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SOIL SURVEY
OF THE
SONGHOR AREA KENYA

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Nyanza and Rift Valley Provinces, Kenya

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I—INTRODUCTION

Location

The Songhor survey area comprises about 203 square miles or nearly 130,000 acres of land on the eastern end of the Kano Plain of Central Nyanza, and contiguous foothills and valleys of the Nandi escarpment, on the north, and of the Tinderet Highlands on the east. The western edge is a north-south line about 18 miles east of Kisumu and 1,400 yards west of Kibigori railway station, where it joins the Sir Alexander Gibb survey of the Kano Plains; the eastern boundary, 34 miles east of Kisumu, follows the meridian 35° 15′ E. latitude; the northern limit is the Nandi escarpment; and the southern boundary follows the Kisumu-Muhoroni road to Kiligis market, and thence to the eastern edge of the area along the boundary of European settlement. The equator traverses the entire length of the northern part of the area, nearly 4 miles north of Songhor Post Office and 5 miles north of Kibigori railway station.

Administration

Government of different parts is administered by the Kericho and Central Nyanza Districts of Nyanza Province, and by the Nandi District of the Rift Valley Province.

Population, Settlement and Agriculture

Land is owned and occupied as follows:—

(1) Europeans	... ...	65.2 per cent in the east.
(2) Luo tribe	... ...	14.4 per cent in the southwest.
(3) Asians	... ...	13.7 per cent in the northwest.
(4) Nandi tribe	... ...	5.0 per cent in the extreme northwest.
(5) Kipsigis tribe	... ...	1.7 per cent in the south-central.

According to old settlers* agriculture as now practised began to develop in the Songhor area several years after the construction of the Uganda railway to the Muhoroni railhead in 1904. No Europeans had settled here prior to this time, and the land had been occupied intermittently by warring Nandi and Kavirondo (Luo) tribes. The 1906 Nandi rebellion halted temporarily the progress of the railway and military forces were called in to restore order and protect the construction crews. The Nandis were driven out of the Muhoroni-Songhor area back into the Nandi Hills; and the other tribes, in fear of the Nandis, generally stayed south of the railway track as it advanced towards Kibigori. Most of the area then remained uninhabited by Africans. The Government decided to use this area as a buffer strip of European settlement between the Luo and Nandi tribes. A survey divided the land into tracts of 1,000 to 1,400 acres, and Europeans and Asians were encouraged to develop stable agricultural communities.

Between 1911 and 1919 about 20 families were farming around Songhor. Sisal, coffee, maize and millet were the principal crops first grown. Rubber trees were tried, but were unsuccessful. Native labour, mostly from the Luo tribe, was employed for farm work and the labourers brought with them their sheep, cattle and goats.

The 1919 Veterans' Settlement Scheme brought many new families into the area, and the 1920 to 1930 period was one of gradual and fairly prosperous agricultural growth. More than 60 Asian and European families lived and farmed in the Songhor, Muhoroni and Chemelil settlements. Coffee, owing to good prices, was the principal cash crop; and sugar cane, sisal, maize and millet also were grown. Sisal prices were low during this time, but with low production costs, a small profit was realized. Most livestock products were consumed locally.

The depression years of the 1930's seriously disrupted agricultural development. Coffee prices took a sharp decline and most of the coffee acreage was completely abandoned. Other agricultural prices also were low and many settlers left their farms and relinquished their estates. Those who stayed struggled along on a subsistence type of agriculture, growing the crops which showed a bare profit. During this period there was a gradual trend towards a more extensive type of agriculture and livestock numbers were increased on native pasture lands.

When war broke out in 1939, most young European farmers from the area joined their brothers-in-arms and for the next three years or so the farms were kept going as far as possible by wives and by the few who were too old or insufficiently fit to fight. Inevitably, the intensity of local farming remained low. Ultimately, however, the war receded from East Africa and as it did so, the territories were called upon increasingly to contribute to the war effort by increasing crop production. With this in view many of the European war-

* We are indebted especially to Mr. W. Perry of Songhor for the brief summary of the history of settlement.

time soldiers were returned to their farms during the latter stages of the war in Africa and this was succeeded by a substantial increase in maize and sisal production at Songhor. World prices remained high after 1945 and continued so until the end of the Korean incident. In consequence, the official marketing organizations concerned with these crops were able to maintain a progressive policy regarding prices and Songhor enjoyed a period of prosperity and development went ahead. Sisal production benefited particularly and growers bought up extensive tracts of land in the locality and many estates were planted up entirely to the crop.

During the present farming period, the 1950's, especially since the Korean war, farmers once more have had to adjust to another downward price trend. Sisal prices declined to near record lows. Maize brought much lower prices than formerly; but Kenya coffee prices are up. Coffee is in good demand, but the production of coffee in Songhor has never regained the importance it held during the 1920's because growing conditions are not ideal for coffee. Low sisal prices have led to the decline and abandonment of many sisal estates. The good coffee prices so increased the interest in coffee growing during the late 1950's that some small new plantings were established, and better husbandry was practised on the older established plantings. Butter-fat prices were lower than a few years earlier. Slaughter steers were in good demand, and good prices were offered by the Kenya Meat Commission.

Asian farmers had long been established in the locality, had found that sugar can can be grown satisfactorily and had responded to post-war improvements in cane and cane products marketing by developing quite extensive commercial plantings of the crop. The success of these plantings inspired a number of European farmers in the search for a new remunerative crop to make trial plantings on their own farms. The possibility of expanding sugar production at Songhor also has attracted the interest of sugar manufacturers on a number of occasions in the past, though until this survey was undertaken no major development of the crop on European farms or of the extra factory capacity required to handle it has resulted. The irrigation of sugar was tried during the early days of settlement at Songhor and was found successful, though only recently has the inspired leadership of the Hindocha family led to any major provision of facilities. Several hundred acres of Asian-grown cane are now under irrigation.

Considerably more than half of the arable land on European farms supports a rank growth of largely native grasses that are grazed by dairy and beef cattle. Many of the pastures are under-used and much work is needed to improve them. Most of the dairy products are sold on the Kisumu and Miwani markets.

The densely populated Luo reserve lands comprise fragmented holdings, used for growing maize, sorghum, millet and other subsistence crops, and these holdings are interspersed with irregular networks of grazing land, used in common by all owners of cattle, sheep and goats. The cultivated land is badly infested with weeds—especially the parasitic witch weed *Striga asiaticus* —which greatly reduce yields; and the grassland networks are heavily over-grazed and are being eroded rapidly on the sloping parts near the water courses. At the instigation of the Kenya Department of Agriculture, rice has been grown in some of the larger swamps south of the Nyando River, but plantings have been abandoned and the land has reverted to native pasture.

About 3,000 acres of the Luo reserve east and northeast of Awasi market are very stony and are used primarily for grazing; but small patches of moderately deep soils within this area are planted to grains and other subsistence crops. An experimental planting of a few hundred acres of sugar cane has been made on the Luo reserve along the railway southeast of Kibigori, under the guidance of the agricultural officers headquartered at Kisumu, to lead the way toward greater cash income for Luo farmers.

Only about 2,250 acres of the Songhor survey area lies in the Kipsigis reserve, west and northwest of Kiligis market and south of the Muhoroni-Kisumu highway. About half of this land is too stony to cultivate and part of the remainder is badly eroded. About one fourth of the Kipsigis land is used for growing subsistence crops and the remainder is grazing land, most of which is badly over-grazed.

The Nandi tribal lands of the Songhor area are confined to about 6,500 acres northeast of Kibigori on the long slopes below the Nandi escarpment. The Nandi people maintain cattle as their main enterprise and cultivate enough maize and other subsistence crops to provide food for their families.

Muhoroni is near the main Kisumu-Nairobi highway, and a narrower all-weather road connects Muhoroni with Kapsabet, by way of Songhor and the Nandi Hills. All-weather roads are available in the following directions:—

(1) Songhor, up Mteitei Valley and from thence across the Tinderet Highlands to Lumbwa. (Part of the Tinderet Highlands is impassable in very wet weather.)

(2) Songhor to Kisumu, via Volo and Chemelil Sisal Estates, past Kibigori and through Miwani.

(3) Songhor to Chemelil station and to Kisumu, through Chemelil Sugar Estate.

(4) Muhoroni, south to Kericho.

In addition roads and "grass tracks" motorable in dry seasons reach within a mile or two of all parts of the area except in the Luo reserve of East Kano. Some of the narrower all-weather roads may be impassable for short periods after very heavy rains when drifts (fords) and bridges may be flooded.

A few poorly equipped African schools are scattered over the area, and several Christian churches have been established by various missions. Most European children are sent to boarding schools in larger centres, outside the Songhor area.

The European community holds Church of England services about twice a month in the church at Songhor. The Songhor Sports Club is an important centre for European social life. Most European farms have party-line telephone service. Muhoroni, Songhor, Kibigori and George Estate have general merchandise shops and petrol pumps.

Purposes of the Survey

The soil survey of the Songhor area is intended to provide specific and moderately detailed information about the physical and chemical properties of the soils for use in improving the local agricultural and living conditions of the people. The individual soil types are outlined on a map as accurately as could be done in a period of about five months. The immediate purpose of the survey was to provide a sound basis for estimating the total area of land that might be reasonably well suited for growing sugar cane in the expectation that capital might be found for establishing a new sugar mill, which would provide a ready cash market for local farmers of Songhor, Muhoroni and the neighbouring African reserves.

How the Survey was Made

Members of the soil-survey party traversed the area at intervals ranging from about one-fourth to three-fourths mile, using aerial photographs to locate exactly each place the soil was examined. Surveyors stopped at appropriate intervals and examined the soil in specially dug pits and auger borings, most of which were at least five feet deep. From the examinations it was possible to describe the colour and to estimate texture (percentages of gravel, sand, silt and clay) in all layers of the soil, and the organic-matter content. The soil structure (size, shape and degree of firmness of the natural lumps of the crumbled soil) was described also, because, to an important degree, it determines where tilth will be good or bad. Soils were given simple chemical tests in the field. They were classified, tentatively, on the basis of these field observations, into *series, types,* and *phases*. The soil series is given a place name (e.g. *Songhor series*). It includes soils that are essentially alike in all respects except in the texture (proportions of sand, silt and clay) in the uppermost layer or plough soil. For example, members of the Mbereri series (named for Mbereri Estate) include reddish soils of the alluvial-fan slopes around the Songhor Hills. *Mbereri coarse sandy loam* is a *soil type* of the *Mbereri series* which has coarse sandy loam plough soil. *Mbereri stony gravelly loam* is another type of the Mbereri series which is too stony to cultivate except with hoes or other hand tools. Phases of soil types have to do chiefly with slope gradients and the degree of agriculturally accelerated erosion which had already taken place before the survey was made.

The soil surveyor bases his outline of each soil type on the map (1) by his spot determinations of the soil in the field, (2) by the lie of the land, (3) by the patterns of natural vegetation, (4) by the appearance of crops to some extent, and (5) by different degrees of shading on the vertical aerial photographs which are used as a base map. Many samples of soil were taken for chemical analysis. In each place subsamples were taken from each different layer of each soil to depths ranging up to about 12 feet, where soils were very deep, and to bedrock where soils were shallower.

The tentative classification, briefly outlined above, was subjected to check and drastic revision after the soil samples had been carried to the laboratories and tested chemically and biologically. Two soils that look very much alike in the field may prove to be different in important respects when they are subjected to analysis. Each of the soil types recognised in the Songhor area is described in detail in the section entitled "Soils".

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 at close hand may vary somewhat from their actual position on the ground.

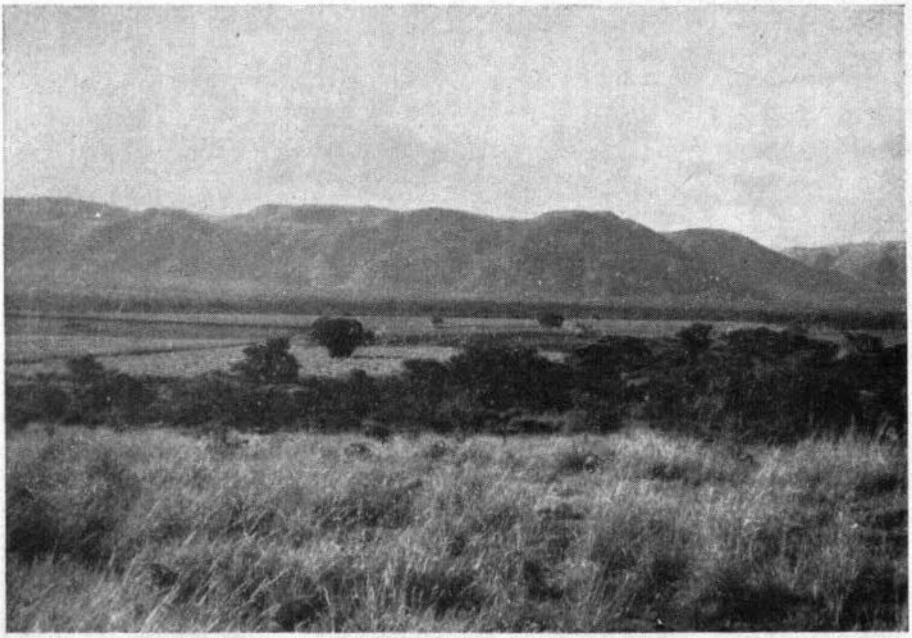
Also, the survey records only the features revealed by the techniques available for undertaking it and it is imperfect to the extent that these techniques or the handling of these techniques is imperfect. In the absence of a detailed examination of every minutest part of the survey area and of every layer of soil in each part, the possibility remains that some soil changes 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 will show an intrinsic heterogeneity of such intensity that the component variants defy mapping. These situations have been met by including in the soil descriptions in the report and in the appendix an indication of the range of characteristics likely to be encountered with each soil. In particular, the small scale of the base map (1/50,000) makes it impracticable to outline many patches of soil of as little as 5 acres. For instance, a number of small stony spots, in soils otherwise moderately deep, could not be shown. These omissions are mentioned in the description of the soil types.

II—GENERAL CHARACTER OF THE AREA

Land Forms Relief, Drainage

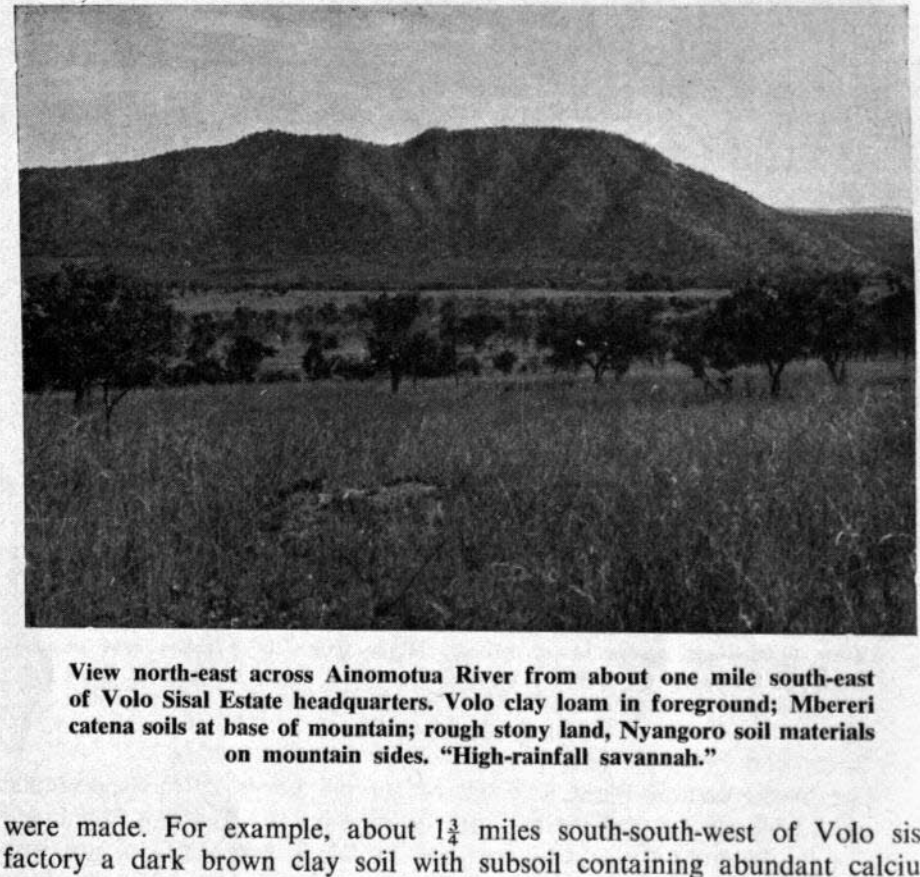
The heart of the Songhor survey area is a broad plain, continuous with the great Kano Plain, but rising eastward and merging with alluvial fans and valley terraces of the hills and mountains to the north, east and south. The nearly level Kano Plain is tributary to the Kavirondo Gulf of Lake Victoria and is believed to have been covered by the lake during the high-water stages that prevailed during certain ages of Pleistocene time. Much of the soil material of the plain was deposited in this old arm of the lake by streams that brought erosion products from the surrounding mountains. The lowest level in the area, on the Nyando River south of Kibigori, is about 3,860 feet above sea level and about 135 feet above Lake Victoria. The highest land is near the top of the Nandi escarpment north of Kibigori, and on the west edge of the Tinderet Highlands, south-east of Songhor, where elevations are somewhat more than 6,000 feet. Gradients of 1,000 to 1,500 feet to the mile are common on the Nandi escarpment.



View north-west across lower Mbogo River from three miles east of Kibigori. Complex of arable clay soils on valley sides; Rama clay loam in sugar-cane at left centre, and Kibigori clay in cane, right centre; Nandi Escarpment at back.

The broad central plain is bordered on the north by the spectacular wall of the Nandi escarpment and on the east by the Tinderet Highlands. South of the Nyando River a lower rocky tableland extends from just west of Muhoroni to the Awasi market, on the Kisumu road, about 2½ miles from the western border of the area. The tableland is a lava bed that lies about 4,500 feet above sea level and 100 to 300 feet above the plain. From Kibigori the central plain merges northward into a series of alluvial fans that come down from the Nandi escarpment. Eastward and north-eastward the plain rises gradually to an elevation of 4,500 feet where it divides and fingers its way up the many stream valleys of the Tinderet Highlands.

On the south-eastern part of the broad central plain the soil materials comprise beds of water-laid heavy clay, up to nearly 100 feet thick, interbedded with several layers of light-coloured laminated volcanic ash of fine sandy and silty textures, and many lenses of gravel, sand and cobble along the courses of former streams that entered the ancient lake from the north and east. Alluvial-fan deposits of mixed, moderately sandy and clayey textures come down from the Nandi escarpment, and their terraced surfaces blend gradually into the level Kano Plain. The clay beds seem to have been deposited partly in marshes and partly in an open lake, and some of them appear to have been subjected to soil-forming processes before later deposits



View north-east across Ainomotua River from about one mile south-east of Volo Sisal Estate headquarters. Volo clay loam in foreground; Mbereri catena soils at base of mountain; rough stony land, Nyangoro soil materials on mountain sides. "High-rainfall savannah."

were made. For example, about 1¾ miles south-south-west of Volo sisal factory a dark brown clay soil with subsoil containing abundant calcium carbonate concretions is overlain in turn by a few feet of laminated volcanic ash, and the modern (present) soil at the surface—all in an area that has been exposed by recent dissection of the lake plain by Ainomotua River. The base of the volcanic ash contains many prints of the leaves of water-loving herbacious plants.

The higher of the alluvial-fan deposits around Volo and Chemelil sisal estates, and along Kundos (Kapchure) River 6½ miles north-east of Kibigori, overlie at least part of the clay-ash beds of the "lake plain" and are, therefore, younger in age. Whether they are younger than *all* of the volcanic ash is not yet known. These high alluvial-fan deposits are strongly weathered and the soils are of kinds that we would expect to require many thousands of years for their formation. The nature of these deposits and the soils to which they give rise are illustrated diagrammatically in the cross-section shown in Figures 1-4 to this Report.

The lake-clay and ash beds extend up to the Mbogo River in an ever-narrowing strip nearly to Songhor, where at an elevation of about 4,600 feet they merge with river sediments. They were traced up the Ainomotua valley to about 1¾ miles east of Volo sisal factory to an elevation of about 4,300 feet; and up the Makindu and Nyando rivers to about 4,500 feet—almost to Muhoroni. Similar beds from near Songhor up Mteitei valley to a point about 3½ miles east-north-east of Mbereri estate headquarters may have been deposited in a basin separate from the Kano Plain arm of Lake Victoria. These beds are about 75 feet thick and have not yet been demonstrated to connect with the other lake beds. If all of these deposits were in fact laid in an arm of Lake Victoria, it is evident that they have been lifted relatively by crustal movements above their original level at the eastern edge of the Songhor area.

The rivers that cross the central plain have cut channels in the clay beds and underlying formations to measured depths of as much as 96 feet in Mbogo valley south-west of Songhor, and possibly deeper in other places, and as much as two-thirds of a mile wide near the confluence of Mbogo and Ainomotua rivers. Some of the valley slopes thus formed are smooth enough to cultivate. Others are as rough and broken and almost as bare as the Badlands of western United States. The valleys were cut in the clay plains in several stages as shown by strath remnants at two or three different levels below the plain, and a series of alluvial-terrace remnants just above the level of frequent overflow. All these features have a bearing on soils and land use in the Songhor area.

The Mbogo and Ainomotua river valleys are separated by high, almost precipitous mountains of gneiss; and similar mountains separate the Nyangoro and Ainomotua headwaters. The gneiss, the same as that of the Nandi escarpment, contains thin veins of white quartz and pegmatite. Soils on these mountains are very thin and stony. Hilly areas of more deeply weathered gneiss lie west and south of Muhoroni.

The foothills and mountains along the eastern border of the area comprise a complex of volcanic tuffs, basalts, phonolites and agglomerates which are products of the successive eruptions which took place some millions of years ago in the Tinderet Highlands. The whole region, formerly much smoother than now, has been cut into rugged forms by the various rivers.

The harder rocks form promontories and cliffs, and softer rocks have been eroded to less precipitous slopes. The oldest of these volcanic deposits is a gritty, whitish to pale yellow tuff with many included small and large broken fragments of granitic gneiss. In many places this tuff has thin veins and spots of secondary calcium carbonate, and it appears to merge with the

Koru limestone about 3 miles east-south-east of Muhoroni. It merges similarly with tuffaceous limestone on Ngeron estate near the foot of the Nandi escarpment.

This tuff, stated by Binge (personal communication) to be of Miocene age, is the parent rock of thousands of acres of dark grey and black clay soils along the eastern border of the area where it was eroded into long smooth slopes before the soils were formed on it. The formation and the rocks overlying it are tilted upward from west to east. It appears in a deep valley trench near Volo at an elevation of less than 4,000 feet and in the Mbogo valley, on the eastern edge of the area, where it is covered by other rocks, at about 5,000 feet. It is an important soil-forming rock from near Muhoroni northward to the Nandi escarpment.

Around the rim of the lake plain are many patches of land that seem to represent a former undulating plain which, since its formation, has been more or less dissected by streams. The soils on these old plain remnants have subsoil layers of vesicular and concretionary ironstone (laterite or murram) that probably formed under a fluctuating high (perched) water table, which still persists in some areas. Some of the laterite is formed from gneiss, some from basalts and phonolites. Patches occur at the following places and elevations:—

(1) West and north-west of Chemelil Sisal Estate H.Q.—4,000 to 4,500 feet.

(2) 2 and 3½ miles south-west of Songhor P.O.—4,800 to 5,000 feet.

(3) 3 miles south-east of Muhoroni—about 4,700 feet.

(4) 5 miles south-west of Muhoroni on Kericho road—about 5,300 feet.

The entire Songhor survey area is drained by the Nyando river and its tributaries. Most of the streams on the lake plains, even those that are deeply entrenched, have meandering courses which suggest that they have been rejuvenated in recent geologic times. The winding streams have cut through the soft clay and ash beds of the lake plains and have superposed themselves on older underlying and harder formations.

The water now flows rather quietly along stretches where the streams are running in clay beds, but more swiftly over the harder beds. For instance, the Ainomotua above Volo sisal factory has a series of rapids and cascades, where the stream has cut through the soft clays and tuffs and has struck buried ridges of hard gneiss and dikes of black porphyry. One such place is at the twin bridges at the confluence of Ainomotua and Ainopsiwa rivers. The streams that come down from the Nandi escarpment and Tinderet Highlands are swift and fairly straight until their speed is checked in the foothills by the sudden decrease in gradient. Here they tend to drop their sediments and many of them have built up beds of alluvium in which some of the streams have spread out and disappeared. In some of these semi-swampy areas new streams are formed at lower ends by seepage.

Drainage is very sluggish on the nearly level interfluves of the lake plain, and much of the level land must have surface drains before optimum crop response can be expected. Curiously enough, farmers experience considerable trouble with waterlogging during the rainy season on some of the sloping black and grey clay soils along the Muhoroni-Songhor road where slope gradients range up to as much as 6 per cent. This problem is discussed in later pages. Rapid run-off from some of the alluvial fans in the area has produced severe erosion, both where the soils have been overgrazed, as in the African reserves, and where water has been concentrated in road ditches and diverted to adjacent sloping land. The lower margins of long gentle slopes in the Songhor area are almost universally waterlogged by the end of the rainy season.

Climate

Climatic data for the Songhor area are sparse. Records of rainfall for Muhoroni cover a period of 49 years and those for Chemelil Plantations cover 21 years. Rainfall data for Muhoroni and Chemelil Plantations, and Kipturu, are all from within the Songhor area. Figures are given also for Siret and Chemartin Estates at the top of the Nandi escarpment, and for Kamareru and Soba Estates and for Koru railway station just east of the surveyed area. All of these stations have in common a marked rainfall peak in April and May. January is relatively dry at all stations. Table 1 shows graphically the monthly rainfall distribution for the various stations and brings out the fact that there is no protracted dry season in an average year.

Probably the average annual rainfall is 45 inches or more everywhere in the area, and much of the land receives well over 50 inches. Unfortunately, the rainfall often varies from the average and the region is sometimes affected by protracted droughts.

Scanty records indicate that average annual temperatures are a little under 70° F. in the coolest areas and perhaps about 70° in the warmer parts of the central plain. Temperatures from September to April may rise occasionally to the mid 90's—most frequently from January to March—and may fall to the middle or low 50's at night. Nights are always cool. The most cloudy weather is from early June until late August, when sunshine averages less than 7 hours a day.

Atmospheric humidity is medium to high except during January and February, when soils tend to dry out and crops may wilt.

Transpiration by plants—especially by native grasses—removes soil water about as fast as it is replenished by rain, except during two or three months of the rainy season. It is during this period that some water moves entirely through many of the soils and temporary perched water tables may be built up locally to the surface or nearly so. Water may appear at the surface on lower slopes as much as 2 or 3 months after the peak in rainfall.

TABLE 1.—RAINFALL IN AND NEAR SONGHOR SURVEY AREA

(East African Meteorological Department—1954)

	Jan.	Feb.	Mar.	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	Years Record
Muhoroni Station	2·25	4·61	6·18	10·01	7·70	4·67	4·25	5·19	4·02	3·01	4·53	4·14	60·56	49
Chemelil Railway Station ..	2·23	3·25	5·51	9·51	7·54	3·60	3·24	4·55	2·94	2·80	3·57	3·12	51·86	18
Kipturu	2·84	2·10	4·79	12·30	9·13	5·02	4·51	4·84	2·84	2·97	3·12	4·58	59·04	7
Siret Tea Estate	1·94	1·65	2·48	9·94	9·69	4·77	6·79	6·25	4·72	4·77	2·91	3·10	58·51	10
Kamareru (East of Songhor) ..	1·82	2·57	4·75	9·47	9·26	5·64	6·45	6·27	3·95	3·27	3·60	2·75	59·80	26
Soba	2·10	3·45	4·81	11·34	9·41	6·56	5·35	6·34	3·88	3·41	3·56	4·06	64·27	15
Koru Railway Station	0·78	2·72	2·21	10·66	9·01	2·80	6·23	4·26	4·46	0·87	0·63	4·47	49·10	21

Water Supply

Farmers in the Songhor area have an adequate potential supply of domestic water and most of them have availed themselves of this potential in one way or another. Several European farmers have boreholes ranging to more than 600 feet deep which supply them with good water for domestic use. Some farmers depend on river water, some get their water from springs, and a large proportion catch rain-water for household use. Asian farmers depend on boreholes and rivers for domestic water and in some instances maintain boreholes for colonies of labourers and their families. African farmers depend almost entirely on rivers and springs for their water supplies and in many instances have to carry their water more than a mile. Most cattle are watered at the rivers and smaller streams or catchment "tanks" dug in clay soils.

The larger rivers, like the Nyando, Mbogo and Ainomotua, carry enough water to supply sisal and sugar factories. A modest irrigation project for sugar cane has been established on the Chemelil Sugar Estate by pumping water from Mbogo River below its confluence with the Ainomotua. Yields of sugar cane have been nearly doubled on this irrigation project.

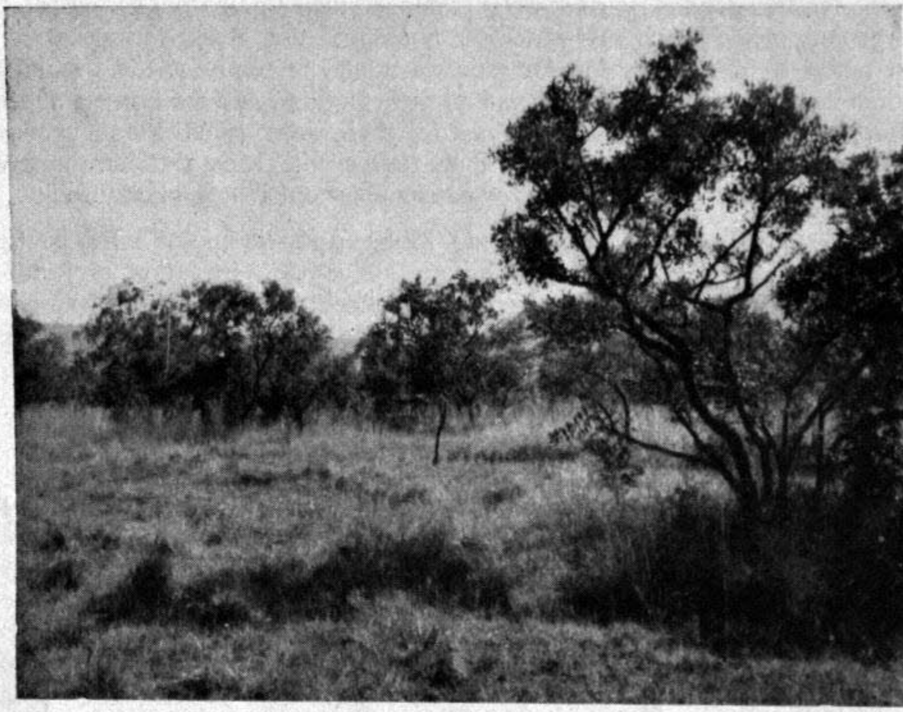
Vegetation

The present vegetation patterns in the uncultivated parts of the Songhor area have been modified by human activity for so many hundreds and perhaps even thousands of years that what we find now may be said to represent an adjustment—perhaps in some places a near-equilibrium—between the nature of the soil on the one hand and vegetation and human activity on the other. Apart from cultivation which completely destroys the original vegetation (probably open forest), the greatest single effect of man on the vegetation patterns is that brought about by frequent bush fires. The tall grasses and shrubby trees are deliberately burned over at intervals of a few months to a few years in order to kill back the shrubs and burn the old unpalatable coarse grasses to make way for succulent new growth.

The practice of frequently burning has killed off all but fire-resistant trees, bushes and forbs, and has changed the composition of the grass cover from one type to another. Thus a sort of equilibrium is set up between vegetation and fire, with the soil apparently playing a modifying rôle in the actual distribution of certain species of trees, grasses and other plants. No one has made a complete detailed study of the exact inter-relationships among vegetation assemblages, soils and geology of the Songhor area, and no one has produced a detailed map of plant associations. Hence, we are not in a position to state exactly the extent to which soil types influence the distribution of plant associations. We consider it desirable that detailed studies be made of these relationships.

Local ecologists speak of the Songhor area as a "high rainfall savannah" —an area of moderately high rainfall, characterized by an incomplete canopy of shrubby and gnarled trees, interspersed with tall grasses, dominated by various species of *Hypharrenia*. The same type of vegetation is also called "Combretum—Hypharrenia woodland".

Mr. G. C. H. Hill, Agricultural Officer (Research) at Kakamega, has made a reconnaissance study of the vegetation in parts of the Songhor area.



"High-rainfall savannah" or "Combretum-Hypharrenia woodland" on Kibubu gravelly loam, one and three-quarter miles south-west of Songhor.

Among the trees, he reports that species of *Acacia, Combretum, Bauhinia* (twin leaf), *Kigelia* (sausage tree), *Terminalia, Ficus* (many figs, especially *F. sycamoris*), *Cassia, Balanites* and *Zizyphus* are important. Our notes suggest the following general relationships of above species to groups of soils:—

Shallow soils, with strongly developed laterite (murram) horizons on gneiss (Kapchure sandy loam), and on basaltic and phonolitic rocks (Kibubu gravelly loam), have savannah vegetation dominated by *Combretum* (sp.) trees and grasses of *Hypharrenia* species. *Bauhinia* and some other trees are less abundant than Combretum, but several shrubby trees, vines and shrubs of various species make dense thickets on the large termite mounds.

The stony gneissic mountains west and north of Songhor are dominated by scattered *Combretum* and *Bauhinia*, with tall grasses between.

Bauhinia is the most important tree of the savannahs, with heavy dark grey and black clay soils, of the eastern part of the Songhor area; but *Combretum* (sp.) is fairly common. *Bauhinia* thrives on clay soils of this group which occur on slopes with good surface drainage, even where subsoils may be very seepy and wet during the rainy season.

Mr. A. V. Bogdan, Pasture Research Officer, Kenya Department of Agriculture, states (personal communication):—

"In all these types of habitat with good or relatively good drainage the grass is of perennial bunch or tufted species of which the more common in open bush are: *Hypharrenia dissoluta, H. filipendula, Soudetra kagerensis* and *Andropogon dummeri*. In denser and more shady bush, *Hypharrenia cymbarra, Beckeropsis uniseta* and *Melinis tenuissima* become dominant."

Acacia seyal was noted to be most abundant on nearly level areas of heavy black and grey soils that may be wet during the rainy season, but are dry or only moist during the dry season. Permanently wet soils do not support this tree in the Songhor area. The species is common also on black clay soils, with volcanic ash within 30 inches of the surface, at the top and on the slopes of a narrow ridge between Mbogo and Kundos rivers about 2 miles north-east of Kibigori. Surface drainage here is rapid and thorough, but water moves very slowly through the soil. The tree is an important constituent on the periodically wet and dry, seepy, Kapkuong loamy coarse sand on the Nandi reserve, west of Kundos River, where deep subsoils contain a little salt.

We noted *Balanites* growing under about the same range of soil conditions as the *Acacia seyal*, but it is less abundant. Mr. Bogdan states additionally:—

"On waterlogged plains with alkaline (and neutral) black clays, *Pennisetium mezeranum* is often a dominant grass with abundant *Chrysochlora orientalis*—a low creeper—as the bottom grass. On non-alkaline (medium-acid) grey clays, in flat bottoms of valleys, *Hypharrenia rufa* forms dense stands."

Acacia campylacantha grows luxuriantly along the banks of the rivers, where soils are fertile and moderately well drained, but it can be found also around the rims of the clay plains where it seems to have spread from the flood plains.

Wild Life

Several kinds of wild animals still live in the Songhor area. Among these, water buck, duiker, oribi, reed buck, topi, forest hog, baboon, several kinds of monkeys, leopard, hyena, wild cat, mongoose and several others are common. Although the wild buck are not abundant, gardeners in the hills are obliged to protect their gardens from them. Baboons and forest hogs are a bad nuisance in the maize fields below the Nandi escarpment and near

TABLE 2.—ACREAGES OF SOIL TYPES AND PHASES, SONGHOR SURVEY AREA

SOIL TYPES AND EROSION PHASES	Symbol	SLOPE CLASSES AND % GRADIENT						Total	% of area
		A 0–3	B 3–8	C 8–13	D 13–20	E 20–35	F 35+		
Ainomotua sandy clay loam	Aic		2,343					2,343	1·79
Ainopsiwa clay loam	As	230						230	0·18
Aristos clay loam	Ac	1,239						1,239	0·95
Awasi loam mod. eroded	Asi		295					295	0·23
Babu clay loam..	Bcl	90	316	145				551	0·42
Bhanji loam	Bil	2,100						2,100	1·61
Bhanji stony loam	Bist		3,389					3,389	2·59
Bhanji stony loam, mod. eroded	Bist		210					210	0·16
Chemelil clay loam	Ccl	3,166	85					3,251	2·48
Complex, arable clay soils	Cxc		671	1,655				2,336	1·78
Complex, mod. eroded	Cxc		655	11,825				12,480	9·54
Farndell clay loam	Fcl	65	53					118	0·09
George clay loam	Gcl	103	3,581					3,684	2·81
Hermann silty clay loam	Hc		273	1,055				1,328	1·02
Kamaasae sandy clay loam	Kcl		60	222				282	0·22
Kamaasae stony clay loam	Kt				73			73	0·06
Kapchure sandy loam	Kps		1,438		36			1,474	1·13
Kapchure, mod. eroded	Kps		41					41	0·03
Kapchure scl.	Kpd		354					354	0·27
Kapkuong loamy coarse sand	Ks	121	3,280	478				3,879	2·97
Kapkuong, severely eroded	Ks		638					638	0·48
Kibigori clay	Kbc	14,643	750					15,393	11·77
Kibubu gravelly loam	Kgl		362	61				423	0·32
Kipsesin clay loam	Knc	87	471	779	1,021	4,284		6,642	5·03
Koru clay loam	Kol	43						43	0·03
Kundos sandy clay	Kuc	457						457	0·35
Kundos, mod. eroded	Kuc		1,010					1,010	0·77
Lemaiywa clay	Lec	1,053						1,053	0·81
Marcantonatos loam	Mal		110					110	0·08
Martin clay loam	Mnc		328	178				506	0·39
Mbereri coarse sandy loam	Msl		2,078	1,588				3,666	2·80

TABLE 2.—ACREAGES OF SOIL TYPES AND PHASES, SONGHOR SURVEY AREA—(*Contd.*)

SOIL TYPES AND EROSION PHASES	Symbol	SLOPE CLASSES AND % GRADIENT A 0–3	B 3–8	C 8–13	D 13–20	E 20–35	F 35+	Total	% of area
Mbereri, mod. eroded	Msl		1,304					1,304	1·00
Mbereri, severely eroded	Msl			117	229			346	0·26
Mbereri st. and gr. sandy loam	Mst			1803 (bracketed across B–D)				1,803	1·38
Mbereri, mod. eroded	Mst				1545 (bracketed across B–E)			1,545	1·18
Mbogo clay loam	Mbc	422	1,667	58				2,147	1·64
Muhoroni clay loam	Muc	834	4,275		528			5,637	4·31
Nandi loam	Nl	110	160					270	0·21
Ngeron silty clay loam	Ngc		447	487				934	0·71
Nyando clay loam	Noc	1,035						1,035	0·79
Nyangoro st. sandy loam	Nyc		254	2,616	919	550		4,339	3·32
Patel clay loam	Pcl	1,905	855					2,760	2·11
Permanent swamp	PS	277						277	0·21
Perry clay loam	Pec	670	423					1,093	0·84
Rama clay loam	Rac	2,442	251					2,693	2·06
Raragegwit sandy clay loam	Rsc		688	112				800	0·61
Rough broken land, clay	Rbc				5,457			5,457	4·17
Songhor silt loam	Ssi	1,127						1,127	0·87
Sossok clay loam	Soc		750	1,746				2,496	1·91
St. land, Kipsesin mat.	Stk				2,678		3,237	5,915	4·51
St. land, Nyangoro mat.	Stn				2,138		10,313	12,451	9·52
Tennant clay loam	Tc	1,763	88					1,851	1·42
Tennant sandy loam	Tsl	652	203					855	0·65
Volo clay loam	Vcl	3,254	813					4,067	3·11
					GRAND TOTAL ..	..		130,800	100·00

TABLE 3.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE SONGHOR AREA

Physiographic Position	Type	Map Symbol	Relief	Internal Drainage	Surface Soil		Approx. thickness	Subsoil		Approx. thickness
					Colour, moist	Consistence, Dry: moist: wet		Colour, moist	Consistence, Dry: moist: wet	
							in.			in.
Soils developed from basic (dark-coloured, largely fine grained) igneous rocks										
Hills and Mountains ..	Stoney land, Kipsesin soil material.	Stk	Steeply sloping to very steep.	Medium	Dark reddish brown.	Firm: friable: slightly sticky and plastic.	6	Dark reddish brown.	Moderately hard: friable: sticky and plastic.	18
Hills and Mountains ..	Kipsesin clay loam.	Knc	Nearly level to very steeply sloping.	Free	Black.	Firm: friable: slightly sticky and plastic.	8	Very dark brown.	Moderately hard: friable: sticky and plastic.	16
Footslopes	Kamaasae sandy clay loam.	Kcl	Gently to moderately sloping.	Medium	Dark reddish brown.	Slightly hard: friable: slightly sticky and plastic.	6	Dark reddish-brown to dark brown.	Slightly hard: friable: sticky and plastic.	22
Footslopes	Kamaasae stony clay loam.	Kt	Steeply sloping.	Medium	Dark reddish brown.	Slightly hard: friable: slightly sticky and plastic.	6	Dark reddish-brown to dark brown.	Slightly hard: friable: slightly sticky and plastic.	15
Footslopes	Muhoroni clay loam.	Muc	Nearly level to gently sloping.	Very slow	Very dark grey.	Very hard: very firm: very sticky and plastic.	15	Very dark grey.	Very hard: firm: very sticky and plastic.	55
Footslopes and Plateau remnants.	Martin clay loam.	Mnc	Gently to moderately sloping: undulating.	Free	Dark reddish-brown.	Firm: friable: slightly sticky and plastic.	14	Dark reddish-brown to dusky red.	Friable: friable: slightly sticky and plastic.	86
Footslopes and Plateau remnants.	Sossok clay loam.	Soc	Gently to moderately sloping.	Free	Dark reddish-brown.	Slightly hard: friable: slightly sticky and plastic.	7	Dark reddish-brown.	Slightly hard: friable: sticky and plastic.	25
Plateau remnants ..	Bhanji loam	Bil	Nearly level	Medium	Black to very dark grey.	Hard: firm: sticky and plastic.	10	Very dark grey to black.	Hard: firm: sticky and plastic.	18
Plateau remnants ..	Bhanji stony loam.	Bist	Gently sloping	Medium	Black to very dark grey.	Hard: firm: sticky and plastic.	4	Very dark grey to black.	Hard: firm: sticky and plastic.	14
Plateau remnants ..	Kibubu gravelly loam.	Kgl	Gently to moderately sloping.	Free	Black.	Slightly hard: very friable: nonsticky and nonplastic.	10	Reddish-yellow.	Moderately hard: friable: non-sticky and non-plastic. (Contains many iron concretions).	15

TABLE 3.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE SONGHOR AREA—(*Contd.*)

Physiographic Position	Type	Map Symbol	Relief	Internal Drainage	Surface Soil: Colour, moist	Surface Soil: Consistence, Dry: moist: wet	Approx. thickness	Subsoil: Colour, moist	Subsoil: Consistence, Dry: moist: wet	Approx. thickness
							in.			*in.*
Soils developed from acidic rocks (granites and granitic gneisses)										
Hills and Mountains ..	Stony land, Nyangoro soil material.	Stn	Steeply sloping to very steep.	Free	Black to very very dark brown.	Hard: friable: sticky and plastic.	6	Dark reddish-brown.	Hard: friable: sticky and plastic.	12
Hills and Mountains ..	Nyangoro stony sandy loam.	Nyc	Gently to very steeply sloping.	Free	Black to very dark brown.	Hard: friable: sticky and plastic.	7	Very dark brown to reddish-brown.	Hard: friable: sticky and plastic.	23
Footslopes and Plateau remnants.	Kapchure sandy clay loam.	Kpd	Gently sloping undulating.	Medium	Very dark brown to brown.	Slightly hard: friable: non-sticky and non-plastic.	8	Dark reddish-brown to reddish-brown.	Hard: slightly friable: sticky and plastic.	30
Footslopes and Plateau remnants.	Kapchure sandy loam.	Kps	Gently sloping.	Slow	Very dark grey.	Hard: friable: non-sticky and slightly plastic.	6	Mottled dark brown.	Hard: firm: sticky and plastic.	30
Soils of Alluvial Fans and River Terraces										
Apex of Alluvial Fan..	Mbereri stony and gravelly sandy loam.	Mst	Gently to steeply sloping.	Rapid	Dark reddish-brown.	Soft: friable: non-sticky and non-plastic.	8	Reddish-brown.	Slightly hard: friable: slightly sticky and plastic.	15
Middle of Alluvial Fan	Mbereri coarse sandy loam.	Msl	Gently to moderately sloping.	Free	Very dark brown.	Soft: friable: non-sticky and non-plastic.	12	Dark reddish-brown to yellowish-red.	Slightly hard: friable: slightly sticky and plastic.	33
Alluvial Fan Base ..	Ainomotua sandy clay loam.	Aic	Gently sloping.	Medium	Very dark grey.	Hard: friable: sticky and plastic.	8	Dark brown.	Hard: friable: slightly sticky and plastic.	20
Alluvial Fan Base ..	Kapkuong loamy coarse sand.	Ks	Nearly level to moderately sloping.	Slow	Black.	Slightly hard: friable: non-sticky and non-plastic.	18	Pinkish-grey, strong brown, black, strongly mottled.	Very hard and brittle: firm: very sticky and plastic.	24

TABLE 3.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE SONGHOR AREA—(*Contd.*)

Physiographic Position	Type	Map Symbol	Relief	Internal Drainage	Surface Soil			Subsoil		
					Colour, moist	Consistence, Dry: moist: wet	Approx. thickness	Colour, moist	Consistence, Dry: moist: wet	Approx. thickness
							in.			*in.*
Alluvial Fan	Awasi loam	Asi	Gently sloping.	Slow	Very dark grey.	Hard: friable: sticky and plastic.	7	Very dark grey to dark greyish-brown.	Hard: stiff: very sticky and plastic.	23
Alluvial Fan	Farndell clay loam.	Fcl	Nearly level to gently sloping.	Slow	Very dark grey.	Hard: firm: sticky and plastic.	10	Dark grey to very dark grey.	Very hard: very firm: sticky and plastic.	50
Alluvial Fan	Kundos sandy clay.	Kuc	Nearly level to gently sloping.	Rapid	Dark reddish-brown.	Slightly hard: friable: slightly sticky and plastic.	10	Dark reddish-brown to reddish-brown.	Hard: friable: slightly sticky and plastic.	33
Alluvial Fan	Marcantonatos loam.	Mal	Gently sloping.	Free	Black.	Slightly hard: friable: non-sticky and non-plastic.	12	Dark reddish-brown.	Hard: friable: slightly sticky and plastic.	43
Alluvial Fan	Nandi loam	Nl	Nearly level gently sloping.	Medium	Black.	Soft: very friable: non-sticky and non-plastic.	12	Very dark grey to dark reddish-brown.	Hard: friable: sticky and plastic.	38
Alluvial Fan	Raragegwit sandy clay loam.	Rsc	Gently to moderately sloping.	Slow	Very dark grey.	Hard: moderately friable: slightly sticky and plastic.	6	Dark grey	Hard: firm: sticky and plastic.	24
Colluvial/Alluvial Fan	Hermann silty clay loam.	Hc	Gently to moderately sloping.	Free	Black.	Slightly hard: friable: slightly sticky and plastic.	12	Very dark brown to dark brown.	Hard: slightly firm: sticky and plastic.	48
Colluvial/Alluvial Fan	Ngeron silty clay loam.	Ngc	Gently to moderately sloping.	Medium	Black.	Slightly hard: firm: sticky and plastic.	12	Very dark grey.	Very hard: firm: very sticky and plastic.	30
Old River Terrace and Alluvial Fan.	Ainopsiwa clay loam.	As	Nearly level	Free	Dark reddish-brown.	Slightly hard: friable: slightly sticky and plastic.	11	Dark red	Slightly hard: friable to firm: slightly sticky and plastic.	51
River Terrace	Koru clay loam.	Kol	Nearly level	Free	Dark reddish-brown.	Slightly hard: friable: sticky and plastic.	7	Dark reddish-brown.	Slightly hard: friable: sticky and plastic.	63
Low River Terrace ..	Nyando clay loam.	Noc	Nearly level	Medium	Very dark brown.	Slightly hard: friable: sticky and plastic.	17	Very dark greyish-brown.	Slightly hard: friable: sticky and plastic.	24
Flood Plain	Tennant clay loam.	Tc	Nearly level to gently sloping.	Medium	Black.	Slightly hard: friable:sticky and plastic.	30	Very dark brown to black.	Hard: friable: sticky and plastic.	30

TABLE 3.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE SONGHOR AREA—(*Contd.*)

Physiographic Position	Type	Map Symbol	Relief	Internal Drainage	Surface Soil		Approx. thickness	Subsoil		Approx. thickness
					Colour, moist	Consistence, Dry: moist: wet		Colour, moist	Consistence, Dry: moist: wet	
							in.			*in.*
Flood Plain	Tennant sandy loam.	Tsl	Nearly level to gently sloping.	Free	Black.	Soft: very friable: slightly sticky and plastic.	30	Very dark brown to black.	Slightly hard: very friable: slightly sticky and plastic.	30
Flood Plain	Lemaiywa clay.	Lec	Nearly level	Slow	Black.	Hard: friable to firm: sticky and plastic.	18	Black.	Very hard: firm: very sticky and plastic.	14
					Soils of Old Lake Bed Sediments					
Ancient River Lines ..	Babu clay loam.	Bcl	Nearly level moderately sloping.	Medium	Very dark grey.	Slightly hard: friable: sticky and plastic.	7	Dark brown to brown.	Hard: friable to firm (gravelly) sticky and plastic.	18
Ancient River Lines ..	Perry clay loam.	Pec	Nearly level to gently sloping.	Free	Dark brown.	Slightly hard: friable: slightly sticky and plastic.	11	Dark reddish-brown.	Hard: friable sticky and plastic.	37
Lake Plains	Chemelil clay loam.	Ccl	Nearly level to gently sloping, undulating.	Moderate	Very dark brown.	Slightly hard: friable: sticky and plastic.	15	Brown to dark greyish-brown.	Hard: friable to firm: sticky and plastic.	41
Lake Plains	Volo clay loam.	Vcl	Nearly level to gently sloping.	Slow	Black to dark greyish-brown.	Slightly hard: friable: sticky and plastic.	12	Dark greyish-brown.	Hard: firm: sticky and plastic.	34
Lake Plains	Patel clay loam.	Pcl	Nearly level depressions.	Very slow.	Very dark greyish-brown.	Hard: friable: sticky and plastic.	11	Grey to dark greyish-brown.	Hard: moderately friable: sticky and plastic.	19
Lake Plains near Rejuvenated Valleys.	Rama clay loam.	Rac	Nearly level to gently sloping.	Slow	Dark brown.	Hard: firm: sticky and plastic.	5	Very dark greyish-brown to brown.	Hard: firm: sticky and plastic.	20
Lake Plains & River Terrace.	Kibigori clay	Kbc	Nearly level to gently sloping.	Slow	Black.	Hard: friable to firm: very sticky and plastic.	8	Black.	Very hard: firm: very sticky and plastic.	40
River Terraces and Lake Plains.	Aristos clay loam.	Ac	Nearly level depressions	Very slow.	Black.	Hard: firm: very sticky and plastic.	5	Very dark grey.	Very hard: firm: very sticky and plastic.	32
Lake Plains	Songhor silt loam.	Ssi	Nearly level depressions.	Very slow.	Very dark brown.	Slightly hard: very friable: non-sticky and non-plastic.	14	Dark grey	Very hard: very firm: very sticky and plastic.	41
Old Stream Terraces ..	George clay loam.	Gcl	Nearly level to gently sloping.	Slow	Very dark grey.	Hard: firm: sticky and plastic.	11	Very dark grey to grey.	Hard: firm: sticky and plastic.	68

TABLE 3.—PHYSIOGRAPHIC POSITION, PARENT MATERIAL, AND PROFILE CHARACTERISTICS OF THE SOILS IN THE SONGHOR AREA—(*Contd.*)

Physiographic Position	Type	Map Symbol	Relief	Internal Drainage	Surface Soil		Approx. thickness	Subsoil		Approx. thickness
					Colour, moist	Consistence, Dry: moist: wet		Colour, moist	Consistence, Dry: moist: wet	
							in.			*in.*
Lake Plains near Rejuvenated Valleys.	Mbogo clay loam.	Mbc	Nearly level to gently sloping.	Slow	Dark reddish-brown.	Hard: friable: sticky and plastic.	14	Dark reddish-brown to dark brown.	Hard: firm: sticky and plastic.	68
Lake Plains and Rejuvenated Valley Sides.	Complex of arable clay soils.	Cxc	Gently to moderately sloping.	Slow	Very dark brown.	Hard: firm: sticky and plastic.	6	Very dark grey brown.	Hard: firm: sticky and plastic.	30
Swamps	Permanent swamp.	PS	Nearly level depressions.	Very slow.	Black.	Hard: firm: sticky and plastic.	12	Dark grey.	Very hard: very firm: very sticky and plastic.	—

the Songhor hills. The nocturnal giant "ant bears" dig many holes in pastures and even in the roads in search of termites and ants. Leopards sometimes attack cattle, sheep and goats but on the whole are valued because they tend to keep baboons and wild hogs under control. A few crocodiles live in Nyando river. The few deadly poisonous snakes, like puff adders, cobras and mambas, are seldom seen except in the hills; and large pythons are seen occasionally. Several kinds of game birds like guinea fowl and francolin live in the area. Weaver birds damage grain crops on many farms; and there is a great variety of other kinds of large and small birds.

III—SOILS OF THE SONGHOR AREA

A total of 39 soil types, subdivided into phases of soil types, based on slope gradients and degree of accelerated erosion, are shown on the map. In addition, a few types, deeper than normal, are shown as phases to avoid establishing new soil series for small total acreages of land. Five miscellaneous land types are shown, to take care of complexes of very stony and eroded soils, the details of which are of little significance. All of these are described in following pages.

Table 2 gives a complete list of recognized soil types and phases, and miscellaneous land types, with area, in acres, of each.

Table 3 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 shown also in Table 3.

The soils are described very briefly in following paragraphs in the alphabetical order of the series names. Shallow soils are described from the surface to bedrock; the deep ones well beyond the depths reached by the roots of most crop plants—in general to depths of 10 to 15 feet. Brief statements cover the present use and the suitability of each soil for various uses. Detailed technical descriptions of the soil series appear in the Appendix along with analytical tables.

(Aic-B) *Ainomotua sandy clay loam,* 3 *to* 8 *per cent slopes*

Ainomotua sandy clay loam is a deep, dark-coloured soil, moderately well supplied with humus. The subsoil comprises a sequence of heavy-textured blocky materials, mostly of clayey textures, which become sticky and plastic when wet. Reaction ranges from nearly neutral at the surface to moderately or strongly alkaline at depth. Parent material is weakly stratified sandy, clayey and ashy deposits, frequently with streaks of gravel.

While sandy clay loam is the dominant texture, some of the plough soil is as light as sandy loam where it merges with Mbereri coarse sandy loam, as it does just west of the "twin bridges". The area of 30 acres 2.4 miles north of Kibigori station is moderately eroded.

The smooth slopes of 3 to 8 per cent gradient provide good surface drainage, but internal water movement is fairly slow. The water in the soil works its way down-slope through the more permeable of the subsoil layers, which remain moist for considerable periods after rains.

The soil is used both for pasture and for cultivation and can produce fairly good yields of maize and other subsistence crops. An experimental planting of sugar cane was growing well when the survey was in progress. The soil is well suited to these crops, but is seasonally too wet for coffee. Cultivated and overgrazed lands are subject to moderate sheet erosion, and a few small areas have lost much of the original surface soil.

A small area with a 2 per cent slope is included in the area mapped.

(As-A) *Ainopsiwa clay loam,* 0-3 *per cent slopes*

This is a deep, dark reddish-brown well-drained clay loam soil, with red crumbly clay subsoil. It lies on gently sloping river terraces at the base of the Nandi escarpment. The soil is slightly acid in reaction at the surface and medium acid below. It is valued highly for its good physical properties, which make cultivation easy, but the reserves of phosphorus and calcium are low. The humus content of the plough soil averages close to 6 per cent and even at a depth of nearly 2 feet is about 2.7 per cent, and this gives the soil a good moisture holding capacity and a good capacity for holding plant nutrients in reserve. Termites have built large mounds of red earth at intervals of 100 to 200 feet in each direction and ranging in size from 3 to 8 feet high and 40 to 120 feet across the base. Crops grow more luxuriantly on the mounds than on the soil between them, but the difference is not great. In sample pits it was noted that roots of grasses and trees extend below depths of 10 feet.

The smooth gentle slopes provide good surface drainage and water moves readily through the subsoil which retains a sufficient supply of moisture to carry crops through short periods of drought. The soil must be protected from sheet erosion when it is used for clean-cultivated crops. Only 230 acres, all near the base of the Nandi escarpment, were mapped in the north-eastern part of the Songhor area.

The soil is used for growing maize, other subsistence crops, coffee and pasture. It has excellent physical properties for cultivation and would support a good growth of sugar cane although growth might be slowed somewhat by the relatively low night temperatures at the base of the Nandi escarpment. With long cultivation it will be necessary to use commercial fertilizers in order to maintain good yields.

(Ac-A) *Aristos clay loam,* 0-3 *per cent slopes*

This very dark grey to nearly black clayey soil (black cotton soil) is poorly drained and too wet for most crops during the rainy season unless surface drains are provided. The very heavy, sticky and plastic clay subsoil retards internal drainage to the vanishing point, once the soil becomes wet. The Aristos clay loam occurs in association with a number of seasonally wet "black cotton" soils and particularly with Kibigori clay; it occupies the lower and flatter positions within areas of those soils. The surface soil is medium acid in reaction and low in available phosphorus. Intermediate subsoil areas also are low in phosphorus but there is a large reserve at depth. Most of the soil occurs on the central lake plain where it has developed from inter-bedded clay and volcanic ash deposits. A total of 1,239 acres was mapped.

The soil is used mainly for pasture but some has been planted to sisal which does poorly, and to sugar cane which grows moderately well. Some sorghum is grown on the Luo reserve where the soil has been drained, and a considerable area was used at one time for growing rice which did quite well. Response can be expected from fertilizers containing nitrogen, phosphorus and sulphur.

(Asi-B-2) *Awasi loam, 3 to 8 per cent slopes, moderately eroded*

This grey soil of low fertility and poor structure is known, to date, only on the gently sloping alluvial fans along the north and west bases of the lava tableland west of Muhoroni, in the Luo reserve. The grey plough soil turns

Awasi loam has been bared by overgrazing on the Luo Reserve. Most other grazing land on the Reserve is similarly affected.

nearly white when dry. The clayey subsoil is columnar in structure and the columns come apart in angular blocks when the soil is moist. When the soil is wet the subsoil swells and becomes very sticky and plastic and water ceases to move through it. It resembles the Songhor silt loam in some respects but differs somewhat in structure and consistency. Reaction is slightly acid at the plough level and mildly alkaline in the upper subsoil. Lime concretions are abundant below a depth of 3 feet. Sheet erosion and a few small gullies have removed part of the original surface soil and have cut into the subsoil in a few places. The texture of the plough soil varies to silt loam and fine sandy loam from place to place. The underlying material appears to be alluvium washed from the adjacent area of black volcanic rocks, but it may include some re-worked volcanic ash.

Luo farmers use the soil for growing sorghum, finger millet, maize and vegetables, and a considerable proportion of the 295 acres mapped is used for pasture all of which is overgrazed. Productivity of all crops is low under present management. If sugar cane were grown on this soil it surely would require fertilization.

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

This soil, associated with Perry clay loam, is developed from thin lake clay deposits overlying a thick bed of round, water-worn pebbles and cobblestones that marked the place where a former river channel entered an ancient lake. The fine-earth part of the soil resembles the Perry clay loam but the gravelly and cobbly material is much closer to the surface than in the Perry, and in a few places is within reach of the plough. The surface soil is a very dark grey, crumbly, slightly acid clay loam frequently with a few scattered pebbles and a moderate amount of organic matter. The dark brown fine-block acid clay subsoil merges with the closely packed gravel and cobblestones at depths ranging up to about 40 inches: locally, the surface soil is gravelly. The stones are largely of hard lava and the spaces between them are filled with dark reddish-brown clay which provides growing space for roots.

The soil is well drained externally and internally but most of it will hold enough moisture to carry crops through short droughts. Unprotected areas are subject to slight sheet erosion. Much of the 90 acres mapped is used for growing sugar cane and subsistence crops and the small remainder is used for pasture. The soil is moderately well suited for growing sugar cane.

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

This phase of Babu clay loam is essentially like the gently sloping phase, except that the average depth to the cobbly layer is somewhat less. Precautions are needed to keep soil erosion under control on this phase of Babu clay loam. 316 acres mapped.

(Bcl-C) *Babu clay loam,* 8 *to* 13 *per cent slopes*

This phase of Babu clay loam has thinner soil horizons and somewhat less organic matter than the normal type. It is too steep for clean-cultivation without erosion-control measures and should be kept under close-growing cover. 145 acres mapped.

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

Bhanji loam is a somewhat shallow, slightly acid, sticky and plastic nearly black soil of the smoothly and gently sloping low ridges of basaltic (lava) rocks which lie just above the level of the lake clays on the central plain of the Songhor area. The clayey subsoil merges with a thin layer of concretionary ironstone or murram. Basaltic bedrock usually lies at depths ranging from about 12 to about 40 inches, but here and there protrudes above the surface. Perhaps two-thirds of the soil is 2 to 3 feet deep, a little of it is more than 3 feet, and the remainder is less. Small outcrops of bedrock are scattered over the fields. Texture of the surface soil varies from loam to clay loam. The soil has a moderate amount of humus and is fairly fertile, but it is so shallow that crops are likely to suffer from drought during the dry seasons. It is more plastic and sticky than the related Kibubu gravelly loam.

The smooth gentle slopes, with a maximum gradient of 3 per cent or a little more, provide slow to moderately rapid surface drainage. Internal drainage is slow and the soil is very wet for short periods during the rainy season. Cultivated areas may be slightly affected by sheet erosion.

Fairly large areas lie south of Mbogo River in the eastern half of the area. A total of 2,100 acres was mapped. Most of the land is used for pasture, but small patches around labourers' homes are planted to maize, sorghum and vegetables. Cane growers consider it to be too droughty during the dry season for good cane production, and the scattered stony spots make ploughing difficult.

(Bist-B) *Bhanji stony loam, 3 to 8 per cent slopes*

This soil resembles Bhanji loam in most respects, except that the profile averages shallower and the soil is too stony for cultivation. Most of it lies on slopes ranging from 5 to 8 per cent gradients. It occurs in close association with Bhanji loam, Kibubu gravelly loam and Muhoroni clay loam. Depth to rock varies from zero to as much as 3 feet, but most of the soil is less than 2 feet deep. Loose rocks and bedrock outcrops take up 20 to 25 per cent of the area. In an area of about 225 acres, centering in the Luo reserve about one mile northeast of Awasi market the soil differs somewhat from typical Bhanji stony loam. Apparently it has been leached under the influence of sodium or possibly magnesium and has been rather drastically modified in the process. The profile of this variant is about as follows:—

(1) 0 to 4 inches. Black (moist) to dark grey (dry) weakly granular silt loam. Slightly acid reaction.

(2) 4 to 18 inches. Light grey clay loam, mottled brown and black, and including dark brown and black iron-manganese concretions. Slightly acid, grading downward to neutral reaction.

(3) Hard phonolite lava with a crust of manganese and iron oxides 1 to 6 inches thick. Reaction is about neutral. The crust is like that in

Bhanji stony loam. This variant of Bhanji stony loam, would be classed as of a different series if the area were larger, but was included on the map for the sake of economy. Its value for agriculture is very low because it is stony and shallow. Some is cultivated by African farmers and produces low yields of subsistence crops. Most of it is used for pasture, most of which is badly overgrazed.

The largest area of Bhanji stony loam comprizes a few square miles on the phonolite tableland in the African reserves west of Muhoroni; and smaller areas are south of Mbogo River in the European reserves. 3,389 acres were mapped.

Used primarily for pasture, but many African farmers are growing maize, sorghum, beans and millet on small patches under hoe culture. Yields are low, Overgrazed slopes have lost a considerable part of their surface soils. Generally unsuitable for cultivation, except as used by African farmers.

(Bist-B-2) *Bhanji stony loam,* 3 *to* 8 *per cent slopes, moderately eroded*

This moderately sloping stony soil resembles the normal Bhanji stony loam, except that much of the surface soil has been washed away following exposure by overgrazing. Reduction of grazing on this land should help to restore the grass cover and would check further erosion. Continued overgrazing will render the soil useless. 210 acres were mapped.

(Ccl-A) *Chemelil clay loam,* 0 *to* 3 *per cent slopes*

Chemelil clay loam is a deep moderately well drained soil of the lake plain, developed from clay and volcanic ash deposits. It is associated on the one hand with the better-drained Babu clay loam and Rama clay, on the other with the more poorly drained Volo, Kibigori, Patel and Aristos soils. The plough soil is a very dark brown, fine-granular, crumbly, medium-acid clay loam with 10 to 20 per cent of buckshot-sized iron oxide concretions. The deep subsoil is mottled red, grey and brown blocky clay that becomes increasingly plastic and sticky below a depth of about 30 inches. Reaction of subsoil layers is neutral to slightly alkaline. The soil has fairly good physical properties and responds generously to fertilization.

Colours vary somewhat from more reddish to more greyish than described above. The surface is marked by slight undulations at intervals of a few yards, with darker and greyer soils in the lower places and browner soils on the slightly higher land. Depth to the very clayey, sticky and plastic subsoil varies from about 18 inches to about 3 feet, and crops may be adversely affected by impeded drainage during wet periods, where depth is minimum.

The land is nearly level, with slopes ranging up to 3 per cent, and with slight depressions and rises every few yards. Occasional termite mounds 5 feet high and 8 to 10 feet in diameter are scattered over the plain but are too few to have any significant effect.

Surface drainage is adequate for most crops, and internal drainage is slow but adequate in most places. Areas adjacent to Volo and Patel soils are improved by surface drains.

This is one of the most important soils of the Songhor area. Most of it lies south of Mbogo River and north of the railway, largely on Chemelil Sugar Estate. 3,166 acres were mapped. Most of it is used for growing sugar cane. Subsistence crops are grown on it in the Luo reserve. Chemelil clay loam is one of the best of the more extensive soils for growing sugar cane. It is satisfactorily for growing maize, millet, sorghum and other subsistence crops, but is unsuitable for coffee.

(Ccl-B) *Chemelil clay loam,* 3 *to* 8 *per cent slopes*

This soil is essentially like the Chemelil clay loam on nearly level areas except that the drainage is somewhat more rapid and the colour is slightly more reddish. Most of this moderately sloping land has gradients not exceeding 4 per cent. It is shown separately on the map only because irrigators will have to pay special attention to the arrangement of irrigation ditches and crop rows in order to prevent loss of soil from erosion. Only 85 acres were mapped.

Chemelil clay loam on Chemelil Sugar Estate, looking toward Londiani-Kericho Highlands. Dark line in middle ground is mature sugar-cane.

(Cxc-B) *Complex of arable clay soils,* 3 *to* 8 *per cent slopes*

As pointed out on earlier pages, soils of the ancient lake plain in the Songhor survey area are developed from a succession of clay and volcanic ash deposits—with occasional lenses of gravel and cobble—which have a maximum thickness of about 100 feet. The Nyando and Mbogo rivers and their tributaries have cut valleys up to 100 feet deep in these deposits, exposing the various kinds of clays and buried soils to new soil-forming processes.

The smoother slopes have long supported a cover of bush and tall grasses, and a surface soil, moderately rich in organic matter, and from 6 to 20 inches thick, has developed under this cover. This dark-coloured surface soil lies on a succession of horizontal bands of brown, yellowish-brown, grey and black clays that have been levelled and exposed at the surface by the formation of the stream valleys. In many places, the soil has great numbers of lime-carbonate concretions that were formed in old soils long since buried by the later deposits of volcanic ash and clay, and re-exposed when the valleys were formed.

Most of the many locally different soils of this complex can be ploughed and will produce moderate to fairly high yields of maize, sorghum, millet, vegetables, bananas and sugar cane. Whilst the soils usually are very cloddy when ploughed, and become exceedingly sticky and plastic when wet, they tend to shrink and crumble with drying so that a fairly good tilth can be maintained. The cobbly spots and some of the poorly structured clay spots are unproductive. Probably 80 per cent of this unit will produce economic yields of sugar cane under good management. Furrow irrigation on this complex of soils is impracticable. The map shows 671 acres of this unit.

(Cxc-B-2) *Complex of arable clay soils,* 3 *to* 8 *per cent slopes, moderately eroded*

The soils in this unit are like those described above except that a considerable proportion of the surface soil, rich in organic matter, has been washed away. Crops do not grow so well nor produce such good yields on this phase. Sheet and gully erosion are hazards. 655 acres were mapped. The best use is for pasture.

(Cxc-C) *Complex of arable clay soils,* 8 *to* 13 *per cent slopes*

This unit is like the more gently sloping complex of clay soils, except for the stronger slope and greater difficulty in soil management, and a greater susceptibility to sheet and gully erosion. 1,665 acres were mapped. Its best use is for pasture, but some of it is used for growing sugar cane.

(Cxc-C-2) *Complex of arable clay soils,* 8 *to* 13 *per cent slopes, moderately eroded*

As its name implies, this complex of formerly arable clay soils has lost much of the more fertile and tractable surface soil to erosion. Economic cultivation is scarcely practicable and the soil should be devoted to pasture. Pasture plants will gradually build a new supply of humus in the uppermost 10 to 20 inches of the soil. 11,825 acres were mapped.

(Fcl-A) *Farndell clay loam,* 0 *to* 3 *per cent slopes*

Farndell clay loam is a deep, poorly drained, medium-acid black clayey (black cotton) soil found on long, gently sloping alluvial fans near the mountains of the Songhor survey area, especially at the foot of the Nandi escarpment. It lies below the better-drained Hermann clay and above the well-drained Nyando clay loam of the low stream terraces. It is closely associated also with the red Ainopsiwa clay loam of the higher stream terraces below the Nandi escarpment. Termits mounds averaging about 3 feet high and 30 feet in diameter occur at intervals of 100 to 200 feet. They are cultivated along with the rest of the soil and appear to be more fertile. Roots are very abundant in the uppermost horizons and some persist to a depth of 10 feet.

The long gentle slopes, with up to 3 per cent gradient, allow surface water to move off readily, but the soil receives seepage water from higher land and is wet during the rainy season. Cultivated crops need drainage.

Some gullies have formed along cattle paths and the soil needs protection from overgrazing and trampling of the herbage.

Only 65 acres, largely in the north-eastern part of the survey district, were mapped.

Some of the soil has been planted to maize which grows rather poorly immediately after clearing, but is said to do better the second and third years. Most of the rest of the soil is in pasture.

Farndell clay loam is physically well suited to maize, sugar cane and vegetables, as well as for pasture, but is entirely unsuitable for coffee. In 1958 young maize of the first planting showed symptoms of deficiency of phosphorus and nitrogen, except on the termite mounds, but the contrast was less noticeable at the time the maize reached maturity. Chemical tests showed that the termite mounds contained several times as much available phosphorus as the soil between the mounds. Artificial drainage is necessary to keep the soil productive. Weeds are a serious problem in wet years.

(Fcl-B) *Farndell clay loam,* 3 *to* 8 *per cent slopes*

A few small areas of Farndell clay loam have slope gradients ranging up to about 8 per cent. The soil differs little from that on gentler slopes, but the erosion hazard is far greater when the soil is cultivated, and farmers will need to pay special attention to this problem. Only 53 acres were mapped.

(Gcl-B) *George clay loam,* 3 *to* 8 *per cent slopes*

George clay loam is a dark-coloured soil, developed from clayey alluvial-fan terraces 30 to 50 feet above stream channels, chiefly in the large valley north of Songhor Post Office, along the Ainomotua River and its tributaries. It is only moderately well-drained but can be used for growing maize, sugar cane, sorghum, millet and vegetables. It is not suitable for coffee. The physical properties of the soil are much like those of the Volo clay loam, but volcanic ash is not a visible part of the parent material.

The plough soil is very dark grey, fine-blocky, medium-acid clay loam, which is hard when dry, stiff when moist and plastic and sticky when wet. Below the plough layer, to a depth of about 22 inches, the soil is similar to the above, but with about 20 per cent of dark-brown, black and red concretions, up to quarter inch diameter. Deep subsoils are clayey, blocky, sticky and plastic, and slowly permeable when wet. Some thin layers of sand and gravel are interbedded with clay deposits below a depth of 6 feet.

Termite mounds up to 5 feet high and 40 feet in diameter, and about 2 to the acre, apparently contain a mixture of materials from all horizons. Sisal and maize growing on these mounds are greener and much more thrifty than on the soil between, suggesting either a concentration of nitrogen or better aeration in the mounds, or both.

Natural drainage is imperfect. Water enters the soil readily, through vertical cracks immediately after the dry season but moves only very slowly through the soil during the wet season. Sheet erosion is active in cultivated areas of this soil.

This moderately sloping phase has a total area of 3,581 acres, mostly on high fan-terraces of the tributaries of Ainomotua River, in the large valley north of Songhor Post Office. In recent years most of the George clay loam has been planted to sisal of which it produced fair yields. Soil not in sisal is largely in pasture, and much of the abandoned sisal land is used also for pasturing dairy cattle. Sugar cane has been started recently on some of the soil. With good management, including the use of fertilizers, yields of 35 to 40 tons to the acre of 2-year cane may be expected. Yields under irrigation should range up to 50 or 60 tons. The soil is not suitable for coffee.

(Gcl-A) *George clay loam,* 0 *to* 3 *per cent slopes*

This nearly level phase of George clay loam resembles the moderately sloping phase, except that surface drainage is less rapid and sheet erosion is less of a hazard. The soil is suited for the same crops and should yield about the same or perhaps a little more. This phase is somewhat less well suited to maize than the moderately sloping soil. It covers only a small area, totalling 103 acres on the smaller parts of the high fan-terraces in association with the moderately sloping phase.

(Hc-C) *Hermann silty clay loam,* 8 *to* 13 *per cent slopes*

Hermann silty clay loam is a dark-coloured fertile soil, developed from colluvial material collected on moderate slopes at the bases of hills and mountains in the eastern and north-eastern parts of the survey area. The soil has abundant humus, good structure, and fairly high natural fertility.

The plough soil is dark reddish-brown to nearly black, fine-granular, medium-acid crumbly clay loam with about 4 per cent humus. Immediately below the plough soil to a depth of about 3 feet, is a black to very dark brown, fine-blocky, medium-acid, crumbly clay with nearly 3 per cent humus. The deeper subsoil is dark reddish-brown, mottled dark reddish-grey, fine-blocky crumbly clay of nearly neutral reaction, grading to strongly mottled yellow, grey, brown and black clay loam with cementation by black manganese oxide, over decayed granitic and basaltic colluvial material. The upper foot or two or soil varies from black to dark reddish-brown; there are occasional patches of black to dark grey soils in seepy spots; deep subsoil mottles vary widely in colour from place to place. Depth to bedrock varies from 3 to many feet. One to three large termite mounds to the acre.

The smooth slopes of 8 to 13 per cent cause moderate to rapid surface run-off; internal drainage is moderate. The soil is never water-logged except on the few included seepy spots.

Cultivated land is subject to sheet erosion and some gullying and needs protective measures, but the hazard is not a serious one, considering the slope.

The 1,055 acres of this soil are used for growing maize, sorghum, pawpaws and other fruits, and pasture. Yields are moderate to high under good management. Sugar cane should grow very well, and all but the few included seepy spots should be moderately well suited for coffee.

(Hc-B) *Hermann silty clay loam,* 3 *to* 8 *per cent slopes*

Most of the Hermann silty clay loam of this unit has slope gradients ranging around 5 to 6 per cent. In all other respects the soil is like the more strongly sloping phase of Hermann silty clay loam, described above. Erosion hazards are slightly less. Crop adaptations are the same. 273 acres were mapped.

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

Kamaasae sandy clay loam is a dark-coloured soil of medium to slightly acid reaction in the top 2 feet, well supplied with organic matter and calcium, but low in magnesium. It is developed from calcareous (limey) volcanic tuff, in close association with the black, humus-rich, Ngeron silty clay loam. It is well suited to most agricultural crops of the region, and moderately well suited for coffee. It is rich in humus to a depth of 2 to 3 feet. Depth to the calcareous tuff varies locally from less than 3 to more than 5 feet. In some places, the plough soil has a neutral instead of medium-acid reaction.

Surface and internal drainage are good, and the soil absorbs water well. Cultivated land needs to be protected from sheet and gully erosion, though the hazard is not a serious one. Small areas occur in the north-eastern part of the survey area, largely on Ngeron farm. Total area only 60 acres.

The soil is used for coffee, general farm crops and pasture. Fertility is fairly high, though magnesium may be deficient. It should produce good yields of sugar cane.

(Kcl-C) *Kamaasae sandy clay loam,* 8 *to* 13 *per cent slopes*

This phase of Kamaasae sandy clay loam is essentially like the gently sloping phase described above except that the gradient is steeper—usually somewhat more than 8 per cent. This soil is used largely for pasture because of the greater erosion hazard. Under hoe culture it produces good yields of maize, vegetables and tree fruits. Part of the soil is too steep to be entirely satisfactory for sugar cane. 222 acres were mapped.

(Kt-D) *Kamaasae stony clay loam,* 13 *to* 20 *per cent slopes*

Kamaasae stony clay loam averages shallower than Kamaasae sandy clay loam. Depth to calcareous tuff varies up to 3 or 4 feet, but most of it is less than 2 feet deep. Many large stones are scattered over the surface and through the soil. The stony condition and steep slopes render impracticable the use of machines in cultivation. Many small patches can be used by African hoe farmers for raising subsistence crops. 73 acres were mapped.

(Kps-B) *Kapchure sandy loam,* 3 *to* 8 *per cent slopes*

Kapchure sandy loam is an imperfectly drained soil with a ground-water laterite (murram) horizon which is saturated with water during and several weeks after the rainy season. It occurs on remnants of an ancient plain that lies 4,500 to more than 5,000 feet above sea level, in the northern and south-eastern parts of the Songhor survey area. A closely similar soil has been noted also, at the same levels, about 20 to 25 miles west and southwest of Kisii (about 50 miles southwest of the Songhor survey area). The soil is not very fertile, but is used for growing sisal and subsistence crops in addition to pasture grasses.

The surface soil to 12 inches is very dark grey when moist to dark brown when dry, weakly fine-granular, crumbly, medium-acid sandy loam. About 3 per cent humus.

The subsoil is mottled dark-brown and brown, fine-blocky plastic sandy clay with medium-acid reaction.

The "murram" or "laterite" horizon consists of about 85 per cent reddish-brown iron-oxide concretions and about 15 per cent of brown and grey-mottled sandy clay loam. It is quite porous and is saturated with water during and several weeks after the rainy season. At levels of 2 to 4 feet below the surface murram is cemented into a hard but porous slag-like mass known also as laterite.

The parent material is greyish-brown, mottled yellowish-brown, gravelly clay loam consisting of weathered and crumbly granitoid gneiss. Water seeps slowly through this material and maintains the high water table referred to above.

The depth to the murram varies from about 8 to about 30 inches. In some places, the loose murram is very thin or lacking and the hard laterite takes its place. Plough-soil textures range locally from loamy sand to sandy clay loam.

Some water runs off, but much is retained in the soil with the water table near a depth of 20 to 24 inches during one third to one half of each year.

Sheet erosion is a hazard on cultivated land, and the soil becomes useless for agriculture as soon as the murram horizon is exposed.

The soil is extensive between the Nandi escarpment and the lake plain (near Chemelil Sisal Headquarters); along the Muhoroni-Koru road about 3 miles southeast of Muhoroni; and $3\frac{1}{2}$ miles southwest of Muhoroni on the Kericho road. 1,438 acres were mapped. It is used for pasture, sisal and some subsistence crops. Sisal yields are fair. For growing sugar cane the soil will require drainage, fertilization, and conservation practices.

(Kps-B-2) *Kapchure sandy loam,* 3 *to* 8 *per cent slopes, moderately eroded*

This phase of Kapchure sandy loam has lost several inches of the plough-soil, but in other respects is the same as the rest of the Kapchure sandy loam. Most of this eroded phase has slopes of 3 to 4 per cent. This soil has little value for agriculture because there is too little tillable material left for adequate support for crop plants. Its best use is for pasture and wood-lots. 41 acres were mapped.

(Kps-D) *Kapchure sandy loam,* 13 *to* 20 *per cent slopes*

This strongly sloping phase of Kapchure sandy loam lies on the sloping edges of the larger areas of this type. The ironstore subsoil is nearer the surface and crops out in many places. The 36 acres of the phase has little value for agriculture, but may provide low-grade pasturage. It lies about $2\frac{1}{2}$ miles southeast of Muhoroni.

(Kpd-B) *Kapchure sandy clay loam,* 3 *to* 8 *per cent slopes*

This soil differs from Kapchure sandy loam in having a little more clay in the plough-soil and water-saturated murram at greater depth. The soil has more effective space for root growth and appears to be considerably better for crops than Kapchure sandy loam.

A representative profile, nine-tenths mile south of Chemutum salt lick, or about 4.2 miles west-southwest of Muhoroni, is as follows:—

0 *to* 7 *inches.*—Very dark (moist) to dark (dry) reddish-grey fine-granular, crumbly, medium-acid clay loam.

7 *to* 19 *inches.*—Dark reddish-brown, crumbly, fine-block, medium-acid clay loam with 10 per cent small quartz fragments.

19 *to* 40 *inches.*—Dark reddish-brown, mottled black, gravelly clay loam, consisting of about 30 to 40 per cent loose and partly cemented ironstone concretions (murram or laterite) with fine earth between.

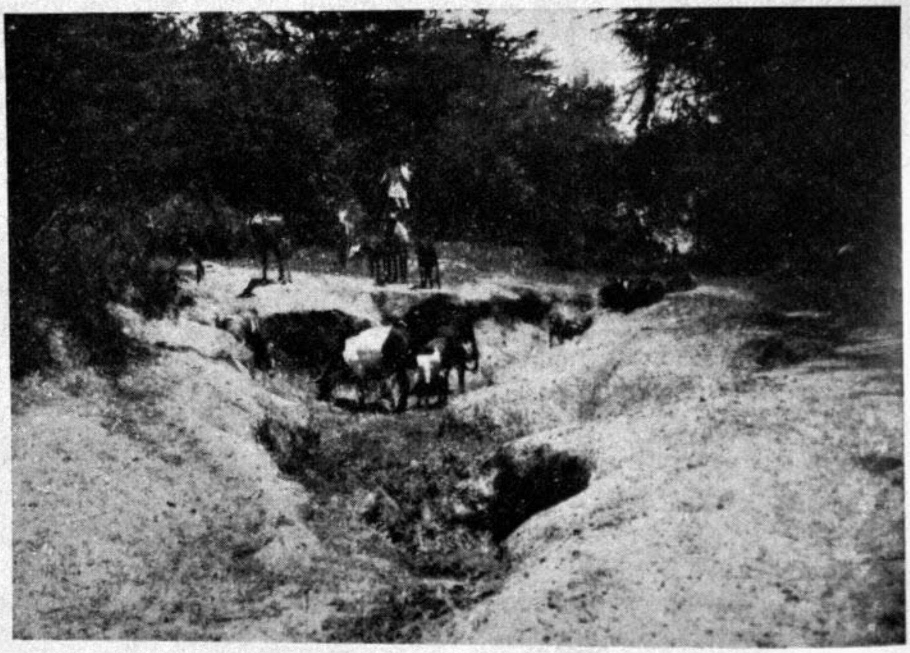
40 *to* 48 *inches*.—Similar to above, but with a larger percentage of murram and with decayed granitic gneiss. This layer is saturated with water during and for some weeks after the rainy season.

48 *to* 60+ *inches*.—Decayed granitic gneiss, with about 20 per cent murram in the upper part. Saturated with water.

Texture of the plough-soil varies from sandy clay loam to clay loam, and thicknesses of horizons vary somewhat from place to place. The undulating to gently rolling surface, with slope gradients of 3 to 8 per cent, permits surface water to run off fairly rapidly, but internal water is held up by the impervious bedrock. The subsoil below 3 to 4 feet is saturated during several months each year.

Cultivated areas are subject to sheet erosion. Overgrazed areas are likely to have bad gullies.

The soil lies west of the Muhoroni-Kericho road and south of the Nyando River. Only 354 acres were mapped. It is used for growing sisal with good yields, maize and other subsistence crops, and pasture. If fertilized it should produce moderate yields of sugar cane.



Chemutum salt lick in Kapkuong loamy coarse sand, three miles south-south-west of Muhoroni. Salts include sodium chloride and sodium bicarbonate.

(Ks-B) *Kapkuong loamy coarse sand*, 3 *to* 8 *per cent slopes*

Kapkuong loamy coarse sand is a dark grey "hardpan" soil, low in organic matter, found on the lower slopes of alluvial fans that border the granitoid gneiss mountains and hills of the Nandi escarpment and outlying ranges near Songhor. Most of the soil lies downslope from Mbereri coarse sandy loam and, in places, is associated closely with Ainomotua sandy clay loam. The texture of the plough-soil varies from loamy coarse sand to sandy loam and the total thickness of soil of these textures varies from about 8 to about 30 inches. The thicker soil is the better one for crops. The soil is derived from sandy, gravelly and clayey alluvial-fan deposits like those beneath the Mbereri coarse sandy loam, washed from granitoid gneiss hills and mountains. There is enough sodium in the subsoil to cause it to disperse to a sticky mass when wet, to become very hard when dry, and to erode very rapidly when not protected by vegetation.

The slopes are long and smooth with a gradient of about 3 to 8 per cent but mostly less than 5 per cent. Surface run-off is rapid and may lead to severe gullying where management is not the best. Internal drainage is slow owing to the heavy impermeable subsoil. Cultivated and overgrazed areas are subject to rapid and severe sheet and gully erosion, which soon get out of control. Patches of the soil are scattered along the base of the Nandi escarpment, the mountains west of Songhor, and the hills immediately west and south of Muhoroni. A total area of 3,280 acres was mapped.

Eight-foot gulley in Kapkuong loamy coarse sand. The bare flat surface is the top of the "B" horizon, exposed by sheet wash, Nandi Reserve.

The soil is used for pasture and various cultivated crops including sisal, maize, sorghum and some sugar cane. It is suitable for these uses only if intensive erosion control measures are adopted. Overgrazed and cultivated areas otherwise are soon ruined by catastrophic erosion. If sugar cane is grown on the contour, with grassed waterways, and with the use of commercial fertilizers, it may grow moderately well; and it is likely that growing sugar cane under the best management may be as good a method as any to control erosion. Fertility status is low, especially in phosphorus, nitrogen sulphur and calcium.

(Ks-B-3) *Kapkuong loamy coarse sand,* 3 *to* 8 *per cent slopes, severely eroded*

Most of this phase of Kapkuong loamy coarse sand has lost a large percentage of its crumbly surface soil and is scored, in many places, by gullies up to 12 feet deep. It is almost useless for cultivation and carries only a very sparse grass cover. A few included areas support enough grass for limited pasturage, and African farmers might find a few patches of less-eroded soil large enough for small garden plots. Erosion in Kapkuong loamy coarse sand tends to spread up-grade into Mbereri coarse sandy loam and other soils. Of the total of 638 acres of this eroded phase, more than half is in the Nandi reserve in the north-western part of the survey area. Other small severely eroded areas are near the main road leading from Songhor to Chemelil railway station. Deep gullies have been cut by water diverted from this road.

(Ks-C) *Kapkuong loamy coarse sand,* 8 *to* 13 *per cent slopes*

This more strongly sloping phase of Kapkuong loamy coarse sand is similar in other respects to the moderately sloping phase. The danger of sheet and gully erosion under cultivation is greater, but a smaller proportion is cultivated. A few deep gullies have formed in it along the Songhor-Chemelil station road where water has been diverted from the road. Erosion control is even more difficult in this phase than on the more extensive moderately sloping phase. 478 acres were mapped.

(Ks-A) *Kapkuong loamy coarse sand,* 0 *to* 3 *per cent slopes*

A few small areas of this nearly level phase of Kapkuong loamy coarse sand were mapped in and near the east edge of the Nandi reserve, not far from Kapkuong. The soil is the same as the normal phase described above, except that erosion control is less of a problem. Most of the soil is used either for pasture or for growing sisal. 121 acres were mapped.

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

Kibigori clay is a black heavy clay soil, one of a group known locally as "black cotton soil". The soil is very cloddy when first ploughed but crumbles to a good tilth after being dried and wetted a few times. It is developed from clay and volcanic ash laid in lakes and swamps and on stream terraces during a period, many thousands of years ago, when it is likely that the waters of Lake Victoria covered the area. It resembles the Ngeron silty clay loam in colour, structure and texture but has less organic matter and the organic-rich material is not so deep as in the Ngeron. On the average it has somewhat more organic matter than the Muhoroni clay loam which is another black cotton soil developed from an old deposit of volcanic tuff on sloping land mostly above the level of the old lake beds.

There is some variation in the amount of organic matter in the uppermost 2 feet of soil. Most of the soil has lime concretions at depths varying from 30 inches to 6 feet but averaging around 4 to 5 feet. In many places a 5-foot auger will reach layers of volcanic ash.

The soil lies on the nearly level lake plains, often slightly depressed, with slope gradients usually not exceeding 2 per cent. The lower and most poorly drained parts of the plains usually are occupied by Aristos clay loam which differs from the Kibigori only in being more poorly drained. Surface drainage is slow on Kibigori clay but water enters the soil readily through cracks which form during the dry season; but once the cracks are closed as the clay swells, internal drainage is very slow and the soil may be waterlogged during the wet season. Erosion is no hazard except in a few places where gullies are forming on the edges of deeply incised valleys.

Large areas in the central and south-eastern sectors of the surveyed land are covered by Kibigori clay which has a total area of 10,288 acres. This soil is used for subsistence crops and pasture on the African reserves and for sugar cane and pasture on European and Asian lands. Yields are moderate. When provided with surface drains, Kibigori clay produces good yields of sorghum, maize, sugar cane and various subsistence crops. It is entirely unsatisfactory for coffee. Surface drains are essential on this soil, and yields of sugar cane should be nearly doubled by irrigation and the use of suitable fertilizers.

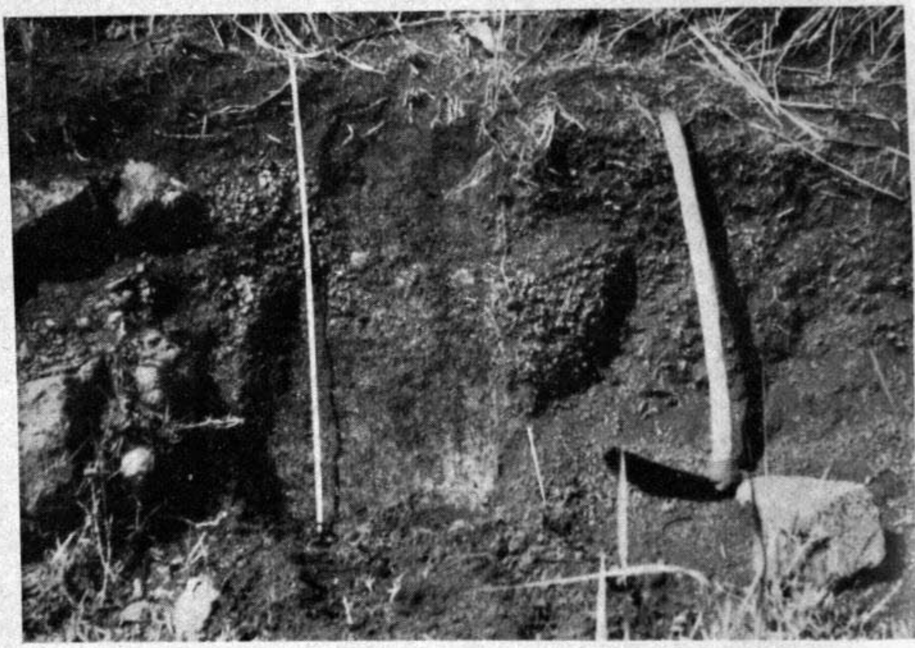
(Kbc-B) *Kibigori clay,* 3 *to* 8 *per cent slopes*

This gently sloping phase of Kibigori clay differs from the nearly level phase only in its slightly stronger gradients, in most places ranging between 3 and 5 per cent. It is most extensive toward the up-valley limits of its range, in the east-central part of the survey area. Surface drainage is somewhat easier on this than on the nearly level phase. A total of 5,105 acres was mapped.

(Kgl-B) *Kibubu gravelly loam,* 3 *to* 8 *per cent slopes*

Most of this soil has slopes of only 3 per cent or slightly more. Kibubu gravelly loam is a shallow, dark-coloured soil of medium-acid reaction, with a good supply of phosphorus and potassium and a deficiency of nitrogen. Because the soil is shallow over bedrock, the crops grown on it are likely to suffer from drought during the dry season. The soil is developed from the same kinds of rock as the Bhanji soils and is closely associated with them.

The plough-soil is black, granular, friable gravelly loam (locally, gravelly sandy clay loam), with about $3\frac{1}{2}$ per cent organic matter. The gravel is concretionary ironstone (murram) and is about 30 to 40 per cent by volume. Slightly acid. Below to a depth of 10 inches is dark reddish-brown (moist) to dark reddish-grey (dry) granular, gravelly sandy loam. About 60 to 80 per cent of the volume is of brown and black-mottled concretions of irregular shapes and from ¼ to 1½ inch in diameter. Medium-acid reaction. Organic matter is less than 2 per cent. 10 to 25 inches is mottled strong-brown and black, weakly cemented lateritic ironstone (murram) with about 15 to 20 per cent of medium-acid sandy loam in the pore spaces. This lies on weathered basaltic lava of light grey colour, with black manganese oxide lining the joins. Fragments of bedrock with brown weathering crust are in this horizon and are scattered through the horizons above it.



Kibubu gravelly loam. The bulge at right-centre is laterite (murram). Rocks at left are laterite-coated basalt. The tape is 3 ft. long.

The depth of the profile varies usually between about 1½ and 3 feet. The murram horizon and the bedrock crop out at the surface here and there. 1 to 3 large termite mounds per acre.

The soil is well drained; surface run-off is moderate; internal drainage is through cracks in the bedrock. Subsoils may be saturated temporarily during the rainy season.

Scattered areas occur at the bases of hills and mountains south of Mbogo River. A total area of 362 acres was mapped.

Most of the soil is used for pasture. Patches of maize, sorghum and other subsistence crops are planted by African labourers for their food supply. Yields are moderate. Soils are too shallow for growing sugar cane, but sisal will grow moderately well.

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

This more strongly sloping phase of Kibubu gravelly loam is much like the more gently sloping phase, described above, but the depths to murram and bedrock average less. Much of this phase is too stony to plough, but a few patches of subsistence crops are grown on the more favourable spots. The land is used primarily for pasture—the best use. Only 61 acres were mapped.

(Knc-E) *Kipsesin clay loam,* 20 *to* 35 *per cent slopes*

Kipsesin clay loam is a shallow, nearly black, fertile soil of the basaltic and phonolitic rocks and volcanic tuff on the hills and mountains of the Songhor survey area. The soil occurs as a very complex pattern of small patches of less than an acre to a few acres in extent interspersed with bare rock or loose boulders. In some places, as much as 50 to 70 per cent of the areas mapped is typical Kipsesin clay loam, with the remainder bedrock. In other areas the exposed bedrock may take up as much as 60 per cent of the area.

The surface soil to 8 inches is black (moist) to very dark-grey (dry) medium to fine-granular, crumbly, slightly-acid clay loam, rich in humus. This grades downward though dark-brown coarsely granular, crumbly with less humus and roots than above, to light-grey weathered and crumbly volcanic tuff with dark-brown films of clay lining the joints.

In some places the true soil is as little as 5 or 6 inches thick; in a few "pockets" it may be as much as 3 feet thick. Some of the soil is dark-reddish to reddish-brown.

The soil occurs on steep slopes of hills and mountains where surface run-off is rapid. Water moves freely through the subsoil, but internal drainage is not excessive. The soil remains moist during most of each year but becomes too dry for crops during protracted droughts.

A total of 4,284 acres was mapped in the hills and mountains of the eastern part of the Songhor survey area.

The soil is used by European farmers chiefly for pasture, and to a limited extent for coffee. African farmers and labourers hand-cultivate the better patches for raising maize, beans, bananas and various other subsistence crops. Cultivated areas must be protected from erosion, usually by contour cultivation and terracing.

This soil is too steep and stony for growing coffee or sugar cane on a commercial scale.

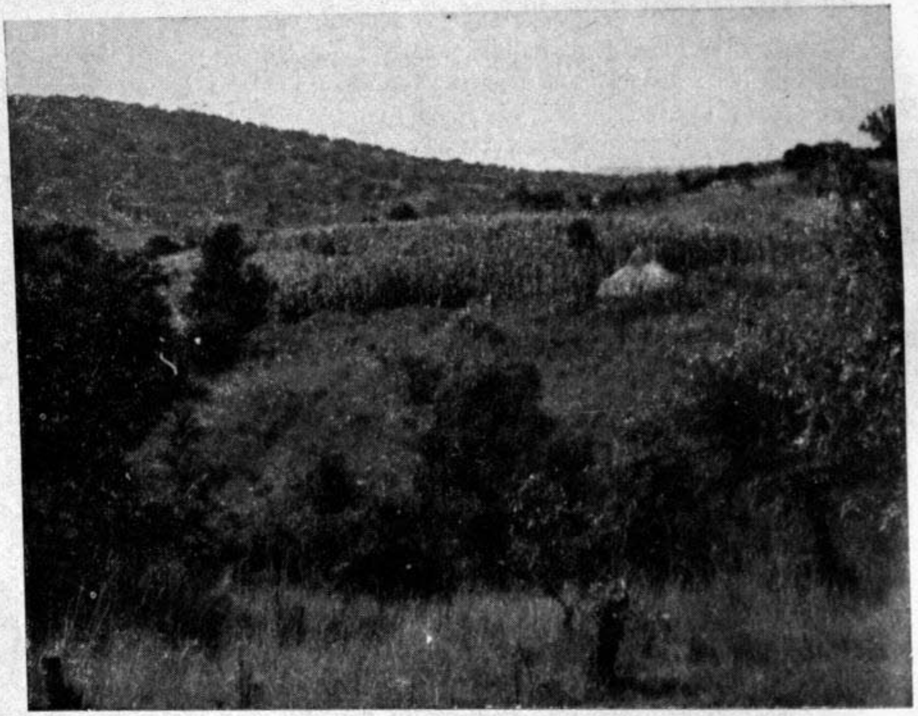
(Knc-D) *Kipsesin clay loam,* 13 *to* 20 *per cent slopes*

This phase of Kipsesin clay loam lies on strong to moderate slopes and a slightly larger proportion of it can be used for subsistence crops than of the more extensive steep phase, described above. There are no other important differences, except that the erosion hazard is less. A total of 1,021 acres was mapped.

(Knc-C) *Kipsesin clay loam,* 8 *to* 13 *per cent slopes, and*

(Knc-B) *Kipsesin clay loam,* 3 *to* 8 *per cent slopes*

These two phases of Kipsesin clay loam were shown separately on the map to give an indication of the relatively more favourable slopes for cultivation as compared to the steep and very steep phases. Their uses are the same as for the steeper phases, but the proportion of land suitable for gardens is somewhat larger. 779 and 541 acres, respectively, were mapped.



Maize growing on Kipsesin clay loam under hoe-culture, one and a quarter miles south-east of Songhor Post Office.

(Knc-A) *Kipsesin clay loam,* 0 *to* 3 *per cent slopes*

87 acres of Kipsesin clay loam has slopes of less than 3 per cent gradient. It is less subject to erosion than other phases and the soil averages slightly deeper.

(Kol-A) *Koru clay loam,* 0 *to* 3 *per cent slopes*

Koru clay loam is a deep, dark reddish-brown, well-structured, fertile clay loam soil of a high alluvial terrace of the Nyando River, west of Koru. The subsoil is a crumbly permeable clay. It is one of the best soils of the Sorghor survey area for a wide variety of crops but, unfortunately, does not cover a very large area. Much larger areas occur outside the limits of the survey.

The gently sloping river terrace of 2 to
slow surface drainage, but internal draina
well drained and never waterlogged.

The soil occupies high river terraces,
the survey area to the outskirts of Koru. O
area, but much more lies farther east.

Commercial sisal and coffee, maize,
crops are grown, with good yields. The
Fertility level is high, and the physical con

(Kuc-A) *Kundos sandy clay,* 0 *to* 3 *per cen*

Kundos sandy clay is a deep, crumbly
soil of low fertility status, but with exce
remnants of old alluvial fans, below the
part of the Songhor survey area. Physic
sandy loam, but is more clayey. It is asso
loam, Kapguong loamy coarse sand, A
Kapchure sandy loam. Kibigori clay and
on the south. It resembles Ainopsiwa clay
matter. Texture of the plough depth vari
to sandy clay loam in a few places. Otherw
parent material is ancient alluvial-fan dep
some layers of volcanic ash are interbed
feet below the surface.

The soil lies on smooth gentle slopes
the dissection of old alluvial fans and r
slowly over the surface, and drains freely
subsoil. The soil is never waterlogged. On
sheet-wash is high and gullies tend to eat th
slopes. A total of 457 acres was mapped.

The soil is used for pasture, maize a
are moderate to low. The soil has good ph
of crops, including sisal, maize, sugar cane
will need organic manure and commercial

(Kuc-B-2) *Kundos sandy clay,* 3 *to* 8 *per*

The moderately sloping areas of K
subjected to moderate sheet erosion with
original surface soil and with a few shall
measures will be necessary to protect this
has been and still is overgrazed. It occurs
reserve, in the north-western part of the sur

per cent gradients provides only
is moderately free. The soil is

near Koru, and extends beyond
y about 40 acres in the surveyed

d a wide variety of subsistence
oil is excellent for sugar cane.
tion is very good for cultivation.

slopes

dark reddish-brown medium-acid
nt tilth. It occurs on scattered
ndi escarpment in the northern
y, it resembles Mbereri coarse
ated with Mbereri coarse sandy
omotua sandy clay loam and
her lake-plain soils are adjacent
oam but has much less organic
locally to clay loam and even
e the soil is nearly uniform. The
its washed from granitic gneiss.
ed with the alluvium 10 to 20

the crests of ridges, formed by
er terraces. Water moves away
rough the porous, crumbly clay
vergrazed areas the hazard from
way back from adjacent steeper

other subsistence crops. Yields
ical properties for a wide variety
nd coffee. Most cultivated crops
rtilizers.

nt slopes, moderately eroded

dos sandy clay have all been
oss of perhaps two-thirds of the
gullies. Drastic erosion-control
oil from destruction. Most of it
hiefly in and close to the Nandi
y area. 1,010 acres were mapped.

(Lec-A) *Lemaiywa clay,* 0 *to* 3 *per cent slopes*

Lemaiywa clay is a black, humus-rich, imperfectly to poorly drained soil of the flood plains and low terraces of the streams in the central and southwestern parts of the survey areas. Subsoil textures range from clay to sandy clay loam. It is closely associated with the better-drained Tennant clay loam and Tennant sandy loam. It lies at a lower level than the Kibigori clay and Aristos clay loam. It is a fertile soil well adapted to maize and sugar cane when it has been drained. It is unsuitable for coffee.

The soil generally is high in clay and humus and near neutral in reaction. If it is drained, it should be at least as productive for sugar cane as Kibigori clay. 1,053 acres were mapped.

(Mal-B) *Marcantonatos loam,* 3 *to* 8 *per cent slopes*

Marcantonatos loam is a deep, dark-coloured, well-drained, crumbly, medium-acid soil with dark reddish-brown crumbly, clayey subsoil, which occurs on old alluvial deposits washed from the granitic gneiss of the Nandi escarpment. It has a more clayey and redder subsoil than the associated Nandi loam. It has excellent physical properties and is moderately fertile, and is well suited for growing maize, coffee, sugar cane and subsistence crops, as well as for pasture. Cool nights may reduce its value for sugar cane.

Run-off is moderate; but water drains freely through the soil. The water-holding capacity is ideal for crops that require both good aeration and a continuous supply of easily available water.

The soil is confined to a few small areas close to the Nandi escarpment with a total area of 110 acres. Most of it is used for pasture; but it is also excellent for coffee, maize and other subsistence crops. It is good for sugar cane, except that the cool climate makes for slow growth.

(Mnc-B) *Martin clay loam,* 3 *to* 8 *per cent slopes*

Martin clay loam has physical properties much like Marcantonatos loam, except that it has a higher percentage of clay. It is a deep dark-coloured well-drained crumbly, medium-acid clayey soil with crumbly dark reddish-brown permeable clay subsoil, developed from deposits associated with basic lavas (phonolites and basalts). It is fertile, rich in humus, well drained, and suitable for a wide variety of crops.

The dark humus-rich surface soil ranges up to 18 inches thick and both surface soils and subsoils are redder in some places than in others. The clayey parent material has accumulated by surface wash or creep, and by weathering from dark-coloured fine-grained lavas (phonolites and basalts).

The gentle to moderate slopes, with gradients of 3 to 8 per cent, provide good surface drainage. Internal drainage is free. The soil is well aerated, but holds enough water to supply plants during droughts of considerable duration. Sheet and gully erosion are a moderate hazard.

The few small areas, scattered through the east-central part of the survey area and totalling 293 acres, are used for pasture, citrus and other orchard fruits, coffee and subsistence crops. Fertility is fairly high, especially as to phosphorus, potash and calcium. Sugar cane should prosper on this soil.

(Mnc-C) *Martin clay loam,* 8 *to* 13 *per cent slopes*

This strongly sloping phase of Martin clay loam has physical and chemical properties like the more gently sloping phase, described above, but is more subject to accelerated erosion. It will support the same crops, provided erosion-control and water conservation practices are applied. 163 acres were mapped.

(Msl-B) *Mbereri coarse sandy loam,* 3 *to* 8 *per cent slopes*

Mbereri coarse sandy loam is a reddish deep soil, closely related to Marcantonatos loam, but is neither so dark coloured nor quite so fertile. It resembles the Kundos sandy clay in structure but is somewhat redder in colour and is more sandy in texture. It lies below Mbereri stony and gravelly sandy loam and is usually at a higher level than the Kapkuong loamy coarse sand on the same alluvial fans. The humus content of the surface soil varies somewhat from place to place and where the soil merges with Kapkuong loamy coarse sand the subsoil is somewhat greyish and mottled. A few loose stones are scattered over the surface near the gneiss hills. The parent material is stratified clayey and sandy deposits washed from adjacent gneiss hills. The surface slope ranges from 3 to 8 per cent gradient. Surface drainage is rapid, internal drainage is free, and the soil has a good capacity to hold water for the use of plants that require aeration.

The soil is used for growing maize and other subsistence crops and for pasture, but the erosion hazard to cultivated and overgrazed land is very severe and requires intensive erosion-control measures. With such measures it is possible to grow various subsistence crops, tree fruits, sugar cane and coffee. Since the general level of fertility is low, fertilization will be needed if agriculture is to be permanent. Scattered areas of considerable size lie below the Nandi escarpment and around the gneiss hills and low mountains near Songhor and the George and Volo estates. A total of 2,078 acres was mapped.

(Msl-B-2) *Mbereri coarse sandy loam,* 3 *to* 8 *per cent slopes, moderately eroded*

This moderately eroded, gently to moderately sloping phase of Mbereri coarse sandy loam has already lost some of its plough-soil through sheet erosion and has a few shallow gullies. The soil profile otherwise is like the one described in the foregoing paragraph. This soil is suitable for the same crops as the normal soil, but yields are likely to be somewhat less. Erosion-control practices are necessary. If they are not put into effect, the soil will very soon become useless for cultivation and will have a greatly reduced value for pasture. 1,304 acres were mapped.

(Mbc-A) *Mbogo clay loam,* 0 *to* 3 *per cent slopes*

This nearly level phase of Mbogo clay loam occurs in association with the more extensive, moderately sloping phase. It has the same kind of profile and the same suitabilities for use. Erosion hazard on this soil is only very slight. A total of 422 acres was mapped.

(Mbc-D) *Mbogo clay loam,* 8 *to* 13 *per cent slopes*

This strongly sloping phase of Mbogo clay loam of only 58 acres is largely used for pasture. If cultivated, this soil will need to have intensive erosion-control practices. It is best suited to pasture, because of the strong slopes.

(Muc-B) *Muhoroni clay loam,* 3 *to* 8 *per cent slopes*

Muhoroni clay loam is a deep, heavy, nearly black, medium-acid clayey soil (commonly called "black cotton" soil) developed largely from a pale-olive-coloured soft volcanic tuff that is exposed on footslopes below the hard, dark-coloured volcanic rocks in the east-central and south-eastern parts of the Songhor survey area. The soil resembles the Kibori clay of the lake plain but contains less organic matter on the average. It is noted for being wet and "cold" during the rainy season and is difficult to manage because of its very clayey texture, sticky consistence, and relatively low humus content. Deep and wide cracks form during the dry season.

The soil varies considerably from place to place, especially in total thickness of the dark-grey to black clay—normally 3 to 4 feet—which locally may extend to depths of more than 6 feet. Calcareous concretions are found in many places, usually below a depth of 5 feet.

The soil occurs on long smooth slopes of 3 to 8 per cent gradient from which surface water runs off fairly rapidly after the soil becomes wet. Following dry periods, water enters the soil through cracks. During and just after the wet season the soil is very wet and impervious. Many seepy areas develop and interfere with crop growth. Surface drainage is required on crop land.

Cultivated and overgrazed areas are subject to moderate sheet erosion, and gullies may be formed. The soil has not been extensively eroded.

This is one of the more extensive soil types in the east-central and south-eastern parts of the survey area. 4,275 acres were mapped. It is used largely for pasture. Some maize and subsistence crops are grown, but yields are low under present management. The soil is moderately well suited for sugar cane if drained and fertilized. It is good pasture land except during the wet season.

(Muc-A) *Muhoroni clay loam,* 0 *to* 3 *per cent slopes*

A small proportion, 834 acres, of Muhoroni clay loam lies on very gentle slopes. The profile has about the same range of characteristics as the

moderately sloping phase, but the soil is likel
during and immediately after the rainy seas
with surface drains to remove excess water. S
soil is drained and fertilized.

(Muc-D) *Muhoroni clay loam,* 13 *to* 20 *per*

This strongly sloping phase of Muhoroni
severe sheet erosion if it were brought under
in pasture. 528 acres were mapped.

(Nl-A) *Nandi loam,* 0 *to* 3 *per cent slopes*

Nandi loam is a dark-coloured, humus-
soil of alluvial fans situated at the base of the N
from which it is developed is of sediments w
hills of the Nandi escarpment and adjacent hi
and boulders may occur locally at depths of
with the Marcantonatos loam of the older al
stony sandy loam of the adjacent mountain
productive soil though it has a more or less st

Drainage is good, and largely internal. T
moisture available for crops. The erosion ha
been formed in a few places.

Small areas are scattered below the Nar
were mapped. It is used for growing maize, c
and other fruits, and pasture. Sugar cane sho
be slowed by cool nights.

(Nl-B) *Nandi loam,* 3 *to* 8 *per cent slopes*

This moderately sloping phase of Nan
higher up the valleys than the more gently sl
sheet erosion if clean-cultivated. It is used fo
sloping phase, but a larger proportion is in p
common in subsoils within 2 to 3 feet of th
mapped. A small area with 12 per cent slope

(Ngc-B) *Ngeron silty clay loam,* 3 *to* 8 *per c*

Ngeron silty clay loam is the most ferti
black clay ("black cotton") soils in the Songh
the eastern foothills of the Nandi escarpmen
of the surveyed area. It is developed from
volcanic tuff. Lower horizons have an abund

The surface soil to 12 inches is black (m
(dry), fine-blocky, heavy silty clay loam which
but crumbly when dry. Medium to slightly-ac

to be wet for longer periods
. The soil must be provided
gar cane can be grown if the

ent slopes

lay loam would be subject to
ultivation and should be kept

h, crumbly, medium-textured
ndi escarpment. The alluvium
shed from the granitic gneiss
s and mountains. Small stones
to 40 inches. It is associated
vial fans and with Nyangoro
Nandi loam is a fertile and
ny subsoil in some places.

e soil holds a good supply of
rd is slight; but gullies have

i escarpment. Only 110 acres
her subsistence crops, pawpaw
ld grow well but growth may

loam usually lies somewhat
ping phase. It may suffer from
the same crops as the gently
ture. Stony-gravelly layers are
surface. Only 160 acres were
s included on the map.

t slopes

and productive of the heavy
r survey area. Most of it is in
and along the eastern border
footslope deposits and limey
t supply of phosphorus.

st) to very dark greyish-brown
is sticky and plastic when wet
reaction; organic matter from

5 to 8 per cent. The black (moist) to very dark-grey (dry) upper subsoil has an average of nearly 3 per cent or organic matter. The deeper subsoil, to a depth of 5 feet, is a dark-grey sticky plastic clay that shrinks strongly, with drying, to form deep cracks. Lime concretions commonly occur at depths of 4 to 5 feet.

The soil is on long, smooth, moderate slopes of 3 to 8 per cent grade, and water runs off the surface quite readily. However, water moves very slowly through the soil in the wet season. Deep cracks let in an abundance of water at the end of the dry season and seepy areas may develop on lower slopes.

The soil needs protection from sheet erosion and gullies may form near the edges of valleys that have been cut into the soil.

Most of the 447 acres of the soil are in the northeastern and eastern parts of the survey area. Ngeron silty clay loam is used for growing maize and for pasture: some sisal is grown. Fertility and productivity are high. Maize yields are high; sugar cane may be limited in some places by cool nights that will make for slow growth.

(Ngc-C) *Ngeron silty clay loam,* 8 *to* 13 *per cent slopes*

This moderately sloping phase of Ngeron silty clay loam has physical and chemical properties the same as the more gently sloping phase. Surface run-off is more rapid and more care is required to keep erosion in check. The chief cultivated crop is maize and about one-half of the phase is in pasture. The larger areas are on Ngeron and Kipsesin estates where relatively low night temperature would tend to slow down the growth of sugar cane. 487 acres were mapped.

(Noc-A) *Nyando clay loam,* 0 *to* 3 *per cent slopes*

Nyando clay loam is one of the best soils in the Songhor survey area for general crops and for sugar cane. It is deep, high in phosphorus and nearly neutral in reaction. The chief deficiencies are in organic matter and nitrogen. It lies on river terraces a few yards above overflow, chiefly along the Nyando River in the Luo reserve. It resembles Koru clay loam, but has a loam instead of a clay subsoil, and the plough soil has less organic matter and nitrogen. Stratified clayey, sandy and silty alluvium are interbedded with volcanic ash below a depth of 7 feet.

The surface of the land has minor undulations that mark former stream courses. The slightly lower spots have a little more clay and organic matter than the higher land.

The land is nearly level and run-off is slow. Water drains fairly readily through the soil and good aeration is maintained; but the soil holds a good supply of water for plant growth. Some surface wash occurs at the edges of the terraces near the streams.

The soil comprises 1,035 acres along the Nyando River, chiefly in the Luo reserve, where it is used for growing maize, sweet potatoes, sorghum, millet and other subsistence crops. Yields are only moderate, chiefly because of need for improvement in management, especially in the control of weeds. This soil is potentially one of the best in the region for general agricultural use. It is especially well suited for growing sugar cane. Sugar cane should respond very well to irrigation, and water is easily available in the Nyando River, subject to water rights. Probably the climate would be unsuitable for coffee.

(Nyc-B) *Nyangoro stony sandy loam,* 3 *to* 8 *per cent slopes*

Nyangoro stony sandy loam is a moderately shallow and stony medium-acid soil, weathered from granitoid gneiss. It varies in texture, thickness and degree of stoniness, and in this respect it resembles somewhat the Kipsesin clay loam, but averages less fertile. Outcrops of slightly weathered rock comprise 30 to 50 per cent of the area in some places, with the typical Nyangoro soil between. In other places the proportions are reversed. It comprises large areas in the gneissic hills and mountains.

Slopes range from 3 to 8 per cent gradient and run-off is rapid. Internal drainage is good. Exposed soil is eroded rapidly and shallow gullies are formed.

This phase of Nyangoro sandy clay loam, limited to about 254 acres, is used chiefly for pasture. African farmers plant the less stony patches to maize, bananas and other subsistence crops which can be grown under hoe culture.

(Nyc-C) *Nyangoro stony sandy loam,* 8 *to* 13 *per cent slopes*

This soil is the same as the more gently sloping phase, except for the stronger slope gradient. Probably as much as 30 to 40 per cent of the soil is in patches large enough for hoe culture, but most of the land is in pasture and bush. A total of 2,616 acres was mapped.

(Nyc-D) *Nyangoro stony sandy loam,* 13 *to* 20 *per cent slopes*

This strongly sloping phase of Nyangoro stony sandy loam has a still lower percentage of soil suitable for hoe culture. Most of its 919 acres is in pasture.

(Nyc-E) *Nyangoro stony sandy loam,* 20 *to* 35 *per cent slopes*

This steep phase of Nyangoro stony sandy loam, reaches the limit of steepness beyond which cultivated patches disappear altogether and value for pasture is greatly reduced. At 35 per cent gradient it merges with "Stony land, Nyangoro soil materials". A total of 550 acres was mapped.

(Pcl-A) *Patel clay loam,* 0 *to* 3 *per cent slopes*

Patel clay loam is a deep greyish, poorly drained, semi-swampy soil of the lake plain and river terraces, that must be drained before it will be satisfactory for cultivation. The closely associated Volo clay loam is somewhat less poorly drained and the Chemelil clay loam is definitely better drained than either the Volo or the Patel clay loam. The plough soil is a very dark greyish-brown clay loam. The subsoil is grey sticky and plastic clay sometimes with red and black mottles and many small concretions. Thicknesses of horizons are quite variable and so are the proportions of brown and black shot-like concretions. Ancient lake clay and alluvium of clayey textures, and perhaps some volcanic ash lie beneath the soil.

The land is nearly level and slightly depressed, and surface and internal drainage both are very slow. The soil is saturated with water during and for some weeks after the rainy season.

Most of the soil is on the central lake plain, but some areas extend to the bases of the eastern hills. Total area is 1,905 acres.

Most of the Patel clay loam is drained and planted to sugar cane; some is pasture land.

(Pcl-B) *Patel clay loam,* 3 *to* 8 *per cent slopes*

This soil is much like the nearly level Patel clay loam, but occurs on stronger slopes, in the valleys at the bases of the footslopes of the eastern part of the Songhor survey area, where it is associated with Muhoroni, Hermann and Songhor soils. Agricultural suitability is about the same as for the nearly level phase but drainage will have to be adjusted to the different slope conditions. A total of 855 acres was mapped.

(PS) *Permanent Swamp*

A few areas of permanent swamp were mapped in small depressions on flat upland and in a few long, narrow strips along streams. The soil was too wet to be studied in detail, but it is clayey and appears to be quite similar to Aristos clay loam, except that it is permanently wet and is not quite so dark coloured. In some of the permanent swamps along stream courses there are a few small patches of "muck" (black, partly decomposed peat). At present these swamps have little use except as a source of water for livestock and domestic use. The herbaceous vegetation provides some pasturage. A total of 277 acres of permanent swamp were mapped.

(Pec-A) *Perry clay loam,* 0 *to* 3 *per cent slopes*

Perry clay loam is a well-drained brown soil with a reddish-brown crumbly subsoil developed in old clayey deposits probably laid down originally near the place where a former river entered an ancient lake or swamp. Most of the Perry clay loam lies 4 to 12 feet above a layer of gravel.

The soil is associated with Babu, Chemelil, Volo and, in places, with George soils. Perry clay loam is fairly easy to cultivate and is suitable for a wide range of crops. There are about three large termite mounds per acre.

The gentle slopes of up to 3 per cent gradient permit water to run off at a moderate rate. Internal drainage is good, though not rapid, and the soil holds enough water to carry crops through short droughts.

The largest areas lie between Ainomotua and Ainopsiwa rivers, and along the south side of the gorge of Mbogo River on and near the Tennant farmstead. A total of 670 acres was mapped.

Perry clay loam is used for growing sisal, maize, coffee, sugar cane and pasture. It is low in available phosphorus, nitrogen and sulphur. Minor elements of plant nutrition may be deficient.

(Pec-B) *Perry clay loam,* 3 *to* 8 *per cent slopes*

This gently to moderately sloping phase of Perry clay loam is similar to the nearly level phase, described above, except that the surface slopes are stronger. Surface drainage is more rapid and farmers need to take precautions against both sheet and gully erosion. The soil is suitable for most crops adapted to the climatic conditions, but requires fertilization for optimum yields. A total of 423 acres was mapped.

(Rac-A) *Rama clay loam,* 0 *to* 3 *per cent slopes*

Rama clay loam is a dark coloured, moderately well drained heavy soil associated closely with Chemelil clay loam, Kibigori clay and Aristos clay loam, on the broad lake plain of the Songhor area. While somewhat hard to manage, it produces moderate crops of sorghum, maize and other subsistence crops, and good pasturage for cattle. It should prove satisfactory for growing sugar cane but is entirely unsuitable for coffee. The plough soil is dark brown (moist) to brown (dry) strongly fine-granular, clay loam. Organic matter ranges from 3 to 5 per cent; reaction is neutral.

Subsoil horizons are medium to fine-blocky clay, firm when dry and moist, sticky and plastic when wet, and organic matter decreases with depth. Soft lime-carbonate concretions throughout give the soil below a depth of 1½ feet a medium to strongly alkaline reaction. Weathered volcanic ash occurs 3 to 6 feet below the surface. Plough-soil texture varies from clay loam to clay.

Slopes usually do not exceed 2 per cent; therefore run-off is slow. Internal water movement also is slow, because of the clay subsoil, but the soil normally is wet for only very short periods.

Rama clay loam lies along the edges of the lake plain, adjacent to deep valleys cut by streams. 2,442 acres were mapped.

(Rac-B) *Rama clay loam, 3 to 8 per cent slopes*

This soil is like the nearly level Rama clay loam, except that much of it has lost some of its surface soil through sheet erosion; and volcanic ash layers are found more frequently within a depth of 4 feet. Agricultural suitability is the same, but farmers will need to apply conservation practices to keep erosion in check. 251 acres were mapped.

(Rsc-B) *Raragegwit sandy clay loam, 3 to 8 per cent slopes*

Raragegwit sandy clay loam, an imperfectly drained slightly acid to neutral soil, occurs on alluvial fans adjacent to gneiss hills and mountains. It lies between Mbereri and Ainomotua soils, higher on the fans, and the Kibigori clay of the lake plains. It has a heavier and more blocky sandy clay subsoil than the Ainomotua soil but is not so dark coloured as Kibigori clay. Texture of the surface soil, while dominantly sandy clay loam, may vary from sandy loam to heavy clay loam. The soil, as mapped, has a nearly black sandy clay subsoil in a few local areas. Alluvial-fan and "creep" deposits, transported largely from gneiss hills, lie below the soil proper. There are 2 to 3 large termite mounds per acre.

Slopes of 3 to 8 per cent gradient provide for fairly rapid surface run-off but internal drainage is slow. The soil is likely to have a temporary high water table during and for a short time after the rainy season.

Raragegwit sandy clay loam occurs on the alluvial fans below the Nandi escarpment north of Kibigori, and on the Muhoroni Sisal Estate. A total of 688 acres was mapped. It is used mainly for pasture and for growing sisal and subsistence crops. It must be protected from sheet wash and gully erosion. It is a fair soil for sisal, but rather poor for maize and sugar cane. Fertility is low and physical condition is poor for cultivation.

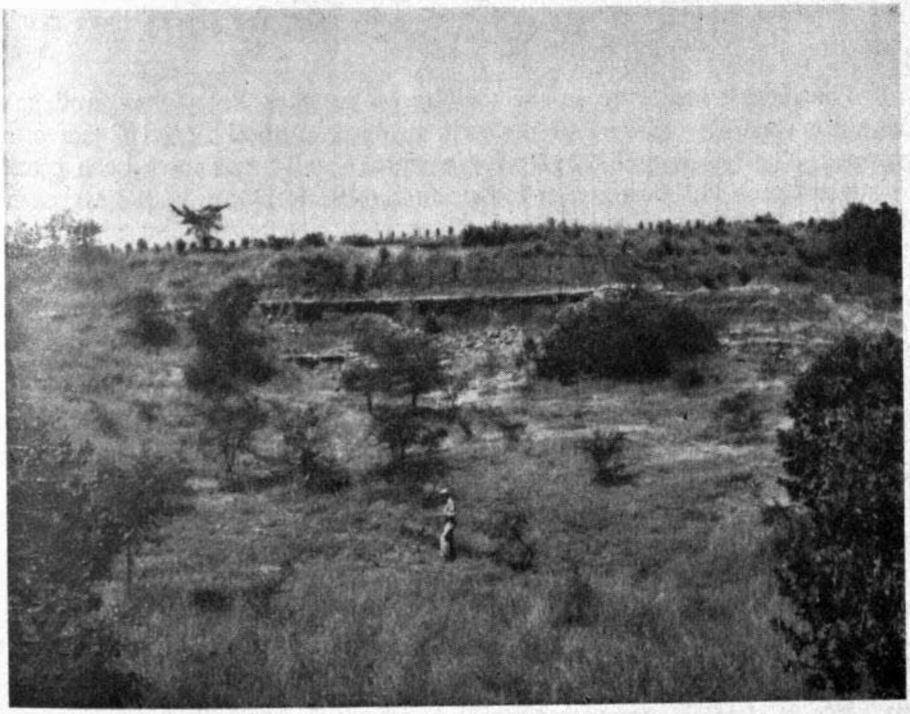
(Rsc-C) *Raragegwit sandy clay loam, 8 to 13 per cent slopes*

This is essentially like the more gently sloping phase except that the slopes are stronger and the soil is more subject to erosion. It can be used for growing sisal and sugar cane for which it is only fairly well suited. Only 112 acres were mapped.

(Rbc-D) *Rough broken land, clay materials, 13 to 20 per cent slopes*

This land unit occurs along the courses of Nyando and Mbogo rivers and their tributaries where these streams have entrenched themselves in the old lake-clay and volcanic-ash deposits. The valley trenches range up to nearly 100 feet deep and up to about a mile wide. Erosion is still very active in this area and much land is deeply cut by innumerable gullies, much like the "badlands" in western United States and in parts of outer Mongolia. The chief difference is that the rough gullied land carries some grass and bush which provide scanty grazing for cattle and sheep, and browse for goats. The land has no value for farming except for very small patches of good soil

—less than an acre each—which African farmers cultivate with their hoes. A total of 5,457 acres of this kind of land is shown on the soil map. It includes a few acres in which the underlying material is firm volcanic tuff instead of soft clay and volcanic ash. Owners of the land need to encourage close-growing vegetation to keep the gullies from cutting headward into the level clay plains that lie above them.



Eroded clay and volcanic ash beds, Volo Sisal Estate. The ash is the prominent stratum in the middle ground. Volo clay loam, with sisal crop on skyline.

(Ssi-A) *Songhor silt loam,* 0 *to* 3 *per cent slopes*

Songhor silt loam is dark coloured and silty in the upper part of the profile, light grey a few inches down, but nearly black and very heavy and clayey in the subsoil. It lies on nearly level plains which probably mark the former positions of small lakes, long since dried up. The plough soil is medium acid in reaction. The soil is associated with Kapkuong, Ainomotua, Mbogo and Volo soils and lies at lower levels. Before it was provided with drain ditches, the Songhor silt loam was covered by water during much of the rainy season, but it always dried out during the drier times in each year. The combined thickness of the nearly black silt loam surface soil and the light-grey silt loam sub-surface, varies from about 8 to 20 inches. Where at its thickest, the second horizon is likely to be very light-grey to almost white when dry. The underlying material is of clayey deposits, probably laid originally in ancient lakes and swamps. There may be a small component of volcanic ash. Songhor silt loam lies in practically level depressions and dead flats on remnants of lake plains. Termite mounds 3 feet high and 10 to 20 feet in diameter are common in some areas—absent in others.

Run-off is very slow or lacking except where surface drains have been dug. Internal drainage is very slow, especially after the cracks have swelled shut after the beginning of the rainy season.

The largest areas are in the vicinity of Songhor Post Office and south of Ainomotua River, west of the twin bridges. A total of 1,162 acres was mapped. The soil is used largely for pasture. Small areas have been planted to sugar cane. The best use is for pasture but sugar cane can be grown if the soil is drained and fertilized. Nitrogen, phosphorus and sulphur are deficient.

(Soc-B) *Sossok clay loam,* 3 *to* 8 *per cent slopes*

Sossok clay loam is a crumbly dark reddish-brown soil of medium depth. with dark reddish-brown friable clay subsoil, weathered from dark coloured basalts, phonolites and volcanic breccias. The soil is associated closely with Kipsesin clay loam and Hermann silty clay loam, in the hills and mountains of the eastern part of the survey area. It is a fertile, well-drained soil with good tilth, and much of it has been used for growing coffee. The surface humus-rich layer may be as much as 18 inches thick and in places has as much as 6 per cent organic matter. Hard bedrock lies from about 2½ to 5 feet below the surface, and crops out at the surface in a few scattered spots. Termite mounds 4 feet high and 20 feet in diameter occur about 2 or 3 to the acre.

Sossok clay loam is well-drained, externally and internally. The erosion hazard is slight, but clean-cultivated land may lose considerable surface soil through sheet wash.

The soil is in the eastern hills area, where 750 acres were mapped. It is used for growing maize, subsistence crops, and coffee. It is very good for maize and other subsistence crops and is a reasonably good soil for coffee to the extent that climate will permit. It is good for sugar cane except in the cooler areas where growth would be slow.

(*Soc-C*) *Sossok clay loam,* 8 *to* 13 *per cent slopes*

This strongly sloping phase of Sossok clay loam is somewhat more variable in thickness than the more gently sloping phase, and has a few more rock outcrops. It is suitable for the same crops, but more care is needed for controlling erosion. 1,746 acres of this phase were mapped.

(Stk-D) Stony land, Kipsesin soil materials, 6 *to* 30 *per cent slopes*

This unit, as its name implies, is very stony land with slopes ranging from 6 to 30 per cent gradient. It consists of about 40 to 70 per cent of outcropping dark coloured volcanic rocks, and some tuff. The rest consists of pockets of soil, mostly Kipsesin clay loam. The soil is suitable primarily for pasture, but a few small pockets may be used for gardens by African farmers. What soil there is, is fertile. 2,678 acres were mapped.

(Stk-F) Stony land, Kipsesin soil materials, 30 *to* 60 *per cent slopes*

This soil is even more stony than the last and about 50 to 75 per cent of the land surface is taken up by rock outcrop and loose boulders. The soil has a limited value for pasture, but is mainly wild land, sparsely inhabited by baboon, leopard and various other animals. Little or none of this land is cultivated even by the hoe. 3,252 acres were mapped.

(Stn-D) Stony land, Nyangoro soil materials, 6 *to* 30 *per cent slopes*

This unit consists of stony land in areas of granitoid gneiss in which about 40 to 60 per cent of the surface is rock outcrop and loose boulders, and the remainder is pockets of Nyangoro stony sandy loam (already described). The soil is less fertile than Kipsesin clay loam and not quite so deep, so much less of this unit is used for African gardens. Most is either used for pasture or is wild land. 2,138 acres were mapped.

(Stn-F) Stony land, Nyangoro soil materials, 30 *to* 60 *per cent slopes*

This unit is so steep and stony that it has little value for pasture and essentially none for cultivation. Most of it is on the Nandi escarpment and on the steep granitoid gneiss hills near Songhor. 10,313 acres were mapped.

(Tc-A) Tennant clay loam, 0 *to* 3 *per cent slopes*

Tennant clay loam is a dark-coloured humus-rich soil of slightly acid to neutral reaction. It occupies the high flood plains, chiefly along the Mbogo and Ainomotua rivers and their tributaries. Subsoil textures vary from clay to sandy clay loam to depths of 4 or 5 feet and usually have more sandy layers at greater depth. Stratification of the profile resembles that of the Tennant sandy loam, except that there are more clayey layers and fewer sandy ones. Humus content varies from place to place. In some places clay loam texture persists to a depth of 6 feet, but sandy layers lie below. The soil is nearly level, mostly with downstream gradients of about 1 to 2 per cent. Drainage is good internally and externally, but somewhat slower than in Tennant sandy loam. The soil is flooded occasionally for very short periods, and a few areas may require surface drains to facilitate removal of water after floods. Stream banks may be undercut during high water.

This is the most extensive of the Tennant soils. Large areas occur along Mbogo river, largely on the lands held by Asian farmers. A total of 1,763 acres was mapped.

Tennant clay loam is used for growing maize, subsistence crops and sugar cane. Yields are generally high. One Asian farmer reported 60 tons of 2-year plant cane per acre, without irrigation or fertilization.

(*Tc-B*) *Tennant clay loam,* 3 *to* 8 *per cent slopes*

This unit is like the nearly level Tennant clay loam except that it has a more uneven surface with slopes ranging up to 4 or 5 per cent. Only 88 acres were mapped.

(*Tsl-A*) *Tennant sandy loam,* 0 *to* 3 *per cent slopes*

Tennant sandy loam is a deep, black, well-drained crumbly soil, rich in organic matter and plant nutrients, and only slightly acid, that lies along the rivers of the northern parts of the Songhor survey area where it is subject to occasional overflow. It has a sandy loam texture to depths of 3 to 6 feet. It is one of the most fertile and potentially most productive soils, but is not very extensive.

The soil is nearly level, with minor undulations and a downstream grade of up to 3 per cent. Drainage normally is good because of the sandy subsoil. The surface of the soil is covered by water only during exceptional floods and the water drains away soon after the floods recede. In a few places the soils are subject to under-cutting by the rivers.

(*Tsl-B*) *Tennant sandy loam,* 3 *to* 8 *per cent slopes*

This phase of Tennant sandy loam has a slightly stronger slope than the normal Tennant sandy loam, but most of it has gradients of little more than 3 per cent. More care is needed in handling the soil to prevent excessive erosion. Crop adaptations and yields are about the same. A total of 203 acres was mapped.

(*Vcl-A*) *Volo clay loam,* 0 *to* 3 *per cent slopes*

Volo clay loam is grey soil with impeded drainage, closely associated with Chemelil and Patel soils of the old lake plain. The drainage is less impeded than in Patel clay loam but slower than in Chemelil clay loam.

The plough soil is very dark grey (moist) to dark grey (dry) granular, medium-acid clay loam with about 4.6 per cent humus.

Immediately below the plough soil, to 12 inches, is a dark greyish brown, granular, medium acid clay with about 2 to 3 per cent organic matter and about 10 to 15 per cent reddish-brown "buckshot" iron-oxide concretions.

The subsoil consists of heavy, sticky and plastic blocky clay of varying shades of grey, mottled red, brown and black and containing from 10 to 20 per cent of the buckshot-sized concretions. The soil has a slightly acid to slightly akaline reaction below 2 feet; and lime concretions often appear at a depth of about 4 feet. Parent materials are stratified lake clays and volcanic ash.

The land is nearly level with slight undulations; and termite mounds 3 to 5 feet high and 20 to 40 feet across the base, appear at intervals of 100 to 300 feet. Some of the mounds have been levelled for cultivation.

Surface drainage is slow and internal drainage is slow to very slow. Temporary water table develops 1 to 3 feet below the surface during the rainy season, but disappears in the dry season. Termite mounds are well drained.

Volo clay loam is in large areas on the lake plains along Mbogo and Nyando rivers. 3,254 acres were mapped. Most of the soil is planted to sugar cane and sisal, but some is in pasture. Sisal grows moderately well on the level land and very much better on the termite mounds. Sugar cane grows well when surface drains are provided. Response may be expected from applications of phosphorus, nitrogen and sulphur. Sugar cane should respond on this soil to irrigation if surface drains are also provided.

Small termite mound on Volo clay loam, three and a half miles south-west of Songhor. The material is mottled clay from the subsoil.

(*Vcl-B*) *Volo clay loam*, 3 *to* 8 *per cent slopes*

Some of the Volo clay loam, near the edges of stream valleys, has slopes of 3 to 8 per cent gradient. Surface drainage is rapid on these areas but some seepage occurs at the bases of slopes. Erosion-control practices are needed on this soil. A total of 813 acres was mapped. This soil is well suited for sugar cane, maize and sorghum.

Fertility Evaluation of Songhor Area Soils

In addition to studying the soils in the field, representative samples from the principal soil types in the Songhor 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 10 soils, fertility tests in the greenhouse were made using tomatoes as the test plant. Detailed descriptions of these procedures are to be published in a separate bulletin of the Kenya Department of Agriculture.

The complete data on these soils will be found in an appendix to this report. Limited data on the surface soils are given in this section (Table 4). The soils are separated into four groups, based on the amounts of phosphorus extracted from surface soils and subsoils. Data on soil reaction (pH), organic carbon (C), total nitrogen (N), chemical phosphorus (P), micro-biological P, N and sulphur (S) are reported in Tables 4 and 4a. Table 4a 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 *High Phosphorus in Surface and Subsoils*

This group covers 5 soils representing 4 types. These soils have a favourable reaction (pH), they are well supplied with phosphorus but indicate a medium to high need for nitrogen and a slight to medium need for sulphur.

There are no indications that trace elements are needed. The magnesium (Mg) and calcium (Ca) supply is high in surface and subsoil with the exception of a low level of Mg in Kamaasae. Potassium (K) is high in the surface soils but drops off fairly sharply in the subsoil. With heavy cropping, attention may have to be given to supplying this element in the future. These soils are well suited for the production of sugar cane and maize and other subsistence crops.

Group 2 *High Phosphorus in Surface, Medium in Subsoil*

This group covers 6 soils representing 5 types. Although these soils are well supplied with phosphorus in the surface, deep-rooting crops cannot be expected to obtain much from the subsoil. These soils are well supplied with potassium, magnesium, calcium and trace elements but are in varying degrees in need of nitrogen and sulphur. Although Bhanji loam has a high supply of phosphorus, it is too stony and shallow for cash crop production. Bhanji and Kipsesin soils are principally suitable for small patch hoe culture. The remaining soils are well suited for sugar cane production and other crops.

Group 3 *Low to Medium Phosphorus in Surface, Low in Subsoil and High in Lower Subsoil*

There are 23 soils in this group representing 12 types. The phosphorus content of the surface soils varies considerably. Both the micro-biological and the greenhouse tests are in accord with these differences. Hence, the need for phosphorus ranges between nil and high. Deep-rooting crops may be expected to be benefited by the high phosphorus in the subsoils (*see* data in appendix). The need for nitrogen ranges between medium and high and that of sulphur between nil and high. There are likewise indications of certain trace element needs in some of these soils. These suggestions will, however, have to be verified by field trials.

All soils in this group are adequately supplied with magnesium, calcium and potassium, excepting Aristos and Kibigori, in which potassium is on the medium to low side.

Sugar cane production is suitable on all soils of this group, but Aristos, Farndell, Muhoroni, Patel and Songhor soils need first to be drained.

Group 4 Low to Medium Phosphorus in Surface and low in Subsoil

This group covers 18 soils represented by 14 types. Practically all of these soils are in need of phosphorus and nitrogen. Even deep-rooting crops cannot be depended upon to obtain any signified share of their phosphorus from subsoil. These soils indicate a variable need for sulphur and trace elements, notably boron (B) and zinc (Zn). Response to these elements requires verification in field trials. These soils are relatively well supplied with calcium, with the possible exception of Kapkuong. The supply of magnesium is low in Kapchure, Kapkuong and Marcantonatos, while potassium is low in Ainomotua, Kapchure, Kapkuong, Marcantonatos and Mbereri.

Awasi, Kibubu and Nyangoro, which are shallow or stony soils, are hardly suitable for sugar cane production. Kapchure and Kapkuong are only poorly suited for sugar cane. The remaining soils in this group are quite suitable.

General Conclusions

There is good evidence that the high phosphorus in the subsoils of group 3 is strongly related to soils derived from volcanic ash or volcanic tuff. This has become strongly evident not only from visual observations accounting for the presence of ash but also from the analysis of a sample of volcanic ash collected in the Songhor area. The extractable phosphorus was 82 ppm of the ash sample and 147 and 260 ppm of the soil 6 inches above and 6 inches below the ash layer, respectively. All the soils in group 4 which were low in phosphorus, showed virtually no indications of the presence of volcanic ash. More often, these soils were derived from gneisses or granites moved into this area from the neighbouring Nandi hills.

It should be emphasized that these samples do not represent a complete coverage of the soils in the Songhor area. The farmer embarking upon a fertility programme for his crops is advised to include samples from the fields to be put into cultivation. Such soils submitted to Scott Agricultural Laboratories will then be given the usual attention, and final recommendations based upon these tests will be made by the Agricultural Officer for the local district. It should be pointed out further that the values obtained by the laboratory and greenhouse tests must be interpreted on the basis of the nutrient require-

TABLE 4.—FERTILITY EVALUATION OF SONGHOR AREA SOILS

Soil No.	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	High Phosphorus in Surface and Subsoil—											
	Kamaasae sandy clay loam	6·0	3·0	·21	14	200	100	12	100	nil	high	medium
	Koru clay loam	6·3	2·5	·18	13	120	94	29	84	nil	medium	slight
	Nyando clay loam	6·4	1·8	·13	14	280	96	8	48	nil	high	medium
	Lemaiywa clay	6·0	4·9	·27	18	217	100	5	37	nil	high	medium
	Tennant sandy loam	6·2	2·3	·13	17	298	90	5	42	nil	high	medium
Group 2	High Phosphorus in Surface, Medium in Subsoil—											
	Bhanji loam	6·2	1·9	·15	12	242	100	31	81	nil	medium	slight
	Kipsesin clay loam	6·0	5·6	·20	28	185	106	41	83	nil	slight	slight
	Martin clay loam	6·0	3·4	·17	20	71	85	14	100	nil	high	nil
	Martin clay loam	5·9	2·8	·17	16	206	105	14	62	nil	high	medium
	Nandi loam	5·5	4·0	·17	23	190	76	12	52	nil	high	medium
	Sossok clay loam	5·9	2·6	·24	10	205	100	24	90	nil	medium	nil
Group 3	Low to Medium Phosphorus in Surface, Low in Subsoil and High in Lower Subsoil—											
	Aristos clay loam	5·6	1·8	·13	13	6	37	11	69	high	high	medium
	Aristos clay loam	5·6	5·0	·22	22	10	50	10	75	medium	high	slight
	Chemelil clay loam	6·4	1·8	·12	15	7	20	13	95	high	high	nil
	Farndell clay loam	5·6	3·4	·26	13	18	96	30	44	medium	medium	medium
	George clay loam	6·1	2·7	·22	12	72	100	10	89	nil	high	nil
	George clay loam	6·2	2·5	·20	12	27	73	22	56	slight	medium	medium
	George clay loam	5·8	1·5	·17	8	—	63	17	67	medium	high	medium
	Hermann silty clay loam	6·0	2·4	·24	10	47	98	24	60	nil	medium	medium
	Kibigori clay	6·3	2·7	·12	22	8	27	11	89	high	high	slight
	Kibigori clay	5·5	3·3	·21	15	17	46	4	70	medium	high	slight
	Kibigori clay	6·0	2·4	·15	16	98	74	0	78	slight	high	slight
	Muhoroni clay loam	5·7	2·6	·13	20	74	78	9	57	slight	high	medium
	Muhoroni clay loam	5·6	2·7	·17	15	11	40	20	76	medium	medium	slight
	Muhoroni clay loam	5·5	1·8	·17	10	3	29	19	86	high	medium	slight
	Ngeron silty clay loam	5·9	4·0	·30	13	74	100	12	89	nil	high	nil
	Ngeron silty clay loam	5·7	4·8	·27	17	48	100	36	94	nil	medium	nil
	Ngeron silty clay loam	5·6	3·0	·23	13	24	25	6	100	high	high	nil
	Patel clay loam	5·5	2·1	·13	16	11	62	19	93	medium	medium	nil
	Rama clay loam	6·6	2·5	·15	16	7	30	12	83	high	high	slight
	Songhor silt loam	5·9	3·4	·26	13	27	75	19	56	slight	medium	medium
	Songhor silt loam	5·7	2·3	·18	12	10	64	23	100	medium	medium	[illegible]
	Volo clay loam	6·0	2·7	·11	24	17	48	14	76	medium	high	slight
	Volo clay loam	5·8	2·9	·21	13	8	24	29	94	high	medium	nil

TABLE 4.—FERTILITY EVALUATION OF SONGHOR AREA SOILS—(*Contd.*)

Soil No.	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 4	LOW TO MEDIUM PHOSPHORUS IN SURFACE, LOW IN SUBSOIL—											
	Ainomotua sandy clay loam	6·8	1·5	·08	18	6	55	30	91	medium	medium	nil
	Ainopsiwa clay loam	6·3	3·5	·21	16	13	20	13	75	high	high	slight
	Awasi laom	5·9	1·8	·11	16	8	44	28	90	high	medium	slight
	Babu clay loam	5·3	2·1	·12	17	10	57	17	78	high	medium	slight
	Kapchure sandy loam	6·5	1·6	·05	32	5	20	13	100	high	high	nil
	Kapchure sandy loam	6·1	1·5	·13	11	7	50	13	100	high	high	nil
	Kapchure sandy clay loam	5·5	2·4	·16	15	14	44	13	65	high	high	medium
	Kapkuong loamy course sand	6·0	0·7	·06	11	0	55	13	100	high	high	nil
	Kapkuong loamy course sand	5·9	0·8	·06	10	2	42	15	95	high	high	nil
	Kibubu gravelly loam	6·0	2·0	·17	11	53	100	13	81	nil	high	nil
	Kundos sandy clay	5·9	2·0	·12	16	12	38	10	100	high	high	nil
	Kundos sandy clay	5·6	1·3	·11	11	5	36	36	96	high	medium	nil
	Marcantonatos loam	5·6	3·0	·20	15	32	62	43	100	medium	slight	nil
	Mbereri coarse sandy loam	5·8	1·4	·10	14	65	85	21	79	nil	high	medium
	Mbogo clay loam	5·6	2·7	·18	15	8	65	20	87	high	medium	slight
	Nyangoro stoney sandy loam	5·8	2·8	·11	25	30	71	41	83	slight	medium	slight
	Perry clay loam	5·9	1·6	·15	10	45	85	11	48	nil	high	medium
	Raragegwit sandy clay loam	6·3	2·5	·14	17	6	50	10	85	medium	high	slight

TABLE 4 (*a*)—FERTILITY EVALUATION OF SONGHOR AREA SOILS INCLUDING GREENHOUSE TESTS

SOIL TYPE	CHEMICAL TESTS					MICRO-BIOLOGICAL TESTS % OF + ALL			GREENHOUSE TESTS % OF + ALL			NUTRIENT NEEDS INDICATED		
	pH	C%	N%	C/N	P (ppm)	−P	−N	−S	−P	−N	−S	P	N	S
GROUP 2—														
Bhanji loam	5·8	3·2	·20	16	23	40	7	27	86	4	2	slight	high	high
GROUP 3—														
Aristos clay loam	5·6	3·5	·24	14	13	31	0	31	1	3	16	high	high	high
Chemelil clay loam	5·8	3·0	·17	17	44	47	7	40	59	10	13	medium	high	high
George clay loam	5·8	3·2	·22	14	7	23	8	62	1	2	1	high	high	high
Kibigori clay	5·6	2·5	·16	15	77	43	0	36	41	3	4	medium	high	high
Songhor silt loam	5·3	2·9	·20	14	10	29	0	64	3	8	1	high	high	high
Volo clay loam	5·7	3·1	·21	14	12	43	21	64	8	37	42	high	medium	medium
GROUP 4—														
Kapkuong loamy coarse sand ..	6·3	1·3	·10	13	5	19	6	25	1	4	3	high	high	high
Kundos sandy clay	5·8	1·6	·12	13	4	26	5	53	1	15	3	high	high	high
Mbereri coarse sandy loam ..	5·4	2·4	·13	18	72	79	14	43	96	15	13	nil	high	high

ments of the crops to be grown. The final answer therefore, must come from the use of suitable field trials with different crops. This applies particularly to studies relating to sulphur and trace elements for which no field experiments from the Songhor area are as yet on hand. The data certainly would lead one to believe that the soils in group 4 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. A carefully selected programme for fertilization should prove of considerable value in increasing crop production in the Songhor area.

Explanation of Soil Test Values in Table 4

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 2.

Micro-Biological Tests and Greenhouse Tests:

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

PRODUCTIVITY ESTIMATES

Table 5 gives estimates of the productivity of the various soils at two levels of management. Level A covers estimated yields under customary farming practices; level B covers yields to be expected under improved practices as followed by the better farmers. The estimates are based both on field observation and on information received directly from European farmers. since records of actual measured yields per acre are very few, the reader will realize that these estimates are only rough approximations. Doubtless some farmers will be able to exceed the best yields indicated and others will fall short. In seasons of inadequate rainfall or locust infestation, crop yields will be drastically reduced.

TABLE 5—PRODUCTIVITY AND RECOMMENDED US

Notes

1. In the following productivity data: *A yields* are the yields under customary practice or the grazing capacity of the unimproved natural grassland. *B yields* are yields or grazing capacity under improved practices, involving the planting of improved, disease-resistant varieties, species or mixtures, subsoiling, soil conservation, drainage, the use of fertilizers, fungicides and insecticides, weed control, the provision of stock watering facilities, fencing, rotational grazing and fire control as necessary and practicable and assume no losses of crop through vermin, damage, hail, exposure or theft. Irrigation will greatly increase sugar yields over some of these estimates. The yield potential of coffee on suitable soils locally is determined largely by the incidence of leaf rust. As it seems there will be great progress in the near future in the control of coffee leaf rust, it is premature to provide B yield estimates for coffee on the various local coffee soils.

2. The crop suitability recommendations take no account of management factors. These are of particular importance in relation to the established organization of sisal and sugar production. This requires that for an area to be suitable for the production of either of these crops it must be conveniently placed and readily accessible to an established factory or to a potential factory site serving an economically large area of land which is suited to the crop. In particular, soils which occur in small isolated inaccessible pockets remote from existing or potential factory sites will be unsuited for sisal or sugar production even though on their soil characteristics they are recommended. The more extreme instances of such soils are designated by a * in the crop suitability recommendation columns. Patches of other soils, the rest of which are better placed, may be similarly handicapped.

3. Special practices and comments are given where these have particular significance to the soil to which they apply. As a general consideration, when considering cultural practices for most of these soils, both drainage and erosion must be considered and indeed erosion measures must be so designed as to aid drainage and not interfere with it. Sufficient slope must be given to all works to give drainage without erosion and it will be found that higher grades than usual are required owing to heavy weed growth during the rainy season.

Cut-off drains and diversion ditches should be grass protected and will be required over most areas. The drainage lines leading from fields and cut-off drains must be grass protected and wide enough to avoid erosion as most of the area tends to gully if deep ditches are used.

In all areas and on all soils give careful consideration to the location and grading of roads serving the field and area, so that they do not cause erosion or waterlogging. It is waterlogging that must be particularly watched in the whole area. The planned layout of a whole farm, roads, etc., and of new fields must suit the topography to fit in with drainage and soil conservation measures required for the various soils.

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/stock unit	Other crops	Special Practices Comments
Ainomotua sandy clay loam (3–8%).	Yes	A25 B30	Yes	A4–5 B10–12	Yes*	A2–2½ B3–3½	No	—	A4 B2	—	Graded contour cultivation. Ridge and furrow surface drainage.
Ainopsiwa clay loam (0–3%).	Yes	A25–30 B35–45	Yes	A6–10 B10–15	Yes	A3–3½ B4–4½	At higher elevations only	A2–4	A4 B2	Citrus, Pawpaw	Contour cultivation, grassed waterways.
Aristos clay loam (0–3%)	Yes	A20 B30	No	—	No	—	No	—	A4 B2	Rice	Ridge and furrow surface drainage: in some situations drainage is uneconomic.
Awasi loam (3–8% moderately eroded).	No	—	Poorly suited	A3–4 B5–8	Yes	A2 B3	No	—	A6 B3	Peasant subsistence crops.	Contour cultivation: controlled grazing.
Babu clay loam (0–3%)	Yes	A30 B35	Yes	A6–8 B10–12	Yes	A2–2½ B3–3½	No	—	A4 B2	—	Ridge and furrow surface drainage with grassed waterways.
Babu clay loam (3–8%)	Yes	A30 B35	Yes	A6–8 B10–12	Yes	A2–2½ B3–3½	No	—	A4 B2	—	Graded contour cultivation with grassed waterways.
Babu clay loam (8–13%)	No	—	No	—	No	—	No	—	A4 B2	—	Controlled grazing: protected waterways.
Bhanji stony loam (3–8%)	No	—	No	—	No	—	No	—	A4 B3	—	Small areas peasant gardens.
Bhanji stony loam (3–8% moderately eroded).	No	—	No	—	No	—	No	—	A6 B3	—	Controlled grazing: fire protection.
Bhanji loam (0–3%) ..	Yes	A20–25 B25–35	Yes	A6–8 B9–10	Yes	A2½ B3	No	—	A3 B2	—	
Chemelil clay loam (0–3%).	Yes	A30–35 B40–45	Yes	A6–8 B10–14	Yes	A3–3½ B4–4½	No	—	A3 B1½	—	Ridge and furrow surface drainage with grassed waterways.
Chemelil clay loam (3–8%).	Yes	A30–35 B40–45	Yes	A6–8 B10–14	Yes	A3–3½ B4–4½	No	—	A3 B1½	—	Graded contour cultivation with grassed waterways.

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE—(*Contd.*)

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/ stock unit	Other crops	Special Practices Comments
Farndell clay loam (0–3%)	Yes	A20–25 B30–35	Yes	A4–7 B6–10	Poorly* suited	A1–1½ B1½–2	No	—	A4 B3	—	Cut-off drains: ridge and furrow surface drainage and grassed waterways. Controlled grazing.
Farndell clay loam (3–8%)	Yes	A20–25 B30–35	Yes	A4–7 B6–10	Poorly* suited	A1–1½ B1½–2	No	—	A4 B3	—	Cut-off drains: graded contour cultivation with grassed diversion ditches and waterways: gully control.
George clay loam (0–3%)	Yes	A25–30 B35–40	Yes	A5–8 B8–12	Yes	A2½–3 B3½–4	No	—	A4 B3	—	Controlled grazing: ridge and furrow surface drainage.
George clay loam (3–8%)	Yes	A25–30 B35–40	Yes	A5–8 B8–12	Yes	A2½–3 B3½–4	No	—	A4 B3	—	Controlled grazing: graded contour cultivation with grassed waterways.
Hermann silty clay loam (3–8%).	Yes	A30–35 B35–40	Yes	A10–16 B16–22	Yes	A3–3½ B4½	Yes	A2–5	A2½ B1–1½	Citrus, pawpaw, dried beans, fodder crops.	Cut-off drains: graded contour cultivation with diversion ditches.
Hermann silty clay loam (8–13%).	Yes	A30–35 B35–40	Yes	A10–16 B16–22	Yes	A3–3½ B4½	Yes	A2–5	A2½ B1–1½	Citrus, pawpaw, dried beans, fodder crops.	Cut-off drains: graded contour cultivation with diversion ditches.
Kamaasae sandy clay loam (3–8%).	Yes	A25–30 B30–35	Yes	A8–12 B12–18	Yes	A3–3½ B3½–4	Where deep	A2–4	A3 B1½–2	Citrus, pawpaw, fodder crops.	Controlled grazing: contour cultivation: terracing.
Kamaasae sandy clay loam (8–13%).	Yes	A25–30 B30–35	Yes	A8–12 B12–18	Yes	A3–3½ B3½–4	Where deep	A2–4	A3 B1½–2	Citrus, pawpaw, fodder crops.	Controlled grazing: contour cultivation narrow based terracing.
Kamaasae stony clay loam (13–20%).	No	—	No	—	No	—	No	—	A4 B3	—	Controlled grazing: small areas peasant gardens.
Kapchure sandy loam (3–8%).	Poorly suited	A15–30 B20–25	Poorly suited	A3–4 B6–8	Yes	A2–2½ B2½–3½	No	—	A4 B3	—	Cut-off drains: contour cultivation with graded interception ditches.
Kapchure sandy loam (3–8% moderately eroded).	No.	—	No	—	No	—	No	—	A6 B3	Woodlots	Controlled grazing: fire protection.

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE—(*Contd.*)

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/ stock unit	Other crops	Special Practices Comments
Kapchure sandy clay loam (3–8 %).	Yes	A20–25 B25–35	Yes	A4–6 B8–12	Yes	A3–3½ B4–4½	No	—	A4 B3	—	Cut-off drains: graded contour cultivation and interception ditches.
Kapkuong loamy coarse sand (0–3 %).	Yes	A20–25 B25–35	No	—	Poorly suited	A1–1½ B1½–2	No	—	A5 B3	—	Erosion hazard reduces suitability for row crops: mulching.
Kapkuong loamy coarse sand (3–8 %).	Yes	A20–25 B25–35	No	—	Poorly suited	A1–1½ B1½–2	No	—	A5 B3	—	Erosion hazard reduces suitability for row crops: wide grassed cut-off drains and waterways: contour cultivation: mulching.
Kapkuong loamy coarse sand (8–13 %).	No	—	No	—	No	—	No	—	A5 B3	—	Controlled grazing: protected waterways: fire protection.
Kapkuong loamy coarse sand (3–8 % severely eroded).	No	—	No	—	No	—	No	—	A10 B5	—	De-stocking: re-seeding: gully restoration: fire protection.
Kibigori clay (0–3 %) ..	Yes	A25–30 B40–45	Yes	A5–7 B10–14	Yes	A3–3½ B4–4½	No	—	A3 B1–1½	Rice	Cut-off drains: ridge and furrow surface drainage: mulching.
Kibigori clay (3–8 %) ..	Yes	A25–30 B40–45	Yes	A5–7 B10–14	Yes	A3–3½ B4–4½	No	—	A3 B1–1½	—	Cut-off drains: graded contour cultivation with grassed diversion ditches: mulching.
Kibubu gravelly loam (3–8 %).	No	—	No	—	No	—	No	—	A5 B3½	—	Grassed cut-off drains: controlled grazing: peasant gardens.
Kibubu gravelly loam (8–13 %).	No	—	No	—	No	—	No	—	A5 B3½	—	Grassed cut-off drains: controlled grazing: some patches peasant gardens.
Kipsesin clay loam (0–3 %).	No	—	Limited patches	A6–8 B12–14 in patches	No	—	In deeper pockets	A2–5	A6 B4	—	Controlled grazing: patches peasant gardens.

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE—(*Contd.*)

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/ stock unit	Other crops	Special Practices Comments
Kipsesin clay loam (3–8%)	No	—	Limited patches	A6–8 B12–14 in patches	No	—	In deeper pockets	A2–5	A6 B4	—	Controlled grazing: cut-off drains: contour cultivation and terracing in patches.
Kipsesin clay loam (8–13%).	No	—	Limited patches	A6–8 B12–14 in patches	No	—	In deeper pockets	A2–5	A6 B4	—	Controlled grazing: cut-off drains contour cultivation and terracing in patches.
Kipsesin clay loam (13–20%).	No	—	Small patches	A6–8 B12–14 in patches	No	—	In deeper pockets	A2–4	A12 B5	—	Controlled grazing: cut-off drains: contour cultivation and terracing in patches.
Kipsesin clay loam (20–35%).	No	—	Occasional small patches	A6–8 B12–14 in patches	No	—	In deeper pockets	A2–4	A15 B12	—	Controlled grazing: cut-off drains and bench terraces in deeper pockets.
Koru clay loam (0–3%)	Yes	A35–40 B45–50	Yes	A10–15 B12–20	Yes	A3½–4 B4½–5	Yes	A2–5	A3 B1–1½	Citrus, pawpaw	Contour cultivation: terracing: mulching.
Kundos sandy clay (0–3%)	Yes	A25–30 B30–35	Yes	A4–6 B8–12	Yes	A2½–3 B3–4	At higher elevations	A2–4	A4 B2	Citrus, pawpaw	Grassed cut-off drains: proper location of cattle tracks.
Kundos sandy clay (3–8% moderately eroded).	Yes	A20–25 B30–35	Yes	A3–5 B8–12	Yes	A2–2½ B3–4	No	—	A6 B2	Citrus, pawpaw	Grassed cut-off drains: contour cultivation: broad based terracing: mulching: controlled grazing: proper location of cattle tracks: gully restoration.
Lemaiywa clay (0–3%) . .	Yes	A30–35 B35–45	Yes	A8–14 B12–18	No	—	No	—	A3 B2	—	Ridge and furrow surface drainage.
Marcantonatos loam (3–8%).	Yes	A30–35 B35–40	Yes	A8–14 B12–18	Yes*	A3–3½ B3–4	Yes	A2–5	A3 B1½	Citrus, pawpaw, vegetables.	Cut-off drains: contour cultivation: terracing: mulching.

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE—(*Contd.*)

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/ stock unit	Other crops	Special Practices Comments
Martin clay loam (3–8%)	Yes	A25–30 B35–40	Yes	A8–12 B12–18	Yes	A2½–3 B3–4	Yes	A2–4	A4 B1½	Citrus, pawpaw, vegetables, fodder crops.	Contour cultivation: terracing.
Martin clay loam (8–13%)	Yes	A25–30 B35–40	Yes	A8–12 B12–18	Yes	A2½–3 B3–4	Yes	A2–4	A4 B1½	Citrus, pawpaw, vegetables, fodder crops.	Cut-off drains: contour cultivation, narrow based terracing.
Mbereri coarse sandy loam (3–8%).	Yes	A25–30 B40–45	Yes	A4–8 B10–13	Yes	A3–3½ B4½–5	Yes	A2–4	A3 B1–1½	Citrus, pawpaw, vegetables, fodder crops.	Grassed cut-off drains and waterways: controlled grazing: contour cultivation: terracing: mulching.
Mbereri coarse sandy loam (8–13%).	Yes	A25–30 B40–45	Yes	A4–8 B10–13	Yes	A3–3½ B4½–5	Yes	A2–4	A3 B1–1½	Citrus, pawpaw, vegetables, fodder crops.	Grassed cut-off drains and waterways: controlled grazing: contour cultivation: narrow based terracing: mulching.
Mbereri coarse sandy loam (3–8% moderately eroded).	Yes	A20–25 B30–40	Yes	A4–5 B6–10	Yes	A2½–3 B4–4½	Yes	A2–4	A4 B2	Citrus, pawpaw, vegetables, fodder crops.	Grassed cut-off drains and waterways: controlled grazing: contour cultivation: terracing: mulching.
Mbereri coarse sandy loam (8–13%) severely eroded).	No	—	No	—	No	—	No	—	A15 B5	—	Re-seeding: controlled grazing: fire protection: gully restoration.
Mbereri coarse sandy loam (13–20% severely eroded).	No	—	No	—	No	—	No	—	A15 B5	—	Re-seeding: controlling grazing: fire protection: gully restoration.
Mbereri stony and gravelly sandy loam 3–20%).	No	—	No	—	No	—	No	—	A6 B3	—	Controlled grazing.
Mbereri stony and gravelly sandy loam (3–25% moderately eroded).	No	—	No	—	No	—	No	—	A10 B5	—	De-stocking: fire protection: controlled grazing.

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE—(*Contd.*)

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/ stock unit	Other crops	Special Practices Comments
Mbogo clay loam (0–3%)	Yes	A25–30 B30–40	Yes	A4–6 B6–10	Yes	A2½–3 B3–4	No	—	A3 B2	—	Ridge and furrow surface drainage.
Mbogo clay loam (3–8%)	Yes	A25–30 B30–40	Yes	A4–6 B6–10	Yes	A2½–3 B3–4	No	—	A3 B2	—	Graded contour cultivation: mulching.
Mbogo clay loam (8–13%)	Yes	A25–30 B30–40	Yes	A4–6 B6–10	Yes	A2½–3 B3–4	No	—	A3 B2	—	Graded contour cultivation: grassed interception ditches: mulching.
Muhoroni clay loam (0–3%).	Yes	A15–20 B20–30	Poorly suited	A2–6 B4–10	Poorly suited	A1½–2½ B2½–3½	No	—	A3 B2	—	Ridge and furrow surface drainage: grassed waterways.
Muhoroni clay loam (3–8%).	Yes	A15–20 B20–30	Poorly suited	A2–6 B4–10	Poorly suited	A1½–2½ B2½–3½	No	—	A3 B2	—	Conservation and drainage requirements require investigation: drainage measures must provide adequate erosion protection.
Muhoroni clay loam (13–20%).	No	—	No	—	No	—	No	—	A3 B2	—	Controlled grazing.
Nandi loam (0–3%) ..	Yes*	A30–35 B35–40	Yes	A12–16 B16–20	Yes*	A3–3½ B4½–5	Yes	A2–5	A3 B2	Most subsistence crops and tree fruits.	Cut-off drains: contour cultivation.
Nandi loam (3–8%) ..	Yes*	A30–35 B35–40	Yes	A12–16 B16–20	Yes*	A3–3½ B4½–5	Yes	A2–5	A3 B2	Most subsistence crops and tree fruits.	Cut-off drains: contour cultivation: terracing.
Ngeron silty clay loam (3–8%).	Yes	A30–35 B40–50	Yes	A12–16 B18–22	Yes	A3–3½ B4–4½	No	—	A3 B1½	—	Cut-off drains: graded contour cultivation: mulching.
Ngeron silty clay loam (8–13%).	Yes	A30–35 B40–50	Yes	A12–16 B18–22	Yes	A3–3½ B4–4½	No	—	A3 B1½	—	Cut-off drains: graded contour cultivation with interception ditches: mulching.
Nyando clay loam (0–3%)	Yes	A30–35 B40–50	Yes	A8–14 B12–16	Yes	A3–3½ B4–4½	No	—	A3 B1½	Citrus, pawpaw, subsistence crops.	Cut-off drains [illegible] age of low spots: mulching.

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE—(*Contd.*)

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/stock unit	Other crops	Special Practices Comments
Nyangoro stony sandy loam (3–8 %).	No	—	Limited patches	A6–7 B9–12 in patches	No	—	No	—	A4 B2	—	Peasant gardens: terracing: controlled grazing.
Nyangoro stony sandy loam (8–13 %).	No	—	Limited patches	A6–7 B9–12 in patches	No	—	No	—	A4 B2	—	Peasant gardens: terracing: controlled grazing.
Nyangoro stony sandy loam (13–20 %).	No	—	Small patches	A6–7 B9–12 in patches	No	—	No	—	A15 B10	—	Small patches peasant gardens: cut-off drains: terracing: controlled grazing: fire protection.
Nyangoro stony sandy loam (20–35 %).	No	—	Occasional small patches	A6–7 B9–12 in patches	No	—	No	—	A20 B15	—	Occasional small patches peasant gardens: cut-off drains: terracing: controlled grazing: fire protection.
Patel clay loam (0–3 %) . .	Yes	A15–20 B20–35	No	—	No	—	No	—	A4 B3	Rice, fodder crops	Surface drainage.
Patel clay loam (3–8 %) . .	Yes	A15–20 B20–35	Yes	A4–6 B7–9	No	—	No	—	A4 B3	Fodder crops	Graded contour cultivation with interception ditches.
Perry clay loam (0–3 %) . .	Yes	A25–30 B35–40	Yes	A5–8 B8–12	Yes	A3–3½ B4–4½	Yes	A2–4	A3 B1½	Citrus, pawpaw, vegetables, fodder crops.	Contour cultivation: tie ridging: mulching.
Perry clay loam (3–8 %) . .	Yes	A25–30 B35–40	Yes	A5–8 B8–12	Yes	A3–3½ B4–4½	Yes	A2–4	A3 B1½	Citrus, pawpaw, vegetables, fodder crops.	Cut-off drains: contour cultivation: tie ridging: terracing: mulching.
Rama clay loam (0–3 %)	Yes	A25–30 B35–40	Yes	A4–6 B6–9	Yes	A2–2½ B3–3½	No	—	A4 B2	—	—
Rama clay loam (3–8 %)	Yes	A25–30 B35–40	Yes	A4–6 B6–9	Yes	A2–2½ B3–3½	No	—	A4 B2	—	Broad based terracing: mulching.
Raragegwit sandy clay loam (3–8 %).	Yes	A20–25 B25–30	Poorly suited	A3–6 B6–8	Yes	A2–2½ B3–4	No	—	A4 B2	—	Cut-off drains: graded contour cultivation: mulching.

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE—(*Contd.*)

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/stock unit	Other crops	Special Practices Comments
Raragegwit sandy clay loam (8–13 %).	Yes	A20–25 B25–30	Poorly suited	A3–6 B6–8	Yes	A2–2½ B3–4	No	—	A4 B2	—	Grassed cut-off drains: contour cultivation with grassed: diversion ditches: mulching.
Songhor silt loam (0–3 %)	Yes	A20–25 B30–35	Poorly suited	A3–6 B5–8	Yes	A2–2½ B2½–3½	No	—	A4 B2	Rice	Ridge and furrow surface drainage.
Sossok clay loam (3–8 %)	Yes	A30–40 B45–50	Yes	A8–14 B15–20	Yes*	A2½–3 B3–4	Where deep	A2–4	A2–3 B1–1½	Citrus, pawpaw, bananas.	Contour cultivation: mulching.
Sossok clay loam (8–13 %)	Yes	A30–40 B45–50	Yes	A8–14 B15–20	Yes*	A2½–3 B3–4	Where deep	A2–4	A2–3 B1–1½	Citrus, pawpaw, bananas.	Cut-off drains: contour cultivation: narrow based terracing: mulching.
Stony land Kipsesin soil material (6–30 %).	No	—	No	—	No	—	No	—	A15 B12	—	Controlled grazing.
Stony land Kipsesin soil material (30–60 %).	No	—	No	—	No	—	No	—	No	—	Water-shed protection: fire protection: wild life protection and control.
Stony land Nyangoro soil material (6–30 %).	No	—	No	—	No	—	No	—	A20 B15	—	Controlled grazing.
Stony land Nyangoro soil material (30–60 %).	No	—	No	—	No	—	No	—	No	—	Water-shed protection: fire protection: wild life protection and control.
Tennant clay loam (0–3 %).	Yes	A35–40 B40–45	Yes	A8–14 B14–20	Yes	A3–3½ B4–4½	No	—	A2½ B1–1½	Citrus, pawpaw, bananas, fodder crops.	Occasional flooding hazard.
Tennant clay loam (3–8 %).	Yes	A35–40 B40–45	Yes	A8–14 B14–20	Yes	A3–3½ B4–4½	No	—	A2½ B1–1½	Citrus, pawpaw, bananas, fodder crops.	Cut-off drains: contour cultivation: terracing: mulching.
Tennant sandy loam (0–3 %).	Yes	A35–40 B40–45	Yes	A8–14 B14–20	Yes	A3–3½ B4–4½	No	—	A2½ B1–1½	Citrus, pawpaw, bananas, fodder crops.	Occasional [illegible]

TABLE 5.—PRODUCTIVITY AND RECOMMENDED USE—(*Contd.*)

Soil	Sugar Cane yield tons plant cane/acre 22–24 months after planting		Maize yield bags/acre		Sisal yield tons fibre/acre over 12-year cycle		Coffee yield cwt./acre/year		Pasture acres/ stock unit	Other crops	Special Practices Comments
Tennant sandy loam (3–8%).	Yes	A35–40 B40–45	Yes	A8–14 B14–20	Yes	A3–3½ B4–4½	In flood free localities	A2–4	A2½ B1–1½	Citrus, pawpaw, bananas, fodder crops.	Cut-off drains: contour cultivation: terracing: mulching.
Volo clay loam (0–3%) . .	Yes	A30–35 B40–45	Yes	A6–8 B8–15	Yes	A2½–3 B3½–4	No	—	A3 B1½–2	Rice	Ridge and furrow surface drainage: mulching.
Volo clay loam (3–8%) . .	Yes	A30–35 B40–45	Yes	A6–8 B8–15	Yes	A2½–3 B3½–4	No	—	A3 B1½–2	Castor	Graded contour cultivation with diversion ditches: mulching.
Complex: arable clay soils (3–8%).	Yes	A20–30 B30–45	Yes	A4–5 B6–8	Yes	A2–2½ B3–3½	No	—	A3 B2	Fodder crops	Graded contour cultivation with diversion ditches: mulching.
Complex: arable clay soils (3–8% moderately eroded).	Yes	A20–25 B30–40	Poorly suited	A3–5 B6–8	Poorly suited	A1½–2 B2½–3	No	—	A6 B3	Fodder crops	Erosion hazard and broken topography reduces suitability for row crops: cut-off drains: graded contour cultivation: mulching: controlled grazing.
Complex: arable clay soils (8–13%).	Yes	A20–25 B30–40	Yes	A4–5 B6–8	Yes	A2–2½ B3–3½	No	—	A4 B2	Fodder crops.	Cut-off drains: contour cultivation with interception ditches: mulching: controlled grazing.
Complex: arable clay soils (8–13% moderately eroded).	No	—	No	—	No	—	No	—	A6 B3	—	Controlled grazing: fire protection.
Rough broken land, clay materials (13–20%).	No	—	No	—	No	—	No	—	A8 B4	—	Controlled grazing: gully restoration: fire protection.
Permanent swamp soils undifferentiated (0–3%).	No	—	No	—	No	—	No	—	—	Rice, fish	—

HOW THE SOILS OF THE SONGHOR AREA WERE FORMED, AND HOW THEY ARE RELATED TO SOILS OF OTHER PARTS OF THE WORLD

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 kinds of peat) with some incorporated mineral material.

Soils of the Songhor 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 primarily mineral soils comprise 36 soil series of 41 types and 95 phases. As indicated on earlier pages, we have shown the distribution of each soil type and phase on the accompanying map as accurately as possible considering the relatively short time (about $4\frac{1}{2}$ months) spent on field work.

Most soils in the area, like Muhoroni and Volo clay loams, are "heavy" and clayey, but a few, like Kapuong loamy sand, are "light" and sandy; some, like Tennant sandy loam, are rich in humus and plant nutrients, and some are infertile; some, like Ainopsiwa clay loam, are crumbly and easily tilled and some, like Muhoroni clay loam, are obdurate and intractible under the plough. In the following pages we shall outline briefly what is known or conjectured about soil-forming factors. Detailed descriptions of the major soil types 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. These 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 gradients 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 a host of variables each of which has its effects on the character of the soil. In this report we can only suggest the contributions each group of factors has made to the soils.

As universally recognized in the field of soil science, the soil is an open system, and as such is in a constant state of change. It is constantly losing some components through leaching and erosion; it is constantly gaining new material through weathering of rocks, additions of dust and rotting of dead vegetation; and the nature of its mineral makeup is changing gradually through continued weathering.

From this, one might conclude that the soil is changing so rapidly that recommendations for improvement would be fruitless. Actually, it seems, changes in most natural soils are not very rapid. Furthermore, newly added material tends to balance much of the material that has been lost in various ways, and a near-equilibrium or balance between the effects of destructive and constructive forces 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. Soils under the influence of agricultural man, however, are changed much more rapidly and drastically than are soils in a nearly stable natural landscape. On the one hand man can destroy or drastically damage a soil in a few weeks or a few years through bad management. On the other hand, through good husbandry, he may transform the soil to a state of productivity far above what it was when first cultivated. That is the advantage of an open system . . . it is open for improvement as well as for destruction.

The Unconsolidated Mineral Deposits and Hard Rocks

Nearly two-thirds of the soils of the Songhor district are developed in unconsolidated mineral deposits of various kinds mostly dumped by sediment-charged streams or settled out slowly from the quiet muddy waters of former lakes, swamps and marshes. Some of the unconsolidated deposits reached their present position by slow gravitational creep from higher to lower slopes.

Most deposits made originally by streams occur now above flood levels on broad fan-shaped areas along the bases of the Nandi Escarpment and the Tinderet Mountains and around the detached hills and mountains near Songhor Post Office and the Volo and Chemelil sisal estates. The loose materials washed from the granitoid gneiss of the Nandi Escarpment are of mixed textures but, generally, are at least moderately sandy and permeable. While these materials include much inert quartz, they also include minerals that weather to form clay and iron oxide, and release some phosphorus and much potassium for the use of plants. These deposits cover somewhat more than 48,000 acres.

Alluvium washed from the dark-coloured so-called "basic" volcanic rocks of the Tinderet Highlands is generally more clayey than the material from the granitoid rocks. The dark-coloured rocks and the light-coloured volcanic tuffs of the lower slopes of these mountains contain much less quartz than the granitoid rocks and a larger proportion of minerals that break down readily to form clay. These soils tend to be somwhat more fertile than those weathered from the granitoid rocks. The differences are not great and in some instances are offset by differences in soils resulting from long exposure to soil-forming processes.

Nearly 35,000 acres of land in the survey area have soils developed from clayey sediments that were deposited in former lakes and marshes or swamps. The clay beds are interbedded with several layers of volcanic ash, part of which has been cemented to make tuff and part of which is almost as soft as when it first settled out of the water.

Some of the clay beds contain many irregular concretions of lime carbonate up to 2 or 3 inches in diameter, and where these are exposed at the surface on the slopes of river valleys they impart a slightly alkaline reaction to the soil. Apparently the lime was concentrated by slowly moving groundwater and by transfer of lime from upper to lower horizons of soils that were later buried when lake levels rose.

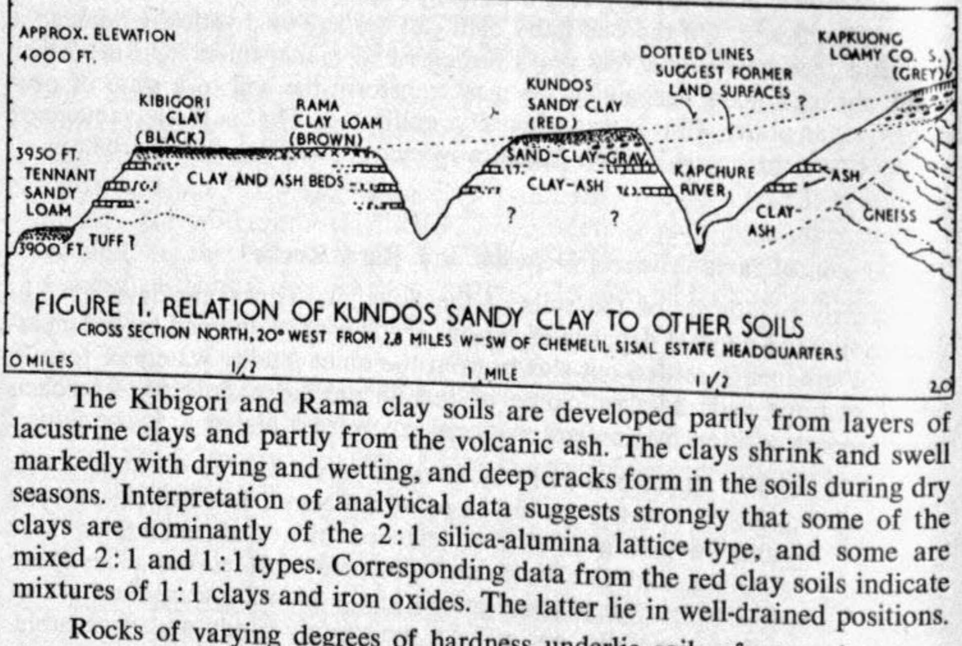


FIGURE 1. RELATION OF KUNDOS SANDY CLAY TO OTHER SOILS
CROSS SECTION NORTH, 20° WEST FROM 2.8 MILES W-SW OF CHEMELIL SISAL ESTATE HEADQUARTERS

The Kibigori and Rama clay soils are developed partly from layers of lacustrine clays and partly from the volcanic ash. The clays shrink and swell markedly with drying and wetting, and deep cracks form in the soils during dry seasons. Interpretation of analytical data suggests strongly that some of the clays are dominantly of the 2:1 silica-alumina lattice type, and some are mixed 2:1 and 1:1 types. Corresponding data from the red clay soils indicate mixtures of 1:1 clays and iron oxides. The latter lie in well-drained positions.

Rocks of varying degrees of hardness underlie soils of somewhat more than one third of the Songhor survey area and have weathered in varying degrees into loose mineral waste that makes up the bulk of the soils.

Granitoid gneiss, with many small veins of quartz and pegmatite, is the chief parent rock of soils of the Nandi Escarpment, of the hills and mountains near Songhor and the Volo and Chemelil sisal estates, of the hills immediately west and south of Muhoroni, and of some of the foothills west of Koru. The gneiss is weathered strongly on most of its smoother and gently sloping exposures, where most of the feldspar grains have either been converted to clay or can be easily crumbled in the hand. The feldspars are much fresher on the steep and very stony hillsides. Wherever moderately deep soils have formed on the granitoid gneiss, one finds a layer of quartz grains one to several inches thick, along the surface of contact between the main part of the soil and the actively weathering rock. Above this contact practically all feldspars have been weathered to clay and most quartz particles are less than ⅛ inch in diameter. Below this layer the weathering rock includes crumbly feldspar grains, quartz fragments of many sizes and clay. The origins of the layer of quartz fragments are discussed on later pages.

Basalt, phonolite, volcanic breccia, coarse-grained tuff, and dark-coloured porphyries comprise an important group of rocks from which soils have developed in this region. All of these but the tuff are dark coloured, hard and very heavy. The tuff is light coloured and includes not only solidified volcanic ash but fragments of gneiss and granite as well that were mixed with the volcanic materials at the time of the eruptions.

Most soils developed from volcanic rocks are more or less clayey and contain little sand; and a fairly large proportion, like Muhoroni clay loam, are of the "black cotton" group, with shrinking-swelling clays that are difficult to cultivate although moderately fertile. Some, like Martin clay loam, are reddish brown or red and easily crumbled to a good tilth. The shallow and stony soils on the volcanic rocks are fertile and can be used for subsistence crops under hoe culture, but they cannot be cultivated with machinery.

It is likely that nearly all of the soils in the Songhor survey area have received at least a sprinkling of volcanic ash in the geologically recent past. Doubtless this ash has contributed significantly to the plant nutrients in most soils, but the ash has been weathered and mixed with the residual materials and can no longer be separately identified.

The Climate

As stated earlier, the rainfall of the Songhor survey area ranges from almost 45 inches to perhaps a little more than 60 inches a year. January is dry, April and May usually are wet, and rainfall tends to be erratic from year to year. The soil dries out markedly from late December to March. Water passes through the soils during the rainy season, 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 during which water passes entirely through the soil, there is a strong tendency for "black cotton" soils to form. These soils are characterized by clay fractions with a high ratio of silica to alumina. These "high-silica clays" shrink strongly with drying and expand correspondingly when they become wet. Deep cracks are formed in the dry season and the surface soil comes apart into fine angular blocks or grains the size of wheat grains. Some of the small grains of clay fall into the deep cracks. During the wet season, water runs into the cracks which are closed gradually by the swelling of the clay. The clay grains that have fallen into the cracks also swell and exert considerable pressure which tends to stir and churn the whole soil mass. Thus the entire soil profile is gradually mixed and becomes almost homogeneous. Organic matter of a peculiar type probably is responsible for the black colour. It is derived mainly from decayed roots of plants, especially grasses.

The "black cotton" soils are developed most extensively on the long, gentle slopes at the bases of the foothills, where they receive some run-off water from higher up the slope, and on the nearly level lake plains. A few areas occur on small high plateau remnants on the eastern side of Kipsesin Estate.

The "black cotton" soils are most extensive in the parts of the Songhor area where seasonal contrasts in rainfall are at a maximum, especially well south of the base of the Nandi Escarpment. Clayey soils, whether black, brown or gray, in the areas with marked dry season, all contain more or less of the high-silica, shrinking-swelling clays. These clays have a high base-exchange capacity, and most carry considerable exchangeable calcium, magnesium and potassium. A few are high in exchangeable sodium. Calcium carbonate concretions form in deep subsoils of most of the "black cotton" soils because so little water drains away. The soil is essentially a closed system.

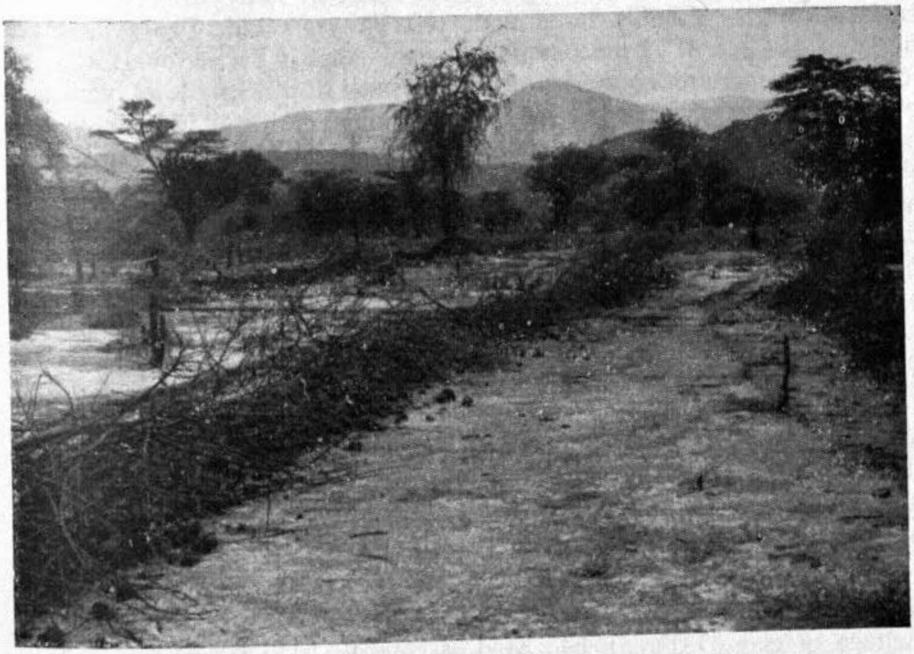
The Nature of the Surface

The nature of the soil surface, both in general and in detail, has important effects on the nature of the soil itself. Minor inequalities of the surface cause water to move away from the higher toward the lower areas. Low areas without adequate outlets cause water to stand for considerable periods before either draining away or evaporating, and soils in these positions, like Patel clay loam, are wet for longer periods than those on higher and better-drained areas like Perry clay loam. The wet soils usually have greyish, black or mottled colours because part of the iron oxide is reduced to a grey form by loss of part of its oxygen. The soils are damp and cold and less responsive to cultivation than those that are naturally better drained.

Where slopes are long, even though they have moderate gradients, water tends to move to the lower parts of the slopes and to keep the soils there in a somewhat poorly drained condition, much as on the flat and depressed low-lands. In many parts of the Songhor area, soils of the lower parts of footslopes contain enough salt to attract cattle and "salt-licks" have developed. The largest of these is the Chemutum salt-lick about $3\frac{1}{4}$ miles south-south-west of Muhoroni. Other salt-licks are scattered along the flanks of the hills north-west of Songhor and in the Nandi Reserve, south-west of Kapkuong. In these places the salt has been dissolved from the higher-lying soils and rocks and has been carried downslope to the areas of seepage where it is concentrated by evaporation and transpiration.

Some soils of the lower footslopes have been converted to Solonetz and solodized Solonetz ("alkali hardpan" soils) through the influence of sodium. The Kapkuong loamy coarse sand is one example.

The formation of salty and alkali soils along the lower footslopes probably is partly the result of the destruction of the open forest that formerly covered the region. Enough remnants of such a forest remain to establish the probability that the whole area once was forested. Experience in Australia has shown that, in regions of seasonally wet and dry climate, the open forest is able to use up most of the rain that falls, and relatively little water reaches the streams. Where trees were destroyed to increase the growth of grass, much more water passed downslope through the soil to the lower slopes and valleys. Salts that had accumulated in the soil in small quantities were dissolved and carried downslope and were concentrated sufficiently on lower slopes and valley bottoms to kill the grass, saturate the soil with sodium, and cause the



Attempts at erosion control on Kapkuong loamy coarse sand on the Nandi Reserve, three and a half miles north-east of Kibigori.

acceleration of erosion (Burvill, 1950; Downes, 1954; Thorp, 1957). It seems very likely that the formation of Solonetz soils and salt-licks on the north flanks of the Songhor Hills, in the Nandi Reserve, near Kapkuong, and at Chemutum salt-lick, has had a similar history. The forests have long since been destroyed by periodic burning to improve pastures and by cutting for timber. More water runs through the soil since the forest was destroyed and salts are gradually concentrated in soils of the lower slopes.

The sources of the salt are not fully known. Part, perhaps most, o must have come from the weathering of local rocks and part may be "cycl as the term is used in Australia. "Cyclic salt" is carried in minute particles the wind and derived either from the salt spray of the sea shore or from s deposits exposed in desert and semi-desert regions. We do not know to wh extent the salt of soils in the Songhor area comes from these different possil sources. Rainwater in many parts of Australia carries from 50 lb. to mo than 100 lb. of salt per acre per year. We do not have any figures for Keny In view of the distance from the sea it is likely that the contribution from th source is small.

Remnants of old plateaus and ancient stream terraces have on the soils that owe their chief characteristics to long exposure to weathering ar to climates and vegetation assemblages different from those of the preser The Kapchure sandy loam and the Kibubu gravelly loam . . . the former c granitoid gneiss and the latter on basaltic rocks . . . are part of an old lar surface that is probably more than 100,000 years old. The soils incluc horizons of "laterite" ironstone or "murram" that is the residual product c long weathering. Probably most of it was formed on a nearly level plain, muc of which has been eroded away. Laterite ironstone forms from many kinc of rocks, frequently under the influence of a seasonally fluctuating water table Water still rises and falls in the laterite subsoil of Kapchure sandy loam, bu apparently not in the Kibubu gravelly loam. The latter appears to b developing at present directly from the hard basaltic lava. It is thickest on th nearly level and gently sloping areas and thinner on the outer slopes of th eroded basaltic rocks. It is likely, but not proved, that the Kibubu gravelly loam formerly had a water table that fluctuated throughout the subsoil zone one to three feet thick, where we now find the laterite.

Patches of the two laterite-bearing soils occur around and above the level of the old lake plain at elevations of about 4,500 feet to somewhat more than 5,000 feet (*see* Fig. 3). At the contact of Kibubu gravelly loam with the lake clays, south-west of Songhor, the truncated basalt and its laterite cap are overlapped by lake-laid clays of probable late Pleistocene age.

The well-drained soils of the older river terraces and alluvial fans are reddish brown or red in colour, crumbly in consistence and have a high per- centage of clay-sized particles. Analyses indicate that the clays are largely mixtures of kaolinite (or other low-silica clays) and red iron oxide, with a small proportion of aluminium oxide. Kundos sandy clay, Mbereri coarse sandy loam, Ainopsiwa clay loam and Marcantonatos loam are examples.

Some old land surfaces on basaltic rocks have reddish soils much like those of the old river terraces. Martin and Sossok clay loams are examples.

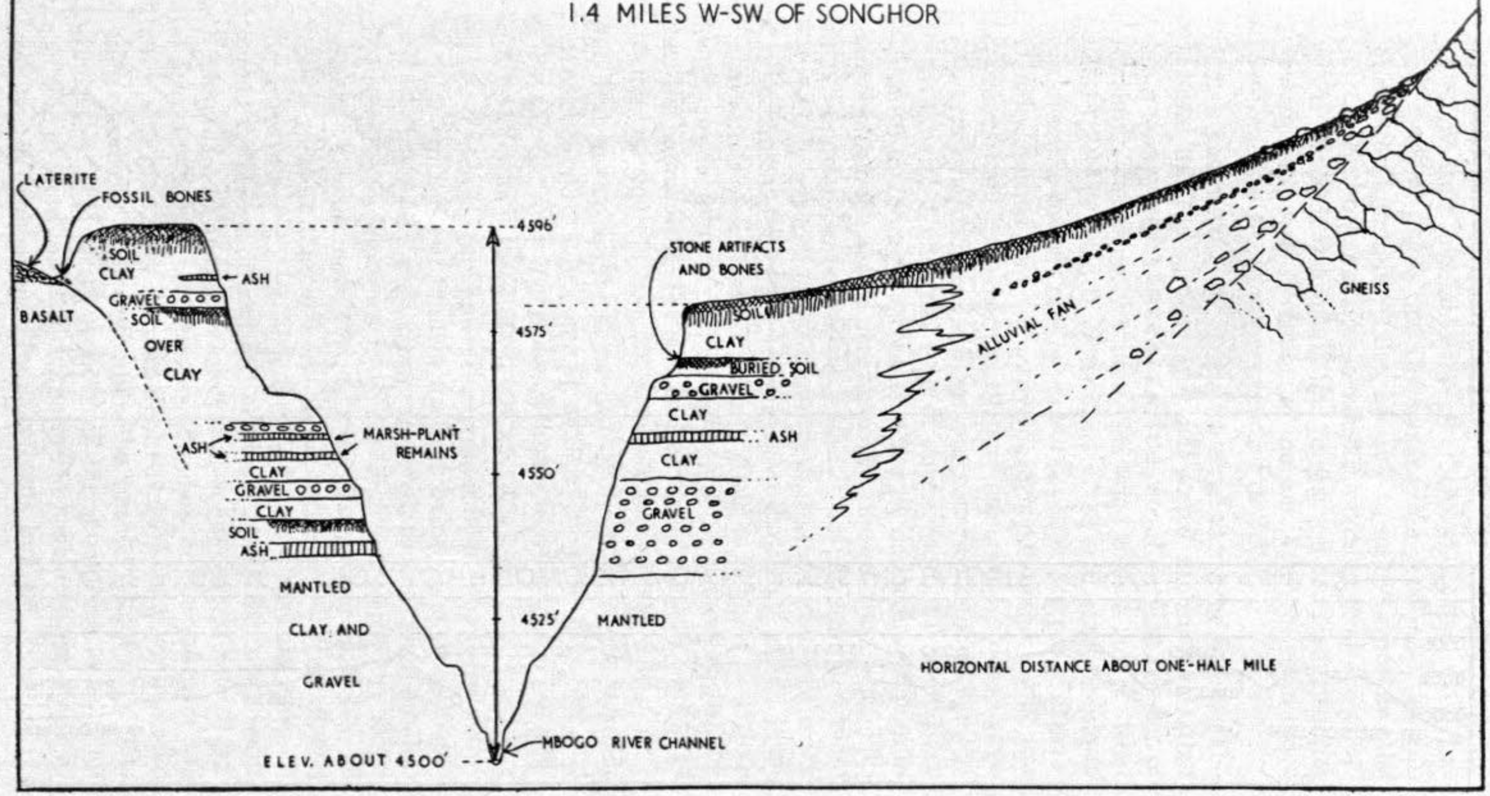
The Biological Environment

Plants and animals (the biological factor) have profound effects on the development of soil. The mineral composition of the parent rocks, the

FIGURE 2

LAKE DEPOSITS-MBOGO VALLEY

1.4 MILES W-SW OF SONGHOR



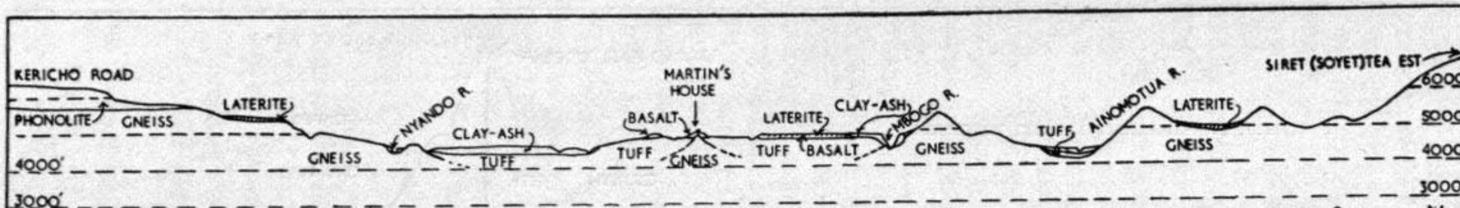
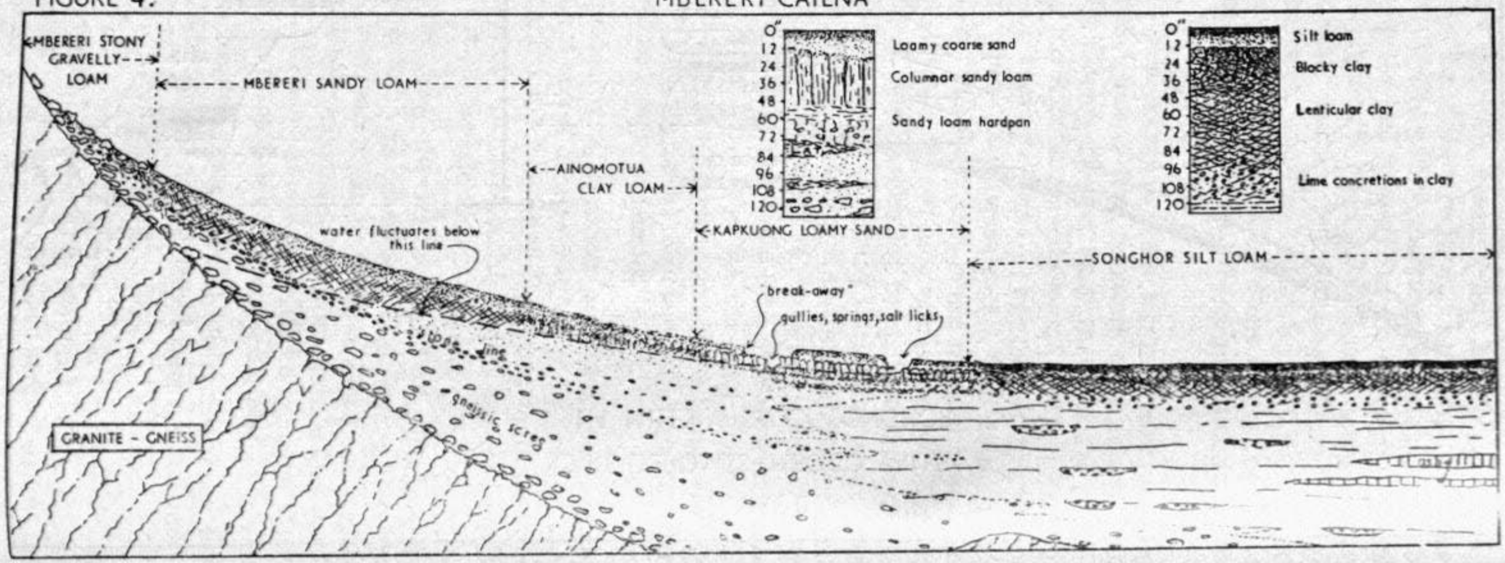


FIGURE 3. CROSS SECTION. SOUTH TO NORTH SHOWING ROCKS AND LATERITE

FIGURE 4. MBERERI CATENA



temperature and the moisture available for plant growth control to a considerable degree the kinds of plants that can survive in a given environment. In turn, the kinds of plants and animals that are able to survive determine the kinds of organic matter and organic acids available for influencing the direction of soil formation. Animals that live in and on the soil use plant material for food and contribute their waste products to the soil. Many of them move and mix mineral soil materials to a very significant degree.

From a few small patches of open forest scattered along the bases of the Nandi Escarpment and the Tinderet mountains it seems almost certain that much of the Songhor survey area carried a forest cover of varying degrees of density before the land was densely settled. To what extent and in what manner this original forest affected the character of the soil is impossible to reconstruct. Tribes of cattle owners and agricultural people for many generations have periodically burned and cut away the original timber until now only a scrubby, fire-resistant growth of scattered trees, with a dense grass cover remains. This type of growth is known among some agricultural workers as "high-rainfall savannah". Under this type of cover, nearly all the surface soils have from about 6 to about 18 inches enriched by dark-coloured humus derived almost entirely from the partial decomposition of dead grass roots. This humus is extremely important to farmers because it holds moisture and plant nutrients which are easily available for plant growth. In the red soils it is the main source of nourishment for crops. In the heavy dark clay soils it helps the farmers to maintain a good state of tilth in their soil. There is a close relationship between productivity and the thickness of the humus-bearing soil and the percentage of humus in it. The significance of high humus content of rain forests in regions outside the Songhor area is quite different.

Animals that live in the soil consume part of the humus and, by their digging, increase permeability to water and mix the minerals of upper and lower horizons. By far the most significant animals in soils of the Songhor area are the termites of which there are many species.

As every farmer in this region knows, the termites build mounds, of many shapes and sizes, of earth and grit brought up from below. The sizes, shapes and numbers of mounds per acre vary greatly from soil to soil. Some mounds are in the form of steeply sloping cones 3 to 8 feet high and 3 to 8 feet across the base. Some mounds have rounded gentle slopes. These range from 1 to 10 feet high and from 5 to more than 100 feet in diameter. The largest mound measured on the survey was 8 feet high and 120 feet across the base. It contains an estimated 1,100 tons of earth, all of which was placed there by the termites. Termit mounds on Ainopsiwa sandy clay loam cover 10 to 20 per cent of the total area and they are at least as abundant on several other soil types. In addition it was noted that termites are actively shifting soil material from lower to higher horizons between the mounds, but the rate of movement appears to be much less. On the footslopes of the mountains at Songhor up to 18 inches of fine earth at the surface appears to have been deposited by termites, and large gneiss boulders are gradually being buried.

The termites dig their tunnels deep into subsoils and weathered rocks and bring the earth to the surface. Subsoil colours appear in many of their mounds on well drained and moderately well drained soils, but only the surface soils are penetrated in very poorly drained soils. Some of the wettest, like the permanent swamps and parts of Patel and Aristos clay loam soil show little or no evidence of termite action.

Termites feed on organic material, chiefly that which is dead; but some species attack living plants, especially sugar cane. The organic material is macerated and stored in cavities hollowed out of their earthen mounds, and fungus is allowed to grow on the organic material. The fungus is then used as food. Fungus "gardens" abound in the mounds but are common also in the soils of the smooth areas between mounds.

Soils developed from rocks rich in quartz (e.g. granitoid gneiss) often have an upper sequence of horizons in which no stone fragments larger than about $\frac{1}{8}$ inch can be found. These horizons have total thicknesses up to 4 or 5 feet, and below them, along a sharp surface of contact, one finds a layer of

Small active termite mound on Songhor silt loam at Songhor, consisting almost entirely of black clay brought up from the subsoil.

quartz fragments from $\frac{1}{8}$ inch to several inches in diameter, imbedded in finer material. This is known as "the stone line". Above this line it seems likely that all or most of the earth has been emplaced by termites who have gathered fine earth from between and below the stones that now comprise the stone line.

This mode of formation of stone lines has been noted by Charter (1949), Nye 1954 and Anderson (1957), but is probably not the only way stone lines have been formed. On steep slopes the stones of the stone line may have collected by being drawn away from quartz veins as the slowly creeping soil mass has passed over the decayed bedrock. In some places stones have been left at the surface during periods when the finer materials have been eroded away and later have been covered by the termites. This can be seen at the bend in the road about one mile north of the Songhor Post Office near the entrance to Mbereri Estate.

Crops in the Songhor area are almost universally more thrifty on the termite mounds than between them. The difference is very conspicuous on the George and Volo Sisal Estates. Chemical analysis of soil from a termite mound on Farndell clay loam showed several times as much available phosphorus as in the soil adjacent to the mound. Part of the difference in crop growth may be due to better aeration on the mounds. Freshly built termite mounds are likely to be very hard and intractable when dry and sticky when wet. These fresh mounds do not appear to be better for crops than surrounding soils, and many are completely bare for several months after they are first built.

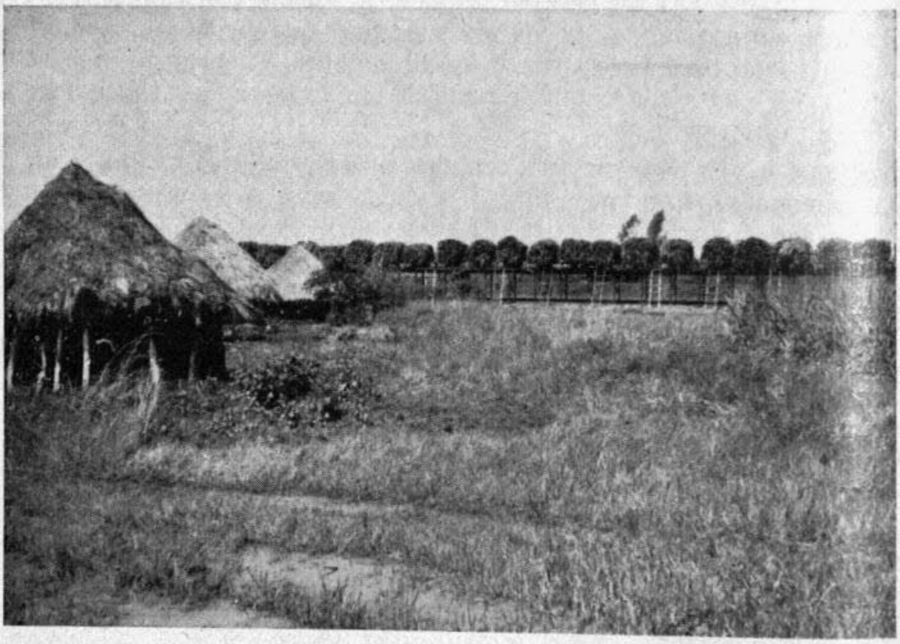
The "ant bear", a nocturnal animal, digs holes in and between the termite mounds in search of termites, and turns over a great amount of earth in the process. The holes are up to 18 inches in diameter and several yards deep. Where this animal is very active he leaves many deep holes and inconvenient piles of earth indiscriminately in fields and on public motor roads. Many other smaller animals stir the soil by digging.

The uses of the land in the Songhor survey area have had some important effects on the character of the soil. The effects of frequent periodic burning of grass and brush on the character of vegetation have already been mentioned. Burning probably has reduced somewhat the total organic matter in the soil and has converted some of the vegetable matter to charcoal which is visible under the magnifying glass in most plough soils. Over-grazing has reduced the grass to a very thin cover on much of the African reserve land and hence there are fewer grass roots to provide humus.

We have already mentioned the probable relationship between the destruction of the forest and the accumulation of salts in the soils of many of the lower slopes of alluvial fans. Resultant deterioration of soil structure in these places is responsible for many of the deep gullies and severe sheet erosion in Kapkuong, Awasi and other soils.

The cultivation of most crops in the Songhor area has reduced the total organic matter in the plough soils and has damaged the soil structure to some extent. Plant nutrients generally are intimately bound up with the organic matter and the clay fraction. When the organic matter is lost the available plant nutrient supply is correspondingly reduced. Many farmers compensate for the loss by allowing the land to be fallow or to revert to savannah at periodic intervals.

Relatively little commercial fertilizer has been used on the soils, except where sugar cane is grown around Chemelil Station. With continued and increased fertilization the content of phosphorus will tend to rise to higher levels than prevailed before the land was cultivated.



Sugar-cane on narrow-gauge cars at Chemelil Railway Station, waiting to be transferred for shipment to Miwani Sugar Factory.

The Time Factor

In an open system like soils, with constant additions and losses of materials, the system will gradually change with time unless a complete equilibrium is achieved. Since complete equilibrium is extremely rare, most soils are changing gradually from one form to another. The degree of change is a function of time when all other factors of soil formation remain constant. The development of many soils is interrupted by erosion, and its direction may be changed by changes in climate, vegetative cover or human activities. In the Songhor area the effects of long time can best be seen in the red soils of the old river terraces, in the laterite-bearing soils of the old plateau remnants and in the black clays of the ancient lake beds. The latter were formed under impeded drainage . . . the former under good natural drainage. The most youthful soils are those of steep mountain sides and of the flood plains of the streams. Examples of soils of different ages are discussed on later pages.

Soil Catenas

Important morphological differences in soils of the Songhor area are related directly not only to the kinds of rocks and loose mineral deposits, but also to the differences in moisture regime. These differences are due in part to the differences in gradient and shapes of slopes, as already mentioned, and to local differences in rainfall. Soils on convex high ground or on level high land with porous substrata are well drained and generally reddish in colour. They are subject to periodic leaching and the dissolved substances are removed by subsurface drainage, either into the deep ground-water or downslope to soils at lower levels. In most of these well-drained reddish soils the clay-sized materials are mixtures of low-silica clays (kaolinite or related clay minerals), red and yellow oxides of iron, with varying but usually low percentages of high-silica clays. Black manganese oxide may appear as spots or concretions at lower levels in the soil, especially in the zone of fluctuating water table. Soils downslope from the reddish ones become more yellowish or greyish in colour as they become wetter from water that has drained to them from higher-lying soils. Some of these moist and wet soils have horizons rich in iron concretions or slag-like laterite (murram) composed of iron oxides, clay and various included minerals in varying stages of decomposition. At still lower levels, where soils are wet during longer periods each year, one finds either heavy black "shrinking clays" (known locally as "black cotton" soils), or solodized Solonetz ("sodium soils"). The periodic swamps may comprise either "black cotton" soils or "Planosols", or both.

Associations of soils of this sort, developed under different moisture regimes from essentially the same kind of parent rock were called "çatenas" by Milne (1935, 1947) in Tanganyika, because the curve of the slope in cross-section resembles a hanging chain. The same term has been used in Britain, the United States and some other countries. The soil associations in the Songhor area are catena-like in character although there is more or less variation in parent material in each association.

One example may be taken from the area along the north slope of the isolated low but steep mountain, north-west of Songhor Post Office. Figure 4 is a composite diagram designed to illustrate the relationships among the various soil types. The diagram illustrates an alluvial fan, the materials of which were washed from granitoid gneiss of the steep mountain on the south. The soil on the mountain was classed as "stony land, Nyangoro soil materials". As the name implies, the land has many outcrops and large boulders of gneiss with pockets of Nyangoro soil between. The Nyangoro soil is described in the appendix.

The high apex of the alluvial fan comprises Mbereri stony and gravelly sandy loam which grades downslope into the reddish brown Mbereri coarse sandy loam. On the basis of its colour and other features of its morphology, this soil could be classed as a Latosol. The dark colour of its "A" horizon suggests an affinity with soils of the Reddish Prairie great soil group. The sand fraction in this soil is almost entirely of quartz except in the lower horizons where some feldspar is present. In many places a "stone line" largely of white quartz fragments appears at depths ranging from 3 to 8 feet. Practically all the sand grains above the stone line are quartz whereas the sand and coarser fragments of stone below it may include fragments of feldspar and granite.

On the slope below the Mbereri coarse sandy loam one may find Ainomotua clay loam in some places, Kapkuong loamy coarse sand in others, and both in still other places. These soils are both radically different from the Mbereri coarse sandy loam and from each other. Sometimes one finds Ainomotua soil immediately above the Kapkuong, but more commonly the Kapkuong loamy coarse sand lies directly below the Mbereri sandy loam and to one side of the Ainomotua soil.

Round-topped columnar structure peds in Kapkuong loamy coarse sand. One foot of steel tape is exposed for scale.

Organic matter is less than 1 per cent throughout the Kapkuong profile and phosphorus is very low throughout. Exchangeable sodium is high in the "B" and "C" horizons of the soil and amounts to more than 20 per cent of the bases. In many places the lower horizons are seepy with water and carry enough soluble salts to attract cattle, so that several saltlicks have been established on this soil.

The soil qualifies as a true solodized Solonetz. Solonetz and solodized Solonetz soils seem to be the result of the effect of sodium ion on the clay fraction of the soil. A small amount of sodium, especially where calcium is low, has the effect of causing the clay in wet soils to separate into its individual particles and to remain in suspension in the waters of the soil. As the water moves downward from upper to lower layers it carries with it in suspension the clay particles which will remain in suspension so long as the sodium ion is

dominant i: ne solution. When it comes ir
lower layers the clay particles tend to be draw
films which can no longer be held in suspensior
to the walls of the cracks through which the w
haps, more important way in which the clay i
by the loss of water from the soil by transpi
removed a large share of the water the clay is
usually clinging to the walls of pore spaces ar
chief means by which the subsoil of Kapkuong
with clay at the expense of the upper horizons
usually lies below the Mbereri and above th
region, where groundwater, moving downslope
becomes more gentle towards these valleys.
that falls on it as rain, but also a consider
through the higher-lying Mbereri soil downslo
seeps through this higher-lying soil it carries wi
which may be present. The fact that seepage
always "milky" until the pools dry up sugge
brought down in suspension from the higher-ly
surface transfer of material is much like that
tropical soils, though he put greatest stress on

Part of the Ainomotua clay loam often li
sandy loam instead of Kapkuong loamy coarse
Kapkuong soil and some lies to either side of
position in relation to the downslope flow of w
seepage from higher land, but contains little o
likely that most of it has lost its salts to the I
streams which drain the area. Its profile shows
moisture, but it cannot be classed as a poorly d
the term. It is too moist to cultivate during t
supply plenty of water for crops well int
characteristics are described in the appendix.

Many of the alluvial fans with Mbereri, K
taper off downslope and merge with the level
in which a great amount of alluvium, and in
collected in the past. At present these flat lar
usually are wet during the rainy season and ma
for periods of a few weeks at a time. Some
surface ditches, or have been drained naturally
that are cutting their way into the lake beds.

On these flat areas one finds at least two
may emerge with either the Kapkuong or the A
is Songhor silt loam which, according to ter
many years in the United States, is a Planosol
parent material of Songhor silt loam is almos

ontact with calcium ion in
ogether into small lumps or
the water, and are attached
er moves. Another and, per-
brought out of suspension is
on. When plant roots have
behind as a jelly-like mass,
cracks. Probably that is the
amy coarse sand is enriched
apkuong loamy coarse sand
lat-bottomed valleys of the
s slowed down as the slope
receives not only the water
le amount that has seeped
to the Kapkuong. As water
t whatever soluble materials
ter in the Kapkuong soil is
that clay, as well, may be
g soils. This downslope sub-
cribed by Greene (1945) for
aterials in solution.

on the slopes below Mbereri
nd. Some of it lies above the
usually in a slightly higher
r. This soil also is subject to
o soluble salt. It seems very
kuong soil below, or to the
vidence of periodic excess of
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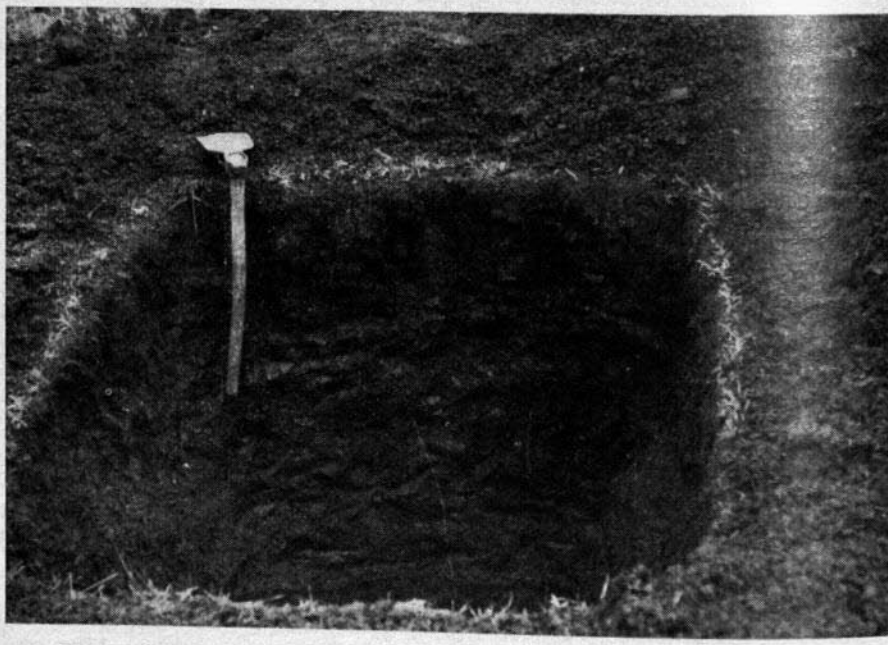
rainy season, but is able to
the dry season. Its profile

kuong and Ainomotua soils
ormerly swampy, lake plain
e places volcanic ash, have
with their deep sediments,
have standing water on them
ve been drained by shallow
y headward-eroding streams

portant soils, either of which
omotua soil. The commonest
nology used during the last
il. As far as we can tell the
xclusively clay and silt that

have settled out of swamp water and lakes to form level land. Soil-forming processes have acted on this material for a long time and, even though the underlying materials are very slowly permeable to water, it seems that enough water gets through to move the clay from upper to lower layers. As is indicated in the description in the appendix, this results in the formation of a very silty "A" horizon which can be subdivided into a nearly black A_1 and a light-grey A_2, separated sharply from the underlying extremely heavy blocky black clay. The clay subsoil is essentially identical to that which one finds in the "black cotton" or Grumusol soils elsewhere on the lake plains and on some of the footslopes of the hills and mountains.

It will be noted that the subsoil has a peculiar form of blocky structure known as "lentil" as described originally by Krishna and Perumal (1948) in India. This peculiar structure is characteristic not only of the Grumusols and



Cross-section of Aristos clay loam, one and a half miles south-east of Chemelil Railway Station. The jembi handle is about 30 in. long. Lentil structure is exposed to the right of the end of the handle.

of this Planosol, but of several other heavy clay soils as well which will be mentioned in due course. The lentil blocks are roughly lens-shaped with sharp edges and rounded faces.

The light-grey A_2 horizon of Songhor silt loam is only rudimentary in some places, while in others it is as much as a foot or even 18 inches thick. In some places it tends to disappear altogether and the soil then merges with the Kibigori clay, which typically has no distinct A_2 horizon and is a true Grumusol.

Thus it can be seen that this catena of soils from the steep mountain slopes and across the alluvial fan is developed from essentially one kind of material, either residuum from granitoid gneiss or alluvial deposits derived from it. However, where the Kapkuong and Ainomotua soils merge with the Songhor silt loam there is an important change in the character of the parent material which, apparently, was washed into swamps and lake beds from other areas where there is a wider range in the kind of rock from which the material was derived. In this respect the Songhor silt loam might be considered not to belong properly to this catena, even though its geographic association is very close.

As pointed out earlier, volcanic rocks in the southern and eastern parts of the Songhor area are high in iron, magnesium and calcium. These are commonly called "basic" or "ferro-magnesian" rocks. Mineralogical composition in them varied somewhat and they are classed by geologists as basalts, dolorites, phonolites, and others. In addition to the hard rocks of this group, formed from the solidification of lava, there are also many outcrops of volcanic tuff—a pyroclastic mixture of volcanic ash, scoria and even many fragments of gneiss and granite that were mixed with the ash at the time of the explosive eruptions of the volcanoes from which the bulk of the tuffs were derived. A great mass of these tuffs covers the lower-lying gneisses of the area and in turn is covered by the hard basic lavas. Erosion has exposed the tuffs along the footslopes of the lava hills and many square miles of soils have developed from them. Locally, near Koru, and on the Ngeron Estate, the tuffs are more or less enriched with calcium carbonate. They merge with a limestone which is exploited for making cement and plaster near Koru.

Catenas of soils developed on the so-called "basic" or "ferro-magnesian" rocks usually include some types developed from scree derived from the lavas, and some directly from the tuff which crops out below the lavas. The sequence of soils of a more or less catenary nature as seen on the Martin Estate is about as follows:—

(1) On the crests of the hills one usually finds either Bhanji stony loam or bare rock.

(2) On the lower slopes of the lava hills one may find a band of Martin clay loam—a deep red Latosol with a dark A_1 horizon and a fairly high humus content.

(3) The Martin clay loam merges gradually downslope into Muhoroni clay loam, a black Grumusol developed directly from the volcanic tuff.

(4) In many places the Muhoroni clay loam merges, in turn, with the Kibigori clay if the lake-clays and volcanic-ash deposits happen to be in the vicinity. Elsewhere, however, the lake-clay beds do not reach the position of the catena, and streams have cut their way back into the tuff which is exposed on the steep slopes of the stream banks.

The Bhanji stony loam is a thin soil with a murram or ferruginous laterite horizon which lies directly on the weathering basic rock. The profile is described in the appendix.

The Martin clay loam is a well-developed soil with considerable humus in the dark-coloured A horizon, and with strongly developed red clay subsoil of friable consistence and granular structure in the subsoil. It is developed under "high-rainfall savannah" of scattered shrubby trees and dense tall grasses. Its profile is described in detail in the appendix.

The Martin clay loam has much in common with some of the "Reddish Prairie" soils of the subhumid parts of the southern Great Plains of the United States which are developed under grassland vegetation. The red colours of the subsoils of some of them are due to long weathering, and it is these that resemble the Martin clay loam of the Songhor area. Others of the Reddish Prairie soils in the Unted States are much younger and owe their red colour to the red shales and sandstones from which they were developed. These are unlike the Martin soils.

Large "lentil" of clay from the subsoil of Muhoroni clay loam. Note curved cracks outlining smaller lentils. The shaded lower surface and the back of the lentil of clay have slickenside surfaces that intersect at the right.

The clay fraction of Martin clay loam has a higher cation exchange capacity than do many Latosols. It is almost certainly a mixture of 1 : 1 and 2 : 1 silica-alumina lattice minerals and sesquioxides of iron and aluminium.

The Muhoroni clay loam developed from volcanic tuff is a well-developed Grumusol which shrinks and cracks markedly with drying and swells correspondingly with wetting. While the clay fraction of the Martin clay loam is a mixture of 2:1 and 1:1 lattice clays, the clay fraction of the Muhoroni soil is predominantly of the 2:1 type. The description of Muhoroni clay loam appears in the appendix.

Most of the Muhoroni clay loam occurs under savannah vegetation on slopes ranging from nearly level to as much as 20 per cent, but most of it is in the range of about 3 to 8 per cent grade. Like the other Grumusols, this soil has well-defined lentil structure in the subsoil, which is especially noticeable where it is exposed in gullies and road ditches. It is evident that the lentil structure is due in large part to swelling and shrinking of the clay with wetting

Cross-section of Rama clay loam on Chemelil Sugar Estate. The lime concretions at centre have been moved upward by the effects of swelling and shrinking with moisture changes (gilgai action).

and drying, often with an accompanying gradual downslope movement of the whole soil mass. All the lentil surfaces are slickensides—the product of shear effects, but the peds are water-stable and water can move slowly between them.

Since it is obvious from the structure of the Muhoroni clay loam and other Grumusols that there is some downslope movement which is probably active during at least one period each year, it is easy to surmise that a great deal of soil must have moved a considerable distance during the course of its development. The heavy clay that has weathered from the tuff now lies farther downslope than when it was first formed, and it continues to creep farther down, little by little. Once it reaches a level position movement is confined to local swelling and shrinking with moisture changes.

As noted in the description (*see* Appendix) the parent tuff of the Muhoroni clay loam has occasional veins and concretions of calcium carbonate scattered through it. In some places it is strongly calcareous, and in others there is little or no calcium carbonate. Similarly the Muhoroni clay loam itself in places contains clusters of calcium carbonate concretions, and in others none have been found within the depth of 5 to 6 feet examined. We believe that the calcium carbonate in the concretions in the soil was dissolved from the veins in the tuff and was reprecipiated during the dry periods. Under such conditions, with slowly permeable soils there is a tendency for the lime to accumulate in irregular lumps and concretions rather than in the soft diffused form characteristic of Chernozem soils.

In spite of the considerable slope characteristic of most of the Muhoroni clay loam, the soil is subject to periodic waterlogging during and immediately after the rainy season, especially where the slopes are concave rather than convex. The water seems to move not only across the surface, but also into the deep cracks. Immediately after the end of the dry season it enters and follows these cracks downslope to make seepages at various points. We found it impracticable to separate on the map the temporarily seepy areas from those which do not appear to be subject to seepage. The relationships are complex and difficult to identify except during a short season each year, and are too complicated to be shown on a map of the scale of the Songhor survey.

The Kibigori clay is associated with this catena in some places, but it is more common with another association, and will be discussed with it.

The deep sediments of the former lakes, marshes and swamps of the Songhor area give rise to an association of soils, the differences among which are due in part to differences in the original material and, more largely, to differences in water relationships in the soils. This association is best seen in an area extending from the Tennant farm south-westward across the lake plains to the Chemelil Sugar Estate. On the Tennant farm, close to the edge of the deep gorge cut by the Mbogo River, is a strip of well-drained reddish soil called Perry clay loam which has an underlying layer of gravel. A short distance back from the edge of the gorge the clayey soils are much less well drained, and there is a complex of several types in which the drainage is more or less impeded. In addition, scattered across the plain, are occasional low ridges a few feet higher than surrounding areas which are the result of resistance of gravel and cobble beds to erosion. These beds were laid originally in the channels of streams that entered the swamps and lakes of this area from surrounding highlands. The cobble and gravel were rolled along the bottoms of the stream beds and filled the channels which the streams had cut in the clays. Parts of the clay beds were washed away and now the cobble beds make the higher ground. Some of the cobble is interbedded with volcanic ash. Babu clay loam, the soil on this material, like the Perry soil, is well drained because the water can escape through the gravel.

Chemelil clay loam has developed from lake clays and volcanic ash on land that lies somewhat lower and considerably farther from river gorges than the Perry, and its drainage is somewhat impeded.

Drainage in the Volo clay loam is more impeded than in the Chemelil, since the soil lies on slightly lower land and water stands on it during a longer period each year. The Patel clay loam occurs in the slightly concave, but practically level, poorly drained surfaces of the old lake-bed area, but generally farther up valley than the black Kibigori clay. The latter, a black Grumusol, is developed from lake sediment in which layers of volcanic ash are interbedded with the lake clays. It may be somewhat higher or lower than the other soils mentioned, but probably has a somewhat different origin. It seems likely that it represents the last stages of an old swamp that existed during the retreat of the lake level. We assume that Kibigori clay was swampy long enough for a large amount of black humus to be incorporated in the soil, and we suspect that most of it represents the bottoms of a series of small residual lakes that persisted after the retreat of the main lake. The various soils mentioned in this association are described in the Appendix.

Analyses show that the more reddish horizons of the Perry clay loam from the surface down to a depth of about 90 inches are dominated by a clay fraction of the 1 : 1 type, although some 2 : 1 clay is present. Deeper horizons, especially from 100 to 128 inches in the sample analysed, are dominantly shrinking-swelling clays of the 2 : 1 type. This soil has much in common with the older of the Reddish Prairie soils of east-central Texas and Oklahoma, U.S.A. They have the dark surface horizons with humus from grass roots, and the reddish colours characteristic of these soils; and the effectiveness of rainfall probably is not greatly different. Rainfall in the Reddish Prairie zone of Texas and Oklahoma is in the neighbourhood of 40 inches, and in the Songhor area is about 50 inches. Since the Songhor area has no cold season it is likely that the moisture effectiveness would not differ greatly in the two areas.

The Perry clay loam occurs on some positions where one would expect some impedence of drainage, but the profile shows no evidence of such impedence. Examination to considerable depths in a number of places showed that most if not all of the Perry clay loam has a layer of gravel and cobblestone beneath it at depths ranging from perhaps 8 feet to as much as 15 or possibly 20 feet. We believe that this accounts not only for the good natural drainage, but also for the red colour which develops in well-drained soils of this region if the time is sufficient.

The Babu clay loam has an upper profile very much like the Perry, but cobblestones and rounded pebbles become abundant at depths ranging from about 18 to about 30 inches. They are usually separated from one another by reddish-brown clay. These cobblestones are partly weathered and doubtless have contributed to the clay content of the soil. At Chemelil Station the cobble beds lie directly on beds of volcanic ash which may have contributed to the lower part of the soil profile.

The Chemelil clay loam, where ploughed, has a strong reddish-brown colour which suggests good internal drainage. When the soil is examined in a pit, however, it is readily seen that the reddish colour is due primarily to the breakdown of red iron oxide concretions, which have been formed under impeded drainage. At depths ranging from 18 inches to about 3 feet there is a sharp change in the character of the subsoil from one which shrinks and swells but little with moisture changes, to one which shrinks and swells a great deal. The profile of Chemelil clay loam is described in the Appendix.

It seems almost certain from the character of this profile that the soil at an earlier stage was more poorly drained than it is at present. Drainage has been improved by gradual deepening of the stream valleys and partial dissection of the level plains on which the soil occurs. Probably the drainage condition at the time of the original formation of the Chemelil soil was about like present conditions, successively, first in the Patel clay loam and later in the Volo clay loam.

The chemical data indicate that the clay fraction to a depth of about 32 inches is dominated by 1 : 1 type clay, but below this depth the clay fraction is a mixture of 1 : 1 with a considerable amount of 2 : 1 type clay. This probably accounts for the swelling and shrinking observed in the lower part of the profile during periods of wetting and drying.

The drainage of Volo clay loam is considerably more impeded than that of the Chemelil clay loam; the soil generally lies on slightly lower levels of the lake plain and is wet during longer periods of each year. One of the outstanding characteristics of the Volo clay loam is the occurrence of small iron-oxide concretions in the upper part of the profile. As much as 20 to 30 per cent of the soil mass in some places is made up of this material. In some places the concretions are abundant in the A_1 horizon, in others they are more concentrated in the A_2 horizon, and in still others in the uppermost part of the B horizon. It seems likely that their position in the profile is related to the local micro-relief, because such concretions tend to form in layers that are seasonally wet for considerable periods.

Like the other clayey soils of the Songhor area the subsoil of the Volo clay loam has a strongly developed lentil structure which is most evident during the period when the soil is saturated with water. Pits dug in this soil filled with water soon after digging, and the soil slumped from the lentil faces into the pit. Not only did the large lentils separate from one another, but it was possible very easily to pull the large lentils apart into small ones along the secondary cleavage planes. When the same soil has dried out it will no longer separate along these planes but, instead, tends to crack up into angular particles. Details of the Volo clay loam are given in the Appendix.

Probably the nearest correlative great soil group of the Volo clay loam would be the Low-Humic Glei soils of the classification scheme used in the United States in recent years (Thorp and Smith, 1949).

The Patel clay loam is still wetter for longer periods each year than the Volo clay loam and some of it has fewer concretions, and generally is greyer throughout than the Volo and Chemelil and more difficult to manage for farming. The reader is referred to the appendix description. It fits fairly well into the great group of Low-Humic Glei soils.

The Kibigori clay has been mentioned a number of times as a well-developed Grumusol of the lake plains. It varies in character somewhat, having considerably more humus in some places than in others and having humus-bearing horizons thicker and thinner from place to place. Deep pits in some areas of the soil show that the dark clay goes to greater depths in some places than others and that volcanic ash occurs within 2 or 3 feet of the surface in a few places, and as deep as 10 to 12 feet in others. One finds volcanic ash interlayered with lake clays within a depth of 10 feet in most places. Kibigori clay is described in the Appendix.

Nearly all of the Kibigori clay has lime-carbonate concretions at depths ranging from 2 or 3 feet to as much as 10 feet, but a few places may be found where there are no such concretions. The concretions appear to be especially abundant adjacent to slopes where streams have, in geologically recent times, cut into the lake deposits. It appears that the calcium carbonate in the soil may be migrating slowly from the main mass of the soil towards the slopes of the stream valleys.

This, like the Muhoroni clay loam, is a good representative of the general group known variously as "black cotton" soils, "Regur", "Tirs" and "Grumusol". This general group of soils is very widespread in regions of rocks that are either high in ferro-magnesian minerals or are calcareous, clayey and slowly permeable. The Grumusols occur also, as far as we know, almost exclusively in regions where rainfall is not excessively high and where there is a marked dry season each year when the soils become dry to a considerable depth. The soils are known in Algeria, British East Africa, parts of South Africa, in large areas in Australia and India, as well as in the region of calcareous clays in east-central Texas and Oklahoma, U.S.A. (Oakes and Thorp, 1951). Small areas occur also on the north China Plain, and on the Shantung Peninsular (Thorp, 1936).

The last of this group of associated soils on the lake plain of the Songhor area, is the Aristos clay loam. This soil, closely associated with the Kibigori and Patel soils, occurs under drainage conditions about like those of the Patel. It differs from the Patel in its higher clay content and its black A horizon. Under natural conditions the water stands on the surface of the Aristos clay loam for much longer periods than it does on the Kibigori clay, but it is very similar to the Patel in this respect. The profile, much like the Kibigori clay, is described in the Appendix.

As one would expect from the shrinking and swelling properties of Aristos clay loam, the clay fraction of the deeper layers is dominated by 2:1 clays. Only the uppermost horizon appears to have more 1:1 clay than 2:1.

Acid-extractable phosphorus is present in the uppermost 3 feet of the soil and increases considerably below that level as it does in other Grumusols.

From the foregoing sections it is easy to see that many radically different kinds of soils occur in close geographic association in the Songhor area. In some instances it appears that these associations are more or less haphazard, but in others, as in the case of the Mbereri catena, there seems to be a systematic relationship. A few notes regarding these relationships are in order at this time.

The Grumusols, including the Muhoroni, Kibigori, Ngeron and Farndell series, all have in common a predominance of 2:1 type clays so far as the physical character of the soils is concerned. From the descriptions of these types it will be seen that apparently the parent materials of these soils are of several sorts. In most instances they seem to have a component of ferro-magnesian minerals in the parent rock or alluvium, from which they are developed. The largest areas of these soils are developed from tuff (Muhoroni series), or from inter-stratified lake clay and volcanic ash (Kibigori series). Thus it appears that volcanic ash and tuff tend to weather into 2:1 type of clay mineral from which the black Grumusols are developed. The Farndell soils, on the other hand, seem to be developed from material washed from gneisses which contain a large amount of quartz and feldspar; but even this soil does have a component of ferro-magnesian minerals from nearby outcrops of tuff and phonolite.

Significant also, in the development of the Grumusols seems very likely to be the water relationships. Nearly all these soils lie below areas of higher land where soils have been weathered and leached from various kinds of rocks. In the leaching process part of the silica from the primary silicate minerals is dissolved and carried downslope in the subsoil water. As far as we know it is a universal process wherever rocks are weathered and leached, and it has been demonstrated in the past to be especially active in tropical regions. As the water seeps slowly through the soils its movement is slowed as gentler slopes are approached, and the dissolved silica remains in close contact with the soil for long periods of time during and following the rainy season. In the dry season much of the water is lost by evaporation and more especially by transpiration by grasses and the shrubby trees of the savannah. This means that the dissolved silica remains in close contact with the soil for considerable periods and it is reasonable to suppose, though not fully demonstrated, that it may combine with 1:1 clay minerals to form 2:1 clay minerals. Since the soils with much 2:1 clay in the Songhor area are generally fairly high in exchangeable bases it is reasonable to suppose that such synthesis has occurred (Russell, 1950, p. 503).

Whether or not this explanation accounts fully for the 2:1 clays in the Grumusols has not been proved, but it seems a reasonable hypothesis.

The Chemelil, Volo and Patel soils also contain a large amount of 2:1 clay, especially in the deeper layers. In upper layers the proportion of 2:1 clay is considerably less in most instances, as can be seen from the analyses in the Appendix, and we suppose that the acid leaching and weathering process in the upper part of the profile removes part of the silica or prevents resynthesis. In most of these soils there is a sharp change from clays which shrink less in the upper part of the profile, to clays which shrink much more with drying in the lower part of the profile, and this line apparently represents the advancing front in the change in the type of clay that goes with the weathering process. At the present moment perched water tables in this area are rather high, and it seems that this line of demarcation is also the line below which soils are saturated for longer periods than above the line. The fact that in the Perry soils the line between the predominantly 1:1 clay and 2:1 clay is at much greater depth, suggests that the process of change from 2:1 to 1:1 clay has advanced much farther because subsoil water is being removed through underlying layers of gravel and dissolved silica remains in contact for much shorter periods of time. Theoretically we can expect that the area of Perry soil may increase with time as the water tables of the area are lowered; but, of course, the time would be so long that it will be of no significance to the present generation.

"B" horizon of Kapkuong loamy coarse sand, exposed by erosion, and very hard when dry. Cracks are lined with grey clay. The open pocket knife is six inches long.

The clays of the lake plain generally seem to be dominantly of the 2:1 type, though some 1:1 clay does occur, especially near the areas of gneiss where alluvium comes from this source. With moderately good to good drainage, gneisses appear to weather more into 1:1 than into 2:1 type clays, and this influence is evident in some of the soils of the lake plains. For example, the Kibigori Grumusol from the sample on the Muhoroni Sisal Estate shows somewhat more 1 : 1 type clay than is characteristic of the series throughout most of its extent. It seems significant that this area of Kibigori clay lies between local hills of gneiss and that there are lenses of gneissic sand and gravel at depth under this profile. A few grains of quartz scattered through the profile indicate that these local beds of gneiss have contributed some material to this profile.

The Solonetz and solodized Solonetz soils like the Kapkuong and Awasi soils are in positions where they receive some seasonal seepage water from higher lying soils. While this seepage water is not very salty it does contain enough salts to cause calcium to be replaced by the sodium, and for the typical Solonetz and solodized Solonetz structure to be developed. Actually, there are some places where salts collect sufficiently that livestock are driven to them to lick up the salt. At the Chemutum salt-lick, for example, the soils have been licked out to depths of several feet by the cattle, and cattle and goats have licked their way from one gully to another to make tunnels through the intervening ridge.

Mention has already been made of the occurrence of large patches of land with laterite horizons in the soil both on ferro-magnesian rocks and on gneisses. These ironstone laterites, also called "murram", occur largely at levels ranging between 4,500 and 5,000 feet above sea level, and they seem to mark an old partially developed peneplain surface, much of which has been eroded away since it was formed. The position of this peneplain surface suggests very strongly that it may date back to early Pleistocene or, perhaps, to Pliocene time. During the period that this area was an undissected plain, it is likely that the laterite formed indiscriminately on all or nearly all exposed surfaces except possibly the ones that were well drained. On these the red, friable, clayey soils were formed with little or no laterite horizons beneath them. The principal soils with laterite are the Kibubu, developed from basaltic rock, and the Kapchure, developed primarily from gneiss. The Kibubu soil is developed from a basaltic rock which may be either of Pliocene or early Pleistocene age (verbal information from the Geological Survey of Kenya). We noted that the Kibubu soil with its strongly developed laterite horizon, follows down the original gentle slope of the old peneplain surface towards the lake plain. Where the lake clays overlap the lava beds the laterite horizon thins out very rapidly and disappears entirely at places where the lake clays are more than 15 feet thick. This suggests that the lava beds were dissected after the formation of the older part of the laterite and before the lake clays were deposited, and that the lake clays lapped over the edge of the truncated laterites. Alternatively, some laterite may have developed beneath the outer edges of the lake clay.

The red soils of the Songhor area are universally very well drained internally even though some are on rather gentle slopes. Water is able to move through them to great depths, and the dissolved products of weathering can be carried to deeper horizons or into the seepage water that goes to lower levels. These soils consist primarily of a residuum of hydroxides of iron and, perhaps, of aluminum and grains of minerals that weather only extremely slowly—especially quartz. The clay fraction of these soils is dominated by 1:1 silicate clays with a minor amount of sesquioxides and also, in some instances, with varying but usually small proportions of 2:1 clays. The Kundos, Ainopsiwa, Marcantonatos and the Martin soils are the principal examples of the red soils. They belong in the very inclusive group called Latosols, but they differ from each other in several respects. For example, the Kundos soils seem to have been weathered for longer periods, or at least more effectively, than the Martin and the Marcantonatos soils, both of which contain a moderate amount of 2:1 clay in addition to the predominant 1:1 clay. The clay fraction of the Martin clay loam has much more of the 2:1 clay than that of the Marcantonatos loam and this difference appears to be almost certainly due to the difference in the kinds of parent materials. As pointed out earlier, materials derived from gneisses of this area tend to go more to 1:1 clay than those developed from ferro-magnesian rocks.

Physiographic evidence suggests that these reddish Latosols may be somewhat younger than the soils with laterite (Kapchure and Kibubu soils).

The time relationships between the red soils and the Grumusols are difficult to determine on the basis of evidence at hand. We do know that many layers of volcanic ash lie beneath both the red Kundos and the black Kibigori soils, but we have not been able to trace the ash layers to determine whether or not they are of the same age. If they are of the same age it would mean that the Kundos and Kibigori soils also are approximately the same age. The high calcium content of the Kibigori soils and the prevalence of 2:1 type clay in them, suggest relative youth as compared to the Kundos soils which have lost much of their silica and calcium. However, it has been pointed out already that the Kibigori soils receive water from higher levels, and the plants on the Kibigori transpire much of this water, which would tend to leave behind the soluble products that have been brought to the Kibigori soils from higher levels. Furthermore, the deep cracking of the Kibigori soils when drying, and swelling with wetting, keeps the soil stirred to depths of several feet, so that it is effectively kept in a youthful state compared to the Kundos even though the age in years of the two may be essentially the same.

Thus it is possible to develop hypotheses regarding the mode of formation of the soils of the Songhor area, but we cannot draw final conclusions at this stage. Many of the soils have been in existence for many tens of thousands of years, and because of this fact, and because we know there have been important changes in climate and vegetation during this time, the soils as we see them today must reflect not only present environmental conditions, but also periods of higher and lower rainfall in the past with corresponding differences in other factors.

The younger soils of the high flood plains and low stream terraces, and on the steep hills and mountains, do reflect the present vegetation and climate to the extent that they can be effective in a short period of time. These soils are relatively little weathered and contain an abundance of fresh minerals which are gradually becoming available for plants. Many of these younger soils are highly fertile, even though they may be too difficult to work with modern machinery, as in the case of the Kipsesin soils on the steep slopes.

TENTATIVE CLASSIFICATION OF THE SOILS OF THE SONGHOR SURVEY AREA

In preceding pages we have mentioned similarities of several soils of the Songhor area to widely recognized great groups of soils in various other parts of the world. Soil scientists in many countries have attempted to devise all-inclusive systems of soil classification. Some are based on the supposed modes of soil genesis, and others are based on the actual physical and chemical properties of the soils. Russian and American soil scientists have influenced strongly the trends of soil classification during the last 30-40 years, and several classification systems have been devised in both countries. Much work has been done in this field in the various European countries, and in Great Britain, Canada, Australia and New Zealand, the Belgian Congo, South Africa, China, Japan and several other oriental countries, and in some of the Latin American countries as well. Many of the systems are designed primarily for local use, and nearly all have much in common. The classification system used most widely in the United States since 1938, was based on an earlier system designed by C. F. Marbut in the 1920's. Marbut's system, borrowed some ideas from both E. W. Hilgard, an early American authority, and from K. D. Glinka and other Russian scientists contemporary with Marbut. Ideas about soil classification and terms for great groups of soils come from many countries.

A new classification scheme for soils has been under development in the United States since 1953, but as of April, 1959, it has not been published and is not available for public use. The scheme is based primarily on physical and chemical properties of soils and is designed to embrace all soils everywhere. Soil scientists in all countries where soil investigation is in progress have been consulted in order to make the system as comprehensive as possible. Since this scheme is not available for use we shall endeavour to indicate the relationship of the soils of the Songhor area to recognize soils in various other countries and according to two systems of classification. Table 6 is an attempt to assign the various soil types of the Songhor area to their appropriate places in the classification scheme of the late G. W. Robinson (1949), Professor of Agricultural Chemistry in the University College of North Wales, Bangor.

Robinson points out the kinship between "Tropical Red Loams" and the "Brown Earths" of Britain but he makes no specific provision for separating Brown Earths and Tropical Red Loams within tropical regions. This has been attempted in Table 6. For the convenience of the reader we have subdivided the Vlei soils into black, brown, grey and light grey subgroups.

TABLE [illegible].—SOILS OF THE SONGHOR AREA, ROUGHLY ACCORDING TO G. W. ROBINSON'S SYSTEM OF CLASSIFICATION (MISSING NUMBERS IN CATEGORY 4 DO NOT OCCUR IN SONGHOR AREA

Category 1	Category 2	Category 3	Category 4	Category 5 (Soil type)
Soils with free drainage.	Completely leached.	Raw humus present.		
		Raw humus absent.	3. Brown earths some of the types in this group could be classed as "Reddish Prairie" soils, not listed in Robinson's classification. (*See* Table 7).	Babu clay loam. Hermann silty clay loam. Kamaasae sandy clay loam. Kipsesin clay loam. Koru clay loam. Nandi loam. Nyando clay loam. Sossok clay loam. Tennant sandy loam. Tennant clay loam.
			8. Tropical red loams.	Ainopsiwa clay loam. Kundos sandy clay Marcantonatos loam. Martin clay loam. Perry clay loam. Mbereri coarse sandy loam. Nyangoro stony sandy loam.
			9. Ferrallites	Bhanji loam. Bhanji stony loam. Kapchure sandy loam. Kapchure sandy clay loam. Kibubu gravelly loam.
Soils with i-m peded drainage.	No soluble salts.	Sub - tropical and tropical.	19. Vlei soils Black:	Aristos clay loam. Farndell clay loam. Kibigori clay. Muhoroni clay loam. Ngeron silty clay loam. Lemaiywa clay.
			Brown:	Mbogo clay loam. Rama clay loam.
			Grey:	Ainomotua sandy clay loam. Chemelil clay loam. George clay loam. Patel clay loam. Raragegwit sandy clay loam. Volo clay loam.
			Light gray:	Songhor silt loam.
	Soluble salts present.		21. Alkaline soils	Kapkuong loamy coarse sand.
			22. Soloti (Solod) soils.	Awasi loam.

TABLE 7.—SOILS OF THE SONGHOR AREA, ACCORDING TO A U.S. DEPARTMENT OF AGRICULTURE CLASSIFICATION SYSTEM, USED UNTIL 1955

ORDER	SUBORDER (numbers omitted are not represented in Songhor area)	GREAT SOIL GROUP (other affinities noted)	FAMILY (suggestive only and subject to change)	SOIL SERIES AND TYPE
ZONAL SOILS (These soils reflect the effects of major features of the climate and vegetation.)	3. Dark-coloured soils of humid and subhumid grasslands. (Mostly savannah and savannah-forest transition in Songhor survey area.) These soils are intergrading toward Latosols. Family 4 has affinities with Grumusols of the intrazonal order.	*Reddish Prairie* (*Reddish Brunizem*) *soils.*	Family 1	Koru clay loam. Perry clay loam. Babu clay loam. Nyando clay loam.
			Family 2	Marcantonatos loam. Martin clay loam.
			Family 3	Mbereri coarse sandy loam. Nyangoro stony sandy loam.
		Brown soils of Heavy Texture. (Australian name.) Reddish Prairie affinities.	Family 4	Mbogo clay loam. Rama clay loam.
	4*a*. Dark, moderately young soils of forests and forest-savannah transition. (Approximately the same soils are listed as of the Intrazonal order in the U.S. Dept. of Agriculture classification).	*Brown Forest soils* (Medium calcium status.)	Family 5	Hermann silty clay loam. Nandi loam.
			Family 6	Kamaasae sandy clay loam.
		Sossok soil has affinities with Latosols.	Family 7	Sossok clay loam.
	6. "Lateritic" soils of forested warm-temperate and tropical regions. (Includes forest-savannah transition zones in Kenya.)	*Reddish-Brown Lateritic* soils; like *Red Latosol* of Belgian Congo.	Family 8	Ainopsiwa clay loam. Kundos sandy clay.

TABLE 7.—SOILS OF THE SONGHOR AREA, ACCORDING TO A U.S. DEPARTMENT OF AGRICULTURE CLASSIFICATION SYSTEM, USED UNTIL 1955—(*Contd*)

ORDER	SUBORDER (numbers omitted are not represented in Songhor area)	GREAT SOIL GROUP (other affinities noted)	FAMILY (suggestive only and subject to change)	SOIL SERIES AND TYPE
INTRAZONAL SOILS (These soils overlap to a considerable extent the various climatic zones, and reflect special effects of impeded drainage and parent materials of extreme textural and mineralogical composition.)	1. Halomorphic soils	*Solonetz* (Solodized).	Family 9	Kapkuong loamy coarse sand.
		Solod affinity with Planosols	Family 10	Awasi loam.
	2. Hydromorphic soils (Lemaiywa clay and Aristos clay loam have affinities with Grumusols.)	*Humic Glei soils swampy*	Family 11	Lemaiywa clay.
		Low-Humic Glei soils somewhat poorly (12) to poorly (13 and 14) drained.	Family 12	Chemelil clay loam. George clay loam. Ainomotua sandy clay loam.
			Family 13	Aristos clay loam.
		Soils of Family 14 have affinities with Planosols.	Family 14	Patel clay loam. Raragegwit sandy clay loam. Volo clay loam.
	2*a*. Amphibious soils. This sub-sub-order is not listed in U.S. Dept. of Agriculture classification. Usually saturated during and immediately after rainy season; dry in dry season.	*Planosols* somewhat poorly drained.	Family 15	Songhor silt loam.
		Groundwater Laterite soils (provisional grouping). Family 17 soils now mostly well drained. Probably seepy in recent geologic past.	Family 16	Kapchure sandy loam. Kapchure sandy clay loam.
			Family 17	Kibubu gravelly loam. Bhanji loam. Bhanji stony loam.
		Grumusols	Family 18	Ngeron silty clay loam.
			Family 19	Muhoroni clay loam. Kibigori clay. Farndell clay loam.
Azonal soils (These soils are very young and weakly developed).		*Lithosols affinity* with *Brown* Forest soils.	Family 20	Kipsesin clay loam.
		Regosols	Family 21	Complex arable clay soils.
		Alluvial soils	Family 22	Tennant sandy loam. Tennant clay loam.

The "alkaline" soil Kapkuong is actually a solodized Solonetz, with a slightly acid surface soil and an alkaline subsoil. It is less alkaline than an ordinary Solonetz would be.

Table 7 is an attempt to classify Songhor area soils according to the system used in the United States from 1938 until about 1955 (Baldwin, Kellogg and Thorp, 1938) and modified from time to time during that period. Actually, the latest version, published in 1949 (Thorp and Smith), was modified by us to fit conditions in Kenya, as indicated in later paragraphs. Soil families indicated on the Table are suggestive only, and groupings may be modified later. We are sure that many of the soil types of surrounding areas, not now well known, would fit into the families and higher categories. Readers should note that several suborders and their corresponding lower categories have been omitted because they do not occur in the Songhor area.

In the American system of classification used here some modifications of the original system seemed desirable. The most radical change is the shifting of the Brown Forest great soil group from the Intrazonal to the Zonal order. Soils classed as Brown Forest seem to owe their physical and chemical properties to the combined effects of humid climate and predominantly forest vegetation acting on materials of mixed mineralogical composition, over a period of time roughly equivalent to that required for the formation "zonal soils" in northern Europe and northern United States. The surfaces on which these soils occur probably have changed relatively little in the last several thousand years, but are not excessively old.

The group name "Brown Soils of Heavy Texture" originated in Australia to cover brownish clayey soils that shrink and swell markedly with moisture changes but are not black like the typical Grumusols (black cotton soils). A subdivision of suborder 2 was added to the scheme and called "amphibious soils", to cover the Planosols, Grumusols and Ground water Laterite soils. It might be as well to put the Brown Soils of Heavy Texture in this suborder rather than giving it separate status.

"Groundwater Laterite soils" is an unsatisfactory group name for the 5 soils grouped under it. All of the soils have more or less continuous horizons of laterite, some of which are thin and others moderately thick. A1 horizons of these soils are dark coloured and fairly high in humus and all have mixed 1 : 1 and 2 : 1 silica-alumina lattice minerals in the clay fraction. Furthermore, the Bhanji and Kibubu soils seldom experience high water table during any significant part of each year. The terms "laterite" and "groundwater laterite", probably should be confined to particular kinds of soil horizons rather than to soil profiles as a whole. Many kinds of soils have laterite horizons. This problem needs further study, and the final disposition of the soils in question remains to be decided.

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Legend for Soil Map of the Songhor Survey Area—

Correlated Name	Symbol on Map
Ainomotua sandy clay loam, 3 to 8 per cent slopes	Aic–B
Ainopsiwa clay loam, 0 to 3 per cent slopes	As–A
Aristos clay loam, 0 to 3 per cent slopes	Ac–A
Awasi loam, 3 to 8 per cent slopes, moderately eroded	Asi–B–2
Babu clay loam, 0 to 3 per cent slopes	Bcl–A
Babu clay loam, 3 to 8 per cent slopes	Bcl–B
Babu clay loam, 8 to 13 per cent slopes	Bcl–C
Bhanji stony loam, 0 to 8 per cent slopes	Bist–B
Bhanji stony loam, 0 to 8 per cent slopes, moderately eroded	Bist–B–2
Bhanji loam, 0 to 3 per cent slopes	Bil–A
Chemelil clay loam, 0 to 3 per cent slopes	Ccl–A
Chemelil clay loam, 3 to 8 per cent slopes..	Ccl–B
Complex of arable clay soils, 3 to 8 per cent slopes	Cxc–B
Complex of arable clay soils, 3 to 8 per cent slopes, moderately eroded ..	Cxc–B–2
Complex of arable clay soils, 8 to 13 per cent slopes	Cxc–C
Complex of arable clay soils, 8 to 13 per cent slopes, moderately eroded ..	Cxc–C–2
Farndell clay loam, 0 to 3 per cent slopes	Fcl–A
Farndell clay loam, 3 to 8 per cent slopes	Fcl–B
George clay loam, 0 to 3 per cent slopes	Gcl–A
George clay loam, 3 to 8 per cent slopes	Gcl–B
Hermann silty clay loam, 3 to 8 per cent slopes	Hc–B
Hermann silty clay loam, 8 to 13 per cent slopes	Hc–C
Kamaasae sandy clay loam, 3 to 8 per cent slopes	Kcl–B
Kamaasae sandy clay loam, 8 to 13 per cent slopes	Kcl–C
Kamaasae stony clay loam, 13 to 20 per cent slopes	Kt–D
Kapchure sandy loam, 3 to 8 per cent slopes	Kps–B
Kapchure sandy loam, 3 to 8 per cent slopes, moderately eroded	Kps–B–2
Kapchure sandy loam, 13 to 20 per cent slopes	Kps–D
Kapchure sandy clay loam, 3 to 8 per cent slopes	Kpd–B
Kapkuong loamy coarse sand, 0 to 3 per cent slopes	Ks–A
Kapkuong loamy coarse sand, 3 to 8 per cent slopes	Ks–B
Kapkuong loamy coarse sand, 3 to 8 per cent slopes, severely eroded ..	Ks–B–3
Kapkuong loamy coarse sand, 8 to 13 per cent slopes	Ks–C
Kibigori clay, 0 to 3 per cent slopes	Kbc–A
Kibigori clay, 3 to 8 per cent slopes	Kbc–B
Kibubu gravelly loam, 3 to 8 per cent slopes	Kgl–B
Kibubu gravelly loam, 8 to 13 per cent slopes	Kgl–C
Kipsesin clay loam, 3 to 8 per cent slopes	Knc–B
Kipsesin clay loam, 8 to 13 per cent slopes	Knc–C
Kipsesin clay loam, 13 to 20 per cent slopes	Knc–D
Kipsesin clay loam, 20 to 35 per cent slopes	Knc–E
Koru clay loam, 0 to 3 per cent slopes	Kol–A
Kundos sandy clay, 0 to 3 per cent slopes	Kuc–A
Kundos sandy clay, 3 to 8 per cent slopes, moderately eroded	Kuc–B–2
Lemaiywa clay, 0 to 3 per cent slopes	Lec–A
Marcantonatos loam, 3 to 8 per cent slopes	Mal–B
Martin clay loam, 3 to 8 per cent slopes	Mnc–B
Martin clay loam, 8 to 13 per cent slopes	Mnc–C
Mbereri coarse sandy loam, 3 to 8 per cent slopes	Msl–B
Mbereri coarse sandy loam, 3 to 8 per cent slopes, moderately eroded ..	Msl–B–2
Mbereri coarse sandy loam, 8 to 13 per cent slopes	Msl–C
Mbereri coarse sandy loam, 8 to 13 per cent slopes, severely eroded	Msl–C–3
Mbereri coarse sandy loam, 13 to 20 per cent slopes	Msl–D

LEGEND FOR SOIL MAP OF THE SONGHOR SURVEY AREA—(*Contd.*)

Correlated Name	Symbol on Map
Mbereri coarse sandy loam, 13 to 20 per cent slopes, severely eroded ..	Msl–D–3
Mbereri stony and gravelly sandy loam, 3 to 20 per cent slopes	Mst
Mbereri stony and gravelly sandy loam, 3 to 25 per cent slopes, moderately eroded	Mst–2
Mbogo clay loam, 0 to 3 per cent slopes	Mbc–A
Mbogo clay loam, 3 to 8 per cent slopes	Mbc–B
Mbogo clay loam, 8 to 13 per cent slopes	Mbc–C
Muhoroni clay loam, 0 to 3 per cent slopes	Muc–A
Muhoroni clay loam, 3 to 8 per cent slopes	Muc–B
Muhoroni clay loam, 13 to 20 per cent slopes	Muc–D
Nandi loam, 0 to 3 per cent slopes	Nl–A
Nandi loam, 3 to 8 per cent slopes	Nl–B
Ngeron silty clay loam, 3 to 8 per cent slopes	Ngc–B
Ngeron silty clay loam, 8 to 13 per cent slopes	Ngc–C
Nyando clay loam, 0 to 3 per cent slopes	Noc–A
Nyangoro stony sandy loam, 3 to 8 per cent slopes	Nyc–B
Nyangoro stony sandy loam, 8 to 13 per cent slopes	Nyc–C
Nyangoro stony sandy loam, 13 to 20 per cent slopes	Nyc–D
Nyangoro stony sandy loam, 20 to 25 per cent slopes	Nyc–E
Patel clay loam, 0 to 3 per cent slopes	Pcl–A
Patel clay loam, 3 to 8 per cent slopes	Pcl–B
Permanent swamp, 0 to 3 per cent slopes	PS–A
Perry clay loam, 0 to 3 per cent slopes	Pec–A
Perry clay loam, 3 to 8 per cent slopes	Pec–B
Rama clay loam, 0 to 3 per cent slopes	Rac–A
Rama clay loam, 3 to 8 per cent slopes	Rac–B
Raragegwit sandy clay loam, 3 to 8 per cent slopes	Rsc–B
Raragegwit sandy clay loam, 8 to 13 per cent slopes	Rsc–C
Rough broken land, clay materials, 13 to 20 per cent slopes	Rbc–D
Songhor silt loam, 0 to 3 per cent slopes	Ssi–A
Sossok clay loam, 3 to 8 per cent slopes	Soc–B
Sossok clay loam, 8 to 13 per cent slopes	Soc–C
Stony land, Kipsesin soil materials, 6 to 30 per cent slopes	Stk–D
Stony land, Kipsesin soil materials, 30 to 60 per cent slopes	Stk–F
Stony land, Nyangoro soil materials, 6 to 30 per cent slopes	Stn–D
Stony land, Nyangoro soil materials, 30 to 60 per cent slopes	Stn–F
Tennant sandy loam, 0 to 3 per cent slopes	Tsl–A
Tennant sandy loam, 3 to 8 per cent slopes	Tsl–B
Tennant clay loam, 0 to 3 per cent slopes	Tc–A
Tennant clay loam, 3 to 8 per cent slopes	Tc–B
Volo clay loam, 0 to 3 per cent slopes	Vcl–A
Volo clay loam, 3 to 8 per cent slopes	Vcl–B

APPENDIX

In following pages we present detailed technical descriptions and chemical and physical data of most of the important soils of the Songhor Survey Area, designed primarily for the use of the 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 .05 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 .05 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 amorphus 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 soils 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 known 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 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 incohesive 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 agriculturalist. 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 the 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 five feet and then a four-inch 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 a 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 initially the pipette method but later, the hydrometer method. This change became necessary in order to speed up the operation so as to have data available for all the soils collected. The soil pH was determined in a 1:1 soil:H_2O ratio, measured after periodic stirring for one hour and using a glass electrode.

Phosphorus, calcium, magnesium, potassium, sodium and manganese were determined in 1:5 soil : (.1N HCl — .025 N H_2SO_4) extractant.

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 after AEC determination, its value being designated the maximum cation exchange capacity (CEC_m). On a separate sample, pretreated with HCl the quantity of barium absorbed from barium chloride was taken as a measure of permanent charge (CEC_p). This value was expressed as a percentage of CEC, viz. (CEC_p/CEC) . 100 and then rounding out to the nearest unit of 10. This value is recorded in the tables by the first figure under "charge distribution".

The other three sets of figures under "charge distribution" denote the percentages, rounded out to the nearest unit of 10, 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) CEC_m — 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) 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 10 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 the presence of approximately 40 per cent permanent, 70 per cent net negative, 10 per cent combined or countered and 20 per cent net positive charges. The 70 per cent of net negative charges stem from montmorin, hydrous mica, vermiculite, other three-layer minerals and from organic matter. The 10 per cent of countered charges stem from kaolinite, haloysite and amorphous materials of the allophane type. The 20 per cent 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. Nevertheless, the data has proved useful and was used extensively by the field surveyors as an aid to soil characterization.

The analytical data for each type profile is tabulated in the appendix either immediately before or immediately after the description of the series to which it belongs.

Further information on some of the soils described in this appendix can be found in the soil descriptions given in the main body of the report and should be sought there.

AINOMOTUA SERIES

Soils of the Ainomotua series are intermediate in physical and chemical properties between low humic gley. Reddish Chestnut and solodized Solonetz soils. They are developed from mixed sandy and clayey sediments washed from areas of granitoid gneiss near the base of the Nandi Escarpment and in outlying areas. They lie on alluvial fans below Mbereri sandy loam and in close association with the Kapkuong loamy coarse sand, a solodized Solonetz. The sodium content of the subsoil is higher than in Mbereri sandy loam, but lower than in Kapkuong loamy coarse sand.

Soil Profile: ***Ainomotua Sandy Clay Loam***

Lab. No. 3119: Hor. A1: Depth 0 to 8 inches

Very dark grey, moist, to dark-grey, dry (7.5YR 2/1.5, 3/1.5) coarse-granular moderately friable sandy clay loam; hard dry; sticky and and plastic, wet; matted with grass roots; clear boundary with next horizon.

Lab No. 3120: Hor. B21: Depth 8 to 15 inches

Dark-brown, moist, to brown, dry (7.5YR 3/2, 4/2) compound medium and fine-blocky clay with thin clay films on the surfaces of the blocks. Crushes to brown colour; many grass roots.

Lab. No. 3121: Hor. B22: Depth 15 to 28 inches

Dark-brown (7.5YR 4/2, moist) mottled strong-brown (7.5YR 5/6) sticky, fine-prismatic and blocky clay loam, with thin clay films on blocks. Crushes to dark yellowish brown; grass roots fairly abundant.

Lab. No. 3122: Hor. B31: Depth 28 to 39 inches

Same colours as above; moderately friable; fine-blocky loam, with about 10 per cent black manganese oxide concretions, ½ inch in diameter. Fewer grass roots.

Lab. No. 3123: Hor. B32: Depth 39 to 50 inches

Dark-brown, mottled brown (7.5YR 3/2 and 4/4) fine-blocky clay loam with harder lime concretions than above and with some manganese oxide; blocky peds are coated with thin films of clay and organic matter. Scattered grass roots.

Lab. No. 3124: Hor. C1: Depth 50 to 62 inches

Yellowish-brown (10YR 5/8) heavy clay loam which is crumbly when moist and hard when dry; contains some manganese oxide spots; very few fine roots; pH 8.3.

Lab. Nos. 3125 and 3126: Hor. C2: Depth 62 to 92 inches

Mottled brown and dark yellowish-brown (10YR 4/3 and 4/6) massive clay loam; plastic wet; crumbly, moist; hard, dry; a few lime concretions; very few fine roots, only in upper part.

Lab. No. 3127: Hor. C3: Depth 92 to 108 inches

Red (2.5YR 4/6, 5/6), nearly massive but friable clay loam, mottled black and yellowish brown; this is underlain by more or less stratified clayey and sandy sediments and volcanic ash; no visible grass roots, but some tree roots reach to 10 or more feet.

Range in Characteristics.—The chief variations are in thicknesses of the various horizons and in the structure of the B2 horizon which is weakly columnar, as in typical Solonetz soils, in a few places, especially on the lower parts of the slopes.

Relief.—Long gentle slopes ranging from 2 to 8 per cent gradient.

Drainage.—The soil is moderately well drained but is subject to occasional seepage in the rainy season and immediately afterwards. Considerable water moves downslope through the subsoil.

Vegetation.—High rainfall savannah and open forest. *Combretum*, various *Acacias*, other thorn bushes and *Euphorbia* are common trees. The soil has a dense cover of tall coarse grasses where not overgrazed.

Use.—Used best for pasture and cultivation. Some sugar cane has been planted on it and is growing well; subsistence crops are grown on some of the soil in African reserves.

Known Distribution.—Areas a few tens of acres each are scattered over the alluvial fans within 3 or 4 miles of the Nandi Escarpment.

Type Location.—Three miles north-east of Kibigori Station at map co-ordinates HZN 292961.

Ainopsiwa Series

The Ainopsiwa series includes deep permeable Latosols with a moderately high humus content, developed from old alluvium of stream terraces and alluvial fans at the base of the Nandi Escarpment. The soils have more clay than the Mbereri soils and considerably more humus than the Kundos soils which they resemble in other respects. The soil is highly valued because of its desirable physical properties, but reserves of plant nutrients are low.

TABLE 8a

Ainomotua sandy clay loam — *Map. Ref.:* HZN 292961 — *Lab. No.:* 3119 to 3127

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	1·48	0·08	6	7·2	4·2	0·3	0·3	6·8	83	13·0	13·6	5–2:6:2	22	28	50
B_{21} ..	8– 15	0·75	0·06	9	8·8	5·9	0·3	0·6	7·2	81	28·0	11·3	6–7:0:3	44	22	34
B_{22} ..	15– 28	0·30	0·03	17	8·8	6·2	0·3	0·7	7·8	58	28·0	15·9	7–6:0:4	36	34	30
B_{31} ..	28– 39			12	10·0	4·9	0·3	0·8	7·8	100	24·4	25·5	7–1:8:1	26	36	38
B_{32} ..	39– 50			10	5·8	3·7	0·2	0·8	8·1	90	22·8	16·5	3–2:8:0	32	28	40
C_1 ..	50– 62			13	12·0	5·7	0·3	1·4	8·3	100	30·0	16·0	5–5:4:1	40	26	34
C_{21} ..	62– 74			14	17·6	6·4	0·3	1·7	8·6	100	22·0	13·3	10–3:7:0	38	28	34
C_{22} ..	74– 92			11	10·4	5·9	0·4	1·7	8·0	97	30·0	9·4	7–8:0:2	34	30	36
C_3 ..	92–108			9	7·0	5·5	0·3	1·7	7·9	95	26·0	12·5	6–4:6:0	40	28	32

Ainopsiwa clay loam — *Map. Ref.:* HAA 427024 — *Lab. No.:* 2161 to 2168

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_{11} ..	0– 7	3·54	0·21	13	14·4	2·2	0·70	0·27	6·3	51	18·8	20·0	3–1:7:2	40	26	34
A_{12} ..	7– 11	2·70	0·14	6	4·2	2·1	0·60	0·21	6·2	51	17·4	25·2	3–2:4:4	50	20	30
B_{21} ..	11– 23	1·35	0·05	6	3·0	1·9	0·68	0·19	6·1	48	21·0	27·5	2–2:5:3	58	20	22
B_{22} ..	23– 32			4	2·6	2·0	0·74	0·17	6·2	47	20·6	30·2	2–1:7:3	56	20	24
B_{23} ..	32– 62			4	4·0	1·8	0·69	0·22	5·9	37	17·2	29·1	3–0:7:3	52	20	28
B_3 ..	62– 92			3	4·1	2·8	0·58	0·32	5·6	51	21·6	30·0	4–0:8:2	52	18	30
C_1 ..	92–122			9	4·9	3·6	0·62	0·28	5·5	67	26·0	22·4	4–1:9:0	50	22	28
C_2 ..	122–128			6	4·0	2·5	0·54	0·20	5·8	56	14·2	14·5	4–1:8:1	24	12	64

Soil Profile: *Ainopsiwa Clay Loam*

Lab. No. 2161 : Hor. A11 : Depth 0 to 7 inches

Dark reddish-brown (5YR 2/2 moist, 3/2 dry), strongly granular clay loam; friable dry moist; slightly sticky wet; matted with grass roots; freely permeable to water. Rich in humus.

Lab. No. 2162: Hor. A12: Depth 7 to 11 inches

Dark reddish-brown (2.5YR 2/2 moist, 3/2 dry). Similar to above, but with light clay texture and less humus.

Lab. No. 2163: Hor. B21: Depth 11 to 23 inches

Dark-red moist and dry (2.5YR 3/5) fine-blocky clay; firm dry; very friable moist; slightly plastic and sticky wet; many grass roots; very permeable to water and roots.

Lab. No. 2164: Hor. B22: Depth 23 to 32 inches

Dark-red moist and dry (2.5YR 3/6)—otherwise as above.

Lab. No. 2165: Hor. B23: Depth 32 to 62 inches

Similar to above but with slightly less clay.

Lab. No. 2166: Hor. B3: Depth 62 to 92 inches

Dark-red (2.5YR 3/6) clay, with about 5 per cent black spots of manganese oxide and a few mica flakes; firm dry; friable moist; sticky wet. Few roots.

Lab. No. 2167: Hor. C1: Depth 92 to 122 inches

Dark-red, mottled very dusky red, light clay; firm dry; friable moist; slightly plastic and sticky wet; few roots; permeable to water.

Lab. No. 2168: Hor. C2: Depth 122 to 128 inches

Light reddish-brown decayed sediments washed from granitoid gneiss. Material is friable sandy clay loam.

Range in Characteristics.—About 10 to 20 per cent of the area is in termite mounds, 3 to 8 feet high and 30 to 120 feet in diameter. Crops grow more luxuriantly on the mounds.

Relief.—River terraces with smooth downstream gradients up to 3 per cent, broken by termite mounds. Surface textures range from sandy clay loam, through clay loam, to clay.

Drainage.—Slow externally; free internally; the soil holds a good supply of moisture against gravity.

Vegetation.—High rainfall savannah with about 50 per cent open canopy; a dense growth of coarse grasses covers the ground.

Use.—Used for maize, tree fruits, coffee and pasture.

Known Distribution.—Known only along the base of the Nandi Escarpment.

Type Location.—East of Ainopsiwa River, 1/50,000 map co-ordinates HAA 427024.

ARISTOS SERIES

Soils of the Aristos series are poorly drained, heavy, black, shrinking-swelling clayey soils associated closely with Kibigori and, to a limited extent, with Ngeron and Muhoroni soils. They occur chiefly in low flat areas on the lake plain, surrounded by Kibigori and Rama soils. Subsoils have a higher percentage of clay than Kibigori soils. In colour, organic matter content and drainage condition they resemble the Humic-Gley soils of the United States. In their structure and shrinking and swelling with moisture changes, they resemble Grumusols. Local farmers group them with Black Cotton soils.

Soil Profile: Aristos Clay Loam

Lab. No. 3128: Hor. A1: Depth 0 to 5 inches

Black, moist to very dark grey, dry (10YR 2/1, 3/1) weakly granular to nearly massive clay loam; hard, dry; plastic, moist; very sticky when wet; matted with roots; shrinks and swells with moisture changes; abrupt boundary with next horizon.

Lab. No. 3129: Hor. B2g1: Depth 5 to 20 inches

Very dark grey, moist, to dark-grey, dry, coarse-blocky, heavy clay; very sticky and plastic wet and moist; very hard, dry; lentil structure evident when wet; many roots; shrinks strongly with drying; clear, wavy boundary.

Lab. No. 3130: Hor. B2g2: Depth 20 to 37 inches

Same colour as above but medium and fine-blocky structure; lentil structure evidence in the wet soil; shrinks strongly with drying; many fine roots; clear boundary.

Lab. No. 3131: Hor. B2g3: Depth 37 to 44 inches

Dark-grey, moist, to grey, dry (10YR 4/1, 5/1) medium to fine-blocky, heavy, shrinking clay; fine roots fairly abundant; graduated boundary.

Lab. No. 3132: Hor. B2g4: Depth 44 to 54 inches

Dark-grey, moist, to grey, dry (10YR 4/5, 5/5) very strongly medium to fine-blocky, shrinking clay; few fine roots; clear boundary.

Lab. No. 3133: Hor. B2g5: Depth 54 to 72 inches

Grey, moist to light-grey, dry (10YR 5/1, 5/1) medium blocky, shrinking clay with many hard lime-carbonate concretions up to 2 inches in diameter. A few very small lumps of volcanic ash; few roots.

Lab. Nos. 3134 and 3135: Hor. B2g6: Depth 72 to 120 inches

Dark-grey, moist to grey, dry (10YR 4/1, 5/1) blocky clay with streaks of weathered volcanic ash and some lime-carbonate concretions. A few scattered fine roots in upper part; none below 7 feet; this material grades downward into intercallated lake clay and volcanic ash.

Range in Characteristics.—Some Aristos clay loam has little or no lime-carbonate concretions, and some has brown and yellow mottles on a grey background, below 2 feet.

Relief.—Flat and slightly depressed areas of lake plains in association with Kibigori clay and Ngeron clay loam.

Drainage.—Very slow surface and internal drainage. Soils are waterlogged in and for a time after the rainy season. Soils dry out during the dry season.

Vegetation.—Nearly all in pasture; stunted *Acacias* and *Balanites* in a few places. Sedges, rushes and grasses are common.

Use.—Largely for pasture. Some subsistence crops are grown with poor success. Experimental rice plantings grew reasonably well but were abandoned by African farmers.

Known Distribution.—Low flats on Kano lake plain. Scattered small areas occur in association with Muhoroni and Ngeron soils on sediments near the foothills.

Type Location.—1½ miles southwest of Chemelil Station, Nyanza. Map co-ordinates: HZN 354865.

AWASI SERIES

The Awasi series includes strongly developed solodic (degraded Solonetz) soils developed from alluvium washed from a large area of Bhanji stony loam, the parent rock of which is phonolite. Volcanic ash may be a component of the parent material. The Awasi soil merges downslope with Aristos clay, a poorly drained Grumusol of the lake plains.

Soil Profile: *Awasi Loam*

Lab. No. 3141: Hor. A1: Depth 0 to 4 inches

Very dark grey moist, to grey dry (10YR 3/1, 5/1), mottled dark greyish-brown, nearly massive loam. Hard, dry; friable moist; sticky wet; many fine roots; slowly permeable when wet.

TABLE 8b

Aristos clay loam — *Map Ref.:* HZN 354865 — *Lab. No.:* 3128 to 3135

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	4·95	0·22	10	12·6	3·6	0·3	0·6	5·6	74	48·0	44·2	4–3:5:2	36	36	28
B_{2g1} ..	5– 20	1·40	0·10	11	13·0	6·4	0·4	1·1	5·8	76	52·0	20·9	6–6:3:1	66	10	24
B_{2g2} ..	20– 37	1·44	0·09	17	15·6	6·2	0·6	1·4	6·4	90	58·0	23·4	5–5:4:1	70	10	20
B_{2g3} ..	37– 44			37	18·4	6·9	0·9	1·4	7·0	95	38·0	17·2	8–6:2:2	66	12	22
B_{2g4}	44– 54			65	16·0	6·1	1·0	1·5	7·2	95	56·0	18·0	6–7:1:2	66	12	22
B_{2g5} ..	54– 72			82	18·4	7·1	0·9	1·6	7·4	94	58·0	24·0	6–5:4:1	60	14	26
B_{2g6} ..	72– 84			182	20·0	8·0	0·8	1·5	7·3	98	78·0	1·8	5–10:0:0	62	12	26
B_{2g6} ..	84–120			160	19·6	9·2	0·7	1·7	7·3	100	68·0	1·6	6–10:0:0	68	10	23

Awasi loam — *Map Ref.:* HZN 313842 — *Lab. No.:* 3141 to 3146

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	1·84	0·11	8	5·6	1·8	0·8	0·5	5·9	68	19·6	8·0	4–4:6:0	18	44	38
A_2 ..	4– 7	0·95	0·07	6	5·6	1·9	0·4	0·6	6·0	80	21·6	9·6	4–4:6:0	18	44	38
B_1 ..	7– 14	0·90	0·08	7	9·6	3·1	0·4	0·9	7·6	68	24·4	17·6	4–3:7:0	40	26	34
B_2 ..	14– 30			12	13·6	2·6	1·0	1·4	6·0	89	58·0	18·1	4–6:4:0	60	18	22
B_3ca ..	30– 46			17	39·2	3·7	0·8	1·7	7·7	97	51·2	15·4	4–6:4:0	32	24	44
C_1 ..	46–100			16	16·0	2·2	0·9	1·5	7·1	95	39·4	8·0	5–7:3:0	38	24	38

Lab. No. 3142: Hor. A2: Depth 4 to 7 inches

Grey moist, to light-grey dry (10YR 5/1, 7/1), mottled dark grey, weakly medium-blocky loam; firm dry; friable moist; slightly sticky wet; many roots; moderately permeable.

Lab. No. 3143: Hor. B1: Depth 7 to 14 inches

Very dark grey moist, to dark-grey dry (10YR 3/1, 4/1), strongly columnar heavy clay loam, with light grey silt coatings. Hard dry; stiff moist; very plastic and sticky wet; many roots; slowly permeable.

Lab. No. 3144: Hor B2: Depth 14 to 30 inches

Same colour as above; compound medium and fine strongly blocky heavy clay; hard dry; very plastic and sticky, wet; shrinks with drying; many roots; very slowly permeable.

Lab. No. 3145: Hor. B3ca: Depth 30 to 46 inches

Dark greyish-brown moist to greyish-brown dry (10YR 4/2, 5/2), granular clay loam with lime concretions and small termite "fungous gardens"; friable moist; plastic wet; black clay fills termite burrows.

Lab. No. 3146: Hor. C1: Depth 46 to 100 inches

Similar to above with less lime and with about 20 per cent black manganese oxide concretions.

Range in Characteristics.—The A_1 plus A_2 horizons vary in thickness every few feet from about 4 to about 18 inches. A-horizon textures range from silt loam to loam and fine sandy loam.

Relief.—Smooth alluvial fans of up to 3 or 4 per cent slope gradient. Many shallow gullies.

Drainage.—External drainage medium to fairly rapid; internal drainage slow.

Vegetation.—Scattered scrubby *Acacias* and other trees and coarse grasses. Many bare "slick spots" appear in overgrazed areas.

Use.—Pasture, sorghum, finger millet, maize and vegetables. Yields are low.

Known Distribution.—Confined to alluvial fans at base of tableland in Luo reserve, west of Muhoroni.

Type Location.—HZN 313842, about 8 miles west of Muhoroni, Nyanza.

BABU SERIES

Babu series includes dark-coloured, moderately well-drained acid soils developed from thin deposits of lacustrine clay and volcanic ash over beds of basaltic gravel and cobblestones. The soil is associated with the deeper well-drained Perry soils and with the Chemelil, Volo and Patel soils of the lake-clay deposits, with their different degrees of impeded drainage. Available phosphorus is somewhat low. The soil resembles some of the Reddish Prairie soils of eastern Texas, Oklahoma and Kansas, U.S.A.

Soil Profile: Babu Clay Loam

Lab. No. 3719: Hor. A1: Depth 0 to 7 inches

Very dark grey moist, to dark-grey dry (7.5YR 3/1, 4/1), fine-granular clay loam; firm dry; friable moist; plastic and sticky wet; matted with roots; moderately permeable.

Lab. No. 3720: Hor. A3: Depth 7 to 17 inches

Very dark brown moist, to dark-brown dry (7.5YR 2/2, 3/2), mottled yellowish red, compound medium and fine-blocky clay loam; firm dry; friable moist; sticky and plastic wet; abundant roots; permeable.

Lab. No. 3721: Hor. B2: Depth 17 to 25 inches

Dark brown (7.5YR 3.5/2, 4/2), mottled as above, medium-blocky clay; consistence as above; peds coated with clay; many roots; moderately permeable.

Lab. No. 3722: Hor. B3: Depth 25 to 34 inches

Brown (7.5YR 4/2, 5/2), mottled yellowish red and black, fine-blocky clay loam; consistence as above; few fine roots; moderately permeable.

Lab. No. 3723: Hor. C1: Depth 34+ inches

Mass of basaltic gravel and cobblestones, with reddish-brown clay loam between and with iron oxide crust on surfaces of individual stones. Few roots; permeable.

Range in Characteristics.—Some of the Babu soils are gravelly at the surface. Depth to the gravel-cobble layer ranges up to 40 inches but averages about 30 inches. Volcanic ash commonly underlies the gravel.

Relief.—Slopes range from 2 to 11 per cent gradient.

Drainage.—Surface drainage moderate to rapid; internal drainage moderate.

Vegetation.—High-rainfall savannah.

Use.—Used for pasture, subsistence crops and sugar cane. Yields are moderate.

TABLE 8c

Babu clay loam *Map Ref.:* HZN 321895 *Lab. No.:* 3719 to 3722

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	2·13	0·12	10	12·4	5·1	1·0	0·6	5·3	57	34·4	28·6	4–2:6:2	30	26	44
A_3 ..	7– 17	1·96	0·11	8	12·8	4·4	1·0	0·4	5·1	58	35·2	30·0	5–3:5:2	36	26	38
B_2 ..	17– 25	0·90	0·07	6	23·2	4·6	0·6	0·6	5·0	56	31·2	36·2	6–1:7:2	62	14	24
B_3 ..	25– 34	0·30	0·05	9	8·2	4·1	0·8	0·4	5·3	79	27·2	33·8	6–2:6:3	38	18	44

Bhanji loam *Map Ref.:* HZN 365914 *Lab. No.:* 1748 to 1751

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– 10	1·90	0·15	242	19·6	7·0	1·30	0·44	6·2	69	28·4	19·8	4–7:0:3	24	36	36
B_{21} ..	10– 20	0·90	0·09	50	16·0	7·8	1·78	0·48	6·7	86	42·4	22·9	6–5:3:2	51	25	10
B_{22} ..	20– 28	0·80	0·08	38	16·0	7·8	1·96	0·52	7·0	88	44·4	20·9	6–5:4:1	58	23	13
$B_{2}ir$ ..	28– 36	0·40	0·04	258	21·6	7·0	1·92	0·70	7·6	87	29·0	24·4	4–3:5:2	32	24	36

Known Distribution.—Scattered areas around the eastern edges of the Kano Plain.

Type Location.—HZN 321895, about 1¼ miles northwest of Chemelil Station.

BHANJI SERIES

The Bhanji series included shallow soils with laterite horizons developed from dark, fine-grained (basaltic) igneous rocks. They occur on broad, smooth plains which lie a little higher than the old lake plains of the Songhor area. They are characterized by having a black (5YR 2/1) loam surface horizon underlain by a black, plastic, clay "B" horizon which grades into a concretionary layer (laterite-like) and then passes abruptly to hard, dark-coloured igneous rock. They are associated with the Kibubu and Muhoroni soils. The Kibubu soils are somewhat lighter textured and lack the heavy "B" horizon. They grade almost imperceptibly into the Kibubu soils on the one hand and with the Muhoroni soils on the other. The latter are developed from volcanic tuff that is closely associated with the basaltic rocks.

Soil Profile: *Bhanji Loam*

Lab. No. 1748: Hor. A1: Depth 0 to 10 inches

Very dark grey (5YR 3/1, dry) to black (5YR 2/1, moist) loam; moderate, coarse and granular structure; 10 per cent very hard red haematite concretions.

Lab No. 1749: Hor. B21: Depth 10 to 20 inches

Very dark grey (5YR 3/1, dry) to black (5YR 2/1, moist) clay; moderate, medium and fine-blocky structure; haemetite concretions as above; hard, dry; firm, moist; sticky and plastic, wet.

Lab. No. 1750: Hor. B22: Depth 20 to 28 inches

Similar to above with weakly developed shiny "slikenside" faces on clay aggregates. Concretions not so hard as above.

Lab. No. 1751: Hor. B2ir: Depth 28 to 36 inches

Dark-grey (10YR 4/1, dry) to very dark grey (10YR 3/1, moist) clay loam with many yellow, brown and black "murram" concretions (laterite-like) passing abruptly to hard dark-coloured fine-grained igneous rock, the surface of which appears to have been leached unevenly much as one sees on the surface of crystalline hard limestone and marble.

Range in Characteristics.—The total soil depth varies from 1 to 3 feet and the proportion of concretions changes from place to place. A few loose basaltic rocks are scattered over the surface.

Relief.—Occurs on smooth, gently sloping plains of dark igneous rocks.

Drainage.—The soils are imperfectly drained. Runoff is slow on the milder slopes and medium on the steeper ones. The soils are waterlooged for short periods each year.

Vegetation.—High rainfall savannah. Scattered shrubby trees and tall grasses.

Use.—Most of the Bhanji soils are used for pasture but small patches are used by African farmers for maize, sorghum and other subsistence crops.

Generally these soils are too stony and too shallow for extensive cultivation.

Known Distribution.—On smooth plains of dark igneous rocks in the Songhor area.

Type Location.—Approximately 250 feet south of the Bhanji Store.

CHEMELIL SERIES

Soils of the Chemelil series are developed from moderately clayey sediments with intermingled volcanic ash on the smooth lake plains of the East Kano plain, near Chemelil railway station, under moderately good drainage conditions. Chemelil soils are not so thoroughly drained as the Perry and Babu soils, but are better drained than the Volo and Patel soils, all of which are associated types. The climate is warm and subhumid with a rainfall of 45 to 50 inches, and a marked dry season in December to March.

Soil Profile: *Chemelil Clay Loam*

Lab. No. 2501: Hor. A1p: Depth 0 to 11 inches

Very dark brown, moist, to dark-brown dry (7.5YR 2/2, 3/2) strongly fine-granular friable clay loam; sticky when wet. This contains from 10 to 20 per cent of brown hard iron oxide concretions of buckshot size, and an abundance of plant roots. Abrupt boundary with next horizon.

Lab. No. 2502: Hor. A12: Depth 11 to 15 inches

Dark-brown (7.5YR 3/2 moist, 4/2 dry) friable gravelly clay loam (30 per cent red iron oxide "buckshot") of strong medium granular structure. Abundant roots; abrupt smooth boundary.

Lab. No. 2503: Hor. B1: Depth 15 to 26 inches

Brown (7.5YR 4/3 moist, 5/3 dry) clay with 10 per cent of dark-red (2.5YR 3/5) soft concretions. Friable, moist; slightly sticky and plastic, wet; abundant roots; clear, smooth boundary.

Lab. No. 2504: Hor. B21: Depth 26 to 32 inches

Brown (7.5YR 4/3, moist; 5/3 dry) with 20 per cent dark red (2.5YR 3/5) mottles, heavy clay, medium lentil structure; clay skins on peds; stiff, moist; sticky and plastic, wet; firm, dry; many roots; clear wavy boundary.

Lab. No. 2505: Hor. B22: Depth 32 to 56 inches

Dark greyish-brown, moist, to greyish-brown, dry (10YR 4/2, 5/2), with coarse lentil structure, breaking down to fine blocky; clay skins on ped surfaces; very firm, dry; sticky and plastic, wet; many roots; clear wavy boundary.

Lab. No. 2506: Hor. B31: Depth 56 to 84 inches

Brown (10YR 4/3, moist) with 30 per cent of brown (7.5YR 4/4, moist) mottles, and 10 per cent of black concretions; clay of compound lentil and fine-blocky structure; very firm, dry; sticky and plastic, wet; few roots; gradual boundary.

Lab. No. 2507: Hor. B32: Depth 84 to 102 inches

Differs from above only in having about 20 per cent black manganese oxide concretions; no roots; thin clay skins on peds.

Lab. No. 2508: Hor. B3g: Depth 102 to 112 inches

Brown (10YR 4/3, mottled 7.5YR 4/4), with 10 per cent of greyish-brown (2.5Y 5/2) mottles; clay texture; fine-blocky structure; firm, dry; sticky and plastic, wet; 10 per cent black concretions; no roots; thin clay skins on some peds.

Lab. No. 2509: Hor. C1g: Depth 112 to 120 inches

Dark-brown (7.5 YR 3/3, moist) heavy, fine-blocky, sticky and plastic clay loam with 20 per cent of soft black concretions and a few red and grey mottles.

Range in Characteristics.—The depth to a sharp change in consistence of the clay subsoil varies from an average of about 26 inches as in the above-described sample, to as little as 18 inches and as much as 3 feet.

Relief.—Gently undulating to nearly level lake plain. Slope gradients range from 1 to 3 per cent.

Drainage.—Surface drainage is moderate to slow; internal drainage is moderate. Deep horizons are always moist. Artificial surface drainage beneficial to crops.

Vegetation.—High-rainfall savannah. Various *Acacias, Kigelia,* figs and *Bauhinia* are common. The surface is covered with densely growing tall grasses.

TABLE 8d

Chemelil clay loam *Map Ref.:* HZN 346896 *Lab. No.:* 2501 to 2509

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– 11	1·79	0·12	7	6·6	3·5	0·78	0·32	6·4	46	20·0	21·0	3–1:8:1	24	20	56
A_{12} ..	11– 15	1·28	0·07	5	3·3	3·2	0·63	0·36	6·1	36	14·6	20·4	5–2:5:3	16	18	66
B_1 ..	15– 26	0·71	0·08	5	4·6	3·4	0·36	0·62	6·0	40	26·0	39·0	6–0:7:3	50	20	30
$B_{21}g$ ..	26– 32	0·71	0·07	3	6·2	3·4	0·54	1·28	6·0	53	27·0	32·4	5–1:7:2	56	18	26
$B_{22}g$ ..	32– 56	0·75	0·06	7	8·0	3·9	0·58	1·80	7·6	83	30·0	28·8	7–2:6:2	58	18	24
$B_{31}g$ ..	56– 84	nil	0·02	27	9·2	4·1	0·74	1·92	7·9	88	28·9	17·6	9–5:3:2	50	20	30
$B_{32}g$ ..	84–102	0·52	0·02	65	10·0	4·2	0·56	2·08	7·2	87	41·6	22·8	7–3:7:0	50	20	30
B_3g ..	102–112	0·38	0·03	85	9·2	4·2	0·54	1·68	7·0	88	43·2	25·1	6–3:7:0	50	26	24
C_1g ..	112–120	0·24	0·02	195	10·4	4·2	0·50	1·68	6·9	85	36·0	35·4	9–1:8:1	40	24	36

Farndell clay loam *Map Ref.:* HAA 433027 *Lab. No.:* 1769 to 1777

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– 10	3·4	0·26	18	20·8	3·9	0·84	0·46	5·6	62	35·1	19·6	4–5:3:2	31	44	23
Bg_{21} ..	10– 14	0·9	0·08	4	9·6	3·9	0·72	0·58	5·7	66	30·6	22·0	6–4:3:3	57	26	12
Bg_{22} ..	14– 26	0·8	0·06	7	20·8	4·2	0·76	0·64	6·0	73	30·6	27·8	7–3:5:2	60	26	13
Bg_{23} ..	26– 50	0·6	0·06	10	21·2	4·0	0·68	0·92	6·4	80	32·1	36·5	6–2:6:2	52	20	18
Bg_{24} ..	50– 60	0·5	0·05	17	20·8	2·7	0·72	1·04	7·0	83	24·6	21·4	10–3:4:3	57	20	15
Bg_{31} ..	60– 96	0	0·02	28	20·4	2·5	0·72	1·32	7·6	96	37·0	8·2	8–8:0:2	54	20	14
Bg_{32} ..	96–120	0	0·02	88	20·8	2·5	0·72	1·32	7·6	93	30·5	7·7	10–8:0:2	56	27	16
C_1 ..	120–126	0	0·01	326	24·4	2·0	0·66	1·20	7·3	93	34·3	10·6	10–7:2:1	36	31	31
C_2 ..	126–136	0	0·02	310	23·2	1·8	0·64	1·08	7·2	91	31·2	8·1	9–6:4:0	29	24	44

Use.—Nearly all the land is cultivated. Much is used for sugar cane; land in the African reserves is used for subsistence crops and pasture. Yields are moderately good.

Known Distribution.—East Kano Plain from near Kibigori to Chemelil railway station.

Type Location.—Three-quarter mile north-northwest of Chemelil station; map co-ordinates HZN 347897.

FARNDELL SERIES

The Farndell series includes slowly drained Grumusols developed in colluvial-alluvial deposits on gentle slopes below outcrops of granitoid gneiss and dark igneous rocks. The parent material is fine-textured alluvium derived from phonolite mixed with granitic wash. They are characterized by their black (10YR 2/1, moist) surface horizons and their very dark grey (2.5Y 3/.5, moist) heavy, sticky, plastic clay subsoil horizons. The surface horizons are densely permeated with roots, some of which persist to the bottom of the profile. The Farndell soils lie downslope from the Hermann soils developed from the same parent material, and in close association with the well-drained red Ainopsiwa soils.

Soil Profile: *Farndell Clay Loam*

Lab. No. 1769: Hor. A(p): Depth 0 to 10 inches

Very dark grey (10YR 3.5/1, dry) to black (10YR 2.5/1, moist) clay loam; strong fine granular structure; hard, dry, friable, moist; very sticky and plastic, wet; contains 15 per cent fine (1/16 to 1/4 inch) brown "buckshot" concretions.

Lab. No. 1770: Hor. Bg21: Depth 10 to 14 inches

Grey (2.5Y 5/1, dry) to dark-grey (2.5Y 4/1, moist) clay; strong fine lentil structure; very firm, moist; sticky and plastic, wet; contains about 15 per cent of "buckshot".

Lab. No. 1771: Hor. Bg22: Depth 14 to 26 inches

Dark-grey (2.5Y 4.5/1, dry) to very dark grey (2.5Y 3.5/1, moist) heavy clay; compound lentil structure with 2 inch to $\frac{1}{4}$ inch peds; thin continuous clay skins; very sticky and plastic; 15 per cent "buckshot".

Lab. No. 1772: Hor. Bg23: Depth 26 to 50 inches

Dark-grey (2.5Y 4/.5, dry) to very dark grey (2.5Y 3/.5, moist) heavy clay; 2 to 3 inch lentils that subdivide into strong medium blocky structure; sticky and plastic, wet; 20 per cent brown "buckshot".

Lab. No. 1773: Hor. Bg24: Depth 50 to 60 inches

Colour as above; clay having coarser lentils and blocks. Lentils are 4 to 6 inches in largest dimension and come apart to form coarse blocks; very hard, dry; very firm, moist; very sticky and very plastic, wet; about 15 per cent brown "buckshot".

Lab. No. 1774: Hor. Bg31: Depth 60 to 96 inches

Dominantly greyish brown (2.5Y 5/1.5, dry) to dark greyish brown (2.5Y 4/1.5, moist) clay; mottled 20 per cent brown and black; medium coarse subangular blocky structure; consistence as above.

Lab. No. 1775: Hor. Bg32: Depth 96 to 120 inches

Colour as above, mottled brown; clay; 20 per cent "buckshot" concretions; hard, dry; firm, moist; sticky and plastic, wet.

Lab. No. 1776: Hor. C1: Depth 120 to 126 inches

Mottled olive-brown (2.5Y 4/3, moist) and greyish-brown (2.5Y 5/2, moist) and dark-brown (7.5YR 4/3, moist) with whitish specks of decayed feldspar, and a few black concretions; clay loam; slightly hard, dry; friable, moist; non-sticky and plastic, wet.

Lab. No. 1777: Hor. C2: Depth 126 to 136 inches

Dominantly greyish-brown (10YR 5/2, dry) to dark greyish brown (10YR 4/2, moist) sandy clay loam; about 30 per cent decayed feldspar, some quartz and mica, and about 30 per cent black manganese concretions.

Range in Characteristics.—The amount of "buckshot" concretions occurring throughout the profile varies considerable from place to place.

Relief.—Gently sloping alluvial fans.

Drainage.—These soils are imperfectly or somewhat poorly drained, surface runoff is moderate.

Vegetation.—High rainfall savannah and open forest. Now mostly cultivated.

Use.—Most of the Farndell soils were being used in 1958 for pasture and maize production. Crops may suffer from waterlogging for short periods unless drainage is provided. When adequately drained and fertilized, good yields of maize and sugar can be expected.

Known Distribution.—On alluvial fans in the Songhor Soil Survey area.

Type Location.—Approximately half mile southwest of the Farndell Headquarters.

GEORGE SERIES

The George series includes intergrades between Low Humic Gley and Planosol soils developed on a nearly level surface about 30 to 50 feet above low water in the Ainomotua river valley. The parent material is clayey deposits, grading downward to gravelly and sandy deposits. The clayey materials are much like those of the "lake beds" further west and south. The George soils are characterized by their very dark grey clay loam surface horizons which are underlain by strongly mottled, sticky, plastic clay. They resemble the Volo soils which have much the same morphology but are developed from lake-clay deposits.

Soil Profile: George Clay Loam

Lab. No. 1785: Hor. Al(p): Depth 0 to 11 inches

Very dark grey (5YR 3/1), moist clay loam; compound blocky and coarse granular structure.

Lab. No. 1786: Hor. B1: Depth 11 to 22 inches

Dark grey (5YR 4/1.5, dry) to very dark grey (5YR 3/1.5, moist) clay; strong fine blocky structure; 20 per cent dark brown, black and red concretions up to ¼ inch diameter; firm, moist; sticky and plastic, wet.

Lab. No. 1787: Hor. B21g : Depth 22 to 44 inches

Similar base colour with 20 per cent soft red (2.5YR 4/4) concretions up to ¼ inch diameter, and a few black concretions; clay; strong coarse prismatic structure, breaking to strong fine blocky; slickensides; firm, moist; sticky and plastic, wet.

Lab. No. 1788: Hor. B22g: Depth 44 to 56 inches

Dark grey (2.5Y 4/1) mottled 50 per cent red (2.5YR 4/6) clay; compound coarse and fine lentil structure; firm, moist; sticky and plastic, wet.

Lab. No. 1789: Hor. B23g: Depth 56 to 70 inches

Dark grey (10YR 4/.5) mottled dark brown (7.5YR 4/4) clay; strong coarse lentil structure; black clay skins on peds, about 1 mm. thick; sticky and plastic, wet.

Lab. No. 1790: Hor. B24g: Depth 70 to 79 inches

Dark brown (10YR 4/4) about 60 per cent, and 15 per cent of black manganese concretions, and some light grey mottles. Medium-blocky, clay.

Lab. No. 1791: Hor. C1g: Depth 79 to 108 inches

Colour as above, but with more manganese concretions up to ¾ inch diameter. Clay loam with medium blocky structure; a few cracks are lined with skins of dark grey clay. Stony and gravelly alluvium of mixed acidic and basic rocks, lies below.

Range in Characteristics.—Surface textures range from clay loam to light clay. Degree of mottling varies considerably as does the amount and size of concretions in the profiles. In many places a few lime-carbonate concretions occur at depths of 4 to 6 feet.

Relief.—Nearly level to gently sloping stream terraces, several feet above flood level.

Drainage.—Natural drainage is imperfect; internal drainage is slow, and the soil may be waterlogged during short periods in the rainy season.

Use.—In 1958 the soil was used largely for sisal and part of it for pasture. Fair yields of sugar cane may be expected, providing adequate surface drainage is provided. Yields could be increased by irrigation during the dry season.

Known Distribution.—On rather smooth gently sloping stream terraces in the Songhor Soil Survey area.

Type Location.—Approximately ⅔ mile north-west of the George Estate office.

HERMANN SERIES

The Hermann soils includes soils much like "Brown Forest" soils developed on colluvial-alluvial slopes below dark coloured igneous rocks, but in close association with granitic gneiss bed rock which has contributed some of the material. The related Martin and Kundos soils are more strongly leached and weathered and have redder profiles. The Hermann soils occur in close association with the Farndell (poorly drained Grumusols) soils and generally lie just above them on the better drained parts of the alluvial fans.

Soil Profile: *Hermann Silty Clay Loam*

Lab. No. 2095: Hor. A1: Depth 0 to 7 inches

Very dark grey (10YR 3/1, dry) to black (10YR 2/1, moist) clay loam; strong fine granular structure; friable, moist; abundant roots; clear-smooth boundary. This varies locally to silt loam and clay loam texture.

Lab. No. 2096: Hor. A12: Depth 7 to 12 inches

Dark brown (7.5YR 3/2, dry) to very dark brown (7.5YR 2/2, moist) clay loam; strong fine subangular blocky structure; friable, moist; abundant roots; clear-smooth boundary.

Lab. No. 2097: Hor. A13: Depth 12 to 25 inches

Colour as above; silty clay loam; strong fine subangular blocky structure; friable, moist; clear-wavy boundary.

TABLE 8e

George clay loam *Map Ref.:* HZN 444980 *Lab. No.:* 1785 to 1791

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– 11	2·5	0·20	27	16·0	2·8	0·84	0·32	6·2	70	34·3	14·7	4–7:1:2	30	35	32
B_1 ..	11– 22	1·6	0·12	0	11·0	3·1	0·44	0·32	5·8	57	23·7	21·8	6–2:6:2	41	31	28
$B_{21}g$ ..	22– 44	0·7	0·08	0	9·0	3·0	0·50	0·44	6·2	69	26·5	23·3	6–4:2:4	54	24	16
$B_{22}g$ ..	44– 56	0·5	0·04	5	11·6	2·8	0·96	0·58	6·6	71	27·4	28·8	5–1:7:2	54	26	16
$B_{23}g$ ..	56– 70	0·3	0·03	48	15·6	3·5	0·96	0·65	6·8	86	32·4	22·5	7–3:5:2	55	27	14
$B_{24}g$ ..	70– 79	0·2	0·04	150	16·4	3·6	0·80	0·62	6·6	86	33·9	16·8	7–4:5:1	45	31	22
C_1g ..	79–108	0·0	0·03	280	16·8	3·2	0·76	0·68	6·0	88	39·9	11·8	6–5:5:0	39	28	26

Hermann silty clay loam *Map Ref.:* HAA 430031 *Lab. No.:* 1778 to 1784

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_{11} ..	0– 12	2·4	0·24	47	19·2	3·1	1·62	0·40	6·0	61	32·6	16·8	6–7:0:3	43	38	11
A_{12} ..	12– 24	1·7	0·15	10	19·6	2·8	0·76	0·44	5·8	62	36·2	11·7	5–8:0:2	54	33	8
B_1 ..	24– 48	1·4	0·06	3	19·2	2·6	0·76	0·60	6·1	75	35·2	18·3	6–7:0:3	58	31	8
B_{21} ..	48– 60	0·5	0·07	3	14·0	2·7	0·88	0·34	6·4	73	26·0	26·5	4–4:2:4	57	28	7
B_{22} ..	60– 85	0·3	0·04	8	15·2	3·1	1·16	0·38	6·4	79	30·8	22·2	3–3:5:2	59	27	6
B_3 ..	85– 96	0·1	0·02	283	20·8	3·2	1·08	0·58	6·2	85	31·5	16·0	6–6:2:2	40	24	33
C_1 ..	96–106	0·1	0·02	326	22·0	3·0	1·20	0·64	6·4	86	38·0	19·3	7–5:4:1	25	25	42

Lab. No. 2098: Hor. B21: Depth 25 to 40 inches

Colour as above; clay; compound prismatic to strong fine subangular blocky structure; firm, moist; clear-wavy boundary.

Lab. No. 2099: Hor. B22: Depth 40 to 60 inches

Dark brown (7.5YR 4/2 dry, 3/2 moist) clay; prismatic breaking to medium blocky structure; black manganese streaks; clay skins on all ped faces; diffuse boundary.

Lab. No. 2100: Hor. B31: Depth 60 to 70 inches

Dark greyish-brown (10YR 4/2, dry) to very dark greyish brown (10YR 3/2, moist) clay; medium blocky structure; firm, moist; clay skins on all ped faces; a few streaks of black manganese oxide; a few rotten tuff fragments.

Lab. No. 2101: Hor. B32: Depth 70 to 80 inches

Colour as above with common fine mottles of dark grey (10YR 4/1, moist) to grey (10YR 5/1, dry) clay; structure as above with clay skins on ped faces; many black manganese concretions. Stopped by rock at this depth.

Soil Profile: *Hermann Clay Loam* (*Alternate Site*)

Lab. No. 1778: Hor. A11: Depth 0 to 12 inches

Dark reddish-brown (5YR 3/2, dry, 2/2, moist) light clay to clay loam; strong fine granular structure; friable, moist; sticky and plastic wet; clear boundary.

Lab. No. 1779: Hor. A12: Depth 12 to 24 inches

Very dark grey (5YR 3/1, dry) to black (5YR 2/1, moist) clay; strong coarse nuciform breaking to strong fine-blocky structure; thin clay skins; very sticky and plastic, wet.

Lab. No. 1780: Hor. B1: Depth 24 to 48 inches.

Colour as above, but with more clay and strong fine-blocky structure, tending to lenticular.

Lab. No. 1781: Hor. B21: Depth 48 to 60 inches

Mottled reddish-grey and reddish-brown (5YR 3/3, 4/3 and 3/2, 4/2) clay; strong fine-blocky structure; a few brown buckshot-sized concretions.

Lab. No. 1782: Hor. B22: Depth 60 to 85 inches

Sixty per cent reddish-yellow (5YR 6/5, dry) to yellowish-red (5YR 5/5, moist) mottled with light-grey, clay; 5 to 10 per cent black buckshot.

Lab. No. 1783: Hor. B3: Depth 85 to 96 inches

Strongly mottled light-yellow medium-grey, nearly white, and with a few black concretions, clay loam with weak blocky to massive structure. Some clay skins line cracks.

TABLE 8f

Hermann silty clay loam (Alternate) *Map Ref.:* HAA 469019 *Lab. No.:* 2095 to 2101

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	2·69	0·22	235	19·2	4·2	0·91	0·47	5·9	54	39·2	26·5	3–3:9:1	22	51	22
A_{12} ..	7– 12	2·59	0·19	220	17·1	3·9	0·75	0·38	5·4	57	44·1	17·1	4–5:4:1	30	44	20
A_{13} ..	12– 25	3·28	0·18	122	18·9	3·7	0·54	0·38	5·4	61	49·6	24·8	3–4:5:1	35	46	16
B_{21} ..	25– 40	1·64	0·12	204	18·9	3·7	0·52	0·42	5·8	69	37·6	21·0	4–4:4:1	42	37	16
B_{22} ..	40– 60	0·82	0·11	62	14·1	3·4	0·60	0·36	6·0	66	32·0	45·0	5–0:8:2	44	29	21
B_{31} ..	60– 70	0·55	0·05	204	18·6	3·3	0·64	0·50	6·4	60	32·0	47·4	6–1:6:3	47	29	17
B_{32} ..	70– 80	0·55	0·07	204	19·5	3·5	0·66	0·57	6·4	60	32·4	44·8	6–1:7:2	41	26	21

Kamaasae sandy clay loam *Map Ref.* HAA 439010 *Lab. No.:* 2155 to 2160

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	3·00	0·21	200	36·0	3·6	0·50	0·51	6·0	63	34·4	22·0	4–6:0:4	28	24	48
B_1 ..	6– 12	2·90	0·18	173	38·4	2·4	0·20	0·50	6·0	68	33·6	23·9	5–6:0:4	32	24	44
B_3 ..	12– 28	2·65	0·10	173	32·8	1·6	0·18	0·54	6·7	87	41·2	38·0	5–3:4:3	26	28	46
C_1ca ..	28– 39			19	18·0	0·9	0·06	0·70	8·3	97	35·2	17·4	7–3:7:0	2	14	82
C_2ca ..	39– 57			15	68·0	0·8	0·06	0·74	8·1	93	28·4	27·8	7–2:6:2	10	22	68
C_3ca ..	57+			15	68·0	1·1	0·04	0·32	8·2	91	43·2	29·4	5–2:8:0	6	16	80

Lab. No. 1784: Hor. C1: Depth 96 to 106 inches

Mottled as above with manganese oxide cement (murram), white weathered feldspar and some quartz grains; sandy clay loam.

Range in Characteristics.—Although these soils are well drained, small local seepage spots may be encountered. The texture of the "A" horizon varies from silt loam to light clay, but averages clay loam in most sites.

Relief.—Gently sloping to sloping alluvial fans with slope gradients from about 5 to 11 per cent.

Drainage.—These soils are well drained. Run-off is medium to rapid.

Vegetation.—High rainfall savannah and open forest with grass understory.

Use.—The Hermann soils are being used for maize, pasture and coffee. Excellent maize growing on it suggests reasonably high native fertility. Except for local seepage spots it should produce fair yields of coffee and good yields of sugar cane.

Known Distribution.—On alluvial fans in the Songhor Soil Survey area, materials are washed largely from basic lavas and tuffs.

Type Location.—Approximately ⅜ mile west of the Farndell house, and about ¼ mile north-east of Iverson's house.

Kamaasae Series

The Kamaasae series includes reddish-brown well-drained friable soils intermediate in character between Brown Forest soils and Rendzina, developed from calcareous tuff. Kamaasae soils occur on footslopes under high-rainfall savannah. They are well supplied with calcium and organic matter, but are low in magnesium. Roots and moisture penetrate easily to the underlying tuff.

The Kamaasae soils are associated mainly with the Ngeron soils which are typical Grumusols (black cotton soils). They occur at elevations of around 5,000 feet where the mean annual precipitation is 55 to 60 inches with marked dry and wet seasons. Kamaasae soils are deeper than the related Kipsesin soils which are developed in part from non-calcareous volcanic tuff.

Soil Profile: Kamaasae Sandy Clay Loam (Cultivated)

Lab. No. 2155: Hor. A1: Depth 0 to 6 inches

Dark reddish-brown (5YR 2/2) sandy clay loam, (5YR 2.5/2) when dry; weak, fine, granular; friable, and soft moist; to slightly hard dry;

slightly sticky, plastic; abundant medium, fine, and a few coarse roots; very few mica flakes; clear smooth boundary; permeable to water.

Lab. No. 2156: Hor. B2: Depth 6 to 12 inches

Dark reddish-brown (5YR 2.5/2) sandy clay loam; strongly fine-blocky; slightly hard to hard, firm, sticky, plastic; abundant fine, medium and few coarse roots; dry; thick clay skins on old root channels and discontinuous on ped surfaces; a few mica flakes; many roots; permeable.

Lab. No. 2157: Hor. B3: Depth 12 to 28 inches

Dark-brown (7.5YR 3/2) sandy clay loam; weak to moderate, fine subangular blocky; slightly hard to hard when dry; friable moist; sticky and plastic wet; few fine, plentiful medium and coarse roots; thin clay skins only along old root channels; permeable; clear, wavy boundary.

Lab. No. 2158: Hor. Clca: Depth 28 to 39 inches

Olive-brown to light olive-brown (2.5Y 4.5/5) sandy clay (2.5Y 5/4) dry; containing few, fine, distinct very dark brown mottles (10YR 2/2) strong, coarse to very coarse platy; very hard, firm, slightly sticky, slightly plastic; few, fine and medium roots; calcareous; abrupt, wavy boundary; slowly permeable.

Lab. No. 2159: Hor. C2ca: Depth 39 to 57 inches

Dark greyish-brown to greyish-brown (10YR 4.5/2) sandy clay loam; moderate, fine to medium platy; slightly hard dry; friable, slightly sticky and slightly plastic wet; few fine and medium roots; few mica flakes; calcareous; diffuse and broken boundary; slowly permeable.

Lab. No. 2160: Hor. C3ca; Depth 57+ inches

Light olive-brown (2.5Y 5/4) sandy clay loam (2.5Y 6/4) dry; with common fine, distinct pale yellow (2.5Y 7/4), mottles; strongly cemented in places breaking to strong coarse plates; very hard; very firm, slightly sticky, slightly plastic; no roots; a few large mica flakes present and many plate-like pieces of slightly weathered "calcareous" tuff.

Range in Characteritics.—Combined thickness of the first three horizons varies from about 18 inches to 4 feet. Surface-soil textures vary from loam, through sandy clay loam to clay loam. Some of the Kamaasae soils are stony.

Relief.—Long footslopes varying in gradient from 3 to 20 per cent.

Drainage.—External drainage is medium to rapid; internal drainage is good; the soil is never waterlogged.

Vegetation.—Formerly broad-leafed open forest; now largely cleared.

Use.—The better areas are used for coffee, bananas, maize and other subsistence crops and pasture. Yields are generally good.

Known Distribution.—A few scattered areas in the north-eastern part of the Songhor survey area.

Type Location.—HAA 439010, about 4½ miles north of Songhor.

KAPCHURE SERIES

The Kapchure series includes groundwater Laterite soils developed from granitic gneiss. It occurs on the flanks of low gneiss hills not far above the level of the higher alluvial fans. It has a strongly developed, but thin, horizon of either pisolitic or cellular laterite 20 to 36 inches below the surface. Kapchure sandy loam differs from the clay loam type not only in texture but also in depth to the pisolitic laterite. The pisolitic laterite horizon is found deeper in Kapchure sandy clay loam, than in Kapchure sandy loam.

Soil Profile: Kapchure Sandy Loam

Lab. No. 2110: Hor. A1: Depth 0 to 6 inches

Dark grey (7.5YR 4/1, moist) to very dark grey (7.5YR 3/1, dry) sandy loam; strong fine granular structure; hard dry; abundant fine roots; clear-wavy boundary.

Lab. No. 2111: Hor. B1: Depth 6 to 12 inches

Dark brown (7.5YR 4/2, 3/2) sandy clay loam; moderate medium to fine blocky structure; hard, dry; plastic wet; roots as above; clear-wavy boundary.

Lab. No. 2112: Hor. B2: Depth 12 to 20 inches

Fifty-fifty mottled (7.5YR 3/2 and 4/2) sandy clay loam; structure as above; hard, dry; firm, moist; slightly sticky and slightly plastic, wet; many roots; abrupt-wavy boundary.

Lab. No. 2113: Hor. B2ir: Depth 20 to 28 inches

Ten per cent soil as above and 90 per cent red and black concretions moderately cemented to form pisolitic, varying to cellular, laterite.

Lab. No. 2114: Hor. B2ir: Depth 28 to 50 inches

As above, but a strongly cemented laterite.

Lab. No. 2115: Hor. C1g: Depth 50 to 60 inches

Mottled 50 per cent each of greyish-brown (10YR 5/2) and yellowish-brown (10YR 5/8) sandy clay loam; very micaceous with many gneiss fragments.

Lab. No. 2116: Hor. C2g: Depth 60 to 72 inches

Loose pale micaceous sandy loam which seasonally carries temporary groundwater.

TABLE 8g

Kapchure sandy loam — *Map Ref.* HZN 352987 — *Lab. No.:* 2110 to 2115

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	1·58	0·05	5	9·6	0·6	0·54	0·31	6·5	81	14·4	12·7	4–3:5:2	17	24	57
B_1 ..	6– 12	1·77	0·09	5	4·2	1·5	0·55	0·26	5·2	64	12·6	12·8	4–3:5:2	23	27	51
B_2 ..	12– 20	0·68	0·07	15	4·8	1·5	0·49	0·31	5·5	28	13·6	13·2	4–2:6:2	25	22	49
B_2ir ..	20– 28			4	4·8	0·9	0·48	0·30	6·2	27	6·8	13·8	3–0:7:3	10	13	73
B_2ir ..	28– 50			3	3·9	0·9	0·44	0·43	6·5	61	7·7	14·7	3–0:7:3	14	19	69
C_1g ..	50– 60			3	6·9	0·9	0·51	0·43	6·5	76	10·2	8·1	7–2:6:2	21	24	55
C_2g ..	60– 72			7	6·0	1·6	0·47	0·42	6·4	94	7·5	6·4	8–1:9:0	9	17	74

Kapchure sandy clay loam — *Map Ref.:* HZN 404768 — *Lab. No.:* 3709 to 3713

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	2·38	0·16	14	7·0	4·0	0·9	0·2	5·5	63	21·2	18·9	5–5:2:3	24	22	54
B ..	7– 19	1·53	0·12	6	4·2	4·0	0·4	0·2	5·2	56	21·6	26·0	5–3:4:3	30	26	44
Bir ..	19– 40	0·57	0·05	6	2·5	3·4	0·3	0·2	5·8	42	12·8	21·6	5–0:7:3	12	16	72
C_1g ..	40– 48	0·30	0·02	4	3·3	3·4	0·6	0·3	6·3	81	12·1	12·5	6–2:6:2	8	22	70
C_2g ..	48+	0·18	0·01	4	4·4	3·5	0·6	0·4	6·5	93	13·6	19·8	6–1:6:3	4	22	74

(For profile description *See* Page 35)

Range in Characteristics.—Depth to laterite horizon varies from 20 to 36 inches.

Relief.—Gently sloping.

Drainage.—These soils are imperfectly drained, subject to periodic high perched water table.

Vegetation.—High rainfall savannah.

Use.—Most of this soil is used for the production of sisal and subsistence crops. Sisal does poorly on this soil. Sugar cane will also do poorly unless an extensive fertilization programme is followed. Crops give higher yields on Kapchure sandy clay loam than on Kapchure sandy loam.

Known Distribution.—Small areas below and adjacent to the Nandi Escarpment in the Songhor Nyanza Survey area.

Type Location.—Approximately ⅔ mile north-west of the Chemelil Sisal Estate office.

KAPKUONG SERIES

The Kapkuong series includes Solodized Solonetz soils developed on alluvial fans. The parent material is alluvium washed from steep hills and mountains of granite and granitoid gneiss. They are characterized by having a "hardpan" or "fragipan" horizon from 6 inches to 3 feet below the surface. The Kapkuong soils occur in association with the Mbereri and Ainomotua soils. They lie directly below the Mbereri soils on gently sloping to sloping alluvial fans. The Ainomotua soils occupy the same relative position as the Kapkuong soils but lack the well defined "fragipan" horizon.

Soil Profile: Kapkuong Loamy Coarse Sand

Lab. No. 1743: Hor. A1: Depth 0 to 9 inches

Very dark greyish brown (10YR 3/1.5, dry) to black (10YR 2/1.5, moist) loamy coarse sand; weak, crumb structure; moderately hard, dry; friable, moist; non-sticky and non-plastic, wet.

Lab. No. 1744: Hor. A2: Depth 9 to 18 inches

Mottled strong-brown and black, moist (7.5YR 5/6 and 10YR 2/1) to reddish-yellow and very dark grey, dry (7.5YR 6/6 and 10YR 3/1) loamy sand; weak crumb structure; consistence as above; abrupt irregular boundary.

Lab. No. 1745: Hor. B21: Depth 18 to 32 inches

Colours as above; sandy loam; coarse columnar structure breaking to strong coarse blocky; columns are 6 to 8 inches in diameter, and of polygonal shapes; they are separated by films of dark grey clay up to 3 mm. thick; very hard and brittle, dry; sticky and plastic, wet.

Lab. No. 1746: Hor. B22: Depth 32 to 60 inches

Pinkish-grey (10YR 7/2, moist) matrix mottled with strong brown (7.5YR 5/6) and black; sandy loam. This material caves when gullied, leaving the horizon above as a projecting shelf.

Lab. No. 1747: Hor. D: Depth 60 to 100 inches

Strong-brown (7.5 YR 4/6, 5/6) sandy clay loam; coarsely mottled with black and light grey. This grades into roughly stratified clay, sand and gravel. In a few places this horizon contains rough, very hard lime concretions; in others it is partly displaced by dark brown vesicular laterite ironstone.

Range in Characteristics.—The combined thickness of the loamy coarse sand horizons varies from a minimum of 6 inches to a maximum of 30 inches. In many places the surface soil has been removed by erosion. Bands of laterite are common in subsoil layers, 4 to 8 feet below the surface.

Relief.—Nearly level to sloping alluvial fans.

Drainage.—This soil is subject to seasonal seepage. Internal drainage is slow and external drainage is rapid.

Use.—Most of the Kapkuong soils are used for pasture. Much of this land has gone out of production because of overgrazing. The erosion hazard is very great and many deep, vertical-walled gullies have been formed.

Known Distribution.—On alluvial fans in the Songhor area.

Type Location.—Approximately 1⅜ miles west-southwest of Perry's homestead.

Remarks.—Cultivation on Kapkuong loamy sand is very hazardous and the importance of erosion-control practices can hardly be over-emphasized.

KIBIGORI SERIES

Soils of the Kibigori series are moderately well drained Grumusols ("black cotton" soils), developed from clay and volcanic ash deposits of former beds of lakes and swamps and on old stream terraces in Central Nyanza Province. They are closely associated with soils of the more poorly drained Aristos series and the better-drained Babu series. In the eastern part of their range they are closely associated with the more sloping Muhoroni soils—Grumusols developed from ancient volcanic tuff deposits on footslopes at the bases of lava hills. Kibigori soils crack deeply with drying and swell equally with wetting.

TABLE 8h

Kapkuong loamy coarse sand *Map Ref.:* HZN 392947 *Lab. No.* 1743 to 1747:

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	0·60	0·06	2	2·5	1·0	0·32	0·24	5·9	58	7·0	2·1	4–7:2:1	6	15	79
A_2 ..	9– 18	0·30	0·04	1	1·7	0·7	0·26	0·36	6·6	60	4·0	2·6	5–4:5:1	4	13	85
B_{21} ..	18– 32	0·40	0·04	6	3·4	1·0	0·52	1·44	7·0	76	9·9	3·0	5–6:4:0	18	17	63
B_{22} ..	32– 60	0·09	0·01	8	2·2	0·9	0·45	1·36	7·9	89	5·4	2·5	5–4:6:0	8	19	73
D ..	60–100	0·10	0·02	4	2·9	1·2	0·52	1·88	6·9	76	11·0	6·6	6–4:5:1	22	20	57

Kibigori clay *Map Ref.:* HZN 447868 *Lab. No.:* 3089 to 3094

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				
$A_{1}p$ ..	0– 8	3·30	0·21	17	15·6	1·7	0·4	0·8	5·5	66	52·0	36·0	4–4:4:2	42	20	38
B_{21} ..	8– 25	0·70	0·10	17	19·0	1·5	0·5	1·4	6·0	85	51·0	22·7	5–6:2:2	60	10	30
B_{22} ..	25– 48	0·60	0·03	28	19·6	0·8	0·6	2·0	7·5	95	56·0	24·9	4–4:6:0	62	12	26
B_{23} ..	48– 60			77	16·4	1·7	0·6	1·7	6·7	96	52·0	23·0	6–5:4:1	58	12	30
B_3 ..	60– 74			42	8·2	2·3	0·8	1·7	6·8	90	30·0	19·6	7–6:0:4	46	18	36
C_1 ..	74– 80			208	7·8	3·3	0·6	1·3	6·8	99	24·0	12·6	6–4:5:1	20	12	[illegible]

Soil Profile: Kibigori Clay

Lab. No. 3089: Hor. A1p: Depth 0 to 8 inches

Black, moist, to very dark grey, dry (10YR 2/1.5, 3/1.5), nearly massive, crumbling to fine-blocky, light clay ranging to heavy clay loam; very sticky and plastic when wet; hard when dry; matted with grass roots; diffuse boundary.

Lab. No. 3090: Hor. B21: Depth 8 to 25 inches

Black, moist, to very dark grey, dry (10YR 2/.5, 3/.5), coarse, angular-blocky heavy clay; hard, dry; stiff, moist; very sticky and plastic, wet; shrinks strongly with drying. Includes about 15 per cent of "buckshot" concretions; diffuse boundary.

Lab. No. 3091: Hor. B22: Depth 25 to 48 inches

Black, moist to very dark grey, dry (10YR 2/1, 3/1) heavy clay with coarse-lentil structure. Other properties as above, except for a few more "buckshot", and a few scattered lime concretions; a few grass roots; diffuse boundary.

Lab. No. 3092: Hor. B23: Depth 48 to 60 inches

Grey, moist and dry (10YR 5/.5, 6/.5) clay, with yellowish-brown (10YR 5/4) mottles and some black manganese oxide concretions; coarse-lentil structure.

Lab. No. 3093: Hor. B3: Depth 60 to 74 inches

Greyish-brown, mottled yellowish brown and black, light clay, with a few small fragments of hard lava rock.

Lab. No. 3094: Hor. C1: Depth 74 to 80+ inches

Similar-coloured water-laid material of sandy clay loam textures.

Range in Characteristics.—Kibigori series includes soils with surface textures of clay loam, silty clay and possibly sandy clay. Near the edges of the old lake basin, as in the sample just described, one may find thin lenses of sandy material below depths of 4 to 5 feet. Farther out in the lake basin, layers of volcanic ash may appear at about the same depths. Calcium carbonate concretions are very common at depths of 3 to 6 feet and in some areas may make up 10 to 20 per cent of the soil mass. In some places a few of these concretions may be scattered on the surface.

Relief.—Nearly level with slight micro-relief in places.

Drainage.—External and internal drainage are slow. The soils may be waterlogged but short periods in and soon after the rainy season, but they dry out sooner than the Aristos soils. Surface drains are needed on crop land.

Vegetation.—Tall coarse grasses, *Acacia seyal* and several other shrubby trees.

Use.—Used for pasture, subsistence crops and sugar cane, unsuitable for coffee.

Known Distribution.—Widely distributed on the Kano Plain of Central Nyanza.

Type Location.—The described sample was taken about 2.4 miles north of Muhoroni railway station. Other samples came from $1\frac{1}{2}$ miles west-south-west of Muhoroni station and $1\frac{1}{2}$ miles west of Kibigori railway station.

KIBUBU SERIES

The Kibubu series include dark soils with strongly developed but thin laterite horizons developed from dark, fine-grained igneous rocks. They occur on broad expanses of dark igneous rock which lie a little higher than the old lake plains of the Songhor area. They are characterized by a gravelly loam surface overlying a horizon which comprises largely a mass of concretionary oxides of iron. They are associated with Bhanji loam and Muhoroni clay loam. The Bhanji appears to have formed from the same kind of rocks. The Kibubu soils lack the heavy, clayey "B" horizon of the Bhanji soils and are somewhat lighter textured throughout. The Muhoroni soils are Grumosols, developed from associated volcanic tuff.

Sol Profile: *Kibubu Gravelly Loam*

Lab. No. 1904: Hor. A11: Depth 0 to 6 inches

Very dark grey (5YR 3/1, dry) to black (5YR 2/1, moist) gravelly sandy clay loam or loam with 30 to 40 per cent fine dark brown iron oxide concretions up to $\frac{1}{2}$ inch in diameter; very friable, moist; non-sticky and non-plastic, wet.

Lab. No. 1905: Hor. A12: Depth 6 to 10 inches

Dark reddish-grey (5YR 4/2, dry) to dark reddish brown (5YR 3/2, moist) gravelly loam with 60 to 80 per cent fine dark-brown concretions up to $\frac{1}{2}$ inch in diameter; consistence as above.

Lab. No. 1906: Hor. Bir: Depth 10 to 25 inches

Concretionary oxides of iron and perhaps manganese. The outsides of the concretions are reddish-yellow (7.5YR 6/6) and the insides are black. Yellowish-red (5YR 5/6) fine earth fills the interstices (about 20 per cent by volume). The whole mass is cemented in varying degrees to form soft to moderately hard rock.

Lab. No. 1907: Hor. C1: Depth 25 to 30 inches

The fine-grained black igneous bedrock is weathering to light grey clay loam, mottled reddish-yellow and with black manganese oxide in the joints.

TABLE 8i

Kibubu gravelly loam *Map. Ref:* HZN 429914 *Lab. No.:* 1904 to 1907

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_{11} ..	0– 6	2·0	0·17	53	7·0	3·8	0·62	0·14	6·0	35	19·4	18·8	3–3:4:3	21	26	49
A_{12}ir	6– 10	1·0	0·07	2	3·3	2·5	0·76	0·13	5·9	31	13·4	13·9	3–3:4:3	9	13	75
Bir ..	10– 25	0·7	0·07	0	2·6	2·0	0·39	0·15	5·7	22	16·8	20·3	3–2:6:3	21	20	54
C_1 ..	25– 30	0·4	0·04	19	2·4	2·7	0·38	0·24	5·8	27	20·2	29·4	3–1:6:3	12	39	43

Kipsesin clay loam *Map Ref.:* HAA 453012 *Lab. No.:* 3086 to 3088

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_{11} ..	0– 8	5·64	0·20	185	12·0	2·1	1·1	0·7	6·0	80	40·0	27·5	3–3:5:2	32	28	40
A_{12} ..	8– 13	1·34	0·12	59	12·8	3·0	0·7	0·4	6·1	80	39·2	39·8	4–1:7:2	34	20	46
C_1 ..	13– 60+	0·30	0·03	36	3·6	0·8	1·1	1·1	7·3	90	19·2	29·2	9–1:5:4	24	22	54

Range in Characteristics.—The soil varies from 1½ to 3 feet in depth. Occasional rock outcrops are encountered. The laterite or murram horizon is cellular in structure in many places. Small and large isolated masses of the lava, with weathered coatings are embedded in the laterite.

Relief.—These soils occur on smooth plains of dark, fine-grained igneous rocks.

Drainage.—These soils are well drained. Runoff is medium on the milder slopes and rapid on the steeper ones. Water collects temporarily in subsoils of some of the lower spots but soon disappears.

Vegetation.—High rainfall savannah with coarse grasses and much *Combretum*.

Use.—Most of the Kibubu soils are used for pasture but Africans use small patches of the deeper parts for raising subsistence crops. It is too shallow and stony for sugar cane or for successful mechanical cultivation of other commercial crops.

Known Distribution.—On smooth plains of dark igneous rocks in the Songhor area.

Type Location.—Approximately 2½ miles southwest of Songhor Post Office.

Kipsesin Series

Soils of the Kipsesin series are Lithosols (shallow, stony soils) developed chiefly on moderately steep slopes from volcanic tuffs, breccias and colluvial fragments of dark-coloured fine-grained basaltic or phonolitic lavas. The soils are dark-coloured, fertile and rich in humus, but most are less than 2 feet thick. They are closely associated with the deeper Sossok soils, of smoother areas of high land, and with the black, heavy, clayey Muhoroni soils of the footslopes below the lava hills. They occur under a rainfall of about 45 to about 60 inches with a marked dry season.

Soil Profile: *Kipsesin Clay Loam*

Lab. No. 3086: Hor. A11: Depth 0 to 8 inches

Black, moist, to very dark grey, dry (5YR 2/1, 3/1), medium to fine strongly granular, light clay loam; friable, moist; firm, dry; slightly plastic, wet; thickly matted with grass roots. Gradational change to next horizon. Many hard, dark breccia fragments scattered over the surface.

Lab. No. 3087: Hor. A12: Depth 8 to 13 inches

Very dark brown, moist to dark-brown, dry (7.5YR 2/2, 3/2) coarse-granular heavy sandy clay loam with fewer roots than above; plastic and sticky wet; moderately hard, dry; shrinks moderately with drying; clay skins on peds.

Lab. No. [illegible]8: Hor. C1: Depth 60 inches +. (Sample taken in decayed rock below soil proper.)

Crumbly, partly weathered tuff-saprolite, with a few brown clay skins lining the joints, decreasing downward. A few grass and tree roots penetrate this material to more than 5 feet depth.

Range in Characteristics.—In some places the rock, beginning at depths of 1 to 2 feet, is little weathered and fairly hard. The shallow soil is dark brown to dark reddish brown in many places.

Relief.—Mostly steep slopes; 25 per cent gradient where sampled.

Drainage.—Rapid surface runoff and good internal drainage.

Vegetation.—High rainfall savannah; tall coarse grasses and *Combretum, Terminalia, Ficus sycamoris, Kigelia, Bauhinia, Zizyphus* and some *Acacias* and other trees.

Use.—Used for pasture, woodlots, and for subsistence crops. African farmers get good yields of maize, beans, bananas and other subsistence crops by means of hoe culture. Some coffee has been planted but most of it shows the bad effects of shallow soil.

Known Distribution.—Hill and mountain sides in areas where hard basic rocks overlie firm tuffs in the region around Songhor and Muhoroni.

Type Location.—At sharp bend in lane to Sossok House. Map co-ordinates HAA 453012.

Koru Series

The Koru series includes slightly acid dark-coloured soils of river terraces, developed from clayey alluvium washed largely from basic lavas and calcareous volcanic tuffs. Rainfall is about 50 inches and there is a marked dry season from December to March. The natural cover consists of shrubby trees and coarse grasses. In colour and texture the soils resemble those of Mbogo series, but the Koru soils have considerably more organic material and several times as much available phosphorus. The Koru soils also have much better structure than Mbogo soils. They have much in common with Reddish Prairie soils of moderately high calcium status.

Soil Profile: Koru Clay Loam

Lab. No. 2517: Hor. A1: Depth 0 to 7 inches

Dark reddish-brown (5YR 2/2 moist, 3/2 dry), strongly fine granular clay loam. Firm dry; friable moist; plastic and sticky wet; matted with grass and tree roots; freely permeable; some snail shells scattered over surface.

Lab. No. 2518: Hor. B21: Depth 7 to 32 inches

Dark reddish-brown, moist to dark reddish-grey dry (5YR 3/2, 4/2) strongly fine-blocky clay; firm dry; friable moist; sticky and plastic wet, many roots; permeable.

Lab. No. 2519: Hor. B22: Depth 32 to 70 inches

Dark reddish-brown moist to reddish-brown dry (5YR 3/4, 4/4) compound medium and fine-blocky clay; firm dry; easily crumbled when moist; plastic and sticky wet; many roots; permeable.

Lab. No. 2520: Hor. B3: Depth 70 to 114 inches

Reddish-brown (5YR 4/4 moist, 5/4 dry) clay, with structure and consistence as above; some mica flakes; about 20 per cent black manganese oxide spots; some roots; permeable.

Lab. No. 2521: Hor. C1: Depth 114 to 126 inches

Colours and structure as above; texture, clay loam; more mica flakes; very few roots; permeable.

Range in Characteristics.—Not known—only a very small total area has been seen.

Relief.—Nearly level terraces with moderate slopes at edges; broken by occasional termite mounds 2 to 4 feet high and 20 to 40 feet across bases.

Drainage.—Good; largely internal.

Vegetation.—High-rainfall savannah.

Use.—Maize and other subsistence crops, coffee and sugar cane. Yields are good.

Known Distribution.—River terraces around Koru, Nyanza.

Type Location.—HZN 495793, about 1 mile south-west of Koru.

KUNDOS SERIES

The Kundos soils are reddish Latosols, akin to some of the Reddish Prairie soils of the United States, developing on old alluvial fans. The parent material is fine-textured alluvium washed from steep hills and mountains of granite and granite-gneiss. They occur at elevations of 4,200 to 4,400 feet in a climate having a mean annual precipitation of approximately 50 inches. These soils are closely associated with the Mbereri and Kapkuong soils but appear to be developing on finer and older alluvial fan deposits. These soils are more clayey and slightly redder than the associated Mbereri soils, and have much less organic matter than the Ainopsiwa soils. They have been

TABLE 8j

Koru clay loam *Map Ref.:* HZN 495793 *Lab. No.:* 2517 to 2521

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	2·52	0·18	120	13·6	6·2	1·04	0·36	6·3	43	34·4	43·2	5–2:6:3	40	34	26
B_{21} ..	7– 32	1·34	0·12	65	11·6	4·4	0·33	0·38	5·9	39	31·2	45·6	3–1:6:3	54	22	24
B_{22} ..	32– 70	0·65	0·07	22	8·6	5·0	0·60	0·68	6·5	60	30·4	52·5	5–0:7:3	54	20	26
B_3 ..	70–114	0·44	0·03	78	11·6	5·4	0·62	0·40	6·3	70	40·0	39·3	6–1:8:1	54	22	24
C_1 ..	114–126	0·24	0·02	305	19·0	4·7	0·58	0·58	6·5	72	40·0	28·7	5–4:4:2	40	22	38

Kundos sandy clay *Map Ref.:* HZN 330966 *Lab. No.:* 2492 to 2499

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– 10	1·27	0·11	5	5·6	2·3	0·82	0·26	5·6	47	15·2	20·9	5–0:8:2	36	14	50
B_{21} ..	10– 19	0·98	0·12	5	4·4	2·7	0·58	0·27	5·8	52	16·2	24·6	5–0:8:2	44	12	44
B_{22} ..	19– 28	0·59	0·08	5	3·0	3·0	0·42	0·28	6·0	63	15·0	23·4	5–0:8:2	40	14	46
B_{23} ..	28– 48	0·65	0·07	4	2·4	2·9	0·45	0·20	6·1	69	14·2	24·7	6–0:7:3	34	24	42
B_{24} ..	48– 56	0·36	0·02	3	2·7	2·5	0·72	0·30	6·3	63	13·8	22·0	6–0:8:2	36	16	48
B_{31} ..	56– 78	0·40	0·05	4	3·4	2·4	0·90	0·29	6·5	77	12·4	17·8	7–0:8:2	26	20	54
B_{32} ..	78– 91	0·31	0·02	4	4·1	2·3	0·98	0·46	6·6	91	13·6	16·6	8–1:7:2	26	20	54
B_{33} ..	91–108	0·24	0·03	9	5·6	2·7	0·88	0·72	6·8	81	17·6	18·8	7–1:8:1	28	26	46

overgrazed, and sheet erosion has removed much of the surface (A horizon) soil in most places. Although these soils are not naturally fertile, fair yields of sugar cane, maize, and sorghum may be obtained with the use of fertilizers.

Soil Profile: *Kundos Sandy Clay*

Lab. No. 2492: Hor. A1: Depth 0 to 10 inches

Dark reddish-grey (5YR 4/2) dry; to dark reddish-brown (5YR 3/2) moist; sandy clay, strong fine, granular structure; slightly hard dry; friable moist; slightly sticky and slightly plastic wet; abundant roots; 10 per cent fine quartz fragments; clear and wavy boundary; permeable to water.

Lab. No. 2493: Hor. B21: Depth 10 to 19 inches

Dark reddish-brown (2.5YR 3/3), dry and moist clay; compound moderate medium blocky and strong fine granular structure; slightly hard, dry; friable moist; slightly sticky and plastic wet; abundant roots; clear wavy boundary; highly permeable.

Lab. No. 2494: Hor. B22: Depth 19 to 28 inches

Dark reddish-brown (2.5YR 3/4) dry and moist; sandy clay; structure and consistence as above, abundant roots; clear and wavy boundary; highly permeable.

Lab. No. 2495: Hor. B23: Depth 28 to 48 inches

Reddish-brown (2.5YR 4/5) dry to dark reddish-brown (2.5YR 3/5) moist, clay loam; compound weak medium-blocky and strong fine angular blocky clay; hard dry; friable moist; slightly sticky and plastic wet; plentiful roots; gradual and wavy boundary; highly permeable.

Lab. No. 2496: Hor. B24: Depth 48 to 56 inches

Reddish-brown (2.5YR 4/5) dry to dark reddish-brown (2.5YR 3/5) moist sandy clay; structure as above; hard, firm, sticky and plastic; 10 per cent fine quartz fragments and a few black manganese concretions; few roots; clear and wavy boundary.

Lab. No. 2497: Hor. B31: Depth 56 to 78 inches

Dark reddish-brown (5YR 3/4), mottled reddish-yellow (7.5YR 6/8) and brownish-yellow (10YR 6/6) sandy clay loam; weak medium and fine-blocky structure; hard, firm, sticky and plastic; 20 per cent fine quartz fragments and 10 per cent black manganese concretions; gradual boundary.

Lab. No. 2498: Hor. B32: Depth 78 to 91 inches

Reddish-brown (2.5YR 4/3) dry to dark reddish-brown (2.5YR 3/3) moist sandy clay loam, weak fine-blocky structure; vary hard, firm, sticky and plastic; 20 to 30 per cent fine quartz fragments; 5 per cent black manganese concretions.

Lab. No. 2499: Hor. B33: Depth 91 to 108 inches

Dark-brown (7.5YR 4/4) moist, with many fine red and yellow mottles; sandy clay loam; weak fine-blocky structure; hard, firm, sticky and plastic; many black manganese stains and concretions; moderately permeable.

Hor. C1: Depth 108 to 120 inches

Reddish-brown (5YR 4/4) moist with many red and yellow mottles; sandy clay loam; firm, sticky and plastic; 20 per cent black manganese stains, and 15 per cent fine quartz fragments.

Range in Characteristics.—Not known.

Relief.—Long, gentle to moderate slopes, broken by occasional low termite mounds. Gradients range from 2 to 6 per cent.

Drainage.—Slow to rapid runoff depending on slope; rapid internal drainage.

Vegetation.—Thorn bush and grass.

Use.—Largely used for pasture; maize and other subsistence crops produce only fair yields.

Known Distribution.—Scattered areas on alluvial fans below the Nandi Escarpment.

Type Location.—HZN 330966, about 4½ miles north-east of Kibigori.

LEMAIYWA SERIES

The Lemaiywa series includes poorly drained, heavy textured black soils (Humic Glei) of occasionally flooded river valleys around the edges of the Kano Plain. The soils are associated with the well-drained soils of the Tennant series. The alluvium from which they are derived comes largely from areas of volcanic tuff and basaltic rocks, but some of it has come from areas of gneiss. The Lemaiywa soils, like the Tennant soils, are rich in organic matter and phosphorus. They resemble superficially the Aristos soils but have much more humus and phosphorus.

Soil Profile: *Lemaiywa Clay*

Lab. No. 3153: Hor. A11: Depth 0 to 5 inches

Black moist, to very dark grey dry (10YR 2/1, 3/1), fine-blocky, humus-rich clay; firm dry; friable moist; sticky and plastic wet; matted with grass roots; moderately permeable.

Lab. No. 3154: Hor. A12: Depth 5 to 18 inches

Same colour and texture; compound medium and fine-blocky structure; moderately high humus; many roots; moderately permeable.

Lab. No. 3155: Hor. A3g: Depth 18 to 32 inches

Black moist, to very dark grey dry (10YR 2/.5, 3/.5) coarsely lenticular-blocky clay with less humus than above; hard dry; stiff moist; very plastic and sticky wet; many roots; slowly permeable.

Lab. No. 3156: Hor. Cg1: Depth 32 to 72 inches

Similar to above with still less humus.

Lab. No. 3157: Hor. Dg1: Depth 72 to 96 inches

Very dark grey moist, to dark-grey dry (10YR 3/.5, 4/.5), strongly medium blocky clay; consistence as above; few fine roots; lime concretions; slowly permeable.

Lab. No. 3158: Hor. Dg2: Depth 96 to 120 inches

Dark greyish-brown moist, to greyish-brown dry (10YR 4/2, 5/2), medium-blocky sandy clay, with lime concretions; no roots; slowly permeable.

Range in Characteristics.—Texture of plough soil varies from sandy clay loam to sandy clay and subsoil textures in some places may range to sandy clay loam. In marshy areas the A horizons may be mottled with dark brown.

Relief.—Nearly level stream valleys, subject to only occasional overflow. Slope gradients range from less than 1 to about 2 per cent.

Drainage.—Normally poorly drained and more or less marshy. The sample was taken from an area that was recently drained after flood waters had deepened the stream channel.

Vegetation.—Sedges, rushes, water-loving grasses and other hydrophylic plants.

Use.—Used largely for pasture. Drained areas will produce high yields of maize, other subsistence crops and sugar cane.

Known Distribution.—Wet areas in stream valleys, occasionally flooded.

Type Location.—HZN 367888.

MARCANTONATOS SERIES

Soils of this series belong to the very broad group of well-drained reddish soils known in recent years as Latosols. They have moderate humus content, mixed clay minerals, and enough iron oxide to impart a reddish hue. They resemble the Martin soils, but are developed from old alluvial deposits washed from the gneissic hills of the Nandi Escarpment, instead of

TABLE 8k

Lemaiywa clay | *Map Ref.:* HZN 367888 | *Lab. No.:* 3153 to 3158

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_{11} ..	0– 5	4·85	0·27	217	27·2	5·5	0·9	0·5	6·0	75	40·8	23·8	5–5:2:3	50	24	25
A_{12} ..	5– 18	2·00	0·15	207	23·2	8·7	0·2	0·6	6·3	87	45·6	20·9	7–5:3:2	50	22	28
$A_{3}g$ ..	18– 32	1·25	0·08	263	26·4	8·2	0·3	1·4	7·2	95	68·0	9·4	5–8:2:0	50	18	32
Cg_{1} ..	32– 72			270	29·6	7·7	0·3	1·6	7·1	96	58·0	28·1	6–5:4:1	50	20	30
Dg_{1} ..	72– 96			285	28·8	5·3	0·3	1·8	7·4	98	72·0	10·0	5–9:1:0	48	20	32
Dg_{2} ..	96–120			53	36·0	5·5	0·2	2·0	7·7	100	48·8	5·4	7–8:2:0	36	16	48

Marcantonatos loam | *Map Ref.:* HAA 416037 | *Lab. No.:* 2169 to 2175

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_{11} ..	0– 12	3·00	0·20	32	9·2	1·0	0·39	0·24	5·6	55	27·0	13·2	2–4:6:0	20	28	52
A_{12} ..	12– 23	2·40	0·09	7	11·4	0·9	0·30	0·20	5·7	44	21·0	14·7	3–4:4:2	24	28	48
B_{1} ..	23– 31	1·11	0·08	8	9·3	0·7	0·31	0·24	5·7	47	17·4	14·3	3–1:9:0	34	18	52
B_{21} ..	31– 53			4	8·0	0·9	0·46	0·25	5·9	57	18·0	18·5	3–2:6:2	40	18	46
B_{22} ..	53– 65			4	6·4	0·9	0·55	0·23	6·0	53	16·0	18·4	3–1:7:2	42	20	44
B_{31} ..	65– 89			4	4·2	0·7	0·48	0·22	6·1	64	12·2	15·0	4–1:8:2	34	16	54
B_{3}–C_{1}	89–150			3	3·6	0·8	0·46	0·24	6·1	57	13·6	13·6	3–2:7:2	32	16	56

from dark-coloured lavas. The Marcantonatos soils are more sandy throughout the profile than the Martin soils, and they contain less calcium and magnesium. Rainfall ranges from about 50 to 60 inches, with a dry season in December to mid-March.

Soil Profile: Marcantonatos Loam

Lab. No. 2169: Hor. A11: Depth 0 to 12 inches

Black (5YR 2/1) moist, to very dark grey (5YR 3/1), dry, granular loam; slightly hard, dry; friable, moist; non-sticky, wet; matted with grass roots; clear smooth boundary.

Lab. No. 2170: Hor. A12: Depth 12 to 23 inches

Dark reddish-brown (5YR 2/2 moist, 3/2 dry) blocky sandy clay loam; hard, dry; friable moist; slightly plastic, wet; many grass roots; gradual smooth boundary.

Lab. No. 2171: Hor. B1: Depth 23 to 31 inches

Dark reddish-brown, moist to reddish-brown dry (5YR 3/2.5, 4/2.5) blocky heavy sandy clay loam; hard, dry; friable, moist; sticky and slightly plastic, wet; many grass roots; gradual smooth boundary.

Lab. No. 2172: Hor. B21: Depth 31 to 53 inches

Dark reddish-brown, moist, to reddish-brown, dry (5YR 3/2.5, 4/2.5) clay loam, crushing to stronger colours; medium, blocky, hard, dry; friable, moist; slightly sticky and plastic, wet; many fine and medium roots; gradual smooth boundary.

Lab. No. 2173: Hor. B22: Depth 53 to 65 inches

Dark reddish-brown, moist, to reddish-brown, dry (5YR 3/4, 4/4) medium-blocky, light clay; hard, dry; friable, moist; slightly sticky and plastic, wet; some fine and medium roots; gradual smooth boundary.

Lab. No. 2174: Hor. B31: Depth 65 to 89 inches

Dark reddish-brown, moist, to reddish-brown, dry (2.5YR 3/4, 4/4) clay loam; fine blocky; hard, dry; very friable, moist; sticky and plastic, wet; few fine roots; gradual smooth boundary; some decomposed granitoid gneiss fragments.

Lab. No. 2175: Hor. B3-C1: Depth 89 to 150 inches

Similar colour and texture to above; contains more streaks of weathered and decomposed gneiss fragments; at undetermined depth this passes into gravelly alluvium of gneissic origin in some places and into gneissic bedrock in others; very few fine roots in upper part.

Range in Characteristics.—Colours of subsoil horizons are stronger than indicated in some places. Too little of the soil occurs in the Songhor area to determine its full range.

Relief.—Gently to moderately sloping alluvial fans.

Drainage.—Internal drainage is free throughout; water-holding capacity is good.

Vegetation.—High rainfall savannah and open forest.

Use.—Used for pasture, subsistence crops and coffee. Yields are good.

Known Distribution.—At the foot of the Nandi Escarpment, north of the Kano Plain.

Type Location.—1¼ miles west of Farndell home, 6¼ miles north-north-west of Songhor Post Office.

MARTIN SERIES

Soils of the Martin series belong to a very large and inclusive group of reddish soils known in recent years as Latosols. They have much in common with Reddish Prairie soils. The Martin soils have a moderate amount of humus, have mixed clay minerals, and a fairly high content of iron oxide. They are developed from dark-coloured fine-grained basaltic and phonolitic lavas. Rainfall ranges from 45 to 60 inches with a marked dry season.

Soil Profile: *Martin Clay Loam*

Lab. No. 2265: Hor. A11: Depth 0 to 8 inches

Very dark grey to dark reddish-brown, moist, to dark reddish-grey, dry (5YR 3/1.5, 4/1.5) granular heavy clay loam; friable, moist and dry; slightly sticky, wet; matted with grass roots; graduational boundary to next.

Lab. No. 2266: Hor. A12: Depth 8 to 14 inches

Dark reddish-brown (5YR 3/2 moist, 4/2 dry) subangular blocky, crumbling to medium-granular, light clay; friable, moist; firm, dry; plastic and slightly sticky, wet; many grass roots; clear boundary to next.

Lab. No. 2267: Hor. B1: Depth 14 to 31 inches

Dusky red, moist, to weak-red, dry; subangular-blocky, crumbling to medium-granular, clay; friable when dry and moist; slightly plastic and sticky, wet; many fine roots; clear boundary.

Lab. No. 2268: Hor. B21: Depth 31 to 42 inches

Dark reddish-brown (5YR 3/2 moist, to 3/4 crushed), coarse sub-angular blocky clay, crumbling to fine blocky; friable, moist and dry; slightly plastic, wet; a few roots; clear boundary.

Lab. No. 2269: Hor. B22: Depth 42 to 53 inches

Dark reddish-brown moist and dry (2.5YR 3/4) crushing to red (2.5YR 4/5), coarse, breaking to fine-blocky clay; friable, dry and moist; slightly plastic, wet; a few grass roots; clear boundary.

Lab. 2270: Hor. B23: Depth 53 to 72 inches

Similar to above, but with about 10 per cent of black manganese oxide concretions $\frac{1}{4}$ to $\frac{1}{2}$ inch in diameter; few roots; clear boundary.

Lab. 2271: Hor. B24: Depth 72 to 90 inches

Dark reddish-brown clay with some grit and bright yellow specks of weathered rock. Friable and nearly massive; few roots; clear boundary.

Lab. No. 2272: Hor. B3: Depth 90 to 100 inches

Similar to last, except it has about 50 per cent manganese concretions; clay texture; friable consistence; no roots; clear boundary.

Lab. No. 2273: Hor. C1: Depth 100 to 115 inches

Crumbly clay with structure of parent basaltic rock still preserved; mottled pale yellow, light olive brown, strong brown and other colours.

Range in Characteristics.—Depth to weathered rock varies from about 4 to about 10 feet. Colours of subsoils are a little stronger in some places and a little weaker in others. Acid-soluble phosphorus is higher in the Martin clay loam northwest of Muhoroni. Surface-soil textures range from clay loam to light clay.

Relief.—Undulating uplands and footslopes of moderate gradients. Slope was about 5 per cent where sampled on the Martin farm.

Drainage.—Drainage is free, internally and externally.

Vegetation.—High rainfall savannah with dense coarse grass and a large variety of shrubby trees.

Use.—Used for maize and other subsistence crops, citrus, coffee and pasture. Well suited for sugar cane.

Known Distribution.—On basaltic and phonolitic hilltops and footslopes around the eastern rim of the Kano Plain. Somewhat similar soils occur in East Konyango, Nyanza.

Type Location.—On the Martin farm $4\frac{3}{8}$ miles north-northwest of Muhoroni station. Map co-ordinates HZN 416896.

Mbereri Series

The Mbereri series includes soils much like Reddish-Brunizen (Reddish Prairie) soils, developed on alluvial fans. The parent material is alluvium

TABLE 81

Martin clay loam *Map Ref.:* HZN 416896 *Lab. No.:* 2265 to 2273

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_{11} ..	0– 8	3·40	0·17	71	20·8	4·4	1·24	0·66	6·0	66	39·5	16·7	4–7:0:3	38	32	28
A_{12} ..	8– 14	1·91	0·13	32	19·2	4·3	0·34	0·34	5·6	61	36·4	17·4	5–4:6:0	42	30	24
B_1 ..	14– 31	1·36	0·11	39	15·6	4·4	0·26	0·40	5·6	64	34·9	16·8	4–4:6:0	50	26	22
B_{21} ..	31– 42			13	11·6	4·4	0·42	0·45	5·9	74	28·3	18·8	5–5:2:3	56	20	24
B_{22} ..	42– 53			11	9·6	4·2	0·62	0·98	6·2	70	29·5	25·4	5–4:3:3	58	16	24
B_{23} ..	53– 72			7	10·4	5·1	0·66	0·34	6·3	72	32·3	21·4	5–4:4:2	60	12	24
B_{24} ..	72– 90			6	10·8	5·3	0·80	0·40	6·5	79	31·9	26·2	6–4:3:3	58	20	22
B_3 ..	90–100			9	24·8	6·7	0·84	0·35	6·5	85	41·2	19·3	7–5:4:1	58	18	24
C_1 ..	100–115			8	44·2	5·4	0·73	0·53	6·2	92	56·0	43·3	8–3:6:2	58	20	22

Mbereri coarse sandy loam *Map Ref.:* HZN 444958 *Lab. No.:* 1897 to 1903

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– 12	1·4	0·10	65	5·9	1·8	0·36	0·15	5·8	62	12·5	5·9	5–6:2:2	10	19	70
B_1 ..	12– 33	0·7	0·07	0	3·2	0·8	0·28	0·16	5·4	40	12·1	7·9	5–5:2:3	22	15	61
B_{21} ..	33– 45	0·6	0·06	0	4·2	1·1	0·37	0·23	5·8	63	11·7	10·5	5–3:5:2	29	15	53
B_{22} ..	45– 65	0·3	0·03	2	3·9	1·3	0·53	0·25	6·0	63	9·7	7·9	4–3:5:2	25	16	58
C_{11} ..	65– 86	0·4	0·02	2	3·1	1·1	0·49	0·22	6·2	66	6·9	5·1	5–2:8:0	13	17	66
C_{12} ..	86–114	0·1	0·02	0	2·4	1·0	0·63	0·18	6·5	95	5·7	5·0	5–2:7:1	12	12	71
D_1 ..	114–130	0·3	0·09	0	4·2	1·9	0·61	0·24	6·2	83	12·9	6·8	6–4:4:1	25	19	54

washed from steep hills and mountains of granite and granitoid gneiss. They the characterized by their reddish colours and their sandy textures. They are underlain by very gravelly, cobbly or stony alluvium at varying depths. On the steeper parts of the fans these soils are stony and gravelly. In many places the Mbereri soils merge rapidly downgrade into the Kapkuong soils which are solodized Solonetz, soils developing in the same type of parent material.

Soil Profile: Mbereri Coarse Sandy Loam

Lab. No. 1897: Hor. A1: Depth 0 to 12 inches

Dark brown (7.5YR 3/2, dry) to very dark brown (7.5YR 2/2, moist) coarse sandy loam; moderate fine-crumb structure; soft, dry; friable, moist; non-sticky and non-plastic, wet; abundant roots; clear wavy boundary.

Lab. 1898: Hor. B1: Depth 12 to 33 inches

Reddish-grey (5YR 4/2, dry) to dark reddish-brown (5YR 3/2, moist) sandy clay loam; weak medium and fine-blocky structure; slightly hard, dry; friable moist; sticky and slightly plastic, wet; abundant fine medium and coarse roots; gradual wavy boundary.

Lab. No. 1899: Hor. B21: Depth 33 to 45 inches

Reddish-brown (5YR 4/3, dry) to dark reddish-brown (5YR 3/3, moist) sandy clay loam; weak fine-blocky structure; consistence as above; plentiful medium and fine roots; gradual wavy boundary.

Lab. No. 1900: Hor. B22: Depth 45 to 65 inches

Yellowish-red (5YR 5/6, dry) to yellowish-red (5YR, 4/6, moist), sandy clay loam; common, fine mottles of very dark brown (7.5YR 2/2); weak fine-blocky structure; slightly hard, dry; friable, moist; slightly sticky and slightly plastic, wet; few fine roots; gradual wavy boundary.

Lab. No. 1901: Hor. C11: Depth 65 to 86 inches

Yellowish-red (5YR 5/6, dry) to reddish-brown (5YR 5/4, moist); sandy loam; weak fine granular structure; 10 per cent black streaks of manganese oxide; consistence as above; very few fine roots; gradual boundary.

Lab. No. 1902: Hor. C12: Depth 86 to 114 inches

Strong-brown (7.5 YR 5/6, moist) streaked about 15 per cent with yellowish-red (5YR 4/6, moist) sandy loam; weak medium to fine-blocky structure; soft, dry; very friable, moist; non-sticky and non-plastic, wet; many fine quartz grains; gradual boundary.

Lab. No. 1903: Hor. D1: Depth 114 to 130 inches

Mottled 40 per cent yellowish-red (5YR 5/6, moist) and 60 per cent dark reddish-grey (2.5YR 4/1, moist) sandy clay loam; weak medium blocky structure; hard, dry; firm, moist; sticky and plastic, wet.

Range in Characteristics.— In much of this soil there is a "stoneline" or stringer at depths ranging from 3 to 10 feet. The upper part consists largely of quartz fragments and a few inches lower, of mixed granitic gneiss and quartz fragments.

Relief.—Gently to moderately sloping alluvial fans with slope gradients from about 3 to 12 per cent with eroded phases up to 20 per cent.

Drainage.—These soils are well drained. Runoff is medium to rapid and water drains readily through the soil.

Vegetation.—High rainfall savannah. *Combretum, Bauhinia, Acacias* and tall coarse grasses.

Use.—These soils have a severe erosion hazard and much of the land cultivated in the past has gone out of production because of sheet wash and gullying. The soil produces good yields of maize and other subsistence crops and will be good for sugar cane and coffee production if erosion can be controlled.

Known Distribution.—On alluvial fans in the Songhor area.

Type Location.—Approximately 1¼ miles north and ¼ mile west of the Songhor Post Office.

MBOGO SERIES

The Mbogo series includes "Brown Soils of Heavy Texture" developed in lake-clay deposits at the inner edges of the lake-plain remnants where the land breaks away toward the deeply incized river beds. Eroded lake-clay deposits usually occur in close association with Mbogo clay loam on one side and either soils of the alluvial fans and uplands or less well-drained soils of the lake-plains occur on the other. They are less permeable than Perry soils and somewhat less well-drained.

Soil Profile: Mbogo Clay Loam

Lab. No. 1752: Hor. A11: Depth 0 to 6 inches

Dark reddish-grey (5YR 4/1.5, dry) to dark reddish-brown (5YR 3/1.5, moist) clay loam; fine granular structure; friable, moist; sticky and plastic, wet.

Lab. No. 1753: Hor. A12: Depth 6 to 14 inches

Stronger chroma than above (5YR 3/2, moist, 4/2, dry) clay loam; strong fine granular structure; about 5 per cent of red "buckshot" concretions.

Lab. No. 1754: Hor. B1: Depth 14 to 20 inches

Reddish-brown (5YR 4/3, moist, 5/3, dry) clay; fine-blocky structure; fine mottles of yellowish red, and 5 to 10 per cent "buckshot" concretions.

Lab. No. 1755: Hor. B21: Depth 20 to 28 inches

Reddish-brown (5YR 4/3, dry) to dark reddish-brown (5YR 3/3, moist) clay; medium-blocky structure which is massive when wet; a few faint lighter-coloured mottles; plastic and sticky, wet.

Lab. No. 1756: Hor. B22: Depth 28 to 52 inches

Dark reddish-grey (5YR 4/2, dry) to dark reddish-brown (5YR 3/2, moist) heavy clay; very coarse blocky, with some imperfectly developed coarse (2 inch) lentils; clay skins on all ped faces; small spots and streaks of black manganese oxide; very firm, moist; sticky and plastic, wet.

Lab. No. 1757: Hor. B23: Depth 52 to 82 inches

Reddish-brown (5YR 4/3, dry) to dark reddish-brown (5YR 3/3, moist) heavy clay; coarse blocky structure; slickensides on peds; about 8 per cent black manganese spots and concretions; sticky and plastic, wet.

Lab. No. 1758: Hor. B3: Depth 82 to 100 inches

Slightly redder hue than above (4YR 3/3, 4/3) heavy clay; coarse blocky structure; sticky and plastic, wet; 10 to 12 per cent manganese spots and concretions that form a weakly cemented layer at the base. This overlies reddish-brown, plastic, sticky clays.

Range in Characteristics.—In some places a few 1 to 2 inch iron oxide concretions lie from 3 to 6 feet below the surface. Occasional lenses of gravel and cobble stones occur in the beds of clay.

Relief.—Nearly level to gently sloping lake plains.

Drainage.—These soils are moderately well drained. Runoff is moderate, but water moves slowly through the subsoils.

Vegetation.—High rainfall savannah: *Bauhinia, Combretum, Kigelia* and various *Acacias* are common. The soil has a thick cover of tall grasses.

Use.—Most of the Mbogo soils are used for pasture. They are well suited for sugar cane, maize, subsistence crops and pastures.

Known Distribution.—Near the inner edges of the lake-clay deposits in the Songhor Soil Survey area.

Type Location.—Approximately $\frac{1}{3}$ mile south of the Songhor Post Office on the south side of Mbogo River.

TABLE 8m

Mbogo clay loam — *Map Ref.:* HZN 452932 — *Lab. No.:* 1752 to 1758

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_{11} ..	0– 6	2·7	0·18	8	11·2	5·7	0·66	0·30	5·6	58	34·0	25·5	5–5:2:3	32	47	18
A_{12} ..	6– 14	1·2	0·11	0	9·6	5·9	0·28	0·32	5·7	70	25·5	26·0	6–3:4:3	34	37	23
B_1 ..	14– 20	0·7	0·07	2	9·8	6·2	0·34	0·56	5·9	70	27·8	28·4	6–4:2:4	43	30	18
B_{21} ..	20– 28	0·4	0·06	8	12·4	7·8	0·44	0·72	6·2	72	28·0	24·3	7–3:5:2	55	26	12
B_{22} ..	28– 52	0·4	0·04	15	10·4	8·0	0·51	0·45	5·6	70	29·0	23·2	7–4:4:2	53	29	11
B_{23} ..	52– 82	0·3	0·04	18	11·2	7·8	0·62	1·16	5·2	77	37·8	21·2	7–4:4:2	56	29	7
B_3 ..	82–106	0·2	0·04	27	11·2	7·5	0·64	1·12	5·1	69	35·1	20·4	6–5:3:2	53	31	7

Muhoroni clay loam — *Map Ref.:* HZN 434901 — *Lab. No.:* 3095 to 3102

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				
$A_{1}p$ ..	0– 6	2·64	0·13	74	14·0	1·5	0·8	0·4	5·7	77	44·8	41·9	4–3:4:3	40	24	36
A_{12} ..	6– 15	3·30	0·18	15	16·6	1·6	0·3	0·8	5·5	71	30·0	24·2	6–5:1:4	38	28	34
B_{21} ..	15– 30	1·19	0·09	14	14·8	1·7	0·5	1·0	5·8	84	52·0	33·3	3–2:8:0	64	10	26
B_{22} ..	30– 42			21	16·4	5·0	0·6	1·3	7·7	92	52·0	25·0	5–5:4:1	60	14	26
B_{23} ..	42– 70			176	10·8	5·1	0·7	1·3	7·7	98	58·0	13·4	6–7:3:1	66	12	22
Bca ..	70– 82			42	33·6	5·6	0·6	1·2	7·7	100	60·0	12·4	5–7:3:0	62	14	24
B_3 ..	82–100			171	23·2	5·6	0·7	0·9	7·3	95	52·0	13·1	6–6:4:0	56	14	30
C_1 ..	100–112			265	10·8	5·2	0·5	0·4	7·6	99	54·0	15·6	7–7:2:1	50	14	36

MUHORONI SERIES

Muhoroni soils are Grumusols ("black cotton" soils) developed primarily from pale-yellow volcanic tuff exposed along the footslopes of the lava hills of Songhor Survey Area. They resemble the Kibigori soils in most respects, but are developed primarily from tuff instead of from lake clays and volcanic ash; and occur on more sloping land. They merge with the Ngeron soils, but generally contain less acid-soluble phosphorus and less humus. Deep cracks form in the soil when it dries.

Soil Profile: *Muhoroni Clay Loam*

Lab. No. 3095: Hor. A1p: Depth 0 to 6 inches

This is plough soil and locally washed material. Dark-brown (7.5YR 3/2 moist, 4/2 dry) fine-granular clay loam, matted with roots; sticky and plastic, wet; crumbly when slightly moist; hard, dry; about 5 per cent "buckshot"; abrupt smooth boundary.

Lab. No. 3096: Hor. A1: Depth 6 to 15 inches

Very dark grey, moist, to dark-grey, dry (7.5YR 3/1, 4/1), medium- and fine-granular clay loam, that is massive when wet; very sticky and plastic when dry, many medium and fine grass roots; clear smooth boundary.

Lab. No. 3097: Hor. B21: Depth 15 to 30 inches

Very dark grey, moist, to dark-grey, dry; sticky, plastic, heavy shrinking clay; coarse lentil structure, coming apart to form irregular, sharply angular blocks ½ to 1 inch in diameter; about 5 per cent "buckshot" concretions; many roots; diffuse boundary.

Lab. No. 3098: Hor. B22: Depth 30 to 42 inches

Very dark grey, moist, to dark-grey, dry (10YR 3/.5, 4/.5), fine lentil and fine blocky, sticky, plastic, heavy shrinking clay; about 5 per cent "buckshot"; many roots; diffuse boundary.

Lab. No. 3099: Hor. B23: Depth 42 to 70 inches

Very dark grey, moist, to dark-grey dry (2.5Y 3/1, 4/1), fine blocky, sticky, plastic clay, with brown mottles and very few "buckshot"; few roots in upper part; none at base.

Lab. No. 3100: Hor. Bca: Depth 70 to 82 inches

Dark-grey, moist, to light-grey, dry (2.5Y 4/1, 6/1) mottled olive-brown, heavy, sticky, plastic, fine-blocky clay, with masses and lumps of nearly white, soft concretions of lime carbonate; diffuse boundary.

Lab. No. 3101: Hor. B3: Depth 82 to 100 inches

Dark-grey, moist, to grey, dry (2.5Y 4/1, 5/1), mottled olive brown (2.5Y 4/4) crumbly clay with some black manganese oxide spots and very fine lime-carbonate concretions. Dark-grey to black films of clay, up to 1 mm. thick, line joints; clear boundary.

Lab. No. 3102: Hor. C1: Depth 100 to 112 inches

Crumbly, decayed, tuff that has weathered to a clay texture; colour is olive, moist, to pale yellow, dry (5Y 4/3, 7/3). The little-weathered tuff, examined elsewhere, consists of a mass of sand- and silt-sized volcanic ash particles, supporting fragments of porous volcanic "cinders", lapilli, phonolite and, even of gneiss, quartz and small "books" of biotite mica. Veinlets of crystalline calcium carbonate follow joints in the tuff, but are not everywhere abundant.

Soil Profile: Muhoroni Clay Loam (Alternate Site)

Lab. No. 1336: Hor. Ap: Depth 0 to 12 inches

Very dark grey (10YR 2.5/1 dry, 3/1 moist) clay loam; strong fine granular structure; hard, dry; slightly plastic, wet.

Lab. No. 1337: Hor. A2: Depth 12 to 18 inches

Light-grey (10YR 7/.5, dry) to grey (10YR 6/.5, moist) loam; strong fine granular structure; 10 per cent "buckshot"; abrupt and wavy boundary.

Lab. No. 1338: Hor. B21: Depth 18 to 32 inches

Dark-grey (10YR 4/.5, dry) to very dark grey (10YR 3.5/.5, moist) clay; strong coarse, medium and fine-blocky structure; thin continuous clay skins on all ped faces; 15 per cent brown "buckshot" concretions; sticky and plastic, wet; gradual-wavy boundary.

Lab. No. 1339: Hor. B22: Depth 32 to 42 inches

Colour as above; clay; strong coarse lentil structure with thick continuous clay skins and slickensides; 15 per cent "buckshot" concretions with brown mottles around concretions; consistence as above; abrupt-wavy boundary.

Lab. No. 1340: Hor. B3: Depth 42 to 52 inches

Strongly mottled black (10YR 2/1, 2/1) strong-brown (7.5YR 5/6, 5/6) and dark-grey (10YR 4/1, 5/1) brittle sandy clay loam which is cemented by black manganese oxide; termite cavities are lined with black clay.

Lab. No. 1341: Hor. C1: Depth 52 to 74 inches

Grey to dark-grey (10YR 5/1, dry) to dark grey (10YR 4/1, moist) sandy loam; mottled light yellowish brown, black and very pale brown; discontinuous light-grey clay skins and black manganese streaks. This appears to be modified saprolite with brittle consistence.

Lab. No. 1342: Hor. C2: Depth 74 to 78 inches

Saprolite from tuff. Sandy loam texture with some black manganese skins.

Range in Characteristics.—Soils of the Muhoroni series have surface textures ranging from sandy clay loam to clay; but clay loam is the most usual plough-soil texture. Depth to little-weathered tuff ranges from about 40 inches to 9 feet with an average near 5 feet. There is considerable local variation in organic carbon content of the A1 horizon from less than 2 per cent to about 3.5 per cent.

Relief.—Gentle to moderate slopes with gradients ranging from about 1 to about 20 per cent. Very little of it is on slopes exceeding 7 per cent.

Drainage.—Surface drainage is moderate to rapid; internal drainage is very slow except during the dry season when water readily enters the deep cracks. Seepages develop during the wet season and early part of the dry season where water is concentrated by downslope movement through the deep cracks and through the joints between the lenticular aggregates of the subsoils.

Vegetation.—High rainfall savannah, with a dense cover of tall grasses and scattered *Bauhinia, Kigelia* and various *Acacias* and other trees.

Use.—Much of the land is used for pasture, some is used for subsistence crops. While the soil is difficult to plough and cultivate, it will produce moderate yields of sugar cane if properly managed.

Known Distribution.—Footslopes of the eastern rim of the East Kano Plain, near Songhor and Muhoroni.

Type Location.—The sample described first was taken about 200 feet north-east of the Chemaros Roman Catholic church, about 5¼ miles north of Muhoroni Station, west of the Muhoroni-Songhor road.

Remarks.—The chemical and physical differences among Muhoroni, Kibigori and Ngeron soils are neither large nor very consistent. Probably the local moisture regime, the thickness of the humus-rich A1 horizon, and the total amount of humus at any given point may outweigh differences between these series in many instances.

Nandi Series

Soils of the Nandi series are developed from medium-textured alluvial fan deposits washed, in geologically recent time, from hills and mountains of granitoid gneiss. They are rich in humus, medium acid in reaction and have a moderate supply of calcium and phosphorus. Physically they resemble the Tennant soils, but they contain less calcium and very much less phosphorus than the latter. They have less strongly developed profiles than the associated Marcantonatos soils.

TABLE 8n

Muhoroni clay loam (Alternate) *Map Ref.*: HZN 437883 *Lab. No.*: 1336 to 1342

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– 12	1·80	0·17	3	17·4	3·2	0·64	0·47	5·5	64	30·0	22·5	6–5:1:4	32	35	24
A_2 ..	12– 18	1·50	0·07	0	9·0	2·7	0·36	0·49	5·8	64	21·0	15·1	6–3:6:1	22	36	41
B_{21} ..	18– 32	1·20	0·06	5	14·4	3·2	0·52	0·69	6·2	79	28·0	18·2	7–6:0:4	42	23	23
B_{22} ..	32– 42	0·70	0·04	22	20·8	3·5	0·73	1·04	6·8	93	47·6	28·5	7–6:0:4	54	22	12
B_3 ..	42– 52	0·00	0·03	298	25·0	3·3	0·62	1·00	6·8	91	47·6	13·5	9–9:0:1	27	25	37
C_1 ..	52– 74	0·30	0·02	298	24·8	2·9	0·54	1·00	7·1	92	45·2	9·8	9–9:0:1	18	23	59
C_2 ..	74– 78	0·30	0·01	280	25·6	2·6	1·00	1·90	7·2	94	45·8	32·8	5–4:3:3	15	26	60

Nandi loam *Map Ref.*: HAA 409029 *Lab. No.*: 3728 to 3731

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_{11} ..	0– 12	4·01	0·17	190	15·6	3·3	0·6	0·2	5·5	55	29·6	4·9	6–8:1:1	14	42	44
A_{12} ..	12– 35	3·00	0·06	20	17·2	2·2	0·2	0·3	5·4	65	33·6	13·6	6–7:1:3	22	34	44
B_1 ..	35– 50	1·26	0·03	37	10·8	2·2	0·2	0·3	5·6	63	17·2	13·4	6–2:7:1	24	28	48
B_2 ..	50– 60	1·04	0·03	41	5·9	2·0	0·2	0·2	5·7	70	18·4	14·7	6–2:7:1	26	26	48

Soil Profile: Nandi Loam

Lab. No. 3728: Hor. A11: Depth 0 to 12

Black moist to dark-grey dry (5YR 2/1, 4/1) strongly fine granular loam; soft dry; very friable moist and wet; high humus content; matted with roots; very permeable.

Lab. No. 3729: Hor. A12: Depth 12 to 35 inches

Similar to above, but heavier loam and less organic matter. Colour 7.5YR 2/1, 4/1.

Lab. No. 3730: Hor. B1: Depth 35 to 50 inches

Very dark grey, moist, to dark-grey, dry (7.5YR 3/1, 4/1), mottled 7.5YR 3/2, medium subangular-blocky, light sandy clay loam; hard, dry; friable, moist; plastic, wet; plentiful roots; moderately permeable.

Lab. No. 3731: Hor. B2: Depth 50 to 60 inches

Dark reddish-brown, moist, to reddish-brown, dry (5YR 3/3, 4/3), finely mottled dark grey, subangular-blocky sandy clay loam; hard, dry; friable, moist; plastic, wet; few roots; moderately permeable. Line of quartz and gneiss fragments at base.

Range in Characteristics.—Surface textures range from loamy sand to loam; gravel and even boulders may be imbedded in the subsoil within 3 feet of the surface.

Relief.—Smoothly sloping alluvial fans with gradients of 3 to 12 per cent, broken by occasional termite mounds up to 3 or 4 feet high.

Drainage.—Surface drainage moderate to rapid; internal drainage good; a few seepy spots may appear in the rainy season.

Vegetation.—High-rainfall savannah and small patches of dense ever-green-broadleaf forest. Tall coarse grasses cover the ground in savannah areas.

Use.—Used for maize, other subsistence crops; pawpaws, bananas and other fruits and pasture. Yields moderate to high.

Known Distribution.—Low alluvial fans below the Nandi Escarpment, north of the Kano Plain.

Type of Location.—HAA 40929, about 6.3 miles north-north-west of Songhor Post Office.

NGERON SERIES

The Ngeron series are Grumusols developed in colluvial-alluvial deposits on gentle to moderate slopes below outcrops of dark igneous rocks (basalt, tuff and breccia). Some of the parent material is weathered in part from gneissic and granitic colluvium. These soils grade downslope almost imperceptibly into the Aris[illegible] soils which are the poorly drained Grumosol associates. The Ngeron soils also occur in association with the shallower Kamaasae soils which are well drained somewhat shallow. Brown Forest soils developed from strongly calcareous (limy) tuff. Ngeron soils are sticky and plastic when wet and shrink and crack deeply when dry.

Soil Profile: Ngeron Clay Loam

Lab. No. 2084: Hor. A1: 0 to 12 inches

Very dark grey (10YR 3/1, dry) to black (10YR 2/1, moist) clay loam; fine granular structure; friable, moist; many fine roots; diffuse boundary; very sticky and plastic when wet.

Lab. No. 2085: Hor. B1: Depth 12 to 26 inches

Dark grey (2.5Y 4/1, dry) to very dark grey (2.5Y 3/1, moist) clay; fine blocky structure; many fine roots; clear boundary. Sticky and plastic when wet.

Lab. No. 2086: Hor. B21: Depth 26 to 42 inches

Colour as above; clay with coarse and fine lentil structure; firm, moist; sticky and plastic, wet; many fine roots; clear boundary; wide cracks form with drying.

Lab. No. 2087: Hor. B22: Depth 42 to 50 inches

Greyish-brown (2.5Y 2/2, dry) to dark greyish-brown (2.5 Y 4/2, moist) clay; a few light brown mottles; strong coarse lentil structure; firm, moist; sticky and plastic, wet; few fine roots.

Lab. No. 2088: Hor. B31: Depth 50 to 60 inches

Strongly mottled grey (10YR 5/1) and dark brown (7.5YR 4/4) and black; clay loam; medium angular blocky structure; friable, moist; a few fine roots. Very sticky and plastic, wet.

Lab. No. 2089: Hor. B32: Depth 60 to 72 inches

Strongly mottled dark brown, black and grey clay loam; many black manganese concretions and mica flakes.

Lab. No. 2090: Hor. B3ca: Depth 72 to 80 inches

Strongly mottled brown, light grey, and black clay loam; many black streaks of manganese oxide. Contains a few lime concretions. Firm moist.

Lab. No. 2091: Hor. B34: Depth 80 to 95 inches

Strongly mottled grey, yellowish brown, reddish brown and black clay loam; very micaceous; friable, moist.

Lab. No. 2092: Hor. D1: Depth 95 to 100 inches

Strongly mottled brown, light grey and black loam; very micaceous; many black streaks of manganese oxide; firm, moist.

Lab. No. 2093: Hor. D2: Depth 100 to 112 inches

Mottled light grey and olive brown (2.5YR 4/4) loam; black streaks of manganese oxide; soft, dry; friable, moist.

Lab. No. 2094: Hor. D3ca: Depth 112 to 120 inches

Similar to above with much mica. This grades downward into calcareous (limy) tuff.

Soil Profile: Ngeron Silty Clay Loam (Alternate Site)

Lab. No. 1881: Hor. A1: Depth 0 to 12 inches

Very dark-grey (10YR 3/1.5, dry) to black (10YR 2/1.5, moist) silty clay loam; strong very fine blocky structure; slightly hard, dry; firm, moist; sticky and plastic, wet; abundant roots; clear, wavy boundary.

Lab. No. 1882: Hor. B1: Depth 12 to 28 inches

Very dark grey (2.5YR 3/.5, dry) to black (2.5Y 2/.5, moist) clay; strong medium and fine subangular blocky structure; very hard, dry; firm, moist; very sticky and very plastic, wet; 10 per cent brown "buckshot"; plentiful roots; clear-wavy boundary.

Lab. No. 1883: Hor. B21: Depth 28 to 50 inches

Colour as above; clay; compound strong coarse lentils which break to strong medium and fine lentils; consistence as above; plentiful roots; clear-wavy boundary.

TABLE 80

Ngeron silty clay loam *Map Ref.:* HAA 478021 *Lab. No.:* 2084 to 2094

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– 12	3·04	0·23	24	18·6	3·8	0·70	0·47	5·6	66	39·6	19·2	5–3:7:0	36	34	27
B_1 ..	12– 26	1·85	0·14	15	13·5	3·9	0·60	0·51	5·5	65	39·6	26·1	5–3:6:1	47	26	18
B_{21} ..	26– 42	1·05	0·08	10	15·2	3·9	0·44	0·49	6·1	75	34·8	23·0	6–6:0:4	52	21	21
B_{22} ..	42– 50	0·26	0·03	198	18·8	3·9	0·36	0·50	6·5	93	40·4	16·8	8–7:0:3	43	26	25
B_{31} ..	50– 60	0·26	0·02	238	22·9	3·9	0·56	0·58	6·6	88	41·5	14·9	7–5:4:1	30	38	27
B_{32} ..	60– 72	0·52	0·06	220	31·2	4·7	0·30	0·84	6·7	85	50·4	10·4	7–8:2:1	35	36	22
B_3ca ..	72– 80	0·26	0·02	232	27·0	3·8	0·55	0·59	6·2	90	51·2	10·0	8–8:1:1	38	32	21
B_{34} ..	80– 95	0·26	0·01	235	27·3	4·4	0·56	0·57	6·1	83	50·4	33·6	8–3:6:1	36	34	24
D_1 ..	95–100	nil	nil	232	25·2	3·8	0·54	0·51	6·3	78	47·2	6·8	8–8:1:1	26	33	35
D_2 ..	100–112	nil	0·25	245	38·0	5·1	0·54	1·53	6·5	83	49·2	7·0	8–8:2:0	24	45	27
D_3ca	112–120	nil	0·15	237	28·0	5·6	0·31	1·16	7·4	99	42·4	4·8	9–8:1:0	21	43	29

Ngeron silty clay loam (Alternate) *Map Ref.:* HZN 441999 *Lab. No.:* 1881 to 1887

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 –12	4·0	0·30	74	28·4	3·5	0·50	0·49	5·9	71	42·8	14·7	5–5:5:0	32	52	14
B_1 ..	12– 28	1·7	0·13	5	20·8	2·9	0·52	0·48	5·9	75	41·9	17·2	6–6:2:2	62	25	9
B_{21} ..	28– 50	1·0	0·08	30	24·8	3·2	0·52	0·72	6·8	88	44·3	14·9	6–5:5:0	63	22	11
B_{22} ..	50– 60	0·6	0·05	70	26·8	3·1	0·62	0·91	7·7	94	40·3	10·0	7–6:4:0	64	20	7
B_{23} ..	60– 99	0·4	0·02	298	29·2	2·9	0·58	0·95	7·9	95	43·9	17·5	7–4:6:0	57	26	6
B_{24} ..	99–114	0·3	0·03	292	29·2	3·1	0·61	0·95	7·6	95	49·1	7·3	7–9:0:1	57	26	6
B_3 ..	114–130	0·3	0·02	155	29·6	2·3	0·40	0·93	8·0	100	51·4	12·3	7–7:2:1	52	26	10

Lab. No. 1884: Hor. B22: Depth 50 to 60 inches

Dark-grey (10YR 4/1, dry) to very dark grey (10YR 3/1, moist) clay; compound strong medium blocky and fine lentil structure; consistence as above; plentiful roots; 15 to 20 per cent brown "buckshot" and small hard lime concretions; plentiful fine roots; gradual boundary.

Lab. No. 1885: Hor. B23: Depth 60 to 99 inches

Dark-grey (10YR 4/.5, dry) to very dark grey (10YR 3/.5, moist) clay; coarse mottles of yellowish brown (10YR 5/4) and black; compound strong medium and fine lentil structure; consistence as above; no roots observed; gradual boundary.

Lab. No. 1886: Hor. B24: Depth 99 to 114 inches

Colour as above with an increase of yellowish-brown mottles (about 30 per cent) clay; structure and consistence as above; clear boundary.

Lab. No. 1887: Hor. B3: Depth 114 to 130 inches

Very dark grey (10YR 3/.5, moist) mottled 50 per cent brown (10YR 5/3) clay; structure as above; hard, dry; firm, moist; sticky and plastic, wet; numerous hard lime concretions $\frac{1}{8}$ to $\frac{1}{4}$ inch in size.

Range in Characteristics.—Surface textures range from silty clay loam to clay loam. Generally the soils are slightly greyer (chromas as low as .5) and less mottled than the first described profile. Lime concretions are generally present in the profile.

Relief.—Gently to moderately sloping colluvial-alluvial fans.

Drainage.—These soils are normally dry enough to cultivate, but become temporarily waterlogged during the rainy season.

Vegetation.—High-rainfall savannah, with dense growth of coarse grasses.

Use.—Most of the Ngeron soil is planted to maize, sisal and pasture. It produces excellent crops of maize and sisal, and sugar cane should do well.

Known Distribution.—On colluvial-alluvial slopes in the Songhor Soil Survey area.

Type Location.—Approximately $\frac{1}{2}$ mile south of Major Cattle's house.

Remarks.—The "lentil" structure in Ngeron and other heavy clay soils consists of lens- or lentil-shaped peds from ¼ in. in largest dimension to several inches. This structure is most noticeable when the soil is thoroughly saturated with water, when the large and small lentils separate very easily. Water circulates between the lentils.

NYANDO SERIES

The Nyando series includes moderately dark coloured fertile soils of river terraces, just above flood levels, in Central Nyanza. Reaction is neutral to slightly alkaline throughout and the soils have an abundance of available phosphorus and calcium. Subsoils are stratified, medium-textured alluvium and have much less clay than the Koru soils.

Soil Profile: Nyando Clay Loam

Lab. No. 3147: Hor. A11: Depth 0 to 5 inches

Very dark brown moist to dark-brown dry (7.5YR 2/2, 3/2) fine to medium-granular clay loam; firm, dry; friable, moist; plastic and sticky, wet; many roots; moderately permeable.

Lab. No. 3148: Hor. A12: Depth 5 to 17 inches

Slightly lighter colours (7.5YR 2.5/2, 3.5/2) compound coarse and medium-blocky clay loam; other features as above.

Lab. No. 3149: Hor. C1: Depth 17 to 32 inches

Very dark greyish-brown moist to dark greyish-brown dry (10YR 3/2, 4/2) medium-blocky loam; firm, dry; friable, moist; plastic and sticky, wet; many roots; permeable.

Lab. No. 3150: Hor. C2: Depth 32 to 50 inches

Differs from above only in being mottled with reddish brown (5YR 4/5).

Lab. No. 3151: Hor. C3: Depth 50 to 70 inches

Mottled brown, dark brown and dusky red, medium blocky loam; firm, dry; friable, moist; sticky and plastic, wet; fewer roots; moderately permeable.

Lab. No. 3152: Hor. C4: Depth 70 to 85 inches

Similar to above except that mottles are of stronger colours. This grades into stratified, more or less, sandy alluvium.

Range in Characteristics.—Colours are darker in slight depressions where mottling is at shallower depths. Surface soils may range from sandy loam to clay loam.

Relief.—Nearly level low stream terraces. Local areas may be flooded occasionally.

Drainage.—External drainage is slow; internal drainage of deep subsoil is slightly impeded as indicated by the mottled colours.

Vegetation.—Formerly, high rainfall savannah. Practically all of the land is now cultivated.

Use.—Used for maize, fruits and other subsistence crops. Yields are moderate to good and could be excellent under good management. This would be an excellent soil for sugar cane.

Known Distribution.—Terraces of Nyando River, south of Chemelil Station.

Type Location.—HZN 346857 about 1¾ miles south of Chemelil Station.

Nyangoro Series

The Nyangoro series includes reddish, acid, shallow to medium-depth soils, with a moderate amount of organic matter, developed from weathered gneiss. The soils are akin to Brown Forest soils of low base status in temperate regions. The rainfall averages close to 50 inches a year, with a dry season from December to March, and the mean annual temperature probably is not far from 70° F.

Soil Profile: Nyangoro Stony Sandy Loam

Lab. No. 3732: Hor. A11: Depth 0 to 7 inches

Black moist to very dark grey dry (7.5YR 2/1, 3/1), granular stony sandy loam; firm, dry; friable, moist; slightly plastic and sticky, wet; matted with grass and tree roots; very permeable. Many fragments of quartz.

Lab. No. 3733: Hor. A12: Depth 7 to 16 inches

Very dark brown moist, to dark-brown dry (7.5YR 2/2, 3/2) granular stony coarse sandy loam; hard dry; friable moist; plastic and sticky wet; abundant roots; very permeable. Many fragments of quartz and weathered gneiss.

Lab. No. 3734: Hor. B2: Depth 16 to 30 inches

Dark reddish-brown moist to reddish-brown dry (5YR 3/4, 4/4), mottled brown, subangular-blocky sandy clay loam; hard dry; friable, moist; plastic and sticky, wet; plentiful roots; permeable. Quartz "stone line" at base. Peds are coated with dark-brown clay.

TABLE 8p

Nyando clay loam *Map Ref.:* HZN 346857 *Lab. No.:* 3147 to 3152

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_{11} ..	0– 5	1·75	0·13	280	26·6	4·7	0·7	0·6	6·4	85	44·7	11·8	3–8:0:2	34	30	36
A_{12} ..	5– 17	0·90	0·08	138	18·8	3·4	0·3	0·8	6·5	90	47·2	10·9	4–8:0:2	32	26	42
C_1 ..	17– 32	0·50	0·07	200	22·4	3·9	0·4	1·0	7·3	96	56·0	7·6	4–8:2:0	24	34	42
C_2 ..	32– 50			170	28·0	2·5	0·4	1·1	7·7	98	46·4	11·0	5–8:2:1	22	38	40
C_3 ..	50– 70			202	26·4	3·4	0·4	2·0	7·7	100	51·2	17·8	5–5:5:0	26	32	42
C_4 ..	70– 85			270	21·6	3·1	0·5	0·5	7·9	96	48·8	17·8	6–6:3:1	26	38	35

Nyangoro stony sandy loam *Map Ref.:* HZN 452958 *Lab. No.:* 3732 to 3735

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_{11} ..	0– 7	2·76	0·11	30	7·5	2·6	0·6	0·2	5·8	77	14·8	7·7	6–5:4:1	14	22	64
A_{12} ..	7– 16	1·45	0·40	7	4·6	1·9	0·4	0·1	6·0	52	10·4	8·4	6–4:3:3	12	16	72
B_2 ..	16– 30	1·26	0·04	6	3·2	1·8	0·4	0·1	5·3	64	15·0	13·9	5–4:3:3	26	22	52
C_1 ..	30– 36	0·87	nil	7	1·2	1·3	0·3	0·1	5·6	55	6·2	11·1	6–0:7:3	6	16	78

Lab. No. 3735: Hor. C1: Depth 30 to 36 inches

Slightly weathered pinkish granitoid gneiss.

Range in Characteristics.—Some of the Nyangoro soil has relatively few stones. Textures range from loamy coarse sand to sandy clay loam; and depth to rock from about 18 to about 40 inches.

Relief.—Moderately sloping to very steep hills and mountains.

Drainage.—Run-off is rapid to very rapid; internal drainage is moderate to free.

Vegetation.—Open forest and high-rainfall savannah, with coarse-grass understory.

Use.—Some of the more favourable areas are cultivated with the hoe and used for maize, fruits and other subsistence crops. Much of the stony land is used for pasture and much is essentially idle.

Known Distribution.—Along the Nandi Escarpment and on outlying hills of gneiss.

Type Location.—HZN 452958, about 1 mile north of Songhor Post Office.

Patel Series

Patel soils are the most poorly drained of the Perry, Chemelil, Volo and Patel soil association. They belong in the great group of Low-Humic Glei soils. They are moderately acid at plough-soil depth and neutral in reaction in the subsoil. Parent materials are clay, and probably some volcanic ash, that were laid in the former lakes and swamps around the eastern end of the Kano Plain.

Soil Profile: Patel Clay Loam

Lab. No. 3159: Hor. A1p: Depth 0 to 11 inches

Very dark greyish-brown moist, to greyish-brown dry (10YR 3/2, 4/2), fine granular clay loam; hard, dry; friable, moist; plastic and sticky, wet; many roots; moderately permeable. Contains 5 to 10 per cent of small black concretions.

Lab. No. 3160: Hor. B1g: Depth 11 to 30 inches

Grey moist, to light-grey dry (10YR 5/1, 7/1), fine-granular gravelly clay loam; firm, dry; moderately friable, moist; sticky and plastic, wet; many roots; moderately permeable. The 20 to 40 per cent gravel in this horizon consists of hard black and brown concretions up to $\frac{3}{8}$ inch in diameter.

Lab. No. 3161: Hor. B21g: Depth 30 to 50 inches

Dark greyish-brown moist, to grey dry (10YR 4/1, 5/1) weakly medium blocky (nearly massive) clay; hard, dry; plastic, moist; very sticky and plastic, wet; few roots; very slowly permeable. The soil is mottled with dark brown and contains 5 to 10 per cent of small black concretions.

Lab. No. 3162: Hor. B22g: Depth 50 to 80 inches

(*Note.*—Depth 60 to 80 inches not analysed; it was about the same as 50 to 60 inches.) Brown moist, to pale-brown dry (10YR 4/3, 7/3), mottled dark brown and dark grey, clay with varying proportions of small concretions; hard, dry; sticky and plastic, wet; no roots; very slowly permeable.

Lab. No. 3163: Hor. B3g: Depth 80 to 84 inches

Mottled grey, brown and strong brown light clay; consistence as above; no roots; slowly permeable and continuously wet.

Range in Characteristics.—Some of the soil has very few concretions; texture of plough soil varies from sandy clay loam to light clay.

Relief.—Nearly level and usually lower than all surrounding soils.

Drainage.—Very slow from the surface and through the soil. Water stands intermittently on the surface for considerable periods during and immediately after the rainy season.

Vegetation.—Largely drained and cultivated. High-rainfall savannah with moisture-loving species of trees and herbaceous plants.

Use.—Largely planted to sugar cane after surface drains have been dug. Some land is used for pasture.

Known Distribution.—On the lake plains at the head of the Kano Plain, chiefly around Chemelil Station.

Type Location.—HZN 354907, about 2 miles north-north-east of Chemelil Station.

PERRY SERIES

The Perry series includes soils resembling maximally developed Reddish-Brunizen (Reddish-Prairie) soils which occur at the inner edges of the lake plain remnants adjacent to the eroded and broken areas of deep river valleys. The parent material consists of fine-textured lake deposits underlain by gravel and cobble beds. They are characterized by a dark-brown granular clay loam surface overlying dark reddish-brown fine-blocky clay. The Perry soils

TABLE 8q

Patel clay loam — *Map Ref.*: HZN 354907 — *Lab. No.*: 3159 to 3163

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				
$A_{1}p$ ..	0– 11	2·09	0·13	11	8·0	3·5	0·6	0·4	5·5	52	22·8	22·9	2–4:2:4	24	22	54
$B_{1}g$ ..	11– 30	0·60	0·05	5	1·9	1·9	0·3	0·4	6·0	65	24·0	21·5	2–1:9:0	31	22	47
$B_{21}g$ ..	30– 50	0·40	0·05	8	5·5	2·7	0·7	1·2	5·9	73	29·0	34·9	5–3:4:3	56	12	32
$B_{22}g$ ..	50– 80			15	6·3	2·5	0·8	1·6	6·8	85	30·0	24·2	6–5:1:4	56	14	32
$B_{3}g$ ..	80– 84			80	9·0	4·2	0·7	1·6	6·7	85	30·0	20·0	8–6:0:4	46	16	38

Perry clay loam — *Map Ref.*: HZN 418974 — *Lab. No.*: 1792 to 1799

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– 11	1·6	0·15	45	12·0	3·6	1·80	0·28	5·9	45	31·1	16·7	5–3:7:0	38	29	28
B_{1} ..	11– 14	1·6	0·13	0	8·4	3·2	0·80	0·24	5·5	56	28·8	26·5	4–2:6:2	49	28	20
B_{21} ..	14– 26	1·5	0·11	0	7·2	4·0	0·54	0·28	5·6	58	22·8	27·8	4–2:5:3	53	24	16
B_{22} ..	26– 48	0·7	0·07	0	5·2	3·6	0·56	0·20	5·6	50	25·7	28·6	4–1:7:2	56	21	18
B_{31} ..	48– 90	nil	0·04	0	7·9	3·8	1·04	0·48	6·0	75	30·6	30·2	5–1:9:0	54	29	14
B_{32} ..	90–102	nil	0·03	3	9·2	4·0	1·12	0·60	6·2	86	32·4	16·9	5–4:5:1	48	32	17
C_{1} ..	102–114	nil	0·03	7	8·4	3·8	1·04	0·60	6·2	76	23·6	15·7	8–6:1:4	44	27	22
C_{2} ..	114–128	nil	0·03	19	9·6	4·2	1·08	0·80	6·0	84	34·8	14·8	6–7:1:2	48	30	17

are the well drained members of the soil catena that also includes the moderately well drained Chemelil, imperfectly drained Volo and the poorly drained Patel series. They occur in the same relative position on the lake plain as the Mbogo soils, but are more permeable and better drained.

Soil Profile: Perry Clay Loam

Lab. No. 1792: Hor. Ap: Depth 0 to 11 inches

Dark-brown (7.5YR 3/2) clay loam; weak granular structure. (Disturbed by recent cultivation.)

Lab. No. 1793: Hor. B1: Depth 11 to 14 inches

Dark reddish-grey (5YR 4/2, dry) to dark reddish-brown (5YR 3/2, moist) clay; crushed colour of aggregates is dark reddish brown (5YR 3/3, moist) to reddish brown (5YR 4/3, dry), nuciform structure; hard, dry; plastic, wet.

Lab. No. 1794: Hor. B21: Depth 14 to 26 inches

Reddish-brown (5YR 4/3, dry) to dark reddish-brown (5YR 3/3, moist) clay, crushing to 3/4, 4/4 clay; strong fine blocky structure; very firm, moist; sticky and plastic, wet, but does not shrink much with drying.

Lab. No. 1795: Hor. B22: Depth 26 to 48 inches

Reddish-brown (5YR 4/4, dry) to dark reddish-brown (5YR 3/4, moist), crushing to 3/5, 4/5 clay; strong fine-blocky structure; friable, moist; sticky and plastic, wet; little or no mica to this depth.

Lab. No. 1796: Hor. B31: Depth 48 to 90 inches

Reddish-brown (5YR 3/5, 4/5 and 7.5YR 4/4, 5/4 crushed) clay; strong fine-blocky structure; half-inch black manganese spots filling 20 per cent of volume and 10 per cent "buckshot"; mica abundant; friable, moist; plastic, wet.

Lab. No. 1797: Hor. B32: Depth 90 to 102 inches

Slightly greyer, heavier and stiffer than above. Micaceous; black manganese oxide spots take up about 30 per cent of the space. Shrinks with drying.

Lab. No. 1798: Hor. C1: Depth 102 to 114 inches

Alternating friable and stiff micaceous clay with mottled colours about like 48- to 90-inch horizon; shrinks strongly with drying.

Lab. No. 1799: Hor. C2: Depth 114 to 128 inches

Similar to above but much less friable; clay; very firm, moist; sticky and plastic, wet; mica abundant; stratified more or less gravelly sediments of mixed acidic and basic origin lie below, intercallated with layers of volcanic ash.

Range in Characteristics.—The amount and size of concretions varies considerably. Surface textures range from silty clay loam to light clay.

Relief.—Nearly level to gently sloping lake plains.

Drainage.—These soils are well drained. Run-off is moderate.

Vegetation.—High-rainfall savannah. Much coarse grass.

Use.—The Perry soils are being used for maize, sisal, coffee and pasture. They are well suited for growing sugar cane and moderately well suited for coffee.

Known Distribution.—On lake plains in the Songhor Soil Survey area.

Type Location.—Approximately ⅓ mile north-west of the two bridges at the junction of Ainomotua and Ainopsiwa rivers in the Songhor Soil Survey area.

RAMA SERIES

The Rama series includes dark-coloured moderately well-drained clayey soils with a moderate amount of organic matter, developed from volcanic ash and clay, laid in former swamps and lakes. The soils are associated closely with Kibigori and Aristos soils which are developed on the same kind of material, but are not so well drained. The Rama soils are closely related to the "Brown Soils of Heavy Texture" of Australia. Available phosphorus is law in the uppermost 2 to 3 feet, but high below. The fairly high exchangeable sodium is more than balanced by exchangeable calcium.

Soil Profile: *Rama Clay Loam*

Lab. No. 2510: Hor. A1: Depth 0 to 5 inches

Dark-brown moist to brown dry (7.5YR 3/1.5, 4/1.5) strongly fine granular heavy clay loam; hard dry; firm, moist; sticky and plastic, wet; many roots; moderately permeable.

Lab. No. 2511: Hor. B21: Depth 5 to 17 inches

Very dark greyish-brown moist to dark greyish-brown dry (10YR 3/1.5, 4/1.5) strongly medium lentil-blocky heavy clay; hard, dry; firm, moist; plastic and sticky, wet; many roots; moderately permeable.

Lab. No. 2512: Hor. B22: Depth 17 to 25 inches

Similar to above, but with less clay.

Lab. No. 2513: Hor. B2ca: Depth 25 to 45 inches

Brown moist to light-brown dry (10YR 4/3, 6/3), with dark-brown mottles, compound medium and fine-blocky clay, with a few lime concretions; hard, dry; firm, moist; sticky and plastic, wet; some roots; moderately permeable.

Lab. No. 2514: Hor. B3ca: Depth 45 to

Similar to above, but with a few r
lime concretions. About 10 per cent "buc

Lab. No. 2515: Hor. C1: Depth 60 to 74

Similar colours; texture sandy c
manganese oxide concretions; consisten
moderately permeable.

Lab. No. 2516: Hor. C2: Depth 74 to 8

Similar to last except fewer concreti

Range in Characteristics.—The horizons
lime concretions have been brought to the s
action (shrinking and swelling).

Relief.—Nearly level to gently sloping
3 per cent.

Drainage.—Surface drainage slow to mo
what slow. The soil is never waterlogged.

Vegetation.—Scrubby thorn trees, chiefly

Use.—Used for subsistence crops, pastu
Yields are moderate.

Known Distribution.—Kano Plain near
where surface drainage is good.

Type Location.—HZN 352863, 1¼ mile
Station.

RARAGEWIT SERIES

Raragegwit series includes soils intermedi
Humic Glei soils, developed from mixed c
deposits that came largely from hills and
Volcanic ash may have contributed to the soil
entirely converted to soil by weathering. The s
the rainy season but dries out during the dry
to the Mbereri, Ainomotua and Kapkuong ser
with dry season from December to March.

Soil Profile: *Raragewit Sandy Clay Loam*

Lab. No. 3136: Hor. A1: Depth 0 to 6 i

Vary dark grey moist, to dark-gre
granular sandy clay loam; with a few sm
moderately friable, moist; sticky and plas

inches

and black mottles and more
ot" concretions; few roots.

ches

loam; 15 per cent black
as above; very few roots;

ches

ry greatly in thickness and
ce in some places by gilgai

th gradients, usually below

ate; internal drainage some-

cacia seyal, and tall grasses.

nd for growing sugar cane.

e edges of stream valleys,

outh-south-east of Chemelil

between Solonetz and Low
ey and sandy alluvial fan
ntains of granitoid gneiss.
aterial but, if so, it has been
is subject to seepage during
son. Associated soils belong
Rainfall is 45 to 50 inches,

es

lry (5Y 3/1, 4/1), weakly
iron concretions; hard, dry;
wet; many roots.

TABLE 8r

Rama clay loam *Map Ref.*: HZN 352863 *Lab. No.*: 2510 to 2516

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	2·54	0·15	7	17·2	5·6	1·44	1·28	6·6	74	35·2	37·7	3–3:4:3	40	28	32
B_{21} ..	5– 17	1·27	0·10	8	20·8	5·1	0·76	1·84	6·7	85	38·4	45·4	3–1:7:2	64	12	24
B_{22} ..	17– 25	0·99	0·09	7	29·6	6·4	0·82	2·52	8·4	100	42·4	34·8	6–2:7:1	48	30	22
B_2ca ..	25– 45	0·56	0·14	32	24·8	5·1	0·79	2·76	8·6	100	39·2	38·7	7–1:8:1	46	28	26
B_3ca ..	45– 60	0·27	0·02	70	25·2	6·7	0·59	2·88	8·7	100	36·8	36·7	8–3:5:3	44	28	28
C_1 ..	60– 74	0·39	0·02	115	15·6	4·6	0·57	2·32	8·4	96	35·6	34·6	8–2:6:2	26	42	32
C_2 ..	74– 85	0·36	0·03	129	14·0	4·5	0·58	2·28	8·3	100	34·8	34·7	8–0:10:0	34	36	30

Raragegwit sandy clay loam *Map Ref.*: HZN 396815 *Lab. No.*: 3136 to 3140

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	2·50	0·14	6	8·0	3·1	0·8	0·7	6·3	66	28·0	11·3	4–5:5:0	20	16	64
B_{21} ..	6– 24	0·90	0·07	10	10·0	3·1	0·4	1·1	6·2	85	30·0	19·3	6–4:4:2	46	12	42
B_{22} ..	24– 30	0·55	0·05	13	10·0	3·2	0·6	1·2	6·9	93	37·0	11·6	5–5:5:0	48	10	42
Dg_1 ..	30– 42			22	11·6	3·3	0·6	1·4	7·5	97	30·0	9·5	7–6:4:0	38	16	46
Dg_2 ..	42– 60			25	12·4	3·0	0·7	1·7	7·6	94	29·0	11·7	7–5:5:0	24	16	60

Lab. No. 3137: Hor. B21: Depth 6 to 2

Slightly lighter colour with about 20
shot" concretions; compound coarse an
clay skins on peds; hard, dry; stiff, moist
roots.

Lab. No. 3138: Hor. B22: Depth 24 to

Similar to above, with slickensides o
ful. Water often stands in the soil below t
and immediately afterwards.

Lab. No. 3139: Hor. Dg1: Depth 30 to

Brown moist to light-brown dry (10
reddish yellow and greyish-brown, san
fewer roots.

Lab. No. 3140: Hor. Dg2: Depth 42 to

Dark greyish-brown moist, to greyi
mottled black, yellow and red, blocky sa
cent gneiss gravel; few roots.

Range in Characteristics.—Plough soil te
heavy clay loam, and there is considerable
sandy clay subsoils. Lime concretions common

Relief.—Sloping alluvial fans with slope
Surface is broken by 2 to 3 termite mounds p

Drainage.—Surface drainage moderate t
many areas subject to seepage during the rai

Vegetation.—Scattered thornbush, chie
grasses.

Use.—Used chiefly for pasture and for gr
poor for sisal.

Known Distribution.—Alluvial fans nort
Muhoroni.

Type Location.—Junction of Muhoroni-
roads, Central Nyanza.

SONGHOR SERIES

The Songhor series includes Planoso
materials on level to slightly depressed lake
horizons which are underlain by a heavy, p
occur in association with the Kibigori soils w

nches

r cent reddish-brown "buck-
fine-blocky sandy clay with
ticky and plastic, wet; many

inches

lock faces. Roots still plenti-
level during the rainy season

inches

5/3, 6/3) coarsely mottled
clay; consistence as above;

+ inches

brown dry (10YR 4/2, 6/2)
clay loam with 20 to 30 per

es range from sandy loam to
iation in the colours of the
occur at depths of 4 to 8 feet.

adients of 3 to 13 per cent.
acre.

apid; internal drainage slow;
season.

Acacia seyal and coarse

ing sisal. Fair pasture, rather

f Kibigori and south-west of

umu and Muhoroni-Kericho

developed in fine-textured
ins. They have silty surface
ic clay subsoil. Some areas
h are Grumusols developing

on somewhat better drained areas on the lake plains. The Songhor soils may have developed by degredation of these Grumusols. They also occur in association with the Volo soils which are Low Humic Glei soils. Some areas of Songhor soils lie immediately below and in contact with either Ainomotua or Kapkuong soils, or both.

Soil Profile: *Songhor Silt Loam*

Lab. No. 1759: Hor. A1: Depth 0 to 8 inches

Very dark greyish-brown (10YR 3/2), dry, to very dark brown (10YR 2/3), when moist, silt loam; crumb structure, a few "buckshot".

Lab. No. 1760: Hor. A2: Depth 8 to 14 inches

Grey (10YR 6/1, dry) to dark grey (10YR 4/1, moist) silt loam; weak crumb structure; 5 per cent "buckshot".

Lab. 1761: Hor. B1-B2: Depth 14 to 22 inches

Dark grey (10YR 4/1, dry) to very dark grey (10YR 3/1, moist) clay loam; weak medium columnar structure which breaks to strong fine blocks; 5 per cent "buckshot".

Lab. No. 1762: Hor. B2g: Depth 22 to 36 inches

Colour as above; silty clay; strong medium and fine-blocky structure; thin continuous clay skins.

Lab. No. 1763: Hor. B23g: Depth 36 to 39 inches

Dark grey (10YR 4/1.5, dry) to very dark grey (10YR 3/1.5, moist) clay; strong medium lentil structure; thick continuous clay skins; sticky and plastic, wet.

Lab. No. 1764: Hor. B24g: Depth 39 to 45 inches

Dark grey (10YR 4/1, dry) to very dark grey (10YR 3/1, moist) clay; strong medium to coarse lentil structure; 5 per cent dark brown (7.5YR 4/4) "buckshot".

Lab. 1765: Hor. B3cag: Depth 45 to 53 inches

Dark greyish-brown (10YR 4/2, dry) to very dark greyish-brown (10YR 3/2, moist) clay loam; strong medium lentil structure; about 3 per cent "buckshot" and a few lime concretions.

Lab. No. 1766: Hor. C1g: Depth 53 to 73 inches

Dark grey (10YR 4/1, dry) to very dark grey (10YR 3/1, moist) clay; strong medium lentil structure; about 5 per cent "buckshot".

Lab. No. 1767: Hor. C2cag: Depth 73 to 90 inches

Dark grey (2.5Y 4/1, dry) to very dark grey (2.5Y 3/1, moist) clay; lentils as above; lime concretions.

TABLE 8s

Songhor silt loam *Map Ref.*: HZN 458942 *Lab. No.*: 1759 to 1768

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	2·30	0·18	10	12·4	3·2	0·40	0·46	5·7	61	26·3	8·9	4–7:1:2	21	60	12
A_2 ..	8– 14	1·00	0·07	0	7·8	1·5	0·40	0·48	5·9	79	16·3	8·5	5–4:5:1	18	59	18
B_1–B_2	14– 22	0·38	0·06	6	15·2	3·3	0·72	0·50	6·3	84	24·8	12·9	6–5:3:2	35	45	13
$B_{2}g$ ..	22– 36	0·47	0·04	10	19·6	3·9	0·88	1·28	7·3	94	30·0	10·2	7–7:1:2	43	41	6
$B_{23}g$ ..	36– 39	0·38	0·04	12	20·4	4·4	0·96	1·36	7·5	94	29·1	13·1	6–6:3:1	43	20	28
$B_{24}g$ ..	39– 45	0·38	0·05	15	24·8	5·1	1·02	1·52	7·5	94	31·7	14·3	7–7:0:3	54	21	10
B_3cag	45– 53	0·10	0·03	62	35·2	5·2	0·92	1·56	7·8	99	37·7	8·3	7–8:0:2	39	33	15
C_1g ..	53– 73	0·35	0·02	57	28·0	5·3	1·08	1·56	7·6	96	40·3	18·1	6–7:0:3	63	29	5
C_2cag	73– 90	0·35	0·02	42	39·2	6·8	0·94	1·52	7·9	100	41·1	9·1	8–8:0:2	63	30	6
C_3cag	90– 96	0·12	0·02	44	64·0	6·5	0·88	1·64	7·9	99	39·4	8·7	8–8:0:2	54	30	9

Songhor silt loam (Alternate) *Map Ref.*: HZN 402956 *Lab. No.*: 1800 to 1807

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	3·4	0·26	27	8·4	3·3	0·72	0·48	5·9	63	28·3	14·7	5–7:0:3	24	57	16
A_2 ..	6– 10	1·5	0·11	0	9·6	2·6	0·44	0·20	5·9	67	24·1	8·0	5–8:0:2	20	56	25
B_1–B_2	10– 15	1·1	0·09	0	10·8	2·5	0·44	2·56	5·6	71	24·1	10·9	6–6:2:2	32	44	20
$B_{22}g$	15– 34	0·8	0·11	3	16·4	2·8	0·64	1·36	6·0	86	36·8	13·6	5–6:2:2	55	30	9
$B_{23}g$ ..	34– 48	0·3	0·07	32	19·2	3·2	0·84	1·52	6·6	86	40·5	8·2	7–7:3:0	63	26	10
$B_{24}g$ ..	48– 66	0·3	0·03	62	19·2	3·1	0·76	1·40	7·2	97	42·8	2·6	6–9:1:0	55	33	7
B_3cag	66– 92	0·1	0·02	115	56·0	2·2	0·60	1·48	7·8	100	28·0	7·0	9–8:0:2	46	35	7
C_1 ..	92– 98	0·1	0·02	97	16·2	3·0	0·74	1·20	7·5	98	27·0	3·8	7–9:1:0	39	43	4

Lab. No. 1768 : Hor. C3cag : Depth 90 to 96 inches

Dark grey to very dark grey (2.5Y 4/1.5, dry) to (2.5YR 3/1.5, moist) clay; strong medium and fine lentil structure; many hard irregular lime concretions; This lies on weakly stratified clayey and silty sediments.

Soil Profile : Songhor Silt Loam (Alternate Site)

Lab. No. 1800 : Hor. A1 : Depth 0 to 6 inches

Very dark greyish-brown (10YR 3/2, dry) to very dark brown (10YR 2/2, moist) silt loam with moderate medium angular blocky structure; friable, moist; non-sticky and non-plastic, wet; diffuse boundary.

Lab. No. 1801 : Hor. A2 : Depth 6 to 10 inches

Grey (10YR 5/1, dry) to dark-grey (10YR 4/1, moist) silty loam; many fine mottles of light grey (10YR 7/1) to grey (10YR 5/1); massive structure; a few fine iron concretions; very friable, moist; non-sticky and non-plastic, wet; clear and wavy boundary.

Lab. No. 1802 : Hor. B1-B2 : Depth 10 to 15 inches

Very dark grey (10YR 3/1, dry and moist) clay loam; moderate coarse columnar structure that breaks to weak medium angular blocks; grey silt coatings on column tops and sides; 15 per cent fine iron concretions; hard, dry; sticky, and plastic, wet; diffuse boundary.

Lab. No. 1803 : Hor. B22g : Depth 15 to 34 inches

Very dark grey (10YR 3/.75, dry and moist) clay; moderate coarse columnar structure that easily breaks to strong coarse and medium blocks; moderate, thick clay skins on all ped faces; 5 to 10 per cent brown iron concretions; very hard, dry; firm, moist; sticky and plastic, wet; diffuse boundary.

Lab. No. 1804 : Hor. B23g : Depth 34 to 48 inches

Very dark grey (10YR 3/.5, moist) clay; strong medium angular blocky structure; thin continuous clay skins on all ped faces; 15 per cent fine brown iron concretions; consistence as above; diffuse boundary.

Lab. No. 1805 : Hor. B24g : Depth 48 to 66 inches

Dark grey (10YR 4/1, dry) to very dark grey (10YR 3/1, moist); moderate medium and fine angular blocky structure. Crushed colour of aggregates is dark greyish-brown (10YR 4/2, moist). Consistence as above.

Lab. No. 1806 : Hor. B3cag : Depth 66 to 92 inches

Very dark grey (10YR 3/1.5, moist) clay; moderate fine angular blocky structure; thin clay skins on all ped faces; many hard lime concretions.

Lab. 1807: Hor. C1: Depth 92 to 98 inches

Greyish-brown (2.5Y 5/2, dry) to dark greyish-brown (2.5Y 4/2, moist) silty clay loam; many fine mottles of yellow and light grey.

Range in Characteristics.—Texture of the surface horizon varies from silty clay loam to silt loam. The thickness of the A2 ranges from only a trace to 12 inches.

Relief.—Nearly level to depressional; slopes are usually less than 1 per cent.

Drainage.—Natural drainage is imperfect to poor. Runoff is very slow or lacking; internal water movement is very slow.

Vegetation.—Scattered shrubby trees (including fever trees) and several species of tall grasses.

Use.—Most farmers have avoided cultivation of the soils and consequently the present use of this soil is for pasture. These soils should produce moderately good yields of sugar cane providing adequate drainage systems are installed to remove excess surface water.

Known Distribution.—In scattered areas on the lake plains within the Songhor Soil Survey area.

Type Location.—Approximately ¼ mile north and ¼ mile east of Songhor.

SOSSOK SERIES

The Sossok series includes moderately deep reddish-brown forest soils developed from dark coloured fine-grained igneous rocks. They have been formed from weathered basalt, tuff, volcanic breccia and other dark igneous rocks. They are characterized by dark reddish-brown, friable clay loam surface soils and dark reddish-brown to strong-brown subangular blocky subsoils which are underlain by hard rock at 30 to 60 inches. They occur in intimate association with the Kipsesin soils which are Lithosols developing from similar parent material. They occupy smoother and more gentle slopes than the Kipsesin soils and are much less stony.

Soil Profile: *Sossok Clay Loam*

Lab. No. 1908: Hor. A1: Depth 0 to 7 inches

Dark reddish-brown (5YR 2/2 dry, 3/2 moist) clay loam; moderate very fine granular structure; friable, moist; this horizon varies from about 6 to about 12 inches in thickness.

Lab. No. 1909: Hor. B2: Depth 7 to 23 inches

Dark reddish-brown (2.5YR 3/3 dry, 3/4 moist) clay; strong medium subangular blocky structure; friable, moist; sticky and plastic, wet; clear wavy boundary.

Lab. No. 1910: Hor. B3: Depth 23 to 32 inches

Strong brown (7.5YR 5/6 dry) to dark reddish-brown (5YR 3/3, moist) clay loam; strong fine subangular blocky structure; friable, moist; gradual wavy boundary.

Lab. No. 1911: Hor. C1: Depth 32 to 40 inches

Brown (10YR 5/3, moist) clay loam; friable, moist; this is decayed volcanic breccia. It grades below 40 inches into hard rock.

Range in Characteristics.—Depth to hard rock varies from 2½ to 5 feet. Occasional large boulders are found on the surface and through the soil. Subsoil colours range from strong brown to red.

Relief.—Gently to moderately sloping, usually on plateau remnants and footslopes.

Drainage.—These soils are well drained. Runoff is medium to rapid, and water drains well through the soil.

Vegetation.—Open forest and high rainfall savannah. Most of soil now under cultivation.

Use.—These soils are used for the production of most kinds of subsistence crops, coffee and citrus. They are good soils for these crops and should be good for sugar cane. Termites may be a problem with sugar cane.

Known Distribution.—On gentle slopes within the hilly to mountainous areas in the Songhor Soil Survey area.

Type Location.—In coffee *shamba* near Sossok House.

Tennant Series

The Tennant series includes well-drained Alluvial soils, rich in humus and phosphorus, and only slightly acid in reaction. They are flooded occasionally by streams. They differ from the Nandi soils chiefly in having several times as much available phosphorus and in having no reddish colour in the deep subsoil. The associated Lemaiywa soils are swampy.

TABLE 8t

Sossok clay loam *Map Ref.:* HAA 456012 *Lab. No.:* 1908 to 1911

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	2·6	0·24	205	19·6	2·6	1·24	0·26	5·9	56	41·6	19·3	2–4:5:1	42	41	13
B_2 ..	7– 23	1·3	0·13	13	12·4	2·1	0·56	0·24	5·9	59	30·4	31·6	3–2:6:2	54	30	9
B_3 ..	23– 32	0·3	0·05	5	13·0	2·2	0·92	0·36	6·0	72	33·6	48·0	4–0:8:2	37	36	21
C_1 ..	32– 40	0·2	0·02	19	15·4	2·9	1·06	0·33	6·1	78	10·8	32·2	4–2:7:1	29	28	44

Tennant sandy loam *Map Ref.:* HZN 432997 *Lab. No.:* 3723 to 3727

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_{11} ..	0– 10	2·26	0·13	298	20·0	3·3	0·6	0·3	6·2	81	26·8	11·4	5–6:3:1	10	18	72
$A_{11}b$ ..	10– 19	2·70	0·13	295	23·6	3·5	0·6	0·3	6·2	85	35·2	17·0	6–6:2:2	16	24	60
A_{12} ..	19– 30	3·33	0·15	294	26·4	4·0	0·3	0·3	6·3	86	41·6	15·3	4–6:2:2	18	22	60
$A_{12}b$ ..	30– 38	1·67	0·08	290	16·8	2·7	0·2	0·3	6·2	75	26·8	11·3	8–6:2:2	16	14	70
A_1bb ..	38– 60	2·18	0·07	280	26·8	2·8	0·3	0·4	6·2	75	30·0	11·8	6–7:1:2	24	26	50

Soil Profile: *Tennant Sandy Loam*

Lab. No. 3723: Hor. A11: Depth 0 to 10 inches

Black moist, to very dark grey, dry (10YR 2/1, 3/1) fine granular humus-rich sandy loam; soft, dry; very friable moist; slightly plastic, wet; matted with roots; very permeable.

Lab. No. 3724: Hor. A11b: Depth 10 to 19 inches

Same colour and texture as above, but with subangular blocky structure; consistence as above.

Lab. No. 3725: Hor. A12: Depth 19 to 30 inches

Black moist to very dark grey, dry (7.55YR 2/1, 3/1) with other properties as above.

Lab. No. 3726: Hor. A12b; Depth 30 to 38 inches

Very dark brown moist to very dark greyish-brown dry (10YR 2/3, 3/2) subangular-blocky sandy loam; firm dry; very friable moist; slightly sticky and plastic wet; many roots; very permeable.

Lab. No. 3727: Hor. A1bb: Depth 38 to 60 inches

Black moist to dark-grey dry (10YR 2/1, 3/1) sandy clay loam, with other properties as above. Stratified sandy and medium textured alluvium lie below this to depths of many feet.

Range in Characteristics.—As mapped in the Songhor survey area the Tennant series has included soils ranging from sandy loam to clay loam. A few small areas of clay texture were included in the mapping. All true Tennant soils are developed in recent more or less sandy alluvium, though subsoils may include layers of alluvium as heavy as sandy clay.

Relief.—Nearly level with downstream gradients up to about 3 per cent.

Drainage.—Largely internal and free in the more sandy types; slower in the more clayey types.

Vegetation.—Originally riverine forest.

Use.—Mostly cleared and used for subsistence crops, fruits and sugar cane. Yields are high.

Known Distribution.—Narrow high floodplains of rivers in the north-eastern part of the East Kano Plain. Alluvium in the sandy types comes mainly from areas of gneiss with some basaltic material; alluvium from clayey types is largely from areas of basaltic rocks with some gneissic material.

Type Location.—Along Ainopsiwa River, northeast of George Estate homestead.

VOLO SERIES

The Volo soils are Low Humic Glei soils developed from fine textured sediments on lake plains. They are characterized by their very dark grey to dark brown surface horizons and their strongly mottled, clayey "B" horizons which generally contain appreciable amounts of black and brown "buckshot" concretions of iron and manganese oxides. The Volo soils are the imperfectly drained members of the soil catena that also includes the well-drained Perry, the moderately well-drained Chemelil, and the poorly-drained Patel series. It merges with areas of the better drained soils and forms low spots within the Chemelil and higher spots within the Patel soils.

Soil Profile: Volo Clay Loam

Lab. No. 2102: Hor. A11p: Depth 0 to 6 inches

Very dark grey (7.5YR 3/1, dry) to black (7.5YR 2/1, moist) clay loam; strong fine-granular structure; matted with fine roots; a few "buckshot"; friable, moist; diffuse-smooth boundary.

Lab. No. 2103: Hor. A12: Depth 6 to 12 inches

Greyish-brown (10YR 5/2, dry) to dark greyish-brown (10YR 4/2, moist) clay loam; medium to fine-granular structure; a few "buckshot"; firm, dry; friable moist; clear-smooth boundary.

Lab. No. 2104: Hor. Bg1: Depth 12 to 20 inches

Same colour as above, with 20 per cent of red (10YR 5/6) mottles and 50 per cent of black and brown "buckshot" concretions. Clay loam having medium granular structure; clear-smooth boundary.

Lab. No. 2105: Hor. Bg21: Depth 20 to 30 inches

Pinkish grey (7.5YR 6/2, dry) to dark brown (7.5YR 4/2, moist) clay; strong fine-blocky structure; 20 per cent red mottles and a few "buckshot"; clear-wavy boundary.

Lab. No. 2106: Hor. Bg22: Depth 30 to 36 inches

Greyish-brown (10YR 5/2, dry) to very dark greyish-brown (10YR 3/2, moist) clay; complex coarse and fine lentil structure; sticky and plastic, wet; diffuse-smooth boundary.

Lab. No. 2107: Hor. Bg23: Depth 36 to 46 inches

Light yellowish-brown (1Y 6/4, dry) to olive brown (1Y 4/4, moist) mottled yellowish-brown (10YR 5/6) clay; fine to medium lentil structure with slickensides on peds; a few black manganese concretions; sticky and plastic, wet; diffuse-smooth boundary.

Lab. No. 2108: Hor. Bg31: Depth 46 to 60 inches

Yellowish-brown (10YR 5/5) with 40 per cent mottles of 10YR 5/6, clay; structure as above, a few soft black manganese streaks.

Lab. No. 2109: Hor. Bg32: Depth 60 to 72 inches

Colours as above; clay with fine-blocky or lentil structure; 10 per cent manganese concretions.

Lab. No. 2110: Hor. Dg: Depth 72 inches +

Similar to above but with much gravel, mainly of basic igneous rocks.

Range in Characteristics.—In some areas the surface horizon has as much as 20 per cent of "buckshot". Surface textures range from loam to light clay.

Relief.—Nearly level to gently sloping lake plains.

Drainage.—These soils are imperfectly to somewhat poorly drained. Water moves slowly off the surface and very slowly through the clayey subsoil.

*Veget*ation.—High rainfall savannah.

Use.—Most of the Volo soil is planted to either sisal or sugar cane, both of which grow fairly well. Some areas may become a little too wet during the rainy season and will require drainage, and the soil sometimes becomes too dry during the dry season.

Known Distribution.—On the lake plains in the Songhor Soil Survey area.

Type Location.—Approximately 0.6 mile southwest of Captain Tennant's house.

TABLE 8u

Volo clay loam *Map Ref.:* HZN 387922 *Lab. No.:* 2102 to 2109

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				
$A_{11}p$ ..	0– 6	2·91	0·21	8	12·3	4·5	0·74	0·38	5·8	53	27·6	33·1	4–2:5:3	25	42	27
A_{12} ..	6– 12	1·91	0·14	7	9·3	3·5	0·90	0·54	5·6	46	23·6	33·0	5–1:6:3	36	30	25
Bg_1 ..	12– 20	1·10	0·07	2	7·2	3·2	0·54	0·38	5·8	35	20·4	33·0	5–1:6:3	36	18	40
Bg_{21} ..	20– 30	1·09	0·18	0	8·8	3·7	0·57	0·69	5·8	38	27·6	43·0	5–1:5:4	53	24	10
Bg_{22} ..	30– 36	0·68	0·05	3	9·9	3·8	0·65	0·78	6·5	53	28·4	39·7	7–0:8:2	54	24	12
Bg_{23} ..	36– 46	0·86	0·03	6	10·8	4·7	0·63	0·95	6·7	59	28·0	35·2	6–2:6:3	52	26	12
Bg_{31} ..	46– 60	0·41	0·04	9	12·0	4·7	0·64	0·89	7·0	79	28·6	33·2	8–2:6:2	50	36	15
Bg_{32} ..	60– 72	nil	0·03	35	9·3	5·2	0·59	1·44	7·6	94	32·4	17·9	7–6:2:3	44	33	25

G.P.K. 4264—500—2/60