. This soil series occupies the upper levels on smoothly pedimented land in an altitude range of from 3,900 to 4,500 feet.

The profile is frequently truncated with little or no development of a humose topsoil. The soils are compact, sandy-clay loam to sandy clay of varying depth from 6 inches to 3 or 4 feet, commonly about 18 inches to 2 feet. The solum frequently rests on a stone line composed of angular quartzite from 1 by 4 inches in dimensions. Below the stone line the subsoil is very variable, a murram layer may be present, with or without brown-stained quartzite gravel. Alternatively, a murram layer of up to 12 inches may cover a more massive, semi-indurated, ferruginized, rotted-rock fragment layer of 2 or 3 feet. The rock fragments are between $\frac{3}{4}$ of an inch and 2 inches in diameter showing various stages of lateritization into ferro-manganese nodules. Underlying the fragmental, rotted-rock layer is a slightly rotted schistose rock.

Profiles 27 and 28 may be regarded as typical of the Panyangara Series:-

Profile 27 (12034-7)

9 miles north of Amudat.

0 - 6"	Dark brown (7.5YR:4/4) clay, structureless.
6 - 12"	Yellow-red (5YR:4/6) sandy-clay loam, loose crumby structure.

/continued

12 - 18"	Yellow-red (5YR:4/8) sandy-clay loam of sub-angular blocky structure.
18 - 30"	Yellow-red (5YR:4/8) sandy-clay loam mottled with black (5YR:2/1) quartzite stone line at 24 inches mixed with semi-indurated, ferruginized, rock fragment layer grading into rotted schist.

Profile 28 (21023-7)

Approximately 30 miles south of Kotido new road.

0 - 28"	Red (2.5YR:4/6) sandy-clay loam, compact angular blocky structure.
28 - 34"	Yellow-red (5YR:4/6) sandy-clay loam with occasional to frequent rounded murram pellets and frequent angular iron-stained quartzite stones; compact, blocky structure.
34 - 89"	Dark red (2.5YR:3/6) sandy-clay loam mottled dark grey (2.5Y:3/0) angular murram-pellet layer with small quartz stones grading into a semi-indurated rotten rock.
89 - 142"	Dark red (2.5YR:3/6) sandy-clay loam mottled with very dark grey (2.5Y:3/0) massive cemented ferruginized rock fragment layer, porous but hard.
142 - 163"	Reddish-brown (2.5YR:4/4) sandy-clay loam mottled dark grey (2.5Y:4/0) rotted, ferruginized, brashy rock. Fairly compact and hard.

The trends in base status in the 18 profiles of this series that were analysed are for increases with depth both in respect of total amounts present and saturation percentages. This feature is not invariable probably because of local differences in rainfall. Again topsoils may be strongly acid and subsoils nearly neutral. Nitrogen, organic matter and available phosphorus are very deficient.

Natural vegetative cover is Acacia bushland with numerous shrubs and a poor development of grass, the result being that there is little effective ground cover and the soils are, therefore, very liable to sheet erosion and compacting influences of storms.

The soils are widely cultivated, usually for four or five years at a time before being abandoned; good crops of sorghum are raised from individual plots for the first two years.

18. Lorengikipi Catena

This unit is a comparatively minor one occurring only in the extreme western part of the district north of Napak mountain, and generally under 4,000 feet in the rainfall range 30 to 35 inches per annum. It includes a distinct series in catenary association with Opopwa orange clay loams and with undifferentiated black clays. Lorengikipi Series is characterized by a brown silty clay loam from 8 to 40 inches in depth. Thereafter there is usually an abrupt change to a soft grey-blue clay horizon of fairly dense texture, occasionally mottled black. This clay horizon extends for about 2 feet and grades into a very dense, compact hard murram pellet and clay layer grading further into laterite. Mottling in these profiles indicates impeded drainage conditions.

The aerial photograph pattern is one of fairly large flattened stipple in a smooth waxy, light-coloured background.

Profile 29 is a good example of this series:-

Profile 29 (21863-6)

Okok Dam road, 4 miles from Lorengikipi Dam. Combretum ghasalense grass savanna.

0 - 8" Dark grey (10YR:4/1) silty-clay loam, massive structure in situ, breaking into blocks, hard compact consistency.

8 - 20" Brown (7.5YR:5/4) clay, similar structure.

20 - 36" Brown (7.5YR:5/4) gravelly clay, massive in situ breaking to single grain; abundant murram pellets.

36 - 60" Light grey (10YR:6/1) with bluish cast, massive clay, mottled brownish-yellow (10YR:6/8) containing frequent black MnO_2/Fe pellets, small quartz stones and rock fragments.

These soils are strongly acid in the topsoil becoming neutral below 36 inches from the surface. The content of bases (increasing with depth) is suggestive of a kaolinite-illite clay mineral complex. Exchangeable potassium is extremely low in the topsoil and available phosphorus low throughout the profile.

The vegetative cover is a Combretum spp. wooded savanna with Hyparrhenia rufa, H. dissoluta, H. filipendula, Themeda triandra, etc. grass layer. No cultivation of this soil has been noticed.

19. Lomerimong Series

This series is widely distributed but very fragmented. It occurs with the Panyangara sandy-clay loams, as a cap on the highest elevations of a catenary sequence. Its occurrence is never very large and, while it is a distinctive mapping unit, it is not important.

Its main feature is its ash-grey coloured surface horizon often of only 3 to 6 inches, sometimes deeper. The grey surface soil may grade into an ochreous-brown coloured lower layer, but frequently the profile is so truncated that the surface lies directly on murram on rotted rock. A feature of the murram and the rotted rock fragments is the dull surface of the fragments - not glossy as in other soils. Red-brown stained angular quartzite stones are invariably associated with the soil, generally mixed with murram or brashy rock. On the aerial photographs it is distinguished by a pronounced stipple pattern.

Two typical profiles are described below:-

Profile 30 (18032-3)

Lomerimong, Bokora County.

0 - 8" Grey (10YR:6/1) sand becoming compact with depth. Occasional quartz stones present. Loose and structureless.

8 - 19" Light brownish-grey (10YR:6/2) and very pale brown (10YR:7/4) brashy, loamy sand, a mixture of quartzite stones, rotted ferruginous rock and sandy topsoil.

Profile 31 (20588-9)

Alerek road 63 miles from Kotido.

0 - 12" Greyish-brown (2.5Y:5/2) sandy-clay loam. Brittle under pressure, angular blocky structure.

12 - 37" Yellow-red (10YR:8/8) mottled (2.5YR:4/8) semi-indurated mixture of soil, rotted rock fragments and occasional quartzite pebbles.

These light shallow soils are usually only slightly acid, contain adequate bases but are low in organic matter and nitrogen. Available phosphorus may be very deficient.

The vegetative cover is Acacia thorn scrub including Commiphora species. This soil is little cultivated as it is generally too shallow.

20. Katikekile Series

Strictly speaking this series is not a soil but a geological phenomenon. Stone mantles in Karamoja are derived from the erosion of the soil profile down to a former stoneline (usually quartzite) or to the fresh or slightly rotted rock. Truncation is initiated by sheet erosion which leads to gully erosion, a very characteristic undulating topography being produced. The creation of stone-mantle topography is fairly widespread over Karamoja, being associated with relatively immature land surfaces such as the Lokitanyala area. It also develops widely on steep hill slopes and to a certain extent on steep pediments. It may also develop on the watershed, between two different erosion surfaces.

The composition of the stone mantles varies according to such factors as slope and parent material. It is usual to find a surface detritus of sharp angular to sub-angular stones with a coarse gravel material in between. This layer may be only 2 or 3 inches, or again it may extend up to a foot. Underneath the stone mantle is a soil layer of varying depth from a few inches to 2 or 3 feet. This soil is often a sandy variant of the former soil mantle.

In the case of the calcareous clays, the profile is frequently eroded down to the level of the $CaCO_3$ concretions, these concretions remaining to form a detrital mantle over the remaining shallow, highly calcareous clay. The $CaCO_3$-nodule mantle is often reinforced by detrital stones and gravel. Stone mantles are usually unsuitable for cultivation but not absolutely so, as where any depth of soil exists below the surface it would be quite feasible to cultivate provided the stones were not too large. The aerial photograph pattern of stone mantles is distinguishable from surrounding soil areas by the pale or whitish appearance on the photographs and by a characteristic drainage pattern.

Two profiles are given below:-

Profile 32 (21072-6)

2 miles from Lokitanyala on Kitale road.

0 - 3"	Yellow-red (5YR:4/6) gravel- the fine earth is silt loam. Abundant brown-stained quartz stones and occasional schist fragments. Soft, loose, single-grain structure.
3 - 7"	Reddish-brown (5YR:4/4) silt loam with very occasional quartzite stones present. Porous, soft, loose, single-grain structure.
7 - 14"	Light reddish-brown (5YR:6/4) gravelly or sandy loam. Small, coarse quartz grit ¼ - 1/3 inch in diameter with occasional quartzite and schist stones up to 3 inches in diameter. Compacted.
14 - 39"	Yellow-red (5YR:4/8) and light brown (7.5YR:6/4) sand, occasional quartzite stones and schist fragments. Soft consistency.
39 - 54"	Yellowish-brown (10YR:5/4) loose soft, rotted schist generally clean and unstained of sand grade.

Profile 33 (21081-4)

2 miles from Nakiloro.

0 - 1"	Dark brown (10YR:4/3) loamy sand and brownish-yellow (10YR:6/3) surface stones. Angular sharp stones up to 9 inches in length.
1 - 9"	Dark brown (10YR:3/3) loamy sand with surface mantle of stones and gravel - soft, loose and crumby structure.
9 - 22"	Dark brown (7.5YR:4/4) and strong brown (7.5YR:5/8) sandy loam with numerous rotted rock fragments mottled red and black, about 1-1½ inches diameter. Massive, slightly compact in situ, otherwise structureless.
22 - 62"	Strong brown (7.5YR:5/8) sand and very dark grey (7.5YR:3/0) rotted-rock layer of brashy fragments, small at first growing larger with depth, soft, loose and porous consistency.

The fine-earth fraction of this profile reflects the influence of the dry climate; bases, while generally low in amount, saturate the exchange capacity to about 70 per cent. increasing to 95 per cent. with depth. Available phosphorus seems to be correlated with organic matter which is low to very low.

The vegetation on Katikekile soils is very variable depending on a number of factors such as density of stone cover, size of stone cover, and the kind of parent material. Generally there is a Combretum transvaalense or Acacia hockii savanna woodland/grassland.

No agriculture is practised on the soils of this series.

21. Amuria Series

This series has a comparatively narrow distribution in a rainfall regime of between 30 and 35 inches. Its main occurrence is south and east of the Labwor Hills and northwards towards the Sudan border in catenary association with other soils. It is generally found on very smooth, flat land over an altitude range of 3,800 to 4,500 feet. In appearance it is very similar to Lomerimong sandy loam but has altogether a deeper profile often with sheet laterite in the lower levels. A typical profile of this soil exhibits a slightly truncated grey sandy surface with some pink sand wash, this horizon extending for 7 to 12 inches. From about 7 or 8 inches a gradual grading into a yellow-brown, sandy-clay loam takes place, extending for possibly 10 inches. Occurring here and in the next horizon are occasional quartzite stones up to 6 inches in diameter. From about 17 to 20 inches the profile shows the development of murram concretions 10 to 15 inches in depth, the concretions gradually coalescing into sheet laterite. This extends for another 4 to 6 feet. The laterite itself is composed of unusual platy sections about half an inch thick, glossy brown on the surface but red and black in cross section, and appears to be formed from the rotted rock in situ.

The aerial photograph pattern shows a strongly marked, evenly spaced stipple which is easily distinguishable from the pattern of adjacent soils.

These soils are little used for cultivation but generally carry a mixed Combretum woodland with a Hyparrhenia - Themeda grass cover which provides useful grazing.

Many profiles of this series are described in the memoirs on the soils of Northern and Eastern Province, respectively.

22. Sebei Series

This mapping unit is the largest unit in Karamoja district and is a complex of varying clays which are impossible to separate when mapping. The black clays or "Black Cotton" soils, as they are often erroneously called, have a wide distribution ranging from probable rainfall areas of 15 inches per annum to as high as 45 inches per annum. The occurrence of the soils appears to be directly correlated with a uniform, fairly level, pedimented landscape. They do not occur on steep slopes. They make up the lowest member in catenary association with the Opopwa and Lolekek clay loams and with the Lomerimong sandy clay loams; their general topographic occurrence being on the lower pediment levels and valley bottoms, but occasionally they extend as a massive blanket over pediments and valleys alike. In low-lying areas they form a continuous sheet for many miles.

Some variation in field characteristics occur, but usually they are simply 3 to 12 feet of very dark brown to dark grey or grey-black clay. When dried out, the clays exhibit deep vertical cracks; at the same time the soil sets so hard that a pick-axe makes little impression. When wetted they become soft and sticky. There is some evidence that the structure at least of the surface 12 inches improves after 2 or 3 years of cultivation and a pronounced crumb is formed. In the lower levels these clays become paler and a zone of accumulated calcium carbonate nodules appears. The texture of this horizon is much softer and more friable than the layer above. The $CaCO_3$ nodules vary greatly in conformation and size, ranging between one-quarter of an inch and one inch with occasional nodules up to two inches in diameter. They are generally rounded and hard but sometimes soft and occasionally they show black mottled or crystalline cores. The soils almost invariably lie on slightly rotted rock with a sharp change from rock to clay with little or no grading of one into the other.

Many profiles show considerable evidence of a colluvial deposition, there being as many as 2 or 3 separate, horizontal stone lines and/or lines of murram and gravel, the surface soil being a reddish-brown clay loam with the development of an intermittent clay profile.

An unsampled profile is described below:-

Composite colluvial clay.

0 - 20"	Reddish-brown clay loam with reddish-brown, sub-angular quartzite stones on surface.
20 - 26"	Compact iron-stained quartzite stone line (stones 6 inches diameter).
26 - 66"	Massive horizon of grey-black compact clay, deeply cracked with very occasional quartzite stones and $CaCO_3$ nodules at lower levels.
66 - 73"	Dense compact angular rounded iron-stained quartzite stoneline. Stones up to 2 inches in diameter.
73 - 98"	Massive mixed quartz gravel and murram pellets mottled red and black with large sharp angular quartzite stones up to 5 inches in diameter, imbedded in compact black clay.
98 - 121"	Iron-stained rotted granite.

Some colluvial black clays may not show a definite stoneline but may only show a distributed accumulation of stones through the solum with a concentration at the lower levels. There is also the tendency to grade into a clay loam with the addition of sand.

[illegible]

These [illegible] soils are the largest soils in [illegible] district and is a complex of [illegible] which are impossible to separate when mapping. The local name is "Black Cotton" soils, as they are [illegible] cotton, have a wide distribution ranging from probably rainfall areas of 25 inches per annum to as high as 45 inches per annum. The occurrence of the soils appears to be directly correlated with a mature, [illegible] landscape. They do not occur on steep slopes. They [illegible] the [illegible] in catenary association with the [illegible] clay loams and with the [illegible] sandy clay loams, their general topographic occurrence being on the lower pediment levels and valley bottoms, but occasionally they extend as a massive blanket over pediments and valleys sides. In low-lying areas they form a continuous sheet for many miles.

Some variation in field characteristic occur, but usually they are simply 3 to 12 feet of very dark brown to dark grey or grey-black clay. When dried out, the clays exhibit deep vertical cracks at the same time the soil sets so hard that a pick-axe makes little impression. When wetted they become soft and sticky. There is some evidence that the structure of [illegible] of the surface 12 inches improves after 2 or 3 years of cultivation and a pronounced crumb is formed. In the lower levels these clays become paler and a zone of accumulated calcium carbonate nodules appears. The texture of this horizon is much softer and more friable than the layer above. The $CaCO_3$ nodules vary greatly in concentration and size, ranging between one-quarter of an inch and one inch with occasional nodules up to two inches in diameter. They are generally rounded and hard but sometimes soft and occasionally they show black mottled or [illegible] edges. The soils almost invariably lie on slightly rotted rock with a sharp change from rock to clay with little or no grading of one into the other.

Many profiles show considerable evidence of a colluvial deposition, these being as much as 3 or 4 concave, horizontal stone-lines and/or lines of [illegible] and gravel, the surface soil being a reddish-brown clay loam with the development of an intermittent clay profile.

An example profile is described below:-

Compact colluvial clay.

0 - 20". [illegible]

20 - [illegible] [illegible]

[illegible]

[illegible]

[illegible] - 90". [illegible]

[illegible] - 98". [illegible] mixed [illegible] and [illegible] with [illegible] quartzite stones up to [illegible] inches in diameter, imbedded in compact black clay.

98 - 121". Iron-stained rotted granite.

Some colluvial black clays may not show a definite stoneline but may only show a distributed accumulation of stones through the solum with a concentration at the lower levels. There is also the tendency to grade into a clay loam with the addition of sand.

A fairly important variant of the Sebei Series is found near Amuda, lying below a long granitic gneiss ridge. The soils may have been derived from this rock by colluviation. They are clays massive grey-black in profile with varying but perceptible amounts of clean or iron-stained sand present. A number of horizons are usually present under the initial massive calcareous grey-black clay horizons. The lowest horizon may show signs of impeded drainage such as slight mottling, but this is not common.

Surface,	clean washed sand.
0 - 60"	Structureless, compact grey-black, deeply cracked clay, with red-stained and clean sand present.
60 - 84"	Structureless less compact, grey-white clay with abundant $CaCO_3$ nodules from ½ inch to 2 inches in diameter.
84-114"	Dense, compact, smooth, grey sandy-clay layer with frequent scattered red and black murram pellets and angular smooth and sub-angular iron-stained quartzite stones up to 2 or 3 inches.
114-129"	Massive sandy grey clay mottled yellow and orange.
129-140"	Clean semi-rotted gneiss.

On the aerial photograph these areas have an extremely smooth, dark, wax-like appearance.

Three profiles out of 26 that were sampled and analysed are described below:-

Profile 34 (12074-9)

Kangole, 1 mile up Kotido road.

0 - 6"	Dark brown (10YR:4/3) sandy-clay loam, hard compact and multi-cracked, sub-angular blocky structure. Very occasional small iron-stained quartzite stones present and a trace of sand.
6 - 12"	Dark brown (10YR:3/3) sandy-clay loam as above but more massive and blocky structure.
12 - 18"	Very dark grey-brown (2.5YR:3/2) sandy-clay loam as above but with many small quartzite stones.
18 - 30"	Similar but more small stones.
30 - 48"	Light olive-brown (2.5Y:5/4) sandy-clay loam with more frequent stones and sand present. Consistency softer and looser than above.
48 - 66"	Pale olive (5Y:6/3) sandy-clay loam with occasional quartz stones and some loose sand - loose nutty structure.

Profile 35 (12819-22)

Nabilatuk road, 2 miles south of Amuda rock.

0 - 3"	Brown (10YR:5/3) sandy loam, compact, hard, massive structure.
3 - 9"	Dark grey (10YR:4/1) sandy-clay loam, cloddy, breaking into nutty fragments; brittle consistency.

/Continued

9 - 33"	Grey (5Y:5/1) sandy-clay loam. Angular blocky structure. Occasional small quartz stones present.
33 - 48"	Grey (5Y:5/1) sandy-clay loam, with very occasional quartz stones, massive, in situ.

Profile 36 (16937-41)

1 mile from Morulinga Hill on Soroti road.

0 - 3"	Dark grey (2.5Y:4/0) clay; massive, very hard compact and deeply cracked.
3 - 24"	Dark grey (2.5Y:4/0) clay as above.
24 - 51"	Dark grey (2.5Y:4/0) clay as above but smoother cut face, denser and more compact.
51 - 78"	Dark grey (2.5Y:4/0) clay mottled white (2.5Y:9/2), crumby with numerous $CaCO_3$ concretions.
78 - 102"	White (5Y:9/1) mottled yellow (10YR:8/6) rotted schisty rock of sand grade. Crumby structure in hand but very compact and hard in situ.

The most widespread soil type within this series is clay, but soils as light as sandy-clay loam occur frequently. Topsoils are invariably slightly acid to neutral in reaction increasing to mildly or moderately alkaline with depth. Bases are present in abundance, particularly magnesium; sodium may be found in deleterious amounts. Available phosphorus is usually adequate but may be deficient. Pot tests have revealed a strong sulphur deficiency in the virgin soils but this can be ameliorated by vigorous cultivation which facilitates the mineralization of humus sulphur. The organic-carbon content is remarkably low for such dark soils and rarely exceeds 1.0 per cent.; nitrogen is correspondingly low.

The vegetation of Sebei soils is very constant within well defined rainfall limits. In the range of 15 to 25 inches an *Acacia mellifera* scattered tree/grass savanna develops where the grazing is not too heavy and the grass is burnt annually. In the same climatic regime under conditions of heavy grazing an *Acacia mellifera* "orchard bushland" develops. In the range from 20 to 30 inches rainfall is a mixed *Acacia mellifera* - *A. seyal* bushland with *A. seyal* dominating at the higher end of the rainfall, say, 25 to 30 inches, with *A. drepanolobium* coming in sporadically. Above 30 inches rainfall, *A. drepanolobium* forms a short scattered tree or bushland area with a 3 to 5 feet high grass cover of *Setaria incrassata*.

Sebei Series is extensively cultivated, the crops being mostly sorghum and maize.

SOILS OF THE POST-AFRICAN SURFACE

23. Kunyao Series

This series is mainly distributed in the southeast of Karamoja in Karasuk on the 'Kunyao' surface. It also occurs north of Moroto mountain along the eastern border at the foot of the Turkana escarpment. The series occupies areas with a probable rainfall regime of only 15 to 20 inches per annum. The soil itself is usually skeletal, of a coarse sandy nature, rarely exceeding 30 inches in depth. Below this is a poorly developed murram, ferruginized rock fragments - quartzite gravel layer mixed with angular sharp quartz stones up to 3 inches in diameter. A fairly rapid grading into ferruginized rotted massive rock takes place. The parent rock is often a hornblende schist or biotite schist or other metamorphic rocks. The aerial photograph pattern is micro[illegible], stipple, having the appearance of very fine sandpaper.

Two typical profiles are described below:-

Profile 37 (15990-3)

Kodich.

0 - 3"	Reddish-brown (5YR:4/4) loamy sand, compact massive structure in situ.
3 - 26"	Dark red (2.5YR:3/6) sandy-clay loam, angular blocky structure.
26 - 30"	Yellow-red (5YR:5/6) sandy-clay loam, mottled very dark grey (7.5YR:3/0), compact brashy mixture of brown quartz gravel, angular brown-stained quartz stones up to 3 inches in diameter, occasional murram pellets and brashy, rotted-rock fragments.
30 - 42"	Reddish-yellow (5YR:6/6) and very dark grey (7.5YR:3/0) mixed layer of broken, angular, sharp, brown-stained quartzite stones and rock fragments mixed with loose sandy-clay loam.

Profile 38 (15994-6)

1.4 miles along Nakuijit road.

0 - 3"	Yellow-red (5YR:4/6) sandy-clay loam of hard brittle consistency with rare small red-brown quartzite stones and occasional murram pellets; angular blocky structure but massive in situ.
3 - 24"	Yellow-red (2.5YR:4/6) sandy-clay loam with occasional quartzite stones. Prismatic to angular blocky structure.
24 - 43"	Light reddish-brown (5YR:6/4) mixed coarse sub-angular murram pellets up to 1/3" in diameter and angular sharp quartzite stones plus rotted sugar quartzite.

As would be expected from soils in what is virtually semi-desert country, the data for the Kunyao Series provided the most striking examples of increasing base content and alkalinity with depth. Magnesium is remarkably high, often being in excess of calcium. Nitrogen, organic matter and C/N ratios are consistently low due to very high temperatures, low rainfall and considerable termite activity. Available phosphorus is adequate. Textures vary from loamy sand to sandy-clay loam.

The vegetative cover is usually an *Acacia misera* - *A. mellifera* community with the admixture of many xerophytic plants.

The series is rarely cultivated, but reasonable crops of sorghum can be raised when the rainfall is sufficient.

24. Kidepo Series

This series has a fairly narrow distribution in the north of the district; it is distinguishable in the field from the undifferentiated alluvium by a more grey surface colour and a yellowish-brown subsoil. These clays occur mostly on gently sloping valley flanks and to a certain extent in valley bottoms. There is a significant but minor occurrence of this clay in the Loyoro area where it occurs in catenary association with Lokitanyala red clay loam. The main occurrence is in the Kidepo valley where it is associated with

red clay loams and other soils. They also differ morphologically from Sebei clays in that the colour is a definite grey to grey-brown, grading to grey and yellowish-brown in the lower layers. The texture of the clay is at the same time coarser with varying amounts of fine sand and gritty particles. Kidepo clay is also highly calcareous with visible $CaCO_3$ particles in the top horizons. The clay sets extremely hard when dry and cracks deeply.

A typical profile is shown below:-

Profile 39 (21047-51)

Lomej road 15 miles from Kaabong.

0 - 9"	Dark grey (10YR:4/1) sandy-clay loam. Massive angular blocky to sub-angular blocky structure. Compact, brittle handling consistency.
9 - 17"	Dark grey (10YR:4/1) sandy-clay loam. Large blocky structure *in situ* breaking into small sub-angular blocky peds.
17 - 32"	Greyish-brown (2.5Y:5/2) clay loam with occasional small quartzite stones up to 2", calcareous nodules and small rounded black pellets.
32 - 62"	Greyish-brown (2.5Y:5/2) clay loam. Large, prismatic to angular blocky structure with occasional small stones and frequent rounded $CaCO_3$ nodules.
62 - 85"	Greyish-brown (2.5Y:5/2) clay loam mottled grey (5Y:6/1). Large prismatic blocky dense. Brittle consistency breaking into peds up to $\frac{1}{4}$" in diameter with smooth shiny faces. Frequent $CaCO_3$ nodules.

A further profile with a similar grey to yellowish-grey subsoil is shown below. This profile shows a decided granular structure with a certain amount of coarse sand present.

Profile 40 (21002-5)

Kaabong road, 3 miles from Loyoro.

0 - 20"	Very dark grey (2.5YR:3/0) sandy clay, loose sub-angular blocky structure, individual peds very hard. Occasional $CaCO_3$ nodules present.
20 - 60"	Light brown-grey (2.5Y:6/2) clay, mottled yellow (2.5:7/4) as before but with more frequent $CaCO_3$ nodules, rounded up to 1 inch in diameter.
60 - 78"	Light brown-grey (2.5Y:6/2) clay mottled brownish-yellow (10YR:6/8) rotted rock mixed with clay. Coarse, crystalline rock fragments slightly yellow stained. Compact and brittle.

The above profile occurs in a much drier climatic regime, the vegetative cover being an *Acacia mellifera - A. seyal* thicket.

The data for profile 39 are very similar to those of the Sebei Series apart from a tendency to be more alkaline.

The vegetative cover is an *Acacia gerrardii* with occasional Balanites, savanna woodland over *Setaria incrassata* and *Hyparrhenia* spp. grass. The grass cover appears to be reasonably good and is at

present in the Kidepo valley little utilized as grazing by cattle. No cultivation of this soil has been observed but it would appear that as it occurs in a reasonably good rainfall area (probably 30 to 40 inches per annum) cotton and cereal food could be grown.

RECENT ALLUVIAL SOILS

25. Loyoro Series

The soils of this series are derived from recent flood sediments of the major east-flowing rivers of the district. On this account they are very variable as the speed of the river determines the size of the particle deposited. Vertical sequences in well-defined bands of coarse sand to very fine sand and silt are to be found but no single profile exhibits the complete range of particle size. Generally speaking the more important expanses of this series are deposited by large (50 to 200 yards wide) rivers.

The rivers from their early stages meander with the result that fairly broad alluvial deposits have been laid down. The Loyoro, Manimani, Nabilatuk and Napiananya rivers all exhibit a multi-stage "step deposition", the earliest sediments being at the highest level and furthest away from the present river bed, the younger ones being stepped down to lower levels until the youngest or present-day level of deposition. The younger levels are initially cut into the older levels in a sequential pattern, with sharp vertical banks between the older and newer levels. Ancient and cut-off meanders are clearly defined as at Napiananya. The sequence of the deposits below Loyoro village also illustrate this and are described below:-

Level 1 - Present river bed and superficial deposits

The river bed below Loyoro village is composed of a superficial loose, sand layer with occasional pockets of silt. The surface layer gradually changes with depth to coarse sand which extends to 8 to 12 feet when it is replaced by gravel and stones. The deposits on either side of the bed extend upwards for a distance of 2 to 3 feet and laterally into the previous higher layer for a distance of between 20 and 100 yards. The river bank reveals about 22 different horizontally bedded layers of fine sand, coarse sand and fine gravel. The bottom-most layer is of very fine semi-indurated sand. The layers above this alternate between fine, medium and coarse sand uniformly brown stained. Scattered among these layers are further occasional mixed deposits of coarse sand and sub-angular gravel up to half an inch in diameter. A few larger stones in no particular layer are scattered through the profile; these stones are mainly quartzite but other minerals are identifiable in the sand such as biotite, hornblende and feldspar. The surface of this deposit is grass covered and generally level, a few trees have established themselves.

Level 2 - Middle layer

A sharp break occurs between the previous level and this one. Level 2 extends in places almost vertically above Level 1. Level 1 extends vertically for about 9 feet and laterally up to 200 yards. Its surface is fairly uniform, traversed only by shallow drainage lines. The development of a fairly thick *Acacia albida* woodland has taken place with some secondary undergrowth of shrubs.

The sand layers of Level 2 differ radically from the layer of Level 1 in their colour, which is much paler brown and not so ferruginized, and their texture which is much more varied from very coarse to very fine. Evidence of wind-bedding is also apparent with unconformable planes at angles as steep as 50 . Both wind-bedded and horizontally-bedded layers alternate over about 14 distinguishable deposits, the uppermost being of a rich chestnut brown silt intercalated with fine sand for a depth of about 2 feet. Below this are deposits of pale-coloured coarse and fine sand.

Level 3 - The upper layer

Level 3 extends in most places almost vertically above Level 2, in other places it overlies Level 1 with no trace of an intermediate step. In conformation it is a wide, very flat deposit with only occasional undulations on the surface. A few large streams and gullies cut back from Level 1 right into Level 3, otherwise there is little dissection. This level has in the past and up to the present been the site of intense cultivation and settlement. As a result, much of the original vegetation cover has been destroyed and the lateral invasion of xerophytic thicket has taken place from the vegetation on other eroded soils.

The profile morphology of Level 3 is very different from Levels 1 and 2, being of a dull to dark reddish-brown colour on the exposed face. About seven large beds exist, the uppermost layer being initially composed of clay grading down to fine sandy silt at the 2 to 3-foot level. Thereafter, from 2 feet there is a massive layer of an orange-brown, slightly mottled clay with a pronounced micro-ped structure extending for 6 to 10 feet. The peds are sharp angular blocky measuring between ¼" and ½" in diameter with dark mottles. Below this the structure becomes prismatic, breaking into large, sharp angular fragments, very hard and compact in texture. Little free sand is apparent in the profile and there are very few stones, but scattered $CaCO_3$ nodules occur from about 3 feet below the surface right down through the profile; these are up to 2 inches in diameter and rounded in conformation.

Other rivers build up different alluvial deposits. The Karita river alluvium, for instance, has a profile of about 12 feet deep. The bottom deposit is composed of a dense, compact sandy clay, grey-brown in colour overlying a coarse sand layer. This clay layer extends for about 4 feet where there is a sharp change to a compact sand layer about 12 inches deep. Above this sand layer lies a massive ochreous-brown, clay deposit transected horizontally by very thin bands of sand and gravel. The top few feet grade into a dull brown clay.

The Manimani river exhibits a two-step deposition, the primary deposits measuring about 12 feet in profile and extending for a wide distance on either side of the river. The profile shows the following succession: brown, cracking clay with slip faces, underneath the clay is a massive layer of a compact, yellow-brown, silty clay which is black mottled; below that is a multi-layered horizontally bedded profile of very fine compacted orange-brown sand; below the sand lie three distinct layers of mottled, very hard, compact sandy clay with considerable amounts of large $CaCO_3$ nodules. The second level or present-day level is a composite profile of alternating sand and gravel layers, the sand being fine to medium in texture of a pale yellow-brown colour. Some wind bedding is evident as the sand occurs in the horizontal to angled layers.

A profile from Level 3 is described below, selected from the 14 analysed.

Profile 41 (12064-8)

Loyoro, approximately ½ mile from river.

0 - 6"	Yellowish-brown (10YR:5/4) sandy-clay loam with quartzite stones present, structureless.
6 - 12"	Dark brown (7.5YR:4/4) sand with occasional quartz stones and rotted gneiss fragments, compact and massive *in situ*, otherwise structureless.
12 - 18"	Strong brown (7.5YR:5/6) pebbly sand. Abundant quartzite stones. Soft, loose consistency.
18 - 30"	Yellowish-brown (10YR:5/4) sand, stony for the first 3 inches - soft, loose consistency.

/continued

30 - 48" Dark brown (7.5YR:4/4) sand grading to sandy clay at base. Stones fragment in the first 6 inches. Single-grain structure.

These sandy alluvial soils are usually adequately supplied with bases and available phosphorus but are invariably poor in nitrogen. This lack of nitrogen is probably compensated for by great depth of root room and a fairly constant reservoir of ground water. Benefits from sulphate of ammonia applications applied during the wet season would probably be economic.

The agricultural utilization of this series is expanding, though cultivation is mainly confined to the production of sorghum and maize. In certain areas bulrush millet may also be grown.

26. Undifferentiated Alluvium

The remaining alluvial soils in Karamoja form a complex through their extreme variability and no hard and fast mappable series can be described. They vary in colour from brown to blue-black and in texture from sandy clay to clay, mottled or concolorous, acid or calcareous. This all reflects the nature of the original deposit and the maturity of the land surface, besides climate and vegetation.

The nature of the original deposit is determined by the length of the river and the stage of grade achieved. Taken overall, there are three main stages of deposition and formation of alluvial deposits. The first stage occurs where the rivers arise in immature land forms such as the Morungole-Zulia area or the Chemorongit Hills; the initial deposits being ill-sorted coarse sand and gravel, which is a feature of the rapid grading of the immature rivers in those areas. The second stage occurs from 4,500 to 4,000 feet when the sediments widen in direct ratio to the more gentle grading of the river bed. The ratio of silt and clay to sand and gravel increases at the same time, the deposits from the Manimani river at Lorengedwat illustrate this. Meanders are a feature of this stage. The third stage is reached when the major river systems have coalesced; the form of deposition now is one of clay and silt, as exemplified by the Lochomon, fairly wide deposits being laid down. The end of the third stage is marked by the passage of the major rivers through very flat land as a number of braided channels. In this penultimate stage, the river bed is usually very shallow and so very wide deposits may be laid down.

Clay alluvia are very homogeneous, with little development in layering. They range in colour from dark brown to intense blue-black with a fading in colour to shades of grey at the lowest levels. The deep subsoils are often calcareous and may be mottled; occasional iron concretions may occur. The depths of the solum are very variable and may be anything from a few feet to 30 feet depending on circumstances.

On the north-western boundary of the district clay alluvium has been differentiated as the Pager Series, described by Ollier (1959).

Two profiles are recorded below:-

Profile 42 (18005-8)

15.1 miles along Soroti road west from Lochomon.

0 - 20" Black (5Y:2/1) clay with frequent small, brown, rounded sand grains. Deeply cracked, massive structure.

20 - 38" Black (5Y:2/1) clay as above.

38 - 63" Dark grey (5Y:4/1) clay. Large angular blocky structure. Very occasional small quartzite stones present and occasional $CaCO_3$ nodules.

/continued

63 - 96" Dark grey (5Y:4/1) clay, mottled strong brown (7.5YR:5/6) as above with more frequent $CaCO_3$ nodules and occasional iron concretions.

Profile 43 (12845-52)

Amuda river.

0 - 6" Dark grey (10YR:4/1) sandy clay. Angular blocky structure with a hard consistency; massive in situ.

6 - 24" Grey (10YR:5/1) clay loam.

24 - 54" Grey (10YR:5/1) silt loam.

54 - 72" Dark greyish-brown (10YR:4/2) to greyish-brown (10YR:5/2) loamy sand. Occasional small stones and some sand. Hard crumbly or sub-angular blocky structure when broken but compact and massive in situ.

72 - 82" Light grey (10YR:7/1) and very pale brown (10YR:7/4) gravelly loamy sand. Single-grain structure.

82 - 100" Light brown-grey (2.5Y:6/2) clay loam with occasional nodules and occasional quartzite stones. Massive in situ otherwise structureless.

100 - 106" Very pale brown (10YR:7/4) and light grey (10YR:3/1) as above with occasional iron concretions.

106" + Light grey (2.5Y:7/2 to 5Y:7/2) rotten schisty rock with very little staining, loamy sand grade.

These soils are rather similar to the Sobei Series but are more variable in texture. They are medium acid to moderately alkaline in topsoil reaction while subsoils are usually neutral to moderately alkaline. Base contents are high and vary according to texture. Available phosphorus is usually adequate.

These soils carry very diverse vegetative cover, usually woodland with trees such as Acacia seyal var. fistula and A. gerrardii make up the bulk of the community. In certain lower lying areas as around Lorengikipi, Acacia drepanolobium may make up the bulk of the community. A great deal depends on the level of the water table and the period of inundation. A perennial ground cover of tufted grasses which vary greatly in species is associated with the trees. Andropogon gayanus var. squamulatus, Hyparrhenia spp., Chloris gayana, Sorghum verticiflorum, Echinochloa indica, E. pyramidalis, Cyperus spp. etc. all occur under different soil moisture conditions.

Agriculturally, these soils are little used because of their remoteness from settlements but they would be useful for food crops such as sorghum, finger millet and maize.

SOIL EROSION

An erosion map has been included in this memoir as it is considered that the erosion factor in such a semi-arid area must be taken into account before a land-use guide can be written. Soil erosion in varying degrees is widespread in the district; it is chiefly dependent on topography, climate, soil type and man.

There is no doubt that the normal processes of planation or geological erosion have been very intense since Tertiary times. Torrential rainstorms beating on the hot, bare soil surface are certainly the prime cause of erosion effects. These storms are still an annual event of short duration but there is no evidence of lowering of the land surface by the agency of wind, i.e. geological deflation. Winds are responsible in part only for a few millimetres of fine sand and silt being moved from place to place and covering the land surface with a thin loose film. There are no signs of dune formation or abrasion effects on rocks. Overgrazing by cattle in the last 50 years and subsequent sheet erosion is probably the cause of the exposed roots and stepped plinths to thicket clumps and soil monoliths under large stones. It would be interesting to obtain some quantitative data on the rate of soil loss by measuring the increases in height of these plinths and monoliths over a period of years. Europeans must take the blame for gully erosion in roadside drains cut across the contour.

Steepness of the surface upon which other factors act determines the rate and kind of erosion that takes place. Mountain and hill masses through having relatively steep slopes are naturally liable to accelerated run-off of water and the resultant erosion of the soil. This process is a natural one and is influenced by the vegetative cover which, in turn, is dependent on climatic factors and man's activities.

The larger mountain masses, rising to more than 6,000 feet, have a decided influence on rainfall and tend to be forest covered in an undisturbed state. The soil mantle in the afforested slopes is stable and not liable to severe erosion. However, alteration of the forest to a grass cover by the action of man through the agency of fire and grazing exposes the soils to increased erosion. All the large mountains of Karamoja to-day reflect to a greater or lesser extent the action of man and the vegetation is thus a mixture of fire-induced grassland and relict forest.

On mountain slopes, 6,000 feet or lower, and hill ranges from 4,000 to 6,000 feet bare scarp faces are exposed. On less steep slopes, skeletal soils and boulder accumulations are found. The high altitude-induced rainfall is sufficient to produce a forest cover and the natural climax is woodland or savanna woodland. These woodland types, where not too altered, allow the development of a soil mantle on slopes up to 30°. However, man has completely altered the original vegetative cover to a grass savanna or shrub savanna and through so doing has exposed the soil

Soil Erosion

An erosion map has been included in this memoir as it is considered that the erosion factor is such a [illegible] that must be taken with account [illegible] land-use [illegible]. Soil erosion in varying degrees [illegible] in the District. It is chiefly dependent on topography, climate, soil type and [illegible].

There is no doubt that the normal processes of [illegible] or [illegible] have been very [illegible]. Forest [illegible] by burning or [illegible], the soil surface [illegible] the protection of organic [illegible]. [illegible] of [illegible] of the land surface by the [illegible]. Where [illegible] hill [illegible] surface with a thin [illegible]. There [illegible] effects of [illegible]. [illegible] by [illegible] 30 years and suggest that erosion is probably the cause of the [illegible] and [illegible] under large [illegible]. It would be interesting to obtain some quantitative data on the rate of soil loss by measuring the [illegible] of these [illegible] and [illegible] over a period of years. [illegible] most [illegible] for gully erosion is [illegible] drains cut across the contours.

[illegible] of the surface [illegible] which other factors act determines the rate and kind of erosion that takes place. [illegible] and hill slopes through having relatively steep slopes are naturally liable to accelerated run-off of water and the resultant erosion of the soil. This process is a natural one and is influenced by the vegetative cover which, in turn, is dependent on climatic factors and man's activities.

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[illegible]

[illegible] slopes of [illegible] has exposed the soil mantle to increased erosion. Continued erosion of this has produced a widespread residual stone and boulder surface as can be seen on the slopes of the Labwor and Magosi hills.

Apart from the mountains in Karamoja the climatic regime over much of the area is on the arid side. To complicate matters further the proximity of the Turkana desert has a considerable desiccating influence on the vegetation and on exposed soil surfaces.

There is a pronounced rainfall gradient in the district, the area of lowest being along the eastern boundary, where it may be as low as 15 inches in parts of Karasuk and Matheniko, to as high as 30 to 35 inches on the western borders of the district. The rainfall gradient from east to west has a pronounced effect on the vegetation. The vegetative communities on the drier eastern parts tend to be xerophytic thickets and bushland with a sparse occurrence of grass which does not amount to a cover except on the black clay soils. A grading of the cover through different types with a lessening of shrub and tree density and a thickening of grass swards occurs as the rainfall increases from east to west. Along the western border a fairly stable grass/tree savanna is widespread which provides ample soil protection. That afforded by the bushland and thicket is very poor and sheet erosion is rampant in all eastern areas; it is further increased by man. The Karamojong being still a pastoral people with large herds of cattle have overgrazed and still continue to overgraze much of the eastern countries. By excessive grazing sheet and gully erosion has been accelerated with resultant increased loss of moisture to the plant. This is followed by inevitable destruction of vegetative cover, further erosion and invasion by semi-desert xerophytic species.

The adjacent areas of bushlands with a reasonable cover of annual and perennial grasses, have suffered as a direct result of the vegetative deterioration to the east. The Karamojong have been forced to graze their cattle further and further west as the grazing in the east was ruined. Overgrazing of the centrally situated grasslands has taken place and is still taking place. This has led to widespread sheet erosion of the biologically active top soil and the loss of much potential soil moisture. The continued loss of soil moisture plus overgrazing has led to the virtual destruction of what were grass savannas and the invasion and multiplication of bushland and thicket-forming trees and shrubs with a very poor coverage. What was once good pasturage is now only marginal ground.

This process is continually going on and it has, unfortunately, been accelerated by the siting of dams and supplementary water supplies in these marginal grassland areas. The road to ruin is depicted below:-

Marginal grasslands

|

Increased to overgrazing by cattle

|

Sheet erosion and loss of soil moisture

|

Complete vegetative change to bushland with little grass growth. Grasses mainly annuals of small bulk.

spells to increased erosion. Continued erosion of this has produced a widespread residual scree and boulder surface as can be seen on the slopes of the [illegible] hills.

Apart from the forests of Karamoja the climatic regime over much of the area is of low rainfall. To complicate matters further the proximity of the Turkana desert has a considerable desiccating influence on the vegetation in conditions of soil moisture.

There is a pronounced rainfall gradient in the district, the amount of rainfall being highest in the western boundary, where it may be as high as 45 inches in [illegible] from 20 to 30 inches in the [illegible]. The rainfall is [illegible] from [illegible] The vegetative [illegible] and bushland [illegible] cover [illegible] different types [illegible] of grass [illegible] Along the western [illegible] which provides ample soil protection [illegible] thicket is very poor and sheet erosion [illegible] It is further increased by [illegible] people with large herds of cattle have overgrazed and still continue to overgraze much of the western catchment. The excessive grazing, sheet and gully erosion has been accelerated [illegible] moisture to the plant. This is followed by inevitable [illegible] of vegetative cover, further erosion and invasion by [illegible] species.

The adjacent areas of lowlands with a [illegible] cover of annual and perennial grasses, have suffered as a direct result of the vegetative deterioration to the east. The Karamojong have been forced to graze their cattle further and further west as the grazing in the east was ruined. Overgrazing of the [illegible] grasslands has taken place and is still taking place. This has led to widespread sheet erosion of the biologically active top soil and the loss of much potential soil moisture. The continued loss of soil moisture plus overgrazing has led to the typical destruction of the [illegible] and the invasion and multiplication of bushland and [illegible] which have a very poor coverage. Thus the [illegible]

This process [illegible]

Improvement [illegible]

Sheet erosion & [illegible] of soil moisture ...

Complete vegetative change to bushland with little grass growth. Occurs mainly outside of small [illegible]

Overgrazing and resultant erosion and vegetation change is, however, not confined to areas of marginal cover. It has spread to good fire-climax grasslands and is causing serious deterioration of the sward over a wide area. At the same time, the practice of burning the grassland during the dry season is getting less and less common and, partly as a result of this, an increase of bush-forming trees is apparent. In relatively dry areas such as Suk and Karasuk the combination of overgrazing and loss of ground cover on a more steeply contoured landscape has led to widespread sheet and gully erosion of the soil. Enormous changes in vegetation have taken place, greater than anywhere in Karamoja, possibly accelerated by the prevalence of readily erodible soil types.

In Suk territory not only has a change from grassland to bushland and thicket taken place but the process has even gone further to the state of complete removal of the soil and its cover. Once this has happened the land is, of course, of no agricultural value though it may eventually be of some pastoral value.

Other minor areas of deterioration in Karamoja are numerous, such as the bases of hills and mountains. Where the slope is sufficient to allow accelerated run-off and where heavy grazing occurs, serious erosion of not only the soil surface but the complete soil profile has taken or is taking place. In such cases there does not seem to be an initial change from grass savanna to bushland. It appears that as soon as the grass cover is bared the degree of slope is sufficient to trigger-off severe fully and sheet erosion. There are many classical examples of this process going on - one is at Karita where large tracts of tree-savanna-covered soil are being completely eroded down to bare rock and a residual stone mantle. The same is going on on the watershed dividing the Kyoga-Turkwell drainage systems.

The impact of widespread erosion on the soils and, therefore, on the agricultural potential is also considerable. Continued sheet erosion of many square miles of agricultural land is reducing soil depth and, therefore, crop potential. The present haphazard agricultural practices of the Karamojong tend to accelerate the erosion process, since no attempt is made to plough on the contour and little or no attempt is made to arrest run-off and thus conserve both moisture and soil.

There is also evidence that prolonged cultivation of certain sandy-clay loams, with resultant sheet erosion and loss of fertility, induces the more rapid invasion of bush species such as <u>Acacia nubica</u>. Changes such as this induced by bad farming are no longer isolated occurrences since cultivation among the Karamojong is widespread. Consequently, single areas, each of several square miles in extent, are now thickly covered with what amounts to useless bush.

The effects of the foregoing erosion processes have been classified into different mapping units as follows:

Erosion slight	1. Forest or potentially forest-covered land.
	2. Undulating land well covered with vegetation.
	3. Gently rolling land, well covered.
Erosion medium	4. Gently rolling land, not so well covered.
Erosion severe	5. Denuded, gently rolling land.
	6. Hills and mountains with strong slopes and fair cover.
	7. Denuded steeply undulating land.
Erosion very severe	8. Completely ruined land.

VEGETATION IN RELATION TO SOIL EROSION AND LAND USE

Much of the eastern and central parts of Karamoja are bushland and thicket with generally a poor grass sward. These areas are, incongruously, also the most heavily stocked - large herds of cattle, goats and sheep being ranged there during the wet season. The grass or pasture potential of the different plant communities is naturally low with the exception of those on black clay soils. The assorted grasses of the bushland and thicket communities are mainly annuals of little bulk like Sporobolus marginatus or Aristida adscensionis with only occasional perennial grasses like Panicum massaiense or Cenchrus ciliaris. Stock, particularly cattle, must be ranged widely to collect enough bulk to satisfy their requirements. The associated herbage cover is often sparse and many of them are inedible, but a few species like Justicia caerulea and Hibiscus spp. are edible and supplement the grasses. The bushland constituents like Acacia mellifera or A. misera provide little or no forage for cattle except by their seed pods. A number of associated shrubs are, however, edible like Cadaba farinosa or Grewia villosa but like the herbs they provide little bulk.

The intense concentration of cattle on these bushlands and thickets has led to the severe overgrazing of the small grasses and has tended to accelerate sheet erosion and even to stimulate gully erosion on undulating land. The adjoining better grassed areas to the west, with a slightly higher rainfall have suffered heavy and concentrated grazing by cattle overflowing from the overgrazed areas.

The present land use of these dry bushlands and thickets appears to be unbalanced as they are not grasslands in the strict sense of the word but "browselands". The grazing is over-utilized while the browse potential is in places hardly touched. The production of meat and milk per square mile could be greatly increased if more reliance were placed on goats instead of cattle. The very dry succulent thickets along the extreme eastern border of the district could usefully support camels as well as goats, as the flora is very similar to that of Turkana at the base of the escarpment. A more balanced use of the eastern countries would then involve some limitation on the numbers of cattle and considerable increase in the numbers of goats.

Grasslands of high quality do exist in the eastern area on the black clays, consisting of a Pennisetum mezianum - Chrysopogon aucheri community. These represent a lightly grazed fire climax, they stretch along the eastern boundaries of the district from north of Moroto to south of Loyoro. They deteriorate rapidly with overgrazing. The reason for their present state of perfection is probably due to the lack of water which allows of grazing only in the wet season. Utilization of these grasslands is, at present, incomplete and might be improved but very careful stocking rates would have to be worked out initially in order to prevent deterioration.

The Kanyangareng enclosure in the Suk country is now theoretically not grazed and is under the direct control of Government. The area is largely bush covered but the plant communities are such that a grass cover of sorts could be induced by carefully controlled stocking and alternate burning. It might best be utilized as a rotational grazing scheme patterned roughly on the Yatta Project in Kenya. The co-operation of the Suk tribesmen would first have to be ensured but once this was accomplished it could prove a useful source of revenue to Karamoja Local Government and would be invaluable as a demonstration of the advantages of controlled stocking. The scheme would depend to a great extent on the regular purchase of the surplus fat stock at a profitable price.

The large areas of marginal Lannea humilis - Acacia senegal bushlands and Acacia brevispica - Lannea humilis - Albizia amara var. sericocephala bushlands are to-day overstocked and are deteriorating further into denser thickets and bushlands. The enclosures laid down by the writer in 1954 in these plant communities have shown that the exclusion of grazing followed by the burning of the accumulated grass, over a number of years, leads to a marked improvement in the ground cover. It appears that a re-colonization by perennial grasses occurs which thickens up in time and provides very useful grazing. There are large expanses of the above-mentioned bushlands which at present are being over-utilized and are deteriorating as a result. A better return from such land would be achieved if the grazing pressure on them was reduced in order to allow the re-establishment of a dominantly perennial grass cover. The Hyparrhenia rufa - H. dissoluta, H. filipendula - Themeda triandra grasslands of Opopwa clay loam and the Setaria incrassata - Dicanthium papillosum - Hyparrhenia spp. - Cymbopogon giganteus black clay grasslands of the western counties are at present misused. These grasslands are used practically only in the dry season when the mature dry grass is burned off and the palatable flush is grazed. No cultivation is done in these areas and there is no balanced wet and dry season grazing. Herds of cattle, and to a certain extent goats and sheep, range over the burned grasslands in large mobs. Their intense heavy grazing if prolonged leads to the destruction of many of the tufts of perennial grasses leaving circular bare patches. These in time tend to increase and coalesce and in turn stimulate destructive sheet erosion. The [illegible] Grasslands of high quality exist in the eastern area on the black clays, consisting of a Loudetia-Setaria - Chloris [illegible] community. [illegible]

[illegible]

[illegible] provide [illegible].

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reduction of the available herbage by the extension of the bare patches leads to increased concentration of stock on the remainder which induces further deterioration. The process is most marked in the communities growing on the Opopwa and Lolokek clay loams where a decided increase in Lannea humilis to form close bushland with little associated grass takes place. The process is not nearly so marked on the black clays which have a better rainfall acceptance because of better topsoil structure and flatter topography.

The indiscriminate siting of dams and other water supplies has not alleviated the deterioration process, on the contrary, it has been a contributory factor. It stands to reason that the siting of dams in marginal ecological areas by increasing the potential and actual grazing, leads to accelerated destruction of the perennial grass cover. This is amply illustrated by the induced overgrazing brought about by the construction of Lokiporangitome dam in 1947. Aerial photographs taken in that year clearly illustrated the presence of a grass savanna around the dam. To-day the whole area has degenerated into a Lannea humilis - Acacia senegal bushland with little or no surviving Hyparrhenia or Themeda grass. At the same time, the area is now subject to intense sheet erosion because of the reduction in the ground cover. The same process has been brought about by the siting of certain other dams in the district, noticeably Nakwakipi and Nagola.

At present it is difficult to see the logic of further dam construction or the provision of water supplies in Karamoja, as it is generally agreed that the area is grossly overgrazed. The need for destocking on a large scale is also generally agreed, so it would appear that the provision of water supplies in what were waterless areas only extends the grazing further westwards. At the same time, the provision of extra grazing permits a further uncontrolled increase in the already swollen cattle population. Both Pian and Bokora counties are saturated with dams, sited all over the perennial grass plains and there are already abundant signs of overgrazing, and it would appear that it is only a matter of time before the Karamojong will be faced with the anomaly of a serious shortage of grazing and ample water supplies.

As yet, no firm policy on stock limitation has been implemented, the measures taken such as the extension of grazing to waterless areas by dams only delay the inevitable day when the Karamojong will have to go into the neighbouring districts of Teso and Acholi in search of grass. These delaying measures have proved costly and, unfortunately, destructive of some of the natural resources of the district, and still the real problem of overstocking has not been tackled. It appears, therefore, that something must be done to remedy the situation. One of the most obvious, cheapest and simplest remedies would be a reversal of the extension process by ceasing to maintain the dams or by putting out of action about half of them in rotation. This is a drastic measure but the position is serious and counteractions are urgently needed. The Karamojong are con-

tinually incurring stock losses such as those of the 1953-54 dry season and recently the 1957-58 dry season. They have faced far worse losses in the past when rinderpest and pleuro-pneumonia outbreaks controlled the stock numbers and when the grasslands were far more extensive than they are now. These past losses did not cause a mass migration of the tribe nor did they wipe the tribe out. The Karamojong to-day although still primitive are tough and resilient.

Limitation of water supplies means, of course, that natural limitation of the stock population would occur, which is agreed to be desirable by all people concerned with the problem. At the same time, it is not too drastic a method or too sudden and would not lead to any real hardship as the production of cereal food in an average year is more than ample for basic requirements. The achievement of the reduction of the cattle population in this way would not necessarily be excessively wasteful, as once the meat and blood meal factory is working at Namalu, a large offtake of starving cattle could be made.

The radical transition from excess to reasonable numbers of stock might stimulate the Karamojong to a long-needed change in way of life from "primitive pastorality" to a more balanced food - cash crop - cattle economy; mixed farming, in fact! The germs of this are there as will be seen in the next section.

PRESENT LAND USE

Karamoja district embracing Karasuk occupies in the region of 13,000 square miles. It is sparsely populated by very primitive, largely pastoral tribes. In many ways the people resemble the Masai in Kenya or any of the other primitive pastoral tribes in East Africa. The district, in spite of at least 30 years of British administration, is still at times unsettled by the outbreak of cattle raiding and consequent fighting (Brasnett, 1958). The individual Karamojong is still closely bound by tribal custom and cannot always act on his own impulses but must follow the dictates of the tribal elders.

Six main tribes are to be found in Karamoja, five of whom Bokora, Dodoth, Jie, Matheniko and Pian speak a common language and have similar customs: the sixth tribe, the Suk, are comparative newcomers. The Suk to-day occupy much land that was formerly settled or grazed by the Karamojong and, on the whole, a bitter enmity exists between the Karamojong and the Suk tribes, periodically culminating in bloodshed. A number of smaller tribes are indigenous, they are the three Tepeth groups occupying the mountainous areas of Kadam, Moroto and Napak. Another sub-tribe are the Labwor people who are an offshoot of the Jie tribe.

The Karamojong group traditionally have been cattle-keeping people from distant times; they have also, according to tribal heritage, always cultivated a certain amount of cereals. Responsible old men who remember the first arrival of the King's African Rifles and even remember Karamoja Bell, tell of conditions of life being very different from what they are

to-day. They relate that formerly the population was smaller than it is now, settlements being confined to areas of permanent water such as large rivers. Cattle populations over periods of time varied considerably in numbers because of rinderpest. At about the turn of the century it is said that cattle numbers were small, ownership being confined to a few individuals. Many Karamojong had no cattle at all, possibly a few goats and sheep. Life was very much at a subsistence level with people depending on game, cultivation of sorghum and finger millet, and on roots, herbs and fruits. Conditions of life were so hard that people used to depend to a large extent on natural foods such as the fruit of Balanites, edible fungi, and the roots of Lannea humilis.

The older men further related that the vegetation of the present day differs from the former times. They repeatedly stated that Karamoja was a "white" country, the meaning of this being that the land was grass covered for immense distances. Also, very extensive grass fires used to spread over very wide areas every dry season. They say that the period of change and growth in population started at the turn of the century, continuing to the present day and that the numbers of cattle and other stock kept now far exceed those kept long ago. They also recognize that vegetative change has taken place but stress that the change has been quantitative more than qualitative. The greatest reason for the increase in population is said to be the bringing of security and the cessation of inter-tribal warfare thus allowing of wider settlement.

The provision of water supplies and the control of rinderpest and pleuro-pneumonia epidemics have, of course, had a tremendous influence in permitting of the phenomenal increase of stock to present-day figures (about one million head).

In spite of their greatly improved welfare the majority of the Karamojong to-day are still primitive pastoral people whose needs of manufactured products such as clothes, bicycles, etc. are probably nil. The average Karamojong male is perfectly content to go completely naked except for a few beads and a cotton sleeping sheet or shuka. The women satisfy their needs by the skilful preparation of well-fitting, fat-softened goat-skin skirts and bead aprons.

The food requirements of the Karamojong are met partly by the herds of cattle and goats. The cattle supply quantities of milk which during the rainy season is plentiful. The practice of withdrawing blood from their mature stock is widespread and mature animals are bled at regular intervals to give one or two pints of blood. The blood is an additional protein supplement to the people's diet. The goats and sheep are also additional sources of milk and meat. Cattle are, however, not generally a source of meat, as the Karamojong are extremely loath to kill their larger stock for food. Meat is available, however, from animals that have died or from those slaughtered on ceremonial occasions. There is now an increasing tendency to sell some of the surplus stock for cash, usually when food supplies are short. Male stock are disposed of first, as

breeding stock are valued too highly. Cash received from the sale of cattle is mainly used for the purchase of maize meal, which supplements the otherwise thin diet, prevalent from the middle of the dry season to the beginning of the rainy season.

The Karamojong by no means subsist purely on their cattle, though this may be true of the Suk. In fact, the Karamojong can no longer be classified as a nomadic pastoral tribe as they are increasingly cultivating cereal crops such as sorghum and maize. Agricultural statistics show that there has been a substantial increase in the acreage of sorghum planted and a phenomenal increase in the acreage of maize which is a comparatively new crop to the tribesmen. The introduction of the ox-drawn mouldboard plough has led to its rapid and widespread adoption by the Pian and Bokora tribes and, to a lesser extent, the Matheniko, Jie and Dodoth. The adoption of the plough has led to an enormous increase in the production of food and a cultivator is now able to work a far larger area than he/she was formerly able to do with hoes. So great has the increase been that in a good year the Bokora and Pian tribes have a surplus of sorghum and maize. The surplus food is exchanged with less fortunate tribes such as the Suk and Turkana for goats and donkeys.

Present land-use in Karamoja is greatly influenced by the climatic regime. Total annual rainfall varies widely over the district, its range being at the lowest about 15 inches to as much as 35 inches per annum. Rainfall tends to be episodic in occurrence over two periods: the first, April to the beginning of June, the second from the beginning of July to the end of September. There is considerable variation from year to year and drought years occur. Rain tends to be precipitated in intense short periods and considerable loss of water occurs from land inadequately protected by vegetation.

There is usually a long, intense dry period from the beginning of October to the end of March. This has a decided limiting influence on vegetative growth and on vegetation type. A combination of comparatively low rainfall and a long dry season with hot winds over large areas of Karamoja induces a dominance of arid or xerophytic plant communities. This climate has also a considerable limiting influence on the type of crop that can be planted.

The driest areas of Karamoja are in the east of the district, where the Karamojong have traditionally made their permanent settlements. They have thus had to adapt themselves to the prevailing natural conditions of vegetation and soil. Their stock have in turn had to adapt themselves to short, sparse grass, sufficient for maintenance during the wet season and part of the dry season. With the advance of the dry season the east can no longer maintain the complete herds of cattle and a large proportion of each herd is split off and transferred to the western side of the district which, for reasons not completely known, has always been unsettled and ungrazed during the wet season. During the dry season the

migrating herds from the east enter the western area and temporary cattle camps (Nawi) are constructed. The vegetation of the west is dominantly a tree or grass savanna developed under more favourable climatic conditions than those in the east. The species of grass comprise mainly tall, tufted perennials which at the time of migration are standing as dry unpalatable mature growth. It is customary for the Karamojong to burn this grass off in order to promote more palatable and nutritious young growth which their cattle subsist on for the duration of the dry season.

Cultivation in Karamoja has naturally occurred around the permanent settlements on the eastern side of the district. Under the prevailing drier conditions, therefore, a primitive agricultural system has been developed. At the present day the Karamojong favour the cultivation of sorghum over all other cereals, as it provides them with a staple cereal food eaten as a porridge (atap) or consumed in the fermented state as beer (agwe). The old men say that finger millet was also widely grown in the past but not to-day. Maize, however, has been increasingly gaining in popularity as a second cereal crop. Yields of cereals vary greatly from year to year; in dry years the sorghum yields are down considerably, and maize yields are practically nil. In good years, though, large crops of both grains are harvested which carry the people over the dry season and make the purchase of supplementary food, such as maize meal, unnecessary.

Certain cultivation customs are rigidly enforced. Traditionally, the preparation of land and the care of crops has been the strict concern of women and children; the amount of grain produced being directly relative to the number of wives and children a man had. Unmarried men who for various reasons are or were unable to marry, had to cultivate for themselves. Otherwise it was and still is rare to see a man taking much part in the growing of crops. Stock are his concern. However, since the introduction of the plough and, therefore, the use of cattle to pull the plough, men now help but this usually goes only as far as ploughing or assisting with the ploughing.

Cultivation rights vary somewhat between tribes but overall the following are exercised. Family plots are a traditional thing, specific areas of land are cultivated by a family group and handed down in that group from mother to daughter. These family plots were usually sited close to the homestead, but with the increase that has taken place they also include land some distance away. No person of the tribe may cultivate the land, long used by another person unless that person has publicly renounced claim to it. This claim to land may extend for as long as ten to fifteen years even though such land has not been cultivated by the owner for such a period. In the same way a homestead may be moved a distance of two or three miles and new land broken, the land around the old homestead being apparently abandoned. Such land around the old homestead, and on land previously farmed may not, however, be used by another person without the permission of the first

cultivator. Such permission may be given gratis or a token payment of a goat or small stock may be made. Any individual, however, is completely free to open up and cultivate land not previously cultivated or abandoned land, the act of breaking itself giving that person future right to the area which he has cleared. It is not necessary for an individual to seek the permission of the tribal elders to open up new land. He is quite unbound by any custom or decree.

The produce from a cultivated plot becomes and remains the property of the cultivator, a wife can do exactly as she pleases with her crop. She will naturally store the bulk of it for feeding her husband and children. However, she will often barter a portion for goats or sell for cash or prepare beer from it which she will then sell for cash. Any stock or cash received belongs to the wife and cannot be taken by the husband.

Cultivation practices are extremely simple. Land chosen is roughly cleared by hand of all surface vegetation, which is dragged to the perimeter of the plot to form a stock-excluding fence. Maintenance of the fence, if cultivation is continued year after year, sometimes involves the cutting of bush some distance away to provide mending material. Clearing usually takes place in the dry season or in the early part of the wet season. The cleared area is then ploughed or hoed by hand after the first rains have fallen, usually in April, followed by the broadcast of seed. The plot until the maturity of the crop is now kept weeded, particularly in the early stages of growth. At harvest time platforms are built in the plots and boys and girls take up daily residence on these platforms armed with sticks and clay balls which are thrown at seed-eating birds in order to frighten them away. Harvesting is carried out by cutting the heads off when the crop is ripe, the stalks being left standing. After harvest, cattle are often browsed communally through the field to clean up the residues; no attempt is made to burn residual stalks and trash and, as a result, a high carry-over of stem borer and bollworm occurs. The entire grain heads are stored after initial drying in large baskets; the grain being threshed by flailing when required and ground to a fine flour on granite grindstones.

In Bokora, Pian and Matheniko counties sorghum and maize are the main crops grown; to a limited extent finger millet and groundnuts are also grown. In Jie county, sorghum is the main crop grown with some cultivation of groundnuts, finger millet and maize. In Dodoth county, bulrush millet and sorghum are most widely cultivated with a little maize, cassava, sweet potatoes and finger millet in some areas. Cotton is also grown to a limited extent close to the Acholi border.

In Labwor county, sorghum, finger millet and groundnuts are the main crops but to a lesser extent cassava, simsim, maize and cotton are also grown. Cotton has spread somewhat but it is often indifferently harvested. In the Suk-Karasuk area little, if any, cultivation is practised,

a few plots are located close to the main rivers and in the Loro area, otherwise it is confined to the foothills of the Chemorongit mountains.

Little, if any, attempt at soil conservation is done by the Karamojong with the exception of the Tepeth group, the Dodoth and the Labwor people. The Labwor carelessly try to follow a pattern of strip cropping, but the plots rarely follow the contour. This system has been borrowed from their more advanced Acholi neighbours.

The Tepeth tribe who formerly occupied the higher slopes of Moroto, Napak and Kadam mountains have evolved a form of terracing. This has probably come about after they experienced the severe loss of soil from cultivated plots on steep mountain slopes. Their plots are cleared in much the same way as the Karamojong do, but felled trees, sticks and trash are piled in lines about 6 inches to a foot high at regular intervals on the contour. More permanent plots have stone-built terraces of large and small stones laid in lines on the contour. The terraces if maintained for a sufficiently long period build up a step effect on the slope which achieves a fair degree of control of surface run-off.

In Dodoth county a widespread system of trash bunding has been evolved. The weeds and trash from cleared and cultivated plots are piled in lines at regular intervals, across the slope and roughly on the contour. The lines are sometimes reinforced with soil but not usually with stones. The system works reasonably well in preventing excessive soil wash but the bunds tend to breach in heavy storms.

Elsewhere in Karamoja little attention is paid, as yet, to soil conservation of food plots. All too frequently, cultivation is very indifferent and ploughing up and down slopes is often seen. Large tracts of soil may be turned over with no provision whatsoever to control wash; sheet erosion is often noticeable as a result.

The Dodoth people appear to prefer the lighter red-brown, sandy-clay loams for cultivation instead of the black clay soils. The Jie, Matheniko, Bokora and Pian, however, cultivate both the black soils and the sandy-clay loams. The Bokora may show a certain preference for the black clay soils over the sandy-clay loams. It is difficult to draw any tribal preference as it is largely a matter of individual taste. Increasing use is being made of the minor and major alluvial deposits, particularly the sandy-clay alluvial deposits. In Pian county particularly, increasing cultivation is apparent on the periodically flooded margins of minor rivers; but good use is also made of favourable sites in other areas as well, such as the vicinity of the Lolachat river and the Manimani rivers.

The following present land-use categories have been mapped.

Area of: 1. Much cultivation, grazing light.

2. Medium to light cultivation, grazing heavy, wet and dry season.

3. Little cultivation, grazing medium-heavy, wet and dry season.

4. Little cultivation, grazing medium-light, wet and dry season.

5. Negligible cultivation, grazing medium-heavy, wet and dry season.

6. Negligible cultivation, grazing dry season only.

7. No cultivation, grazing wet season only.

POTENTIAL LAND USE

In order to make an appraisal of the agricultural potential of the land of Karamoja the various soil-mapping units have been re-arranged in order of descending value and presented in Table 2.

The nine land classes will now be described in more detail.

1. Irrigable Bottomlands

Soil units: Namalu, Loyoro, Undifferentiated alluvium

Considerable areas of alluvial soils, of both non-volcanic and volcanic origin are suitable for flood irrigation. They are incompletely utilized at present by the Karamojong and could support a wider range of crops with additional water. Irrigation by using the flash floods has already been investigated by Government on non-volcanic alluvium. Two small and widely separated schemes at Nadunget and Nabilatuk were run for several years but were later abandoned due to high cost of maintenance and very low return. The human factor is probably the main difficulty involved as the Karamojong have not as yet shown any pronounced skill in intensive cultivation. It is probable that they are not at present capable of operating an irrigation system. However, a number of potential flat low-lying irrigable areas with reasonably fertile soil do exist in the districts which are at present unexploited. It is conceivable that these areas might be exploited in the future, as they would prove a useful adjunct to food production, particularly in marginal areas. A variety of crops such as sorghum, finger millet, rice, groundnuts, pulses and cotton could be raised under such flood irrigation schemes. Also there are several streams which could be used for the permanent irrigation of the surrounding soils. These appear to be just as suitable for irrigation as the Namalu irrigation scheme has proved.

A few acres of volcanic alluvium of the Namalu river have been irrigated perennially for about the last ten years. Long-term crops such as sugar cane, bananas and citrus have been successfully grown; while temporary food crops such as rice, sorghum, finger millet, maize, sweet potatoes, melons and squashes have all yielded well. A wide range of vegetables can also be grown such as cabbage, cauliflower, kale, tomatoes, onions, beans, peas, lettuce, carrots, and egg plant. A much larger area is at present undeveloped and awaits the settlement of cultivators who would be willing to exploit the potential, probably with individual holdings in a regional irrigation system using the proposed Kadam reservoir for storage and the Namalu river system for distribution purposes.

TABLE 2

POTENTIAL LAND-USE

LAND CLASS	SOIL UNITS	VEGETATION	PRESENT USE	POTENTIAL USE
DRAINAGE SLOW				
1. Irrigable Bottomlands	25, 26 7.	Acacia albida, A. tortilis, A. gerrardii, A. milbraedii, Kigelia aethiopica, Terminalia brownii, Zizyphus spp. etc.	Seasonal cultivation of sorghum and maize. -	Flash flood irrigation Extended crop range to include groundnuts, rice, finger millet on potentially irrigable land. Permanent irrigation Bananas, sugar cane, citrus fruits, fruit and vegetables rice, sorghum, maize.
2 (a) Clay Plains, drier	22 (in part)	Pennisetum mezianum, Chrysopogon aucheri.	Light grazing, sorghum and maize.	Production of fat stock on properly rotated grazing systems with arable rotations.
(b) Clay Plains, wetter	22 (in part) 24.	Acacia drepanolobium, occasional A. seyal, Setaria incrassata, Hyparrhenia spp., Dicanthium papillosum, etc. Grass savanna.	Grazing dry season only	Rotational grazing. Cultivation of cereals and cotton.
DRAINAGE FAST				
3. Valleys of Volcanoes	4, 5, 9, 26 (in part)	Riparian forest of Acacia gerrardii, A. sieberiana, Kigelia aethiopica etc. Sorghum spp.-Hyparrhenia spp.-Panicum spp., grass layer.	Some cultivation of sorghum and maize in lower reaches.	Extended cultivation to include arabica coffee where suitable, cassava, sweet potatoes etc.
4. North-western Uplands	6, 12, 15, 18 (in part) 21.	Acacia nockii, Commiphora pilosa, savanna woodland. Hyparrhenia spp., Themeda triandra etc. grass layer.	Light cultivation in parts. Medium grazing.	Increased cultivation of cotton, cereals, sweet potatoes and cassava.

LAND CLASS	SOIL UNITS	VEGETATION	PRESENT USE	POTENTIAL USE
5. South-western Uplands	9 (in part), 16.	Acacia sieberiana, Lannea humilis Hyparrhenia spp., Themeda triandra grass savannas.	Dry season grazing. No cultivation.	Rotational grazing with planned settlements and cultivation of sorghum, maize, finger millet, cassava and cotton.
6. Eastern Heavy Land	11, 13 (in part)	Acacia brevispica, Euphorbia candelabrum, Acacia seyal, A. mellifera, Themeda triandra etc.	Intense grazing, little if any cultivation.	Improved grazing with control of stocking sites. Cultivation of sorghum, finger millet, cassava, etc.
7. Eastern Light Land	13 (in part), 17, 19, 23.	Bushland and thicket including Acacia mellifera, A. tortilis, A. brevispica, A. nilotica, Lannea humilis & xerophytic communities.	Intense grazing and some cultivation of sorghum and maize.	Reduced grazing to produce better quality stock. Increased use of browse stock. Widened range of crops to include bulrush millet and perhaps finger millet.
8. Mountains	1, 2, 3, 4, 5, 10 (all in part)	Teclea, Cedar, Podo, Olea forest or Protea - Faurea montane grasslands.	Light grazing of grasslands.	Cultivation of temperate food crops and coffee.
9. Rocky slopes and stone mantles	8, 14, 20.	Very varied from savanna woodland to grass savanna or thicket.	Light grazing and browsing.	Light grazing and browsing.

2. Clay Plains

Soil units: Sebei (in part), Kidepo.

The clay plains occupy more land than any other class in Karamoja. They are cultivated fairly widely in Bokora county where they appear to be capable of long-continued use without a fall-off in productivity. They are further not so liable to erosion as the less cohesive sandy-clay loams and, therefore, can be cultivated with less risk of soil loss. The main limiting factor in their utilization is, of course, rainfall. The easterly areas of the black clays are probably best managed as grazing in rotation with food crops. Excellent grass cover of Pennisetum mezianum and Chrysopogon auchori is naturally present under light grazing conditions.

3. Valleys of Volcanoes

Soil units: Katabok, Napak, Apedet, Undifferentiated alluvium (in part)

On Moroto and Napak are deep soils which are fertile, but are little used at present. Where they are used the potential is never fully exploited and the cultivation system practised is harmful. The range of crops that could be grown is, of course, limited largely by the prevailing climatic conditions, but on the whole it could be extended. Around Kadam and Napak, cassava, sweet potatoes and groundnuts could be introduced or extended and cotton could be tried as an economic crop. The present system of completely clearing the vegetative cover is harmful as it exposes the soils to unnecessary erosion and probably reduces yields through removal of shade.

Many well-wooded or forest-covered colluvial deposits of a deep humose-topped granular clay loam extend up numerous sheltered valleys on Kadam mountain and to a lesser extent on Napak and Moroto mountains. These valleys are at present virtually unexploited agriculturally and no forest products are produced from them. It would appear that some of these valleys could be used for the production of perennial crops such as arabica coffee and bananas. The cultivation of these would not involve total removal of the forest cover but would entail a thinning out of the scrub and small trees. The larger trees would be left to provide shade and protection from wind. A system of simple terracing should be introduced to protect against soil erosion.

4. North-western* Uplands

Soil units: Lolikok, Kalapata, Pajule, Lorengikipi (in part), Amuria.

The higher rainfall of the north-western uplands west and north of the district makes them suitable for development. At present they are sparsely cultivated and mainly used as grazing land. However, some permanent settlement has taken place by the indigenous people and further agricultural expansion should be encouraged. At present, sorghum, finger millet, cassava and sweet potatoes are grown in the Labwor area while in the Napore-Karenga area bulrush millet, etc. are widely grown. Cotton,

* Roughly north of the Soroti-Moroto road and west of the main clay plain.

as an economic crop, is also grown to a limited extent, but considerable improvement and extension of its cultivation could take place. Soil conservation methods in Labwor follow a rough strip cropping system and in Napore-Kerenge a trash bunding system. More organization with proper rotations and a wider range of crops would be beneficial.

5. South-western* Uplands

Soil units: Apedet (in part), Opopwa.

The utilization of the soils of this class of land for crop production at the present time is negligible. But the land is used to a certain extent for dry-season grazing of cattle. The Karamojong prefer to cultivate and remain settled in the eastern parts of the district. Without some re-settlement of the indigenous tribes or of people from outside the district these soils will remain uncultivated. Cassava, finger millet, maize, sorghum and sweet potatoes could all be grown, preferably under a properly organized rotational system of farming with appropriate soil conservation practices. Cotton would also be possible on these soils. Cultivation would be limited by soil depth, which is often shallow (6 to 12 inches) with murram or massive sheet laterite underneath, but there are very large acreages of deep soils.

6. Eastern** Heavy Land

Soil units: Lokitanyala, Lokapel (in part)

The soils of this class are at present little cultivated but where the topsoils are intact good crops of sorghum can be raised. Since there is between 30 and 35 inches of rainfall per annum, the production of a fair range of crops is possible, including sorghum, finger and bulrush millets, cassava, beans and cowpeas; cotton could probably be grown as a cash crop. The present overall land-use is pastoral but the vegetative cover of dominantly thorn bush gives little return. The geographical occurrence of this heavy land is also important as it is widespread in the Suk area, where the tribesmen have shown singularly little interest in arable agriculture. The potential production is well exemplified around Loro village where quite a variety of crops, including cassava, are grown by one or two individuals. Undulating topography and fine texture of soil renders this land extremely liable to erosion and strict soil conservation measures would have to be exercised where it was cultivated.

7. Eastern** Light Land

Soil units: Lokapel (in part), Panyangara, Lomerimong, Kunyao

These soils of this class appear to be of general low fertility and their occurrence in marginal climatic areas renders their utilization

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* Roughly south of the Soroti-Moroto road and west of the main clay plain.

** Roughly east of the main expanse of clay plains.

difficult. Some use as arable land must, however, occur, as the Karamojong permanent settlements are found extensively on them. At present fair crops of sorghum and, to a certain extent, maize are cultivated until soil fertility is exhausted. High productivity would accrue if a wider range of crops were grown. Finger millet is a possible crop but one more drought-resistant crop and which grows well on poorish soils is bulrush millet. Groundnuts should also be tried more often as they are little cultivated at present. Some form of soil conservation practice on these soils such as trash bunding is urgently needed as the current Karamojong practice of indiscriminate cultivation of large clearings on undulating land leads to considerable loss of soil and soil moisture through wash and sheet erosion.

8. Mountains

Soil units: Kadam, Moroto, Nadiket, Katabok, Napak, Morongola (all in part).

Below 8,500 feet these soils have a potentially high productivity which is, at present, completely unutilized. There are no forest commercial products but considerable areas are being preserved for no good reason other than the conservation of water. The vegetative cover indicates a fairly well distributed rainfall of between 40 and 50 inches which should be adequate for some perennial crops. Arabica coffee, almost certainly, could be cultivated extensively on Kadam mountain and, to a lesser, extent, on Napak, while annual and perennial food crops such as bananas, maize and sweet potatoes could also be grown. Permanent crops do not necessarily entail complete removal of the forest cover, in fact, many of the larger trees would be left as shade. There again is no particular reason why there should be accelerated run-off and loss of water if the plots were properly laid out on the contour. Many marginal areas of forest on the steeper slopes would, of course, not be cultivated. As a method of conserving run-off, properly supervised cultivation, laid out on terraces, might well be superior to the establishment of grassland which has gained a lot of ground at the expense of forest on Moroto, Napak and Kadam mountains. The higher but sheltered slopes of Kadam which are at present largely grassland and heath might be potential tea-growing land, as the rainfall is fairly high and well distributed and the soils are acid.

9. Rocky Slopes and Stone Mantles

Soil units: Toror, Metu, Katikekile.

These are quite uncultivable but are occasionally useful for grazing.

SPECIAL CROPS

A climatically suitable range of economic crops is urgently needed for Karamoja if the Karamojong are to be stimulated to change from their conservative pastoral ways which are so wasteful of the natural resources.

difficult. Some parts of arable land may, however, [illegible] permanent [illegible] found [illegible] of scrubland [illegible] [illegible]

8. [illegible]

Soil [illegible]

[illegible]

steeper slopes [illegible] contour, [illegible] cultivated. [illegible] serving [illegible] supervised cultivation [illegible] might well be [illegible] cultivation [illegible] has gained a lot of ground at the expense of forest on [illegible] mountains. The higher but sheltered slopes of [illegible] which are at present largely [illegible] and [illegible] might be potential tea-growing land, as the rainfall is fairly high and well distributed and the soils are acid.

9. [illegible]

Soil series [illegible]

[illegible] but are occasionally [illegible] for [illegible]

[illegible]

Tobacco is such a potential economic crop; as yet, it has not been tried but it would appear that it is a crop, especially the Turkish type, suited to the climatic and soil conditions of parts of Karamoja. It is perhaps interesting to record that tobacco is widely planted by the Karamojong in very small plots as a local source of snuff.

Sisal is worthy of trial on the drier black clays of Karamoja as these are ideal for this crop. It should not, of course, be cultivated in large plantations but in small acreages of planned farm units. Mauritius hemp is another source of fibre which grows well in Karamoja with little care or attention.

Sansevieria ehrenbergii abounds on the drier thicket areas of the eastern parts of the district. The fibre is probably commercially marketable while the plant may also be the source of cortisone or cortisone-related compounds. Collection of the plant would be a relatively simple matter as it is so widespread and common.

Mexican fibre, Agave lecheguilla and A. funkiana have been suggested by the Uganda Development Corporation as possible crops for Karamoja. Material of the former species has been received from Kew and experimental plantings will be made.

Hibiscus cannabinus (fibre hibiscus) is very common in all parts of Karamoja, particularly in low-lying areas or near rivers. Some interest is being taken in its cultivation in Kenya and Southern Rhodesia as a potential substitute for jute and the U.D.C. are interested in its occurrence in Karamoja. The seeds of Hibiscus cannabinus are eaten by Karamojong. As a source of food, the seed is pleasant tasting and slightly oily. This plant occurs in a range of forms differing in leaf and floral characteristics. There are also a number of other hibiscus species which might also be useful sources of fibre. Calotropis procera is a shrub which is fairly widespread in Karamoja, the inflated fruit being a source of a fine silky fibre which is attached to the seeds in the centre of the fruit. The fibres have been used in the past as a substitute for kapok. A plant possibly worthy of investigation is the fairly common succulent plant Sarcostemma viminale, the mature branches of which yield an extremely strong fibre. The desert date - Balanites aegyptiaca, B. orbicularis and, to a lesser extent, B. pedicillaris are common throughout the district. The fruits are not only an important source of food in times of famine but are also a source of oil, the kernels containung up to 40 per cent. oil (Eggeling, 1951). The fruits also contain a substance which is lethal to Bilharzia hosts and the parasites themselves.

Aloes. Aloes are widespread and common in the drier eastern areas and have a possible economic potential as a source of at least one drug. The commonest aloe in Karamoja is Aloe tweediae but many other varieties are to be found. In South Africa Aloe ferox is cultivated as the source of the drug "aloes" and this species might do quite well in Karamoja.

Tobacco is such a potential economic crop [illegible] has not been tried but it would appear [illegible] the Turkish type, suited to the climatic and soil conditions [illegible]. It is perhaps interesting to [illegible] that [illegible] has, [illegible] very small places [illegible] local source of snuff.

Sisal [illegible] in the [illegible] crop. [illegible]

[illegible]

[illegible]

Hibiscus cannabinus (fibre [illegible]) [illegible] of Karamoja, particularly in low-lying [illegible] in the cultivation [illegible] that investigations for jute and [illegible] Karamoja. The seeds of Hibiscus cannabinus are eaten by Karamojong [illegible] source of food, the seed is pleasant tasting and slightly oily. This plant occurs in a range of forms differing in leaf and floral characteristics. There are also a number of other fibrous species which might also be useful sources of fibre. Calotropis procera is a shrub which is fairly widespread in Karamoja, the inflated fruit being a source of a fine silky fibre which is attached to the seeds in the centre of the fruit. The fibres have been used in the past as a substitute for kapok. A plant possibly worthy of investigation is the fairly common succulent plant [illegible], the leaves of which yield an extremely [illegible]. The other [illegible] are common throughout the [illegible]

[illegible]

well in Karamoja.

Essential Oils. Cymbopogon giganteus is related to lemon grass and is common on the wetter clay plain areas. There is also another Cymbopogon, markedly aromatic, which is present in greater quantity on all the higher mountains in Karamoja. The U.D.C. has shown some interest in the essential oil of this genus.

Another source of essential oils might be the very common plant in the dry thicket areas, Plectranthus cylindraceus, which is distinctly aromatic.

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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 < 2μ, silt 20 - 2μ
sand 20 - 2000μ

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.	%	pH	Organic	Truog

APPENDIX

ANALYTICAL DATA FOR SOIL PROFILES

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							
KADAM															
Kadam Mountain, 8,500 feet								Profile 1 (21016-18)							
13	9	14	16.4	2.1	1.42	0	0.06	19.98	15.8	35.78	56.8	6.3	11.17	24	High C and N
24	11	20	3.4	<.6	1.00	0	0	5.00	14.0	19.00	26.3	5.9	3.99	4	Very low P_2O_5
60	15	22	4.4	1.3	0.56	0	0	6.26	13.2	19.46	36.2	5.4	1.43	6	Very low P_2O_5
							N%	0-13"	1.059	C/N 10.6					
Kadam Mountain, 9,600 feet. Oboa Summit								Profile 2 (21014-15)							
7	18	34	<.8	<.6	0.38	0	0	1.78	14.4	16.18	11.0	5.3	2.65	5	Very low P_2O_5, Ca and Mg
28	5	40	<.8	<.6	0.38	0	0	1.78	14.7	16.48	10.8	5.4	1.82	5	
							N%	0-7"	0.273	C/N 17.7					
MOROTO															
Forest Camp, Moroto Mountain								Profile 3 (20579-82)							
7	16	34	12.8	6.9	1.78	0	0.33	9.01	8.4	17.41	51.8	6.0	2.76	10	Low P_2O_5
14	14	50	7.0	4.5	0.98	0	0.11	5.59	8.0	13.59	41.1	5.8	1.83	1	"
35	8	56	5.1	4.5	0.48	0	0.04	5.02	6.0	11.02	45.6	6.2	1.20	5	"
70	5	67	7.3	6.9	0.41	0	0.02	7.33	6.1	13.43	54.6	6.2	0.48	7	"
							N%	0-7"	0.253	C/N 9.2					
Kadam Mountain, forest 7,500 feet								Profile 4 (21019-22)							
3-0	24	7	11.1	2.2	0.73	0	0.01	14.04	8.7	22.74	61.8	5.4	18.20	52	High C and N but
25	18	23	6.9	2.2	0.87	0	0.01	9.98	10.0	19.98	49.9	5.0	5.50	19	C/N is normal
45	10	41	2.0	2.3	Tr.	0	0	4.30	5.4	9.7	43.3	4.5	0.69	9	indicating well humified
72	16	27	3.6	1.3	0	0	0	5.90	5.0	10.9	54.1	5.8	0.16	15	organic matter
							N%	0-3"	1.665	C/N 10.9					

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch Capacity	% Satur-	pH	Organic Carbon	Truog P_2O_5	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							

Depth Ins.	Mechanical Analysis % Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total	Exch. H m.e.%	Exch Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
								NADIKET							
								Profile 5 (18531-34)							
12	29	22	26.9	15.1	0.52	2.5	0	45.02	0.9	45.92	98.0	6.8	0.80	590	High bases and P_2O_5
72	17	38	30.0	10.7	0.64	2.3	0	43.64	0	43.64	100.0	7.2	0.66	950	" " " "
144	23	40	29.7	16.4	0.55	3.1	0	49.75	0	49.75	100.0	7.5	0.20	810	" " " "
180	21	36	19.7	14.5	0.48	3.6	0	38.28	0	38.28	100.0	7.4	0.14	1000	" " " "
								N% 0-12" 0.077		C/N 10.0					
								Profile 6 (20608-11)							
South side of Moroto Mountain, 5,800 feet															
0	16	36	16.0	8.2	2.67	0	0.02	26.89	4.2	31.09	86.5	6.7	3.72	135	High bases
13	14	42	13.1	8.7	1.66	0	0	23.46	6.4	29.86	78.6	6.1	2.51	15	
24	14	42	11.3	8.8	1.03	0	0	21.13	18.4	39.53	53.5	5.9	1.75	1	Very low P_2O_5
38	10	42	12.5	6.9	1.23	0	0	20.63	7.2	27.83	74.1	5.8	1.13	6	
								N% 0-3" 0.267		C/N 13.9					
								KATABOK							
								Profile 7 (21867-69)							
13	10	36	12.1	2.9	2.15	0	0.07	17.3	5.8	23.10	74.9	6.3	3.34	90	Bases increase with depth
40	14	36	12.8	3.0	1.59	0	0	17.4	N.D	N.D.	N.D.	6.6	1.30	10	
58	10	46	16.4	3.5	1.69	0	0	21.6	0.9	22.50	96.0	7.3	0.41	26	
								N% 0-13" 0.231		C/N 14.5					
								NAPAK							
								Profile 8 (19209-16)							
3	18	45	11.3	10.1	0.59	0	Tr.	21.99	7.8	29.79	73.8	5.5	2.12	95	High bases increasing with depth, very high K and Mg
6	10	53	11.8	10.7	0.67	0	0.02	23.19	7.7	30.89	75.1	5.5	1.84	69	
12	10	53	11.4	7.4	0.62	0	0.02	19.44	8.1	27.54	70.6	5.5	1.81	59	
24	14	53	15.1	8.8	0.92	0	0.02	24.84	7.6	32.44	76.6	5.5	1.78	90	
30	12	55	12.6	12.0	0.91	0	0.02	25.53	7.4	32.93	77.5	5.4	1.75	83	
48	10	59	19.8	10.8	1.31	0	0	31.91	6.1	38.01	84.0	5.9	1.64	53	
60	12	57	18.3	9.5	1.42	0	0	29.22	5.6	34.82	83.9	5.9	1.41	42	
72	12	57	21.4	9.8	1.40	0	0	32.60	5.0	37.60	86.7	6.0	1.13	45	
								N% 0-3" 0.126		C/N 16.8					
								3-6" 0.136		13.5					

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							
								LOLEKEK							
								Profile 9 (14596-600)							
8 miles along Namalu Lolekek Road															
12	3	58	11.5	5.9	0.97	0	0.13	18.50	8.0	26.50	69.8	5.8	2.16	15	High bases, low P_2O_5
18	3	62	12.5	5.8	0.75	0	0.08	19.13	6.9	26.03	73.5	5.8	1.65	9	" " " "
30	4	60	11.7	5.4	0.94	0	0.15	18.19	6.4	24.59	74.0	5.8	1.61	13	" " " "
48	3	24	4.8	2.1	0.73	0	0.05	7.68	4.0	11.68	65.8	6.2	0.56	20	
							N% 0-12"	0.148		C/N 14.6					
								Profile 10 (21068-71)							
3	10	27	6.5	3.8	0.83	0	0	11.13	5.3	16.6	67.2	6.3	2.36	71	
13	8	27	4.5	3.3	0.97	0	0	8.77	5.4	14.2	62.2	6.2	2.31	51	
50	8	45	1.2	2.0	1.07	0	0.02	4.29	8.8	13.1	32.7	5.8	0.74	3	Low P_2O_5 Raw humus
							N% 0-3"	0.143		C/N 16.5					
								NAMALU							
								Profile 11 (12049-53)							
Namalu Irrigation Scheme															
6	11	20	10.9	2.9	1.39	0	<.02	15.21	5.0	20.21	75.3	6.1	1.41	270	High K and P_2O_5
12	11	26	11.8	3.1	0.39	0.6	0.04	15.93	4.9	20.83	76.5	5.8	0.93	132	High P_2O_5
18	21	26	14.8	3.1	0.39	0.6	0.03	18.92	4.4	23.32	81.1	6.0	0.98	126	" "
30	19	26	15.6	2.4	0.34	1.1	0.03	19.47	N.D.	N.D.	N.D.	5.9	1.13	121	" "
48	16	25	14.1	4.1	0.31	2.4	0.05	20.96	5.9	26.86	78.0	5.9	0.98	139	" "
							N% 0-6"	0.130		C/N 10.8					
								APEDET							
								Profile 12 (14584-89)							
5½ miles up Namalu road from Greek River Bridge															
12	26	40	11.7	8.8	0.97	0	0.02	21.49	5.4	26.89	79.9	6.0	1.53	27	High bases
24	26	40	14.8	10.1	1.34	1.1	0.03	27.37	3.9	31.27	87.5	6.2	1.31	37	" "
40	6	56	17.2	9.1	1.13	1.5	0.02	28.95	2.2	31.15	92.9	6.8	0.93	31	" "
61	4	52	25.7	10.1	1.42	2.6	0.02	39.84	0.8	40.64	98.0	6.9	0.49	41	" "
68	8	54	26.5	10.1	1.34	2.3	0	40.24	0.7	40.94	98.3	6.9	0.41	41	" "
							N% 0-12"	0.116		C/N 13.2					

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch H m.e.%	Exch. Capacity m.e. %	% Satur-ation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							

Profile 13 (14606-10)

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							
Profile 13 (14606-10)															
5 miles from Namalu towards Lolekek Hill															
12	5	45	17.9	9.1	1.31	3.3	0.05	31.66	0.1	31.76	99.7	7.1	1.56	42	High bases
30	3	45	16.4	11.0	0.95	7.8	0.04	36.19	0	36.19	100.0	7.7	0.74	20	" "
54	4	47	20.7	12.6	1.08	13.2	0.04	47.62	0	47.62	100.0	7.9	0.44	57	" "
54+	4	53	22.6	20.2	1.08	15.7	0.03	59.61	0	59.61	100.0	7.9	0.32	102	" "
							N% 0-12"		0.152	C/N 10.3					
MORONGOLE															
Profile 14 (21267-69)															
Mount Morongole 8,500 feet, forest															
7	10	25	19.5	7.6	2.42	0	0.05	29.57	6.3	36.1	82.1	7.1	10.55	950	High bases, P_2O_5,
22	14	31	6.8	3.3	0.53	0	0.03	10.66	8.7	19.4	55.0	5.8	7.31	81	N and C
46	9	40	<.8	1.5	0.07	0	0.07	1.64	9.3	10.9	15.1	5.0	1.26	18	
							N% 0-3" 1.577, 0-6" 0.630				C/N 15.6				
Profile 15 (21271-73)															
Mount Morongole 8,500 feet, grassland															
15	11	24	3.9	2.5	0.64	0	0.04	7.10	9.9	17.0	41.8	5.6	4.64	33	All nutrients
27	15	28	1.5	1.0	0.28	0	0	2.78	13.8	16.6	16.7	5.6	3.46	10	low compared with
42	15	32	1.8	1.0	0.27	0	0.02	3.07	9.2	12.3	24.9	5.7	2,12	7	Profile 14
							N% 0-15"		0.321	C/N 14.4					
LOKITANYALA															
Profile 16 (12038-43)															
6 miles from Lokitanyala															
6	2	18	9.2	5.8	1.54	0	0.63	17.17	1.6	18.77	91.5	6.6	0.61	24	Low C and N
12	3	19	7.6	12.4	0.66	0	0.75	21.41	N.D.	N.D.	N.D.	5.8	0.35	10	
18	3	29	8.7	6.9	0.69	0	0.69	16.98	3.4	20.38	83.3	5.4	0.35	12	
36	3	31	10.8	9.0	0.47	0	0.11	20.38	N.D.	N.D.	N.D.	5.3	0.26	27	
48	8	28	8.8	2.2	0.39	0	<.02	11.41	1.0	12.41	91.9	6.6	0.23	17	
60	5	24	10.9	1.9	0.38	0	0	13.18	N.D.	N.D.	N.D.	7.6	0.13	18	High pH for red loam
							N% 0-6"		0.091	C/N 6.9					

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch H m.e.%	Exch. Capacity m.e. %	% Satur- ation	pH	Organic Carbon %	Truog P_2O_5	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							

Depth Ins.	Mechanical Analysis % Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total	Exch H m.e.%	Exch. Capacity m.e. %	% Satur-ation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
Loro Village								Profile 17 (16036-39)							
9	6	45	3.2	3.8	0.81	0	0.14	7.95	3.1	11.05	71.9	5.6	0.71	18	
36	6	45	3.9	4.7	0.42	0	0.10	9.12	3.3	12.42	73.4	5.9	0.66	18	
54	4	43	4.5	4.7	0.53	0	0.08	9.81	3.0	12.81	76.6	6.0	0.41	18	
66	8	35	9.4	3.9	1.05	0	0.03	14.38	0.5	14.88	96.6	7.1	0.45	26	High pH for red loam
							N% 0-9" 0.085			C/N 6.1					
								KALAPATA							
8 miles north of Kaabong, 5,000 feet								Profile 18 (21035-38)							
7	6	28	5.9	2.6	0.62	0	0.02	9.14	3.8	12.94	70.6	6.1	0.84	11	Very low P_2O_5
18	4	42	6.2	2.8	0.73	0	0	9.73	4.4	14.13	68.9	6.0	0.77	2	High pH
42	4	18	2.7	1.3	0.27	0	Tr.	4.27	2.2	6.47	66.0	6.2	0.35	6	
62	6	12	2.7	1.1	0.16	0	0	3.96	1.0	4.96	79.8	6.5	0.22	4	
							N% 0-7" 0.120			C/N 30.0					Raw humus
1 mile north Kalapata Camp, 5,200 feet								Profile 19 (21282-84)							
12	10	12	2.3	1.5	0.39	0	0.06	4.25	2.6	6.85	62.0	6.2	1.24	89	High pH
16	6	22	2.5	1.6	0.25	0	0.08	4.43	2.8	7.23	61.3	6.1	0.90	36	" "
72	7	22	3.5	1.8	<.16	0	0.05	5.51	1.3	6.81	80.9	6.9	0.43	14	" "
							N% 0-12" 0.134			C/N 8.6					
								LOKAPEL							
Atumatak Catchment Experiment								Profile 20 (16961-63) Series 1 (Lokitanyala)							
6	11	24	4.2	4.8	0.38	0	<.02	9.40	3.2	12.60	74.6	5.9	0.44	5	Low C, N and
19	5	34	4.4	4.8	<.16	0	Tr.	9.36	2.5	11.86	78.9	6.1	0.36	7	P_2O_5
49	7	24	5.8	3.4	0.41	0	0	9.61	1.2	10.81	88.9	6.8	0.26	11	High pH
							N% 0-6" 0.067			C/N 6.5					

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H	Exch. Capacity	% Satur-	pH	Organic Carbon	Truog P_2O_5	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							
							Profile 21 (12792-97) Series 3								
Kalomeo Enclosure															
4	1	7	1.3	1.5	0.30	0	0.06	3.16	2.5	5.66	55.8	5.4	0.65	23	Low C, N and bases
10	5	9	1.6	2.2	0.16	0	0.02	3.98	2.8	6.78	58.7	5.2	0.54	13	
23	7	19	6.1	5.0	0.16	1.9	0.22	13.38	1.8	15.18	88.1	6.1	0.50	11	
39	7	23	10.9	6.9	0.27	2.5	0	20.57	0	20.57	100.0	7.5	0.35	32	High pH and bases
46	12	23	13.2	6.3	0.23	3.1	0	22.83	0	22.83	100.0	7.7	0.20	63	" " " "
58	8	23	10.9	5.2	0.30	2.8	0	19.20	0	19.20	100.0	7.7	0.28	44	" " " "
							N% 0-4"	0.064		C/N 10.1					
							Profile 22 (13450-54) Series 6								
Kakumongole															
5	0	0	1.2	<.6	0.24	0	<.02	2.06	1.1	3.16	65.2	6.4	0.22	13	Low C, N, P_2O_5
17	6	0	1.2	<.6	0.24	0	<.02	2.06	1.6	3.66	56.3	5.7	0.26	10	and bases
27	6	0	0.9	0.6	0.27	0	0.02	1.79	2.1	3.89	40.0	5.4	0.82	16	" "
50	3	12	1.6	0.7	0.37	0	<.02	2.69	3.1	5.79	46.5	5.4	0.38	8	" "
70	2	24	3.3	1.4	0.92	0.4	0	6.02	3.3	9.32	15.5	5.4	0.17	3	
							N% 0-5"	0.056%		C/N 4.0					
								PAJULE							
							Profile 23 (16080-82)								
3½ miles from Iriri on Nabilatuk road															
9	13	44	7.3	8.8	0.86	0	0.27	17.23	5.9	23.13	74.5	6.2	2.07	84	Enrichment of bases
30	12	51	7.8	10.1	0.97	0	0.08	18.95	4.3	23.25	81.5	6.3	1.20	10	and P_2O_5 from
54	10	39	7.0	8.2	0.70	0	0.11	16.01	3.2	19.21	83.3	6.4	0.51	15	volcanic material
							N% 0-9"	0.152		C/N 13.6					
							Profile 24 (20594-95)								
18.3 miles from Kotido on Labwor road															
3	6	12	1.6	0.6	0.39	0	0.03	2.62	2.0	4.6	56.7	6.0	0.45	11	Low C, N, Ca, Mg
14	6	30	<.8	<.6	0.45	0	0.05	1.90	3.3	5.2	36.5	4.5	0.47	4	and P_2O_5
59	4	42	<.8	<.6	0.45	0	0.05	1.90	6.0	8.9	21.3	4.9	0.45	6	
							N% 0-14"	0.064		C/N 5.5					

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							

Depth Ins.	Mechanical Analysis % Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total	Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
OPOPWA															
Profile 25 (13396-400)															
2 miles north of Nabilatuk															
3	5	9	2.4	1.8	0.61	0	<.02	4.83	2.2	7.03	68.7	5.7	0.70	25	Sand wash
9	5	27	3.7	3.2	0.28	0	0.02	7.20	4.1	11.30	63.7	5.4	0.90	23	Low C, N
26	5	31	4.1	3.3	0.27	0	<.02	7.69	4.0	11.69	65.8	5.4	0.96	21	
38	3	29	4.4	4.0	0.52	0.7	0	9.62	2.9	12.52	76.8	6.1	0.98	25	
63	5	23	3.5	3.3	0.52	0	0	7.32	N.D.	N.D.	N.D.	6.3	0.66	42	High pH
N% 0-3" 0.066, 3-9" 0.080 C/N 10.7, 11.2															
Profile 26 (16062-64)															
Near Opopwa															
15	4	43	7.3	4.3	1.31	0	0.09	13.00	5.2	18.20	71.4	5.7	1.45	18	
37	7	34	6.9	3.8	1.43	0	0.05	12.18	3.9	16.08	75.7	6.0	0.67	11	Low P_2O_5
50	5	48	7.8	4.4	1.37	0	0.06	13.63	N.D.	N.D.	N.D.	6.3	0.45	13	
N% 0-15" 0.121 C/N 13.4															
PANYANGARA															
Profile 27 (12034-37)															
9 miles north of Amudat															
6	13	44	6.7	2.4	0.85	0	0.05	10.00	1.6	11.60	86.2	5.8	0.45	9	Low C, N, P_2O_5
12	13	20	9.8	7.3	0.97	0	0.25	18.32	N.D.	N.D.	N.D.	5.3	0.41	9	
18	2	24	12.8	7.4	1.01	0	<.02	21.23	3.1	24.33	87.3	5.4	0.38	7	
30	10	32	15.9	8.2	0.50	0	0.66	25.26	2.8	28.06	90.0	5.5	0.32	9	High bases
N% 0-6" 0.052 C/N 8.7															
Profile 28 (21023-27)															
Approx. 30 miles south of Kotido New Road															
28	4	27	1.9	1.3	0.34	0	0.12	3.66	3.0	6.66	55.0	5.8	0.33	3	Low P_2O_5 throughout
34	4	37	5.0	3.2	0.81	0	0.04	9.05	2.7	11.75	76.9	6.5	0.30	5	pH increase with
89	N.D	N.D	4.1	2.3	0.83	0	0.05	7.28	N.D.	N.D.	N.D.	6.4	0.29	5	depth due to dry
142	6	27	2.2	2.3	0.59	0	0.02	4.11	N.D.	N.D.	N.D.	6.3	0.33	4	climate
163	N.D	N.D	3.7	2.1	0.83	0	0.02	6.65	N.D.	N.D.	N.D.	7.2	0.24	7	
N% 0-28" 0.076 C/N 4.3															

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H	Exch. Capacity	% Satur-	pH	Organic Carbon	Truog P.O.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							
								LORENGIKIPI							
								Profile 29 (21863-66)							
8	30	28	4.6	1.1	<0.16	0	0.05	5.75	4.5	10.25	56.1	5.1	0.98	4	High silt
20	8	46	5.0	1.8	0.16	0	0.02	6.98	4.8	11.78	59.1	5.3	0.65	4	Low K
36	6	46	4.8	1.4	0.39	0	0	6.59	4.1	10.69	61.6	5.5	0.66	5	Bases increase
60	4	46	7.9	2.0	0.69	0	0	10.59	1.9	12.49	84.8	6.6	0.25	5	with depth
							N%	0-8"	0.095	C/N 10.3					
								LOMERIMONG							
Lomerimong								Profile 30 (18032-33)							
8	0	8	1.2	0.6	0.53	0	Tr.	2.33	1.3	3.63	64.2	5.9	0.30	101	High P_2O_5, low C & N
19	10	12	1.9	2.1	0.77	0	0.03	4.80	1.5	6.30	76.2	6.0	0.29	163	" " " " "
							N% 0-8"	0.040		C/N 7.5					
Alerek road 63 miles from Kotido								Profile 31 (20588-89)							
12	10	22	4.6	2.5	1.11	Tr.	0.04	8.25	N.D	N.D.	N.D.	6.1	0.76	10	Low C, N & P_2O_5
37	8	34	5.5	3.5	0.86	0.4	0.03	10.29	3.4	13.69	75.2	5.8	0.47	5	" " " "
							N% 0-3"	0.080		C/N 9.5					
								KATIKEKILE							
2 miles from Lokitanyala on Kitale Road								Profile 32 (21072-76)							
3	28	11	2.4	1.8	0.36	0	0.01	4.57	1.3	5.87	77.8	6.8	0.63	49	Low bases, high
7	28	11	2.2	1.7	<.16	0	0.02	4.02	1.8	5.82	69.3	6.4	0.53	20	pH increasing with
14	8	15	1.7	1.9	<.16	0	0.02	3.60	2.2	5.80	62.2	6.3	0.65	13	depth - dry climate.
39	4	9	2.0	2.3	Tr.	0	0.02	4.35	1.0	5.35	81.4	6.9	0.17	0	Very low P_2O_5
54	0	0	1.2	0.8	<.16	0	0.02	2.00	0.1	2.10	95.3	7.6	0.09	1	
							N% 0-3"	0.105		C/N 6.0					

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							

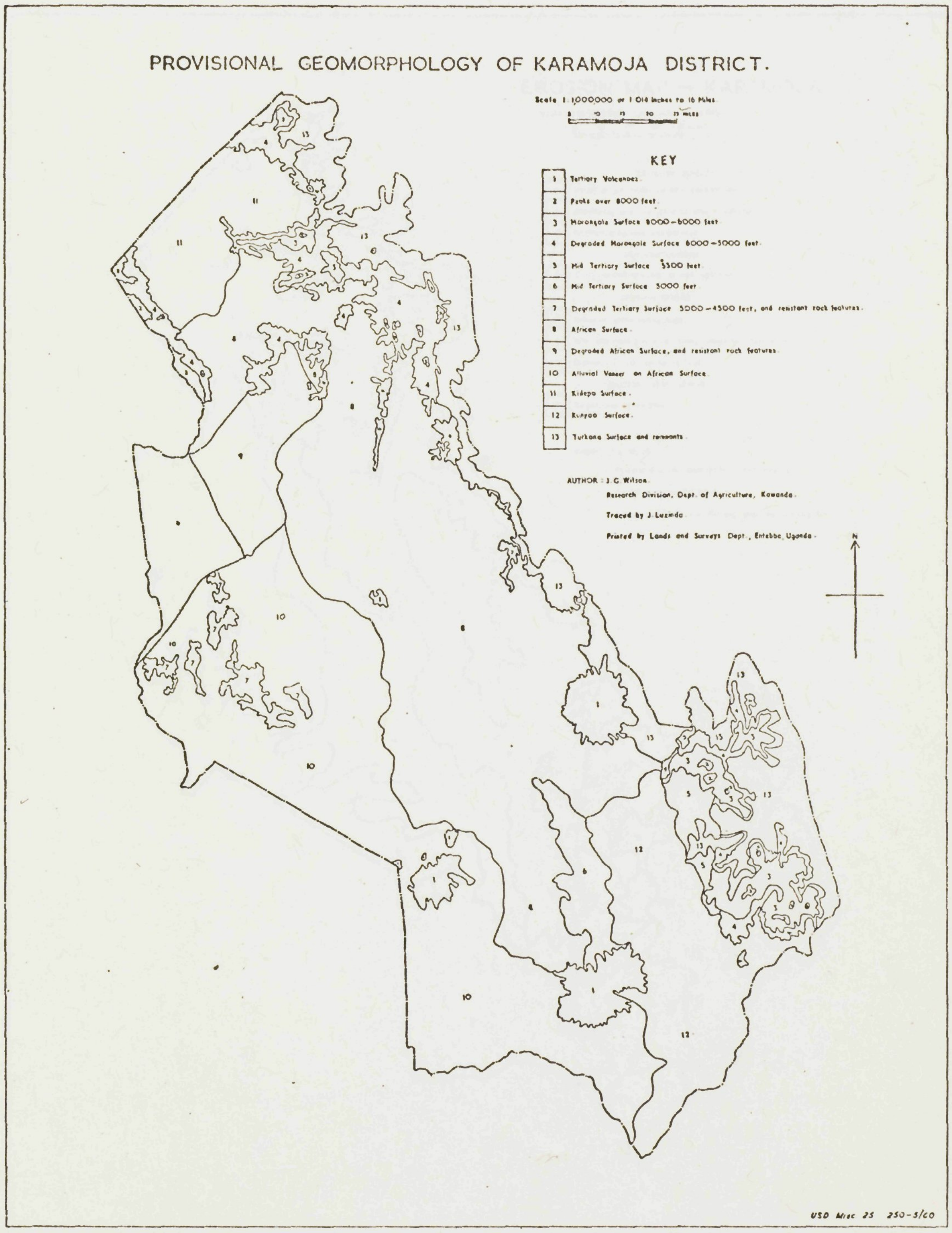
Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							
								Profile 33 (21082-84)							
2 miles from Nakiloro															
9	4	13	6.7	4.5	0.34	0	0.02	11.56	1.0	12.56	92.3	7.1	1.06	120	Low C, high pH
22	6	17	8.7	6.2	Tr.	0	0	14.90	0.5	15.30	97.4	7.6	0.83	54	increasing with
62	2	5	3.7	2.3	0	0	0	6.00	0.3	6.30	95.3	7.6	0.17	94	depth - dry climate
								N% 1-9"	0.148	C/N 7.2					
								SEBEI							
								Profile 34 (12074-79)							
6	8	33	17.9	5.2	1.04	1.2	<.02	25.36	0.2	25.56	99.2	7.1	0.55	11	Low C,N,P_2O_5, high bases
12	8	31	17.2	5.2	0.58	1.9	0	24.88	0	24.88	100.0	7.6	0.51	15	High bases indicating
18	8	31	25.0	4.4	0.63	2.0	0	32.03	0	32.03	100.0	7.7	0.50	70	montmorillonitic clay
30	14	27	25.0	6.3	0.89	2.5	0	34.69	0	34.69	100.0	7.7	0.41	120	
48	12	29	30.0	7.5	0.94	2.5	0	40.94	0	40.94	100.0	7.7	0.28	164	
66	14	25	30.0	4.1	0.72	1.9	0	36.72	0	36.72	100.0	7.7	0.15	131	
								N% 0-6"	0.075	C/N 7.3					
								Profile 35 (12819-22)							
Nabilatuk road 2 miles south of Amuda Rock															
3	4	14	9.8	5.0	0.56	0	0	15.36	0.2	15.56	98.7	6.9	0.65	20	Low C,N,P_2O_5, high bases
9	4	27	17.5	6.5	0.28	1.2	0	25.48	0.2	25.68	99.2	6.8	0.44	8	High bases indicating
33	7	27	24.4	10.0	0.33	1.4	0	36.13	0	36.13	100.0	7.4	0.44	10	montmorillonitic clay
48	9	34	32.8	12.0	0.36	2.0	0	47.16	0	47.16	100.0	7.4	0.29	25	
								N% 0-3"	0.083	C/N 10.4					
								3-9"	0.062	C/N 7.1					
								Profile 36 (16937-41)							
1 mile from Morulinga Hill on Soroti Road															
3	9	55	51.4	20.2	1.07	2.1	0	74.77	0.4	75.17	99.5	7.2	0.74	23	Low C and N, very
24	9	55	39.0	15.8	0.92	2.9	0	58.62	0	58.62	100.0	7.4	0.69	23	high bases
51	7	55	42.8	20.8	0.89	5.0	0	69.49	0	69.49	100.0	7.5	0.72	22	
78	7	45	36.7	12.0	0.80	4.1	0	53.60	0	53.60	100.0	7.7	0.36	95	
102	1	5	6.8	2.3	0	0.9	0	10.00	0	10.00	100.0	8.2	0.06	82	
								N% 0-3"	0.058	C/N 12.7					

Depth Ins.	Mechanical Analysis %	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil	Exch. H	Exch. Capacity	% Satur-	pH	Organic Carbon	Truog P O	Remarks

Depth Ins.	Mechanical Analysis % Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total	Exch. H m.e.%	Exch. Capacity m.e. %	% Satur-ation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks			
KUNYAO																		
Profile 37 (15990-92)																		
Kodich																		
3	3	10	3.5	1.5	0.50	0	Tr.	5.50	0.7	6.20	88.7	6.4	0.51	57	Low C and N			
26	4	28	3.8	3.9	0.38	0	0.11	8.19	3.0	11.19	73.2	5.3	0.38	46	Bases increase			
30	4	30	5.0	5.4	0.75	0	0.12	11.27	1.6	12.87	87.6	6.3	0.32	33	with depth			
																N% 0-3"	0.092	C/N 5.5
Profile 38 (15994-96)																		
1.4 miles along Nakujit Road																		
3	3	28	3.9	4.8	1.03	0	0.23	9.96	2.8	12.76	78.1	5.4	0.39	21	Low C and N			
24	3	36	4.7	5.3	0.42	0	0.15	10.57	2.7	13.27	79.7	5.7	0.44	17	Bases increase			
43	4	32	6.9	5.7	0.84	0	0.06	13.50	1.1	14.60	92.5	6.5	0.26	30	with depth			
																N% 0-3"	0.075	C/N 5.2
KIDEPO																		
Profile 39 (21047-51)																		
15 miles from Kaabong on Lomej Road																		
9	10	22	21.4	1.1	0.56	0	0	23.06	0	23.06	100.0	7.9	1.25	150	High Ca, low Mg			
17	16	26	20.2	2.3	0.42	0	0	22.92	0	22.92	100.0	8.1	0.61	35				
32	16	26	18.9	4.6	0.48	0.7	0	24.68	0	24.68	100.0	8.2	0.48	49				
62	14	32	16.5	8.7	0.42	3.1	0	28.72	0	28.72	100.0	8.3	0.38	158	High P_2O_5			
85	12	42	21.8	8.7	0.42	3.6	0	34.52	0	34.52	100.0	8.2	0.37	390				
																N% 0-9"	0.118	C/N 10.6
Profile 40 (21003-05)																		
3 miles from Loyoro on Kaabong road																		
20	10	42	25.8	8.4	0.69	2.6	0	37.49	0	37.49	100.0	8.0	0.42	28				
60	10	52	25.8	9.6	0.52	6.9	0	42.82	0	42.82	100.0	8.0	0.29	56	High Na			
78	26	28	16.0	7.6	0.34	5.0	0	28.94	0	28.94	100.0	7.9	0.30	31				
																N% 0-20"	0.070	C/N 2.2

Depth Ins.	Mechanical Analysis %		Exchangeable Bases (Cations) Milli-equivalents per 100g Soil						Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
	Silt	Clay	Ca	Mg	K	Na	Mn	Total							

Depth Ins.	Mechanical Analysis % Silt	Clay	Exchangeable Bases (Cations) Milli-equivalents per 100g Soil Ca	Mg	K	Na	Mn	Total	Exch. H m.e.%	Exch. Capacity m.e. %	% Saturation	pH	Organic Carbon %	Truog P_2O_5 p.p.m.	Remarks
								LOYORO							
								Profile 41 (12064-68)							
Loyoro, approx. ½ mile from river															
6	3	28	1.2	0.9	0.72	0	0.05	2.87	0.7	3.57	80.4	6.6	0.35	31	Low bases, C,
12	0	9	1.8	1.4	0.49	0	0.04	3.73	N.D.	N.D.	N.D.	6.2	0.21	30	N; pH increases
18	7	0	2.0	0.6	0.22	0	<.02	2.84	0.3	3.14	90.4	6.8	0.19	26	with depth due
30	5	0	1.8	0.7	0.19	0	0.03	2.72	0.3	3.02	90.1	6.7	0.07	36	to dry climate
48	9	38	2.1	0.7	0.22	0	0.02	3.04	0.3	3.34	91.0	6.7	0.17	26	
								N% 0-6"	0.052	C/N 6.6					
								UNDIFFERENTIATED ALLUVIUM							
								Profile 42 (18005-08)							
15.1 miles along Soroti road west from Lockomon															
20	4	50	17.9	14.8	0.61	Tr.	0.1	33.33	3.7	37.03	90.0	5.7	0.95	9	Very high bases
38	2	50	20.6	15.8	0.89	0.09	Tr.	37.38	1.9	39.18	95.4	6.5	0.89	16	particularly Mg
63	8	54	25.7	19.5	0.81	2.30	0	48.31	0.1	48.41	99.8	7.2	0.62	35	
96	8	54	22.6	16.5	0.73	2.00	0	41.83	0.4	42.23	99.1	7.0	0.78	35	
								N% 0-20"	0.131	C/N 7.2					
								Profile 43 (12845-52)							
Amuda River															
6	8	34	23.4	9.5	0.72	0.5	0	34.12	0.5	34.62	98.6	7.5	0.81	42	Low C and N
24	12	36	22.2	13.2	0.39	1.0	0	36.79	0	36.79	100.0	7.5	0.34	32	High bases
54	38	10	16.0	5.0	0.36	0.5	0	21.86	0	21.86	100.0	7.8	0.22	34	Very mixed
72	2	13	7.3	2.4	0	0	0	9.70	0.2	9.90	98.0	7.6	0.09	23	banded profile
82	0	15	12.0	2.1	0	0	0	14.10	0.5	14.60	96.6	7.9	0.08	21	
100	14	29	26.5	7.6	0.31	0.5	0	34.91	0	34.91	100.0	7.3	0.07	46	
106	2	23	17.9	3.2	0.20	0	0	21.30	0	21.30	100.0	7.5	0.06	18	
106+	4	7	6.2	1.6	0	0	0	7.80	0	7.80	100.0	7.8	0.03	48	
								N% 0-6"	0.068	C/N 11.9					


PROVISIONAL GEOMORPHOLOGY OF KARAMOJA DISTRICT.
Scale 1:1,000,000 or 1·014 inches to 16 Miles
KEY
1 Tertiary Volcanoes.
2 Peaks over 8000 feet.
3 Morongole Surface 8000–6000 feet.
4 Degraded Morongole Surface 6000–5000 feet.
5 Mid Tertiary Surface 5300 feet.
6 Mid Tertiary Surface 5000 feet.
7 Degraded Tertiary Surface 5000–4300 feet, and resistant rock features.
8 African Surface.
9 Degraded African Surface, and resistant rock features.
10 Alluvial Veneer on African Surface.
11 Kidepo Surface.
12 Kunyao Surface.
13 Turkana Surface and remnants.
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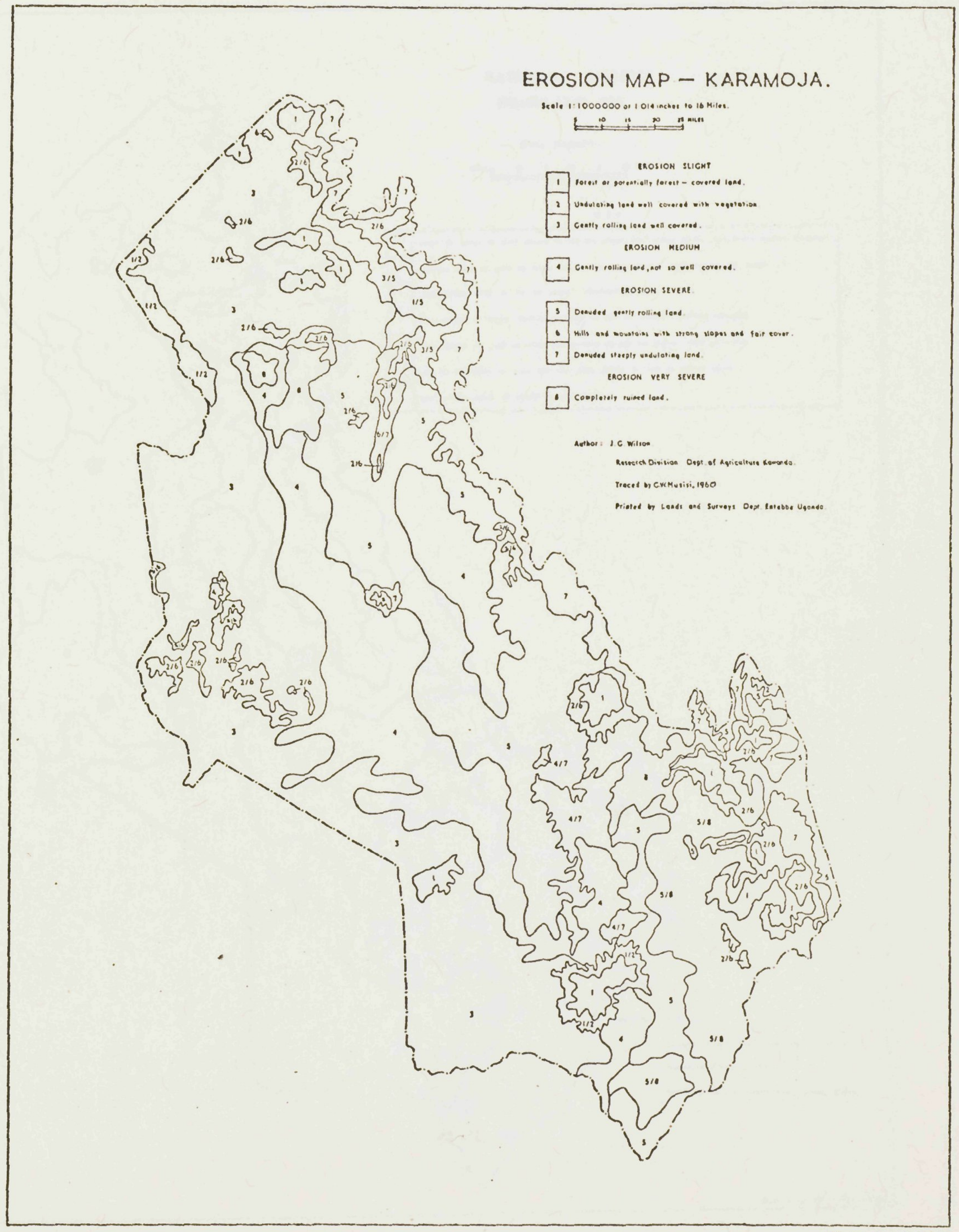
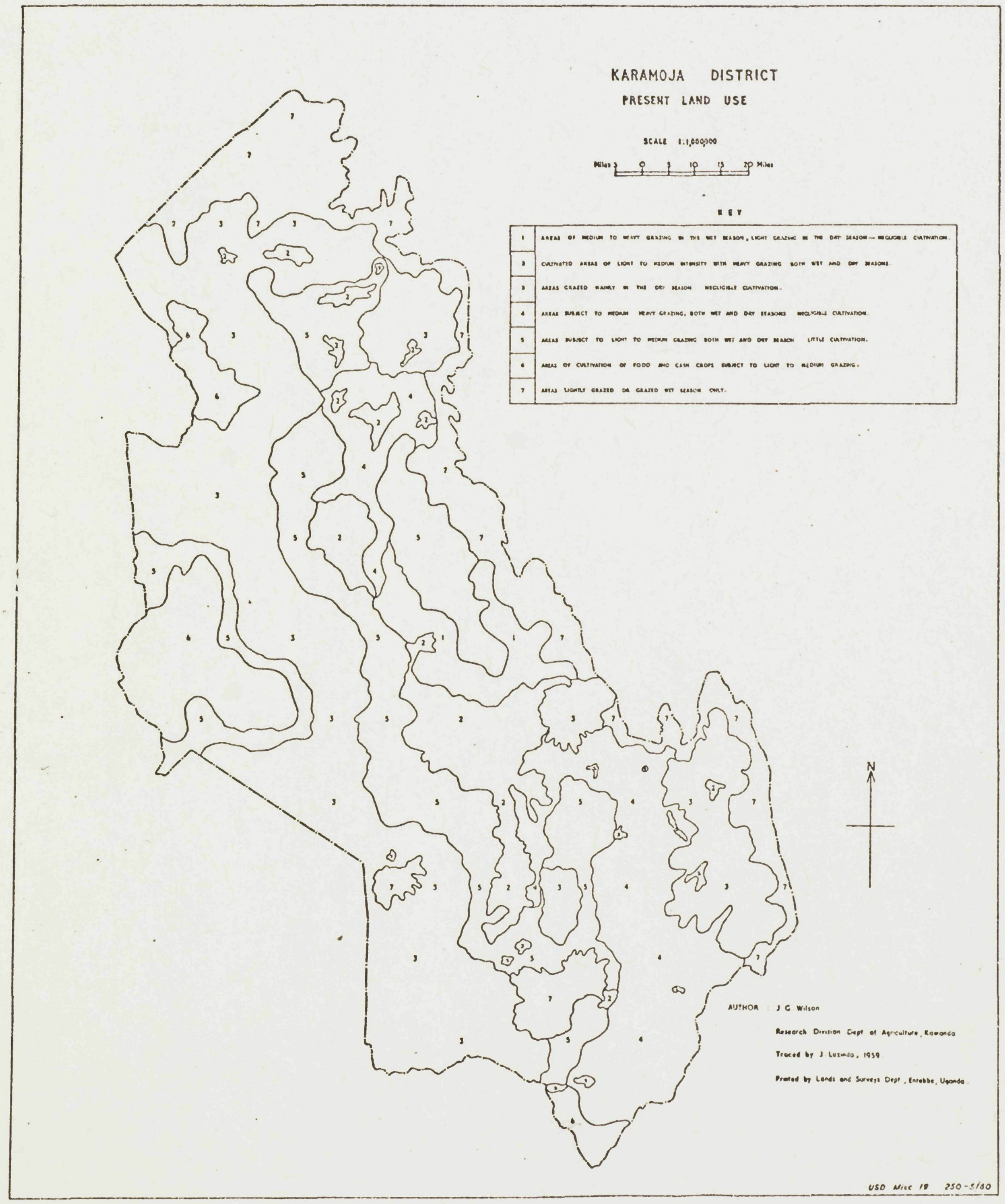
Traced by J. Luzinda.
Printed by Lands and Surveys Dept., Entebbe, Uganda.
N
U.S.D. Misc 25 250-5/60



USD Misc 35 200-8/60


KARAMOJA DISTRICT
PRESENT LAND USE
SCALE 1:1,000,000
Miles 5 0 5 10 15 20 Miles
KEY
1 AREAS OF MEDIUM TO HEAVY GRAZING IN THE WET SEASON, LIGHT GRAZING IN THE DRY SEASON — NEGLIGIBLE CULTIVATION.
2 CULTIVATED AREAS OF LIGHT TO MEDIUM INTENSITY WITH HEAVY GRAZING BOTH WET AND DRY SEASONS.
3 AREAS GRAZED MAINLY IN THE DRY SEASON NEGLIGIBLE CULTIVATION.
4 AREAS SUBJECT TO MEDIUM HEAVY GRAZING, BOTH WET AND DRY SEASONS NEGLIGIBLE CULTIVATION.
5 AREAS SUBJECT TO LIGHT TO MEDIUM GRAZING BOTH WET AND DRY SEASON LITTLE CULTIVATION.
6 AREAS OF CULTIVATION OF FOOD AND CASH CROPS SUBJECT TO LIGHT TO MEDIUM GRAZING.
7 AREAS LIGHTLY GRAZED OR GRAZED WET SEASON ONLY.
N
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Printed by Lands and Surveys Dept, Entebbe, Uganda.
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