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DEPARTMENT OF AGRICULTURE, KENYA

In collaboration with the International Co-operation Administration of the Government of the United States of America

SOIL SURVEY OF THE EAST KONYANGO AREA

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SOIL SURVEY
OF THE
EAST KONYANGO AREA

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Soil Survey: G. A WOODRUFF
F. T. MILLER

Correlation: J. THORP
E. BELLIS

Chemistry: A. MEHLICH
W. ROBERTSON
R. J. KEMPTON

Bioassays: A. PINKERTON
A. MEHLICH

Compilation: F. T. MILLER

Editing: E. BELLIS

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South Nyanza, Kenya*

Soil Survey by: F. T. Miller, G. A. Woodruff and F. Collier.
Soil Chemistry by: A. Mehlich and W. Robertson.
Survey reviewed and correlated by: E. Bellis and J. Thorp.
Bio-assays by: A. Pinkerton and A. Mehlich.

I—INTRODUCTION

Location and Extent

The East Konyango Soil Survey, comprising 99,206 acres, is located in South Nyanza District of Nyanza Province. The northern boundary follows the Rangwe-Mirogi road west to Imbo. From Imbo to Rodi the boundary parallels the road about half a mile to the north-west of it. From there it runs straight west for 7½ miles and then turns south-west and follows an old road on top of the Lambwe Valley escarpment back to the main Mirogi-Lambwe Valley road. The western boundary follows this road south to Mirogi where it turns west and follows the Mirogi-Karungu road to the Ndhiwa River. The Ndhiwa River, south to the Kuja River, forms the remainder of the western boundary. The eastern boundary follows the Rangwe-Rongo road south of Rangwe for approximately 2¼ miles, and then turns one mile east and parallels this road south to the Misathe River. The southern boundary follows the Misathe River to the junction with the Riana River where it turns due south to the Kuja River. The Kuja River, back to the Ndhiwa River, makes up the remainder of the southern boundary.

Administration

This area came under the administration of the District Commissioner for South Nyanza at Kisii. It comprises parts of four locations: East Konyango, Kanyada, Gem and East Nyokal. The District Officer of Eastern Division at Homa Bay had overall administration of Kanyada, Gem and East Nyokal locations. A second District Officer at Lambwe Valley is in charge of East Konyango Location. Each location has an African chief who is directly under the District Officer in charge of the location. The locations are divided into sublocations and each sublocation has an African subchief who is responsible to the chief of the location. Agricultural programmes for the entire area are administered by the District Agricultural Officer at Kisii. He is assisted by three divisional assistant agricultural officers, each in charge of a specific location, or locations. Each location has a number of African agricultural instructors and assistant agricultural instructors who are responsible to the divisional assistant agricultural officer in charge of that location. From 1st January, 1961, the area has been administered from the newly established District Headquarters at Homa Bay.

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* This survey was accomplished by the joint efforts of the Agricultural Department of Kenya and the International Co-operation Administration of the United States of America.

History of Settlement*

This area was formerly inhabited by members of the Masai Tribe, who moved away about 200 years ago, although their raiding parties were a constant anxiety to later occupants until the First World War. The Kisii Tribe then occupied the area for about two generations and they in their turn were displaced by the Luo Tribe, round about the 1850's. The Luo came originally up the Nile River from the Sudan and settled along the shores of Lake Victoria. The first settlers were engaged primarily in fishing, but as their numbers increased they began moving inland. Cattle raising was their sole means of livelihood until the early 1900's, when they began to grow sorghum, finger millet (wimbi) and sweet potatoes.

A Luo tribal elder.

When the Luo moved inland they built their houses on hills and ridges. This was done primarily for protection against the raiding Masai.

As the population continued to increase, people began settling along the Kuja River. They cleared some of the less dense timber and bush and began farming small areas. At this time the Kuja River forest was infested with tsetse fly (*Glossina* spp.), which carries human sleeping sickness. It has been reported that many lives were lost before the people abandoned the area and moved back to the higher lying lands. The fly has been controlled in recent years by spraying the forest along the river, and the people are now beginning to re-inhabit the area.

No accurate population figures are available for the area. The only accurate figures are for the number of taxpayers in each sublocation, but even this poses several problems. First, the only people who are on the tax

* Information collected from local people.

rolls are adult males over 18 years of age. Secondly, the survey does not coincide with sublocation boundaries, and consequently in many instances only fractions of sublocations are within the area. Because of this, it was necessary to estimate the proportion of a sublocation which occurs within the survey area and use only that fraction of the total taxpayers for that sublocation. By this method it was determined that there are a total of about 4,757 taxpayers within the East Konyango soil survey area. To each taxpayer was added one wife and three children, which gives an estimated total population of 23,185.

Land Tenure

The land within the East Konyango survey area is owned by the clans who first settled the land and not by individuals. As the clans settled a given area, individual families would locate their houses on the tops of hills and ridges. The elders of the clan then divided the land in long narrow strips from the tops of the hills to the bottoms. Each strip or parcel of land was allocated to a specific family within the clan. As the population of the individual clans increased, the strips were further divided. In some cases the strips became so narrow that it was necessary to divide them horizontally. This resulted in some fragmented holdings by individual members of the clan. In order to ensure an equitable distribution of land after the strips were divided horizontally it was necessary to allocate a number of fragments of land located at different positions on the hill to one individual family. Consequently, the farm of any one family may be divided into as many as three or four fragments. The size of the holdings of a family ranges from as low as two to three acres near the lake shore, north of the survey area, to as much as 100 acres within the area. The average is eight to ten acres per family. After the initial dividing and allocation of the land by the clan elders, the rights of cultivation and grazing become inherited.

Shifting cultivation is practised and the number of acres cultivated at any one time depends on the size of the individual family. It averages from three to five acres. A given plot of land is tilled until the soil becomes exhausted and is then abandoned and a new plot is broken out of grass.

All grazing is communal. Supposedly it is controlled by the clan elders, but without enclosure they find it difficult even to stop grazing from other clans. In recent years a few families have started to enclose their land, but this is exceedingly difficult in view of the fragmented nature of their holdings.

Every 10 to 15 years the houses are shifted. This is done for several reasons. The most important being the cultural background of the people. If a member of a family has been stricken with illness or death the survivors believe that some bad influence has come over their house which, therefore, must be moved. Another, more practical reason, is that the dwellings are constructed of mud walls with grass roofs, and consequently are not very permanent.

Industries

With the exception of agriculture, the main industry in the area is the production of jaggery (brown sugar) by the two small factories located at Ongeng and Mirogi. These factories buy sugar-cane from the farmers within the area and produce jaggery which is sold to the local *dukas* (shops) at Mirogi, Rangwe, Marinde and other nearby villages. The *dukas* in turn sell the jaggery to the local Africans and some of it is made into illegal home-brewed spirits known as "Nubian Gin". The jaggery factories were built with funds from the African District Council. They were taken over in January, 1959, by the Nyanza Province African Sugar Marketing Board.

Three African Co-operatives operate boiling centres for the production of ghee (drawn butter) in the area. The ghee is bought by the Nyanza Province Marketing Board and they sell it to Asians who use it as cooking fat. Three to four times as much ghee is produced by local families and sold directly to Asian *dukas* without going through the Co-operatives.

A few small brick factories near Ndhiwa produce poor to fair quality bricks. These bricks are sold locally and used for building *dukas*, houses, schools and churches.

Hides and skins are cured by the local people and sold to Arab traders at Marinde and Mirogi.

Transportation and Markets

All of the major markets within the area are connected by fair to good murram roads. The Rangwe-Mirogi and Mirogi-Lambwe Valley roads are in fair condition. The Rongo-Rodi road is now (1959) being rebuilt and improved. The Rongo-Rangwe road is the only other murram road in the area, but it is in poor condition. Several bus lines give daily service to the markets from the larger nearby communities. The area south of the old District Commissioner's road (from Nyanga to Mirogi) to the Kuja River is not reached by any motor roads. Before any extensive agricultural developments are undertaken in this area it will be necessary to construct access roads.

The area has three trading centres at Marindi, Rangwe and Mirogi where Asians, Arabs and a few Africans run reasonably lucrative businesses. There are large African markets at Ndhiwa and Ongeng and smaller ones at Magina, Imbo and Oboke, where some African traders run good businesses, but others are traders only in name.

Each of the markets has a weekly market day. On these days produce is carried to the market by the women and sold. Cattle auctions, under the supervision of the Veterinary Department, are held every week at Marinde, Ndhiwa and Rangwe. Buyers often come from the Ahero-Kisumu area and drive small herds back along the roads to be slaughtered and sold or sold alive in the market at Ahero. Market day is an important occasion for the people. It is their primary social outlet. On these days they have the opportunity to meet their friends and exchange the latest news and gossip. Most of the agricultural products of the area are sold or bartered through these local markets. The Nyanza Marketing Board does, however, buy all non-perishable African produce. Practically all groundnuts, simsim (sesame), green grams and cowpeas are sold either directly to the Marketing Board or to Asian *dukas* who in turn sell to the Board.

Schools and Other Social Facilities

There are 14 primary and two intermediate schools in the area, managed by either the District Education Board or by a religious organization. All but a few unaided mission schools are financed from public funds administered by the District Education Board. Most of the children complete four years' primary education, and about one-third eight years' primary and intermediate education. Facilities for secondary education do not exist within the area. Only a very small number, not more than three or four a year, leave the area for secondary education.

Market day at Ongeng.

There are seven churches of various faiths in the area. There is a dispensary at Marinde and a health centre at Ndhiwa.

The chief social outlet is market day. It affords a chance for people to meet and visit. Several of the markets have licensed African beer clubs where beer made from wimbi and sorghum is sold. Funerals as well as markets are important social outlets.

Water Supply

The principal sources of water for domestic and livestock use are the streams and their tributaries. Livestock is driven daily to the streams for water. African women obtain water for domestic use from the most convenient source available, streams, seepage spots, and from temporary water holes following rains. Asian and Arab *dukas* in the various markets collect rain-water from metal roofs for domestic use. Bilharzia is prevalent in the streams throughout the area.

There are a number of hand-built small earth dams and pans in the area, built by local communal effort. The possibility of obtaining water by boreholes has, in some places, been investigated, but it appears that the water table is too deep for hand-rig boreholes. McCall [5] considers the rocks which underlie the survey area in the south and in the north-east to be fairly good water-bearing rocks.

Wild Life

This area does not support much wild life. With the exception of birds, such as quail and Kavirondo cranes, most of the game is concentrated in the forested areas along the Kuja and Ndhiwa rivers. Here can be found water-buck, reedbuck, bushbuck, monkeys and baboons. The monkeys and baboons cause considerable damage to the nearby *shambas*. Hippos can be found in the Kuja River and there are leopard and rhino in the riverine bush.

Agriculture and Livestock

The East Konyango Soil Survey area occurs entirely within the Luo Reserve, and consequently only a strictly peasant type of agriculture is followed. The people tend to cling to their old habits and customs and, there-fore, the agriculture of the area is not very far advanced. Almost all agricul-tural operations, tillage, seed bed preparation, planting and harvesting are initiated by the clan elders. This is based on the fear that some disaster will befall anyone that tills his land or plants his crop before the clan elder. His crop may fail; he, or a member of his family may become ill; or he or someone in his family may even die. In short, agricultural practices are largely controlled by traditional ideas, some of which, in effect, may be good, and others may have no value or may actually be harmful. Probably the net effect of these ideas and customs is to retard the progress of agriculture in this area.

Neither commercial fertilizers nor manure is used to improve crops. Vegetation is periodically burned during the dry period, after the grass has matured and become rank and unpalatable for livestock, to encourage succulent growth in the following wet season.

Firewood is becoming scarce in the area. Some woman walk as much as ten miles to obtain firewood for cooking purposes. This could be remedied by planting more groves of Eucalyptus to supplement the plantings of cassia which have been made in the past for this purpose and the few Eucalyptus groves which already exist.

General view of the Rangwe Hills.

Most of the soils in the area have been cultivated at one time or another, but only about 10 to 15 per cent of the total area is under cultivation at any one time. For several reasons the most intensively farmed soil in the area is the Rangwe sandy loam. The main is the relative ease with which this soil may be tilled. It is loamy, friable and easy to work. Since most of the tillage operation is done with a *jembe* (grubbing hoe) the Luo have shied away from the more intractable clayey soils. Also the people tend to locate their *shambas* as close to their houses as possible. In the past, their houses were located on high ridges and hills for protection against raiding Masai tribes, and this custom has persisted. Rangwe sandy loam is the commonest soil on these sites and it is very likely that it has been farmed longer than any other soil in the area. Remnants of old stone *bomas* (enclosures) built by the Luo to protect their stock from Masai raiders can still be seen in many areas of Rangwe sandy loam. It is very likely that they too, settled on the higher ridges and hills for protection against warring tribes.

Most of the crops grown in the area are for subsistence and are consumed locally; cowpeas, groundnuts, simsim, green grams and sugar-cane are the major cash crops. The major foodstuffs that are bought are fish and meat.

Some of the children are undernourished; probably through ignorance rather than actual lack of food. They suffer from protein deficiency because they do not get enough meat, milk and fish.

A cattle census in 1950 showed that there are some 43,000 head of cattle in East Konyango Location, all of native breeds. There are fewer goats and sheep than cattle, and fewer sheep than goats, but figures on their total numbers are not available. Feed is not grown nor purchased for any of the livestock. They graze all year long on native pastures. Livestock is sold at the weekly auctions at Marinde, Ndhiwa and Rangwe. Goats and sheep are butchered and eaten at various native ceremonies. Cattle are a measure of wealth to the African and consequently he is more interested in numbers than in quality. They are still used as bride payments, the number ranging from 10 to 20, depending upon the quality of the cattle and also on the status of the bride.

An average of 150 tins of ghee per month is sold to the Nyanza Marketing Board by the boiling centres in the area; but much more ghee is sold directly to the Asian *dukas* and does not appear in marketing statistics.

Survey Methods

In this semi-detailed soil survey, traverses were made at ½ to ¾ mile intervals throughout the area using new (November, 1958) 1:20,000 aerial photographs to help determine the traverse lines and the points at which to examine the soil.

These photographs were used as base maps. The geographical extent of each soil was shown on the base maps by means of lines intended to separate one soil type from another. Soil boundaries, however, are not everywhere abrupt. Rather, in most instances, there is a transition or gradual change from one soil to another, and consequently the soils occurring near the boundaries may have characteristics similar in part to those on both sides.

Soils were examined in auger holes to a depth of 5 ft. providing bedrock was not found sooner. The holes were not spaced in any definite or regular pattern but were located on the basis of discernible changes in topography and vegetation and of indications obtained from the aerial photographs. These were studied thoroughly and any change in tone or colour noted as such changes are important clues helping to locate soil differences. The soil surveyor based the outline of each soil unit mapped (1) on his spot determination of the soil in the field, (2) on his appraisal of the lie of the land, (3) on the local vegetation, (4) to some extent on the appearance of the crops in the field, and (5) on differences in the degree and pattern of shadowing in the aerial photographs. Deep pits were dug on carefully selected sites representing the model or central concept of each soil found. In these pits attempts were made to dig deep enough to reach the underlying bedrock and the pits ranged in depth from 2 ft. to 9 ft. These pits revealed distinct horizontal layers called "horizons" which collectively make up the soil profile. The individual horizons revealed in the pits and the profiles as a whole were examined in detail and observations were made on the number, arrangement and thickness of the horizons; colour of each horizon; texture, or the relative proportions of the various size groups of individual soil grains (sand, silt, clay) present; structure, or the arrangement or natural grouping of soil particles; consistence, or the tendency for the soil to crumble or to stick together; and other characteristics.

For standardization purposes *colour* is measured by comparison with the Munsell soil colour charts. Colour is usually related to the kind and amount of organic matter and the kinds of minerals present. Spots and streaks of grey, brown, yellow and red in the lower layers generally indicate poor drainage and poor aeration. *Texture* is estimated in the field by the way the moist soil feels when rubbed between the fingers. For example, the sandy soils feel coarse, loamy soils feel friable and somewhat floury, and the clayey soils are usually hard when dry and plastic when moist. Moist clayey soils form "ribbons" when pinched between thumb and finger. The textural class is later checked by laboratory analysis. The principal texture classes are: sand, loamy sand, sandy loam, loam, silt loam, clay loam, sandy clay, silty clay and clay. Texture affects moisture retention and the difficulty or ease with which the soil may be cultivated.

Structure refers to the shape and arrangement of the natural groups of individual soil particles, and gives clues as to how readily the soil is penetrated by moisture and plant roots and how it will respond physically to cultivation. Important structure terms are: *Platy*—particles arranged horizontally in plates; *Granular*—particles firm and rounded; *Blocky*—particles arranged in blocks with flat or slightly rounded surfaces and relatively sharp angles; *Prismatic*—particles arranged vertically into prisms; and *Columnar* in which the particles are arranged into prisms with rounded tops.

Consistence of each horizon is determined by the way the soil feels under different moisture conditions (hard when dry; friable when moist; sticky and plastic when wet, etc.). This is a valuable aid not only in helping to assess soil texture but it also furnishes a clue as to the character of the individual soil grains (type of clay present).

Other important characteristics observed in the field include the following: the depth of the soil over bedrock or compact layers; the presence of stones that will interfere with cultivation; the steepness and pattern of slopes; the presence of laterite or "murram" layers; the amount or degree of erosion; the nature of the parent material; and the acidity or alkalinity of the soil, as measured by simple chemical indicators and later checked in the laboratory.

After observing and recording the foregoing physical characteristics in the field, each horizon in the soil pit was sampled and chemical and physical determinations made in the laboratory to help characterize the various soils. Besides plant nutrient determinations (i.e. phosphorus, nitrogen, potassium, etc.) some of the more important examinations made in the laboratory and used in recognizing different kinds of soil are as follows: organic carbon; pH and per cent base saturation; per cent sodium saturation; size distribution of the soil particles as determined by mechanical analysis; and the determination of the nature and kind of secondary minerals present as measured by electro-chemical charge distribution of the soil colloids. These chemical and physical data ultimately were used for the evaluation of each of the soils and for checking (and where necessary amending) the field classification.

Classification

On the basis of the characteristics observed in the field and those determined in the laboratory, the soils are classified into series, types and phases. A *soil series* is a group of soils that are essentially alike in every respect except for the texture of the surface soil. This group is given a geographical name taken from the area in which the series was first found and described. An example of this is the Ongeng series.

A *soil type* is a subdivision of the soil series. It is the same as the soil series, but with the additional information on the texture of the surface soil. Therefore, the soil type name consists of two parts: the series name and the textural class name of the surface soil. It is possible to have more than one soil type in a soil series. For instance, there are Ongeng sandy loam, Ongeng loam, and Ongeng clay loam. However, most of the soil series mapped in this survey area are represented by only one soil type.

The *soil phase* is a further subdivision of the soil type. It is used as a means of adding useful supplementary information to the soil type. Such information as degree of slope, amount of erosion and occurrence of stones or rock outcrops is added to the soil type to arrive at the soil phase. The soil phase is the unit usually shown on the map (though in certain complex situations the phases mapped are of soil associations and not soil types). The soil phase has the narrowest recognized range of characteristics and therefore it is for the soil phase that use and management practices can be stated most specifically. An example of a soil phase is "Ongeng loam, 0-3 per cent slopes".

The boundaries marked on the aerial photographs between the various soils ultimately identified in the classification were projected optically and traced on to the 1:50,000 Survey of Kenya series GSGS 4786 sheets, Nos. 129/II, 129/IV, 130/I and 130/III which cover the survey area.

Users of the soil map and report are cautioned that this is a semi-detailed survey not a highly detailed one. This means that the surveyors can vouch for the accuracy along the lines of traverse but that the boundaries drawn across areas not seen close at hand may vary somewhat from their actual position on the ground. Also the survey records only the features revealed by the techniques available for undertaking it and it is imperfect to the extent that these techniques or the handling of these techniques is imperfect. In the absence of a detailed examination of every minutest part of the survey area and of every layer of soil in each part, the possibility remains that some soil differences have passed unnoticed. Furthermore, where soils grade into each other imperceptibly, some uncertainty must always exist regarding the number of subdivisions to recognize and where to draw their boundaries. Again, certain soil units show an intrinsic heterogeneity of such intensity that the component variants defy mapping. These situations, where they occur, have been met by including in the soil description in the report an indication of the range of characteristics likely to be encountered with each soil, by the mapping of soil associations and complexes and describing the component soils of the association and by the inclusion of minor described units in the mapping unit of the major soil in association with which they occur. The smaller scale of the base map (1:50,000) makes it impracticable to outline patches of soil of less than about five acres extent.

II—GENERAL CHARACTER OF THE AREA

Land Forms, Relief

The main part of the East Konyango soil survey area is an undulating plain, with broad, nearly level ridges, and with wide valleys flanked by gentle slopes. The monotony of this plain is broken by Gem ridge in the north-east which rises 100 or more feet above the plain to a maximum elevation of 4,687 ft. above sea level. A series of similar ridges breaks the plain along the eastern side of the area. The Kuja River and its tributaries have cut fairly deep valleys in the southern and south-western parts of the plain, leaving hills and ridges 100 to 200 ft. high. The lowest point, where the Kuja River leaves the area, is about 4,100 ft. above the sea.

This present landscape is a remnant of a much more ancient plain which was the product of a long period of erosion sometime before the mid-Miocene. Geologists [3] [5] speak of it as the "sub-Miocene peneplain". As the Lake Victoria basin developed, this plain became tilted to the west and most of it became dissected, well-marked sub-Miocene land surfaces now being recognized only on the uplands and rising land bordering the survey area in the south-east. The western part of the peneplain was covered by lava and volcanic tuff probably in Pliocene times [5]. In the Tertiary period the area was affected by faulting associated with the development of the Kavirondian Rift Valley and this gave rise to a south-easterly dip slope to the northern part of the survey area, much of whose northern boundary follows the crest of the magnificent Kaniamwia escarpment which was formed as a result of this faulting. These earth movements have rejuvenated the streams which now run rapidly and have cut their way to bedrock in most places. Probably erosion has removed all but the most deeply weathered parts of the soils and rocks of the original peneplain, and none of the present soils can have begun to form until late Pliocene or early Pleistocene times. The question of soil age is discussed in a later section.

Stream terraces and flood plains are limited to small areas along the streams and are not continuous. Most of the streams are flanked by long, gentle, fan-like slopes that merge with the bordering hills, especially in the eastern part of the area. Most of these slopes are affected by seepage and become semi-swampy during the long rains.

Drainage

Most of the area is drained by the Kuja River and its major tributaries, the Riana, Kibugo, Mirogi and Ndhiwa rivers and their numerous branches. The Ogweo River drains a few square miles of land between Rodi and Rangwe. Water from the Ogweo flows north into the Awach River, which enters Lake Victoria at Homa Bay.

Drainage is rapid from the steep hills in the eastern part of the survey area and on the steep slopes near the lower courses of the main rivers. It is more sluggish on the smooth uplands and on the fan-shaped gentle slopes bordering the middle and upper courses of the streams. The lower slopes of the hills and smooth lands near stream courses have slow drainage, and seasonally swampy conditions prevail in these places during the long rains.

Stream flow in the Riana and Kuja rivers varies considerably, and maximum discharge is reached in April and May. Intense rain storms in these two months cause local flooding of the tributaries to these rivers. The water table is near the surface in many places at this time and local areas of poorly drained land and marshes occur.

Geology

The geology of the East Konyango soil survey area is complex. The geological formations which occur in the area are divided into four main groups. They are Tertiary volcanics, Kavirondian conglomerates, Nyanzian rhyolites and intrusives [3] [5], the last three of which are of pre-Cambrian age.

The "Tertiary volcanics" are soda-rich basic lavas and tuffs which dominate the northern section of the survey area. Most of the bedrock north of the Rodi-Mirogi road consists of Tertiary volcanics, but some Kavirondian conglomerate is exposed near Ongeng. A large body of the Tertiary volcanic rocks lies some two miles south of Marinde and extends to Imbo.

The Kavirondian rocks are of metamorphosed ancient sedimentary material ranging from coarse boulder conglomerates through grits and sandstone to fine-grained mudstones and shale. The coarse boulder conglomerates are most extensive, while the other members of the series usually comprise of only minor intercalations within them. The matrix of the conglomerate varies considerably. The most abundant feldspars are orthoclase and oligoclase. "Sub-rounded quartz grains are common and calcite relatively abundant in interstitial pools" [3]. The main area of Kavirondian conglomerate mapped by the geologist is south of Ongeng. It goes as far west as Okok and east nearly to Magina. Between the Kibugo and Olungo rivers it swings south as far as the Riana River. There is also an area of the conglomerate exposed between Imbo and Rodi, one at Ongeng, and another fairly large area just to the east of Gem. Underlying rocks found in this area during the soil survey were usually Tertiary volcanic rocks. The discrepancy arises in part from the much greater intensity of traversing of the area in the soil survey than in the geological survey and in part from the lithological thinness of the Tertiary rocks in the locality.

The Nyanzian rhyolites are acid volcanics with layers of banded ironstone. The rhyolites contain many quartz phenocrysts set in a very fine-grained material. Large areas of the rhyolite are exposed south of Ndhiwa Market and extend to the Kuja River.

The pre-Cambrian intrusives are represented by the Kitere granite which covers a large area in the south-eastern section of the area, beginning some four miles east of Magina and extending to the Olungo River and south to the Kuja River.

Volcanic ash, probably derived from the nearby centres of Tertiary volcanism, occurs in most of the low areas and along all the streams. Deep exposures (10 to 15 ft.) along the Kuja River show alternating ash and clay beds. Some of the ash beds attain thickness of over 4 ft. Many isolated ash deposits were observed on the smooth, gently undulating plain formed by the Tertiary volcanics in the northern part of the survey area.

Climate

The climate of the East Konyango area is warm throughout the year, with well-pronounced wet and dry periods. Rainfall records for the survey area have been kept for only a few years. The Marinde and Mirogi station records may be considered fairly representative, but are for periods of only ten and seven years respectively, and do not show complete cycles of longer periods. For the southern part of the survey area, mainly along the Kuja River, there are no records at all.

The rainfall varies between 40 in. to often more than 50 in. most of the time, but there are many years when the rainfall is less than 40 in. Records from the Kisii District Office show that the rainfall in Mirogi has been as low as 23.68 in. and that four years out of ten the rainfall was less than 40 in. Marinde records from the same source show a low year of 32 in. and eight years out of ten less than 40 in. of rainfall. Experienced agriculturists familiar with the area say that there has been more than one severe dry cycle in the last 20 years.

January and February are hot and dry and much of the communal pasture land is burnt over at this time. Occasionally this drought period is relieved by unseasonal falls of grass rains which freshen up the countryside and bring on a flush of young succulent green grass. March brings increasingly more cloudy days and more total rainfall. In April and May the "long rains" are at their peak. During this time the mornings are sunny but after midday clouds begin to gather and it rains rather hard in the mid-afternoons. Some of the mornings in May are foggy. The last half of April and the first half of May are the wettest part of the year. The monthly rainfall in June is similar to that of March. July and August, like January, are also dry months. September and October have more rainy and cloudy days, but the total monthly rainfall is only 1 in. or 2 in. higher than the summer months. The "short rains" are expected in November and December, but are unreliable. There is often some localized hail at this time of the year.

Maximum daily temperatures during the hotter, drier parts of the year are usually in the upper 80's, but can attain 95° F. Minimum daily temperatures drop to about 50° F. in the cooler months. The humidity is rather high. Strong winds are common, but during the afternoons a mild breeze often blows from Lake Victoria towards the Kisii hills. At twilight the direction of the breezes is reversed. Since 1955 there has been good rainfall over the entire area.

Most of the East Konyango area is much warmer than the Kisii region which lies at higher elevations with corresponding higher rainfall.

The African peasant farmer starts planting his crops when the local elders assess the time as propitious and give their approval. This usually results in land preparation and planting being left too late.

Table I, page 15, gives some average monthly and yearly rainfall figures. Table II represents some recent records which, atlhough they are only for a five-year period, are probably more accurate than other rainfall records.

TABLE I.—AVERAGE RAINFALL RECORDS

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Years Record
Marinde	1·73	1·53	5·81	8·89	8·12	3·57	1·85	3·49	5·23	4·90	4·68	5·48	55·28	10
Mirogi	1·49	1·73	3·29	5·86	5·27	2·25	2·21	2·88	3·67	4·35	4·14	3·99	41·08	7
Lambwe E.A.T.T.R.R. Orgn.	1·74	1·39	5·33	7·86	7·95	3·18	1·99	3·43	5·62	4·63	6·20	2·41	51·73	4

TABLE II.—MONTHLY RAINFALL RECORDS

(*Homa Bay Cotton Sub-Station* (3 *miles north of Rodi*))

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
1953.. ..	1·12	—	4·38	5·63	5·30	5·17	2·18	4·02	1·88	4·96	4·46	2·52	41·62
1954.. ..	0·66	0·39	2·48	9·35	9·60	3·32	3·45	5·00	4·08	5·77	1·44	4·54	48·95
1955.. ..	0·57	0·97	2·34	11·24	5·22	5·04	4·07	4·27	6·14	1·54	4·42	2·15	47·69
1956.. ..	1·73	1·85	3·84	9·41	13·61	2·61	4·19	5·22	1·69	2·73	2·02	1·57	50·62
1957.. ..	2·66	1·86	4·67	5·10	7·37	2·75	1·04	2·36	3·04	·73	3·45	2·03	37·06
1958.. ..	1·54	4·99	3·97	11·96	5·59	4·12	1·99	2·78	3·18	5·84	2·49	4·42	52·87

Vegetation

Mr. T. Chapman, Agricultural Officer (Research), Experiment Station, Sotik, kindly made a brief study of the vegetation in the area and reports as follows: —

'Although the vegetation of this area is influenced primarily by drainage it can be divided for convenience into three main types [2]: —

(1) Low Tree—High Grass Savannah (Combretum Woodland) on well drained land (e.g. the hills close to Rangwe).

(2) Grouped Tree Grassland on poorly drained land (e.g. the Rodi-Ongeng areas).

(3) Riverine bush along the main rivers.

Low Tree—High Grass Savannah

The association is somewhat atypical as a result of previous and widespread cultivation. For instance, in the vicinity of Mirogi there is very little of the tree flora left except for the odd *Acacia* spp.

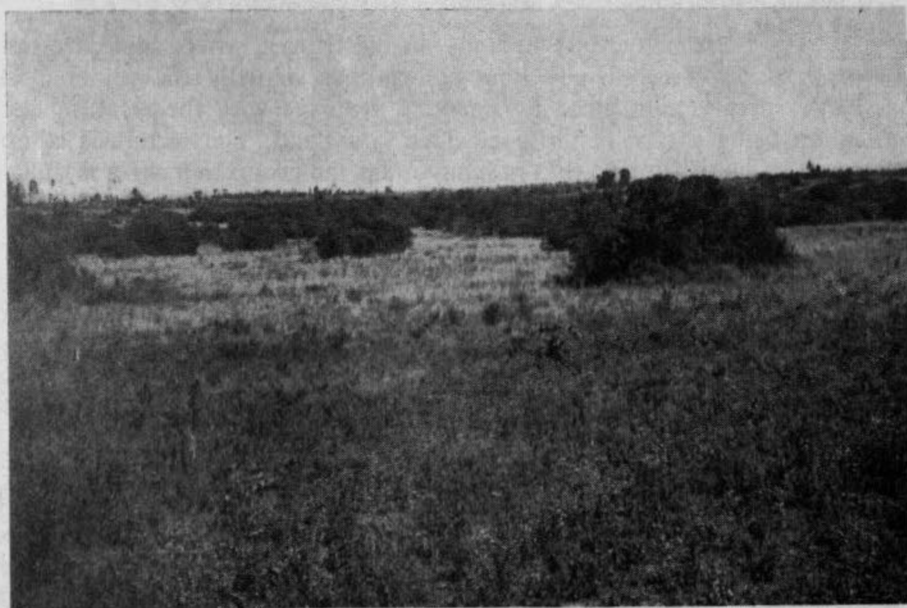
However, remnants of this association can be found. *Cymbopogon afronardus* comprises the greater bulk of the "high grass" with small quantities of *Hyparrhenia rufa*. Where cultivation has taken place poorer grass types are evident: examples are *Harpachne schimperi, Chloris pycnothrix, Rhynceletrum repens, Aristida adoensis* and *Eragrostis* spp.

The tree flora consists mainly of *Combretum* spp., with smaller numbers of *Euphorbia candelabrum, Synadenium grantii, Carissa edulis, Acacia sieberiana, Acacia gerrardii, Acacia* spp. and *Ficus* spp.

Grouped Tree Grassland

The tree cover in these poorly drained areas varies greatly and in some situations there are very few trees at all apart from planted *Eucalyptus* spp. and *Markhamia platycalyx*. Again, *Acacia sieberiana* and *A. gerrardii* are present with *Acacia seyal var. fistula* (mainly near Mirogi) in small numbers. In many places the termite hills have been cleared and cultivated.

The dominant grass species over most of this area is *Pennisetum catabasis*, although where previous cultivation has taken place, *Digitaria scalarum* (African Couch Grass) is dominant and *Imperata cylindrica, Bracharia soluta, Sorghastrum rigidifolium* and *Eragrostis* spp. can be found.



Grouped tree grassland.

Riverine Bush

This is extremely thick and appears to be again a type of Group Tree Grassland with the clumps of trees very close together. The grass species occupying the small glades in the bush comprise many of the better types such as *Cynodon dactylon, Panicum maximum,* with *Setaria caudula* on the edge of the thickets. The probable reason for the presence of these better grasses is that owing to the impenetrable nature of the bush and the presence of leopard and rhino the local inhabitants have yet to come to grips with it.

Trees typical of the thickets are *Grewia* spp., *Carissa edulis, Rhus natalensis, Acacia* spp., *Albizzia* spp., *Tylosenia fassoglensis* and *Piliostigma thonningii,* with *Sansevieria* spp. growing at ground level.

Within the riverine bush are river terraces on which the tree groups are much more scattered. The boundaries of the river terraces are marked by *Acacia polyacantha var. campylacantha* (Falcon's claw Acacia), and on the terraces there are very few *Piliostigma thonningii.* Common tree species are *Erythrina abyssinica, Euphorbia candelabrum, Carissa edulis, Vernonia* spp. (*V. magdalina*?), *Capparis percicifolia* and *Ficus* spp.

The grass is mainly *Hyparrhenia* spp.

Conclusions

Apart from the hilly uplands on the fringes, where there are relics of the Low Tree—High Grass association, virtually the whole of the survey area is influenced by impeded drainage with the resulting vegetation being a type of Grouped Tree Grassland. The picture is complicated by cultivation so that in many areas the group tree effect is difficult to discern and the natural vegetation difficult to determine.'

III—SOILS OF THE EAST KONYANGO AREA

A total of 28 soil types subdivided into phases of soil types based on slope gradients and degree of accelerated erosion are shown on the map. In addition, one complex and one variant are shown. The complex is shown because the two soils occurring in the complex are so intermixed that separation of each was impractical on the scale of the map of the East Konyango survey area. In the case of the variant, it is shown to avoid establishing a new soil series for only a small total acreage of land. Seven miscellaneous land types are shown, to take care of complexes of very stony and eroded soils, the details of which are of little significance. Permanent swamps and alluvial lands which are subject to periodic flooding are also included in the miscellaneous land types. All of these soils are described in the following pages.

Table III gives a complete list of recognized soil types and phases, and miscellaneous land types, with area in acres of each.

Table IV shows some of the important characteristics of the soils that bear directly on problems of use and management, such as natural drainage, permeability and natural fertility. The relationships of soils to parent rocks and topography are also shown.

The soils are described very briefly in following paragraphs in the alphabetical order of the series names. Most of them are described from the surface to bedrock and the deeper ones to 8-10 ft.

Brief statements cover the present use and suitability of each soil for various uses. Detailed technical descriptions of the soil types appear in the Appendix along with analytical tables.

TABLE III.—ACREAGES OF SOIL TYPES AND PHASES, EAST KONYANGO SURVEY AREA

SOIL TYPES AND PHASES	Symbol	SLOPE CLASSES AND % GRADIENT									Total acreage	% of area
		A 0–3	AB 0–8	AC 0–13	B 3–8	BC 3–13	C 8–13	CD 8–20	D 13–20	E 20+		
Akijo clay loam	Acl	380			2,377		1,249		94		4,100	4·2
Akijo clay loam, mod. eroded..	Acl						186				186	·2
Alluvial Soils, undifferentiated	A	1,030									1,030	1·1
Bhanji clay loam	Bcl	385			371						756	·8
Bhanji stony loam	Bst		2,130				146				2,276	2·4
Eroded salt licks and volcanic ash	ES	1,478									1,478	1·5
Kibigori clay loam	Kbc	2,064									2,064	2·2
Kibubu gravelly sandy loam	Kgl		1,936				464				2,400	2·4
Kibubu stony loam	Kst		2,292								2,292	2·3
Kibugo loam	Kil	1,030			1,826						2,856	3·0
Konyango clay loam	Kcl	2,402			775						3,177	3·2
Kuja loam	Kul	2,645									2,645	2·6
Langi loam	Ll	1,279			508						1,787	1·8
Magina loamy coarse sand	Mls		855			1,980					2,835	2·8
Marinde clay loam	Mcl	4,343									4,343	4·3
Mirogi clay	Mrc	767									767	·7
Misathe loam	Mil	2,660			2,590						5,250	5·3
Ndhiwa loam	Ndl				490						490	·5
Nyamauro loam..	Nyl	8,290			2,490						10,780	10·8
Nyangu stony sandy loam	Nst		1,280								1,280	1·3
Nyangu-Magina complex	Mx					695					695	·7
Nyokal sandy loam	Ncl	880			900						1,780	1·7
Obiero sandy clay loam	Orl				180						180	·2
Oboke sandy clay loam	Ocl				725						725	·7
Okok clay loam	Ok				204		318				522	·5
Olungo clay loam	Ol	1,295									1,295	1·4
Ongeng clay loam	Onc	1,852			85						1,937	1·9
Ongeng loam	Onl	4,392			4,391						8,783	8·8
Ongeng sandy loam	Ons	157									157	·2
Permanent Swamps	PS	150									150	·1

TABLE III.—ACREAGES OF SOIL TYPES AND PHASES, EAST KONYANGO SURVEY AREA—(*Contd.*)

Soil Types and Phases	Symbol	Slope Classes and % Gradient									Total	% of area
		A 0–3	AB 0–8	AC 0–13	B 3–8	BC 3–13	C 8–13	CD 8–20	D 13–20	E 20+		
Rangwe sandy loam	Ral	140				10,669					10,809	10·8
Rangwe clay loam, colluvial variant ..	Rac				576						576	·5
Rarage loam, mod. saline	Rgl	1,006									1,006	1·1
Rodi clay loam	Rcl	4,209			9,415						13,624	13·7
Stony land (basaltic rocks)	Sb							782		255	1,037	1·1
Stony land (Kavirondian Conglomerate) ..	Sml			532							532	·5
Stony land (Kibubu soil mat.)..	Stk							771			771	·7
Stony land (siliceous rocks)	Ss		135					1,700			1,835	2·0
								GRAND TOTAL ..			99,206	100

TABLE IV.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE EAST KONYANGO AREA

Physiographic Position	Series	Map Symbol	Relief	Internal Drainage	Surface Soil		Approx. thickness	Subsoil		Approx. thickness
					Colour (moist)	Dry; moist; wet Consistence		Colour (moist)	Dry; moist; wet Consistence	
							in.			*in.*
			Soils developedl argely from basic (dark-coloured, largely fine grained) igneous rocks							
Upland plains and low ridges	Bhanji clay loam	Bcl	Nearly level to gently sloping.	Slow	Black.	Slightly hard; friable; slightly sticky and plastic.	6	Black	Hard; firm; sticky and plastic.	18
Upland plains and low ridges.	Bhanji stony loam.	Bst	Gently sloping to steep.	Slow to medium.	Black.	Slightly hard; friable; slightly sticky and plastic.	4	Black.	Hard; firm; sticky and plastic.	14
Upland hills and ridges	Kibubu gravelly, sandy loam.	Kgl	Nearly level to sloping.	Rapid.	Dark reddish brown.	Soft; friable; non-plastic, non-sticky.	8	Dark reddish brown.	Slightly hard; friable; sticky and slightly plastic.	24
Hill tops and ridges ..	Kibubu stony loam.	Kst	Nearly level to gently sloping.	Rapid.	Dark reddish brown.	Slightly hard; friable; non-plastic, non-sticky.	6	Dark reddish brown.	Slightly hard; friable; slightly sticky, slightly plastic.	18
Upland plains ..	Kibugo loam.	Kil	Nearly level to gently sloping.	Slow to medium.	Very dark grey brown to very dark brown.	Slightly hard; friable; slightly sticky, plastic.	6	Dark grey to black.	Hard; firm; sticky, plastic.	12
Upland plains, concave positions.	Langi loam.	Ll	Nearly level to gently sloping.	Slow.	Very dark grey.	Soft; very friable; non-sticky, non-plastic.	3	Very dark grey to dark greyish brown.	Very hard; very firm; very sticky, very plastic.	29
			Soils developed largely from basaltic type rocks with minor volcanic ash or tuff areas							
Upland plains ..	Ongeng clay loam.	Onc	Nearly level to gently sloping.	Slow to medium.	Very dark grey brown.	Slightly hard; friable; sticky and plastic.	6	Black to very dark grey.	Hard; firm; sticky and plastic.	42
Upland plains	Ongeng loam.	Onl	Nearly level to gently sloping.	Slow to medium.	Very dark brown.	Slightly hard; friable; slightly sticky and plastic.	5	Very dark grey to dark greyish brown.	Hard; firm; sticky and very plastic.	44

TABLE IV.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE EAST KONYANGO AREA—(*Contd.*)

Physiographic Position	Series	Map Symbol	Relief	Internal Drainage	Surface Soil		Approx. thickness	Subsoil		Approx. thickness
					Colour (moist)	Dry; moist; wet Consistence		Colour (moist)	Dry; moist; wet Consistence	
							in.			*in.*
Soils developed largely from basaltic type rocks with minor volcanic ash or tuff areas—(*Contd.*)										
Upland plains	Ongeng sandy loam.	Ons	Nearly level.	Medium.	Very dark brown.	Soft; friable; non-sticky, non-plastic.	5	Dark greyish brown.	Hard; firm; sticky and plastic.	40
Upland plains	Rodi clay loam.	Rcl	Nearly level to gently undulating.	Slow to medium.	Black to very dark grey.	Slightly hard; friable; sticky and plastic.	7	Dark grey.	Hard; firm; sticky and plastic.	22
Soils developed largely from tuffs with minor basaltic areas										
Hill sides	Akijo clay loam.	Acl	Nearly level to moderately steep.	Slow to medium.	Black.	Hard; firm; sticky and plastic.	5	Black to dark grey.	Hard; firm; sticky and plastic.	18
Upland plains and ridges.	Konyango clay loam.	Kcl	Nearly level to gently sloping.	Slow to medium.	Black.	Hard; firm; slightly sticky and slightly plastic.	7	Dark greyish brown.	Hard; firm; very sticky and very plastic.	24
Upland footslopes and fans.	Okok clay loam.	Ok	Gently sloping to sloping.	Slow to medium: subject to seepage.	Dark reddish brown.	Slightly hard; friable; slightly sticky, non-plastic.	6	Dark reddish brown to dark brown.	Slightly hard; friable; sticky and slightly plastic.	42
Soils developed from acidic rocks (granites and rhyolites)										
Upland hills and ridges	Magina loamy coarse sand.	Mls	Nearly level to sloping.	Rapid.	Dark reddish brown.	Loose; very friable; non-sticky, non-plastic.	6	Dark reddish brown.	Loose; friable; non-sticky, non-plastic.	8
Plains	Misathe sandy loam.	Mil	Nearly level to gently sloping.	Slow	Very dark grey to very dark grey brown.	Soft; friable; non-sticky, non-plastic.	6	Black to very dark grey brown.	Hard; firm; sticky, plastic.	29
Plains	Nyokal sandy loam.	Ncl	Nearly level to gently sloping.	Slow.	Very dark grey to grey.	Slightly hard; friable; non-sticky, non-plastic.	6	Black.	Very hard; very firm; very sticky, very plastic.	22
Upland hills	Rangwe sandy loam.	Ral	Nearly level to sloping.	Medium to rapid.	Dark reddish brown.	Loose; friable; non-sticky, non-plastic.	3	Dark reddish brown.	Hard; firm; slightly sticky, plastic.	7

TABLE IV.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE EAST KONYANGO AREA—(*Contd.*)

Physiographic Position	Series	Map Symbol	Relief	Internal Drainage	Surface Soil		Approx. thickness	Subsoil		Approx. thickness
					Colour (moist)	Dry; moist; wet Consistence		Colour (moist)	Dry; moist; wet Consistence	
							in.			*in.*
Soils developed from acidic rocks (granites and rhyolities)—(*Contd.*)										
Upland hills, concave positions.	Rangwe clay loam, colluvial variant.	Rac	Gently sloping.	Medium.	Dark reddish brown.	Slightly hard; friable; slightly sticky, plastic.	7	Dark reddish brown.	Slightly hard; firm; slightly sticky, plastic.	24
Upland hillsides ..	Nyangu stony sandy loam.	Nst	Nearly level to gently sloping.	Slow	Very dark grey to very dark grey brown.	Soft; friable; non-non-sticky, non-plastic.	5	Black to very dark grey variegated.	Hard; firm; sticky, plastic.	14
Alluvial fans and fan terraces.	Oboke sandy clay loam.	Ocl	Gently sloping.	Medium.	Black.	Slightly hard; friable; slightly sticky, slightly plastic.	7	Dark grey.	Very hard; very firm; very sticky, very plastic.	20
Alluvial fans and fan terraces.	Ndhiwa loam	Ndl	Gently sloping.	Slow: subject to seepage.	Black.	Slightly hard; friable; slightly sticky, slightly plastic.	9	Very dark grey to dark grey brown.	Extremely hard; very firm; very sticky, very plastic.	28
Soils of stream terraces (developed from alluvium often with volcanic ash horizons)										
High stream terrace ..	Marinde clay loam.	Mcl	Nearly level	Slow.	Very dark brown to very dark grey brown.	Hard; firm; sticky, plastic.	3	Very dark brown to dark grey.	Very hard; very firm; very sticky, very plastic.	21
High stream terrace and small valley fills.	Mirogi clay.	Mrc	Nearly level.	Slow.	Black.	Very hard; firm; very sticky, plastic.	6	Dark grey.	Very hard; very firm; very sticky, very plastic.	61
Stream terrace.. ..	Kuja loam.	Kul	Nearly level.	Medium.	Black.	Soft; very friable; non-sticky, non-plastic.	5	Very dark brown to dark brown.	Hard; very firm; very sticky, very plastic.	25
Stream terrace.. ..	Kibigori clay loam.	Kbc	Nearly level.	Slow to medium.	Black to very dark grey.	Hard; firm; slightly sticky, plastic.	5	Black to dark grey.	Very hard; very firm; very sticky, very plastic.	13

TABLE IV.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE EAST KONYANGO AREA—(*Contd.*)

Physiographic Position	Series	Map Symbol	Relief	Internal Drainage	Surface Soil		Approx. thickness	Subsoil		Approx. thickness
					Colour (moist)	Dry; moist; wet Consistence		Colour (moist)	Dry; moist; wet Consistence	
							in.			*in.*
Soils of stream terraces (developed from alluvium often with volcanic ash horizons)—(*Contd.*)										
High stream terrace and fans.	Nyamauro loam.	Nyl	Nearly level to gently sloping.	Slow.	Black to very dark grey.	Slightly hard; friable; non-sticky, non-plastic.	4	Very dark brown.	Very hard; very firm; very sticky, very plastic.	13
Stream terrace.. ..	Olungo clay loam.	Ol	Nearly level.	Slow.	Very dark brown.	Hard; firm; slightly sticky, plastic.	8	Very dark grey to dark grey-brown.	Very hard; very firm; very sticky, very plastic.	16
High stream terrace and valley fills.	Rarage loam, mod. saline.	Rgl	Nearly level.	Slow.	Very dark brown.	Slightly hard; firm; slightly sticky, plastic.	3	Black to greyish brown.	Very hard; very firm; very sticky, very plastic.	56
Soils developed from volcanic ash										
Hills and ridges ..	Obiero sandy clay loam.	Orl	Gently undulating.	Slow to medium.	Black to very dark brown.	Slightly hard to hard; friable; slightly sticky, plastic.	6	Very dark brown to dark grey brown.	Hard; firm; slightly sticky, plastic.	25

SOILS AND MISCELLANEOUS LAND TYPES OF EAST KONYANGO

(Acl-A) Akijo clay loam, 0 *to* 3 *per cent slopes*

The Akijo clay loam is a dark-coloured shallow soil in the western part of the area in the vicinity of Okok. The larger acreages of this soil have 3 to 8 per cent slopes and they will be discussed more fully in that mapping unit. Crops grown on this soil will benefit from a ridge and furrow drainage scheme. 380 acres of this mapping unit was delineated.

Greenhouse test: Akijo clay loam.

(Acl-B) Akijo clay loam, 3 *to* 8 *per cent slopes*

The Akijo clay loam is a moderately shallow to shallow soil with a thin loose layer of black-red iron oxide concretions over the tuff parent material. The plough soil is a fairly hard clay loam, but it has a good subangular blocky structure. Good seed beds can be prepared when the moisture conditions are right. The soil can be sticky and plastic if worked when too wet. The subsoil is a blocky clay which grades into a thin, loose, red-black concretionary layer, about 2 in. to 6 in. thick, and then into a grey, fairly friable, gravelly sandy loam weathering rock containing many pieces of recognizable tuff and basalt. Occasional surface outcrops of basalt are found.

The Akijo soils are similar to the Bhanji soils. They differ from the Bhanji soils in having greyer subsoil horizons and looser and thinner red-black concretionary layers. They are closely related to the Rodi soils, but are shallower with greyer subsoils, have thin loose concretionary layers and are formed more from volcanic tuff than from basaltic materials. The Akijo soils also are related to the Kibugo soils.

Akijo clay loam was mapped in fairly large bodies south of Okok. This mapping unit consists of 2,377 acres. The phosphate reserves are fairly good and pH's are favourable, but available sulphur and nitrogen are low and there is some indication of a need for boron. The soil is moderately well suited for sugar cane. Most of the use of this soil is for grazing, but small patches of maize are raised. Contour planting and cultivation would help to protect this soil from erosion. Its shallowness limits its fertility.

(Acl-C) Akijo clay loam, 8 *to* 13 *per cent slopes*

This mapping unit differs from Akijo clay loam (Acl-B) in that it is found on steeper slopes. The effective depth of the soil profile averages somewhat less, and more outcrops and surface stones are present. All of this mapping unit is now used for pasture, but it could grow fair yields of sugar cane if protected by contour plantings and mulches. 1,249 acres are in this mapping unit.

(Acl-C-2) Akijo clay loam, moderately eroded, 8 *to* 13 *per cent slopes*

This phase of Akijo clay loam has topsoil that has been moderately eroded. About half of the depth of the original topsoil has been lost and there are small areas of gully erosion cutting clear down to the underlying parent material. This area is still being overgrazed and the eroded condition is getting worse. Grazing should be stopped in order that the natural vegetation be given a chance to come back and help protect the soil. There are 186 acres in this mapping unit. The phase is not suited for sugar cane.

(Acl-D) Akijo clay loam, 13 *to* 20 *per cent slopes*

This phase differs from Akijo clay loam (Acl-C), 8 to 13 per cent slopes, in being found on steeper slopes ranging from 13 to 20 per cent. This soil is used only for grazing, and care should be used to prevent overgrazing. If overgrazed this unit would soon be eroded and gullied. Only 44 acres of this mapping unit were found. The phase is not suited for sugar cane.

(A) Alluvial soils, undifferentiated

This land type occurs in narrow bodies along low flood plains of the Riana and Kuja rivers which are subject to frequent overflow during the spring rains. The profiles vary considerably from place to place. The friable topsoil is nearly black, contains a fair amount of organic matter and has a fine blocky structure. The substratum varies from thick lenses of dark brown clay to strata of coarse sand, fine sand, sandy loam, gravel and shingled cobbled beds in the lower depths. Thick beds of volcanic ash are often found along the cut banks of the river channels.

Both the Nyamauro and Kuja soils are found at slightly higher elevations along the stream terraces. Eroded salt licks (ES) and swampy land (PS) are mapped in close association with this unit. The soils are mostly used for pasture, but small patches of fairly good maize are grown during the short rains on the higher spots. Nitrogen and phosphate would increase yields, and applications of manure would improve the maize. Sugar cane, mostly because of the flooding hazard, is not recommended. 1,030 acres of this soil were mapped.

(Bcl-A) Bhanji clay loam, 0 *to* 3 *per cent slopes*

The Bhanji series was first described and mapped at Songhor [10]. Bhanji clay loam is a moderately deep to shallow slightly acid soil developed on smooth, nearly level to gently sloping, low ridges of basaltic (lava) rocks in the north-western part of the survey area. It has a very dark grey to black friable clay loam surface soil, 4 in. to 8 in. thick, which is underlain by black, sticky, plastic clay, having coarse to medium angular blocky structure. This clayey subsoil merges with a thin to moderately thick layer of concretionary ironstone or murram at a depth of 1 ft. to 2 ft. The concretionary layer goes abruptly into basaltic bedrock which usually lies at depths ranging from about 20 in. to 40 in. Occasional bedrock outcrops occur throughout the area. The concretionary ironstone layers may be anything from a few inches to several feet thick.

Bhanji clay loam closely resembles Akijo clay loam which also has a horizon of concretionary ironstone or murram. But the Akijo clay loam is greyer in colour, has less well-pronounced concretionary horizons and is developed from tuff. Bhanji clay loam is more sticky and plastic than the related Kibubu gravelly loam. It is on slightly higher ridges in association with Akijo clay loam and Rodi clay loam.

This soil has a moderate amount of humus and is fairly fertile, but its moisture-holding capacity is so limited by its shallowness that crops are likely to suffer from drought during the dry season. Internal drainage is slow and the soil is very wet during rainy periods. At these times the crops suffer from too much water. Laboratory data on the related Akijo clay loam and on Bhanji loam at Songhor [10] indicate the likelihood of nitrogen and sulphur deficiencies.

This soil occurs in small isolated areas, mainly in the Rodi-Marinde area. A total of 385 acres was mapped. Most of the land is used for pasture, but small patches are planted to sorghum, maize, millet and sweet potatoes.

(Bcl-B) Bhanji clay loam, 3 *to* 8 *per cent slopes*

This phase of Bhanji clay loam is essentially like the nearly level phase, except that the average depth to the basaltic bedrock is somewhat less. More frequent outcrops of basaltic rock are encountered. A total of 371 acres was mapped.

(Bst-AB) Bhanji stony loam, 0 *to* 8 *per cent slopes*

This soil resembles Bhanji clay loam in most respects, except the profiles are much shallower and rock outcrops are much more common. Depth to rock varies from zero to as much as 3 ft., but most of the soil is less than

2 ft. Loose rocks and bedrock outcrops take up 20 to 30 per cent of the area. This soil occurs in association with Bhanji clay loam, Kibubu gravelly sandy loam, Kibubu stony loam and Rodi clay loam. It occurs in scattered areas throughout the north and western part of the survey area. One of the largest areas is found three to four miles east of Mirogi on the smooth table-land of Tertiary volcanic rocks. 2,000 acres were mapped.

This land is used primarily for pasture, but small patches are planted to maize, sorghum, beans, millet and sweet potatoes. It is too stony for extensive cultivation and is not suitable for growing sugar cane.

(Bst-C) Bhanji stony loam, 8 *to* 13 *per cent slopes*

This strongly sloping phase of Bhanji stony loam occurs on steep slopes where the relatively smooth uplands have been dissected by deep drainage-ways. It resembles the more gently sloping phase in most respects, but due to steepness of slope it is much more susceptible to erosion. Even under grass, care will be needed in order to prevent overgrazing and subsequent soil loss.

(ES) Eroded salt licks and volcanic ash

This land type occurs in rather narrow bodies along stream channels throughout the entire survey area. About 75 per cent of this unit consists of eroded salt licks. These were probably started by livestock coming down to the streams for water. In their eagnerness for mineral they started to lick or eat the soil along the cut banks. The Rarage soil is often adjacent to stream channels, and contains sodium in the subsoil. By licking and trampling holes, particularly during the rainy seasons, livestock have created large puddled bare spots that have since been eroded with large gullies. Stock owners tend to aggravate this situation by driving their herds to these salt licks.

The volcanic ash beds comprise the remaining 25 per cent of this unit. These beds of yellowish-brown ash are sometimes more than 2 ft. thick, and are alluvial accumulations from the geologic past. Also included in this unit, in occasional small areas, are bedrock outcroppings and boulders. This unit covers 1,478 acres.

(Kbc-A) Kibigori clay loam, 0 *to* 3 *per cent slopes*

The Kibigori series was first described and mapped in the Songhor survey near Muhoroni [10].

The Kibigori soils consist of very deep imperfectly drained Grumusols (Black Cotton soils) developed from clayey water-deposited materials on nearly level stream terraces. The topsoil of Kibigori clay loam is dark-coloured clay loam that is sticky and rather hard to work, but contains a moderate amount of organic matter. The structure of the subsoil is of moderately developed prisms that upon handling separate into good-sized angular blocks. Many fine roots are present as well as many yellowish-red mottles. The substrata (C horizon) are dark grey to grey clays that have a lentil (lens-shaped more or less horizontally arranged) structure. Lime (calcium carbonate) concretions are abundant. Kibigori clay loam retains moisture rather well, and like the Marinde clay loam it also receives additional moisture by run-off from higher lands and may need surface drainage during wetter periods. Beds of volcanic ash crop out along stream banks and no doubt form part of the parent material.

The Kibigori clay loam lies near the Rodi and Ongeng soils but occupies lower positions. It is mapped in one large body of 2,064 acres along the Ogweo stream. Both the associated Rodi and Ongeng soils lack lime concretions, are developed from basaltic rocks and occupy the basaltic plains and ridges at higher elevations than Kibigori clay loam.

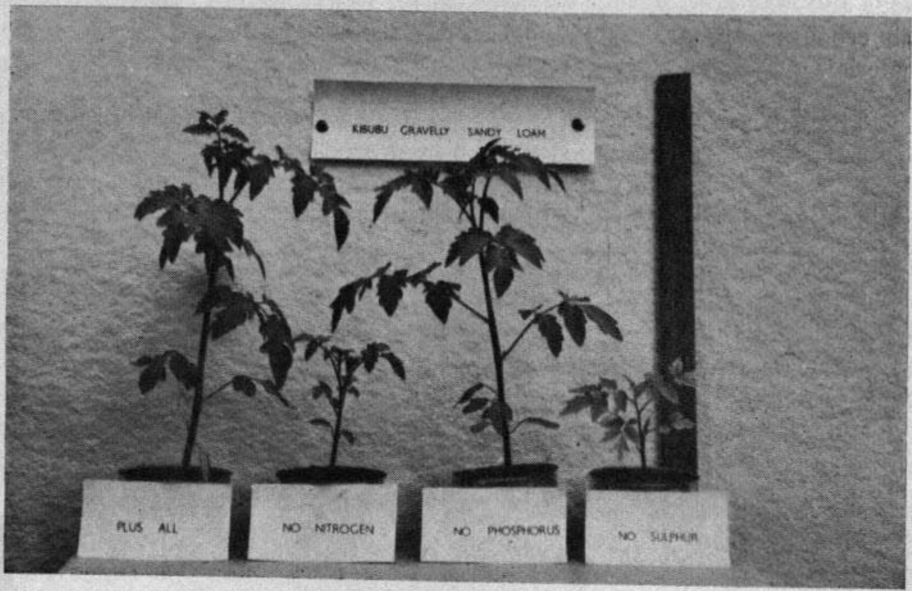
The main present use of this soil is for grazing. *Pennisetum catabasis* is the dominating grass. Small clumps of thorn trees, *Acacia* sp., grow along the stream channels. The overall fertility status of this soil is good, but applications of nitrogen and phosphate and probably boron would increase yields. Where this soil is farmed, it produces fair yields of maize. Although there are no cane yield records for this soil in East Konyango it should be as well suited for sugar cane as it is in the Songhor survey area.

(Kgl-AB) Kibubu gravelly sandy loam, 0 *to* 8 *per cent slopes*

The Kibubu gravelly sandy loam is a dark-coloured soil with strongly developed laterite horizon, developed from dark, fine-grained basaltic rocks. It occurs on broad expanses of nearly level to gently sloping uplands in the north-western part of the survey area, and in small patches elsewhere in the area. It is characterized by a dark reddish-brown gravelly sandy loam surface soil, 6 to 8 in. thick, overlying a horizon which is largely a mass of iron-oxide concretions. The concretionary layer grades into basaltic parent rock at a depth of 1½ to 3 ft. and there are occasional rock outcrops. Most of the 1,936 acres that was mapped occur on slopes of 3 to 6 per cent, but it is found on all slopes from 0 to 8 per cent.

The Kibubu soils are more reddish in colour and are more sandy textured throughout than the Bhanji soils with which they are associated. The Rangwe soils have very similar characteristics to the Kibubu soils but are developed from rhyolites. Much of the Kibubu soil is in pasture. Some of the more important grasses are *Aristida adoensis, Digitaria scalarum, Rhynchelytrum repens, Harpachne schimperi,* and *Eragrostis* sp.

The Kibubu gravelly sandy loam is easy to work because of its sandy loam surface soil. Consequently, there are many small *shambas* on it. Some of the more important crops grown are: maize, sorghum, millet, cassava, groundnuts, sweet potatoes, simsim, cowpeas and beans. The soils have adequate amounts of extractable phosphorus but Cunninghamella and greenhouse pot tests have shown a large need for nitrogen and a variable but quite often considerable need for phosphorus and sulphur. It tends to be quite droughty because it is loose and shallow and unless the rainfall is plentiful, yields are poor. The soil is not recommended for sugar-cane.



Greenhouse test: Kibubu gravelly sandy loam.

(Kgl-C) Kibubu gravelly sandy loam, 8 *to* 13 *per cent slopes*

The relatively small patches (total: 464 acres) of this soil occur on the complex slopes of low hills and ridges, and at the edges of the large basalt plains. It is like Kibubu gravelly sandy loam, gently sloping (Kgl-AB), but shallower. It also contains more rock and laterite outcrops. Steep and stony lands associated with areas of this soil are mapped as Kibubu stony loam, stony land (Kibubu soil materials) and stony land (basaltic rocks).

Areas of this soil are cultivated in about the same intensity as those on the lesser slopes. The steeper slopes of this soil makes it susceptible to erosion in rainy seasons. Conservation measures, such as terracing and contour planting, should be applied when this land is under cultivation. Its water-holding capacity is even less than that of Kibubu gravelly sandy loam, gently sloping; and because of greater run-off it absorbs less water.

(Kst-AB) Kibubu stony loam, 0 *to* 8 *per cent slopes*

A total of 2,292 acres of this soil are mapped, and most of it occurs on 3 to 6 per cent slopes. It is on the low hills and ridges and at the outer edges of the basaltic plain in the north-western part of the survey area. It is characterized by a dark reddish-brown loam surface soil which has many large basaltic stones scattered about. This grades into hard laterite layers at depths of 12 to 30 in. In many places patches of hard laterite are exposed at the surface.

This soil resembles Kibubu gravelly sandy loam in many respects, but contains many more loose stones and rock and laterite outcrops. Because of its stoniness only very small patches of this soil are cultivated. The most important crops are simsim, cassava and sweet potatoes.

(Kil-A) Kibugo clay loam, 0 *to* 3 *per cent slopes*

The Kibugo clay loam is a moderately deep to deep imperfectly drained soil developed in fine-textured residuum weathered from dark-coloured basaltic rock and minor areas of Kavirondian conglomerate. The surface soil is very dark greyish-brown to very dark brown clay loam with good friable consistence. Seed beds are easily prepared. The subsoil horizons are dark grey to black clays with a well developed fine subangular-blocky structure. The deeper subsoil is greyish-brown clay that contains many black manganese stains and concretions. Many brown stains (mottles), show that the soil is poorly drained during some times of the year. Weathered bits of parent rock are found in the soil layers immediately above the parent rock. Depth to parent rock varies from about 30 to 50 in. There are a few rock outcrops.

The Kibugo soils are found most commonly with the Rodi, Kibubu, Ongeng and Bhanji soils. In some places Marinde clay loam occupies lower stream terrace positions near the Kibugo loam.

Kibugo soils resemble the Rodi soils as to position and parent materials but are somewhat poorer drained. The substratum is greyer and may have thin layers of black-red iron-oxide concretions over the parent rock. The Akijo clay loam resembles somewhat the Kibugo clay loam but is less grey in colour (indicating better drainage) and is formed from volcanic tuff. The 1,030 acres of Kibugo clay loam, 0 to 3 per cent slopes, lies north of Magina market and on the level plains east and south of the Obera school road running west from Magina market.

Surface drains on the flatter slopes remove the excess water during the rains. The overall fertility status of this soil is medium to poor. Nitrogen is low and phosphate is moderate only. Sugar-cane is moderately well suited, but will need to be fertilized for good yields. Some maize is grown on this soil but the main use is for pasture.

(Kil-B) Kibugo clay loam, 3 *to* 8 *per cent slopes*

This gently sloping phase of Kibugo clay loam differs in no important respects from Kibugo clay loam, 0 to 3 per cent slopes (Kil-A), except for the stronger slope gradients and a few more basaltic rock outcrops. Surface drainage is more rapid; hence more topsoil may be lost unless suitable conservation practices are applied.

(Kcl-A) Konyango clay loam, 0 *to* 3 *per cent slopes*

The Konyango clay loam is a black, moderately well drained clayey soil developed from volcanic tuff and basalt. This rather extensive soil, 2,402 acres, occurs in large continuous bodies on the nearly level to gently sloping plain in the north-western part of the survey area.

The surface soil is a black clay loam which is underlain by a dark grey-brown heavily mottled, sticky and plastic, clay subsoil. The subsoil breaks easily to subangular blocks. This horizon ranges in thickness from 8 to 20 in. It grades into a grey to greyish-brown clay substratum which has brown and yellowish brown spots and streaks in the lower part. The substratum goes abruptly into the hard, basalt or volcanic tuff at a depth of 2½ to 3½ ft.

The Konyango soils resemble somewhat the Ongeng and Rodi soils with which they are associated. They differ from the Ongeng soils in that they are much shallower and also lack the discontinuous grey bleached horizon often found in the Ongeng soils. They differ from the Rodi soils not only that they lack the thin, grey bleached horizon, but also in having lighter and stronger-coloured lower horizons.

There is some surface drainage on most areas of this soil, but water will pond in low areas during the rainy season. Internal drainage is adequate during most of the year, but during the long rains the soil becomes saturated and waterlogging becomes apparent in the more level areas. A ridge and furrow-type surface drainage scheme should be of benefit.

Much of the Konyango clay loam is in pasture. Some of the more important grasses are *Pennisetum catabasis, Beckeropsis uniseta, Hyparrhenia* sp., and *Bothriochloa insculpta.* Some of the more important cultivated crops grown on this soil are: maize, sorghum, cassava, sweet potatoes, and some sugar-cane. Yields are fair, but the use of commercial fertilizers should increase the yields considerably as these soils are deficient in nitrogen, phosphorus and sulphur. There is also some indication of a need for boron. A sugar-cane plot on this soil was measured, cut, and weighed by the soil survey party, and the yield obtained was 45 tons per acre. This cane had been cut at 12 months for seed and it was 22 months later when cut and weighed by the survey party. This is a fair yield of sugar-cane considering that no commercial fertilizers were used, but it must be remembered that in the past three or four years rainfall has been very favourable.

(Kcl-B) Konyango clay loam, 3 *to* 8 *per cent slopes*

Degree of slope differentiates this soil from Konyango clay loam, 0 to 3 per cent slopes (Kcl-A). The 775 acres of this soil that are mapped are on the more sloping areas of the plain where it has been dissected by shallow drainages.

The profile characteristics of this soil are identical to Konyango clay loam, 0 to 3 per cent slopes (Kcl-A). The same crops are also grown on this soil and it is farmed to the same intensity as the lesser slope phase. This soil will erode under cultivation unless adequate conservation measures, such as contour farming and terracing, are carried out.

(Kul-A) Kuja loam, 0 *to* 3 *per cent slopes*

The Kuja loam is a deep, moderately well drained, fine textured soil that is developed on low stream terraces along the Kuja and Ndhiwa rivers. This soil is confined to that area covered by tall, dense bush and forest. The bush is mainly of *Carissa* sp., with some *Setaria chevalieri*. Many thick, hard layers of volcanic ash are present in the subsoil and have contributed to the chemical and physical properties of the Kuja soils.

The Kuja loam has a fairly thin black loam topsoil but contains large amounts of organic matter that make it soft, friable, and easy to work. The subsoil has clayey texture and well developed prismatic structure. A thin grey coating is present over the tops of the prisms, in places ½ to 1 in. thick. This grey coating is characteristic of leached soils. Underneath the prisms the profile grades into dark brown to brown, moderately developed, angular blocky structure with plentiful fine roots.

The Kuja loam is found in close association with the Olungo clay loam which is developed from the same parent material. The Olungo soil occupies the open grassy park areas adjacent to and within the dense bush vegetation of the Kuja soils, and has slightly thicker, more pronounced, leached layers.

The Kuja loam is a poor agriculture soil. It is extremely acid in reaction and would need almost prohibitive amounts of lime before any economic returns would be realized. Land clearing operations would also be expensive. The topsoil does contain much organic matter and is easy to work, and this could support a few hand-cleared small *shambas* along the edge of the thick bush. Nitrogen-phosphate would greatly benefit maize and other crops on these small *shambas*. Sugar-cane is not recommended on this soil.

The 2,645 acres of the Kuja loam mapped in the survey area are all nearly covered by the dense "bush" that is the habitat of most of the wild life in the area. It is a refuge for several hundred baboons and monkeys that venture forth on raiding expeditions in nearby African maize *shambas*.

(Ll-A) Langi loam, 0 *to* 3 *per cent slopes*

The Langi loam is a dark coloured, deep clayey, soil developed from basalt. A total of 1,279 acres has been mapped and most of it occurs in rather large blocks on the nearly level to gently sloping plain in the northern part of the survey area. It has a thin, very dark grey loam surface horizon which is underlain by a highly leached dark grey to light grey loam which becomes very much lighter in colour on drying. This layer breaks sharply into a dark grey, heavy clay subsoil. The clay horizon has a pronounced columnar structure, and the tops of the columns are rounded and are coated light grey when dry. The columns grade into light yellowish-brown to olive brown subangular blocky clay at a depth of 36 to 46 in. Below this depth grey and yellowish-brown stains are evident which indicates poor internal drainage. The soil grades into the underlying hard basalt parent rock at a depth of 50 to 60 inches.

The Langi loam is associated with the Rodi and Ongeng soils which are developed from the same parent material. They occupy smaller areas of the smoother parts of the same plain. Langi loam differs from both these soils in that it has the well developed, leached (grey or ashy appearing) layer over hard vertical prisms with rounded tops. The Langi loam has profile characteristics similar to the Misathe soils which are developed from granitic parent material, the Ndhiwa loam which is developed from rhyolite, and the Nyamauro loam which is developed from alluvium from acidic and basic rocks with ash layers.

The granular structure and loam texture of the surface horizon makes the Langi loam easy to work. Internal drainage is poor because of the dense, heavy textured subsoil. During periods of heavy rain the very slow movement of water through the subsoil causes the upper layers to become saturated and water ponds on the surface in the more level areas. Surface drainage would help relieve this situation.

The Langi loam can be used for the production of most of the local crops, like sugar-cane, maize, sorghum, sweet potatoes, cassava and pasture. The organic matter is moderately high in these soils but the phosphorus and nitrogen status is low. Sulphur status generally is adequate, but there is some indication of a need for boron. With adequate fertilization fair yields of sugar-cane can be expected.

(Ll-B) Langi loam, 3 *to* 8 *per cent slopes*

Degree of slope differentiates this soil from Langi loam, nearly level. The soil occurs on the more sloping areas where the plain has been dissected by shallow drainages. A total of 508 acres was mapped. The soil profile does not differ appreciably from that of Langi loam, nearly level, but it is perhaps somewhat shallower to bedrock.

(Mls-AB) Magina loamy coarse sand, 0 *to* 8 *per cent slopes*

The Magina loamy coarse sand is a shallow to moderately deep, well drained, dark reddish-brown soil formed from granite. The topsoil has a fine granular structure that is easily cultivated. Hard layers of laterite are found anywhere from the surface to 2 ft. below the surface. Roots and water penetrate easily to the underlying layers or horizons. Because of the shallow depth, crops may often suffer from lack of moisture during the drier seasons. The surface of the soil often has outcrops of granite as well as many rounded pieces of laterite or ironstone scattered about.

Magina loamy coarse sand resembles the Rangwe and Kibubu soils as to physical and chemical properties, but differs in the type of parent rock. Rangwe is formed from rhyolite, Kibubu from basalts and Magina from granite. The Magina soil is extensive around the Magina market locality on gently undulating ridges and hills.

On the gently sloping lands the Magina soil should be protected by contour plantings and tillage operations. It will erode quite easily and will form rills except on the nearly land level (0 to 3 per cent slopes) and should be protected by appropriate conservation measures. The soil is farmed intensively and is used to produce finger millet, groundnuts, simsim, sweet potatoes, cowpeas and some maize (though this does poorly). The local farmers consider Magina loamy coarse sand a very good soil for groundnuts. It is not recommended for sugar. The soil is droughty on account of its shallowness and sandiness. It is low in fertility; chemical and biological tests show needs for nitrogen, phosphate and possibly sulphur. Total reserves of calcium and potash are also low. 855 acres were mapped in this unit and this includes 90 acres of nearly level land.

(Mls-BC) Magina loamy coarse sand, 3 *to* 13 *per cent slopes*

This phase of Magina loamy coarse sand resembles the phase just described, except that the slope gradients are steeper. It occurs on moderately sloping upland hills and ridges. Many large granite boulders are present on the ridge tops. The surface soil has an occasional granite stone on it as well as small round stones of laterite or ironstone. Soil conservation measures are particularly important on these steeper sloping situations.

This mapping unit is found in large bodies on the hills and ridges east of Nyambija market and totals 1,980 acres.

(Mcl-A) Marinde clay loam, 0 *to* 3 *per cent slopes*

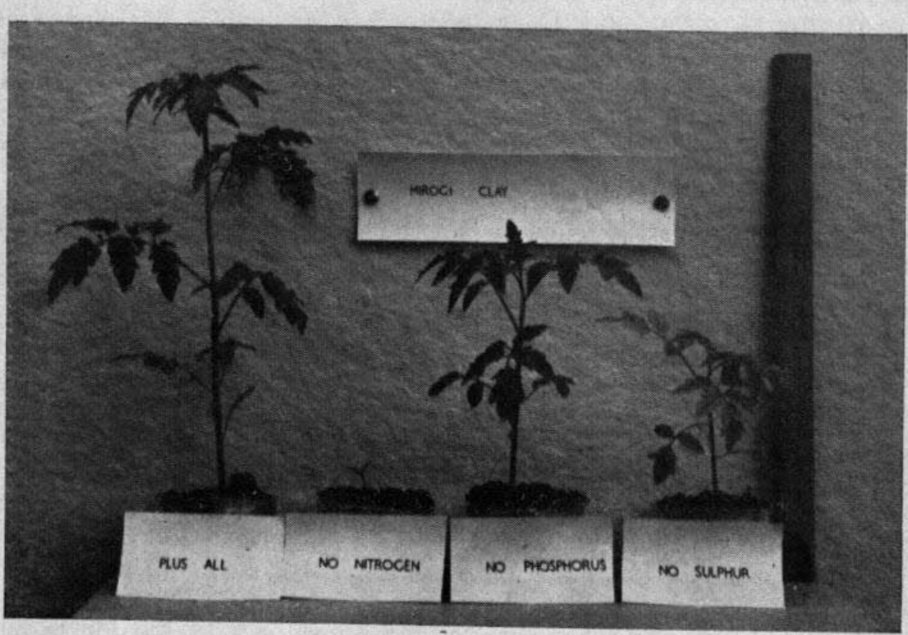
The Marinde clay loam is a very deep, somewhat poorly drained soil, formed from water-deposited clayey materials of stream terraces. The clay loam topsoil is very dark brown to very dark greyish-brown in colour, and is friable to firm when moist. When dry the topsoil could be hard to work up to a good seed bed. The structure of the clay subsoil usually is of strongly developed columns with thin grey ashy coatings of loam over the tops and down the cracks. Salts, mainly of sodium, are concentrated in this horizon, and tend to make the clay more sticky when wet and harder when dry. Roots can penetrate this part of the soil profile only when the soil is moist during the rainy seasons. The substratum, or the deeper part of the soil profile, consists of greyish-brown clay with well developed blocky structure. Mottles or stains of strong brown and yellowish-brown colours are present along with 10 to 15 per cent of the soil mass consisting of hard round black manganese iron concretions or "shot". Lime concretions are found usually at about 6 ft.

Marinde clay loam, like the Nyamauro soils, is found on flat stream terraces, but is not so strongly leached. Rodi, Misathe and Ongeng soils lie above the Marinde soils on higher ridges and gently sloping hills.

Marinde clay loam is in large bodies along upper tributaries of the Riana River, both to the east and west of Marinde. The main use of this soil is grazing, and *Pennisetum catabasis* is the dominant grass. Cane should do moderately well on this soil as it has the advantage of receiving extra moisture in the form of run-off from the surrounding higher land during the drier years. Surface drainage would need to be considered for wet years. The overall fertility status is rather low and for best yields of sugar-cane and other crops moderate applications of nitrogen, phosphorus and potash will be needed. Also there is some indication of a need for boron. 4,343 acres of this soil was mapped.

(Mrc-A) Mirogi clay, 0 *to* 3 *per cent slopes*

The Mirogi clay is a very deep, imperfectly drained, clay soil developed in deep fine-textured sediments which have accumulated as small valley hills along the small tributaries of the major streams in the northern and western parts of the survey area. The parent material is derived from a mixture of basalt, tuff and ash, which occur in the catchment area.



Greenhouse test: Mirogi clay.

The surface soil is a black, fine blocky clay. This is underlaid by a dark grey to dark greyish-brown blocky clay which is sticky, plastic and contains many dark brown streaks and stains. At depth it grades into strongly mottled light brownish-grey, dark grey, yellowish-brown and black clay. Black manganese concretions and hard lime concretions occur at 6 to 7 ft. depths. Below 7 ft. the clay grades into strongly mottled clay loam. Volcanic ash fragments are often found between 7 and 10 ft.

The Mirogi clay occurs in positions similar to the Kibigori clay loam. It has much more strongly mottled subsoil horizons. It is associated with the Rodi, Ongeng and Bhanji soils which occupy the higher slopes.

This soil received considerable run-off water from higher levels. In some areas the surface drainage is adequate to remove excess water, but water does pond in many of the lower places during the rainy season. The movement of air and water through this soil is slow, due to the sticky, plastic, clay subsoil. During the rainy season the soil becomes temporarily waterlogged and remains moist for a good part of the time.

The poor drainage condition is borne out by the presence of *Cyperus* sp. (papyrus) and large clumps of *Imperata cylindrica* grass. Some of the other important grasses and herbs that occur on this soil are *Pennisetum catabasis, Brachiaria* sp., *Bothriochloa insculpta, Eragrostis* sp., *Digitaria* sp., *Alysicarpus* sp. and *Vigna* sp. Most of the Mirogi clay is used for pasture, but small areas are planted to maize and sorghum. Yields are fair to poor owing to the poor internal drainage. Sugar-cane yields of 30 to 40 tons per acre on 24-month-old cane—first cutting—can be expected, providing adequate drainage measures and fertilization are provided. Applications of commercial fertilizers to provide for the nitrogen, phosphorus, sulphur and possibly boron deficiencies in this soil will be needed. 767 acres of this soil was mapped; this includes less than 40 acres which are on slopes greater than 3 per cent.

(Mil-A) Misathe sandy loam, 0 *to* 3 *per cent slopes*

The Misathe sandy loam is a deep, imperfectly drained, strongly leached soil with thick, bleached, light grey loamy layers in the upper part of the soil profile. The nearly level slopes are underlain by the parent granite.

The topsoil is very dark grey to very dark greyish-brown (when moist) sandy loam containing a fair amount of organic matter. It has a good fine granular structure and is easy to plough and cultivate. Roots and water penetrate easily through the first two layers of the profile, but not so easily through the underlying subsoil. The subsoil is of acid, black to very dark grey clay with weak to moderate prismatic structure, that breaks upon handling, to strong medium-sized angular blocks. Many strong brown and red mottles give evidence of the periodic wetness of this part of the soil profile. The soil then grades into dark greyish-brown sandy clay with fine yellowish brown mottles. Many bits of weathered parent rock and black manganese stains and concretions are mixed in with the clays. The strongly weathered granite is found usually at 4 to 5 ft.

The Misathe sandy loam is associated mainly with Nyangu stony sandy loam. The Nyangu soil has the same kind of parent rock but is sandier: it is found on long gentle slopes above streams, is covered by large granite boulders and has a much better developed concretionary horizon. The Nyangu stony sandy loam—Magina loam complex—is often found adjacent to the Misathe soils. This mapping unit is a complex mixture of the two soil types that did not warrant separating.

Very little of this soil is farmed. The Africans say it is waterlogged during the spring rains and they use it for pasture land. *Pennisetum catabasis* is the dominant grass, with subordinate *Brachiaria soluta* and *Adropogon* sp.

The loamy friable deep soil of the upper part of the profile should be good for groundnuts, sweet potatoes and other shallow rooted subsistence crops. The fertility level of this soil is low. Nitrogen, phosphate, potash and possibly boron and copper will be needed for satisfactory yields, particularly if sugar-cane is grown on this soil. On these flat slopes, surface drains would help to remove excess rainfall. 2,660 acres of this soil was mapped.

(Mil-B) Misathe sandy loam, 3 *to* 8 *per cent slopes*

There are no important differences between this phase of Misathe sandy loam and that on the nearly level land. The A horizons tend to be somewhat thinner in places owing to minor erosion. A few granite stones and outcrops are present. On this more sloping land, waterlogging is not so severe. The loamy topsoil will tend to erode rather badly if this soil is ever ploughed out to grass. Appropriate conservation practices should be applied. This is also a rather large unit of 2,215 acres.

(Ndl-B) Ndhiwa loam, 3 *to* 8 *per cent slopes*

The Ndhiwa loam is a deep, imperfectly drained soil that has developed in fine textured alluvium derived from rhyolite. It occurs on gently sloping fans in the south-western part of the survey area. A total of 490 acres of this soil was mapped.

The surface soil is a black friable loam. This is underlain by a highly leached, light grey loam horizon which becomes dark grey on wetting. This leached horizon ranges from 6 to 12 in. in thickness and it breaks abruptly into a very dark grey, sticky, plastic clay subsoil. This clayey horizon has columnar structure, and the tops of the columns are rounded and are coated light grey. At 30 to 40 in. the columns grade into blocky clay which is dark greyish-brown in colour and contains many dark brown streaks and stains and some concretions. These stains become more pronounced and the concretions more abundant with depth.

The Ndhiwa loam occurs in close association with the Rangwe soils and occupies the alluvial fans below them. It resembles the Nyamauro loam which occurs on stream terraces and which is developed from mixed alluvium from both acidic and basic rocks in having a thick leached horizon below the humic surface soil. It resembles also the Misathe sandy loam which is derived from granite.

Another soil which is closely related to both the Ndhiwa loam and the Rangwe soils occupies approximately 10 to 15 per cent of the area mapped within the Ndhiwa loam, 3 to 8 per cent slopes. This soil characteristically occurs at the contact margin between the Rangwe and Ndhiwa soils, where there is a maximum amount of seepage. This soil, shown as part of the Ndhiwa loam, is characterized by a dark brown sandy loam surface horizon which grades into light grey to nearly white gravelly sandy loam at about 20 in. depth. The gravels are concretions of iron-oxide. In places this grades into a thick "murram" layer, and in others it goes directly into highly weathered rhyolite at depths of 30 to 40 in. This soil is used by the local people for making bricks. Because of the scale of the base map and the limited detail of the survey, areas of this soil were not separated on the map but were included within the Ndhiwa loam. A similar soil over granite was found below Magina loamy coarse sand but its occurrences were too limited to map. The Ndhiwa loam is subject to seepage from the higher lying lands. Its wetness and leached condition results in low fertility with poor yields of most crops. However, with the use of adequate commercial fertilizers a fair production should be possible. The highly leached soil that is included within the areas of Ndhiwa loam is not suitable for cultivation. It remains wet for much longer periods, and has been depleted of most of its plant nutrients. 490 acres of Ndhiwa loam were mapped.

(Nyl-A) Nyamauro loam, 0 *to* 3 *per cent slopes*

The Nyamauro loam is a deep, somewhat poorly drained soil developed from fine-textured alluvium interlayered with volcanic ash. It occurs in large bodies on the terraces of the Kuja and Riana rivers. It has a black or dark grey loam surface soil, 4 to 5 in. thick, which is underlain by a fairly thick highly leached grey to dark grey brown loam. This horizon breaks abruptly into a very dark brown clay B horizon. This clay horizon has strong columnar structure and the tops of the columns are rounded and coated with grey loam from above. The columns grade into dark greyish brown subangular blocky clay at depths of 25 to 30 in. Below this the clay becomes increasingly mottled, indicating poor internal drainage. Thin layers of volcanic ash become common at depths of 60 to 90 in.

The Nyamauro loam occupies slightly higher elevations than the Kuja and Olungo loams with which it is associated. The morphology is similar to that of the Langi loam, developed from basaltic lava rocks. The Misathe sandy loam, developed from granite and the Ndhiwa loam, developed from rhyolite.

The native vegetation is mainly open savannah, with *Hyparrhenia* sp., *Sporobolus pyramidalis* and *Digitaria scalarum* dominating. Small clumps of *Acacia* sp., *Euphorbia* sp. and *Carissa edulis* are found growing on large termite mounds that dot the landscape.

Grazing is the main use of this soil. Some maize is grown but growth and yields are poor. African women often dig clay from the subsoil to smear on the walls of their wattle houses, as well as to make pots and jars. They also mix the grey loamy upper layers with water and use it as whitewash for the walls of the houses.

The Nyamauro loam is low in fertility. The Africans could grow fair yields of shallow-rooted crops in the upper layers if they would use lots of manure. This soil is low in nitrogen phosphate and potash (in the upper horizons) and probably is deficient also in copper, zinc and boron. Good yields, particularly if sugar-cane is to be grown, will depend on fairly heavy applications of commercial fertilizer. Surface drainage would help relieve the wetness during the long rains. This is a large mapping unit consisting of 8,290 acres.

(Nyl-B) Nyamauro loam, 3 *to* 8 *per cent slopes*

This mapping unit differs mainly from Nyamauro loam (Nyl-A) in that it is found on gently sloping land. There are no important chemical or physical differences in the soil profile.

The topsoil is thinner in many places. In small areas that have been overgrazed it has been moderately eroded. Termite mounds are neither so large nor so numerous in this unit as on the very gently sloping phase of Nyamauro loam. This phase of Nyamauro soil has the same agriculture potential as does the other, but conservation practices, such as contour tillage and cultivation, should be applied. The topsoil will erode easily if not protected. Surface drainage, due to the slope of the land, is somewhat better. The area totals 2,490 acres.

(Nst-AB) Nyangu stony sandy loam, 0 *to* 8 *per cent slopes*

The Nyangu stony sandy loam is a moderately deep, imperfectly drained, strongly leached soil that has a thick bleached ashy grey layer in the upper part of the profile. It is found on long gentle slopes, mostly above the Nyangu stream, and is weathered from granite. The surface of the mapping unit is covered by many large granite stones and outcrops. The topsoil is very dark grey to very dark greyish-brown soft friable sandy loam. This overlies a thick dark greyish-brown to dark grey soft friable sandy loam horizon prominently mottled at depth which breaks sharply at about 30 in. to a variegated black and very dark grey mottled sandy clay. The sandy horizon becomes ashy in appearance when dry. Over the weathered parent rocks a fairly thin, somewhat soft, layer of red-black iron-oxide or laterite is sometimes present. This laterite layer is not consistent in all places but is more often found about a third of the way down the slopes. The large stones prevent any major attempts at cultivation. This soil is used only for pasture. *Pennisetum catabasis* and *Hyparrhenia* sp. are the dominant grass species.

The Nyangu stony sandy loam is associated with the Misathe loam. The two soils are closely related in that both are strongly leached and formed from the same parent rock; but the Nyangu soil has a more sandy profile, is stony and has the discontinuous laterite layer over the parent rock. It is also associated with Magina loamy coarse sand in which the laterite development is even more pronounced. 1,280 acres of this soil were mapped.

(Mx-BC) Nyangu-Magina complex, 3 *to* 13 *per cent slopes*

This complex includes areas of both the Nyangu and Magina soils that are so intermixed that separations of each were impracticable on the scale of mapping used. About 60 per cent of the area is Nyangu stony sandy loam and the remaining 40 per cent is of the Magina soils.

Surface textures are mainly stony sandy loams, but small areas of loamy sands do occur in the eroded areas. Many of the granite stones are over 3 ft. in diameter. In the areas consisting largely of the Magina soils, they are very shallow with many laterite horizons exposed. Occasional small gullies have been cut on the steeper slopes.

The best use of this unit is for pasture, which is its main present use. A very few small patches of poor maize are raised on this soil. This complex occurs in moderate sized bodies on upland hill sides that flank the lower Olungo and Riana streams. A total of 695 acres was mapped.

(Ncl-A) Nyokal sandy loam, 0 *to* 3 *per cent slopes*

Nyokal sandy loam is an imperfectly drained, very strongly leached soil, developed from rhyolite on nearly level plains. The topsoil is very dark grey to grey sandy loam containing moderate amounts of organic matter. The crumb structure and humus make it fairly easy to work into a good seed bed.

Underneath the topsoil there is a thicker very dark grey to dark grey (grey when dry) sandy loam layer. The subsoil horizons are black clays with strong developed columnar structure that breaks with handling into strong coarse angular blocks. Fine roots are plentiful and some of them grow through the columns. Many fine prominent yellowish-red mottles indicate imperfect drainage. The clay of this layer is very hard when dry, and very sticky and plastic when wet. Black manganese shot and fine weathered bits of rhyolite are distributed throughout the soil mass. The lower part of the subsoil is transitional to the substratum and consists of mixed coloured clays, black, yellowish-red and greyish-brown. The soils are lighter textured and more friable than that in the columns, and have a more favourable medium-sized subangular blocky structure. The substratum is made up of greyish-brown and light olive-brown loamy sands containing much mica. Yellowish-red mottles are also present. The structure grades to fine granular. Roots can grow fairly continuously in these deep horizons as the soil is not so sticky when wet nor so hard when dry as in the subsoil.

The Nyokal sandy loam is associated with the Rangwe and Nyamauro soils. The Rangwe soils are shallow, dark reddish-brown loamy soils, and have a hard laterite layer over the parent rock and are found on higher gently sloping hills. The Nyamauro soils are very deep strongly leached soils found at lower elevations along the terraces of the Kuja and Riana rivers. The Misathe loam is closely related to the Nyokal sandy loam. Both occupy similar positions and both have thick light textured grey upper layers and similar clayey subsoils; but they differ in the type of parent rock. The Nyokal sandy loam is found in rather large bodies, totalling 880 acres, north and south of the old District Commissioner's road between Magina market and Nyango school. Pasture is the main use of this soil. The few maize plots look fair to poor. One or two small patches of cane were growing but they are over-ripe and no reliable yield figures were obtained. The Nyokal sandy loam has been so strongly leached that most of the plant nutrients have been removed from the root zone. Nitrogen, phosphate, potash and sulphur will all be needed for satisfactory yields. Manure would help increase yields of maize and shallow rooted crops such as cassava, sweet potatoes and groundnuts.

(Ncl-B) Nyokal sandy loam, 3 *to* 8 *per cent slopes*

This phase differs from Nyokal sandy loam (Ncl-A), 0 to 3 per cent slopes, only in that it is found on somewhat steeper slopes. The surface soil is somewhat thinner and bedrock is often found at shallower depths—about 5 ft. A total of 900 acres was mapped in this unit.

(Orl-B) Obiero sandy clay loam, 3 *to* 8 *per cent slopes*

The Obiero sandy clay loam is a very deep, imperfectly drained soil developed from volcanic ash. It occurs on gently sloping hills and ridges. The volcanic ash is probably of Pliocene age.

The topsoil is a black to very dark brown sandy clay loam that contains only a moderate amount of organic matter. The topsoil, if not worked at the correct moisture stage, will be difficult to convert to a good seed bed. The subsoil is a very dark brown to dark grey sandy clay loam, with structure of medium to coarse prisms that break rather easily, to strongly medium-sized angular blocks. Abundant fine and medium roots are present, some growing through the prisms. The lower part of the subsoil has many prominent red mottles indicating the periodic wetness of this layer. The deeper subsoil is a grey sandy clay with fairly well developed fine to medium blocky structure. The colour changes with increasing depth, becoming a mixture of grey, red, black and yellowish-brown with many black manganese stains and concretions. The last layer of the soil is slightly weathered hard yellowish-brown volcanic ash. Most of the profile is influenced by ash and the large percentage of shrinking and swelling clays in this soil is due to weathering of this material.

The Obiero soils are found mostly near the Kibugo soils. The Kibugo soils are dark grey and contain much "shot" or small round concretions in the subsoil and have greyish-brown mottled substrata. While many of the other soils found in the survey area contain traces of ash, there is no other soil that gives as much evidence as does the Obiero soil of being developed strictly from volcanic ash.

The fertility of this soil is only fair. It is low in nitrogen and phosphate. The soils are used for pasture, but are moderately well suited for most of the crops grown locally. Heavy applications of manure would increase maize yields. This soil is strongly acid, and trials with 1-1½ tons of lime per acre to correct the acidity are needed. Nitrogen and phosphate are needed for satisfactory yields of cane.

Only 180 acres of Obiero sandy clay loam was mapped in small bodies between Magina market and Marinde.

(Ocl-B) Oboke sandy clay loam, 3 *to* 8 *per cent slopes*

The Oboke sandy clay loam is a moderately deep to very deep imperfectly drained soil developed from rhyolite. It is found on gently sloping alluvial fans. The sandy clay loam topsoil contains moderate amounts of organic matter and is black to very dark greyish-brown. The topsoil has a well developed medium-sized granular to rounded blocky structure. It can be somewhat sticky when wet, or hard when dry, and should be ploughed or worked when moisture conditions are just right. The dark grey to very dark brown clayey subsoil has a well developed prismatic structure that breaks into medium-sized angular blocks. Below this, the profile grades into greyish clays that are strongly mottled with yellowish-brown, strong brown, and to a lesser extent dark red. In some places lime concretions as well as thin layers or small pockets of volcanic ash are present in this horizon. Black manganese stains and concretions in round "shot" form are nearly always found. Variable amounts of rounded quartz may be found throughout the profile.

Oboke sandy clay loam is associated with the Rangwe soil. The Rangwe soil, with its shallow dark reddish-brown soil and hard laterite horizon, occupies the upland position and the Oboke soil the adjacent alluvial fan position. The Oboke clay loam is in small patches near Rangwe village, in the Ofwanga school area, and three-quarters of a mile west of the junction of the Kibugo and Kuja rivers. Altogether they total 514 acres.

The soil is used mainly for grazing. A few small patches of subsistence crops are grown. The overall soil fertility, with the exception of the thin topsoil, is low. Applications of nitrogen, phosphate and sulphur are needed to increase yields. Sugar-cane, if fertilized, would do rather well on this soil. Contour plantings, cultivation and other conservation measures would help control erosion.

(Ok-B) Okok clay loam, 3 *to* 8 *per cent slopes*

Okok clay loam occurs in scattered small areas in the west part of the survey area. It is an imperfectly to moderately well drained, moderately deep to deep dark reddish-brown soil developed from volcanic tuff, breccia and basalt. It has a dark reddish-brown granular clay loam surface soil, and a thin dark reddish-brown blocky clay subsoil. The subsoil grades into a dark brown to very dark grey gravelly clay loam substratum at 12 to 20 in. deep. The substratum contains many red-black concretions up to ¼ in. in size and many fine fragments of weathered basalt parent material. It also has many yellowish-brown, brown and black streaks and stains. Rock outcrops and loose basaltic stones are not uncommon.

The Okok clay loam occurs on gently sloping footslopes below usually, the stony-land (basaltic rocks) land types.

Although the surface drainage is good, this soil is periodically quite wet. Because of its position in the landscape it is subject to seepage from the higher lying land. This seeped condition, coupled with numerous rock outcrops and large basalt stones, make this soil unsuitable for sugar-cane production.

Most of the Okok soil is used for pasture, but small areas are planted to maize, sorghum and simsim. It is deficient in nitrogen, phosphorus and sulphur, and commercial fertilizers are needed to increase yields. Only 204 acres of this phase of Okok clay loam were mapped.

(Ok-C) Okok clay loam, 8 *to* 13 *per cent slopes*

This is the strongly sloping phase of Okok clay loam. This phase of 318 acres, occurs on footslopes below the stony-land (basaltic rocks) land type in the northern and north-western part of the survey area.

The soil is similar to the moderately sloping phase, but it contains many more rock outcrops and loose stones which prohibit cultivation on any large scale. The cultivation that exists is limited to small patches of maize and sorghum. There are a few small areas relatively free of stones and rock outcrops, but this soil erodes easily and adequate conservation measures, such as terracing and contour tillage will need to be applied for it to be successfully farmed.

(Ol-A) Olungo clay loam, 0 *to* 3 *per cent slopes*

The Olungo clay loam is a deep, imperfectly drained, soil developed from fine-textured alluvium on low stream terraces. The clay loam topsoil is very dark brown (moist) in colour and contains a fair amount of organic matter. The structure is of strong fine to medium-sized subangular blocks and the soil should work into quite good seed beds if not ploughed too wet or too dry. The subsoil is very dark grey clay arranged into a strong coarse prismatic structure containing a good deal of sodium. A thin discontinuous layer, 1 to 2 in. thick of grey sandy loam caps the tops of the prisms and extends down the cracks between them. The high clay content, combined with the sodium makes this layer very hard when dry, very firm moist and very sticky and plastic wet. In the lower part of the subsoil the structure changes to medium-sized angular blocks. Roots can penetrate this layer best during the rains when the whole profile is moist most of the time.

The substratum is made up of yellowish-brown, greyish brown and brown clay banded with layers of hard light yellowish-brown ash. Many black manganese stains and concretions are present. The structure is mainly of well developed fine to medium-sized angular blocks. Roots can grow somewhat more easily in this level than above.

The Olungo clay loam lies adjacent to the Kuja loam and the two soils are closely related. They are formed from the same parent material and occupy the same positions. They differ in that the Kuja loam has more humus in the topsoil, has less well developed grey caps in the subsoil prisms and is found only in the dense bush areas. Olungo clay loam is found in the grassy pastures near to the thicker bush. Olungo clay loam is mapped along the Kuja and Ndhiwa rivers. It is used only for grazing. The main species of grasses are *Hyparrhenia* sp., *Pennisetum catabasis* and *Themeda triandra.* This is a low fertility soil; nitrogen potash, phosphate and possibly copper will all be needed for satisfactory results. The soil profile is strongly acid and lime may be needed if sugar-cane is to be grown. 1,295 acres of this unit were mapped.

(Onc-A) Ongeng clay loam, 0 *to* 3 *per cent slopes*

The Ongeng clay loam is a moderately well drained soil developed mainly from basalt on nearly level to gently sloping plains. The parent material also includes smaller areas of volcanic tuff and ash interspersed with the basalt.

The topsoil is very dark greyish-brown to very dark brown clay loam containing a good supply of organic matter. The top soil is crumbly and works up into a good seed bed. The subsoil is composed of sandy clay loam in the upper part and clay in the lower part that breaks into medium-sized angular blocks. In many places a very thin, grey, strongly leached layer of loam or sandy loam caps the tops of the prisms. Many fine and medium roots are found in this layer. The substratum is dark greyish-brown clay with a few fine strong brown mottles. The structure of the substratum is of strongly developed fine angular blocks containing black manganese concretions, particularly just above the parent rock. The depth to the basalt varies from about 4 to 6 ft. Tuff or volcanic ash may be found instead of the basalt.

The Ongeng soils are associated with the Rodi soils and they are closely related. They have much the same range of parent material and are found in the same physiographic positions. The main difference between the Rodi and Ongeng series is the depth to basalt. In the Rodi soils basalt is usually found at about 36 to 40 in. while in the Ongeng soils it is usually found at about 5 ft.

The Ongeng soils are among the better soils in the East Konyango area. Fair to good yields should be obtained from most crops. Chemical and biological tests, however, show that potash, nitrogen, phosphate and possibly sulphur and boron are low. Sugar-cane should do well on Ongeng soils, but for best yields fertilizer application to adjust the deficiencies may be needed. Most of Ongeng clay loam is found south of Mirogi in large bodies. 1,852 acres are mapped. This unit is rather wet during the rainy season, and could benefit from surface drainage.

(Onc-B) Ongeng clay loam, 3 *to* 8 *per cent slopes*

There are no significant profile differences between this soil and Ongeng clay loam (Onc-A) 0 to 3 per cent slopes, but the stronger slopes call for conservation practices. Only 85 acres were mapped.

(Onl-A) Ongeng loam, 0 *to* 3 *per cent slopes*

This soil has a loam instead of a clay loam topsoil as in Ongeng clay loam (Onc-A), 0 to 3 per cent slopes. Profile and chemical properties are similar. The basalt parent rock in this unit was found at a little over 5 ft. in most places.

Surface drains would be beneficial on this soil. This is a large unit and is found largely between Imbo and Ongeng with 4,392 acres being mapped.

(Onl-B) Ongeng loam, 3 *to* 8 *per cent slopes*

This moderately sloping phase of Ongeng loam is found on steeper slopes than Ongeng loam (Onl-A), 0 to 3 per cent slopes. The loamy topsoil will erode easily and must be protected by appropriate conservation measures. Profile and chemical properties are essentially the same as in other Ongeng soils. This also is a large mapping unit containing a total of 4,391 acres.

(Ons-A) Ongeng sandy loam, 0 *to* 3 *per cent slopes*

The Ongeng sandy loam is found in one small area of 157 acres north-west of Magina Market. Profile and chemical properties are similar to other Ongeng units, but basalt is very deep under these soils. The deeper layers are well mottled but roots grow almost to 7 ft. There are many sugar-cane plots on this soil and yields estimated to be 40 tons or more have been reported.

(PS) Permanent Swamp, 0 *to* 3 *per cent slopes*

This land consists of a fairly small acreage of peat and muck soils, covered with sedge-type vegetation, along nearly level stream channels and terraces. They are usually found in association with the Marinde clay loam and the Nyamauro loam. The soil could be used for rice production. Only 150 acres of this unit were mapped.

(Rac-B) Rangwe clay loam, colluvial variant, 3 *to* 8 *per cent slopes*

Rangwe clay loam, colluvial variant, is a well drained, very deep, dark reddish-brown soil. It is moderate in fertility and has good water holding capacity. Roots grow easily through the profile. The topsoil is crumbly and it is simple to prepare good seed beds. Much of the present parent material for this soil comes from other soils that have been washed down from higher hills and ridges. Many small, round, hard black-red concretions are found in the soil profile. These were also mixed in with the soil from above, and are pieces of hard laterite layers that have weathered since being exposed. Most of this variant of Rangwe clay loam is over 5 ft. deep, but occasionally hard parent rock is found between 4 and 5 ft.

This soil is found in the gently sloping hollows or depressions between rounded fingers of Rangwe soils that extend on both the north and south sides of the ridge that is in the vicinity of Gem peak. This soil is farmed intensively and produces fair to poor yields of finger millet, sweet potatoes, maize and cassava. Some bananas and a few small citrus groves are also grown. This soil will wash or erode easily during heavy rains and should be protected by contour plantings and tillage. A total of 576 acres was mapped. Sugar-cane is not likely to be grown on this soil because of possible termite damage. The fertility of this soil is low, and manure would do much to increase yields on the African *shambas*. Applications of nitrogen, phosphate and sulphur will be needed for best yields.

(Ral-A) Rangwe sandy loam, 0 *to* 3 *per cent slopes*

The Rangwe sandy loam is a well drained, shallow to moderately deep, dark reddish-brown soil throughout, with hard laterite layers over rhyolite parent rock. The topsoil is a friable sandy loam and works up easily into good seed beds. The crumbly subsoil has a well developed fine to medium-sized subangular blocky structure. Many hard round iron oxide concretions are found mixed with the soil, particularly in the layer just above the parent rock. Roots and water penetrate easily. The larger acreages of these soils have 3 to 8 per cent slopes and they are more fully discussed in that mapping unit.

This phase of Rangwe sandy loam occupies only 140 acres.

(Ral-BC) Rangwe sandy loam, 3 *to* 13 *per cent slopes*

This is the major phase of the Rangwe sandy loam. It is a well drained shallow to medium-depth soil. The surface soil is a dark reddish-brown friable sandy loam with many gravelly fragments of iron-oxide concretions. The subsoil becomes increasingly gravelly with depth and has a fine to medium subangular blocky structure. A horizon of ironstone laterite at 20 to 30 in. depth separates the soil from the bedrock. Bedrock and laterite outcrops are numerous. The stony land (siliceous rocks) land type nearly everywhere caps the steeper hilltops of the ridges and hills on which the Rangwe soils are found. Rangwe sandy loam supports large African population and is farmed very intensively. It produces fair yields of simsim, cowpeas, finger millet, cassava, sweet potatoes, kale and some groundnuts. Maize is often grown but does not yield well. These soils are often droughty during the short rains. The available water holding capacity is low. Sugar-cane is not recommended. The fertility status of this soil is rather poor, but its physical condition favours cultivation. It will respond well to applications of nitrogen, phosphate and sulphur. The Africans could easily increase yields by using large amounts of manure on these soils.

Rangwe sandy loam is mapped mainly in the eastern part of the survey area on the hills south of Rangwe market and along the road going south to Rongo. Smaller areas are found on the uplands in the south-western part between the Ndhiwa and the Kuja rivers. This is the largest mapping unit in the surveyed area. 10,669 acres were mapped.

While no erosion was indicated on the map, there has been widespread moderate erosion throughout the Rangwe soils, especially on the steeper slopes. Conservation practices are needed to conserve soil.

Greenhouse test: Rangwe (sandy) loam.

(*Rgl-A*) *Rarage loam, moderately saline,* 0 *to* 3 *per cent slopes*

The Rarage loam is a somewhat poorly drained, very deep soil, formed on nearly level surfaces along drainageways. The parent material is a mixture of weathered basaltic materials, tuff, ash and in some places granite washed from the upstream catchment areas.

The Rarage loam has about 3 in. of very dark brown loam topsoil well supplied with humus. If this soil were ploughed deep it would be mixed with the heavy clay subsoil which would result in a furrow slice that could be much harder to work than would otherwise be the case. The thin topsoil is underlain by a black clay subsoil with strongly developed, coarse prismatic structure. Roots penetrate this layer, but with difficulty. Below this, the profile grades into strongly mottled light brownish-grey, greyish-brown and yellowish-brown clays and clay loams.

The Rarage loam, moderately saline, is found associated with the Rodi, Ongeng and other soils which are formed from basaltic materials and occupy higher elevations away from the immediate drainageways where the Rarage soil is found. In the Magina market area, Rarage loam comprises one small continuous body on an old drainageway on the west side of the Nyangu stream.

An unusual characteristic of Rarage loam is that it contains moderate amounts of salt—mostly of sodium. The soil in the Magina market area has these salts in the upper 30 in. of the profile, while in the larger area in the Ongeng vicinity the salt content increases with depth. Sugar-cane that has been raised on this soil is reported to contain enough salt to affect the quality of the jaggery sugar and must be mixed with cane grown on other soils. The saline content varies from place to place but it will no doubt have a limiting effect on most crops, especially maize and beans. Most of this soil is used only for pasture. Sugar-cane grows moderately well on this soil when it is drained and fertilized. The Rarage loam is low in nitrogen and phosphate. Small applications of sulphur are worth trying. A total of 1,006 acres of this soil was mapped. The Eroded Salt Lick soils develop where the Rarage soils are gullied as a result of the trampling and licking of the subsoil by livestock.

(Rcl-A) Rodi clay loam, 0 *to* 3 *per cent slopes*

The Rodi clay loam is a moderately well drained, deep, to moderately deep soil that is derived from a complex of basalts, conglomerates, ash and lesser areas of tuff. It is found on nearly level to gently sloping plains.

The topsoil is a black to very dark brown clay loam with a moderately good amount of organic matter, and works up into good seed beds at the right moisture content. The subsoil is of very dark grey sandy clay loams to clays with moderately developed coarse prismatic structure that breaks upon handling to fine to medium-sized rounded blocks. Sometimes a very thin grey friable layer of sandy loam is sprinkled on the prism tops. Below this, the soil grades into dark greyish-brown and greyish-brown sandy loams to clays with medium angular blocky structure. The clay is very hard when dry, firm when moist, and very sticky and plastic when wet. Roots are found throughout the profile to the underlying parent basaltic rock.

The Rodi clay loam is closely related to the Ongeng soils. The main difference between the Rodi and Ongeng soils is the depth to the parent rock. In the Rodi soils basalt is usually found at about 36 to 42 in., while in the Ongeng soils it is usually found about 5 ft. The Ongeng soils are associated mainly with the Rodi soils, but minor areas of Bhanji and Kibubu are also present. Small pockets of volcanic ash are often found over the weathered parent rock.

The fertility of the Rodi soils is moderate, but nitrogen and phosphate are low and heavy applications of manure would greatly improve yields of maize and other crops. Sugar cane does well on these soils, despite the tight consistence and limited depth. Applications of commercial fertilizers, containing nitrogen, phosphate and perhaps some sulphur in good rainfall years, should yield 35-40 tons first cut. Surface drainage will help relieve the wetness conditions during the spring rains.

This phase of Rodi clay loam is extensive. It is found in large bodies, totalling 4,209 acres, in the northern part of the survey area and mainly along the road from Imbo to Mirogi.

(*Rcl-B*) *Rodi clay loam,* 3 *to* 8 *per cent slopes*

This phase differs from Rodi clay loam (Rcl-A), 0 to 3 per cent slopes, in being found on moderately sloping land. Profile and chemical characteristics are the same. Rock outcrops and loose basaltic stones are a little more common in this mapping unit. Sugar-cane and other locally adapted crops are not as well suited as on the nearly level phase. Surface drainage is better, but conservation measures should be applied. This phase of Rodi clay loam is very extensive, comprising a total of 9,415 acres.

(*Sb-CD*) *Stony-land* (*basaltic rocks*), 8 *to* 20 *per cent slopes*

Most of this basaltic stony land is found in the north-western part of the survey area. Small portions of this unit can be found on the 8 to 10 per cent sloping land, but mostly the unit comprises the steeper slopes. The grazing is somewhat limited due to the stones and slope of the land. 782 acres are mapped.

(*Sb-E*) *Stony-land* (*basaltic rocks*), *greater than* 20 *per cent slopes*

Steep basaltic escarpments make up most of this mapping unit. Goats graze over most of the 255 acres of this land type.

(*Sml-AC*) *Stony-land* (*Kavirondian conglomerate*), 0 *to* 13 *per cent slopes*

This land type is extremely stony land with patches of soils of variable depth lying on Kavirondian conglomerate. The soil between the rocks has a dark grey to black loam surface which is underlain by a dark greyish-brown blocky clay subsoil, like Ongeng loam. This grades into only slightly weathered rock at 20 to 48 in. depths. The large boulders of conglomerate are weathered slightly on the surface, and cover as much as 40 to 50 per cent of the land surface.

Included within the area of this unit are patches of a soil having distinct leached horizons and Planosol characteristics, essentially like the Langi loam. This soil has a light grey to grey leached horizon of loam texture which lies abruptly on a heavy, sticky, plastic clay. The clay subsoil has prismatic to columnar structure, characteristic of the Planosols. Soils having these characteristics make up approximately 20 to 30 per cent of the area of the unit.

This soil occurs in association with Rodi clay loam and Ongeng loam, and occupies the high ridges where the Kavirondian conglomerate protrudes through the basaltic (lava) rocks of the Tertiary volcanics. Most of it occurs on slopes of 2 to 5 per cent with only a small percentage exceeding 5 per cent gradients. This land is too stony for cultivation. It is so stony that the Africans in the area have excluded it from hoe culture.

(Stk-CD) Stony land, Kibubu soil materials, 8 *to* 20 *per cent slopes*

This land type occurs on steep ridges and along the edges of the basalt plain where it has been dissected by streams. A total of 771 acres was mapped in scattered small areas throughout the survey area. This land type is characterized by the large number of stones and bare rock outcrops that are present. A few patches of dark reddish-brown Kibubu-like soils have developed to very shallow depths. It occurs on 8 to 20 per cent slopes where surface run-off is very rapid.

This land type is similar to the Stony-land (basaltic rocks) with which it is often associated. The latter is even more stony and the patches of soil are shallower; also it lacks the Kibubu-type very shallow soils which occur in this unit. This land type is too stony for cultivation with the exception of very small pockets, and is now used only for rather poor grazing.

(Ss-AB) Stony-land (siliceous rocks), 0 *to* 8 *per cent slopes*

This land type consists of gently sloping land covered by fairly large rhyolite stones. The stones prevent any attempts at cultivation with the exception of hoe farming on a very few small areas. These soils are mostly used for grazing. Only 135 acres were mapped.

(Ss-CD) Stony-land (siliceous rocks), 8 *to* 20 *per cent slopes*

This land type differs from Stony-land (siliceous rocks) (Ss-AB), 0 to 8 per cent slopes, in having steeper slopes. It caps the hills south of Rangwe. The rhyolite stones cover almost all of the ground surface. This unit, being stonier and steeper, is less desirable for grazing and is used only by goats. 1,700 acres were mapped.

IV—CROPS

The following discussion on crops is presented in the order of importance of the particular crop in the present farming system of the African peasant. No reliable acreage or yield estimates are available.

Sorghum.—Sorghum is planted in February or March and matures in late July or early August. It is used as a food porridge and to make beer. Sorghum is never sold, and each family raises enough for its own needs. It is common practice to sow a few handfuls of maize kernels in the sorghum fields before the sorghum is seeded. Sorghum yields rather well, and it is said to do better on the darker coloured soils than on the reddish-brown hill soils. Sorghum is one of the best host plants for *Striga hermonthica* and *Striga asiaticus* and is mainly responsible for the increase of these aggressive parasitic weed in the area. The grain is thrashed by the primitive method of beating the bundles with sticks as they are spread out on the ground.

Millet.—Finger millet or "wimbi" is mature somewhat more quickly than sorghum. Most of it is planted at about the same time as sorghum and is mature in June. All of the crop is used at home for food and beer brewing. It is always the first crop on new soil because its early maturing qualities enable the farmers to gain a crop before the weeds destroy it. *Striga* is not nearly as plentiful in the millet *shambas* as in the sorghum. The dark reddish-brown hill soils are favourite soils for millet. A few stalks of maize are nearly always found interplanted with millet. Millet is harvested by hand methods as is sorghum.

Maize.—Maize is the principal African food crop, although some of it is used for brewing. All of this crop is either used for home consumption or is sold to other Africans at the local weekly markets. White maize is planted at the same time as sorghum to take advantage of the long rains; and it matures in five or six months. Coloured maize (coloured kernels saved from the white maize cobs) is planted with a companion crop of cowpeas in late August or early September, and matures in four months' time. Maize is harvested and shelled by hand. It is grown on many different kinds of soil.

Maize/legume mixed cropping.

Cowpeas.—Cowpeas are another important African food crop. They grow in the short rains and are planted any time from late August to early October. It is a common practice to plant cowpeas and coloured maize together. About half of the cowpea crop is sold to the Asian traders who also use them as food. The young green leaves of the plant are often picked and boiled as a green vegetable. The tender young pods are sometimes sold as "green peas", but are usually left to ripen upon the vine. They are picked and shelled by hand. Cowpeas help to keep weeds under control, and do best on the darker coloured soils.

Sweet Potatoes.—Sweet potatoes are planted all year round, depending upon the whim of the planter. They are raised largely on the loamy or sandier textured dark reddish-brown hill soils. The stems are planted and the roots are mature in about three months. They are harvested by hand hoe digging, and are often stored as a reserve food crop. Although sweet potatoes are a popular food among the Africans, they are not a mainstay in their diet. They are often eaten as a "sweet" along with other foods during their meal.

Groundnuts.—Groundnuts are planted in late February or early March and are dug by hand from four to six months later. They are sometimes planted as late as early May. They are grown on most kinds of soils, but yield best on the friable dark reddish-brown loamy or sandier textured soils. The Africans report groundnuts do exceptionally well on the soil mapped as Magina coarse loamy sand. They are the most important cash crop of the area, and are sold at controlled prices through the Indian traders to the marketing board associations. The acreage of groundnuts is increasing every year.

Simsim.—Simsim (sesame seed) is planted in September and matures, like cowpeas, at the end of December or early January. It is usually planted alone, but it is not uncommon to find it growing with cowpeas, green grams or even coloured maize. The stalks of simsim are cut in the field by hand, tied in bundles, and hung upside down on wooden rails in the fields to ripen and dry in the sunshine. The seed is thrashed by hand and sold as the area's second most important cash crop. It is used as an oil seed crop for making soap. Fairly good yields are obtained. It is grown on both dark reddish-brown soils and dark coloured clayey soils, with some difference of opinion as to which soil is best suited for simsim.

Green Grams.—Green grams are planted for the short rains, but mature two weeks earlier than cowpeas which have similar soil requirements. It is quite common practice for green grams to either be grown under coloured maize, or to have a lot of coloured maize plants growing in a patch of green grams. About one-fifth of the annual green gram crop is used as food, and four-fifths is sold to the Asians who use them in a popular curry dish.

Vegetables.—Vegetables constitute an important part of the African diet. Some are planted all year round, but most are planted for the long rains. Vegetables are usually planted in moist sites, such as small plots of soil around seepy areas. The vegetables grown are cabbage, kale, cauliflower, onions, tomatoes, carrots and beans. Cabbage is the most important vegetable that is raised. Families will often sell surplus cabbage, onions and tomatoes in the weekly markets. In addition to the usual vegetables, the Luo also gather the tender leaves of the weeds known as *Osuga, Ododo,* and *Dek* (Luo names), which are boiled and eaten.

Cassava.—Cassava, of the sweet kind, is usually raised in the drier areas, and stem cuttings can be planted throughout the entire year. Dark reddish-brown hill soils are favoured planting sites. Cassava is used as an emergency crop and is not very popular in the area. Both the dwarf and the tall variety are planted, but the tall variety can stay in the ground much longer than the dwarf variety without harm. Cassava roots are poisonous in some stages of growth. The roots are usually boiled and the water drained before they are suitable for eating. Cassava roots can be boiled and eaten, or mixed with sorghum and eaten as porridge. Dried cassava roots are mixed with cereals, ground, and used as a cereal flour.

Fruits.—Bananas, oranges, tangerines, rough lemons and limes are all grown but on a very small scale. The cultivation of bananas is on the increase, but most of the bananas consumed are imported from the Kisii highlands. There are less than 10 acres of fruit grown in the entire area. Bananas growing on Rangwe clay loam, colluvial variant in the Gem peak vicinity, appeared to be of good quality.

Sugar Cane.—Two hundred and forty acres of sugar cane were growing in 1959 in small trial plots scattered over most of the survey area. C.O.421 is the major variety, while C.O.419 and C.O.331 make up the smaller acreage. Other varieties of lesser importance are C.O.290, C.O.281, C.O.490 and C.O.408. These varieties are often grown mixed with each other. P.O.J. varieties were brought in by sugar mill workers from Central Nyanza and planted along stream banks for home use. Uba, a South African hard cane variety, is sometimes grown with C.O.421. The sugar-cane variety C.O.421 has done very well. It is a good jaggery cane, and stays in the field longer than any other variety without sugar loss, lodging or pith formation. Sugar-cane yields, for which the growers were paid by the jaggery mill, run from a high of 66 tons to a low of 14 tons an acre. How much influence poor management or the soil itself has on this wide variation in yields is not clearly known. A yield check of the C.O.421 cane variety at Okok in January, growing on Konyango clay loam, came out at 45 tons per acre. This cane was 22 months' old when cut and weighed, and was cut once before for seed 12 months after planting. No commercial fertilizers have been used on any of the cane trial plots. A sample of jaggery analysed by Scott Agricultural Laboratories had 74.2 per cent sucrose content and a juice to baggasse ratio of 50.88 to 49.42. The rainfall has been very favourable since 1952 and at no time have the sugar-cane trial plots ever suffered from lack of moisture. In drier cycles, sugar-cane yields may be considerably less. Sugar-cane cuttings are planted throughout July, August and September, and sprout with the help of moisture from the fall rains. The dry period between the short rains and the long rains encourages tillering. Two hand weedings are necessary. The cane is mature at 24 months, and two ratoon crops of about 20 to 22 months each are taken. The ratoons are mulched. Ridge and furrow surface drains are necessary on the poorer-drained flatter soils.

Ratoon stunting disease is in the area and will probably get worse, but no other sugar-cane diseases have yet been identified. Termite damage to cane raised on the dark reddish-brown soils is reported by sugar-cane specialists and cane plantings should avoid these soils.

Suitability of Soils for Growing Sugar-Cane.—All soils in the East Konyango survey area are less than ideal for growing sugar-cane. The ideal sugar-cane soil should have a deep profile, considerable capacity for moisture storage, friable consistence, well developed structure enabling roots to penetrate several feet and excess water to drain away, nearly neutral reaction, abundant humus, and a good supply of plant nutrients. The ideal soil should be located in a climatic region where the cane will never suffer from lack of moisture, or where irrigation water can be made readily available.

Available climatic data may be somewhat misleading, in that they cover only a few recent years. These records show a rather favourable rainfall that is no doubt reflected in the moderately high yields obtained in some of the sugar cane trial plots. Records obtained from the Kisii District Office show that the rainfall in Mirogi has been as low as 23.68 inches, and that four years out of ten the rainfall was less than 40 in. Marinde records show a low year of 32 in. and eight years out of ten less than 40 in. of rainfall. Experienced agriculturists, familiar with the area, say that there has been more than one severe dry cycle in the last 20 years. Raising cane for jaggery would, of course, be less affected than would large commercial plantings needed to sustain a white sugar industry. The prospects of irrigation in this area are poor.

The soils are placed in three groups according to their suitability for growing sugar-cane, assuming rainfall approximately equal to the recorded averages in the area.

Group I—Soils Suited for Sugar-cane

Eleven soil types and phases were placed in this group. These soils should yield between 35 and 50 tons of cane, first cut, with fertilizers and good management. The structure of these soils, while not ideal, does allow plant roots to penetrate the profile during the most favourable moisture periods. However, during the long rains the soil structure peds (once saturated), swell and expand, thereby sealing off water penetration. During the dry periods of the year, the peds turn very hard and crack, making root growth conditions far from ideal. A ridge and furrow system of drainage will be needed on the flatter land. Deep cane residue mulches will help maintain more favourable moisture conditions in the soil profiles. Some of the soils, Rodi clay loam for example, have a minor depth limitation which may make a difference in yields during dry periods. 21,232 acres of land were placed in this group as follows:—

	Acres
Kibigori clay loam, 0-3 per cent slopes	2,064
Konyango clay loam, 0-3 per cent slopes	2,402
Konyango clay loam, 3-8 per cent slopes	775
Obiero sandy clay loam, 3-8 per cent slopes	180
Oboke clay loam, 3-8 per cent slopes	725
Ongeng clay loam, 0-3 per cent slopes	1,852
Ongeng clay loam, 3-8 per cent slopes	85
Ongeng loam, 0-3 per cent slopes	4,392
Ongeng loam, 3-8 per cent slopes	4,391
Ongeng sandy loam, 0-3 per cent slopes	157
Rodi clay loam, 0-3 per cent slopes	4,209
	21,232

Group II—Soils Usable for Sugar-cane

Twenty-one soil types and phases, totalling 44,531 acres, were placed in this grouping. These soils have more limitations than do the soils in the first group. Depth to parent rock, lower fertility status, presence of salts in the profile, steeper slopes, more frequent bedrock outcrops and scattered surface stones are some of the soil characteristics that make these soils less desirable. Surface drainage will also need to be considered on the soils occupying flatter slopes. Approximate yields run between 15 and 30 tons per acre but fertilizers and good management should increase these yields.

	Acres
Akijo clay loam, 0-3 per cent slopes	380
Akijo clay loam, 3-8 per cent slopes	2,377
Akijo clay loam, 8-13 per cent slopes	1,249
Bhanji clay loam, 0-3 per cent slopes	385
Bhanji clay loam, 3-8 per cent slopes	371
Kibugo loam, 0-3 per cent slopes	1,030
Kibugo loam, 3-8 per cent slopes	1,826
Langi loam, 0-3 per cent slopes	1,279
Langi loam, 3-8 per cent slopes	508
Marinde clay loam, 0-3 per cent slopes	4,343
Mirogi clay 0-3 per cent slopes	767
Misathe loam, 0-3 per cent slopes	2,660
Misathe loam, 3-8 per cent slopes	2,590
Ndhiwa loam, 3-8 per cent slopes	490
Nyamauro loam, 0-3 per cent slopes	8,290
Nyamauro loam, 3-8 per cent slopes	2,490
Nyokal sandy loam, 0-3 per cent slopes	880
Nyokal sandy loam, 3-8 per cent slopes	900
Olungo clay loam, 0-3 per cent slopes	1,295
Rarage loam, 0-3 per cent slopes	1,006
Rodi clay loam, 3-8 per cent slopes	9,415
	44,531

Group III—Soils Not Suited for Sugar-cane

Thirty-three thousand, four hundred and forty-three acres of land, comprising 26 soil types and phases were placed in this group. All of the dark reddish-brown soils containing hard laterite concretionary layers over the parent rock are unsuited because of shallow depth, low moisture-holding capacity, low fertility status, and possibly cane damage from termites, Stoniness and steep slopes make many of the soil types unsuitable for sugar-cane. Wetness of the swampy land, and the annual flooding hazard of the alluvial soils rule out their use. The expense of land clearing operations of the thick bush found on the Kuja soils combined with their extreme acidity preclude their use for cane production. The Okok soils are studded with rock outcrops and are seasonally waterlogged.

	Acres
Akijo clay loam, 8-13 per cent slopes, moderately eroded	186
Ajiko clay loam, 13-20 per cent slopes	94
Alluvial soils, undifferentiated	1,030
Bhanji stony loam, 0-8 per cent slopes	2,130
Bhanji stony loam, 8-35 per cent slopes	146
Eroded salt licks and volcanic ash	1,478
Kibubu gravelly sandy loam, 0-8 per cent slopes ...	1,936
Kibubu gravelly sandy loam, 8-13 per cent slopes ...	464
Kibubu stony loam, 0-8 per cent slopes	2,292
Kuja loam, 0-3 per cent slopes	2,645
Magina loamy coarse sand, 0-8 per cent slopes	855
Magina loamy coarse sand, 8-13 per cent slopes	1,980
Nyangu stony sandy loam, 0-8 per cent slopes	1,280
Nyangu-Magina complex, 3-13 per cent slopes	695
Okok clay loam, 3-8 per cent slopes	204
Okok clay loam, 8-13 per cent slopes	318
Permanent swamps, nearly level	150
Rangwe clay loam, colluvial variant, 3-8 per cent slopes	576
Rangwe sandy loam, 0-3 per cent slopes	140
Rangwe sandy loam, 3-13 per cent slopes	10,669
Stony-land (basaltic rocks), 8-20 per cent slopes	782
Stony-land (basaltic rocks), 20 per cent plus slopes ...	255
Stony-land (Kavirondian conglomerates), 0-13 per cent slopes	532
Stony-land (Kibubu soil materials)	771
Stony-land (siliceous rocks), 0-8 per cent slopes	135
Stony-land (siliceous rocks), 8-20 per cent slopes ...	1,700
	33,443

V—FERTILITY EVALUATION OF EAST KONYANGO SOILS

In addition to studying the soils in the field, representative samples from the principal soil types in the East Konyango area were collected and analysed in the laboratory for various chemical constituents. Surface samples were also tested for phosphorus, nitrogen, sulphur and trace elements by the micro-biological Cunninghamella method and in the case of 14 soils fertility tests in the greenhouse were made using tomatoes as the test plant. Detailed descriptions of the laboratory procedures followed are given by Mehlich *et al.* [6]. The greenhouse tests measured the reduction of the growth of tomatoes in a limited volume of soil resulting from the withholding of nutrients singly from a complete nutrient solution. A growing period of five weeks was allowed and the procedure followed a modification of the method used by Webb [12] for the evaluation of the nutrient status of soils in Gambia.

The complete data on these soils will be found in the Appendix. Limited data on the surface soils are given in this section. The soils are separated into three broad groups, based on the amounts of phosphorus extracted from surface and subsoils. Data on soil reaction (pH), organic carbon (C), and total nitrogen (N), chemical phosphorus (P), micro-biological P, N, and sulphur (S) are reported in Table V. Table VI also contains greenhouse data on P, N and S. Tests for trace elements were also made by both micro-biological and greenhouse methods. The nutrient needs indicated by all these tests are suggested in the tables.

Group 1—Low to Medium Phosphorus in Surface, Low in Subsoil, and Medium to High in Lower Subsoil (below 36 in.)

There are 22 soils in this group representing 14 types. The phosphorus content of the surface soils varies considerably. Hence, the need for phosphorus ranges between slight and high, with the majority indicating medium requirements. Deep-rooting crops may be expected to be benefited by the high phosphorus in the subsoils (*see* data in Appendix). Akijo clay loam, Kibubu gravelly sandy loam, and Konyango clay loam indicate a medium need for nitrogen while all the other soils have high requirements. Sulphur needs range between nil and medium. These soils are well supplied with magnesium and calcium but many of them indicate rather low potassium (K) levels in the subsoils. Akijo, Konyango, Langi, Marinde, Mirogi and Ongeng indicate a variable need for boron (B). Response to these elements requires verification in field trials. Greenhouse tests on Marinde clay loam produced a very dark green colour in the plants, especially along the veins. This can probably be attributed to the higher sodium contents of this soil.

Per cent base saturation of the soils in this group ranges from 53 to 74 per cent.

With the exception of Kibubu gravelly sandy loam, all of the soils in this group are moderately well to well suited for the production of sugar-cane. Kibubu gravelly sandy loam is too shallow for cash crop production and is principally suited to small patch hoe culture.

Group 2—Low Phosphorus in the Surface, Medium to High in the Subsoil

This group covers only four soils represented by three types. These soils are all in need of phosphorus and nitrogen. Deep-rooted crops, however, may be expected to be benefited by the medium to high phosphorus in the subsoils. Sulphur needs range between slight and high. They are all well supplied with magnesium and calcium. Kibigori clay loam indicates a slight boron (B) deficiency.

Per cent base saturation ranges from 59 to 75 per cent and pH from 5.7 to 6.1.

Of the three soil types in this group, only Kibigori clay loam is suitable for sugar-cane production. Kuja loam supports a dense stand of forest and bush. It is also extremely acid in reaction. These two factors make this soil unsuitable for sugar-cane production. Land clearing operations would be expensive and the soil would require almost prohibitive amounts of lime before any economic return would be realized. Okok clay loam is too wet and too broken with rock outcrops for cash crop production and is principally suited for small patch hoe culture.

Group 3—Low Phosphorus in Surface and Low in Subsoil

There are 16 soils in this group representing seven types. These soils are virtually all in need of phosphorus and nitrogen. Even deep-rooted crops cannot be depended upon to obtain any significant share of their phosphorus from the subsoil. Sulphur needs vary from medium to slight. The supply of potassium (K) is low in both the surface and subsoil of all these soils. There are indications of low copper and of low zinc in Nyamauro and slight boron (B) deficiencies in Misathe and Nyamauro. Response to these elements requires verification in field trials. These soils are relatively well supplied with calcium, with the possible exception of Rangwe. The supply of magnesium is low in Rangwe.

Per cent base saturation is 50 per cent and below in all of these soils. It ranges between 29 and 50 per cent.

Magina loamy coarse sand, Nyangu stony sandy loam, Rangwe sandy loam and Rangwe clay loam, colluvial variant, which are shallow or stony soils, are not suitable for sugar-cane production. The remaining soils in this group are moderately well suited.

General Conclusions

Most of the soils in groups 1 and 2 are derived from basic parent materials—volcanic tuff, ash and basaltic (lava) rocks. The high phosphorus in the subsoils of these soils is a reflection of this. This is in agreement with the Songhor area where soils derived from volcanic tuff or ash were especially noted as being high in phosphorus. All of the soils in group 3, except Nyamauro loam, are derived from acid parent materials (granite and rhyolite). Nyamauro loam is a strongly leached Planosol developed from alluvium derived from a mixture of both acidic and basic parent rocks.

It should be emphasized that these samples do not represent a complete coverage of the soils in the East Konyango area. Furthermore, it should be pointed out that the values obtained by the laboratory and greenhouse tests must be interpreted on the basis of the nutrient requirements of the crops to be grown. The final answer, therefore, must come from the use of suitable field trials with different crops. The data certainly would lead one to believe that most of the soils should definitely be expected to show response to phosphorus for any intensive cropping system. The same applies to nitrogen for virtually all of the soils investigated. Any extensive agricultural development, such as sugar-cane production, will necessitate a carefully planned programme for fertilization.

Explanation of Soil Test Values in Tables V and VI and Appendices

Chemical Tests:

pH refers to soil acidity and alkalinity. pH 7 denotes neutrality. Below pH 7 the values denote progressively higher acidity, and above pH 7 progressively higher alkalinity.

C% represents organic carbon. To obtain conventional organic matter multiply by 1.76.

N% refers to the total nitrogen. To obtain pounds nitrogen per acre multiply by 20,000.

C/N is the C% divided by N%.

P to convert P ppm into pounds per acre of phosphorus, multiply by two.

Micro-biological Tests and Greenhouse Tests:

—P, —N and —S denote the per cent vegetative growth obtained when each of these nutrients was omitted, compared to that growth in which all nutrients were added.

TABLE V.—FERTILITY EVALUATION OF EAST KONYANGO SOILS

Soil Type	Chemical Tests					Micro-Biological Tests % of + All			Nutrient Needs Indicated		
	pH	C%	N%	C/N	P (ppm)	−P	−N	−S	P	N	S
Group 1—Low to Medium Phosphorus in Surface, Low in Subsoil, and Medium to High in Lower Subsoil (below 36 inches)—											
Akijo clay loam	6·1	2·26	0·17	13	73	48	29	72	medium	medium	slight
Kibubu gravelly sandy loam	6·5	1·05	0·11	9	238	70	0	22	slight	high	high
Kibubu gravelly sandy loam	6·2	0·54	0·09	6	68	35	35	95	high	medium	slight
Kibugo loam	5·3	2·05	0·15	13	30	42	15	100	medium	high	nil
Konyango clay loam	5·5	2·45	0·25	9	27	23	0	23	high	high	high
Konyango clay loam	5·4	2·30	0·24	9	35	35	0	40	high	high	medium
Langi loam	5·5	3·22	0·22	14	38	50	18	100	medium	high	nil
Langi loam	5·3	1·63	0·14	11	18	53	26	55	medium	medium	medium
Marinde clay loam	5·0	1·80	0·17	10	22	57	0	65	medium	high	medium
Mirogi clay	5·1	2·40	0·25	9	35	32	0	55	high	high	medium
Nyokal sandy loam	5·9	1·86	0·17	10	18	22	4	52	high	high	medium
Obiero sandy clay loam	5·0	1·26	0·16	8	22	36	0	71	high	high	slight
Oboke sandy clay loam	5·8	3·39	0·26	13	27	63	0	41	medium	high	medium
Olungo clay loam	5·4	1·80	0·13	13	12	47	0	53	medium	high	medium
Ongeng clay loam	5·4	2·42	0·14	17	18	70	5	70	slight	high	slight
Ongeng loam	5·6	3·11	0·33	13	63	53	10	57	medium	high	medium
Ongeng loam	5·2	2·55	0·18	14	20	60	7	93	medium	high	nil
Rarage loam	5·8	4·74	0·24	19	34	50	16	67	medium	high	slight
Rarage loam	6·6	2·45	0·19	13	23	42	4	92	medium	high	nil
Rodi clay loam	5·6	1·99	0·19	10	23	55	3	41	medium	high	medium
Rodi clay loam	5·4	2·26	0·15	15	18	44	16	100	medium	high	nil
Rodi clay loam	5·3	2·70	0·18	15	17	67	7	93	medium	high	nil
Group 2—Low Phosphorus in Surface, Medium in Subsoil—											
Kibigori clay loam	5·8	3·62	0·30	12	29	30	0	74	high	high	slight
Kibigori clay loam	6·1	2·60	0·18	14	11	40	10	60	high	high	medium
Kuja loam	5·6	4·93	0·40	12	12	60	38	105	medium	medium	nil
Okok clay loam	5·8	2·07	0·21	9	18	46	0	27	high	high	high
Group 3—Low Phosphorus in Surface, Low in Subsoil—											
Magina loamy coarse sand	5·4	1·95	0·14	13	10	75	0	42	slight	high	medium
Misathe sandy loam	4·8	2·66	0·15	17	16	41	41	73	high	medium	slight
Misathe sandy loam	5·1	1·42	0·13	10	4	33	33	67	high	medium	slight
Misathe sandy loam	4·7	1·53	0·13	10	15	19	31	50	high	medium	medium
Ndhiwa loam	5·4	2·12	0·11	19	18	64	10	78	medium	high	slight
Ndhiwa loam	5·5	1·95	0·14	13	16	42	0	50	high	high	medium
Ndhiwa loam	5·7	1·80	0·12	15	12	41	23	64	high	high	medium
Ndhiwa loam	5·4	1·57	0·08	19	18	27	14	64	high	high	medium

TABLE V.—FERTILITY EVALUATION OF EAST KONYANGO SOILS—(*Contd.*)

SOIL TYPE	CHEMICAL TESTS					MICRO-BIOLOGICAL TESTS % OF + ALL			NUTRIENT NEEDS INDICATED		
	pH	C%	N%	C/N	P (ppm)	−P	−N	−S	P	N	S
Nyamauro loam	5·1	1·65	0·12	13	18	36	12	71	high	high	slight
Nyamauro loam	5·2	1·39	0·16	8	7	24	20	80	high	high	slight
Nyamauro oam	5·2	3·33	0·21	15	9	39	8	73	high	high	slight
Nyangu stony sandy loam	4·8	1·51	0·09	16	7	93	27	120	nil	medium	nil
Rangwe clay loam, colluvial variant	5·3	1·05	0·17	6	11	42	15	69	high	high	slight
Rangwe sandy loam	6·0	1·35	0·11	12	13	42	23	77	high	high	slight
Rangwe sandy loam	5·3	1·56	0·13	12	10	35	0	55	high	high	medium
Rangwe sandy loam	5·1	0·84	0·09	9	8	27	10	100	high	high	nil

TABLE VI.—FERTILITY EVALUATION OF EAST KONYANGO AREA SOILS INCLUDING GREENHOUSE TESTS

SOIL TYPE	CHEMICAL TESTS		MICRO-BIOLOGICAL TESTS % OF + ALL			GREENHOUSE TESTS % OF + ALL			NUTRIENT NEEDS INDICATED		
	pH	P (ppm)	—P	—N	—S	—P	—N	—S	P	N	S
GROUP 1—											
Akijo clay loam	5·9	43	72	0	44	73	2	2	slight	high	medium
Kibubu gravelly sandy loam	6·2	60	64	8	40	69	13	7	medium	high	medium
Konyango clay loam	5·3	15	37	5	46	22	2	3	medium	high	medium
Langi loam	5·1	9	33	0	63	2	2	2	high	high	medium
Marinde clay loam	5·4	12	19	5	57	2	4	13	high	high	medium
Marinde clay loam (B horizon)	5·5	9	25	10	50	5	4	4	high	high	medium
Mirogi clay	5·1	9	24	10	53	43	1	18	medium	high	medium
Olungo clay loam	5·4	8	37	23	55	2	2	10	high	medium	medium
Olungo clay loam	5·2	8	15	11	52	25	35	83	high	medium	slight
Ongeng loam..	5·0	18	28	0	52	54	1	18	medium	high	medium
Rodi clay loam	5·9	50	32	0	40	38	1	1	medium	high	medium
GROUP 2—											
Kuja loam	4·9	8	45	25	90	4	42	81	high	medium	nil
Kibigori clay loam	5·9	19	0	0	48	1	1	82	high	high	slight
GROUP 3—											
Misathe sandy loam..	5·1	8	17	26	44	4	2	13	high	high	medium
Nyamauro loam	5·3	10	30	30	70	2	2	2	high	medium	medium
Nyamauro loam	4·9	8	36	20	72	4	4	5	high	medium	medium
Rangwe sandy loam..	6·0	11	12	4	35	2	2	7	high	high	high
Rangwe sandy loam..	5·7	9	31	0	73	2	17	3	high	high	medium

VI—HOW THE SOILS OF THE EAST KONYANGO AREA WERE FORMED

Soils in general can be grouped in two very broad classes:—

(1) Soils composed primarily of minerals in various stages of decomposition, with more or less incorporated organic matter, and

(2) Soils composed primarily of organic matter (various bands of peat or muck) with some incorporated mineral matter.

Soils of the East Konyango area fall almost entirely into the first class, although there are a few acres of primarily organic soils in some small, scattered swampy spots. These last can be dismissed as insignificant for this discussion. The mineral soils comprise 24 soil series of 28 types and 47 phases. In addition, there is one variant unit, one complex unit and seven miscellaneous land types. As indicated on earlier pages, the distribution of each soil type and phase is shown on the soils map as accurately as existing facilities permitted.

Many of the soils in the area are "moderately heavy" like Rodi and Marinde clay loam, but some are of a "medium" texture such as Langi loam or Ongeng sandy loam; some, like Rodi clay loam, are fairly well supplied with humus and plant nutrients, and some are infertile; some, like Rangwe loam, are crumbly and easily tilled, and some, like Mirogi clay, are hard to plough and to prepare for good seed beds. In the following pages we shall discuss briefly what is known or conjectured about soil forming factors. Detailed descriptions of the major soil series appear in the Appendix.

The Factors of Soil Formation

Most soil scientists recognize five major groups of factors that are responsible directly or indirectly for the soils as we find them today. They are:—

(1) The nature of the rocks and loose mineral deposits from which the bulk of the soil material is formed.

(2) The climatic conditions under which the soils have formed.

(3) The nature of the surface of the soil, particularly the shape and gradient of slopes.

(4) The biological environment of the soil, including the activities of man.

(5) The approximate length of time the soil has been exposed to the influence of the first four groups of factors.

It is obvious that each of these groups of factors includes many variables, each of which has its effect on the character of the soil. In this report we can only suggest the contributions each group of factors has made to the soils.

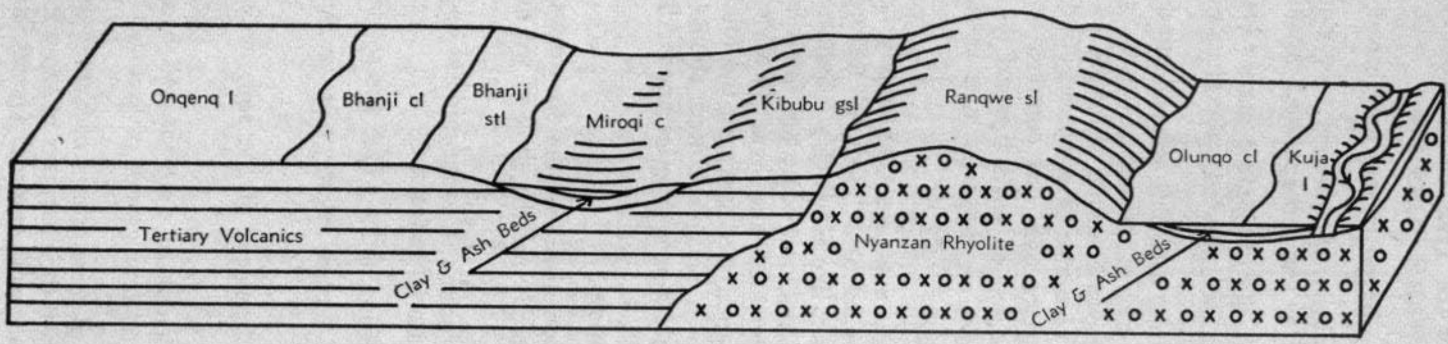


Fig. 1—Cross section from the Kuja River N.-N.W. to 5 miles S.-S.W. of Mirogi.
(Length of section: 5 miles.)

As universally recognized in the field of soil science, the soil is in a dynamic condition, or constant state of change. It is losing some components through leaching and erosion; it is gaining new material through weathering of parent rocks, ground water movement, additions of dust and decaying of dead vegetation; and the nature of its mineral status is changing gradually through continued weathering.

One might conclude that the soil is changing so rapidly that recommendations for improvement would be of no avail. Most changes in soils are not very rapid and take place gradually over fairly long periods of time. Furthermore, newly added material tends to balance much of the material that has been lost in various ways, and often a near-balance between these two effects develops in the soil. Under natural conditions, then, *net* soil changes may be relatively minor over periods of many hundreds or even thousands of years.

The Loose Mineral Deposits and Hard Rocks

About one-fifth of the soils in the East Konyango District are developed in loose mineral deposits of various kinds, mostly dumped by sediment-charged streams or settled out slowly from the quiet muddy waters of what may be former shallow lakes, or in the backwaters of meandering streams. Some of the unconsolidated deposits could have reached their present position by slow gravitational creep from higher to lower slopes.

Most deposits made originally by streams occur above flood levels, on broad, nearly level, terraces along the Riana, Ogweo and Kuja rivers and their tributaries. The Kuja, Kibigori, Olungo and Nyamauro soils have developed in these deposits. The unconsolidated mineral deposits along the stream flood plains are of a more variable nature. Beds of volcanic ash, often over 2 ft. thick, are to be found along the Ogweo, Riana and Kuja flood plains. Some deep cut banks along the Kuja River show two and sometimes three different ash deposits with different textural alluvial material between. These volcanic ash deposits were no doubt washed off higher lands after their deposition, and concentrated in lower positions along with other unconsolidated deposits. Shingled cobble beds of great thickness as well as areas of rounded boulders can be found along the Riana River below where it is joined by the Misathe and Nyamauro tributaries.

Both the Kuja and the Olungo soils have subsoil horizons of what appear to be nothing but slightly weathered volcanic ash. The clays of both of these soils are dominantly of the 2:1 silica-alumina lattice type.

The alluvium of the stream terraces in which the Nyamauro soils have developed is of mixed origin of both basic and acidic type rocks. The acidic rock may be dominant because the upstream catchment area, most of which is outside the survey area, is mainly of rhyolite, andesite and quartzite of the

Nyanzian and Bukoban series and granite intrusions. The basic rocks are mainly basalts of the Bukoban series. The dark coloured Kibigori soils are formed in alluvium washed from basaltic aglomerates, and volcanic ash also may have contributed.

The Marinde soils are formed in deep sediments that may be partly lacustrine in origin. Shallow lakes could easily have been where flat broad stream terraces are now. Both the Marinde and Kibigori soils have lime concretions very deep in the profile, which could have been concentrated by groundwater and by transfer of lime from upper to lower horizons of the soils. Auger borings from the bottoms of 5-ft. pits in the Marinde soils revealed layers of ash deposits mixed with the soil.

Rocks of different composition and degrees of hardness underlie soils of the other four-fifths of the area and have weathered in varying degrees into loose minerals that make up the bulk of the soil parent materials.

Soda-rich basalt and tuff are the chief parent rocks of soils found in the Rodi, Marinde, Mirogi, Ongeng and the Obera school areas [5]. Soils derived from dark coloured parent rocks are more extensive than those from other rocks. All of these soils have more or less dark coloured surface soils and heavy textured profiles, with strongly developed structure. Most soils developed from the volcanic rocks are more or less clayey with subordinate sand. The clays in most of these soils are of the type that shrink and swell greatly with moisture changes, as in the Kibigori clay loam, a "black cotton" soil, or Grumosol. The flattened appearance of the fine roots noted between the soil peds reflects the pressure exerted by swelling clay. The Kibigori clay loam has 2:1 type of clay.

Practically all of the soils lying on Tertiary volcanic rocks have been influenced by volcanic ash. Some, such as Kuja, Obiero, Ongeng, Olungo and the Rodi soils, have either discontinuous horizons or pockets of volcanic ash, or horizons that are mixed with weathered ash particles. The Obiero, Kuja and Olungo soils have ash as their parent materials, and in these soils the 2:1 type of clay is dominant.

Almost all of the soils formed from Tertiary volcanics are well supplied with phosphorus, especially in subsoil horizons.

Soils developed from rhyolite are the second most important group. The Rangwe and Nyokal soils are derived from rhyolite and have somewhat sandier textured profiles than do the soils formed from Tertiary volcanic rocks. They have low reserves of nitrogen, phosphate and potash. Greenhouse pot tests show a response to sulphur. They are low in calcium and reaction varies from medium acid to strongly acid.

Granite is the parent rock of the last group of soils that are formed from hard rocks. Soils derived from granite are mostly dark reddish-brown to dark brown in colour, and are the sandiest soils mapped in the area. The Magina soils are shallow, sandy and infertile. They are strongly to medium acid and are low in calcium, nitrogen, phosphorus and potassium.

The Misathe and Nyangu soils also are derived from granite like that under the Magina soils. These soils have been strongly leached and have grey surface soils. Their physical and chemical properties resemble the Magina soils. They have sandier horizons, and even in the clayey B horizons they still have two to three times as much sand as silt. Like the Magina soils they are low in calcium, nitrogen, phosphorus and potassium. The Magina soils have more of the friable 1 : 1 type clays than do the Misathe or Nyokal soils.

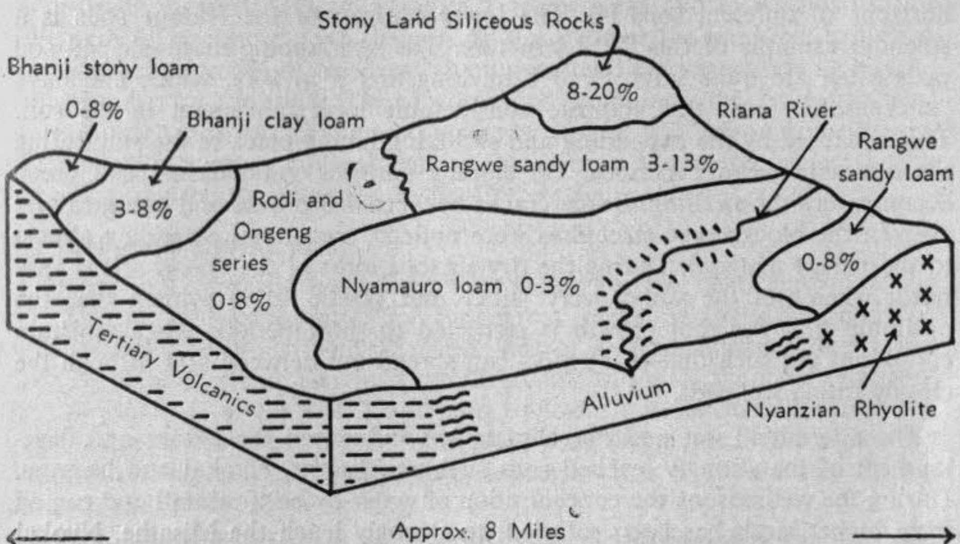


Fig. 2—Relationship of soils to parent material and relief east of Marinde.

The Climate

As stated earlier, the rainfall of the East Konyango survey area ranges from about 40 to over 50 in. a year. December, January and February are increasingly dry, April and May are wet. The soil dries out markedly from late December to early March. The year-round frost-free climate causes more rapid chemical weathering of rocks than would be the case in colder climates.

Water percolates through the soil during the rainy season, the rate depending on internal drainage of the soil type, but is largely exhausted by evaporation and transpiration about as fast as it falls during the rest of the year. In regions like this with soils alternately wet and dry and with only short periods in which water passes entirely through the soil, there is a tendency for soils of the so-called "black cotton" or Grumosol group to form. The Kibigori clay loam is an example. This soil was first identified, described and mapped in the Songhor survey [10]. The "black cotton" soils have the type of clays that shrink and swell with moisture changes. Deep cracks are formed in the dry season and the soil takes on a peculiar structure. The surface soil shrinks and slakes to a fine blocky structure, and the small blocks fall into deep cracks. During the wet season water runs into these cracks which are gradually closed by the swelling of the clay. The fine blocks of clay expand with wetting and exert great pressure which tends to stir or churn up the whole soil mass. Calcium carbonate concretions from the deep subsoil are thus mixed all through the soil and even appear on the surface of the Kibigori soils.

The uneven shrinking and swelling also brings about shear effects that produce lens- or lentil-shaped structure aggregates that were noted in many horizons of different soils [4]. The lower horizon of the Rarage soils is a splendid example of this lentil structure. The overlapping discus-shaped soil peds often are quite large (5 to 8 in. long and 3 to 5 in. wide), and have "slickenside" faces that indicate considerable local movement in the soil. This is caused by the expanding and shrinking taking place in the soil during the alternate wet-dry periods. On sloping surfaces gravitational soil creep accompanies the swelling. Large cracks between the prisms and columns and even in the blocky type structures were noticed, sometimes extending almost to the parent material. During the dry seasons most of the clayey soil is very hard; when wet the soil is very sticky and plastic. It is evident that the optimum time for root growth is restricted to short periods when moisture conditions are such that plant roots can spread out between and through the closely fitting soil peds.

The alternately wet and dry climate has influenced the nature and development of the strongly leached soils such as Misathe, Nyokal and Nyangu. During the wet seasons the concentration of water by both rainfall and run-off from higher lands has been sufficient to strongly leach the Misathe, Nyokal and Nyangu soils. They have light grey loamy A horizons and heavy clay B horizons. Clay films on surfaces of blocks and prisms in the B horizon suggest that the clay has been moved down from the A horizon. Chemical analyses show that sodium and calcium have been reduced and the soils have become acid in reaction. The Marinde soils occupy positions similar to the Nyamauro soils but have not been as severely leached. They still retain considerable exchangeable sodium and have all the characteristics typical of a Solonetz soil.

The Kuja, Marinde and Olungo soils have light grey layers of silty or loamy material over the clay column tops and a considerable accumulation of sodium in the B horizon. The fact that these soils have retained Solonetz characteristics while other soils found in similar position and climate have been leached of excessive sodium may possibly be explained by larger amounts of sodium in the original parent rocks, but this has not actually been studied in detail. Lime concretions are found at a depth of 6 to 7 ft. in the Marinde profile, though these are probably the result of precipitation from groundwater. The depth of leaching in the Marinde soils is represented more nearly by the accumulation of exchangeable sodium in the B horizons.

While little information is available on humidity, records at the cotton substation at nearby Homa Bay show that the relative humidity is in the high 90's. Such high humidity tends to lower the rate of evaporation and thus to increase the amount of water available for passing through the soils. Soils of the Rangwe, Magina, Bhanji and Kibubu series, with their subsoil horizons of laterite, while radically different from the dark-coloured soils, may still reflect the effects of the periodically wet and dry climate. Most of these soils occur in situations where temporary water tables fluctuate seasonally, as in the black soils, but where considerable water drains away to lower areas and to streams, instead of being lost by evapo-transpiration. Thus, silica dissolved from silicate minerals is gradually lost to lower areas and to streams instead of being held in contact with the soil. In this manner the insoluble low-silica clays and sesquioxides of iron and aluminium tend to accumulate as laterite or "groundwater laterite". The dry seasons encourage the oxidation and partial dehydration of the iron compounds. In the wet season some of the iron compounds are mobilized by the activities of anaerobic bacteria, only to be immobilized by oxidation in the dry season.

The Biological Environment

Plants and animals have important effects on the development of the soil. The mineral composition of the parent rocks, temperatures and the moisture available for growth of plants control to a considerable degree the kinds of plant that can survive. Organic matter is one of the chief contributions of plant life to the soil. Plants also translocate plant nutrients from the lower layers to the upper layers. Weathered rock fragments in themselves do not constitute soil unless organic matter is present. It is often said that organic matter is the life of the soil itself.

Both trees and grasses have contributed to the formation of the soils that we find in the East Konyango region. The past influence of trees has no doubt been more important than it would appear today. Luo tribal elders say that when their people moved into this area (90-100 years ago) there were considerably more trees than there was grass. Today the reverse is true, more grass than trees. Only along the Kuja River are remnants of forest-type vegetation found. We can only speculate as how much of the countryside was covered by forest before settlement. The virgin surface soil of the Kuja series (formed under forest) contains over 8 per cent organic matter, which is twice as high as soils we now find under grass cover. The Rodi and Ongeng soils have mainly grass-type vegetation and contain about 4 per cent organic matter in their topsoils. The difference in organic matter content may not only be evidence that the Kuja-type forest did not cover all of the countryside, but it also points out the influence of different types of vegetation on soil properties.

Another example of how vegetation can influence soils may be seen by contrasting chemical properties of forested and grassland soils. Kuja soils, densely covered with scrub forest, are, with the exception of the thin A1 horizon, very strongly acid. None of the soils found under present grassland or open savannah-type vegetation are as strongly acid as the Kuja series. The acidity of the Kuja soils probably is a direct result of the organic acids of various kinds created by the decay of forest debris.

Burrowing animals such as rodents and earthworms, while important in many places of some temperate zones, have played a minor role in local soil formation. Earthworm activities are especially important in soils of some regions but are unimportant in the East Konyango area. Instead, termites replace the activities of earthworms or rodents in mixing the soil, and they are the most important animals influencing the soil in the survey area. In their tunnelling activities termites move considerable quantities of soil from the lower soil horizons to the upper ones. They build mounds of many sizes and shapes on many different soil types. The exact reasons for the differences are not clearly understood, but they may be related to variations in moisture conditions of the soil as well as to differences between the termite species. The most conspicuous termite mounds noted in the area are on the Nyamauro soils. The mounds range from 4 to 6 ft. high and from 30 to 50 ft. in diameter. They are grey in colour and have a characteristic "clump-tree" vegetation growing on the mounds with grass between. The grey colour results from the leached grey A horizons of the Nyamauro soils that the termites have used as building material. The clump-type vegetation is mainly of *Euphorbia* sp. and *Carissa edulis* and probably results from the more favourable air-moisture relationships created by the termites in their mound-building activities. Termite mounds of different shapes and sizes are found on nearly all the different soils, and often the colour is an aid to the soil surveyor in his field work. Some mounds are built largely of subsoil material and others, like these on Nyamauro loam, are built of surface soil material. Termite mounds occupy an estimated 20 to 35 per cent of the total surface area of the Nyamauro soils.

Man's activities have also influenced the soils of this area. One of the most obvious changes is in the destruction of the original vegetation and the substitution of crop plants. Trees have been cut and the grasses and bushes have been repeatedly burned over. The repeated seasonal grassland firing as well as the practice of burning the topsoil in the *shambas* has destroyed much of the organic matter.

The Rangwe sandy loam is the most densely populated and intensively cultivated soil of the entire survey area. Most of it is found on the higher hills that command tactical defence positions. The advantageous defensive positions of these hill soils, combined with the fact that they are easily cultivated with hand tools, has led to an almost continuous occupancy by man for a long time. The Luo drove out the Kisii and occupied these hills about 100 years ago. Their land tenure system divided the individual holdings into long narrow strips up and down the slopes. This resulted in considerable sheet erosion and some gullying, although present signs of erosion do not indicate erosion of disastrous proportions. Recently established contour farming and continuous cultivation keeps the rills and small gullies filled in. The present profile of the Rangwe soils is only about 20 in. of usable soil material over hard laterite layers. The Rangwe soils are low in fertility. This is partly inherent in the soil and partly a result of man's past activities. Another of man's customs having a deleterious effect on the soil is excessive communal grazing, which greatly reduces the density of the grass cover and lowers the humus content of the soil. This is especially important on soils like the Rangwe sandy loam in which most of the available plant nutrients reside in the soil humus.

Much of the cultivation in the East Konyango area is on moderately to strongly sloping land. Tillage causes soils to creep gradually down hills, leaving soils of upper slopes thin and depleted of humus and plant nutrients. Contour terraces reduce such movement to a minimum.

The Nature of the Surface

The nature of the soil surface, particularly the degree and gradient of slopes, has important effects on the nature of the soil itself. Surface differences cause water to move away from higher areas to lower areas. If the lower areas do not have adequate outlets, water accumulates and stands for long periods before either draining slowly away or evaporating. Soils in these positions, like Mirogi clay, are wet for longer periods of time than soils on better drained positions like Rodi clay loam. The soils in these low areas exhibit definite characteristics associated with wetness. They are nearly always mottled in the lower horizons with various shades of grey, brown and yellow. Many of them are very grey or gleyed. The degree of mottling and amount of grey colour is dependent largely on the length of time the soil remains saturated each year. Because of poor air-water relationships, many of these soils are less responsive to cultivation for ordinary crops than those that are naturally better drained.

Where slopes are long, lateral movement of water from the upper part to the lower part tends to keep the soils in the lower slopes in a somewhat poorly drained condition similar to that of the flat and depressed lowlands. Consequently, soils on convex high ground are well drained and generally reddish in colour. They are subject to periodic leaching and the dissolved substances are removed into the deep groundwater or downslope to soils at lower levels. Soils downslope from the reddish ones become more yellowish or greyish in colour as they become wetter. They may also contain appreciable amounts of salt which has been dissolved from the higher lying soils and rocks and deposited in areas of seepage where it has been concentrated by transpiration and evaporation. Some of these moist and wet soils have horizons rich in iron concretions which can also be attributed to the lateral movement of dissolved iron compounds.

The Time Factor

It is well established that soils are changing constantly, both in physical properties and in chemical composition; but in most soils the changes are very slow except where interference by man has increased the rate of erosion or has caused either rapid increase or decrease in nutrients available for plants. If we ignore for the moment the effects of man's interference in the rate and direction of soil formation we may say something about the effects of time in soil development.

Soils are dynamic: they are receiving constantly new materials (organic matter, dust, nitrogen compounds, from the rainwater, and minerals from the weathering of rocks); and they are losing materials constantly through leaching and gradual erosion. Some kinds of materials are leached more readily than others; hence, some compounds are depleted, and others—those that are almost inert—tend to become more concentrated. Thus, in a more or less humid climate we may expect to find the old soils less fertile than the younger soils. Admittedly this is an oversimplified statement.

Probably the most nearly reliable way of estimating relative and absolute ages of soils is through a study of the distribution of the chief soil types in relation to the various geomorphic land units of the area under review. Geologists and geomorphologists who have studied the land forms of South Nyanza have recognized a sequence of erosion cycles and land surfaces. Dissected remnants of the latter made up the present complex surface of the land on which the soils occur.

Huddleston [3], after Shackleton [9], recognized the following stages in the development of the present land surface in the part of the Kisii District studied which lies also in the East Konyango soil survey area:—

(1) A gently undulating sub-Miocene peneplain was carved out of the pre-Cambrian rocks and was bounded on the east by hilly remnants of the Kisii Highlands peneplain of probable Cretaceous age. The sub-Miocene peneplain was completed many millions of years ago.

(2) The sub-Miocene peneplain was dissected by streams and, probably in Pliocene time, lava and tuffs from the Homa volcano, near the present shore of Lake Victoria, partly covered the eroded surface.

(3) Since the deposition of these volcanic rocks the land surface has been faulted in places and the whole region has been dissected to various depths by the rivers and their tributaries. Recent rejuvenation of the streams has caused them to deepen their valleys, and in many places they are running now over bedrock.

During the millions of years following the formation of the sub-Miocene peneplain, deep soils were formed on the nearly level surface, and the underlying rocks were weathered to many tens of feet deep. The deep soils and weathered rocks were dissected by streams and only the weathered rock and some resistant laterite horizons remained as evidence of the former deep soils. Possibly parts of the Magina laterite on the highest ridges (mostly east of the surveyed area) may have developed during this long period, and certainly some of the decayed pre-Cambrian rocks were weathered during Miocene and Pliocene time. However, most of the Rangwe sandy loam ("Groundwater Laterite") soil must have developed after dissection of the sub-Miocene peneplain, because most of this soil lies on hillsides flanking the valleys, while many of the higher hill crests, above the Rangwe sandy loam, are capped by little weathered bedrock. At most, we can say, that only the "roots" of some of the Miocene-aged soils have contributed to present-day soils.

The Pliocene volcanic rocks (basalts and tuffs) smoothed to some extent the surface of the land they covered; but they also, have been more or less dissected since they were deposited. Therefore, most of the soils developed on the Pliocene volcanic rocks are of post-Pliocene age. Most of the Kibubu gravelly loam with its well-developed laterite horizon lies on smooth, high, ridge tops on the Pliocene volcanic rocks. Hence, some of it may have begun to develop as early as late Pliocene time (possibly a million years ago). The Akijo clay loam, with its thin groundwater or "seep-laterite" horizon is developed from tuff below layers of basaltic rocks, on slopes that were cut into the volcanic deposits in Pleistocene time. The laterite in Akijo clay loam appears to be still in the process of formation, but it may have begun to form as early as middle Pleistocene time.

Thus, it seems that some of the laterite may be quite old, but most of it in the East Konyango area appears to be no more than a few tens of thousands of years old.

Soils on the stony ridge crests are mostly young and weakly developed, but small remnants of weathered rock remain as evidence of old deep soils long since destroyed by erosion.

The Grumusols range in age from late Pleistocene, as in the case of Kibigori clay loam, to possibly somewhat older in the Ongeng soils of the smooth uplands. We do not have satisfactory evidence for close geologic dating of the Grumusols. Kibigori clay loam is in a valley 1½ miles east of Imbo, where it is developed from clay and volcanic ash that partially filled the valley in late Pleistocene time. The area is now drained by Ogweo River.

The Langi loam, a Planosol, is on the smooth upland, overlying Pliocene volcanic rocks, and it might conceivably have begun to develop in early Pleistocene time. Similar Planosols, like Ndhiwa and Nyamauro loams, are on long, gentle, fan-like slopes adjacent to the rivers. These surfaces could be no older than middle Pleistocene. The soils have morphology that would place them in the category of strongly solodized Solonetz, but they are acid in reaction and rather low in exchangeable sodium, and for this reason were classed as Planosols.

We regret that time for field work was too limited to enable us to make a sufficiently detailed and careful study of the different land forms to permit a better estimation of the time factor involved in each of the soils. We must be content to state that few, if any, soils antedate the Pleistocene, and that a large share of the land surfaces achieved essentially their present form in the late Pleistocene (probably on the order of 15,000 to 40,000 years ago). Soils of a few narrow flood plains are actively accumulating now.

VII—CLASSIFICATION OF EAST KONYANGO SOILS

Differences in moisture régime engendered by gradient and shapes of slopes cause important morphological differences in soils. As mentioned earlier, where slopes are long, lateral movement of water from the top of the slope to the lower part tends to keep the soils in the lower areas in a somewhat poorly drained condition, similar to the flat and depressed lowlands. The Ndhiwa loam is a good example of this. It lies downslope from the highly permeable Rangwe sandy loam from which it receives extra water. The typical soil has a highly leached light grey surface horizon underlain by a heavy claypan subsoil. It has the morphology of the *Planosol* soils of the United States, but its mode of development is questionable. One of the hypotheses for its development relates to the effects of exposure to salts which have been dissolved from the higher-lying soils and rocks and carried downslope to areas of seepage where they were concentrated temporarily by evaporation and transpiration. Through the influence of the excess sodium, these salty soils were then converted to Solonetz and later to solodized-Solonetz soils. By continued leaching and gradual replacement of the sodium ions by hydrogen, these soils have reached their present state. They still retain most of the physical characteristics of typical solodized-Solonetz soils, but they have lost much of their sodium and are now medium to strongly acid throughout. Salt licks that persist on some of the lower slopes in a number of places throughout the area, an appreciable amount of salt in soils such as the Rarage series which occur along local drainageways, provide evidence that these soils may have gone through this process of salinization, alkalization and dealkalization or solodization. If these soils have gone through this process, they are then more closely related genetically to the Solod (Soloth) soils than to Planosols, since the Solod is the end product of solodization. The Solod is strongly acid throughout and most of the clay has been removed, with only the structure remaining as evidence of its former condition. Since these soils still retain their heavy claypan B horizons they are called Planosols in this report, because their morphology is like Planosols. In any case, strongly solodized Solonetz soils are much like Planosols in both physical and chemical properties.

At the line of contact between the Rangwe and Ndhiwa soils, are narrow bands of Groundwater Laterite soils. They occur characteristically in areas of fluctuating water tables or periodic seepage. They have leached light grey A2 horizons underlain by horizons which are high in concretionary oxides of iron. Since the scale of the base maps and the detail of the mapping did not allow the separation of these soils they were included in the areas of Ndhiwa loam.

There are a number of other soils in the survey area which occur on flat, smooth terraces having morphology similar to the Ndhiwa loam which may be classified as Planosols. They all have in common the light grey to grey leached A2 horizon expressed in varying degrees, over strongly columnar, clayey B horizons. They are all medium to strongly acid throughout. The Langi loam is typical of these soils. It occurs on relatively smooth plains of Tertiary volcanic rocks, in smooth, slightly depressed areas, associated with the Rodi and Ongeng soils of the slightly higher, somewhat better drained positions. The Misathe and Nyokal are other examples of soils having similar morphology but are developed from acid igneous rocks. Nyamauro soil, which is developing from a mixture of clayey alluvium and volcanic ash of stream terraces, is another example of a soil with similar characteristics but developing from a different parent material.

Soils in which sodium has surely played a major role in development are Kuja loam, Marinde clay loam and Olungo clay loam and Rarage loam. These are true Solonetz. They occur on nearly level stream terraces between higher gently undulating hills from which they receive not only runoff from rain but also a considerable amount of water that has seeped downslope through the higher-lying soils. As it seeps through these higher-lying soils the water carries with it whatever soluble salts may be present. The effect of the sodium ion on the clay fraction of the soil has largely been responsible for the characteristic morphology of the Solonetz. If the calcium content is relatively low and the sodium content high, the lumps of colloidal clay will defloculate or separate into individual particles and remain in suspension in the soil water. The suspended clay particles tend to migrate downward through the soil and collect at slightly lower levels, leaving the coarser textured material at the surface. With drying, the clayey horizon takes on a distinct prismatic or columnar structure. The columns or prisms tend to become rounded at the top and the frequent movement of water over them causes them to become highly leached, and a thin light grey to nearly white siliceous layer develops. These soils have this characteristic morphology. They have an A horizon 3 to 6 in. thick which overlies a strong coarse columnar or prismatic clay B horizon. The tops of the columns or prisms have a very thin sprinkling of light grey siliceous silt. This grey coating also carries down the cracks between the upper parts of the prisms. In the lower parts of the prisms the exchangeable sodium is more than 15 per cent of the total exchangeable bases.

Another extensive group of soils includes the Grumusols or "black cotton" soils. These soils are characterized by clay fractions with a high ratio of silica to alumina. They shrink or crack greatly when drying and expand correspondingly when they become wet. Laboratory data based on electrochemical charge distribution of the soil colloids show these soils to be dominantly of the 2 : 1 type lattice clays, which have a high base exchange capacity.

A number of soils in this area have the above characteristics and can be considered Grumusols. Konyango clay loam is a typical Grumusol. It is an imperfectly drained, moderately deep soil developed from volcanic tuff and basaltic (lava) rocks. It is acid in reaction and moderately fertile. The

Ongeng soils are intermediate in character between Grumusols and Planosols. They differ slightly from the Konyango series in that they are slightly deeper and are developed primarily from basaltic rocks. They are moderately to strongly acid and moderately fertile. Kibigori clay loam is still another example of the Grumusols. It is developed from clays interbedded with volcanic ash on nearly level stream terraces. Kibigori clay loam is probably the most typical of the Grumusols in that it is only slighlty acid to neutral in the surface and it has calcium carbonate concretions in the lower horizons. In this respect it resembles more closely the Grumusols developed from calcareous clays in East-Central Texas and Oklahoma, U.S.A. (Oakes and Thorp, 1951) [7].

From the above example, it is readily seen that the Grumusols in the East Konyango area have in common, parent materials that have a component of ferro-magnesium minerals. It is apparent that tuff, basaltic lava and ash, as well as alluvium derived from these materials, tend to weather into 2:1 type of clay material under the climatic conditions prevailing in this area. Soils having dominant 2:1 clays, however, are not confined to the Grumusols. Many of the Planosols also have similar subsoil morphology, even including lentil structure. But again, there is a reflection of parent rock, as some of the Planosols such as Misathe loam, developed from granitic parent material, exhibits mixed 2:1 and 1:1 clays, especially in the upper horizons. In some instances there seems to be more 2:1 clay in the B horizon which tapers off to a dominant low-silica 1:1 clay as the underlying granite parent rock is approached. We must point out, however, that ferro-magnesium rocks weather to mixed sesquioxides of iron and aluminium and 1:1 clays where climate is humid and the period of weathering is long enough.

Laboratory data in this and the Songhor survey have shown that granite and granitic gneiss tend ordinarily to weather to 1:1 clay. This may account for the dominance of 1:1 clay in the lower part of the profile of Misathe loam. The bulge or apparent accumulation of 2:1 clay in the B horizon may possibly be ascribed to the movement of soluble materials from higher to lower horizons in the soil where it recombines to form new secondary minerals as described by Russell [8]. Dissolved silica moves to lower horizons within the profile. In a soil such as Misathe loam, which has a seasonally fluctuating water table, the dissolved silica stays in contact with the soil for considerable periods of time. This dissolved silica, which may have moved down the profile by leaching and accumulated in the subsoil water through drainage from higher areas, may combine with 1:1 clay minerals to form 2:1 clay minerals. The 2:1 clay minerals appear to attain their maximum accumulation at a point in the profile where leaching and the fluctuating water table have been most effective. Although this explanation may be speculative, it appears to be a reasonable hypothesis.

Akijo clay loam and Bhanji clay loam and stony loam, which cover extensive areas, are soils having quite unusual characteristics. They exhibit many of the characteristics of the Grumusols, but also contain horizons of "laterite" ironstone. They are black in colour, slightly acid to neutral, and are dominated by 2:1 lattice clays. To a depth of 16 to 20 in. they have the physical and chemical characteristics of the typical Grumusol. Below this is a horizon containing concretionary oxides of iron, some of it indistinguishable from ordinary laterite. This concretionary horizon varies in thickness from as little as 2 to 6 in. in the Akijo soils to as much as 6 in. to 2 ft. in the Bhanji soils. The presence of laterite ironstone in these soils appears to be closely connected with the effects of a seasonally fluctuating water table. The Bhanji soils occur on smooth, low ridges of basaltic (lava) rocks in the north-western part of the survey area. They are shallow (from 20 to 40 in.) over basalt bedrock. Because of their shallowness, the nature of their clay, and occurrence on relatively smooth slopes, it is not unreasonable to expect that at certain times of the year these soils are under the influence of a temporary high water table. The Akijo clay loam occurs on gently sloping to sloping areas where volcanic tuff outcrops below the basaltic lavas. In spite of the considerable slope characteristic of most of the Akijo soils, the soil is subject to periodic waterlogging. Water seeps downslope from higher-lying soils causing the entire profile to become saturated for considerable lengths of time during the rainy season.

A larger group of soils in this area which owe their characteristics to impeded drainage are what have been called, in the United States in recent years, the Low-Humic Glei soils (Thorp and Smith, 1949) [11]. A number of soils in this area appear to fit fairly well into this great group. These soils have a number of things in common, probably the most characteristic being the grey and mottled colours which appear in the lower horizons. The degree of mottling and proportion of grey colour depends on how long the soil has remained saturated each year. Although these soils are developed from different parent materials, they all occupy positions in the landscape where water stands for long periods, or where seepage waters from higher areas are concentrated. Many of them occupy low areas or swale positions where they receive maximum surface runoff. Water stands on the surface for relatively long periods following rain. Some of them, such as Okok clay loam and Oboke clay loam (*see* Appendix) occupy alluvial fan positions where seepage from higher-lying soils is at a maximum. Probably the best example of the Low Humic Glei soils is Mirogi clay. It is developed from fine-textured sediments interlayered with volcanic ash. These clayey sediments and ash have accumulated as small valley fills along the tributaries to the major drainage systems. They have very dark grey to black clay surface soils which are underlain by strongly mottled clay having lentil structure. The colloid fraction is predominantly of the 2:1 type.

Kibugo loam, developed from basaltic (lava) rocks and volcanic tuff is also a Low Humic Glei soil. It occurs on low swale positions in association with the Rodi and Ongeng soils on the large basalt plain in the northern part of the survey area. Besides exhibiting mottles and being gleyed, the Kibugo soils often have iron-oxide and manganese concretions in the lower horizons. Here also, the colloid fraction is dominated by the 2:1 type.

Oboke clay loam and Okok clay loam, as previously mentioned, are other examples of the Low Humic Glei soils. Oboke clay loam occurs on gently sloping fans where the parent material is derived from a mixture of weathered rhyolite and volcanic ash. It occurs downslope from the Rangwe soils and receives considerable seepage from these higher lying soils during the rainy season. Okok clay loam occurs on footslopes below outcrops of basaltic materials and is developed from basaltic lava and volcanic tuff. It is strongly mottled and has many iron-oxide concretions. It differs in several respects from the typical Low Humic Glei soil. First of all, it is dominated by red hues which ordinarily is an indication of better drainage. Secondly, the clay fraction of this soil is dominated by the 1 : 1 type which is in strong contrast to the other Low Humic Glei soils of the East Konyango area. However, in the actual mapping of this soil it was readily seen that the drainage characteristics were so complex and difficult to identify that it was impossible to separate the wetter areas from the drier ones on a map of the scale of the East Konyango survey. The profile of Okok clay loam described in the Appendix is typical only of the drier part of this soil. The wetter parts are less red and are much more gleyed in the lower horizons.

Rangwe sandy loam profile.

Mention has been made earlier of the occurrence of large areas of land with laterite horizons in the soil. These soils occur on ferro-magnesium rocks as well as on granites and rhyolites. Rangwe sandy loam, with its strongly developed laterite horizon, is the most extensive of these soils. It is developed from rhyolite. It occurs on gently undulating to sloping areas in the eastern part of the survey area. Magina loamy coarse sand, developed from granite is much less extensive but also exhibits well pronounced laterite ironstone horizons. Kibubu gravelly sandy loam, with similar characteristics, is derived from basaltic (lava) rocks. As previously explained, the laterite ironstone horizons are products of weathering, probably under the influence of a seasonally fluctuating water table.

The clay fraction of these soils is mixed 2:1 and 1:1 lattice clays with 1:1 generally dominating. The laterite horizons are dominated by sesquioxides but do contain surprisingly large amounts of 2:1 lattice clay, the amount of 2:1 colloid depending largely on the nature of the parent rock. As mentioned earlier, materials derived from ferro-magnesium rocks in this area tend to weather into 2:1 clay, while those derived from siliceous rocks such as granite go more into 1:1 clay. Rangwe sandy loam and Magina loamy coarse sand are dominantly mixed sesquioxide, and 1:1 clay with only small amounts of 2:1. Kibubu gravelly sandy loam, on the other hand, exhibits mixed 2:1 and 1:1 colloids. The sesquioxides dominate and generally there is a marked increase in the amount of 2:1 clay as the weathered basaltic rock is approached. In some instances all that remains is 2:1 and sesquioxides.

In the preceding discussion we have attempted to explain in part the mode and origin of development of the soils of the East Konyango area. For detailed descriptions and chemical data of the various soils the reader is referred to the Appendix.

The American Soil Survey is, at the present time, undertaking a complete revision of the Soil Classification Scheme. To date, August, 1959, this scheme has not been approved for general use. Consequently, in Table VII we have classified the soils of the East Konyango area into Great Soil Groups based on the 1938 system of classification of the American Soil Survey [1] and on the more recent revisions of this system. This system has undergone changes from time to time, probably the most recent large scale change occurring in 1949 [11]. We fully realize the inadequacies of this system, especially when applied to equatorial regions. However, we feel that this survey has helped to point out some of those inadequacies and offers further proof of the need for a more thorough, comprehensive, soil classification scheme. Nevertheless, the soils of the East Konyango area do have much in common with the great soil groups mentioned.

Soils classed as belonging to the Groundwater Laterite group probably developed under periodic high water table. Most of them are now at least moderately well drained and the laterite horizon is largely relict. Upper horizons in these soils bear little resemblance to Marbut and Manifold's Groundwater laterite soil of the Amazon Basin. These horizons are composed largely of material that has been worked over by termites.

In Table VI the soils of East Konyango are classified tentatively by great soil groups; and the parent material, relief and drainage are given for each series. The effects of the remaining two factors of soil formation, vegetation and climate are not discussed because they are relatively uniform throughout the area and do not account for broad differences among soils.

TABLE VII—CLASSIFICATION OF THE SOILS IN THE EAST KONYANGO AREA

Series	Great Soil Group	Parent Material	Relief	Drainage
Akijo	Shallow Grumusol*, intergrading to Groundwater Laterite soil.	Volcanic tuffs.	Nearly level to moderately steep hillsides.	Medium to rapid externally; slow to medium internally.
Bhanji	Grumusol*, intergrading to Groundwater Laterite soil.	Dark fine-grained basaltic (lava) rocks.	Nearly level to gently sloping upland plains.	Slow to medium externally; slow to medium internally.
Kibigori	Grumusol.	Fine textured alluvium and volcanic ash.	Nearly level terraces.	Slow externally; slow to medium internally.
Kibubu	Groundwater Laterite† soil.	Dark fine-grained basaltic (lava) rocks.	Nearly level to sloping uplands.	Medium to rapid externally; rapid internally.
Kibugo	Low Humic Glei.	Basaltic lavas and tuffs with minor areas of Kavirondian conglomerates.	Nearly level to gently sloping upland plains.	Medium to rapid externally; slow to medium internally.
Konyango	Grumusol.	Tuffs with minor areas of basaltic lava.	Nearly level to gently sloping upland plains and ridges.	Slow to medium externally; slow to medium internally.
Kuja	Solonetz.	Fine textured alluvium and volcanic ash.	Nearly level stream terraces.	Slow externally; medium internally.
Langi	Planosol.	Basaltic lavas with minor areas of tuffs.	Nearly level to gently sloping concave upland plains.	Slow to medium externally; slow internally.
Magina	Groundwater Laterite† soil.	Granite.	Nearly level to sloping uplands.	Rapid externally; rapid internally.
Marinde	Solonetz.	Fine textured alluvium.	Nearly level high stream terraces.	Slow externally; slow internally—subject to run-off from above.
Mirogi	Low Humic Glei.	Fine textured alluvium and volcanic ash.	Nearly level high stream terraces and small valley fills.	Slow externally; slow internally—seasonally fluctuating water table.
Misathe	Planosol.	Granite.	Nearly level to gently sloping upland plains.	Slow to medium externally; slow internally—seasonally fluctuating water table.
Ndhiwa	Planosol.	Fine textured alluvium derived from rhyolite.	Gently sloping fans and fan terraces.	Medium externally; slow internally—seasonally fluctuating water table, and subject to seepage.
Nyamauro	Planosol.	Fine textured alluvium and volcanic ash.	Nearly level to gently sloping high stream terraces and fans.	Slow to medium externally; slow internally—seasonally fluctuating water table.
Nyangu	Planosol.	Granite.	Nearly level to gently sloping uplands.	Medium externally; slow internally—seasonally fluctuating water table.
Nyokal	Planosol.	Rhyolite.	Nearly level to gently sloping upland plains.	Medium externally; slow internally—seasonally fluctuating water table.
Obiero	Not placed.	Volcanic ash.	Gently undulating uplands.	Rapid externally; slow to medium internally.

TABLE VII—CLASSIFICATION OF THE SOILS IN THE EAST KONYANGO AREA—(*Contd.*)

Series	Great Soil Group	Parent Material	Relief	Drainage
Oboke	Low Humic Glei.	Fine textured alluvium derived from rhyolite and volcanic ash.	Gently sloping fans and fan terraces.	Rapid externally; medium internally—seasonally fluctuating water table.
Okok	Low Humic Glei (?).	Tuffs with minor areas of basaltic lavas.	Gently sloping to sloping upland footslopes and fans.	Medium to rapid externally; slow to medium internally—seasonally high water table from seepage.
Olungo	Solonetz.	Fine textured alluvium and volcanic ash.	Nearly level stream terraces.	Medium externally; slow internally—seasonally high water table.
Ongeng	Grumusol, intergrading to Planosol.	Basaltic lavas with minor areas of tuffs.	Nearly level to gently sloping upland plains.	Slow to medium externally; slow to medium internally.
Rangwe	Groundwater Laterite† soil.	Rhyolite.	Nearly level to sloping uplands.	Medium to rapid externally; medium to rapid internally.
Rarage	Solonetz.	Fine textured alluvium and volcanic ash.	Nearly level high stream terraces and valley fills.	Slow to medium externally; slow internally.
Rodi	Grumusol, intergrading to Planosol.	Basaltic lavas with minor areas of tuffs.	Nearly level to gently sloping uplands.	Slow to medium externally; slow to medium internally.

*Grumusol with laterite ironstone horizon.

†Relict Groundwater Laterite soils.

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LEGEND FOR SOIL MAP OF THE EAST KONYANGO SURVEY AREA—SOUTH NYANZA

Correlated Name	Symbol on Map
Akijo clay loam, 0 to 3 per cent slopes	Acl–A
Akijo clay loam, 3 to 8 per cent slopes	Acl–B
Akijo clay loam, 8 to 13 per cent slopes	Acl–C
Akijo clay loam, mod. eroded 8 to 13 per cent slopes	Acl–C–2
Akijo clay loam, 13 to 20 per cent slopes	Acl–D
Alluvial soils, undifferentiated	A
Bhanji clay loam, 0 to 3 per cent slopes	Bcl–A
Bhanji clay loam, 3 to 8 per cent slopes	Bcl–B
Bhanji stony loam, 0 to 8 per cent slopes	Bst–AB
Bhanji stony loam, 8 to 13 per cent slopes	Bst–BC
Eroded Salt Licks and Volcanic Ash	ES
Kibigori clay loam, 0 to 3 per cent slopes	Kbc–A
Kibubu gravelly sandy loam, 0 to 8 per cent slopes	Kgl–AB
Kibubu gravelly sandy loam, 8 to 13 per cent slopes	Kgl–C
Kibubu stony loam, 0 to 8 per cent slopes	Kst–AB
Kibugo clay loam, 0 to 3 per cent slopes	Kil–A
Kibugo clay loam, 3 to 8 per cent slopes	Kil–B
Konyango clay loam, 0 to 3 per cent slopes	Kcl–A
Konyango clay loam, 3 to 8 per cent slopes	Kcl–B
Kuja loam, 0 to 3 per cent slopes	Kul–A
Langi loam, 0 to 3 per cent slopes	Ll–A
Langi loam, 3 to 8 per cent slopes	Ll–B
Magina loamy coarse sand, 0 to 8 per cent slopes	Mls–AB
Magina loamy coarse sand, 8 to 13 per cent slopes	Mls–BC
Marinde clay loam, 0 to 3 per cent slopes	Mcl–A
Mirogi clay, 0 to 3 per cent slopes	Mrc–A
Misathe sandy loam, 0 to 3 per cent slopes	Mil–A
Misathe sandy loam, 3 to 8 per cent slopes	Mil–B
Ndhiwa loam, 3 to 8 per cent slopes	Ndl–B
Nyamauro loam, 0 to 3 per cent slopes	Nyl–A
Nyamauro loam, 3 to 8 per cent slopes	Nyl–B
Nyangu stony sandy loam, 0 to 8 per cent slopes	Nst–AB
Nyangu-Magina complex, 3 to 13 per cent slopes	Mx–BC
Nyokal sandy loam, 0 to 3 per cent slopes	Ncl–A
Nyokal sandy loam, 3 to 8 per cent slopes	Ncl–B
Obiero sandy clay loam, 3 to 8 per cent slopes	Orl–B
Oboke sandy clay loam, 3 to 8 per cent slopes	Ocl–B
Okok clay loam, 3 to 8 per cent slopes	Ok–B
Okok clay loam, 8 to 13 per cent slopes	Ok–C
Olungo clay loam, 0 to 3 per cent slopes	Ol–A
Ongeng clay loam, 0 to 3 per cent slopes	Onc–A
Ongeng clay loam, 3 to 8 per cent slopes	Onc–B
Ongeng loam, 0 to 3 per cent slopes	Onl–A
Ongeng loam, 3 to 8 per cent slopes	Onl–B
Ongeng sandy loam, 0 to 3 per cent slopes	Ons–A
Permanent Swamps	PS
Rangwe clay loam, colluvial variant 3 to 8 per cent slopes	Rac–B
Rangwe sandy loam, 0 to 3 per cent slopes	Ral–A
Rangwe sandy loam, 3 to 13 per cent slopes	Ral–BC
Rarage loam, mod. saline, 0 to 3 per cent slopes	Rgl–A
Rodi clay loam, 0 to 3 per cent slopes	Rcl–A
Rodi clay loam, 3 to 8 per cent slopes	Rcl–B
Stony land (Basaltic rocks), 8 to 20 per cent slopes	Sb–CD
Stony land (Basaltic rocks), greater than 20 per cent slopes	Sb–E
Stony land (Kavirondian conglomerates), 0 to 13 per cent slopes	Sml–AC
Stony land (Kibubu soil materials), 8 to 20 per cent slopes	Stk–CD
Stony land (Siliceous rocks), 0 to 8 per cent slopes	Ss–AB
Stony land (Siliceous rocks), 8 to 20 per cent slopes	Ss–CD

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VIII—APPENDIX

In the following pages we present detailed technical descriptions and chemical and physical data of most of the important soils of the East Konyango Survey Area, designed primarily for the use of soil scientists interested in soils of tropical highlands. For the benefit of those who are not soil scientists but who wish to go into the details of the soils of this region we append a few notes regarding terminology. The soils are described in terms of texture, structure, consistence and colour.

The term "soil texture", as used by soil scientists, has to do exclusively with the proportions of different particle sizes in the soil mass under consideration, and a separate texture designation is given for each layer or horizon of soil in which there are significantly different proportions of these particle sizes. The major particle sizes recognized are called gravel, sand, silt and clay. Without going into the minor details already familiar to soil scientists, we say simply that gravel consists of small stone fragments 2 mm. to 75 mm. in diameter. Sand covers the range from just less than 2 mm. to about .02 mm. When making fine distinctions the sand fraction is classed as very coarse, coarse, medium, fine and very fine, according to systems that differ slightly in different countries and which we do not need to discuss here. Silt is a mineral material of about the consistence of flour, with particle sizes ranging from less than .02 mm. to more than .002 mm. Any minerals or particle sizes less than .002 mm. are classified by soil scientists as "clay", regardless of their composition, although in the strict sense only certain silicates should be considered as true "clay minerals". "Clay", as used here, then, includes the true silicate clay minerals as well as various crystalline and amorphous silicates and sesquioxide hydrates. This is a technical detail we do not need to discuss here, except to say that even very finely divided more or less hydrated iron oxide is grouped with the clay fraction when mechanical analyses of soil are made, even though iron oxide, strictly speaking, is not a true clay mineral.

In establishing texture classes, different ranges of proportions of the different particle sizes are grouped into texture classes which carry such names as sand, loamy sand, sandy loam, loam, silt loam, clay loam, clay, etc. For instance, the term "loam" applies to well-balanced mixtures of sand, silt and clay particles. Most loam soils are rather easily tilled. Clay loams have more clay than either loams or silt loams. Silt loam has more silt than loams; it has the same amount of clay as loam, but less sand. "Clay" as a texture term differs from "clay" as a particle-size term. Soil of "clay texture" may carry as little as 40 per cent of clay-sized particles. This is because of the great effect the clay-sized particles have on the cultivation of soil.

The mineral particles of practically all soils are grouped or bunched together into larger particles of various sizes and shapes and of varying degrees of firmness. This grouping of mineral and organic particles in the soil is described as "soil structure". The individual clumps of soil minerals are known as aggregates or, more briefly, as "peds", and they are given names according to shapes and sizes. Again, without attempting to list all of the different structure peds we can mention the names of the major classes which give some idea of shapes and sizes. The terms are taken from the *Soil Survey Manual* of the United States Department of Agriculture, Handbook No. 18 (1951).

The chief structure adjectives are the following: —

Platy—in which peds are thin, flat flakes or plates, usually orientated in a horizontal position.

Prismatic—in which peds are roughly prism-shaped and orientated vertically in the soil with sizes ranging from about 10 mm. to more than 100 mm. in diameter. Where the prisms are round-topped they are classified as "columnar" and have the same size ranges as typical prismatic peds.

Blocky—the mineral particles of some soil horizons are clumped in more or less angular blocks, some of which are cuboidal in shape and some of which are irregular. These blocky peds range in size from less than 5 mm. to more than 50 mm. Some blocky peds are sharp-angled on one or more edges and rounded on others, and are called "subangular blocky" or "nuciform" (nut-shaped) peds. They have the same size range as the more angular blocky peds. Lentil or lenticular structure comprises roughly lens-shaped blocks with sharp edges and in sizes ranging from 5 mm. to at least 300 mm. across.

Granular—peds are those which are roundish in shape throughout and are firm in consistence and range from less than 1 mm. to more than 10 mm. in size. For agricultural purposes granular structure usually is ideal.

Crumb structure—peds are of the same shapes and sizes as granular peds, but they are more porous and are easily crushed and destroyed.

Massive—the soil behaves as a coherent mass without separate peds.

Single-grain—the individual soil particles are separate from each other and the soil is loose and incoherent, without peds.

Most of these terms appear in the following descriptions.

Consistence terms have to do with the response of the soil to pressure in the fingers. Soil consistence is extremely important to the farmer because, in combination with texture and structure, it determines the ease or difficulty of tilling the soil. Such terms as brittle, crumbly dense, fluffy, mealy, mellow and so on are plain English terms and easily understood. Consistence also covers the degree of stickiness, plasticity and hardness of the soil, especially under different moisture conditions.

Soil colours in themselves mean relatively little, but they are often correlated with other soil properties which are extremely important to the agriculturist. Furthermore, colour is the first thing noted about the soil by most people. Experience has shown, however, that no two people will give exactly the same name to the colour of a soil, or of anything else for that matter, unless there is some sort of standard on which to base the colour name. The Munsell Colour Company, an endowed non-profit organization in Baltimore, Maryland, U.S.A., has issued a set of soil-colour charts, with standardized names, for the use of soil scientists. In the following soil descriptions standard colour names, along with an accurate measure of the colour of each soil horizon, are given. The colour charts consist of a series of sheets, each of which contains from 20 to 30 blocks or "chips" of standardized colours of a given hue or dominant wavelength of light. Each of the hues is modified systematically from chip to chip to give dark and light colours and greyish to strong colours, all of the same wavelength. Those who have the colour charts are already familiar with the abbreviations. Those who do not have colour charts can gain a good idea of the soil colour from the plain English names. Soil colours are nearly always described both in the dry and moist state, because they are nearly always different. However, the hue or wavelength reflected by the soil almost always remains constant in the moist and dry soil and the difference in colour is usually one of degree of darkness or lightness. The lighter colours are characteristic of the dry soils and the darker colours are characteristic of moist soils. Where chromas are strong or high the difference between wet and dry soils is likely to be small, unless the soil contains considerable amounts of organic matter. Greyish soils are likely to change from one to three steps in darkness from the dry to wet state. It will be noted in the descriptions that the same colour name may cover two or three adjacent chips on the colour chart. There are too many colour variations for each to have a separate name.

The soil descriptions were made from pits dug in representative areas of each type of soil studied. In most instances pits were dug to a depth of 5 ft. and then a 4-in. auger hole was dug at the base of the pit to varying depths according to the type of soil. Samples were selected from each recognizably different horizon in the soil profile and were submitted to the laboratory for analysis. The analyses made were for particle size—composition (texture) of the soil, pH, and for the "surface chemistry", which has to do with the more or less active elements in the soil. No attempt was made to make complete analyses of the whole soils, and for this reason we can give no figures for total phosphorus, alumina, iron, etc., in the soils.

The soil samples were air dried and ground to pass a 2 mm. sieve. The particles held on the 2 mm. sieve were recorded as "per cent gravel". For the determination of organic carbon and total nitrogen, a sub-sample was taken and ground to pass a 40-mesh sieve. The Kjeldahl method was used for total nitrogen and the Walkley-Black method was used for total organic carbon. The 2 mm. ground soil was used for the physical analyses employing the hydrometer method. The soil pH was determined in a 1 : 1 soil : water ratio, measured after periodic stirring for one hour and using a glass electrode.

Phosphorus, calcium, magnesium, potassium, sodium and manganese were determined on a 1 : 5 soil : (.1N H Cl − .025N H_2SO_4) extractant without repeated leaching. Exchangeable sodium following the U.S.D.A., Agriculture Handbook No. 60 procedure was also determined on representative sets of samples including, where possible, those whose sodium content by the routine extraction procedure was found to exceed 2 me/100 ml or those soils having morphological indications of solonetz conditions. Much higher sodium recoveries were obtained by the Handbook No. 60 procedure than by the routine single dilute acid extraction procedure from soils whose available sodium contents were high. On such soils the ammonium acetate extraction indications of the Agriculture Handbook No. 60 method accorded much more satisfactorily with field morphology interpretation than the routine procedure.

The exchangeable aluminium, hydrogen and cation exchange capacity (CEC), were determined by barium chloride triethanolamine buffered at pH 8.1-8.2. The anion exchange capacity (AEC) was measured from the phosphorus retained by soil after phosphating and establishing equilibrium at its pHe value. The CEC was also determined on the phosphated soil used for the AEC determination, its value being designated the maximum cation exchange capacity (CECm). On a separate sample, pretreated with Hcl the quantity of barium absorbed from barium chloride was taken as a measure of permanent charge (CECp). This value was expressed as a percentage of CEC, viz. (CECp/CEC).100 and then rounding out to the nearest unit of ten. This value is recorded in the tables by the first figure in the "charge distribution" columns.

The other three sets of figures in the "charge distribution" columns denote the percentages rounded out to the nearest unit of ten, of net negative, combined or countered negative and positive and net positive charge. The principal use of such data is to obtain an indication of the colloidal constitution of soils as given in detail by Mehlich *et al.* (Mass analysis methods for soil fertility evaluation; Kenya Department of Agriculture, 1959.)

These values are calculated from exchange data as follows: —

(1) CECm − CEC = me% net positive charges; these are mainly attributed to sesquioxide-hydrates.

(2) (AEC − me% net positive charges) × 2 = me% combined or countered charges; these are mainly attributed to 1 : 1 lattice material.

(3) CEC − (AEC − net positive charges) = me% net negative charges; these are mainly attributed to 2 : 1 lattice material and organic matter.

For presentation of the charge distribution data, the sum of items (1), (2) and (3) (which in fact is identical with the combined cation and anion exchange capacities) was divided into the content of each respective charge and the results expressed as percentages. The percentages thus found were rounded to the nearest unit of ten and recorded in a conventional manner; viz. permanent charge - net negative : combined or countered : net positive.

In illustration, the figures 4-7 : 1 : 2 indicate that approximately 40 per cent of the cation exchange capacity is attributable to permanent charge, and of the combined cation and anion exchange capacities 70 per cent is associated with net negative charges, 10 per cent with combined or countered positive and negative charges and 20 per cent with net positive charges. The 70 per cent associated with net negative charges stem from montmorin, hydrous mica, vermiculite, other three-layer minerals and from organic matter. The 10 per cent associated with countered charges stem from kaolinite, haloysite and amorphous materials of the allophane type. The 20 per cent associated with net positive charges stem from gibbsite, hematite, goethite and reactive amorphous sesquioxide hydrates. Specific identification of the individual colloid constituents contributing to each charge class and actual quantitative estimation of colloidal constituents of the soil are not possible under this scheme. The analytical data for each type is tabulated in the appendix either in the body of or as near the description of the series to which they belong as printing requirements permit.

Further information on some of the soils described in the appendix can be found in the soil descriptions and an appraisal of the nutrient status of their surface soils can be found in the fertility evaluation discussion in the main body of the report. These should be sought there.

SOIL SERIES, DESCRIPTIONS AND ANALYTICAL TABLES

Akijo Series

The Akijo series consists of moderately well drained dark coloured soils with thin laterite horizons, developed from tuff. They occur on gently sloping to sloping hillside areas under open grass-type vegetation. Akijo soils are shallow Grumusols—Ground-Water Laterite intergrades.

Akijo soils have black clayey surface horizons underlain by well developed dark coloured B horizons which grade into thin reddish-brown (black inside) laterite concretionary layers and then pass abruptly into weathered tuff.

The Akijo soils are similar to the Bhanji soils but differ from them in having greyer C horizons. The laterite horizons are also thinner and less well developed in the Akijo soils. The Rodi soils are associated with the Akijo soils but are formed from basalts and lack the grey C horizon and the laterite horizons.

The Akijo soils occur at elevations of 4,400 to 4,500 ft. in a climate having a mean annual precipitation of 45 to 50 in. with marked wet and dry seasons. They are mapped near Mirogi and Okok.

Soil Profile: Akijo Clay Loam

Lab. No. 3994/1958: A1: 0 to 5 in.

Very dark grey (7.5YR 3/1) clay loam; black (7.5YR 2/1) when moist; strong, fine, subangular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; abundant fine and medium roots; approximately 10 per cent fine brown "buckshot"; slightly acid (pH 6.1); abrupt smooth boundary. 4 to 7 in. thick.

Lab. No. 3995/1958: B21: 5 to 18 in.

Very dark grey (7.5YR 3/1) clay loam; black (7.5YR 2/1) when moist; strong, medium, angular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; abundant fine and medium roots; approximately 5 per cent fine brown "buckshot" concretions; medium acid (pH 5.9); abrupt wavy boundary. 12 to 14 in. thick.

Lab. No. 3996/1958: B2ir: 18 to 24 in.

Grey (10YR 5/1) gravelly (concretions) clay loam, dark grey (10YR 4/1) when moist; weak, medium, angular, blocky structure; 20 per cent dark brown (7.5YR 4/4) and 10 per cent very dark grey (7.5YR 3/1) mottles; consistence as in horizon above; plentiful medium roots; approximately 40 per cent reddish-brown concretions; slightly acid (pH 6.1); abrupt wavy boundary. 5 to 7 in. thick.

Lab. No. 3997/1958: C: 24 to 30 in.

Strongly weathered tuff of sandy loam texture which has very dark grey (7.5YR 3/1) clay skins on fractured surfaces; has a few medium roots; neutral (pH 7.1).

Range in Characteristics.—Chief variations are in the depth to the underlying tuff and the amount of concretionary material in the horizon above the tuff. The depth to the tuff ranges from 20 to 40 in. The concretionary horizon (B2ir) varies in thickness from 2 to 6 in., and it is not uncommon to find this horizon completely missing from the profile.

Relief.—Gently sloping to sloping uplands with slope gradients from about 4 to about 8 per cent.

Drainage.—Moderately well drained, medium run-off dry seasons and rapid in wet seasons; internal drainage is slow to medium depending upon the time of year.

Vegetation.—Mainly grass, *Pennisetum catabasis* dominant species.

Use.—Most of the Akijo soils are used for pasture, but small areas are planted to maize and sorghum.

Distribution.—Mapped in the Mirogi and Okok areas of the East Konyango region, South Nyanza Province.

Type Location.—Along the road to the Okok chief's camp, approximately quarter of a mile south of the experimental sugar-cane plots. Map grid reference GZU 136257.

Series Established.—March, 1959.

Source of Name.—Akijo stream.

BHANJI SERIES

The Bhanji series includes shallow Grumusolic soils with laterite horizons developed on smooth, gently sloping, low ridges of basaltic (lava) rocks. They occur on nearly level to gently sloping areas at elevations of from 4,000 to 4,500 ft. The series was first described and the type profile was set up near Songhor (Thorp, J., *et al.*, Soil Survey of the Songhor Area, 1960, Government Printer, Nairobi).

The Bhanji soils closely resemble the Akijo soils. They have nearly black clayey surface soils which are underlain by a very dark brown to black clayey B horizon. This clayey B horizon merges with a thin layer of concretionary ironstone or murram. Basaltic bedrock occurs at depths of from 20 to 40 in. The Akijo soils differ from Bhanji soils in that they exhibit greyer subsoil horizons, have less well pronounced laterite horizons and are developed from tuff.

The Bhanji soils occur on slightly higher ridges in association with the Rodi and Akijo soils.

Soil Profile: *Bhanji Clay Loam*

A: 0 to 6 in.

Very dark grey (10YR 3/1) clay loam, black (10YR 2/1) when moist; strong medium subangular blocky structure; slightly hard, dry; friable, moist; slightly sticky and slightly plastic, wet; abundant roots; clear smooth boundary.

B2: 6 to 24 in.

Black (10YR 2/1.5 dry and moist); strong to medium angular blocky structure breaking to strong fine angular blocks; hard, dry; firm, moist; sticky and plastic, wet; thick continuous clay skins on all ped faces; plentiful roots; clear boundary.

B2ir: 24 to 33 in.

Dark greyish-brown (10YR 4/2) gravelly clay loam, very dark greyish-brown (10YR 3/2) when moist; approximately 30 per cent red-black iron-oxide concretions; gradual boundary.

C: 33 to 36 in. +

Concretionary oxides of iron and perhaps manganese with approximately 20 per cent by volume of fine earth which fills the interstices.

Range in Characteristics.—Chief variations are in the depth to the underlying basalt and the thickness of the concretionary horizon. The depth to the basalt usually ranges from 20 to 40 in. The concretionary horizon (B2ir) varies in thickness from 2 in. to several feet. Texture of the surface soil varies from clay loam to loam.

Relief.—Nearly level to gently sloping uplands with slope gradients from about 2 to 8 per cent.

Drainage.—Medium to slow run-off; slow internal drainage.

Vegetation.—Grassland vegetation; *Pennisetum catabasis* dominant species.

Use.—Most of the Bhanji soils are used for pasture, but small areas planted to maize and sorghum were observed.

Distribution.—Mapped in small scattered areas in the north-western part of the East Konyango area, and near Muhoroni and Songhor, Central Nyanza.

Location of Profile Described Here.—Approximately quarter of a mile north-west of Rodi in northern part of the East Konyango survey area. Map grid reference GZU 226313.

Type Location.—Approximately 250 ft. south of the Bhanji Store, Songhor. Map grid reference HZN 365914.

Series Established.—September, 1958.

Source of Name.—Bhanji Estate, Songhor.

TABLE VIII (*a*)

Akijo clay loam — *Map Ref.* GZU 136257 — *Lab. No.* 3994 to 3997/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–5	2·26	0·17	73	16·8	6·2	1·0	0·5	6·1	73	46·4	34·1	6–6:0:4	38	24	38
B_{21} ..	5–18	2·26	0·16	25	17·6	7·0	0·9	0·4	5·9	69	39·2	39·5	7–5:0:5	38	20	42
B_2ir ..	18–24	0·68	0·08	23	12·8	6·0	0·7	0·4	6·1	76	36·0	43·4	8–5:0:5	32	16	52
C ..	24–30	—	—	315	20·8	7·0	0·5	0·7	7·1	91	38·4	35·4	7–5:0:5	8	16	76

Kibigori clay loam — *Map Ref.* GZU 251310 — *Lab. No.* 3961 to 3965/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–5	2·60	0·18	11	11·8	4·1	0·9	1·2	6·1	75	30·4	15·9	5–6:2:2	10	32	58
B_2 ..	5–16	0·92	0·08	15	14·4	5·5	0·5 {	3·7* / 2·1	7·6	96	30·0	21·2	6–3:6:1	—	—	—
B_3 ..	16–26	0·67	0·07	19	22·4	7·7	0·4 {	7·8* / 3·0	8·1	100	47·2	32·3	7–5:2:3	48	12	40
Ccal ..	26–55	0·31	0·03	13	11·4	7·1	0·4	2·2	7·8	56	36·8	28·0	7–6:0:4	52	10	38
Cg ..	55–75	—	—	23	13·4	7·7	0·6	0·7	7·2	72	42·4	35·8	8–3:5:2	40	12	48

*Neutral normal ammonium acetate extraction following U.S.D.A. Agriculture Handbook No. 60. Content expressed as Me/100 gm. soil.

KIBIGORI SERIES

The Kibigori series consists of very deep, imperfectly drained Grumusols, developed from fine-textured sediments and volcanic ash. They occur on nearly level stream terraces and lake beds and swamps under a savannah-type high grass vegetation. Parent material is derived mainly from the basalt-type rocks of the catchment area. The series was first described and the type profile was set up near Muhoroni (Thorp, J., *et al.*, 1960, Soil Survey of the Songhor Area, Government Printer, Nairobi).

The Kibigori soils are characteristically black to very dark grey in the A horizon, with nearly black, moderately developed prisms in the B horizons. The C horizons are dark grey to grey of 10YR hue, and are noted for the lenticular structure and presence of lime concretions. In many places, where the stream has cut deep banks, beds of volcanic ash are to be seen.

The Kibigori soils in the East Konyango area are geographically associated with the Rodi and Ongeng soils. Large acreages of Kibigori clay were first mapped in the Songhor area. Both the Rodi and Ongeng soil profiles have no lime concretions and are residual from basaltic rocks at various depths and occupy nearly smooth plains and gently sloping ridges at somewhat higher elevations.

The Kibigori soils occur at elevations of about 4,350 ft. in a wet-dry climate having a mean annual precipitation of 45-50 in. The Kibigori series is mapped in large continuous bodies along the upper Ogweo stream in the East Konyango area, as well as in large acreages in the Muhoroni-Kibigori regions in the Songhor area.

Soil Profile: Kibigori Clay Loam

Lab. No. 3961/1958: A1: 0 to 5 in.

Black to very dark grey (10YR 2.5/1) clay loam; moderate, very fine to fine subangular blocky; hard, dry; firm, moist; slightly sticky and plastic, wet; abundant fine and medium roots; many yellowish-red concretions due to burning; slightly acid (pH 6.1); lower boundary clear and smooth. 5 to 6 in. thick.

Lab. No. 3962/1958: B2: 5 to 16 in.

Black (10YR 2/1) clay; moderate coarse prisms breaking to strong, coarse, angular blocks; very hard, dry; firm, moist; very sticky and very plastic, wet; plentiful fine roots with some through peds; thick clay skins on all ped faces, and common fine prominent yellowish-red (5YR 5/6) mottles; mildly alkaline (pH 7.6); clear smooth boundary. 11 to 12 in. thick.

Lab. No. 3963/1958: B3: 16 to 26 in.

Very dark grey to dark grey (10YR 3.5/1) clay; strong, medium, angular blocky; very hard, dry; very firm, moist; very sticky and very plastic, wet; plentiful fine roots; a few thin clay skins and many slickenside faces; has 10 per cent fine brown-black concretions; moderately alkaline (pH 8.1); lower boundary gradual and wavy. 10 to 11 in. thick.

Lab. No. 3964/1958: Cca-1: 26 to 55 in.

Dark grey to grey (10YR 4.5/1) clay; strong medium to coarse lenticular structure; consistence as above; plentiful fine roots; some flattened between peds; contains many rounded lime concretions of ¼ to ⅜ in. in size mainly in the lower part of horizon; mainly calcareous; mildly alkaline (pH 7.8); gradual wavy lower boundary. 28 to 32 in. thick.

Lab. No. 3965/1958: Cg: 55 to 75 in.

Variegated colours in equal proportions of olive grey (5Y 5/2) and olive brown (2.5Y 4/2) clay with many black manganese spots and stains and 10 per cent brownish-yellow mottles (10YR 6/6); strong, medium, subangular blocky structure; hard, dry; friable to firm, moist; sticky and plastic, wet; very few fine roots; neutral (pH 7.2); lower boundary undetermined.

75 in. +

Auger stopped by basalt float rock.

Range in Characteristics.—Hues in the A horizon are usually 10YR, but may be 7.5YR, and values may be as low as 2 moist. Structure of the B2 horizon may be strong medium angular blocky instead of prismatic. Colour and size of mottles vary considerably. Depth to lime concretions is also very variable as is the occurrence and thickness of the ash beds. Small areas of sandy clay loam are included in the surface horizon. At Songhor, surface texture ranged as heavy as clay.

Relief.—Nearly level stream terraces, lake beds and old swamps.

Drainage.—Imperfectly drained, runoff is slow during most of the year, internal drainage is slow during the rainy periods and medium during the drier seasons.

Vegetation.—Mostly tall grassy areas with *Pennisetum catabasis* dominant and flat topped *Acacia* sp. along the streams.

Use.—Maize, sugar-cane and pasture. A good soil for cane if managed properly.

Distribution.—Known to occur along the upper Ogweo stream in the East Konyango area, and in the Songhor survey area, Central Nyanza.

Location of Profile Sampled and Described Here.—Soil pit about ½-mile south of Gem peak, map grid reference GZU 251310.

Type Location.—2.4 miles north of Muhoroni Station. Map grid reference HZH 447868.

Series Established.—September, 1958.

Source of Name.—Kibigori Railway Station, Central Nyanza.

KIBUBU SERIES

The Kibubu series consists of well-drained dark reddish-brown soils with strongly developed laterite horizons developed from dark coloured fine-grained basaltic rocks. They occur on broad expanses of nearly level to gently sloping uplands under a present tall grass-type vegetation. The series was first described and its type profile was set up near Songhor (Thorp, J., *et al.*, 1960. *Soil Survey of the Songhor Area,* Government Printer, Nairobi).

They are characterized by a dark reddish-brown gravelly sandy loam solum overlying a horizon which is comprised largely of laterite (iron oxide concretions). The laterite horizon, in turn, rests upon the parent rock. Many laterite concretions are present in the horizons above the laterite horizon.

The Kibubu soils are associated with the Bhanji and Akijo soils which are formed from the same kind of parent rock. The Kibubu soils lack the clayey B horizon of the Bhanji soils and are lighter textured throughout. The Akijo soils are darker in surface colour, heavier textured, and more poorly drained. They also have a laterite horizon, but is not as well developed as in the Kibubu soils. The Rangwe and Magina soils are closely related to the Kibubu soils, but have been developed from different types of parent rocks.

The Kibubu soils occur at elevations of from 4,400 to 4,500 ft. in the East Konyango area. The climate has a mean annual precipitation of 45 to 50 in. with marked wet and dry seasons.

Soil Profile: *Kibubu gravelly sandy loam*

Lab. No. 453/1959: A1: 0 to 8 in.

Dark reddish-brown (5YR 3/2) dry and moist gravelly sandy loam; strong medium granular structure; soft, dry; friable, moist; non-sticky and non-plastic, wet; 5 to 10 per cent fine dark brown iron-oxide concretions; abundant fine and medium roots; clear smooth boundary; (pH 6.5). 6 to 8 in. thick.

Lab. No. 454/1959: B2: 8 to 14 in.

Reddish-brown (5YR 4/3) sandy clay loam, dark reddish-brown (5YR 3/3) when moist; strong, medium, granular structure; slightly hard, dry; friable, moist; sticky and slightly plastic, wet; abundant fine and medium roots; approximately 20 per cent dark brown iron-oxide concretions ($\frac{1}{8}$ to $\frac{1}{4}$ in. in diameter); neutral (pH. 6.6); gradual wavy boundary. 6 to 8 in. thick.

Lab. No. 455/1959: B2ir: 14 to 33 in.

Dark reddish-brown (2.5YR 3/4) gravelly sandy loam, dark reddish-brown (2.5YR 2/4) when moist with 20 per cent dark red (2.5YR 3/6) and 10 per cent strong brown (7.5YR 5/8) mottles; massive structure; plentiful fine roots; neutral (pH 6.6); clear wavy boundary. 19 to 21 in. thick. Approximately 60 per cent iron-oxide concretions up to 2 in. in diameter which are reddish-yellow on the outside and black on the inside.

C1: 33 to 36 in. +

Fine-grained basalt which is weathering to grey clay loam with reddish-yellow mottles and black manganese oxide skins in the joints.

Range in Characteristics.—The soil varies from 1½ to 3 ft. in depth. Occasional rock outcrops are encountered. Small and large isolated masses of basalt with weathered coatings are imbedded in the laterite horizon. Pieces of quartz are also to be found in the laterite. Surface soil includes small areas of gravelly sandy clay loam textures.

Relief.—Nearly level to gently sloping smooth upland plains.

Drainage.—Well drained; runoff is medium in dry seasons and rapid in wet periods; internal drainage is rapid.

Vegetation.—Present vegetation tall grasses; *Aristida adoensis, Digitaria scalarum,* common grass species.

Use.—Most of the Kibubu soils are used for pasture, but many small patches of the deeper parts are used for raising subsistence and garden crops such as maize, millet, sorghum, groundnuts, simsim, cassava, sweet potatoes, cowpeas and beans.

Distribution.—In the Songhor area, south of the Songhor hills and in the north-west area of the East Konyango area.

Location of Profile Sampled and Described Here.—In the north-west corner of the survey area about 300 yards south of the northern boundary and three-quarters of a mile east of the Lambwe Valley road. Map grid reference GZU 067272.

Type Location.—Approximately 2½ miles south-west of Songhor Post Office. Map grid reference HZN 429914.

Series Established.—September, 1958.

Source of Name.—Kibubu Estate, Central Nyanza, near Songhor.

TABLE VIII (*b*)

Kibubu gravelly sandy loam *Map Ref.* GZU 067272 *Lab. No.* 453 to 455/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–8	1·05	0·11	238	14·4	8·4	1·6	0·2	6·5	66	30·4	44·9	3–2:4:4	20	28	52
B_2 ..	8–14	1·35	0·10	245	15·4	9·6	1·9	0·2	6·6	74	33·6	38·6	4–2:5:3	26	22	42
B_2ir ..	14–33	0·3	0·06	8	4·8	3·4	2·1	0·1	6·6	51	21·6	35·1	4–4:0:6	16	14	70

Kibugo clay loam *Map Ref.* GZU 209242 *Lab. No.* 3966 to 3970 /1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–6	2·05	0·15	30	8·7	4·3	0·7	0·3	5·3	59	30·0	18·3	5–5:3:2	26	32	42
A_2 ..	6–8	0·64	0·07	8	6·7	3·5	0·3	0·5	5·6	40	18·8	22·0	7–4:1:5	14	12	74
B_2 ..	8–20	1·25	0·10	7	14·4	5·1	0·3	0·8	5·2	76	37·6	30·1	6–5:0:5	52	10	38
C_1 ..	20–30	0·40	0·04	20	15·6	6·2	0·4	0·9	6·1	75	39·2	33·3	7–5:0:5	48	20	32
C_2 ..	30–50	—	—	375	23·2	7·7	0·4	1·0	6·7	78	44·0	34·6	6–5:1:4	26	20	54

Kibugo Series

The Kibugo series consists of deep, somewhat imperfectly drained soils developed in fine textured residuum from basic igneous rocks. They occur on nearly level to gently undulating plains. The parent rock most common is basic dark grey nepheline basalts.

Kibugo soils are characteristically very dark greyish-brown in the A horizon. In some places a discontinuous thin A2 lens of grey sandy loam, containing much hard, manganese "shot", overlies the B2 horizon. The B horizons are dark grey to black, fine textured, and have strong subangular blocky structure with thick clay skins. The C horizons are greyish-brown, fine textured, and contain mottles and black manganese stains and pieces of weathered parent rock.

The Kibugo soils are geographically associated with Rodi, Ongeng, and stony Bhanji soils. In some places Marinde soil occupies adjacent lower stream terrace positions.

Kibugo soils closely resemble the Rodi soils as to position and parent materials, but the C horizons are greyer and wetter and often have a thin layer of iron-oxide concretions formed over the parent rock. The Akijo soils are also closely related to the Kibugo soils but are somewhat better drained and less grey in the C horizon and are formed from volcanic tuffs.

The Kibugo soils occur at elevations of about 4,400 ft. in a climate having a mean annual precipitation of 45 to 50 in. with marked wet and dry seasons. They are mapped north of Magina market, and on the nearly smooth plains east and south of the Obera school road from Magina market.

Soil Profile: Kibugo Clay Loam

Lab. No. 3966/1958: A1: 0 to 6 in.

Very dark greyish-brown (10YR 3/2) clay loam; moderate, fine to medium granular; slightly hard, dry; friable, moist; slightly sticky and plastic, wet; abundant fine and medium roots; has many yellowish-red burnt concretions; strongly acid (pH 5.3); abrupt smooth boundary. 6 to 8 in. thick.

Lab. 3967/1958: A2: 6 to 8 in.

Grey (10YR 5/1) when dry, dark grey (10YR 4/1) when moist, sandy loam; weak, fine to medium, granular; soft to slightly hard, dry; very friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; about 30 to 40 per cent of the mass is made up of hard, round, very fine manganese "shot"; medium acid (pH 5.6); abrupt discontinuous boundary. 1½ to 2 in. thick.

Lab. No. 3968/1958: B2: 8 to 20 in.

Dark grey (10YR 4/1) clay, strong, fine to medium subangular blocky; hard, dry; firm, moist; sticky and plastic, wet; abundant fine and medium roots; thick clay skins on all ped faces; 10 per cent strong brown (7.5YR 5/6) "shot"; strongly acid (pH 5.2); clear wavy boundary. 12 to 14 in. thick.

Lab. No. 3969/1958: C1: 20 to 30 in.

Greyish-brown (2.5YR 5/2) clay; strong fine to medium subangular blocky; hard, dry; firm, moist; sticky and plastic, wet; plentiful fine to medium roots; no clay skins; a few slickensides; common, fine, distinct strong brown (7.5YR 5/6) mottles; slightly acid (pH 6.1); clear wavy boundary. 10 to 14 in. thick.

Lab. No. 3970/1958: C2: 30 to 50 in.

Greyish-brown (2.5YR 5/2) clay; structure and consistence as above; plentiful fine and medium roots; contains many particles of weathered parent rock and 30 per cent black manganese stains; mottles as above; neutral (pH 6.7); gradual wavy boundary. 19 to 23 in. thick.

C3: 50 in. +

Hard, slightly weathered parent basaltic-type rock.

Range in Characteristics.—The thin A2 horizon is not present in all places. Thickness of solum ranges from 30 to 50 in., with most of it being about 40 in. Moist surface colours vary from values of 10YR 2/2 to 3/2. The B2 horizons are often black (10YR 2/1). Amount of "shot" and manganese stains is variable. Sometimes a very thin loose layer of red-black iron-oxide concretions lies above the weathered parent rock.

Relief.—Nearly smooth to gently sloping upland plains with slope gradients of 2 to 5 per cent.

Drainage.—Somewhat imperfectly drained, runoff is medium in dry periods and rapid in wet seasons; internal drainage is slow when wet and medium in drier parts of the year.

Vegetation.—Mainly tall grasses of *Pennisetum* and *Hyparrhenia* spp.

Use.—Maize, sweet potatoes, cassava, simsim, and small areas of sugar-cane.

Distribution.—Presently mapped north of Magina market and east and south of Obera school road in East Konyango area.

Type Location.—Sample pit 300 yd. west of Obera School, 200 ft. on the north side of the road and 30 ft. west of a small sugar-cane plot; map grid reference GZU 209242.

Series Established.—March, 1959.

Source of Name.—Kibugo stream.

KONYANGO SERIES

The Konyango series consists of deep to moderately deep imperfectly drained Grumusols developed in fine textured residuum from Tertiary volcanic materials. They occur on nearly level plains and gently sloping ridges under a grass-type vegetation. The parent rock most commonly found is tuff, but in places may be basaltic-type rocks.

Konyango soils have black, when moist, clay loam A horizons and moderately developed black to greyish-brown prismatic B horizons that readily break to subangular blocks. The C horizons are strongly mottled, and have a tendency towards lenticular-type structure, particularly so on the gentle slopes. The clays are of the shrinking swelling 2:1 type.

The Konyango soils are associated mainly with Ongeng and Rodi soils. They are much shallower than the Ongeng soils and lack the very thin discontinuous A2 horizon of both the Ongeng and Rodi soils. The Konyango soils have strongly mottled browner, 10YR hue, C horizons than do either the Rodi or Ongeng soils. The Kibigori clay loam, a Grumusol, has similar structure but contains lime concretions which the Konyango soils do not.

The Konyango soils occur at elevations of from 4,400 to 4,500 ft. on a climate having a mean annual precipitation of 45 to 50 in. with a marked wet-dry season. They are well suited for sugar-cane production.

Soil Profile: Konyango Clay Loam

Lab. No. 5069/1958: Ap: 0 to 7 in.

Very dark grey (10YR 3/1) clay loam, black (10YR 2/1) when moist, containing many yellowish-red concretions due to periodic burning; moderate fine subangular blocky structure; hard, dry; firm, moist; slightly sticky and slightly plastic, wet; abundant roots; strongly acid (pH 5.4); clear wavy boundary. 6 to 7 in. thick.

Lab. No. 5070/1958: B21: 7 to 17 in.

Greyish-brown (10YR 5/2) clay, dark greyish-brown (10YR 4/2) when moist; strong, fine to medium, angular blocky structure; hard, dry; firm, moist; very sticky and plastic, wet; thick clay skins on all ped faces; plentiful roots; mottled 40 per cent dark grey (10YR 4/1) and 20 per cent yellowish-brown (10YR 5/4); very strongly acid (pH 4.9); clear wavy boundary. 10 to 12 in. thick.

Lab. No. 5071/1958: B22: 17 to 26 in.

Strongly mottled in equal proportions of dark yellowish-brown (10YR 4/4), grey (10YR 5/1), and brown (10YR 5/3) clay; strong, fine to medium, angular blocky structure; hard, dry; firm, moist; very sticky and very plastic wet; plentiful roots; very strongly acid (pH 4.8); thick clay skins on all ped faces; clear wavy boundary. 9 to 11 in. thick.

Lab. No. 5072/1958: B3: 26 to 32 in.

Strongly mottled in equal proportions of brown (10YR 5/3), greyish-brown (10YR 5/2), dark grey (10YR 4/1), and yellowish-brown (10YR 5/4) clay, strong, medium, angular, blocky structure with tendency towards coarse lentils; consistence as above; a few thin clay skins; contains many broken fragments of weathered tuff; strongly acid (pH 5.2); abrupt wavy boundary.

C: 32 to 36 in. +

Slightly weathered rather hard tuff.

Range in Characteristics.—The chief variation is in the depth of the soil profile to the parent materials. Thickness of the solum ranges from 30 in. to about 42 in., with most of it being about 36 in. Moist values of the A1 horizon are usually 2 but increase to 3. Hues are mostly 10YR. Gilgai action often produces thin tongues of the A1 horizon down to 20 in. Thickness of the B2 horizon ranges from 8 to 20 in. Surface texture includes small areas of sandy clay loam. Mottles vary greatly.

Relief.—Nearly level to gently sloping plains.

Drainage.—Imperfectly drained. Runoff is slow when soil is saturated and medium during drier periods of the year. Internal drainage is slow during the long rainy season and medium during the rest of the year.

Vegetation.—Mainly tall grasses, *Pennisetum catabasis* dominant; also present are *Beckeropsis uniseta, Hyparrhenia* sp., *Bothriochloa insculpta, Cynodon dactylon* and *Alysicarpus* sp.

Use.—Maize, sorghum, cassava, sweet potatoes and some sugar-cane.

Distribution.—Mapped in the Ongeng and Okok districts in the East Konyango area.

Type Location.—Okok experimental cane plots. Map grid reference GZU 131262.

Series Established.—March, 1959.

Source of Name.—Konyango District.

TABLE VIII (*c*)

Konyango clay loam — *Map Ref.* GZU 131262 — *Lab. No.* 5069 to 5072/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
Ap ..	0–7	2·30	0·24	35	15·0	6·2	0·1	0·8	5·4	72	62·0	32·4	7–5:3:2	34	26	40
B_{21} ..	7–17	0·97	0·14	13	12·6	5·6	0·1	1·0	4·9	68	56·0	37·6	7–4:4:2	50	16	34
B_{22} ..	17–26	0·77	0·12	15	13·2	6·2	0·2	1·9	4·8	71	58·0	34·2	7–5:3:2	58	10	32
B_3 ..	26–32	0·56	0·10	28	12·8	5·6	0·2	0·2	5·2	76	60·0	32·3	7–5:3:2	54	10	36

Kuja loam — *Map Ref.* GZU 139143 — *Lab. No.* 2905 to 2909/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–5	4·93	0·4	12	17·6	6·0	1·0	0·5	5·6	100	48·0	49·9	3–0:10:0	26	28	46
B_{21} ..	5–17	1·25	0·12	10	8·8	5·2	0·8	13·9* 1·8	4·2	92	44·0	47·5	4–2:5:3	58	14	28
B_{22} ..	17–30	0·85	0·10	12	8·6	4·0	0·5	18·7* 3·2	3·8	88	51·0	45·1	3–1:9:0	62	12	26
B_3 ..	30–37	0·50	0·05	16	9·8	4·7	0·5	9·6* 3·6	4·0	100	40·8	42·4	3–1:8:1	56	18	26
C ..	37–42	0·09	0·01	17	5·8	3·3	1·0	8·7* 3·7	4·4	100	14·8	22·0	10–3:0:7	6	36	58

*Neutral normal ammonium acetate extraction following U.S.D.A. Agriculture Handbook No. 60. Contents expressed as Me/100 gm. soil.

KUJA SERIES

The Kuja series consists of moderately well drained, deep fine textured Solonetz soils, developed from old alluvium. The alluvium is predominantly fine textured material with thick layers of volcanic ash present at varying depths. They occupy the first terrace above the Kuja River and are confined to that area covered by dense forest and bush. They occur at elevations of about 4,100 ft., in a wet and dry seasonal climate with a total annual precipitation of about 45 to 50 in.

The Kuja soils are characterized by a very dark grey to black loam surface containing large amounts of organic matter underlain by a very dark greyish-brown prismatic clay B horizon. The tops of the prisms have a distinct light grey (10YR 7/1) sandy loam coating and thin discontinuous A2 horizons up to ½ or 1 in. in thickness are not uncommon in this soil. Volcanic ash is generally found at depths of 36 to 60 in. The soil profile is extremely to strongly acid.

The Kuja soils occur in close association with the Olungo soils which are developed from the same parent material. The Olungo soils occupy the open grassy park areas adjacent to, or surrounded by, the dense bush, and exhibit slightly thicker, more pronounced, A2 horizons.

Soil Profile: Kuja Loam

Lab. No. 2905/1959: A1: 0 to 5 in.

Very dark grey (10YR 3/1) loam, black (10YR 2/1) when moist; strong, fine, crumb structure; soft, dry, very friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; medium acid (pH 5.6); abrupt irregular boundary. 5 to 6 in. thick.

Lab. No. 2906/1959: B21: 5 to 17 in.

Very dark greyish-brown (10YR 3/2) clay, very dark brown (10YR 2/2) when moist; moderate, medium and coarse prismatic, breaking to medium, angular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; tops of prisms have a light grey (10YR 7/1) coating approximately ½ to 1 in. in thickness, but this grey coating is discontinuous; thin clay skins on all peds; abundant fine and medium roots; extremely acid (pH 4.2); clear wavy boundary. 12 to 14 in. thick.

Lab. No. 2907/1959: B22: 17 to 30 in.

Dark brown (10YR 4/3) clay, dark brown (10YR 3/3) when moist; moderate, medium and fine, angular, blocky structure; thin clay skins on moist peds; consistence as above; plentiful fine roots; extremely acid (pH 3.8); clear wavy boundary. 13 to 16 in. thick.

Lab. No. 2908/1959: B3: 30 to 37 in.

Brown (10YR 5/3) clay, dark brown (10YR 4/3) when moist; moderate, medium and fine, angular, blocky structure; hard, dry; friable, moist; sticky and plastic, wet; plentiful fine roots; extremely acid (pH 4.0); abrupt boundary. 7 to 9 in. thick.

Lab. No. 2909/1959: C: 37 to 42 in. +

Only slightly weathered pale yellow (2.5Y 8/4) volcanic ash. The ash has many dark brown to very dark brown clay skins on fractured surfaces.

Range in Characteristics.—The chief variation is in the depth to and thickness of the volcanic ash. Ash layers may be found anywhere below 26 in. and may vary from 8 in. to an undetermined thickness. The very thin A2 coating on top of the prisms of the B horizons is discontinuous. Hues in the A horizon are usually 10YR but are often 7.5YR; most values are 2 and vary from 3 to 4 when dry. Mottles and manganese stains and concretions vary.

Relief.—Nearly level river terraces.

Drainage.—Moderately well drained. Surface run-off is slow, and internal drainage is medium.

Vegetation.—Very thick dense bush, mainly *Carissa* sp. and *Setaria chevalieri*.

Use.—Not farmed; wildlife habitat.

Distribution.—Confined to thick bush areas along the Kuja River.

Series Proposed.—March, 1959.

Source of Name.—Kuja River.

Type Location.—Sample pit about 100 ft. into the thick bush on tsetse fly cutting No. 4 along the Kuja River. Map grid reference GZU 139143.

Langi Series

The Langi series consists of somewhat poorly drained Planosol soils developed in fine textured residuum from basaltic rocks. They occur on nearly level to gently sloping plains under a high grassland type vegetation.

The Langi soils are characterized by having a well developed A2 horizon, 2 to 10 in. in thickness, which is underlain by a clay columnar B horizon. The solum is strongly acid.

The Langi soils are found in rather close association with the Rodi and Ongeng soils which are developed from the same parent rocks. Langi soils are found in slightly concave areas and differ from the Rodi and Ongeng soils in exhibiting thick leached A2 horizons and strongly developed columnar B horizons. The Langi soils are similar to the Misathe soils which are developed from granitic materials.

Termite mounds cover about 20 per cent of the surface area and the soils under these mounds are not so strongly leached and exhibited Grumusolic tendencies.

The Langi soils occur at elevations of 4,400 to 4,500 ft., in a climate having a mean annual precipitation of 45 to 50 in. with marked wet-dry seasons.

Soil Profile: Langi Loam

Lab. No. 3415/1958: A1: 0 to 3 in.

Dark grey (10YR 4/1) loam, very dark grey (10YR 3/1) when moist with 15 per cent dark brown (7.5YR 4/5) mottles; weak, medium, fine, granular structure; soft, dry; very friable, moist; non-sticky and non-plastic, wet; plentiful fine roots; strongly acid (pH 5.3); clear smooth boundary. 3 to 5 in. thick.

Lab. No. 3416/1958: A2: 3 to 10 in.

Light grey (10YR 7/1) loam, dark grey (10YR 4/1) when moist; moderate, fine, crumb structure; soft, dry; very friable, moist; non-sticky and non-plastic, wet; plentiful fine roots; a few fine brown and reddish-brown mottles; strongly acid (pH 5.4); abrupt wavy boundary. 7 to 9 in. thick.

Lab. No. 3417/1958: B21: 10 to 23 in.

Dark grey (10YR 4/1) clay, very dark grey (10YR 3/1) when moist; strong, coarse, columnar, breaking to strong, medium, angular, blocky structure; very hard, dry; very firm, moist; sticky and plastic, wet; tops of columns are coated with light grey (10YR 7/1), when dry, sandy loam; roots confined largely to cracks between columns; a few weathered basalt fragments and a few brown concretions; thick continuous clay skins outside of peds; strongly acid (pH 5.1); clear wavy boundary. 13 to 15 in. thick.

Lab. No. 3418/1958: B22: 23 to 32 in.

Very dark brown to very dark greyish-brown (10YR 2.5/2) clay; very dark brown (10YR 2/2) when moist; strong, fine, angular, blocky structure; very hard, dry; very firm, moist; very sticky and plastic, wet; few fine roots; thick continuous clay skins; strongly acid (pH 5.2); clear wavy boundary. 10 to 12 in. thick.

Lab. No. 3419/1958: B23: 32 to 43 in.

Greyish-brown to light brownish-grey (10YR 5.5/2) clay; dark greyish-brown (10YR 4/2) when moist; strong, fine, angular, blocky structure; consistence as above; few fine roots; a few thick discontinuous clay skins; very strongly acid (pH 4.8); clear wavy boundary. 11 to 13 in. thick.

Lab. No. 3420/1958: B3: 43 to 51 in.

Light yellowish-brown (2.5Y 6/4) sandy clay loam, light olive brown (2.5Y 5/4) when moist; moderate, fine, subangular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; approximately 15 per cent fine brown concretions; grey clay skins on cracks between peds; strongly acid (pH 5.2); clear wavy boundary. 9 to 12 in. thick.

Lab. No. 3421/1958: C1: 51 to 55 in.

Strongly mottled yellowish-brown and reddish-brown weathered medium acid (pH 5.8) basalt bedrock.

Range in Characteristics.—The chief variation is in the thickness of the A2 horizon which ranges from 2 to 11 in. The thickness of the solum varies from 36 to 50 in. Soils under the termite mounds are not so strongly leached (less thick A2 horizons) and show evidences of Gilgai action. Hues of the B horizons are usually 10YR but may be 7.5YR with values 3 or lower. A few lime concretions are sometimes found in the profile below 4 ft.

Relief.—Concave areas of nearly level to gently sloping plains.

Drainage.—Imperfectly drained, run-off is slow during the long rains and medium during the rest of the year. Internal drainage is slow.

Vegetation.—Tall grass vegetation, *Hyparrhenia* sp. dominant with *Digitaria scalarum* and some *Solanum inearnum*.

Use.—Pasture with small areas of maize and sorghum. Sugar-cane would do moderately well if soils had surface drainage and were fertilized.

Distribution.—Presently mapped in Langi school vicinity in the East Konyango area.

Type Location.—Sample pit about three-quarters of a mile south-east of the Langi school. Map grid reference GZU 149301.

Series Established.—March, 1959.

Source of Name.—Langi school.

TABLE VIII (*d*)

Langi loam *Map Ref.* GZU 149301 *Lab. No.* 3415 to 3421/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–3	3·22	0·22	38	5·0	3·4	0·7	0·4	5·5	7	48·8	45·3	5–2:6:2	18	44	38
A_2 ..	3–10	1·78	0·10	7	4·9	1·7	0·4	0·5	5·4	46	15·2	13·4	7–1:9:0	20	42	38
B_{21} ..	10–23	2·02	0·12	8	2·5	4·5	0·8	1·5	5·1	53	36·0	38·2	8–3:4:3	52	22	26
B_{22} ..	23–32			6	19·0	5·1	1·2	1·6	5·2	51	29·0	34·9	5–4:1:5	52	22	26
B_{23} ..	32–43			9	15·8	4·1	1·1	1·8	4·8	85	46·4	22·3	9–5:3:2	58	16	26
B_3 ..	43–51			85	21·6	4·7	1·2	1·8	5·2	86	56·0	23·3	8–7:1:2	28	12	60
C_1 ..	51–55			232	30·8	4·8	1·2	1·8	5·8	73	28·8	17·2	6–5:2:3	12	14	74

Magina loamy coarse sand *Map Ref.* GZU 245241 *Lab. No.* 5043 to 5046 /1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–6	1·95	0·14	10	2·8	1·4	0·3	0·2	5·4	50	10·0	6·5	4–5:2:3	6	10	84
B_2 ..	6–14	0·60	0·06	9	0·6	0·9	0·1	0·1	5·6	28	7·5	10·3	5–1:7:2	2	8	90
B_{21}r ..	14–28	0·30	0·03	12	0·8	0·7	0·1	0·1	5·8	14	7·8	14·6	5–1:5:4	2	8	90
C_1 ..	28–40	0·36	0·03	15	9·4	2·1	0·1	0·5	6·1	93	20·8	14·3	6–4:4:2	16	10	74

Magina Series

The Magina series consists of shallow to moderately deep, well-drained, dark reddish-brown soils with laterite horizons developed in sandy residuum from acid igneous rocks. They occur on nearly level to gently undulating hills and ridges under a savannah-type vegetation. The parent rock is granite.

Magina soils are characteristically dark reddish-brown, 5YR hues, with weak, fine, granular structure in the A horizon. The B horizon contains many iron-oxide concretions and overlies an indurated laterite or ironstone layer. The surface soil has occasional granite boulders and often has outcrops of "ironstone" or hard laterite.

The Magina series are geographically associated with the Misathe, Nyangu and Nyangu-Magina complex soils. They resemble the Rangwe and Kibubu soils as to physical and chemical properties, but differ in the type of parent rock. Rangwe is formed from rhyolite, while Kibubu is developed from basalts. Magina soils occur at elevations of 4,400 to 4,500 ft. in a climate having a mean precipitation of 45 to 50 in. with marked wet-dry seasons. The Magina series is mapped mainly in the Magina and Nyambija market area. The soils grow finger millet, simsim, sweet potatoes, cowpeas and some maize. Sugar cane is not recommended.

Soil Profile: Magina Loamy Coarse Sand

Lab. No. 5043/1958: A1: 0 to 6 in.

Dark reddish-brown (5YR 3/2) loamy coarse sand, dark reddish-grey (5YR 4/2) when dry; weak, fine, granular structure; loose, dry; very friable to friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; strongly acid (pH 5.4); abrupt smooth boundary. 4 to 6 in. thick.

Lab. No. 5044/1958: B2: 6 to 14 in.

Dark reddish-brown (5YR 3/2) gravelly, coarse sand; weak, very fine subangular blocky structure; consistence as above; plentiful fine and medium roots; a few thin discontinuous clay skins in pores; gravels are iron-oxide concretions; medium acid (pH 5.6); gradual wavy boundary. 8 to 12 in. thick.

Lab. No. 5045/1958: B21r: 14 to 28 in.

Dark reddish-brown indurated laterite horizon; strongly cemented in place but can be broken out to $3\frac{1}{2}$ in. × 6 in. pieces; contains a few fine roots; medium acid (pH 5.8); gradual wavy boundary. 14 to 17 in. thick.

Lab. No. 5046/1958: C2: 20 to 40 in. +

Weathered granitic material containing a few fine roots; slightly acid (pH 6.1).

Range in Characteristics.—The chief variation is in the depth of the solum which ranges from 14 to 30 in. with most of it about 24 in. deep. Surface textures include small areas of sandy loam. The amount of surface stones, granite and laterite, outcrops vary considerably. Small areas of moderate sheet and rill erosion were not mapped out. Depth to hard laterite ranges up to 2 ft.

Relief.—Nearly level to sloping hills and ridges.

Drainage.—Well drained. Runoff is rapid and internal drainage is rapid.

Vegetation.—Much of the original vegetation has been destroyed. On the ridge tops a few *Combretum* sp. and *Bauhinia* sp. trees remain. The grasses are mainly *Hyparrhenia* sp.

Use.—These soils are farmed intensively and produce fair to poor yields of finger millet, simsim, sweet potatoes, cowpeas, cassava and some maize.

Distribution.—Mapped in the Magina and Nyambija market areas.

Type Location.—Pit description from murram pit 100 yd. south of Magina market on the north side of the road going to Rongo. Map grid reference GZU 245241.

Series Established.—March, 1959.

Source of Name.—Magina market, East Konyango area.

Marinde Series

The Marinde series consists of somewhat imperfectly drained Solonetz soils developed in very deep, fine-textured alluvium. They occur on nearly level stream terraces between somewhat higher adjacent gently undulating hills under a grassy savannah type of vegetation. The terraces are dissected by youthful intermittent streams.

Marinde soils are very dark brown to very dark greyish-brown, 10YR hue, in the A horizon. The B horizons are usually strongly developed black to very dark brown columns containing large amounts of sodium with a thin $\frac{1}{4}$ to $\frac{1}{8}$-in. A2 cap of ashy grey loam over the top of the columns and down the cracks between. In places where the structure of the B horizon is more prismatic than columnar the A2 resembles more of a thinner sprinkling on the prism tops and cracks. The C horizons are greyish-brown 10YR to 2.5Y hues, and subangular in structure. Lime concretions are normally found between 6 and 7 ft.

Marinde soils are associated mainly with Rodi and Ongeng residual soils of the hills occupying higher positions. Rodi and Ongeng soils differ from Marinde in that they have not developed into a Solonetz and are derived from basalt-type parent rocks. On the Olungo stream and its tributaries, Marinde soils are also found with other residual soils derived from acidic-type parent rocks such as Nyangu stony sandy loam. Small pockets of muck soils are included on the map with the Marinde soils.

Marinde soils occur at elevations of about 4,200 ft. in a climate having a mean annual precipitation of 45 to 50 in. with pronounced wet and dry seasons. They are mapped in large continuous bodies along upper tributaries of the Riana River, both to the east and west of Marinde.

Small plots of cane and maize are grown by the Africans on this soil. Cane should do moderately well on this soil, as it has the advantage of receiving more moisture in the form of rainfall runoff. This would be very advantageous in low rainfall years. Much of the soil is now used for pasture.

Soil Profile: *Marinde Clay Loam*

Lab. No. 3794/1958: A1: 0 to 3 in.

Very dark brown to very dark greyish-brown (10YR 2.5/2) clay loam, very dark greyish-brown (10YR 3/2) when dry; strong, fine, subangular blocky structure; hard, dry; firm, moist; sticky and plastic, wet; abundant fine and medium roots; a few yellowish-red burnt concretions; strongly acid (pH 5.2); abrupt smooth boundary. 3 to 5 in. thick.

Lab. No. 3795/1958: B21: 3 to 12 in.

Very dark brown (10YR 2/2) clay; strong, coarse prisms coated with a very thin sprinkling of grey (10YR 6/1) dry, silt loam or loam on prism tops and down cracks between prisms; very hard, dry; very firm, moist; very sticky and very plastic, wet; plentiful fine and medium roots with some through prisms; thick continuous clay flows on all ped faces; medium acid (pH 6.0); clear wavy boundary. 9 to 11 in. thick.

Lab. No. 3796/1958: B22: 12 to 24 in.

Dark grey (10YR 4/1) clay; strong, medium, subangular blocky structure; hard, dry; firm, moist; sticky and plastic, wet; plentiful fine and medium roots somewhat flattened between peds; thin discontinuous clay flows on some peds; mildly alkaline (pH 7.4); gradual boundary. 12 to 14 in. thick.

Lab. No. 3797/1958: C1: 24 to 46 in.

Grey to greyish-brown (10YR 5/1.5) clay; structure and consistence as above; plentiful fine roots; distinct, common, fine strong brown (7.5YR 5/6) mottles, and 10 per cent fine brown hard "shot"; mildly alkaline (pH 7.8); gradual wavy boundary. 22 to 27 in. thick.

Lab No. 3798/1958: C2: 46 to 70 in.

Greyish-brown (10YR 5/2) clay; strong, medium, subangular blocky structure; hard, dry; firm, moist; sticky and plastic, wet; few fine roots; common, fine, faint, yellowish-brown (10YR 5/4) mottles, about 5 per cent concretions as above. Moderately alkaline (pH 8.4); gradual wavy boundary. 24 to 28 in. thick.

Lab. No. 3799/1958: C3: 70 to 82 in.

Grey (10YR 5/1) clay; structure and consistence as above; no roots; few slickensides and 5 to 10 per cent manganese stains and spots; strongly alkaline (pH 8.5); gradual wavy boundary. 12 to 16 in. thick.

Lab. No. 3800/1958: Cca—4: 82 to 94 in.

This horizon is the same as above but 25 to 30 per cent of the soil mass contains soft ¼ to ½-in. lime concretions. Strongly alkaline (pH 8.7); abrupt clear smooth boundary. 10 to 12 in. thick.

Lab. No. 3801/1958: C5: 94 to 106 in.

Olive (5Y 5/3) clay; strong, medium, angular blocky structure; hard, dry; firm, moist; sticky and plastic, wet; no roots; many medium prominent yellowish-brown (10YR 5/6) mottles. Strongly alkaline (pH 8.6).

Range in Characteristics.—The chief variation is in the depth to the lime concretions. They are usually found at about the 6 ft. level, but many vary from 40 to 84 in. The structure of the B horizon varies from columnar to prismatic, but is usually more columnar than prismatic. Hues of the B horizon are usually 10YR or 7.5YR with moist values as low as 1 and up to 3. The colour of the C horizon is of either 2.5Y or 10YR hues with values of 5 and 6 and Chroma of 2 to 4. Mottles in the C horizon vary from reddish-yellow to yellowish-red in colour and are usually less than 20 per cent. Surface soil is friable to firm in consistence.

Relief.—Nearly level stream terraces with slope gradients of less than 2 per cent.

Drainage.—Somewhat imperfectly drained. Runoff is slow, and internal drainage is also slow, particularly during the long rains.

Vegetation.—Mainly tall grasses with probably *Pennisetum catabasis* dominant. Flat-topped thorn trees *Acacia* sp. along streams.

Use.—Mainly grazing with some small patches of maize and sugar cane.

Distribution.—Mapped in large continuous bodies along upper tributaries of the Riana River to the east and west of Marinde.

Type Location.—Map grid reference GZU 227274. Sample pit on large flat about ½ mile west of Marinde.

Series Established.—March, 1959.

Source of Name.—Marinde market, East Konyango.

TABLE VIII (*e*)

Marinde clay loam — *Map Ref.* 227274 — *Lab. No.* 3794 to 3801/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–3	2·12	0·50	18	19·2	6·8	0·8	0·9	5·2	54	42·0	28·7	5–5:2:3	38	30	32
B_{21} ..	3–12	0·89	0·09	28	10·8	5·1	0·5	6·1* 2·5	6·0	87	34·4	27·8	5–4:3:3	42	32	26
B_{22} ..	12–24	0·65	0·07	38	9·4	5·9	0·4	8·2* 3·0	7·4	97	41·6	35·3	4–3:4:3	44	30	26
C_1 ..	24–46	0·25	0·03	85	6·3	7·1	0·4	20·5* 3·8	7·8	92	48·0	41·1	7–2:7:1	54	22	24
C_2 ..	46–70	0·22	0·02	138	10·0	5·1	0·4	30·5* 4·0	8·4	96	48·8	42·4	8–4:3:3	66	18	26
C_3 ..	70–82	0·09	0·03	163	7·2	5·7	0·4	35·7* 3·7	8·5	97	56·0	48·6	8–3:5:2	62	16	22
Cca_{-4}	82–94	0·39	—	12	10·0	7·5	0·3	3·8	8·7	92	60·0	55·3	7–2:6:2	58	14	28
C_5 ..	94–106	0·49	0·02	65	16·8	8·4	0·5	38·3* 3·8	8·6		50·0			62	12	26

*Neutral normal ammonium acetate extraction following U.S.D.A. Agriculture Handbook No. 60. Contents expressed as Me/100 gm. soil

Mirogi clay — *Map Ref.* 125201 — *Lab. No.* 478 to 487/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–6	2·40	0·25	35	13·8	7·5	1·2	0·5	5·1	67	55·0	40·0	7–4:4:2	40	24	36
B_{21} ..	6–12	1·04	0·15	15	12·2	5·2	0·8	0·9	5·0	63	55·0	39·8	6–4:3:3	44	22	34
B_{22} ..	12–39	0·59	0·08	18	11·2	5·3	0·3	1·8	4·2	66	59·0	54·5	8–2:6:2	58	18	24
Bg_{23} ..	39–67	0·33	0·03	23	13·6	6·3	0·4	3·1	4·1	71	60·0	43·4	7–4:3:3	66	8	26
Bg_3 ..	67–82	0·09	0·02	23	8·8	7·2	0·5	2·6	5·5	78	68·0	46·6	6–5:2:3	54	10	36
Cgca ..	82–90	0·18	0·04	18	48·0	8·0	0·3	2·4	7·5	95	60·0	50·6	8–4:3:3	50	14	36
C_2g ..	90–97	—	0·04	100	42·4	8·0	0·6	2·5	7·5	96	70·0	45·8	6–5:3:2	52	16	32
C_3g ..	97–102	0·03	0·04	18	48·8	6·3	0·3	1·9	7·8	95	50·4	34·5	6–5:2:3	30	28	42
C_4g ..	102–108	Missing		—	—	—	—	—	—	—	—	—	—	—	—	—
C ..	108–112	0·06	0·04	15	48·8	6·2	0·3	1·8	7·8	92	64·0	46·3	6–4:3:3	28	22	50

Mirogi Series

The Mirogi series consists of imperfectly drained Low Humic Glei soils developed in deep fine-textured sediments which have accumulated as small valley fills along small tributaries of the major drainage systems in the East Konyango survey area. They occur on nearly level stream terraces at elevations of about 4,300 ft. in a wet-dry climate having a mean annual precipitation of 45 to 50 in. Parent material is derived from a mixture of basalt, tuff and ash which occur in the catchment area.

The Mirogi soils are characterized by a very dark grey to black clay surface which is underlain by strongly mottled angular blocky clay. Lime concretions are generally encountered from 60 in. downward. Volcanic ash is often found in the deeper layers of the profile.

The Mirogi soils are similar to the Kibigori soils but are more brown throughout and have much more strongly mottled subsoil horizons. They are associated with the Rodi, Ongeng and Bhanji soils which occupy the higher slopes and are developing in residuum from the dark-coloured basic igneous rocks.

Soil Profile: *Mirogi Clay*

Lab. No. 478/1959: A1: 0 to 6 in.

Very dark grey (10YR 3/1) clay, black (10YR 2/1) when moist; moderate fine subangular blocky structure; very hard, dry; firm, moist; very sticky and plastic, wet; abundant roots; (pH 5.1); clear wavy boundary. 4 to 8 in. thick.

Lab. No. 479/1959: B21: 6 to 12 in.

Grey (10YR 5/1) clay, dark grey (10YR 4/1) when moist; strong, medium, prismatic which breaks to strong, medium, angular blocky structure; very hard, dry; very firm, moist; very sticky and very plastic, wet; a few black manganese concretions; abundant roots; (pH 5.0); clear wavy boundary. 6 to 14 in. thick.

Lab. No. 480/1959: Bg22: 12 to 39 in.

Greyish-brown (10YR 5/2) clay, dark greyish-brown when moist; mottled approximately 20 per cent dark brown (7.5YR 4/4); strong, fine and medium angular blocky structure; hard, dry; firm, moist; sticky and plastic, wet; prominent slickensides; a few quartz fragments; very prominent clusters of an unidentified yellow (10YR 7/6) substance present; (pH 4.2); gradual wavy boundary. 20 to 32 in. thick.

Lab. No. 481/1959: Bg23: 39 to 67 in.

Grey (10YR 5/1) clay, dark grey (10YR 4/1) when moist; mottled as above; strong medium lenticular structure; hard, dry; firm, moist; sticky and plastic, wet; prominent slickensides; a few quartz fragments; plentiful fine roots; (pH 4.1); gradual wavy boundary, 25 to 30 in thick.

Lab. No. 482/1959: Bg3: 67 to 82 in.

Strongly mottled light brownish-grey (10YR 6/2), dark grey (10YR 4/1), yellowish-brown (10YR 5/6), and black clay; massive structure; hard, dry; friable, moist; sticky and plastic, wet; many black manganese concretions; (pH 5.5); gradual boundary. 12 to 18 in. thick.

Lab. No. 483/1959: Cgca: 82 to 90 in.

Similar to above but with hard lime concretions from ¼ to ¾ in. in size; fewer manganese concretions; (pH 7.5); diffuse boundary. 6 to 12 in. thick.

Lab. No. 484/1959: C2g: 90 to 97 in.

Strongly mottled yellowish-brown (10YR 5/4) (approximately 40 per cent); light brownish-grey (2.5YR 6/2) (30 per cent), and black clay; massive; hard, dry; friable, moist; sticky and plastic, wet; a few lime concretions; approximately 15 per cent black manganese concretions; (pH 7.5); diffuse boundary. 4 to 8 in. thick.

Lab. No. 485/1959: C3g: 97 to 102 in.

Mottled 40 per cent yellowish-brown (10YR 5/4), 30 per cent light brownish-grey (2.5YR 6/2), and 30 per cent yellowish-brown (10YR 5/6) clay loam; massive; hard, dry; friable, moist; sticky and plastic, wet; (pH 7.8); diffuse boundary. 6 to 10 in. thick.

Lab. No. 486/1959: C4g: 102 to 108 in.

Strongly mottled greyish-brown (10YR 5/2), light grey (10YR 7/2), and yellowish-brown (10YR 5/4) clay loam; hard, dry; friable, moist; sticky and plastic, wet; massive; many fine ash fragments. 6 to 8 in. thick.

Lab. No. 487/1959: C: 108 to 112 in. +

Strongly mottled dark brown (7.5YR 4/5); grey (10YR 5/1) and dark greyish-brown (2.5 YR 4/2); sandy clay loam; massive; hard, dry; friable, moist; sticky and plastic, wet; a few hard lime concretions; black manganese stains and concretions; a few fine ash fragments; (pH 7.8).

Range in Characteristics.—Degree of mottling varies considerably with some profiles showing stronger evidence of gleying than others.

Use.—Most of the Mirogi soils are used for pasture, but small areas are planted to maize and sorghum. Yields are fair to poor due to poor internal and external drainage.

Relief.—Nearly level to gently sloping stream terraces and valley fills.

Drainage.—Imperfectly drained, runoff is slow and water ponds in local depressions during heavy rains; slow internal drainage.

Vegetation.—Mixed grass with *Sporobolus* sp., *Pennisetum catabasis* and *Cyperus* sp. dominating. Also large clumps of *Imperata cylindrica.*

Distribution.—Presently mapped only in western part of East Konyango survey area. Mostly just south of Mirogi.

Type Location.—One and a half miles south-east of Mirogi. Map grid reference GZU 125201.

Source of Name.—Mirogi Market, East Konyango.

MISATHE SERIES

The Misathe series consists of imperfectly drained deep Planosols developed from granite. They occur on nearly level to gently sloping plains.

The Misathe soils are characterized by thick, grey to light grey A2 horizons which are underlaid by strong angular blocky clay at a depth of 18 to 22 in. The clayey B horizon characteristically contains many strong brown and red mottles. Strongly weathered granitoid rock underlies the profile at 48 to 60 in. depths.

The Misathe soils are geographically associated with Nyangu stony sandy loam and with the Nyangu-Magina complex. Nyangu soils, which are also developed from granite, are sandier textured and in many places they contain horizons of laterite ironstone. They are Planosol Ground-water Laterite intergrade soils, Nyangu-Magina complex is a mixture of Nyangu and Magina, the latter having a well-developed laterite horizon.

Misathe soils resemble the Langi soils which are developed from basalt. The Langi soils, however, lack the mottling in the B horizon and exhibit stronger prismatic to columnar structure.

The Misathe soils occur at elevations of 4,500 to 4,600 ft. in a wet-dry climate having a mean annual precipitation of about 40 to 45 in.

Soil Profile: Misathe Sandy Loam

Lab. No. 3971/1958: A1: 0 to 6 in.

Very dark grey to very dark greyish-brown (10YR 3/1.5) sandy loam; moderate, medium, granular structure; soft, dry; friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; non-calcareous; (pH 4.8); lower boundary clear and smooth. 6 to 8 in. thick.

Lab. No. 3972/1958: A2: 6 to 19 in.

Very dark greyish-brown (10YR 3.5/2) sandy loam, grey to light grey (10YR 5/1) when dry; moderate medium subangular blocks breaking to fine granular structures; slightly hard, dry; friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; non-calcareous; (pH 5.0); smooth boundary. 13 to 15 in. thick.

Lab. No. 3973/1958: B2: 19 to 32 in.

Black to very dark grey (10YR 2.5/1) clay; weak to moderate prisms in places breaking to strong, medium, angular blocky structure; hard, dry; firm, moist; sticky and plastic, wet; plentiful fine and medium roots, some through peds; thick clay flows on all ped faces; common, fine, distinct, strong brown (7.5YR 5/6) mottles and common, fine, prominent, red (2.5YR 4/8) mottles; contains a few fine quartz grains; non-calcareous; (pH 5.0); boundary gradual and wavy. 13 to 14 in. thick.

Lab. No. 3974/1958: B3: 32 to 48 in.

Dark greyish-brown (10YR 4/2) clay; structure and consistence like above horizon; plentiful fine and medium roots; common, fine, faint, light yellowish-brown (10YR 6/4) mottles; many quartz fragments and weathered white gneissic fragments; many black manganese stains and spots; a few thin clay discontinuous skins; (pH 4.5). 14 to 18 in. thick.

Lab. No. 3975/1958: C1: 48 in. +

Variegated colours of equal proportions, olive (5Y 5/3) and grey-brown (2.5Y 5/2) gravelly clay; strong, medium, angular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; a few fine roots; common, fine, distinct, strong brown mottles (7.5YR 5/6). The gravels are weathered gneissic fragments and difficult to auger; lower boundary undetermined; non-calcareous; (pH 4.5).

Range in Characteristics.—The chief variation is in depth of the soil profile to granite bedrock. Thickness of solum ranges from 48 to 60 in. Some deeper profiles do occur, but they are not common.

Relief.—Nearly level to gently sloping plains.

Drainage.—Imperfectly drained. Runoff is medium to slow. Internal drainage is slow. Seasonally fluctuating water table.

Vegetation.—Grass with *Pennisetum catabasis* dominant. Also *Brachiaria soluta, Andropogon* sp. and *Hyparrhenia* sp.

Use.—Used mainly as pasture, but small areas are planted to sweet potatoes, finger millet and cassava. A small patch of cane on this soil was observed and it appeared to be doing very poorly.

Distribution.—Mapped in the East Konyango area, mainly south-east of Magina along the Rongo-Homa Bay road.

Type Location.—Approximately 1¼ miles south-east of Magina on the large flat between the Riana and Misathe rivers. Map grid reference GZU 263234.

Series Established.—March, 1959.

Source of Name.—Misathe River.

TABLE VIII (*f*)

Misathe sandy loam *Map Ref.* GZU 263234 *Lab. No.* 3971 to 3975/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–6	2·66	0·15	16	2·7	0·7	0·4	0·5	4·8	46	17·4	14·1	5–5:1:4	12	28	60
A_2 ..	6–19	1·07	0·07	7	2·4	0·1	0·2	0·7	5·0	57	12·4	10·0	7–5:1:4	14	26	60
B_2 ..	19–32	1·10	0·10	8	8·3	0·7	0·3	1·0	5·0	67	26·4	21·2	7–5:0:5	48	10	42
B_3 ..	32–48	—	—	8	10·0	1·3	0·3	1·5	4·5	83	26·0	18·6	7–6:0:4	56	8	36
C_1 ..	48+	—	—	10	9·2	1·1	0·3	1·4	4·5	63	22·4	9·1	4–7:1:2	50	8	42

Ndhiwa loam *Map Ref.* GZU 082194 *Lab. No.* 2928 to 2934/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–9	1·95	0·14	16	11·2	6·0	0·1	0·3	5·5	90	19·1	22·2	7–1:8:1	26	30	44
A_{21} ..	9–15	0·90	0·06	11	7·0	2·7	0·1	0·3	5·6	81	11·0	14·5	8–4:0:6	26	28	46
A_{22} ..	15–20	0·71	0·05	8	5·0	2·3	0·1	0·3	5·8	86	7·4	12·1	10–4:0:6	24	28	48
B_{21} ..	20–30	0·75	0·08	14	9·6	6·8	0·1	0·8	5·6	62	18·8	27·1	7–4:4:2	38	14	48
B_{22} ..	30–37	0·53	0·06	12	11·8	7·5	0·3	1·1	5·6	80	20·0	27·2	4–4:1:5	56	8	36
B_3 ..	37–48	0·39	0·03	12	11·2	5·6	0·4	1·0	5·2	33	22·4	24·2	4–4:0:6	58	6	36
C ..	48–69	0·08	0·02	10	8·6	6·0	0·4	0·8	5·2	39	30·4	18·2	3–4:0:6	36	12	52

Ground-water laterite soil (*inclusion in Ndhiwa loam*) *Map Ref.* GZU 124179 *Lab. No.* 1394 to 1398/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–2	1·57	0·08	18	2·4	2·4	0·2	0·2	5·4	35	12·0	7·9	5–6:1:3	10	32	58
A_{21} ..	2–12	0·73	0·05	8	0·8	0·4	0·1	0·3	5·5	53	9·1	6·3	4–5:2:3	14	20	66
A_2ir ..	12–20	0·29	0·03	8	1·6	0·7	0·2	0·7	5·8	23	9·8	17·9	5–4:4:2	10	14	76
A_2ir ..	20–26	0·26	0·02	5	2·2	0·9	0·1	0·7	6·1	50	10·4	14·2	6–0:8:2	10	18	72
C ..	26–30	0·23	0·02	9	3·0	1·1	0·1	0·7	5·9	75	10·8	10·9	8–4:2:4	12	22	66

Ndhiwa Series

The Ndhiwa series consists of imperfectly drained Planosols developed in fine textured alluvium derived from rhyolite. They occur on gently sloping to sloping fans at elevations of 4,200 to 4,300 ft., in a climate having a mean annual precipitation of 45 to 50 in. with pronounced wet and dry seasons.

The Ndhiwa soils are characterized by having a well pronounced A2 horizon, 6 to 12 in. in thickness, which is underlain by a heavy clay columnar B horizon. The columns grade into strong, medium, and coarse angular blocks at depths of 30 to 40 in.

The Ndhiwa soils occur in close association with the Rangwe soils and occupy the alluvial fans below them. The Rangwe soils are well drained, relict Groundwater Laterite soils developed from rhyolite. The Ndhiwa soils have similar profiles to the Nyamauro soils but occur on fans and their parent materials are derived from rhyolite. The Nyamauro soils occur on stream terraces and their parent material is alluvium derived from a mixture of both acidic and basic rocks.

At the contact point between the Ndhiwa and the Rangwe soils there characteristically occurs a highly leached Groundwater Laterite soil. It occurs at a position on the fan where seepage from higher areas is at a maximum. It is very pale brown to light grey in colour and contains many iron-oxide concretions. This soil has been included on the map with the Ndhiwa soils because it was impossible to separate out on a map of the scale of the East Konyango area. This soil differs in several ways from the Rangwe soils which also have laterite horizons. It is still under the influence of a fluctuating water table and consequently is still in the process of formation. The Rangwe soils are no longer wet but were formed under similar wet conditions some time in the geologic past. They do not have the very pale brown to light grey colours of this soil and have better developed laterite ironstone horizons. The Ndhiwa series contain from 10 to 15 per cent of this soil.

Soil Profile: *Ndhiwa Loam*

Lab. No. 2928/1959: A1: 0 to 9 in.

Dark grey (7.5YR 4/1) loam, black (7.5YR 2/1) when moist; strong, medium, and coarse granular structure; slightly hard, dry; friable, moist; slightly sticky and slightly plastic, wet; abundant roots; (pH 5.5); clear wavy boundary. 6 to 10 in. thick.

Lab. No. 2929/1959: A21: 9 to 15 in.

Grey to light grey (10YR 6/1) loam; dark grey (10YR 4/1) when moist; strong, medium, granular structure; slightly hard, dry; friable, moist; slightly sticky and slightly plastic, wet; mottled approximately 50 per cent grey (10YR 5/1); plentiful roots; (pH 5.6); abrupt wavy boundary. 4 to 8 in. thick.

Lab. No. 2930/1959: A22: 15 to 20 in.

Light grey (10YR 6.5/1) loam, dark grey (10YR 4/1) when moist; structure and consistence as above; approximately 20 per cent brown iron-oxide concretions; plentiful roots; (pH 5.8); abrupt wavy boundary. 6 to 12 in. thick.

Lab. No. 2931/1959: B21: 20 to 30 in.

Very dark grey (10YR 3/1, dry and moist) clay; strong, coarse and very coarse columnar, breaking to moderate, medium, angular, blocky structure; tops of columns are rounded and have light grey (10YR 6.5/1) coatings; extremely hard, dry; very firm, moist; very sticky and very plastic, wet; thick continuous clay skins on all ped faces; 30 per cent iron-oxide concretions; few fine roots; (pH 5.6); clear wavy boundary. 1 to 16 in. thick.

Lab. No. 2932/1959: B22: 30 to 37 in.

Greyish-brown (10YR 5/2) clay, dark greyish-brown (10YR 4/2) when moist; strong, medium and coarse, angular, blocky structure, with a tendency towards lentils; consistence as above; prominent slickensides; mottled approximately 20 per cent dark brown (10YR 4/3); a few fine iron-oxide concretions; a few fine roots; (pH 5.6); clear wavy boundary. 6 to 10 in. thick.

Lab. No. 2933/1959: B3: 37 to 48 in.

Greyish-brown (2.5YR 5/2) clay; dark greyish-brown (2.5YR 4/2) when moist; strong, coarse, lentil structure which breaks to strong, medium and fine, angular, blocks; extremely hard, dry; very firm, moist; very sticky and very plastic, wet; prominent slickensides; approximately 20 per cent dark brown (10YR 4/3) mottles; (pH 5.2); clear wavy boundary; approximately 20 per cent black manganese concretions; many quartz and rhyolite fragments.

The following is a profile description of the Groundwater Laterite soil which occurs within Ndhiwa loam.

Soil Profile: *Inclusion in Ndhiwa Loam*

Lab No. 1394/1959: A1: 0 to 2 in.

Dark greyish-brown (10YR 4/2) sandy loam, dark brown (10YR 3/3) when moist; strong, medium, and fine crumb structure; soft, dry; very friable, moist; non-sticky and non-plastic, wet; abundant roots; (pH 5.4); abrupt smooth boundary. 2 to 4 in. thick.

Lab. No. 1395/1959: A21: 2 to 12 in.

Very pale brown (10YR 7/3) sandy loam, dark brown (10YR 3.5/3) when moist; very weak, medium, angular, blocky structure which breaks to moderate, medium and fine, crumb; soft, dry; very friable, moist;

non-sticky and non-plastic, wet; approximately 20 per cent yellowish-brown (10YR 5/4) mottles which are dark yellowish-brown (10YR 4/4) when moist; abundant roots; (pH 5.5); abrupt wavy boundary. 8 to 14 in. thick.

Lab. No. 1396/1959: A2ir: 12 to 20 in.

Light grey (10YR 7/2) gravelly sandy loam, dark brown (10YR 4/3) when moist; massive to weak fine crumb structure; consistence as above; 50 to 60 per cent iron-oxide concretions $\frac{1}{4}$ to $\frac{1}{2}$ in. in size which are brown on the outside and black inside; plentiful roots; (pH 5.8); clear wavy boundary. 6 to 12 in. thick.

Lab. No. 1397/1959: A2ir: 20 to 26 in.

White (10YR 8/1) gravelly sandy loam, light grey (10YR 7/2) when moist; massive to weak fine crumb structure; soft, dry; very friable, moist; non-sticky and non-plastic, wet; concretions as above; plentiful fine roots; (pH 6.1); clear wavy boundary. 6 to 18 in. thick.

Lab. No. 1398/1959: C: 26 to 30 in. +

Strongly weathered rhyolite which is light grey (10YR 7/1) when dry and grey (10YR 6/1) when moist; thick clay skins on fractured surfaces.

Range in Characteristics.—The Groundwater Laterite soil, occurring in Ndhiwa loam, makes up from 10 to 15 per cent of the area. Ndhiwa soils range from reddish-brown to black in colour and the A2 horizon ranges from 6 to 12 in. in thickness. They have a reddish-brown colour near the top of the fan where the soil grades into the Rangwe soils and a very dark grey to black colour near the base of the fan as it grades into the Nyamauro or Olungo soils. The included Groundwater Laterite soil ranges from reddish-brown to dark greyish-brown in colour. As it grades upslope into the Rangwe soils hard pisolitic laterite horizons are encountered at 30 to 36 in. depths.

Relief.—Gently sloping to sloping fans.

Drainage.—Imperfectly to poorly drained; moderate runoff. Internal drainage is poor; seasonally fluctuating water table.

Vegetation.—Mixed tall grasses with *Cymbopogon* sp., *Loudetia kagerensis* and *Imperata cylindrica* dominating. A few scattered trees, such as *Erythrina abyssinica* and *Combretum* sp. occur.

Use.—Mostly used for pasture, but small areas are planted to maize, sorghum and simsim. Yields are fair to poor due to the waterlogging effect caused by the heavy, very slowly permeable B horizon during the rainy season. In many places the local people use the Groundwater Laterite soil, that is included in the Ndhiwa series, for making bricks. The entire profile, down to the hard weathered rocks, is used.

Distribution.—Mapped in the south-western part of the East Konyango soil survey area.

Type location: Ndhiwa loam.—South of the road going to the brick factories approximately ¼ mile south of the main Mirogi-Ndhiwa road. Map grid reference GZU 082195. Inclusion in Ndhiwa loam: GZU 124179.

Series Established.—March, 1959.

Source of Name.—Ndhiwa market.

NYAMAURO SERIES

The Nyamauro series are somewhat poorly drained, deep, fine textured soladized solonetz developed in fine textured alluvium derived from a mixture of both acidic and basic rocks. In many places the alluvium is interlayered with volcanic ash. They occur on nearly level to gently sloping fan terraces and old river terraces under a grouped tree grassland vegetation. Large grey termite mounds supporting clumps of *Euphorbia* sp., *Carissa edulis* and *Acacia* sp. dot the landscape.

The Nyamauro soils are characterized by their grey surface soil (when dry), thick A2 horizon and well developed columnar structure. They have morphology similar to the Langi and the Ndhiwa soils. The Langi soils are developed from basaltic lava and the Ndhiwa soils from alluvium derived from rhyolite. Nyamauro series are associated with the Kuja soils and the Nyangu-Magina complex. They lie at slightly higher elevations than the Kuja soils and occupy an intermediate position between the Kuja and the Nyangu-Magina complex. The Kuja soils are also solodized solonetz but do not exhibit as thick an A2 horizon as the Nyamauro soils. They are developed under dense tree and bush vegetation along the Kuja River. The Nyangu-Magina complex consists of Planosol and Groundwater Laterite soils developed from granite.

The Nyamauro soils occur at elevations of 4,100 to 4,200 ft. in a wet and dry seasonal climate with a total annual precipitation of 40 to 45 in., most of which falls during the spring long rains.

Soil Profile: *Nyamauro Loam*

Lab. No. 1371/1959: A1: 0 to 4 in.

Black to very dark grey (10YR 2.5/1), dark grey to grey (10YR 4.5/1) when dry, loam; moderate to strong, fine subangular blocky; slightly hard, dry; friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; non-calcareous; (pH 5.2); lower boundary clear and smooth. 4 to 5 in. thick.

Lab. No. 1372/1959: A2: 4 to 12 in.

Very dark greyish-brown (10YR 6/1) when dry, loam, with common, fine, prominent reddish-brown (5YR 4/3) mottles; massive, breaking to weak, very fine, granular structure; loose to slightly hard, dry; friable, moist; non-sticky and non-plastic, wet; plentiful fine and medium roots; non-calcareous; (pH 5.4); lower boundary clear and wavy. 6 to 12 in. thick.

Lab. No. 1373/1959: B2: 12 to 25 in.

Very dark brown (10YR 2/2) either moist or dry clay; strong, coarse, columnar structure; top of columns and peds coated with thin A2 horizon as above; very hard, dry; very firm, moist; very sticky and very plastic, wet; thick continuous clay flow on all ped surfaces; few fine roots often flattened between columns; non-calcareous; (pH 5.3); lower boundary gradual and wavy. 13 to 14 in. thick.

Lab. No. 1374/1959: B3: 25 to 40 in.

Dark greyish-brown (10YR 4/2) clay; strong, medium, subangular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; a few thin discontinuous clay flows on some peds and thick clay flows along old root channels; few fine roots; non-calcareous; (pH 4.9); lower boundary gradual and wavy. 15 to 16 in. thick.

Lab. No. 1375/1959: C1: 40 to 52 in.

Brown (10/YR 5/3) matrix mixed with dark grey (10YR 4/1) clay; structure and consistence as above; few fine roots; contains 5 to 10 per cent soft brown concretions; non-calcareous; (pH 4.7); lower boundary gradual and wavy. 12 to 14 in. thick.

Lab. No. 1376/1959: C2: 52 to 95 in.

Variegated colour clay of about 50 per cent of the mass yellowish-brown (10YR 5/4), 25 per cent grey (10YR 5/1) and 25 per cent very dark greyish-brown (10YR 3/2); consistence and structure as in the 25 to 40 in. horizon; few fine roots; non-calcareous; (pH 4.9); lower boundary gradual and wavy. 43 to 46 in. thick.

Lab. No. 1377/1959: C3: 95 to 112 in. +

Strong brown (7.5YR 5/6) clay mixed with volcanic ash and about 30 per cent black-brown "shot"; strong, fine, subangular, blocky structure; hard, dry; friable to firm, moist; sticky and plastic, wet; no roots; (pH 5.4).

Range in Characteristics.—The chief variation is in the thickness of the A2 horizon which ranges from 6 to 12 in. Moist colours of the surface horizon vary from very dark grey to black. Structure of the B horizon varies from strong prismatic to strong columnar. Volcanic ash often occurs below 60 in. depths. Degree of mottling in lower horizons varies considerably. The colour of the A2 horizon may be grey.

Relief.—Nearly level to gently sloping fan terraces and river terraces.

Drainage.—Somewhat poorly drained; medium run-off on steeper slopes but slow on nearly level areas. Slow internal drainage. Seasonally fluctuating water table.

Vegetation.—Grouped tree grassland (savannah). Grasses include such species as *Imperata cylindrica, Brachiaria soluta, Hyparrhenia* sp., *Sporobolus pyramidalis, Loudetia kaegerensis* and *Digitaria scalarum.* Trees are confined to termite mounds and include *Euphorbia* sp., *Carissa edulis* and *Acacia* sp.

Use.—The maize on this soil is poor in the few patches that are cultivated. Grazing is the dominant use. The A2 horizon is used for making pots, as plaster and as whitewash for the walls of native houses.

Distribution.—Mainly along the Kuja River and its major tributaries in the East Konyango area.

Type Location.—Approximately 200 yards west of the bulldozer trail to the Kuja River where the dense vegetation of the Kuja River merges with the open savannah type. Map grid reference GZU 171172.

Series Established.—March, 1959.

Source of Name.—Nyamauro River.

TABLE VIII (*g*)

Nyamauro loam — *Map Ref.* GZU 172172 — *Lab. No.* 1371 to 1377/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–4	3·33	0·21	9	5·2	2·4	0·1	0·7	5·2	38	29·2	28·1	5–4:2:4	22	36	42
A_2 ..	4–12	1·47	0·06	5	3·0	0·8	0·1	1·0* / 0·7	5·4	33	9·2	8·7	6–4:3:3	22	42	36
B_2 ..	12–25	1·26	0·11	6	9·6	1·6	0·1	3·1* / 1·9	5·3	60	30·0	31·3	7–5:0:5	48	14	38
B_3 ..	25–40	0·69	0·05	9	8·4	1·7	0·1	4·2* / 2·4	4·9	74	36·8	45·7	8–4:1:5	56	10	34
C_1 ..	40–52	0·48	0·03	13	9·2	1·9	0·2	4·9* / 2·6	4·7	80	32·0	41·4	7–4:1:5	58	10	32
C_2 ..	52–95	0·51	0·03	15	10·4	1·9	0·3	5·1* / 2·8	4·9	74	32·0	41·2	7–4:1:5	58	18	24
C_3 ..	95–112	0·39	0·03	10	10·2	2·3	0·3	4·9* / 2·6	5·4	83	34·4	46·9	7–3:2:5	44	18	38

*Neutral normal ammonium acetate extraction following U.S.D.A. Agriculture Handbook No. 60. Contents expressed as Me/100 gm. soil.

Nyangu stony sandy loam — *Map Ref.* GZU 268233 — *Lab. No.* 3982 to 3986/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–5	1·51	0·09	7	2·3	1·1	0·3	0·2	4·8	37	12·4	8·0	5–6:0:4	12	18	70
A_{21} ..	5–14	0·77	0·06	4	2·1	0·1	0·3	0·1	5·0	47	10·4	7·1	6–5:3:2	14	18	68
A_{22} ..	14–23	0·56	0·04	4	2·6	0·1	0·2	0·3	5·3	52	10·2	7·8	6–6:0:4	16	12	72
A_{23} ..	23–30	0·68	0·05	2	4·0	0·2	0·3	0·5	5·6	50	10·4	8·4	8–4:4:2	12	6	82
B_2 ..	30–44	—	—	2	8·0	0·7	0·2	0·9	5·4	46	15·2	18·8	8–1:6:3	26	8	66

Nyangu Series

The Nyangu series consists of somewhat poorly drained Planosol-Groundwater Laterite intergrade soils developed in sandy textured residuum from granite parent rocks. They occur on nearly level to gently sloping uplands under a stand of tall grass and scattered trees.

Nyangu soils are characteristically dark greyish-brown or dark grey in the deep, sandy loam textured, strongly acid, A horizon. The surface soil is covered with many large granite stones which range from less than one to over three feet in diameter. The B horizon is sandy clay loam in texture, variable in colour from dark grey to black, usually 10YR hue, and has moderate medium, blocky structure. Often, in a down-slope concave position, a thin loose discontinuous layer of laterite is present over the slightly weathered parent rock.

The Nyangu soils are associated with the Misathe soils and the Nyangu-Magina complex mapping unit. They are similar to the Misathe soils, but are stony and are more sandy in the A and B horizons. The Misathe soils do not contain the laterite layer that is often found in the Nyangu soils.

The Nyangu soils occur at elevations of about 4,400 ft. in a climate having a mean annual precipitation of 40 to 45 in. with marked wet-dry seasons. The soils are used only for grazing.

Soil Profile: Nyangu Stony Sandy Loam

Lab. No. 3982/1958: A1: 0 to 5 in.

Very dark grey to very dark greyish-brown (10YR 3/1.5) sandy loam, light brownish-grey (10YR 6/2) when dry; weak, fine, granular structure; soft, dry; friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; very strongly acid (pH 4.8); clear smooth boundary. 5 to 6 in. thick.

Lab. No. 3983/1958: A21: 5 to 14 in.

Dark greyish-brown (10YR 4/2) sandy loam, light brownish-grey (10YR 6/2) when dry; structure and consistence as above; abundant fine roots; common, fine, faint greyish-brown (10YR 5/2), dark yellowish-brown (10YR 4/4) and dark brown (7.5YR 3/2) mottles; many coarse quartz particles; very strongly acid (pH 5.0); clear wavy boundary. 9 to 12 in. thick.

Lab. No. 3984/1958: A22: 14 to 23 in.

Dark grey (7.5YR 4/1) sandy loam; weak, fine, angular blocky structure; soft, dry; friable, moist; non-sticky and slightly plastic, wet; plentiful fine roots; common, fine, prominent yellowish-red (5YR 4/6) and dark brown (7.5YR 3/2) mottles; has many coarse quartz particles; strongly acid (pH 5.3); clear wavy boundary. 9 to 11 in. thick.

Lab. No. 3985/1958: A23: 23 to 30 in.

Dark grey (7.5YR 4/1) sandy loam; structure and consistence as above; plentiful fine roots; common, medium, prominent reddish-brown (5YR 3/4) mottles; medium acid (pH 5.6); clear smooth boundary. 7 to 9 in. thick.

Lab. No. 3986/1958: B2: 30 to 44 in.

Variegated colours, 50 per cent of the mass very dark grey (10YR 3/1) 50 per cent black (10YR 2/1) gravelly sandy clay loam; moderate, medium, angular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; very few fine roots; a few thin discontinuous clay skins; 30 per cent black iron manganese concretions; strongly acid (pH 5.4).

Many large loose granite stones prevented further descriptions of this pit. However, further observations from auger borings and murram pits of this series showed that the B horizon is often underlain by a thin, 2 to 5 in., layer of laterite that is usually discontinuous. This laterite layer rests on the partially weathered granite parent rock.

Range in Characteristics.—The main range in characteristics is the depth and texture of the A horizons. Thickness of this horizon varies from 12 to nearly 30 in. Textures are often loam. Hues are usually 10YR in the A horizon, but can occasionally be 7.5YR. Moist values can be as low as 3 and up to 6 dry. Chromas run from 1 to 2. The amount and size of the stones vary considerably. They range from over 1 ft. in diameter to sometimes more than 4 ft. Bedrock outcrops of granite also occur. The laterite layer is most often found in mid-slope situations.

Relief.—Nearly level to gently sloping upland hills with about 6 per cent slope gradients.

Drainage.—Somewhat poorly drained. Surface runoff is medium, and internal drainage is slow. Waterlogged during the wet season.

Vegetation.—Mainly tall grasses with *Hyparrhenia* sp. and *Pennisetum catabasis* dominant.

Use.—Pasture.

Distribution.—Presently mapped in the Magina Market region in the East Konyango area.

Type Location.—About one mile south-east of Magina Market. Map grid reference GZU 268233.

Series Established.—March, 1959.

Source of Name.—Nyangu stream.

NYOKAL SERIES

The Nyokal series consists of deep to very deep somewhat poorly drained Planosol soils developed from acid igneous rocks. They occur on nearly level to gently undulating upland plains under a tall grass savannah-type vegetation. The parent rock is rhyolite.

The Nyokal soils are characterized by a very dark grey to grey surface soil, and thick, grey, granular A2 horizons. The B2 horizon is nearly black with strong columnar structure containing many quartz and rhyolite gravels. The C horizons are micaceous sandy clays that contain many particles of weathered parent rock. The depth to bedrock varies from about 4 to 8 ft. The A and B horizons are strongly to medium acid.

The Nyokal soils are geographically associated with the Rangwe and Nyamauro soils. The Rangwe series is shallow, dark reddish-brown soil containing hard laterite layers that occupy the hill positions on the upland plains. The Nyamauro soils are very deep Planosols found on stream terraces along the upper tributaries of the Riana and Kuja rivers. The Misathe soils strongly resemble the Nyokal series in that they both have thick A2 horizons, similar B horizons, and occupy the same physiographic positions. They differ, however, in the type of acid igneous parent rock.

The Nyokal series occur at elevations of from 4,550 to 4,600 ft. in a climate having a mean annual precipitation of about 45 in. with marked wet and dry seasons. This soil is not farmed intensively and pasture is the main use.

Soil Profile: Nyokal Sandy Loam

Lab. No. 5077/1958: A1: 0 to 6 in.

Very dark grey to grey (10YR 3.5/1) sandy loam, dark grey to grey (10YR 4.5/1) when dry; moderate, fine, granular structure; slightly hard, dry; friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; medium acid (pH 5.9); clear wavy boundary. 4 to 6 in. thick.

Lab. No. 5078/1958: A2: 6 to 24 in.

Very dark grey to dark grey (10YR 3/1.5) sandy loam, grey (10YR 5/1) when dry; weak to moderate, fine, granular structure; slightly hard to soft, dry; friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; has many very fine quartz particles through horizon; strongly acid (pH 5.5); clear wavy boundary. 16 to 18 in. thick.

Lab. No. 5079/1958: A3: 24 to 28 in.

Very dark grey (10YR 3/1) fine gravelly loamy sand; moderate, medium, granular structure; loose, dry; very friable, moist; non-sticky and non-plastic, wet; plentiful fine and medium roots; medium acid (pH 5.6); lower boundary abrupt and broken. 2 to 4 in. thick.

Lab. No. 5080/1958: B2: 28 to 40 in.

Black (N 2/0) sandy clay; moderate, coarse, columnar structure breaking to strong, coarse, angular blocks; very hard, dry; very firm, moist; very sticky and very plastic, wet; plentiful fine roots, some through peds; many fine, prominent yellowish-red (5YR 4/6) mottles; 15 per cent of the mass is composed of fine weathered rhyolite fragments; 5 to 10 per cent black fine iron manganese "shot", thick black clay flows on all ped faces; medium acid (pH 5.8); gradual wavy boundary. 12 to 16 in. thick.

Lab. No. 5081/1958: B3: 40 to 50 in.

Variegated colour with 40 per cent of the mass black (N 2/0), 30 per cent yellowish-red (5YR 4/6) and 30 per cent greyish-brown (10YR 5/2); sandy clay loam; strong, medium, subangular blocky structure; hard, dry; firm, moist; sticky and plastic, wet; few fine roots; thick clay flows down old root channels and on some slickenside faces; 50 per cent of the mass of this horizon is well-weathered rhyolite particles, and one side of the pit has a vein of well-weathered rhyolite; neutral (pH 6.7); gradual wavy boundary. 7 to 10 in. thick.

Lab. No. 5082/1958: C1: 50 to 70 in.

Variegated loamy sand as above; compound moderate, fine, granular to subangular blocky structure; slightly hard, dry; loose to friable, moist; non-sticky and non-plastic, wet; very few fine roots; neutral (pH 7.0); gradual smooth boundary. 8 to 22 in. thick.

Lab. No. 5083/1958: C2: 70 to 90 in.

Light olive brown (2.5Y 5/4) loamy sand; weak, fine, granular structure; soft, dry; loose, moist; non-sticky and non-plastic, wet; no roots; much mica, 40 per cent of the mass is weathered rhyolite; neutral (pH 6.8); gradual smooth boundary. 18 to 22 in. thick.

Lab. No. 5084/1958: C3: 90 to 110 in. +

Light olive brown (2.5Y 5/4) fine gravelly sand; structure and consistence as above; no roots; horizon contains more mica than above; neutral (pH 6.9).

Range in Characteristics.—The thickness of the A horizon varies from 10 to 24 in. Small areas of loam surface soils are included. The A3 horizon is not present in all places. In the A horizon 10YR hues of moist values as low as 3 and up to 6 dry and 1 and 2 chromas are commonly found. Occasionally the B horizons are of 10YR hue, 2 to 3 moist values, and of 1 to 2 chroma. Depth to the parent rock varies considerably, being somewhat deeper on the nearly level slopes.

Relief.—Nearly level to gently sloping upland plains.

Drainage.—Natural drainage is somewhat poor. Run-off is medium, and internal drainage is slow, particularly during the wet season. Soil is waterlogged during the wet season.

Vegetation.—A few scattered shrubs found mainly on the termite mounds, much tall coarse grass in between.

Use.—Mainly grazing. A few small patches of poor maize are to be found. Sugar-cane could be grown if surface drainage and fertilizers were applied.

Distribution.—Mapped in rather large bodies along the north and south sides of the old District Commissioner's road between Magina market and Nyangao school in the East Konyango area.

Type Location.—From a pit on the road going from Magina market to Nyangao school, about one mile west from the crossroads, on the north side of the road from an unnamed African primary school. The pit was dug close to a large dead fig tree, and the map grid reference is GZU 307239.

Series Established.—March, 1959.

Source of Name.—Nyokal Market in the East Konyango area.

TABLE VIII (*h*)

Nyokal sandy loam *Map Ref.* GZU 307239 *Lab. No.* 5077 to 5084/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–6	1·86	0·17	18	6·0	2·3	0·6	0·2	5·9	54	19·2	23·8	6–1:8:1	10	22	68
A_2 ..	6–24	1·2	0·15	12	6·0	2·2	0·1	0·2	5·5	51	16·4	21·6	5–0:8:2	16	14	70
A_3 ..	24–28	1·16	0·13	12	5·2	2·3	0·1	0·1	5·6	50	16·4	26·9	5–0:8:2	14	14	72
B_2 ..	28–40	0·99	0·12	18	8·6	4·0	0·1	0·4	5·8	72	—	—	—	34	14	52
B_3 ..	40–50	0·12	0·05	217	10·2	5·4	0·1	0·5	6·7	80	22·0	22·4	—	26	18	56
C_1 ..	50–70	Nil	Nil	200	11·8	5·8	0·1	0·4	7·0	82	20·8	17·8	—	4	10	86
C_2 ..	70–90	0·15	Nil	208	15·0	5·4	0·1	0·3	6·8	79	16·0	14·9	—	2	16	82
C_3 ..	90–110	Nil	Nil	228	15·6	4·7	0·1	0·2	6·9	73	12·1	11·9	—	0	12	88

Obiero sandy clay loam *Map Ref.* GZU 242248 *Lab. No.* 3945 to 3951/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–6	1·26	0·16	22	8·0	3·9	0·5	0·4	5·0	57	32·0	21·9	6–6:0:4	20	28	52
B_{21} ..	6–20	0·85	0·12	11	9·6	3·0	0·4	0·5	5·0	60	32·8	25·0	6–5:1:4	24	20	56
B_{22} ..	20–31	Nil	0·06	8	8·8	2·7	0·4	0·6	5·0	63	26·4	23·1	7–5:1:4	32	16	52
B_3 ..	31–46	Nil	0·04	8	17·6	2·7	0·5	0·8	4·8	74	29·2	25·1	7–5:0:5	40	16	44
C_1 ..	46–62	—	—	10	18·8	2·7	0·5	0·8	4·9	75	42·2	27·7	5–6:0:4	28	26	46
C_2 ..	62–96	—	—	31	20·0	2·6	0·4	0·9	5·7	68	37·4	27·0	6–6:0:4	26	30	34
C_3 ..	96–100	—	—	65	21·6	2·5	0·5	0·5	5·3	83	25·6	22·8	7–5:1:4	16	22	62

OBIERO SERIES

The Obiero series consists of very deep, imperfectly drained soils developed in moderately fine textured residuum from volcanic ash. They occur on gently undulating hills and ridges under a stand of tall coarse grasses. The parent material is volcanic ash, probably of the Pliocene age. The soil does not fit well in any known established great soil group.

Obiero soils are characteristically black to very dark grey in the A1 horizon, and have strong, very dark brown prisms with thick clay skins. The C horizons are dark grey to grey, with red, dark red and often yellowish-brown mottles and many black manganese stains and concretions. At varying depths, hard layers of yellowish-brown to green volcanic ash is often found. These are often difficult to auger out.

Obiero soils are associated with the Kibugo and Bhanji soils. The Kibugo soils are dark grey in the B horizons, have greyish-brown mottled C horizons and contain many hard round black manganese "shot". The Bhanji soils occupy higher ridge positions, are shallow, usually stony, and have indurated laterite layers over the parent rocks.

The Obiero series occur at elevations of about 4,400 ft. in a climate having a mean annual precipitation of 45 to 50 in. with contrasting wet and dry seasons. The Obiero series are mapped in small bodies between Magina market and Marinde. The soils are used principally for pasture.

Soil Profile: Obiero Sandy Clay Loam

Lab. No. 3945/1958: A1: 0 to 6 in.

Black to very dark brown (7.5YR 2/5) sandy clay loam; moderate, medium, granular structure; slightly hard to hard, dry; friable, moist; slightly sticky and plastic, wet; abundant medium and fine roots; very strongly acid (pH 5.0); clear smooth boundary. 4 to 6 in. thick.

Lab. No. 3946/1958: B21: 6 to 20 in.

Very dark brown (10YR 2/2) sandy clay loam; strong, medium to coarse prisms, breaking to strong, medium, angular, blocky structure; hard, dry; firm, moist; slightly sticky and plastic, wet; abundant fine and medium roots; thick continuous clay skins on all ped faces; very strongly acid (pH 5.0); gradual wavy boundary. 14 to 18 in. thick.

Lab. No. 3947/1958: B22: 20 to 31 in.

Dark grey to dark greyish-brown (10YR 4/1.5) sandy clay loam; consistence and structure as above; abundant fine and medium roots; some through peds and some flattened between peds; thick continuous clay skins on all ped faces; many prominent red (2.5YR 4/6) mottles; 20 per cent of mass is brown "shot"; very strongly acid (pH 5.0); gradual wavy boundary. 11 to 14 in. thick.

Lab. No. 3948/1958: B3: 31 to 46 in.

Grey (10YR 5/1) sandy clay; compound lenticular to strong, angular, blocky structure; very hard, dry; firm, moist; sticky and plastic, wet; abundant fine and medium roots.

Lab. No. 3949/1958: C1: 46 to 62 in.

Variegated colours, 40 per cent of the mass being grey (10YR 6/1), 40 per cent red (2.5YR 4/6) and 20 per cent black manganese stains and concretions; sandy clay loam; moderate, fine to medium, angular, blocky structure; hard, dry; firm, moist; slightly sticky and plastic, wet; few fine roots; many ash fragments; very strongly acid (pH 4.9); clear wavy boundary. 16 to 18 in. thick.

Lab. No. 3950/1958: C2: 62 to 96 in.

Variegated colours, 40 per cent of the mass being grey (10YR 6/1), 50 per cent yellowish-brown (10YR 5/8) and 10 per cent red (2.5YR 4/6) loam; structure as above; slightly hard, dry; friable, moist; slightly sticky and slightly plastic, wet; very few fine roots; much of this horizon consists of ash particles; medium acid (pH 5.7); lower boundary indeterminate.

Lab. No. 3951/1958: C3: 96 to 100 in. +

Hard, slightly weathered yellowish-brown volcanic ash; many black manganese skins or clay skins between cracks.

Range in Characteristics.—The chief range in characteristics is the depth to and the thickness of the volcanic ash horizons. They vary considerably as well as does the colour. The colour of the ash is usually yellowish-brown but sometimes is a bright green. Colours of mottles and amounts of iron manganese stains and "shot" also vary. The surface colour can be either 10YR or 7.5YR hues with moist values of 2 and 3 and 1 and 2 chroma. The structure of the C horizon is often lenticular.

Relief.—Gently sloping with slope gradients of about 4 per cent.

Vegetation.—Tall coarse grasses of mainly the *Hyparrhenia* sp.

Use.—Used only for pasture. Sugar-cane would do moderately well if fertilized.

Distribution.—Presently mapped in small bodies north of Magina market in the East Konyango area.

Type Location.—Sample pit is located about one mile north of Magina market on the east side of the road. Map grid reference is GZU 242248.

Series Established.—March, 1959.

Source of Name.—Obiero school by the village of Rodi in the East Konyango area.

Oboke Series

The Oboke series consists of moderately deep to deep, somewhat poorly drained soils, derived from rhyolite. They are weakly developed Grumusols. Their strongly mottled subsoil horizons suggest a close affinity with the Low Humic Glei soils. They occur on gently sloping fans and fan terraces.

The Oboke soils are characterized by a very dark grey sandy clay loam surface which is underlain by a sandy clay to clay B horizon having strong prismatic structure. This grades into strongly mottled clay to sandy clay loam at depths of 30 to 36 in. Rounded quartz fragments characteristically occur throughout the profile.

The Oboke soils occur downslope from the Rangwe soils which are developed from the same parent material. The Rangwe soils are shallow, dark reddish-brown soils with laterite horizons.

Oboke soils occur at elevations of 4,200 to 4,300 ft. in a climate having a mean annual precipitation of 45 to 50 in. with a marked wet and dry season.

Soil Profile: Oboke Sandy Clay Loam

Lab. No. 463/1959: A1: 0 to 7 in.

Very dark grey (7.5YR 3/1) sandy clay loam, black (7.5YR 2/1) when moist; strong, medium, granular structure; slightly hard, dry; friable, moist; slightly sticky and slightly plastic, wet; approximately 20 per cent fine quartz fragments; (pH 5.8); abundant roots; clear wavy boundary. 4 to 8 in. thick.

Lab. No. 464/1959: B21: 7 to 20 in.

Very dark grey (7.5YR 3/1), dry and moist, sandy clay loam; strong, coarse, prismatic, which breaks to strong, medium, angular, blocky structure; very hard, dry; very firm, moist; sticky and plastic, wet; thick continuous clay skins on all ped faces; 15 per cent rounded quartz fragments; abundant roots; (pH 5.5); clear wavy boundary. 12 to 15 in. thick.

Lab. No. 465/1959: B22: 20 to 27 in.

Grey (10YR 5/1) sandy clay, dark grey (10YR 4/1) when moist; weak, coarse, prismatic, breaking to strong, coarse, angular, blocky structure; very hard, dry; firm, moist; very sticky and very plastic, wet; a few dark brown (7.5YR 4/4) mottles; thick continuous clay skins on all ped faces; approximately 15 per cent rounded quartz fragments; plentiful roots; (pH 5.4); clear wavy boundary. 6 to 10 in. thick.

Lab. No. 466/1959: B3: 27 to 35 in.

Grey (10YR 5/1), dark grey (10YR 4/1) when moist; mottled approximately 30 per cent dark greyish-brown (10YR 4/2), strong, medium to coarse, angular blocky structure; consistence as above; very prominent slickensides with a tendency towards lenticular structure; a few black manganese stains; approximately 20 per cent rounded quartz fragments ½ in. in size; a few large float rocks; few fine roots; (pH 5.5); clear wavy boundary. 6 to 12 in. thick.

Lab. No. 467/1959: C1: 35 to 44 in.

Strongly mottled grey (10YR 5/1), strong brown (7.5YR 5/6) and strong brown (7.5YR 5/8) sandy clay loam with approximately 30 per cent black manganese stains and soft concretions; massive structure; hard, dry; firm, moist; sticky and plastic, wet; 20 per cent very fine rounded quartz fragments; (pH 5.9); gradual wavy boundary. 8 to 12 in. thick.

Lab. No. 468/1959: C2: 44 to 54 in.

Strongly mottled grey (10YR 5/1) and strong brown (7.5YR 5/6) sandy clay loam with approximately 5 per cent dark red (2.5YR 3/6) mottles; 30 per cent black manganese stains and soft concretions; many dark brown rounded quartz fragments; (pH 5.7); clear wavy boundary. 10 to 20 in. thick.

Lab. No. 469/1959: C3: 54 to 60 in. +

Dark brown (10YR 4/3) sandy loam; massive, slightly hard, dry; friable, moist; non-sticky and non-plastic, wet; many coarse boulders of acid igneous materials; many black manganese skins on the fractured faces of the rocks; stopped by boulders at 60 in.; just above the boulders appears to be highly weathered volcanic ash; (pH 6.2).

Range in Characteristics.—The amount of quartz fragments encountered throughout the profile varies considerably. Volcanic ash is not commonly recognized in the profile. Topsoil colours range to very dark grey brown and subsoil colours to very dark brown. Lime concretions sometimes are found.

Relief.—Gently sloping fans.

Drainage.—Somewhat poorly drained. Run-off is moderate. Internal drainage is medium.

Vegetation.—Grass, with *Pennisetum catabasis, Sporobolus* sp., *Hyparrhenia* sp. and *Imperata cylindrica* dominant.

Use.—Most of the Oboke soils are used for pasture, but small areas are planted to maize, sorghum, finger millet and sweet potatoes.

Distribution.—Mapped only in small scattered patches in the East Konyango area.

Type Location.—Approximately three-quarters of a mile west of the junction of the Kibugo and Kuja rivers. Map grid referenec GZU 139173.

Series Established.—May, 1959.

Source of Name.—Oboke Market, East Konyango area.

TABLE VIII (*i*)

Oboke sandy clay loam — *Map Ref.* GZU 139173 — *Lab. No.* 463 to 469/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–7	3·39	0·26	27	15·2	7·3	0·6	0·2	5·8	64	54·0	49·8	6–5:1:4	20	26	54
B_{21} ..	7–20	1·89	0·15	10	14·0	8·4	0·1	0·6	5·5	68	41·0	47·7	6–3:3:4	34	16	50
B_{22} ..	20–27	0·87	0·12	10	12·0	8·7	0·2	0·8	5·4	75	50·0	46·1	7–5:0:5	44	8	48
B_3 ..	27–35	0·61	0·11	17	11·8	7·3	0·2	0·8	5·5	69	52·0	50·1	6–4:2:4	46	10	44
C_1 ..	35–44	0·45	0·05	93	14·4	8·3	0·2	0·9	5·9	81	57·0	50·9	8–3:5:2	28	12	60
C_2 ..	44–54	0·21	0·04	31	15·4	8·7	0·2	0·9	5·7	99	58·0	51·3	8–4:2:4	26	12	62
C_3 ..	54–60	0·21	0·02	275	18·2	9·6	0·3	0·9	6·2	58	21·6	20·9	6–3:4:3	12	14	74

Okok clay loam — *Map Ref.* GZU 113222 — *Lab. No.* 5073 to 5076/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–6	2·07	0·21	18	12·8	7·1	0·5	0·2	5·8	70	65·8	52·2	6–2:7:1	34	30	36
B_{21} ..	6–13	1·51	0·18	15	11·8	6·1	0·2	0·3	6·0	74	60·4	49·4	6–2:6:2	38	26	36
B_{22} ..	13–20	0·63	0·09	16	9·8	6·0	0·2	0·3	6·3	72	59·8	43·7	6–3:7:0	28	16	56
B_3 ..	20–40	0·48	Nil	28	11·0	6·7	0·2	0·5	6·8	79	59·4	46·8	7–2:8:0	16	14	70

Okok Series

The Okok series includes imperfectly drained, moderately deep to deep, Low Humic Glei soils developed from dark-coloured, fine-grained igneous rocks. They have been formed from weathered volcanic tuff breccia and basalt. They occur on gently sloping to sloping footslopes and fans.

Okok soils are characterized by dark reddish-brown to dark brown clay loam surface horizons which are underlain by strongly mottled fine subangular blocky B horizons. The hue of the A horizon ranges from 5YR to 7.5YR and the degree of mottling in the subsoil horizons varies considerably. The redder hues occur at the upper part of the slope and the soil becomes progressively greyer down slope. Hard rock is encountered at depths of 36 to 60 in. Rock outcrops and basaltic stones are not uncommon.

The Okok soils occur downslope from the land type Stony-land (basaltic rocks). This unit consists of shallow Lithosols developing from similar parent material.

The Okok soils occur at elevations of 4,200 ft. to 4,300 ft. in a wet-dry climate having a total annual precipitation of 45 to 50 in.

Soil Profile: *Okok Clay Loam*

Lab. No. 5073/1958: A1: 0 to 6 in.

Dark reddish-grey (5YR 4/2) clay loam, dark reddish-brown (5YR 3/2) when moist; strong, fine, granular structure; slightly hard, dry; friable, moist; slightly sticky and non-plastic, wet; abundant roots; (pH 5.8); clear smooth boundary. 4 to 8 in. thick.

Lab. No. 5074/1958: B21: 6 to 13 in.

Dark reddish-brown (5YR 3/2) dry and moist clay loam; strong, fine, subangular, blocky structure; slightly hard, dry; friable, moist; sticky and slightly plastic, wet; abundant roots; (pH 6.0); clear wavy boundary. 6 to 10 in. thick.

Lab. No. 5075/1958: B22: 13 to 20 in.

Dark brown (7.5YR 4/2) sandy clay loam, dark brown (7.5YR 3/2) when moist; strong, fine, subangular, blocky, structure; slightly hard, dry; friable, moist; sticky and slightly plastic, wet; approximately 20 per cent red-black concretions; ¼ in. in size; 15 per cent weathered rock fragments; (pH 6.3); clear wavy boundary. 6 to 12 in. thick.

Lab. No. 5076/1958: B3: 20 to 40 in.

Dark brown (7.5 YR 4/2) sandy loam, dark brown (7.5YR 3/2) when moist; mottled strong brown (7.5YR 5/6) and black; moderate, medium, subangular, blocky structure; slightly hard, dry; friable, moist; non-sticky and non-plastic, wet; approximately 40 per cent weathered basalt fragments; (pH 6.8); abrupt smooth boundary. 10 to 44 in. thick.

C: 40 to 48 in.

Strongly mottled, yellowish-brown, brown and black weathered basalt bedrock; clay skins on fractured faces.

Range in Characteristics.—The chief variation is in the degree of mottling. Subsoil colours range from dark brown to very dark grey with many profiles showing much stronger evidence of gleying. The profile described is better drained than most of the Okok soils. Depth to hard rock varies from 36 to 60 in. Occasional outcrops and large boulders are found on the surface and through the soil.

Relief.—Gently sloping to sloping footslopes and fans.

Drainage.—Imperfectly drained. Medium to rapid runoff. Slow to medium internal drainage. Seasonally high water table from upslope seepage.

Vegetation.—Grass vegetation with *Pennisetum catabasis* and *Imperata cylindrica* dominant.

Use.—Most of the Okok soils are used for pasture, but the drier areas are planted to maize, sorghum and simsim.

Distribution.—In scattered small areas in the west of the East Konyango area.

Type Location.—Approximately one mile east of the Mirogi jaggery factory. Map grid reference GZU 113222.

Series Established.—March, 1959.

Source of Name.—Okok School, East Konyango soil survey area.

Olungo Series

The Olungo series consists of deep, somewhat poorly drained Solonetz developed from fine textured alluvium that includes lenses of volcanic ash. These occur on low river terraces along the Kuja River under a fairly open stand of low brush and tall grass type vegetation.

The Olungo soils have very dark brown clay loam surface textures and strongly developed prismatic B horizons. The B horizon is usually capped by a thin discontinuous A2 horizon of grey sandy loam. Thick lenses of fairly hard volcanic ash (tuff) are present in the profile. The solum is very strongly acid.

The Olungo soils are similar to the Kuja soils but occupy the more grassy areas adjacent to them. They differ in having thinner, less well developed, A2 horizons. They are associated with the Kuja soils and the land type "Alluvial soils, undifferentiated".

Olungo soils are developed in a climate having a mean annual precipitation of 40 to 45 in. of rainfall with contrasting wet and dry seasons. They are found at elevations of about 4,100 ft. Most of this soil is used for pasture with the exception of small patches that are planted to maize, millet and yams. Yields are poor.

Soil Profile: Olungo Clay Loam

Lab. No. 1378/1959: A1: 0 to 8 in.

Very dark brown (10YR 2/2) clay loam, very dark grey to very dark greyish-brown (10YR 3/1.5) when dry; strong, fine to medium subangular blocky structure; hard, dry; firm, moist; slightly sticky and plastic, wet; abundant fine and medium roots; very strongly acid (pH 4.9); abrupt smooth boundary. 8 to 10 in. thick.

Lab. No. 1379/1959: B2: 8 to 24 in.

Very dark grey (10YR 3/1) clay; strong, coarse prisms with thick, very dark brown clay flows on all ped faces; very hard, dry; firm, moist; very sticky and very plastic, wet; plentiful fine and medium roots; the prisms are capped with a friable, grey, sandy loam horizon (not sampled) that is discontinuous and varies from $\frac{1}{2}$ to 2 in. in thickness; few coarse roots above prisms; very strongly acid (pH 4.9); lower boundary clear and wavy. 16 to 18 in. thick.

Lab. No. 1380/1959: B3: 24 to 36 in.

Dark greyish-brown (10YR 4/2) clay; strong, medium, angular, blocky structure with thin discontinuous clay flows; hard, dry; firm, moist; sticky and plastic, wet; few fine flattened roots between peds; very strongly acid (pH 4.7); clear wavy boundary. 12 to 14 in. thick.

Lab. No. 1381/1959: C1: 36 to 42 in.

Brownish-yellow (10YR 6/6) volcanic ash arranged in weak to moderate, very fine, platy structure; friable, thick, very dark brown clay flows along vertical cracks; few fine roots; very strongly acid (pH 4.7); lower boundary abrupt and smooth. 6 to 7 in. thick.

Lab. No. 1382/1959: C2: 42 to 56 in.

Greyish-brown (2.5Y 5/2) and strong brown (7.5YR 5/6) clay (equal colour proportions), with 30 per cent black iron manganese stains and concretions; strong, medium, subangular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; very few fine roots; very strongly acid (pH 4.6); lower boundary clear and wavy. 14 to 15 in. thick.

Lab. No. 1383/1959: C3: 56 to 82 in.

Variegated colour; brown (10YR 5/3) 3/4 of mass with strong brown (1/4) (7.5YR 5/6) clay loam containing much volcanic ash; moderate, fine, subangular, blocky structure; consistence as above; no roots; very strongly acid (pH 4.6); lower boundary clear and wavy. 16 to 18 in. thick.

Lab. No. 1384/1959: C4: 82 to 88 in.

Light yellowish-brown (10YR 4/6) volcanic ash with about 25 per cent black iron manganese stains; strong, fine, subangular structure; hard to auger; no roots; very strongly acid (pH 4.8); lower boundary abrupt and smooth. 6 to 7 in. thick.

Lab. No. 1385/1959: C5: 88 to 105 in.

Variegated colours with brown (10YR 5/3) 75 per cent of the mass, and strong brown (7.5YR 5/6) 25 per cent; clay; strong, medium, subangular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; no roots; very strongly acid (pH 4.8).

Range in Characteristics.—The A2 horizon is not distinct in all places and varies from a mere trace to about 2 in. in thickness. The lenses of volcanic ash vary greatly in number and thickness. Hues of the profile are mainly 10YR, moist values of the A horizon vary from 3 to 4, and chromas 1 to 2. The structure of the B2 horizon is more prismatic that columnar.

Relief.—Nearly level with slope gradients of about 1 per cent.

Drainage.—Somewhat poorly drained. Runoff is medium and internal drainage is slow. Waterlogged during much of the rainy season.

Vegetation.—Tall grass and scattered bush. The tall grass is mainly *Hyparrhenia* sp. with some *Panicum maximum, Pennisetum catobesis, Themeda triandra* and *Cyndon dactylon.*

Use.—Mainly grazing with a few small patches of maize.

Distribution.—Mapped along the terraces of the Kuja River This soil is confined to the grassy areas immediately adjacent to the thick Kuja bush.

Type Location.—The sample pit is located along the bulldozer trail to the Kuja River, about 300 yards north of the river. Map grid reference is GZU 168170.

Series Established.—March, 1959.

Source of Name.—Olungo stream in the East Konyango area.

TABLE VIII (*j*)

Olungo clay loam — *Map Ref.* GZU 168170 — *Lab. No.* 1378 to 1385/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–8	2·01	0·04	10	3·8	2·7	0·2	0·5	4·9	50	12·4	16·4	7–3:2:5	28	32	40
B_2 ..	8–29	1·11	0·11	9	9·2	3·8	0·2	2·0	4·9	66	31·2	33·8	7–4:1:5	52	12	36
B_3 ..	29–36	0·58	0·05	12	9·0	3·6	0·1	2·5	4·7	73	30·8	27·1	7–4:2:4	62	6	32
C_1 ..	36–42	0·32	0·03	13	8·0	3·5	0·1	2·2	4·7	72	26·8	27·9	7–3:3:4	30	26	44
C_2 ..	42–56	0·17	0·03	15	8·0	3·4	0·2	2·3	4·6	69	32·0	27·0	7–4:2:4	46	18	36
C_3 ..	56–82	Nil	0·02	13	7·6	3·2	0·3	2·4	4·6	71	32·0	39·7	7–3:4:3	38	18	44
C_4 ..	82–88	Nil	0·02	10	5·8	2·8	0·3	2·1	4·8	75	21·6	25·9	6–3:4:3	24	26	50
C_5 ..	88–105	Nil	0·01	14	8·6	3·5	0·3	{ 6·0* 2·9	4·8	73	26·4	30·7	5–1:5:4	48	12	40

*Neutral normal ammonium acetate extraction following U.S.D.A. Agriculture Handbook No. 60. Content expressed as Me/100 gm. soil.

Ongeng loam — *Map Ref.* GZU 171285 — *Lab. No.* 3759 to 3765/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
Ap ..	0–5	3·11	0·23	63	10·2	4·3	0·2	0·4	5·6	69	39·2	38·2	4–4:4:2	20	30	50
B_{21} ..	5–14	0·99	0·11	21	13·0	4·6	0·1	0·5	5·6	70	36·8	45·1	5–1:7:2	22	26	52
B_{22} ..	14–25	0·67	0·10	6	15·8	4·0	0·2	0·8	4·9	74	39·2	28·3	7–6:0:4	48	18	34
B_{23} ..	25–32	0·64	0·08	8	10·0	4·5	0·4	0·9	4·8	70	28·0	18·0	6–6:0:4	52	14	34
B_3 ..	32–49	0·30	0·05	12	12·6	4·6	0·3	1·0	4·3	71	35·2	27·2	7–5:1:4	58	10	32
C_1 ..	49–54	0·09	0·02	25	14·2	5·8	0·3	1·0	4·9	74	41·6	35·2	7–5:1:4	22	28	50
C_2 ..	54–60	0·09	0·01	157	6·5	3·5	0·3	0·6	5·1	61	26·8	19·8	5–2:7:1	8	26	66

Ongeng Series

The Ongeng series consists of moderately well drained Grumusol-Planosol intergrade soils developed from basalt-type rocks with minor volcanic tuff and ash areas. They occur on nearly level to gently sloping upland plains under a grassland-type vegetation.

The Ongeng soils are characterized by a very dark greyish-brown or very dark brown loam surface horizon which is underlain by a medium acid clayey prismatic B horizon. The tops and sides of the prisms often are coated with a discontinuous thin grey ($\frac{1}{4}$ in. to 2 in. thick) horizon. The prisms grade into a greyish-brown, strong, angular, blocky clay at approximately 30 in. A horizon containing as much as 30 per cent soft black manganese concretions characteristically occurs above the partially weathered basalt parent material.

The Ongeng soils occur in close association with the Rodi soils which are developed from the same parent material. The main difference between the Rodi and the Ongeng series is the depth to basalt. In the Rodi soils basalt is usually found at about 36 to 40 in., while in the Ongeng series it is found at about the 5-ft. depth. The Ongeng series are also related to the Langi soils. They also have similar parent rocks but the Ongeng soils lack the very thick leached A2 horizon of the Langi series.

The Ongeng soils occur at elevations of from 4,400 to 4,500 ft. in a climate having a mean annual precipitation of 45 to 50 in. with pronounced wet and dry seasons.

Soil Profile: *Ongeng Loam*

Lab. No. 3759/1958: Ap: 0 to 5 in.

Very dark greyish-brown (10YR 3/2) loam; very dark brown (10YR 2/2) when moist; moderate, fine, granular structure; slightly hard, dry; friable, moist; slightly sticky and slightly plastic, wet; abundant fine and medium roots; medium acid (pH 5.6); clear wavy boundary. 5 to 6 in. thick.

Lab. No. 3760/1958: B21: 5 to 14 in.

Very dark grey (10YR 3/2), dry and moist, sandy clay loam; moderate, coarse, prismatic structure, breaking to moderate medium sub-angular blocks; hard, dry; firm, moist; sticky and plastic, wet; approximately 10 per cent black-brown concretions; grey (10YR 5/1) coating on upper 1 in. to $\frac{1}{2}$ in. of prisms and down the cracks between prisms; plentiful fine and medium roots; medium acid (pH 5.6); abrupt wavy boundary. 9 to 11 in. thick.

Lab. No. 3761/1958: B22: 14 to 25 in.

Greyish-brown (10YR 5/2) clay, dark greyish-brown (10YR 4/2) when moist with 10 per cent strong brown (7.5YR 5/6) mottles; strong, fine, angular, blocky structure; hard, dry; firm, moist; sticky and very plastic, wet; very strongly acid (pH 4.9); 10 to 15 per cent fine brown concretions; thick continuous clay skins on all ped faces; plentiful fine and medium roots; gradual wavy boundary. 10 to 14 in thick.

Lab. No. 3762/1958: B23: 25 to 32 in.

Greyish-brown (10YR 5/2) clay, dark greyish-brown (10YR 4/2) when moist with 20 per cent strong brown (7.5YR 5/6) mottles; strong, medium and fine, angular, blocky structure; very hard, dry; very firm, moist; very sticky and very plastic, wet; plentiful fine and medium roots; a few thin clay skins; very strongly acid (pH 4.8); lower boundary as above. 19 to 24 in. thick.

Lab. No. 3763/1958: B3: 32 to 49 in.

Greyish-brown (10YR 5/2 moist) clay; compound strong coarse lentil and fine to medium angular blocky structure; consistence as in above horizons; many flattened roots in cracks between peds; approximately 5 per cent large, soft, black manganese concretions; many prominent slickenside surfaces; extremely acid (pH 4.3); gradual wavy boundary. 17 to 21 in. thick.

Lab. No. 3764/1958: C1: 49 to 54 in.

Variegated colours in equal proportions of strongly mottled greyish-brown (2.5Y 5/2), strong brown (7.5YR 5/6), grey (10YR 5/1) and black (10YR 2/1) sandy clay loam; moderate fine subangular blocky structure; hard, dry; friable, moist; slightly sticky and slightly plastic, wet; few fine roots; a few particles of weathered phonolite; 30 per cent black manganese concretions; very strongly acid (pH 4.9); abrupt smooth boundary. 6 to 8 in. thick.

Lab. No. 3765/1958: C2: 54 to 60 in. +

Partially weathered basalt parent rock.

Range in Characteristics.—The chief variation is in the depth to the parent material, which ranges from 4 to 6 ft. Small areas of sandy clay loam surface soil are included in the area mapped as Ongeng clay loam. Surface textures range over sandy loam, loam and sandy clay. The thin coatings to the tops and sides of the prisms in the B21 horizons are discontinuous.

Relief.—Nearly level to gently sloping residual uplands.

Drainage.—Moderately well drained, medium runoff in dry season; slow runoff in flatter slopes during wet season; slow internal drainage when profile is wet, but medium during dry periods.

Vegetation.—Parent vegetation mainly tall grasses with *Pennisetum catabasis* dominant species.

Use.—Most of the Ongeng soils are under cultivation and the more important crops grown are maize, sorghum, cassava, sweet potatoes and sugar-cane. It is probably one of the better soils for sugar-cane production in the East Konyango area. When rainfall is adequate yields of 30 to 40 tons of cane in a 24-month growing season may be expected.

Distribution.—Mapped in the northern part of the East Konyango area in the Rodi-Mirogi vicinity.

Type Location.—150 ft. north and 50 ft. west of Ongeng market. Map grid reference GZU 171285.

Series Established.—March, 1959.

Source of Name.—Ongeng market.

RANGWE SERIES

The Rangwe series consists of shallow to moderately deep well drained relic Groundwater Laterite soils developed from rhyolite. They occur on gently undulating to sloping uplands. At the present time the vegetation is predominantly grass but over part of the area there is a secondary vegetation mainly of *Combretum* sp. and *Tylosema fassoglensis*.

Rangwe soils are characteristically dark reddish-brown to reddish-brown throughout, usually of 5YR hues. In one small area, about four miles south-east of Mirogi, the subsoils have hues of 2.5YR. The structure of the B horizon is generally strong, fine to medium, subangular blocky. Iron-oxide concretions become numerous at a depth of 10 to 20 in. and at a depth of 20 to 30 in. massive indurated pisolitic laterite is encountered.

The Rangwe soils are geographically associated with the Nyokal, Ndhiwa and Nyamauro soils. The Nyokal soils are Planosols developed from rhyolite. The Ndhiwa soils, which are also Planosols are developed from alluvium derived primarily from rhyolite. It is the catenary associate of the Rangwe and occupies the lower footslopes and fans in some places. Nyamauro soils are Planosols developed in deep, fine textured, alluvium on stream terraces below the Rangwe soils.

The Rangwe soils have similar morphology to the Kibubu and Magina soils, the former developing from basaltic lava rocks and the latter from granitics.

Rangwe soils occur at elevations of 4,600 to 4,800 ft. in a climate having a mean annual precipitation of 45 to 50 inches with marked wet and dry seasons. The Rangwe soils occur mainly in the eastern part of the East Konyango area but rather extensive areas are also found in the south-western section between the Ndhiwa and the Kuja rivers.

Soil Profile: Rangwe Sandy Loam

Lab. No. 1356/1959: A1: 0 to 3 in.

Reddish-brown (5YR 4/3) sandy loam; dark reddish-brown (5YR 3/3) when moist; moderate, fine, granular structure; loose, dry; friable, moist; non-sticky and non-plastic, wet; abundant fine and medium roots; (pH 6.0); abrupt and smooth boundary. 3 to 5 in. thick.

Lab. No. 1357/1959: B2: 3 to 10 in.

Dark reddish-brown (5YR 3/3) sandy clay loam; strong, fine, subangular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; thin discontinuous clay skins on most ped faces; peds, when crushed, gain stronger chroma (5YR 3/4); a few fine quartz gravels and fine laterite concretions; abundant fine and medium roots; (pH 5.7). Lower boundary gradual and wavy. 7 to 10 in. thick.

Lab. No. 1358/1959: C1: 10 to 19 in.

Dark reddish-brown to reddish-brown (5YR 3.5/4) gravelly sandy loam; strong, fine, subangular, blocky structure; slightly hard, dry; friable, moist; non-sticky and non-plastic, wet; 50 to 60 per cent of the mass is laterite concretions; abundant fine and medium roots; (pH 6.2); gradual wavy boundary. 9 to 12 in. thick.

C2: 19 in. +

Massive indurated layer of laterite ironstone. Permeable but cannot be penetrated with auger.

Range in Characteristics.—Chief variation is in depth to indurated laterite ironstone horizon which ranges from 20 to 30 in. The laterite ironstone horizon varies from 1 to 4 ft. thick over the parent rock. Quartz and rhyolite rock fragments occur on the surface in many places. Subsoil structure ranges to medium subangular blocky. Bedrock and laterite outcrops are numerous.

Relief.—Nearly level to sloping uplands.

Drainage.—Well drained—runoff is medium to rapid. Internal drainage is medium to rapid.

Vegetation.—Grass vegetation, consisting primarily of *Panicum maximum, Setaria* sp., *Hyparrhenia dissoluta, Aristida adoensis, Erogrostis* sp., *Harpachne schimperi, Chloris pychnothrix* and *Rhynchelyrum repens.* In most places there is a secondary regeneration of *Combretum* sp. and *Tylosema fassoglensis.*

Use.—The Rangwe soils are the most intensively farmed soils in the East Konyango area. They produce fair yields of simsim, cowpeas, finger millet, sweet potatoes, kale, groundnuts and cassava. Maize is grown but does not do well.

Distribution.—Mainly in the eastern part of the East Konyango survey area and also between the Ndhiwa and Kuja rivers in the south-western section of the area.

Type Location.—Along the Rangwe-Marinde cut-off road, approximately 2½ miles south-west of Rangwe. Map grid reference GZU 304314.

Series Established.—March, 1959.

Source of Name.—Rangwe market, East Konyango soil survey area.

TABLE VIII (*k*)

Rangwe sandy loam *Map Ref.* GZU 304314 *Lab. No.* 1356 to 1358/1959

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1 ..	0–3	1·35	0·11	13	6·8	2·1	0·4	0·4	6·0	48	19·2	31·1	3–3:2:5	20	22	58
B_2 ..	3–10	1·32	0·09	9	6·8	2·0	0·1	0·3	5·7	47	21·6	37·6	4–2:3:5	28	22	50
C_1 ..	10–19	0·62	0·05	8	3·6	1·5	0·2	0·4	6·2	35	9·6	16·6	5–2:3:5	14	18	68

Rarage loam *Map Ref.* GZU 163279 *Lab. No.* 3773 to 3780/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A ..	0–3	4·74	0·24	34	6·3	5·0	1·0	1·0	5·5	69	48·0	38·2	5–4:3:3	26	38	36
B_2 ..	3–10	0·15	1·96	11	18·8	5·7	0·5	1·9	5·5	78	58·0	48·8	6–5:1:4	52	18	30
B_{23} ..	10–20	0·12	1·52	14	16·8	5·5	0·3	2·5	5·5	79	62·0	45·3	6–4:3:3	58	16	26
B_{24} ..	20–59	0·05	0·51	8	10·4	2·9	0·3	3·1	4·8	79	58·0	42·4	4–5:1:4	68	8	24
B_3 ..	59–69	0·02	0·09	15	13·2	4·2	0·4	3·6	7·6	96	52·0	35·5	4–5:3:2	58	16	25
C_{1g} ..	69–87	0·02	0·30	21	23·2	4·4	0·3	4·0	7·5	96	51·2	35·0	4–5:2:3	52	20	28
C_{2g} ..	87–98	0·02	0·69	34	20·0	5·9	0·3	3·5	7·6	97	52·0	44·0	8–4:3:3	44	22	34
C_3 ..	98–110	Nil	0·30	40	18·0	4·9	0·3	3·2	7·4	92	52·0	42·0	7–4:3:3	46	20	34

RARAGE SERIES

The Rarage series consists of imperfectly or somewhat poorly drained clayey soils having weak solonetzic characteristics. They occur on nearly level stream terraces and valley fills along the present drainage systems in the East Konyango area. The parent material consists of fine-textured alluvium derived from both basic and acidic parent rocks.

The Rarage soils are characterized by a very dark brown to very dark grey loamy surface soil which is underlain by sticky, plastic clay, having coarse prismatic structure. The prisms grade into strongly mottled clay at 10 to 14 in. depths. These soils have the physical properties and the high exchangeable sodium percentage in the B horizons of Solonetz soils.

The Rarage soils are associated with the Rodi, Ongeng and Akijo soils which are developed in residuum from basic igneous rocks and occupy higher elevations away from the present drainageways. Rarage soils occupy similar positions as Marinde clay loam which is also a Solonetz soil.

The Rarage soils occur at elevations of about 4,250 ft. in a climate having a mean annual precipitation of 45 to 50 in. with a marked wet and dry season.

Soil Profile: Rarage Loam

Lab. No. 3773/1958: A: 0 to 3 in.

Dark greyish-brown (10YR 4/1.5) loam, very dark brown (10YR 2/1.5) when moist; strong, fine, subangular, blocky structure; slightly hard, dry; firm, moist; slightly sticky and plastic, wet; abundant fine and medium roots; approximately 20 per cent yellowish-red spots due to periodic burning; (pH 5.5); abrupt wavy boundary. 3 to 6 in. thick.

Lab. No. 3774/1958: B2: 3 to 10 in.

Very dark grey (10YR 2.5/1) clay, black (10YR 2/1) when moist; strong coarse, prismatic, breaking to strong, medium subangular blocky structure; very hard, dry; very firm, moist; very sticky and very plastic, wet; thick continuous clay skins on ped faces; in some parts of the pit there is a grey (10YR 6/1) sprinkling on top of prisms and down the cracks between prisms; plentiful fine and medium roots; (pH 5.5); clear wavy boundary. 7 to 14 in. thick.

Lab. No. 3775/1958: B23: 10 to 20 in.

Dark grey (10YR 4/1) clay, very dark grey (10YR 3/1.5) when moist; strong, fine to medium subangular blocky structure; consistence as above; thin discontinuous clay skins on ped faces; plentiful fine and medium roots; (pH 5.5); gradual wavy boundary. 10 to 14 in. thick.

Lab. No. 3776/1958: B24: 20 to 59 in.

Greyish-brown (10YR 5/2) dry and moist, clay; strong coarse lentils which break to strong, medium and fine, angular, blocky structure; consistence as above; a few black (10YR 2/1) clay skins on ped faces; prominent slickensides with many flattened roots along joints; (pH 4.8); gradual wavy boundary. 30 to 40 in. thick.

Lab. No. 3777/1958: B3: 59 to 69 in.

Light brownish-grey (2.5Y 6/2) clay, greyish-brown (2.5Y 5/2) when moist; mottled approximately 10 per cent yellowish-brown (10YR 5/6); strong, medium, angular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; prominent slickensides; a few fine roots along joints; (pH 7.6); clear boundary. 8 to 12 in. thick.

Lab. No. 3778/1958: C1g: 69 to 87 in.

Light brownish-grey (2.5Y 6/2) clay loam, greyish-brown (2.5Y 5/2) when moist; approximately 20 per cent strong brown (7.5YR 5/6) and 10 per cent yellowish-red (5YR 4/6) mottles; strong, medium, angular, blocky structure; hard, dry; friable, moist; sticky and plastic, wet; approximately 5 per cent soft brown iron-oxide concretions; (pH 7.5); clear boundary. 16 to 20 in. thick.

Lab. No. 3779/1958: C2g: 87 to 98 in.

Strongly mottled greyish-brown (2.5Y 5/2) light brownish-grey (10YR 6/2) and very dark greyish-brown (10YR 3/1.5) clay; moderate, fine, angular, blocky structure; hard, dry; friable, moist; sticky and plastic, wet; (pH 7.6); clear boundary.

Lab. No. 3780/1958: C3: 98 to 110 in.

Greyish-brown (2.5Y 5/2, moist) clay; mottled 20 per cent light yellowish-brown (10YR 6/4). Approximately 30 per cent soft black manganese concretions and stains; moderate fine, angular, blocky structure; (pH 7.4); consistence as above.

Range in Characteristics.—The chief variation is in degree of mottling. Some profiles exhibit much more strongly mottled subsoil horizons than the above profile. Strong prismatic structure in the B horizon is not always evident. Visible salt specks often occur at depths of 4 to 5 ft.

Relief.—Nearly level stream terraces and valley fills.

Drainage.—Imperfectly drained. Runoff is slow to medium. Internal drainage is slow.

Vegetation.—Grass, with *Pennisetum catabasis, Sporobolus* sp., *Hyparrhenia* sp. dominant.

Use.—Most of this soil is used for pasture. Sugar cane growing on it appeared to be doing fairly well. However, it has been reported that the cane contains enough salt to affect the quality of jaggery.

Distribution.—At the present time, known only in the East Konyango area, where it occurs as small continuous bodies along the tributaries of the major drainage systems.

Type Location.—Along main Ongeng-Mirogi road, approximately one mile west of Ongeng Market. Map grid reference GZU 163279.

Series Established.—April, 1959.

Source of Name.—Rarage River, East Konyango.

RODI SERIES

The Rodi series consists of somewhat poorly drained, moderately deep to deep, Grumusol-Planosol intergrade soils developed from basaltic lavas, conglomerates and volcanic tuff. They occur on nearly level to gently undulating plains, mainly in the northern part of the East Konyango area.

The subsoils of the Rodi series are characteristically dark grey to grey sandy clays to clays, having moderately well-developed prismatic structure. The prisms break readily into strong, medium, subangular blocks. The prisms grade into subangular blocky clay at 14 to 20 in. depths, and this is underlain by hard rock at 36 to 40 in. depths.

Rodi soils are found mainly in association with the Ongeng soils, with minor areas of both Bhanji and Kibubu series being present. The main difference between the Rodi and the Ongeng series is the depth to the underlying rock. In the Ongeng series it is much deeper and parent rock is seldom found within the 5-ft. auger depth.

The Rodi series occur at elevations of from 4,400 to 4,500 ft. in a climate having a marked wet and dry season with a total annual precipitation of 45 to 50 in.

Soil Profile: Rodi Clay Loam

Lab. No. 3781/1958: A1p: 0 to 7 in.

Black to very dark brown (7.5YR 2.5/2) clay loam, very dark grey when dry (7.5YR 3/2); strong, fine, subangular, blocky structure; slightly hard, dry; friable, moist; sticky and plastic, wet; many fine and medium roots; many yellowish-red burnt concretions; abundant fine and medium roots; non-calcareous; (pH 5.3); abrupt and smooth boundary. 7 to 8 in. thick.

Lab. No. 3782/1958: B2: 7 to 14 in.

Very dark grey (7.5YR 3/1) sandy clay loam; moderate, coarse prisms, breaking to strong, fine, subangular, blocky structure; hard, dry; firm, moist; sticky and plastic, wet; plentiful fine and medium roots; contains 10 per cent fine iron manganese concretions; non-calcareous; (pH 5.3); lower boundary clear and wavy. 6 to 12 in. thick.

Lab. No. 3783/1958: B3: 14 to 29 in.

Dark grey to grey (10YR 4.5/1) sandy clay, with common, fine, faint greyish-brown (10YR 5/2) mottles; strong, medium to coarse, angular, blocky structure; non-calcareous; very hard, dry; very firm, moist; very sticky and very plastic, wet; many fine roots, some through peds; many slickensides; (pH 5.4); gradual wavy boundary. 15 to 16 in. thick.

Lab. No. 3784/1958: C1: 29 to 36 in.

Variegated colours of equal proportions, dark greyish-brown (2.5Y 4/2) and greyish-brown (10YR 5/2) sandy loam; moderate, medium, angular, blocky structure; very hard, dry; firm, moist; very sticky and very plastic, wet; contains many black weathered basaltic fragments; (pH 6.0); abrupt and clear lower boundary. 7 to 9 in. thick.

Lab. No. 3785/1958: C2: 36 to 40 in.

Hard, black, slightly weathered, basalt parent rock; (pH 6.7).

Range in Characteristics.—Depth to parent rock ranges from 36 to 40 in. Surface textures vary from loam to sandy clay to clay loam. B horizons vary from sandy clay to clay. Small pockets of volcanic ash are often found over the weathered basalt parent rock. Rock outcrops and basaltic stones are not uncommon. Occasionally a very thin grey layer of sandy loam occurs over the tops of the prisms.

Relief.—Nearly level to gently undulating plains.

Drainage.—Somewhat poorly drained. Runoff is medium in most places, but slow in more level areas. Internal drainage is medium to slow.

Vegetation.—Grass, with *Pennisetum catabasis, Sporobolus* sp. and *Hyparrhenia* sp. dominant.

Use.—Much of the Rodi soil is cultivated. Crops grown include maize, sorghum, finger millet, beans, cowpeas, simsim, yams, cassava and sugar cane.

Distribution.—The Rodi series covers extensive areas of the larva-covered upland plains of the northern part of the East Konyango Survey area, the main areas being in the vicinity of Rodi, Marinde and Ongeng.

Type of Location.—Along main Ongeng-Mirogi road approximately 1½ miles west of Ongeng. Map grid reference GZU 156276.

Series Established.—1959.

Source of Name.—Rodi Market, Kanyada location.

TABLE VIII (*l*)

Rodi clay loam *Map Ref.* GZU 156276 *Lab. No.* 3781 to 3785/1958

Hor.	Depth inches	% Org. C	% N	ppm P	ME/100 ml soil				pH 1:1	% sat.	ME/100 g soil		Charge dist.	% clay	% silt	% sand
					Ca	Mg	K	Na			CEC	AEC				
A_1p ..	0–7	2·7	0·18	17	15·6	8·0	0·3	0·7	5·3	53	46·4	44·7	5–5:0:5	26	22	52
B_2 ..	7–14	1·79	0·11	9	14·4	6·3	0·3	0·8* 0·7	5·3	51	41·6	51·6	4–3:4:3	26	22	52
B_3 ..	14–29	—	0·04	10	10·4	7·9	0·4	1·3* 0·9	5·4	70	48·0	41·2	6–5:1:4	42	6	52
C_1 ..	29–36	0·09	0·02	34	9·6	10·9	0·3	1·7* 0·9	6·0	80	62·0	52·3	6–4:3:3	16	14	70
C_2 ..	36–40	—	—	303	11·2	8·4	0·4	1·6* 1·8	6·7	87	54·0	57·0	4–3:4:3	2	10	88

*Neutral normal ammonium acetate extraction following U.S.D.A. Agriculture Handbook No. 60. Contents expressed as Me/100 gm. soil.

G.P.K. 5529—500—8/60

NYA 1:50,000

EAST KONYANGO SOIL SURVEY

Sheet 129/II, 129/IV, 130/I & 130/III (Parts of)

c) 3010A
- D.O.S.
Directorate of Overseas Surveys

photographed by D.O.S.
repared from D.O.S. 23 with some later corrections

SCALE 1:50,000

Mile 1 ¾ ½ ¼ 0 1 2 3 4 5 6 7 8 9 10 Miles
Yards 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 Yards
Metres 1000 500 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Kilometres

Printed for D.O.S. by the Ordnance Survey.
Soil survey carried out with the aid of the International Co-operation Administration of the United States of America.
Soil survey : F.T. Miller, G.A. Woodruff and F.W. Collier, October 1958-June 1959.
Correlation : James Thorp and E. Bellis.
This map is one of two which accompany Soil Survey Report No. 2/60 of the Department of Agriculture, Kenya.
2,500/3/61/1183/O.S.

Alluvial soils, undifferentiated, 0%-3% slopes	A-A
Akijo clay loam, 0%-3% slopes	Acl-A
Akijo clay loam, 3%-8% slopes	Acl-B
Akijo clay loam, 8%-13% slopes	Acl-C
Akijo clay loam, 13%-20% slopes	Acl-D
Akijo clay loam, moderately eroded, 8%-13% slopes	Acl-C-2
Bhanji clay loam, 0%-3% slopes	Bicl-A
Bhanji clay loam, 3%-8% slopes	Bicl-B
Bhanji stony loam, 0%-8% slopes	Bisl-AB
Bhanji stony loam, 8%-13% slopes	Bisl-C
Eroded salt licks and volcanic ash, 0%-3% slopes	Es-A
Kibubu gravelly sandy loam, 0%-8% slopes	Kgl-AB
Kibubu gravelly sandy loam, 8%-13% slopes	Kgl-C
Kibubu stony loam, 0%-8% slopes	[illegible]
Kibugo loam, 0%-3% slopes	Kll-A
Kibugo loam, 3%-8% slopes	Kll-B
Kibigori clay loam, 0%-3% slopes	Kbc-A
Konyango clay loam, 0%-3% slopes	Kcl-A
Konyango clay loam, 3%-8% slopes	Kcl-B
Kuja loam, 0%-3% slopes	Kul-A
Langi loam, 0%-3% slopes	Ll-A
Langi loam, 3%-8% slopes	Ll-B
Magina loamy coarse sand, 0%-8% slopes	Mls-AB
Magina loamy coarse sand, 3%-13% slopes	Mls-BC
Marinde clay loam, 0%-3% slopes	Mcl-A
Mirogi clay, 0%-3% slopes	Mrc-A
Mirogi clay, 3%-8% slopes	Mrc-B
Misathe loam, 0%-3% slopes	Mll-A
Misathe loam, 3%-8% slopes	Mll-B
Ndhiwa loam, 3%-8% slopes	Ndl-B
Nyangu stony sandy loam, 0%-8% slopes	Nss-AB
Nyangu-Magina complex, 3%-13% slopes	Nx-BC
Nyamauro loam, 0%-3% slopes	Nyl-A
Nyamauro loam, 3%-8% slopes	Nyl-B
Nyokal sandy loam, 0%-3% slopes	Ncl-A
Nyokal sandy loam, 3%-8% slopes	Ncl-B
Obeiro sandy clay loam, 3%-8% slopes	Orl-B
Oboke sandy loam, 3%-8% slopes	Ocl-B
Okok clay loam, 3%-8% slopes	Ok-B
Okok clay loam, 8%-13% slopes	Ok-C
Olungo clay loam, 0%-3% slopes	Ol-A
Ongeng clay loam, 0%-3% slopes	Onc-A
Ongeng clay loam, 3%-8% slopes	Onc-B
Ongeng loam, 0%-3% slopes	Onl-A
Ongeng loam, 3%-8% slopes	Onl-B
Ongeng sandy loam, 0%-3% slopes	Ons-A
Permanent Swamps, 0%-3% slopes	PS-A
Rangwe sandy loam, 0%-3% slopes	Rsl-A
Rangwe sandy loam, 3%-13% slopes	Rsl-BC
Rangwe clay loam, colluvial variant, 3%-8% slopes	Rac-B
Rarage loam, moderately saline, 0%-3% slopes	Rgl-A
Rodi clay loam, 0%-3% slopes	Rcl-A
Rodi clay loam, 3%-8% slopes	Rcl-B
Stony land, Kibubu soil material, 8%-20% slopes	Stk-CD
Stony land, Ongeng and Langi soil material, 0%-13% slopes	Sml-AC
Stony land, basaltic rocks, 8%-20% slopes	Sb-CD
Stony land, basaltic rocks, 20%+ slopes	Sb-E
Stony land, siliceous rocks, 0%-8% slopes	Ss-AB
Stony land, siliceous rocks, 8%-20% slopes	Ss-CD

Main Roads
Secondary Roads
Tracks
Rivers
Permanent buildings
Soil survey boundary

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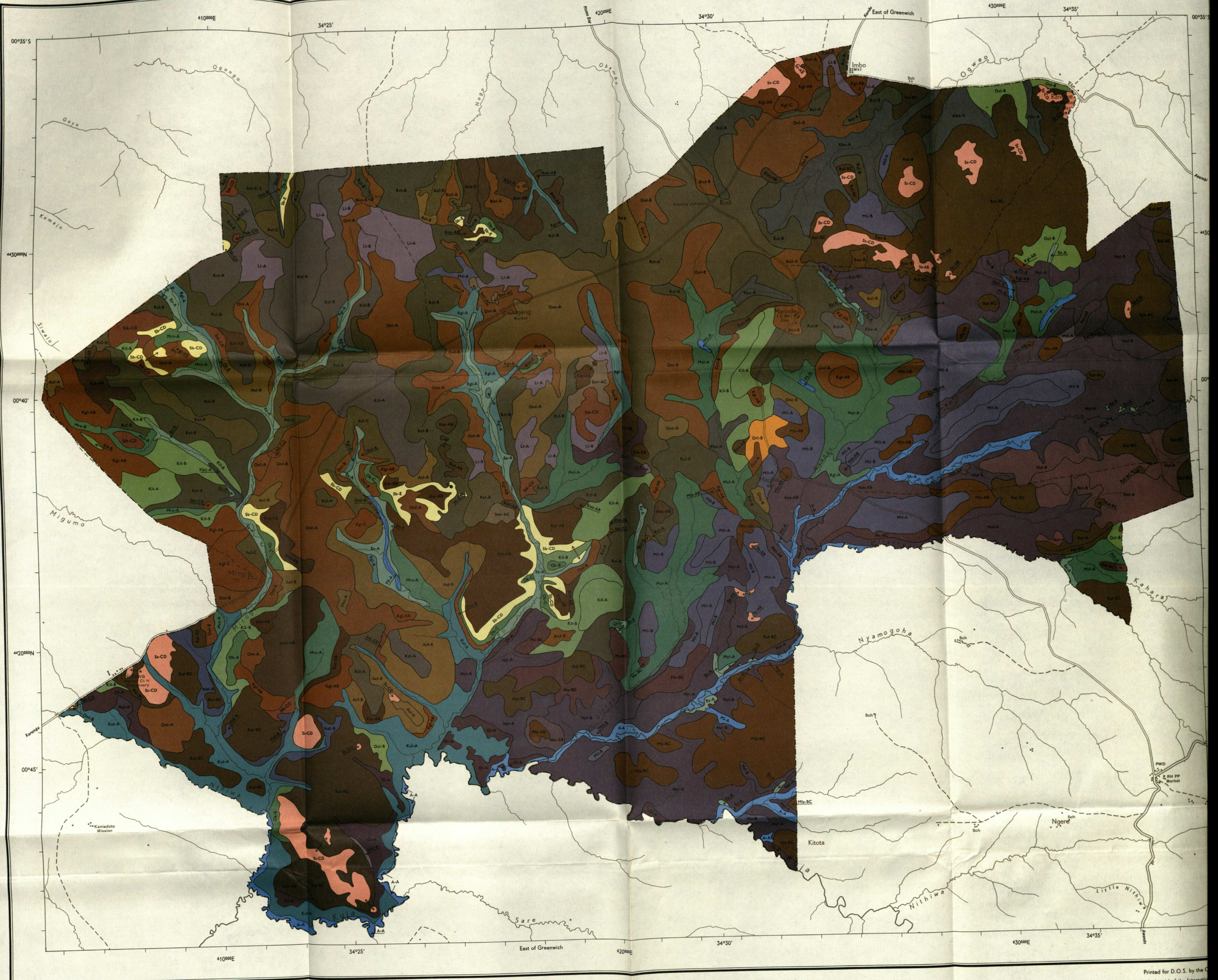
Copies of the report, which includes both maps, may be obtained from the Government Printer, Nairobi, Kenya.

KENYA 1:50,000

EAST KONYANGO SOIL SURVEY

Sheet 129/II, 129/IV, 130/I & 130/III (Parts of



D.O.S. (Misc) 3010A
First Edition - D.O.S.
Published by Directorate of Overseas Surveys

Drawn and photographed by D.O.S.
Base map prepared from D.O.S. 23 with some later corrections

SCALE 1:50,000

Mile 1 ½ 0 1 2 3 4 5 6 7 8 9 10 Miles

Yards 1000 0 1000 2000 3000 4000 5000 6000 7000 8000 9000 10000 11000 12000 13000 14000 15000 16000 17000 Yards

Metres 1000 500 0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 Kilometres

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Soil survey carried out with the aid of the Internatio
Administration of the United S
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Correlation: James Th
This map is one of two which accompany Soil Survey
of the Department of A

Alluvial soils, undifferentiated, 0%-3% slopes	A-A
Akijo clay loam, 0%-3% slopes	Acl-A
Akijo clay loam, 3%-8% slopes	Acl-B
Akijo clay loam, 8%-13% slopes	Acl-C
Akijo clay loam, 13%-20% slopes	Acl-D
Akijo clay loam, moderately eroded, 8%-13% slopes	Acl-C-2
Bhanji clay loam, 0%-3% slopes	Bicl-A
Bhanji clay loam, 3%-8% slopes	Bicl-B
Bhanji stony loam, 0%-8% slopes	Bist-AB
Bhanji stony loam, 8%-13% slopes	Bist-C
Eroded salt licks and volcanic ash, 0%-3% slopes	Es-A
Kibubu gravelly sandy loam, 0%-8% slopes	Kgl-AB
Kibubu gravelly sandy loam, 8%-13% slopes	Kgl-C
Kibubu stony loam, 0%-8% slopes	Kst-AB
Kibugo loam, 0%-3% slopes	Kil-A
Kibugo loam, 3%-8% slopes	Kil-B
Kibigori clay loam, 0%-3% slopes	Kbc-A
Konyango clay loam, 0%-3% slopes	Kcl-A
Konyango clay loam, 3%-8% slopes	Kcl-B
Kuja loam, 0%-3% slopes	Kul-A
Langi loam, 0%-3% slopes	Ll-A
Langi loam, 3%-8% slopes	Ll-B
Magina loamy coarse sand, 0%-8% slopes	Ms-AB
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Mirogi clay, 3%-8% slopes	Mrc-B
Misathe loam, 0%-3% slopes	Mll-A
Misathe loam, 3%-8% slopes	Mll-B
Ndhiwa loam, 3%-8% slopes	Ndl-B
Nyangu stony sandy loam, 0%-8% slopes	Nst-AB
Nyangu-Magina complex, 3%-13% slopes	Mx-BC
Nyamauro loam, 0%-3% slopes	Nyl-A
Nyamauro loam, 3%-8% slopes	Nyl-B
Nyokal sandy loam, 0%-3% slopes	Ncl-A
Nyokal sandy loam, 3%-8% slopes	Ncl-B
Obeiro sandy clay loam, 3%-8% slopes	Orl-B
Oboke sandy loam, 3%-8% slopes	Ocl-B
Okok clay loam, 3%-8% slopes	Ok-B
Okok clay loam, 8%-13% slopes	Ok-C
Olungo clay loam, 0%-3% slopes	Ol-A
Ongeng clay loam, 0%-3% slopes	Onc-A
Ongeng clay loam, 3%-8% slopes	Onc-B
Ongeng loam, 0%-3% slopes	Onl-A
Ongeng loam, 3%-8% slopes	Onl-B
Ongeng sandy loam, 0%-3% slopes	Ons-A
Permanent Swamps, 0%-3% slopes	PS-A
Rangwe sandy loam, 0%-3% slopes	Ral-A
Rangwe sandy loam, 3%-13% slopes	Ral-BC
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Main Roads
Secondary Roads
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