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LAND RESOURCES OF NORTHWEST TANZANIA

by

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INTRODUCTION

The purpose of this report is to assess land resources and to aid the further agricultural development of Mwanza, Shinyanga, Mara, West Lake, Tabora and Kigoma Regions. In all, this is an area of about 146,720 square kilometres, excluding water.

The survey was started in September 1967. Field equipment consisted of a landrover, camping gear, soil augers, shovels, Abney hand level, "Munsell Color Charts", a Hellige-Trueg Soil Reaction (pH) Tester and field keys for the identification of vegetation(2)(3)(12). Office equipment consisted of drafting materials, stereoscopes, aerial photographs of approximate scale 1:40,000, uncontrolled mosaics of scale 1:50,000, print laydowns of scale 1:50,000 and 1:250,000, and planimetric and topographic maps of scale 1:50,000 and 1:125,000. Geological information(5) and maps of scale 1:125,000 were available for over half the area.

Initially, soils were inspected at regular intervals along all roads and tracks and notes were taken on land form and vegetation. A preliminary map was then drawn and the units described on the basis of physiography, geology, rainfall, soils and natural vegetation. These factors were also considered when assessing agricultural potential. Many parts of the area are inaccessible to wheeled vehicles and these boundaries were drawn from aerial photographs, print laydowns and geology maps.

The area was then traversed a second time to check the boundaries and descriptions. At this time, 10 representative pits were dug and soil samples were collected for laboratory analysis. The higher category classification of these was determined with reference to D'Hoore(4).

In describing the units, all terms were taken from the "F.A.O. Guidelines for Soil Profile Description"(7) and the "U.S.D.A. Soil Survey Manual"(17). "A Classification of East African Rangeland"(15) was used to describe vegetative patterns. Soil profile depths were rated as shallow(0-30 cm.), moderately deep(30-100 cm.) and deep(greater than 100 cm.).

Physiography

The map area lies between the Eastern (Gregory) and the Western Rift Valleys and much of it covers the Central Plateau, an immense peneplain lying at an average elevation of 1200 metres above sea level. Granite outcrops, often in the form of huge boulders piled one on top of another, are a striking feature of the plateau.

Mwanza and Shinyanga Regions are generally flat to undulating, with an elevation of 1100 to 1200 metres, and they rise gradually towards higher land in both the east and west. On the east side of Lake Victoria, the Serengeti Plains are about 1500 metres above sea level and the highest point, in Mara Region, reaches 1818 metres. Large parts of West Lake Region lie above the 1500 metre contour and long sandstone escarpments are prominent features. All major rivers in these regions flow into Lake Victoria. Of these, the most important is the perennially flowing Kagera which, for a large part of its length, forms the Tanzania-Rwanda boundary.

Tabora Region is situated on the Central Plateau, while the Kigoma Region is mainly highlands. The widespread swamps of the Malagarasi-Moyowosi River system lie between these two regions. The perennially flowing Malagarasi River rises in the highlands north of Kigoma and flows northeast to form the Tanzania-Burundi boundary for about 160 kilometres. It then bends southeast and finally west to flow into Lake Tanganyika 80 kilometres due south of its source. This river, with its tributaries, drains all of Tabora Region west of 33°E. longitude, Kahama District and nearly all of Kigoma Region. On the eastern side of Shinyanga and Tabora Regions, the Manonga and Wembere Rivers drain to Lake Eyasi which lies in a subsidiary fissure of the Eastern Rift Valley.

Geology

Geologically the area is underlain by rocks of Pre-cambrian Age which form the base on which younger rock formations have been laid down. In some areas, these have been overlain by recent alluvial-lacustrine deposits. Intrusives

of a very old age, mainly granites and granodiorites, appear as small outcrops throughout the entire area.

In most of the areas south (the Central Plateau) and east of Lake Victoria, rocks of the basement complex lie near the surface and frequently rise high above the plain. These are mainly granites and granodiorites with associated quartzites, schists and gneisses.

There are two younger associated formations scattered throughout the same region. One contains banded ironstone interbedded with quartzites and metavolcanics while the other consists of quartzites and metasediments with occasional schists.

In the Tarime Highlands and on the Serengeti Plains, the basement rock is overlain by basalts and volcanic ash.

Rocks of yet another group appear throughout the Lake Victoria region. These occur mainly in a narrow belt on the west side of the lake running from the Uganda border south through the Kibondo - Kasulu Highlands and across the Malagarasi River towards Mpanda. The base of this formation is a group of sandstones, quartzites and shales overlain by distinctly banded red marls and dolomitic limestones. These are exposed along the lower Malagarasi River (Unit 316). This base is overlain by basalts (the Kasulu Highlands) and more limestones. The upper layer of this formation consists of very thick white sandstones with occasional bedded shales. These are seen in the Biharamulo - Bukoba escarpments (Unit 324).

In the extreme west of the country is another system which goes from the Uganda border south through the Ngara Highlands into Burundi. It reappears in a narrow strip along Lake Tanganyika north of Kigoma and again south of the Malagarasi River. This is a series of folded shales and sandstones with associated quartzites, schists and intrusive granites.

In the downwarped basins of the Central Plateau, particularly the Malagarasi and Manonga - Wembere, the basement rock is overlain by recent lacustrine and fluvial deposits of sands, silts, limestones and tuffs. At some point in recent

geologic time, parts of the Manonga - Wembere depressions were covered by a large lake in which deep beds of limestone formed. The remnants of these lake bed deposits now occur as steep escarpments throughout the valleys (Unit 305).

In still more recent times, there has been deposition of clays and sands in the valleys and the formation of residual overburden over most of the parent rock.

Climate

The most important features of climate are rainfall and temperature. In East Africa, elevation and the presence of large lakes introduce significant local modification in these features.

Generally the rains begin in late September and carry through until June. In the north, the main crop producing area, the rainfall is bimodal with the months of January and February experiencing a decrease in rainfall. Towards the south the rainfall is almost unimodal with only a slight decrease in January and February. The Central Plateau experiences hot days and contrasting cool nights while near Lake Victoria and in the highlands the daytime temperatures are moderated by the lake winds and the elevation.

The annual potential evaporation is higher than the rainfall and since soil water holding capacity is generally low, there is very little retention of moisture into the dry season. At Ukiriguru, potential evaporation is 2100 millimetres while the average rainfall is 850 millimetres.

Most of the Districts around Lake Victoria average (approximately) 750 to 1000 millimetres of rainfall per year, but in Bukoba District prevailing east-west wind currents over the lake have increased the rainfall to 1500 to 2000 millimetres per year. Generally rainfall decreases with distance from the lake. The annual mean maximum and minimum temperatures are 27 - 29°C and 13 - 16°C respectively.

Since the Central Plateau lacks prominent physical features such as mountains and lakes, the climatic conditions are fairly uniform throughout most of Shinyanga and Tabora

Regions. Yearly rainfall averages 750 millimetres and the annual mean maximum and minimum temperatures are 28°C and 15°C respectively.

In Kigoma Region, the Malagarasi Swamp, Lake Tanganyika and the highlands act as climate modifiers. In the highlands, this results in a higher annual rainfall (1100 to 1400 millimetres) and slightly lower annual maximum and minimum temperatures. The lower areas (Units 306, 316) have a yearly rainfall average of 900 millimetres and the annual temperatures are similar to the Central Plateau.

The growing season depends upon the individual crop but usually starts about mid-November. Harvesting usually takes place in June.

Vegetation

Brachystegia-Julbernardia woodland covers nearly all of the Tabora and Kigoma Regions along with Kahama, Geita and Biharamulo Districts. The bushed grassland, with species of Acacia-Commiphora bushes and Hyparrhenia-Bothriochloa grasses, coincides closely with areas of high population density which are mainly in the Mwanza, Mara and Shinyanga Regions. Bushland areas are scattered throughout the bushed grassland and seem to indicate areas that were once cleared of woodland but found unsuited for cultivation. On the other hand, the Acacia-Commiphora bushland of Unit 313 appears to be a climax vegetation like the woodland.

Hyparrhenia, Loudetia, Aristida, Andropogon and Sporobolus species grasslands are found in the highland and hilly units where the soils are shallow and slopes steep. Andropogon-Themeda grassland dominates the Serengeti Plains, while Bothriochloa-Themeda-Hyparrhenia grassland dominates the seasonally flooded lowlands. Everywhere small isolated areas of grassland indicate shallow or hardpan soils or seasonally flooded depressions. Large Vossia-Cyperus permanent swamps are found in the Malagarasi basin, the Mara River Valley and several valleys in the West Lake Region.

Land Use

Throughout the area the major agriculture is subsistence farming that produces maize, cassava, bananas, pulses and certain food crops particular to the various regions. Live-stock is important to the majority of the people and large herds are severely overgrazing the drier areas causing much erosion. The most important cash crop is cotton, grown throughout the entire area but mainly in the Mara, Mwanza and Shinyanga Regions. Coffee and tea are grown at Bukoba and in the highlands. Tabora District is one of Tanzania's major tobacco producing areas.

Annual burning is the main method of clearing brush and old grass. At present this is carried out at the beginning of the dry season, but trials at Ukiriguru have shown that burning is best done at the end of the dry season when there is sufficient dry fuel for complete destruction of the brush. It is also recommended that no grazing be done on the site until the rains have started. This conserves the food reserves in the palatable grasses, since they are the first to be eaten, and allows them to compete with the unpalatable species.

Soils

In the area, the most important factor influencing soil character is geology. Therefore, the soils will be discussed in 4 broad groups based on their parent rocks. These are i) granite-gneiss, ii) sandstone-shale, iii) banded ironstone-volcanic and iv) alluvial-lacustrine, including all valley soils.

Throughout the area the soils vary in depth from shallow on the slopes and hillcrests, where erosion is active, to deep in the valleys and low areas, where the eroded material collects. Generally the texture of the subsoil is more clayey than that of the surface (Units 304, 310, 311).

Water erosion is a widespread problem as most soils do not have the structure or vegetation cover to withstand the intense rainfall and run-off experienced during the rainy season.

i) Soils of granite-gneiss origin

These soils cover the greater part of the area and are generally freely drained, loamy sands and sandy loams with

sandy clay loam subsoils. The clay fraction, which ranges up to 40 percent, is primarily kaolinite. The pH of the surface horizon is generally slightly acid to mildly alkaline, but pHs below 4.5 have been recorded where these soils are intensively cultivated and highly leached. Reduced crop yields as a result of extreme acidity have been experienced in Mwanza Region.

Fertility is poor to moderate with proven deficiencies in phosphorus and nitrogen. Good response has been achieved with applications of 125 kilograms per hectare of single superphosphate and ammonium sulphate on cotton at Ukiriguru(9). Little or no response has been recorded from potassium fertilizers though this element appears to be low in some areas. Boron deficiency symptoms have been noted in some areas and responses to borates have been recorded, particularly in the presence of high rates of nitrogen and phosphate. Sulphur deficiencies may occur in wetter areas but are overcome if single superphosphate and ammonium sulphate fertilizers, containing suitable amounts of sulphur, are used.

Agricultural potential ranges from low to good depending on slope, soil depth and rainfall but is generally rated as fair.

ii) Soils of sandstone-shale origin

These soils are mostly found in West Lake Region and are loamy sands and sandy loams that often have a sandy clay loam subsoil. Like the granite-gneiss soils they are well drained and have a low water holding capacity. In Bukoba District they are highly leached. pH is slightly to medium acid and fertility is poor to moderate, depending upon the extent of leaching. Fertilizer trials near Bukoba indicate some response to nitrogen, phosphate and potassium, particularly on tea. Small responses to phosphorus and potassium have been recorded in Karagwe and Ngara Districts but they are not considered economic(16).

Agricultural potential is fair where not limited by slopes, low fertility and shallow soils.

iii) Soils of banded ironstone-volcanic origin

These soils are mostly well drained clay loams that are high in organic matter and, hence, have moderate to high

fertility. The clays are mainly kaolinite. The pH is generally in the slightly acid to mildly alkaline range.

The banded ironstone soils (Unit 322) are responsive to phosphate fertilizers(16). This is probably due to their high content of oxides of iron and aluminum which may fix phosphorus. Little economic response to nitrogen has been recorded, perhaps because of the higher levels of organic matter in these soils; nor has there been response to potassium. There have been no fertilizer trials on the soils of volcanic origin but economic responses are not likely.

These soils have good agricultural potential but are limited in some areas by slopes and shallow soils.

iv) Soils of alluvial-lacustrine origin

These soils are generally imperfectly drained, cracking clay loams and clays, though some have a fairly high sand content and others are silt loams. The clay fraction contains high amounts of montmorillonite. pH is moderately to strongly alkaline and significant amounts of free calcium carbonate occur in the subsoil.

These soils have moderate fertility and so far no economic response to phosphate and nitrogen has been recorded. The latter is perhaps due to the higher levels of organic matter which these soils accumulate. (?)

Depending upon drainage, these soils have low to good agricultural potential. The high clay content presents some difficulty in tilling these soils as they are very sticky when wet and very hard when dry.



Plate 1. - Granite rock outcrop, typical of the
Central Plateau.

UNIT DESCRIPTIONS

Unit 301a

- Physiography:** Flat swamps and floodplains of the Malag-
arasi and Moyowosi Rivers. There is a large
shallow fresh water lake at the junction of
these two rivers and a few low granite out-
crops are scattered throughout the unit.
The elevation is 1050 - 1100 metres.
- Geology:** Alluvial and lacustrine deposits of granitic
and limestone origin.
- Rainfall:** 900 - 1000 millimetres.
- Soils:** Deep, very poorly drained, black sandy clay
loams and clay loams covered by at least 15
centimetres of organic matter. Around the
granite outcrops there are imperfectly
drained, greyish brown sandy loams over sandy
clays with fine quartz gravel throughout the
profile.
- Vegetation:** Vossia-Cyperus permanent swamp dominated by
Vossia cuspidata, Cyperus papyrus, Echinochloa
pyramidalis and Sorghum verticilliflorum.
Medium to tall Hyparrhenia-Themeda-Chloris
grassland dominates the higher floodplains
on which scattered trees of Acacia spp. and
Combretum spp. are found(18).
- Features:** Since most of this unit is permanently
inundated, the agricultural potential is
very low.

Unit 3016^b

- Physiography:** Flat to almost flat swampland. Drainage is slow to Lake Victoria via the Kagera and Mara Rivers.
The elevation is 1150 - 1200 metres.
- Geology:** Alluvial sands and clays derived from surrounding sandstones, granites and quartzites.
- Rainfall:** Estimated 950 - 1600 millimetres.
- Soils:** Very poorly drained, black peaty clay loams over grey sandy clays with frequent calcareous nodules throughout the surface horizon. The accumulation of organic matter on the surface may be as deep as 100 centimetres.
- Vegetation:** Cyperus-Vossia permanent swamp with Cyperus papyrus, Vossia cuspidata and Miscanthidium violaceum the dominant species. Echinochloa pyramidalis and Imperata cylindrica grow along the margins. Tall Hyparrhenia-Panicum grassland dominates the slightly higher sites and scattered Acacia spp. are found throughout the unit.
- Features:** Some sugar cane is grown in the Ngono Valley west of Bukoba, but since about 45 percent of the unit is permanently inundated its principal use is for fishing. With drainage and irrigation, much of this unit could be used agriculturally(6).

Unit 302a

- Physiography:** Wide, flat to almost flat seasonally flooded valleys that drain slowly to Lake Victoria. The elevation is 1100 - 1200 metres.
- Geology:** Alluvial and lacustrine sands and clays of granitic origin.
- Rainfall:** 750 - 1150 millimetres.
- Soils:** Deep, imperfectly drained, cracking, very dark grey to black clays with fine quartz gravel throughout and calcareous nodules in the lower profile. There are numerous slightly elevated sites with moderately well drained, brown sandy loams over sandy clays. Beach deposits are common adjacent to the lake.
- Vegetation:** Medium to tall Hyparrhenia-Acacia seasonally flooded bushed grassland. The dominant grasses are Hyparrhenia filipendula, Bothriochloa insculpta, Sporobolus pyramidalis and Echinochloa pyramidalis. Acacia burttii, A. drepanolobium and Combretum spp. are the dominant bushes. The slightly elevated sites have Acacia-Combretum bushland.
- Features:** The primary use of this unit is for grazing livestock, but some chickpeas and rice are grown on the lower sites, and maize and sorghum on the better drained sites. Agricultural potential is fair but seasonal flooding is a limitation to mechanized agriculture. A large part of this unit lies within the Serengeti National Park and is not open for agricultural development.

Unit 302b

- Physiography:** Flat to almost flat with scattered large granite outcrops, often 30 metres high. The elevation is 1150 - 1300 metres.
- Geology:** Alluvial and lacustrine sands and clays of granitic origin underlain by biotite granodiorites and granites.
- Rainfall:** 700 - 1000 millimetres.
- Soils:** Deep, imperfectly drained, cracking, very dark grey to black clays over grey clays with frequent calcareous nodules throughout the profile. Around the outcrops, the soils are grey sandy loams over reddish grey sandy clays. Both soils contain fine pink quartz gravel and have moderate fertility. Beach deposits are found near Lake Victoria.
- Vegetation:** Short to medium Bothriochloa-Themeda seasonally flooded grassland dominated by Bothriochloa insculpta, Themeda triandra, Setaria holstii and Sporobolus pyramidalis. Around the outcrops and in shallow depressions, there are scattered patches of Acacia burttii, A. seyal A. drepanolobium bushland.
- Features:** The greater part of this unit is used for grazing livestock, but maize, cassava and cotton are grown on the better drained sites and rice in the lower areas. Agricultural potential is fair, but seasonal flooding is a limitation to mechanized agriculture.



Plate 2. - Alluvial-lacustrine plain of Unit 302b,
showing granite rock outcrop in the
distance.



Plate 3. - Erosion gully, in alluvial-lacustrine clays.

Unit 303

- Physiography:** Flat to almost flat seasonally waterlogged plain through which the Kagera River flows. The elevation is 1200 - 1300 metres.
- Geology:** Deep lacustrine sediments of shale, quartzite and sandstone origin.
- Rainfall:** 850 - 1000 millimetres.
- Soils:** Imperfectly drained, very dark grey clays over dark brown clays cover most of the unit and contain, at depths varying from 100 - 250 centimetres, a thin layer of diatomaceous earth 15 - 30 centimetres thick. Woodland sites have deep, imperfectly drained, dark reddish brown sandy clays over dark grey clays. Both soils have yellowish red mottles throughout the profile. Beach deposits are found throughout the unit.
- Vegetation:** Medium Themeda-Acacia bushed grassland dominated by Themeda triandra, Hyparrhenia filipendula and Loudetia simplex grasses and the bushes Acacia nigrescens and Commiphora subsessilifolia. Adjacent to the Kagera River is a Brachystegia-Acacia woodland dominated by Brachystegia boehmii and Acacia mildbraedii with an understorey of Hyparrhenia rufa and Themeda triandra. North of the Kagera there are two large tracts of groundwater forest.
- Features:** The main crops include maize, sorghum and bananas. There is a large cattle ranch south of the Kagera River and a large sugar and small coffee estates north of the river. Lumbering is also a main industry north of the river. Agricultural potential is fair while ranching potential is good because of the excellent grass cover. Some of the area is tsetse infested.

Unit 304

- Physiography:** Flat to almost flat lake beds, flood plains and, in the northeastern part, alluvial fans. The elevation is 1030 - 1050 metres.
- Geology:** Unconsolidated alluvial and lacustrine sediments of granitic origin and calcareous tuff underlain by limestone.
- Rainfall:** Estimated 500 - 700 millimetres.
- Soils:** Deep, moderately well drained dark brown to to brownish grey sandy loams over extremely hard brown to grey sandy clay loams with small calcareous nodules. The entire profile is moderately alkaline. The alluvial fans have deep, dark brown silt loams over fine sandy loams. The lowest areas have deep, imperfectly drained, saline black clays.
- Vegetation:** Short to medium Sporobolus-Acacia bushed grassland. The dominant grasses are Sporobolus marginatus, S. helvolus and S. robustus. Acacia stuhlmannii, A. drepanolobium, A. mellifera, Commiphora campestris and C. mollis are the dominant bushes. The low areas have a tall Echinochloa haploclada seasonally flooded grassland.
- Features:** There is very little cultivation. The sparse nomadic population depends on livestock and hunting. Agricultural potential is limited by drainage, salinity and low, unreliable rainfall.

Unit 305

- Physiography:** Flat to almost flat plain broken by occasional limestone escarpments. Broad seasonal streams, filled with sand and gravel derived from the granites of adjoining units, drain to Lake Eyasi via the Manonga River. The elevation is 1050 - 1150 metres.
- Geology:** Unconsolidated alluvial and lacustrine sediments of granitic and calcareous tuff origin underlain by limestone.
- Rainfall:** 650 - 800 millimetres.
- Soils:** Moderately well drained, very dark grey clay loams over light brownish grey clay loams with fine quartz gravel and small calcareous nodules throughout the profile. A shallow horizon of secondary calcium carbonate nodules directly overlies the vesicular limestone at about 70 centimetres. These soils have moderate fertility and are moderately alkaline. Severe gully erosion is common throughout the unit.
- Vegetation:** Medium Bothriochloa-Acacia bushed grassland with Bothriochloa insculpta, Pennisetum spp. and the short annuals Eragrostis patens and Chloris pycnothrix. The dominant bushes are Acacia mellifera, A. senegal, Commiphora schimperi and C. campestris.
- Features:** A densely populated unit with cotton, maize and sorghum the main crops. Large herds of livestock have severely overgrazed the land with the result that thorn shrubs are encroaching upon the areas used for grazing. This unit has fair agricultural potential, but unreliable rainfall and the ease with which these soils erode are limitations.



Plate 4. - Clay loam near Mwamashele in Unit 305, showing size of calcium carbonate nodules. (Surface horizon is about 20 cm.).



Plate 5. - Eroded landscape near Mwamashele in Unit 305.

Unit 306

- Physiography:** Flat to undulating with occasional small hills. Drainage is slow to the Malagarasi Swamp. The elevation rises from 1100 metres in the east to 1450 metres in the west.
- Geology:** Dolomitic limestones overlain in the western part by reddish flood basalts and in the southwest by interbedded sandstones and limestones.
- Rainfall:** 900 - 1500 millimetres; increasing from east to west.
- Soils:** Deep, well drained, dusky red sandy clay loams over dark red clay loams on the upper slopes and crests. On the lower slopes and in the depressions, the soils are shallow, imperfectly drained, dark grey to black clays that contain indurated plinthite. These soils have moderate fertility.
- Vegetation:** Brachystegia-Julbernardia woodland dominated by Brachystegia boehmii, B. spiciformis, B. microphylla and Julbernardia globiflora* with an understorey of tall Panicum maximum and Hyparrhenia spp. A Loudetia arundinacea-Microchloa indica grassland occurs on the shallow soils.
- Features:** About 15 percent of this unit is cultivated and maize, sorghum and tobacco are the main crops. The remainder is tsetse fly infested woodland. The clay loams have good agricultural potential.

* Julbernardia globiflora is also known as Isoberlinia globiflora.

Unit 307

- Physiography:** Flat to undulating unit that is slowly drained by the Kigosi, Nkongga and Igombe Rivers into the Malagarasi Swamp. Low areas are seasonally flooded. There are occasional low granite outcrops and a few volcanic cones. The elevation is 1100 - 1200 metres.
- Geology:** Medium to coarse-grained biotite granites overlain by interbedded sandstones and limestones, and in small areas by basalts.
- Rainfall:** Estimated 800 - 1150 millimetres.
- Soils:** Deep, imperfectly drained, black sandy clay loam over dark grey sandy clays with calcareous nodules at about 20 centimetres, are the soils of the lower areas. The rises have moderately deep, moderately well drained, red sandy clay loams over reddish yellow clay loams. On the lower slopes, indurated plinthite often occurs within a few centimetres of the surface. Around the outcrops the soils are grey sandy loams over sandy clays.
- Vegetation:** Brachystegia-Julbernardia woodland dominated by Brachystegia boehmii, B. spiciformis, B. microphylla and Julbernardia globiflora with associated trees of Burkea africana, Pterocarpus angolensis and Uapaca spp. and a grass understorey of Hyparrhenia rufa and Panicum maximum. Medium to tall Loudetia arundinacea-Hyparrhenia rufa grassland is found on areas which are underlain by indurated plinthite or seasonally flooded.
- Features:** Maize, sorghum and sweet potatoes are staple crops while sesame, rice and beeswax are cash crops. Agricultural potential is low to fair depending upon drainage and soil depth. The unit is infested with tsetse fly.

Unit 308a

Physiography: Approximately 70 percent of this unit is flat to almost flat with slow and poorly defined drainage. The remainder, mostly in the northern and western parts, is undulating with occasional low granite outcrops. The elevation ranges from 1000 to 1600 metres.

Geology: Medium to coarse-grained greyish biotite granites.

Rainfall:

Rainfall: 800 - 1100 millimetres.

Soils: Deep, imperfectly drained, medium acid, dark greyish brown loamy sands and sandy loams over yellowish brown sandy clay loams cover the flat to almost flat areas. These soils frequently contain mottles and have poor fertility. In the undulating areas, the higher sites are deep, well drained, neutral to medium acid, dark red loams and sandy clay loams that frequently have a layer of pisolitic indurated plinthite immediately overlying the bedrock(13). In the drainage ways the soils are deep, imperfectly drained, very dark brown sandy clays and clays. These soils have poor to moderate fertility.

Vegetation: Brachystegia-Julbernardia woodland dominated by Brachystegia boehmii, B. spiciformis and Julbernardia globiflora. Associated trees include Burkea africana, Afrormosia angolensis, Pterocarpus angolensis, Combretum spp. and Dalbergia spp. Tall Hyparrhenia spp. and Panicum spp. form the grassland of the drainage ways and the grass understorey in the woodland.

Features: Flue-cured tobacco is grown for some distance on either side of the railway from Tabora to Urambo. Staple crops are maize, sorghum and bulrush millet. The major portion of this unit is uninhabited woodland that is game and forest reserve and is infested with tsetse fly. The agricultural potential of the red sandy clay loams is good, while the potential of the other soils is fair due to drainage and fertility. The soils in general give significant response to fertilizers and manures(8).



Plate 6. - Brachystegia woodland with Hyparrhenia
understorey near Bwanga in Unit 308a.



Plate 7. - Mixed cotton and cassava field in
Brachystegia woodland near Bwanga.

Unit 308_b

- Physiography:** Almost flat to undulating with occasional low granite outcrops.
The elevation is 1150 - 1350 metres.
- Geology:** Medium to coarse-grained greyish biotite granites.
- Rainfall:** 650 - 1000 millimetres; averaging 750 millimetres.
- Soils:** Deep, imperfectly drained, dark greyish brown sandy loams over yellowish brown sandy clay loams that frequently contains mottles and fine quartz gravel. Slightly higher sites have deep, well drained, medium acid to neutral, dark red sandy clay loams containing red ironstone nodules. These soils have poor to moderate fertility.
- Vegetation:** Acacia-Commiphora bushland dominated by Acacia fischeri, A. pseudofistula and Commiphora schimperi with frequent patches of Hyparrhenia rufa, Chloris gayana and Sporobolus spp. grasses. Associated bushes include Markhamia obtusifolia, Combretum grandifolium, Lannea humilis and Brachystegia spp.
- Features:** Cotton, maize and cassava are the main crops but most of the unit is used for grazing livestock. The agricultural potential of the red sandy clay loams is good, but the potential of the other soils is low because of drainage and fertility.

Unit 308a

- Physiography:** Flat to almost flat with gilgai micro-relief and numerous interconnecting drainage ways. There are occasional low granite outcrops. The elevation is 1200 - 1300 metres.
- Geology:** Medium to coarse-grained granites and acid gneiss overlain by unconsolidated materials.
- Rainfall:** Estimated 600 - 800 millimetres.
- Soils:** Imperfectly drained, light brownish grey sandy loams over sandy clay loams that contain reddish mottles and frequent red ironstone nodules. There is a continuous massive grey cement-like hardpan at about 200 centimetres(10). These soils have poor fertility.
- Vegetation:** Deciduous Baphia-Bussea bushland thicket dominated by Baphia burttii, Bussea massaiensis, Combretum trothae and Grewia burttii. Tall Hyparrhenia-Acacia bushed grassland covers the drainage ways. The dominant species are Hyparrhenia rufa and Acacia drepanolobium.
- Features:** This unit is not used agriculturally and has low potential because of drainage and fertility. The soils are difficult to till because they are extremely hard when dry and puddle when wet.

Unit 309.

- Physiography:** Flat to undulating with occasional low granite outcrops. Shallow, wide seasonal rivers, filled with coarse granite sand, drain to Lake Eyasi. The elevation is 1050 - 1250 metres.
- Geology:** Alluvial and lacustrine materials over limestone which is underlain by medium-grained biotite granites.
- Rainfall:** Estimated 650 - 750 millimetres.
- Soils:** Moderately well drained, very dark grey sandy clays over very dark grey clays that change to sandy clay loams near the granite outcrops. These soils have small calcareous nodules in the subsoil and have moderate fertility. Moderate gully erosion occurs throughout the unit.
- Vegetation:** Acacia-Commiphora bushland dominated by Acacia stuhlmannii, A. fischeri, A. nilotica and Commiphora campestris with an understory of short Pennisetum spp. and Sporobolus spp. grasses.
- Features:** The main crops are maize, sorghum and cotton. Large herds of cattle severely overgraze much of the unit. Agricultural potential is fair but the soils are difficult to till and rainfall is unreliable. Flooding rivers isolate this unit for as much as six months of the year.

Unit 309b

- Physiography:** Flat to undulating plain with few well-defined drainage ways and occasional low granite outcrops. Drainage is slow to Lake Eyasi via the Manonga River.
The elevation is 1100 - 1300 metres.
- Geology:** Alluvial and lacustrine sediments and calcareous tuff over limestone which is underlain by granites.
- Rainfall:** 700 - 800 millimetres.
- Soils:** Moderately well drained, dark grey sandy clay loams over grey sandy clays that contain fine quartz gravel, calcareous nodules and reddish mottles throughout the profile. These soils have moderate fertility, but are extremely hard when dry and easily eroded.
- Vegetation:** Acacia-Commiphora bushland dominated by Acacia mellifera, A. seyal, A. malacocephala, Commiphora campestris and C. schimperi. Acacia kirkii is found in small depressions while Acacia spirocarpa is scattered throughout the unit. Bothriochloa insculpta, Sporobolus spicatus and Chloris gayana are the dominant grasses.
- Features:** While some cotton is grown, the unit is mostly used for grazing livestock and growing subsistence food crops. Grazing, however, is often limited by the sparse grass cover that quickly dies at the onset of the dry season. Agricultural potential is fair.

Unit 310

- Physiography:** Undulating lowlands with wide flat drainage ways that drain into Lake Victoria. The elevation ranges from 1150 metres at lake level to 1300 metres.
- Geology:** Pale pink to grey, medium-grained granites and biotite granites and some meta-volcanics, with alluvial sands and clays in the drainage ways.
- Rainfall:** Estimated 900 - 1000 millimetres.
- Soils:** Deep, well drained, dark brown sandy loams over yellowish red sandy clay loams, of poor to moderate fertility, on the slopes and crests. The flat areas have deep, imperfectly drained, calcareous, cracking, very dark grey clays that have fine quartz gravel throughout the profile and moderate fertility.
- Vegetation:** Tall Hyparrhenia-Acacia bushed grassland dominated by Hyparrhenia rufa, Sporobolus pyramidalis, Acacia nigrescens and A. burttii in the drainage ways and in the eastern part. The remainder is Brachystegia-Julbernardia woodland with Brachystegia boehmii, B. microphylla, Julbernardia globiflora, Burkea africana and Uapaca spp.
- Features:** The agricultural area, where cotton, maize and rice are the major crops, is near the lake. The western part of this unit is a tsetse infested forest reserve. The sandy loams and sandy clay loams have good agricultural potential while the clays have only fair potential.

Unit 311

- Physiography:** Undulating with low granite outcrops and wide flat drainage ways.
The elevation is 1150 - 1400 metres.
- Geology:** Unconsolidated alluvial and colluvial materials underlain by granites, granodiorites and quartzites.
- Rainfall:** 700 - 1250 millimetres.
- Soils:** Deep, well drained, neutral to slightly acid, reddish brown sandy loams over sandy clay loams with fine quartz gravel throughout that become shallow and gravelly near the outcrops. These soils have poor fertility. The drainage ways have deep, imperfectly drained, moderately alkaline, very dark grey sandy clay loams over dark grey sandy clays. Slight to moderate rill erosion occurs throughout the unit. Beach deposits are common adjacent to Lake Victoria.
- Vegetation:** Short to medium Bothriochloa-Commiphora bushed grassland dominated by Bothriochloa insculpta, Commiphora schimperi and C. pilosa. The outcrops have a bushland cover of Acacia hebecladoides, A. tortilis, Combretum obovatum and Commiphora eminii. Medium to tall Hyparrhenia-Pennisetum grassland occurs on the drainage ways.
- Features:** Cotton, maize and cassava are the main crops and livestock is important. Agricultural potential is fair to good. In some areas increasing acidity due to intense cultivation and leaching has been reported and this will be a future problem.



Plate 8. - Mixed cassava and sweet potatoe field
on grey granite sands.



Plate 9. - Cassava grown on grey granite sands.

Unit 312

- Physiography:** Undulating plain with occasional granite outcrops. Incised seasonal streams drain to Lake Victoria through the Mara and Grumeti Rivers. The elevation rises from 1350 metres in the west to 2000 metres in the east.
- Geology:** Thin calcareous tuff underlain by medium-grained grey biotite granites and coarse-grained pinkish granites.
- Rainfall:** Estimated 800 - 900 millimetres.
- Soils:** The soils of the lower slopes and depressions are deep, cracking, very dark brown to black sandy clays over clay. The profile contains small calcareous nodules. The soils on the upper slopes and crests are very dark brown sandy clay loams which are often shallow with fine quartz gravel at about 30 centimetres.
- Vegetation:** Approximately 40 percent of this unit is Acacia-Commiphora bushland which occurs on the lower slopes and depressions. The dominant species are Acacia senegal, A. drepanolobium, A. nilotica, Commiphora schimperi and Albizzia harveyi. The remainder is medium to tall Hyparrhenia-Themeda grassland dominated by Hyparrhenia rufa, Themeda triandra and Panicum maximum.
- Features:** Most of this unit lies within the Serengeti National Park and the North Mara Game Reserve. The extreme western part, however, supports a subsistence agriculture where maize and sorghum are the principal crops. Agricultural potential is fair in the western part but further development may interfere with park animals.

Unit 313a

- Physiography:** An undulating plain with occasional massive granite outcrops. Seasonal streams drain to Lake Victoria via the Grumeti and Mbalageti Rivers.
The elevation is 1400 - 1500 metres.
- Geology:** Limestone and unconsolidated sands underlain by sandstones, fine-grained quartzites and coarse-grained granites.
- Rainfall:** Estimated 750 - 1000 millimetres.
- Soils:** Moderately deep, moderately well drained, dark reddish brown sandy clay loams over brown clay loams that contain small calcareous nodules. These soils have moderate fertility. Slight rises are often capped with a calcareous crust. The seasonal rivers are bordered by calcareous black clays.
- Vegetation:** Acacia-Commiphora bushland dominated by Acacia senegal, A. nilotica, Commiphora schimperi and C. eminii with an understorey of Themeda triandra and Hyparrhenia rufa.
- Features:** Most of this unit lies within the Serengeti National Park. The extreme northwestern part supports subsistence agriculture where maize and sorghum are the main crops. Agricultural potential is fair where there is no calcareous crust, but further development may interfere with park animals.

Unit 313b

- Physiography:** An undulating plain with occasional granite outcrops and wide, shallow seasonal streams draining to Lake Victoria. The elevation is 1200 - 1400 metres.
- Geology:** Unconsolidated materials of granitic and limestone origin underlain by granites and granodiorites.
- Rainfall:** 700 - 900 millimetres.
- Soils:** Deep, well drained, dark reddish brown sandy loams over sandy clay loams with frequent small calcareous nodules and a few red ironstone nodules throughout the profile. The low-lying areas have a deep, imperfectly drained, grey to black sandy clays that have many reddish mottles, fine quartz gravel and large hard calcareous nodules in the lower part of the profile. The soils have moderate fertility.
- Vegetation:** Acacia-Commiphora bushland dominated by Acacia hebecladoides, A. nilotica, Commiphora emini, C. schimperi and Combretum gondense with an understory of medium Pennisetum spp. and Sporobolus spp. grasses. The slopes are frequently medium Bothriochloa-Acacia bushed grassland dominated by Bothriochloa insculpta, Sporobolus spp., Acacia hebecladoides and Commiphora boiviniana.
- Features:** The eastern part of this unit lies within a game control area but is used to some extent for grazing livestock. On the remainder, cotton and maize are the major crops. The soils have fair to good agricultural potential, depending upon drainage.

Unit 314

- Physiography:** An undulating unit with several small well-defined rivers that drain to Lake Victoria. The elevation is 1400 - 1500 metres.
- Geology:** Conglomerates and quartzites underlain by acid and basic meta-volcanics which appear in some areas.
- Rainfall:** Estimated 900 - 1300 millimetres.
- Soils:** Moderately deep, moderately well drained, dark greyish brown clay loams over red clay loams with indurated plinthite at about 60 centimetres. Soils on the meta-volcanics have frequent red ironstone nodules beginning at about 15 centimetres. Slight to moderate rill erosion occurs throughout the unit.
- Vegetation:** Tall Hyparrhenia-Acacia bushed grassland that changes to Acacia-Combretum bushland in the drainage ways. The dominants are Hyparrhenia rufa, Sporobolus pyramidalis and Eragrostis exasperata grasses and Acacia nilotica, Combretum spp. and Protea madiensis bushes. Digitaria scalarum is a major weed.
- Features:** The dense population grows subsistence crops of maize, cassava and bananas and raises livestock. The occurrence of indurated plinthite and surface stones reduces the agricultural potential to low.

Unit 315

- Physiography:** An undulating plain with gilgai micro-relief. Granite and gneiss outcrops are scattered throughout the unit and shifting sanddunes are prominent in the eastern part. The elevation rises from 1350 metres in the south to 1650 metres in the north and the whole unit slopes gently downwards to the east.
- Geology:** Volcanic ash and calcareous tuff over fine-grained hornblende granites and gneisses.
- Rainfall:** 600 - 800 millimetres; increasing from east to west.
- Soils:** Dark grey to very dark brown fine sandy loams and silty clay loams with a calcareous pan at depths varying from 15 to 80 centimetres(1). Frequent alkali crusts are seen in the gilgai depressions and in general the surface horizons are neutral to mildly alkaline. The granite-gneiss outcrops have almost no influence on the surrounding soils, due to the overlying volcanic ash.
- Vegetation:** Medium to tall Andropogon-Themeda grassland with Andropogon greenwayi and Themeda triandra the dominant species. Other grasses include Sporobolus marginatus, Digitaria macroblephara and Cynodon dactylon. Many of the water courses are bordered by Acacia xanthophloea.
- Features:** This unit lies within the Serengeti National Park and the Ngorongoro Conservation Area.

Unit 316

- Physiography:** Undulating to rolling with occasional low ridges and hills. Most of this unit is in the Malagarasi River valley and drainage is rapid to Lake Tanganyika. The elevation is 800 - 1100 metres.
- Geology:** Most of this unit is underlain by medium to coarse-grained reddish sandstones. Adjacent to the lake, these are overlain by flood basalts or limestones.
- Rainfall:** 850 - 1050 millimetres.
- Soils:** Deep, well drained, slightly to medium acid, yellowish red fine sandy loams over sandy clay loams developed from the sandstones. These soils have poor fertility. The soils derived from basalts and limestones are deep, moderately fertile, dark red sandy clay loams and dark reddish brown to dark grey clay loams respectively.
- Vegetation:** Brachystegia-Julbernardia woodland dominated by Brachystegia boehmii, B. longifolia, Julbernardia globiflora and Pterocarpus angolensis in association with Acacia hebecladoids, Combretum zeyheri and Lannea schimperi. Grasses include Hyparrhenia newtonii, Panicum maximum, Rhynchelytrum repens and Sporobolus spp.
- Features:** Rice and oil palm are the principal cash crop and fishing is carried out along the lake shores. Maize, sorghum and bananas are the main food crops. This unit has fair agricultural potential. Although the soils of the lower Malagarasi River basin are more fertile, they are often subjected to seasonal flooding.

Unit 317a

Physiography: Undulating to rolling with massive granite outcrops and wide, flat interconnecting mbugas* that drain slowly to Lake Victoria.

The elevation ranges from 1150 metres at lake level to 1450 metres.

Geology: Coarse to medium-grained biotite and hornblende granites, with outcrops of quartzites, that are overlain by lacustrine and alluvial sediments in the valleys.

Rainfall: 800 - 1200 millimetres.

Soils: This is the Ukiriguru Soil Catena described by Milne(10). Around the granite outcrops at the top of the slope the soils are shallow greyish brown loamy sands. Below these are the moderately deep, well drained, reddish brown coarse sandy loams which change downslope, where seepage occurs, to grey sandy loams that are underlain by irregular indurated plinthite. Next in the sequence are poorly drained, dark greyish brown sandy loams over a continuous clay pan at about 40 centimetres. On the valley floor the soils are imperfectly drained, cracking, calcareous black clays.

Vegetation: The only vegetation which is not regrowth is on the granite outcrops. This is a Commiphora-Combretum bushland with Commiphora eminii, C. africana, Combretum zeyheri and C. molle bushes and a tall understory of Hyparrhenia dissoluta, H. filipendula, Loudetia simplex and Panicum maximum. The valleys support a grassland dominated by Bothriochloa insculpta, Panicum maximum, Hyparrhenia spp. and Aristida spp.

Features: About 60 percent of this unit is cultivated and the main crops are cotton, maize, cassava, rice and sorghum. The soils have a fair agricultural potential and are responsive to fertilizers(14). The hardpan and valley soils are difficult to till and are thus used mainly for grazing.

*mbuga - broad, flat grassy valley bottom.



Plate 10. - Alluvial-lacustrine clay at Ukiriguru.
Site shown in Plate 11. (The knife is
about 20 cm. long.)



Plate 11. - Mbuga at Ukiriguru in Unit 317a, with
Acacia bushes and tall Hyparrhenia grasses.
Granite rock outcrops in background.

Unit 317b

- Physiography:** Undulating to rolling with frequent massive granite outcrops and fast flowing well-defined seasonal streams.
The elevation ranges from 1150 to 1400 metres.
- Geology:** Fine-grained granites and associated gneisses, micro-granites and quartzites.
- Rainfall:** 800 - 1000 millimetres.
- Soils:** The upper slopes have moderately deep, well drained, dark reddish brown loamy sands over reddish brown sandy loams that are shallow and stony near the outcrops. On the lower slopes the soils are deep, imperfectly drained, greyish brown sandy loams, while the valleys have deep, imperfectly drained, cracking, very dark brown clays. The fertility of the sandy loams is poor while that of the clays is moderate.
- Vegetation:** Bothriochloa-Grewia bushed grassland dominated by Bothriochloa insculpta, Grewia trichocarpa and G. bicolor in association with the bushes Combretum zeyheri, Acacia pennata and the grasses Panicum maximum, Hyparrhenia spp. and Sporobolus spp. Around the outcrops there is a Grewia-Combretum bushland with Grewia trichocarpa, Combretum zeyheri and a tall understory of Hyparrhenia spp.
- Features:** The main crops are maize, cassava, cotton and pulses. This unit has fair agricultural potential but rock outcrops and surface stones on the upper slopes and erosion hazards make further development of 30 percent of this unit impossible.



Plate 12. - Typical agricultural scene in Unit 317.
Cotton and maize growing on hillsands
below the granite rock outcrops.



Plate 13. - Paddy rice in depression between granite
rock outcrops in Unit 317.

Unit 317c

- Physiography:** Undulating to rolling with many well-defined river channels and numerous granite outcrops. The southern boundary is a sheer escarpment that forms part of the Rift Valley wall. The elevation rises towards the east from 1400 to 1900 metres.
- Geology:** Fine to medium-grained microgranites and coarse-grained biotite granites with associated meta-volcanics along the escarpment.
- Rainfall:** Estimated 650 - 800 millimetres.
- Soils:** Moderately deep, well drained, dark reddish brown sandy loams with frequent fine quartz gravel and small stones in the profile. Near the granite outcrops the soils are shallow and gravelly. Shallow dark brown loams occur along the escarpment.
- Vegetation:** Commiphora-Acacia bushland dominated by Commiphora merkeri, C. eminii, C. africana, Acacia hebecladoides and A. nilotica with an understory of Hyparrhenia spp. grasses.
- Features:** There is very little agriculture in the unit. Agricultural potential is low to fair depending on soil depth and slopes.

Unit 318a

- Physiography:** Undulating to rolling plateau, known as the Tarime Highlands, with wide valleys and occasional steep-sided hills. The Utimbara escarpment forms an abrupt southern boundary. The elevation is 1650- 1850 metres.
- Geology:** Flat sheets of dark grey basic basalts with associated acid metavolcanics along the Utimbara escarpment.
- Rainfall:** 1350 - 1500 millimetres.
- Soils:** Deep, well drained, dusky red clay loams that become shallow and stony on the steeper slopes and occasionally contain small red ironstone nodules near the surface of the lower slopes. The soils have high fertility. There is slight to moderate rill erosion throughout the unit.
- Vegetation:** Tall Pennisetum-Protea bushed grassland dominated by Pennisetum polystachyon, Hyparrhenia rufa and Sporobolus pyramidalis grasses. The dominant bushes, Protea madiensis and Solanum incanum, are more prominent on the hillsides. Imperata cylindrica and Digitaria scalarum are weeds.
- Features:** Coffee, bananas, maize, rice and vegetables are the main crops. Agricultural potential is good but limited by slopes in some areas.



Plate 14. - Tarime Highlands - Unit 318a.



Plate 15. - Clay loam of volcanic origin near Tarime.
Site shown in Plate 14. (Ruler is about
46 cm. long.)

Unit 318.b

- Physiography:** This unit rises abruptly from the south to form an undulating to rolling plateau known as the Kasulu Highlands. There are many incised seasonal streams and rivers. The elevation ranges from 1400 - 1700 metres.
- Geology:** Reddish fine-grained flood basalts with occasional interbedded cherts.
- Rainfall:** Estimated 1000 - 1400 millimetres.
- Soils:** Deep, well drained, dark reddish brown to dark red clay loams and clays with frequent small red ironstone nodules in the profile. Slopes and crests often have shallow soils due to erosion. Fertility is moderate. There is severe rill and gully erosion throughout the unit.
- Vegetation:** Medium to tall Hyparrhenia-Aristida grassland dominated by the grasses Hyparrhenia filipendula, H. hirta and Aristida atrovioacea. Other species include Sporobolus marginatus and Loudetia arundinacea. In the north there are areas of Hyparrhenia-Combretum bushed grassland with Hyparrhenia filipendula and H. dissoluta grasses and Combretum zeyheri and Acacia spp. bushes.
- Features:** This unit is densely populated and the main crops are bananas, sweet potatoes and coffee. Large herds of livestock are also kept. Agricultural potential is fair to good depending upon texture. The high rainfall results in heavy leaching and soil erosion, the latter being the main limitation to mechanized agriculture.

Unit 318g

- Physiography:** Undulating to rolling plateau with scattered ridges and flat-topped hills. The elevation is 1400 - 1700 metres, rising to the west.
- Geology:** Reddish fine-grained flood basalts with occasional interbedded cherts.
- Rainfall:** Estimated 1000 - 1200 millimetres.
- Soils:** Deep, well drained, dusky red to dark red sandy clay loams and clay loams with frequent iron-stone nodules in the profile. Slopes and crests often have shallow soils. Small areas of vesicular indurated plinthite are common throughout the unit. These soils have moderate fertility. Slight rill erosion occurs on the steeper slopes.
- Vegetation:** Brachystegia-Pterocarpus woodland dominated by Brachystegia boehmii, B. spiciformis and Pterocarpus angolensis with a tall understory of Hyparrhenia spp. and Panicum spp. grasses. Other tree species include Cussonia arborea and Uapaca spp. In the south there are small areas of Hyparrhenia-Combretum bushed grassland.
- Features:** The main crops are maize, sorghum, cassava and tobacco. Some cotton is also grown. Agricultural potential is fair to good.

Unit 319

- Physiography:** This unit is a plateau that is divided by the Ruvuvu River and bounded on the northwest by the Kagera River, both of which are about 350 metres below the plateau. The Bugufi Highlands, west of the Ruvuvu, are undulating to rolling while the Busubi Highlands, east of the Ruvuvu, are almost flat to undulating. Both rivers are perennial and fast flowing, but tributary drainage is seasonal and slow. The elevation ranges from 1450 metres in the river valleys to over 1800 metres on the plateau.
- Geology:** Greyish brown shales interbedded with quartzites and fine-grained sandstones which, in some localities, have been intruded by granites.
- Rainfall:** 800 - 1200 millimetres; increasing from east to west.
- Soils:** Deep, well drained, dark reddish brown sandy clay loams over clay loams that become yellowish brown to dark grey on the lower slopes. Fertility is moderate. The soils on the steep slopes are often shallow and stony. Slight to moderate rill erosion occurs throughout the unit.
- Vegetation:** Tall Hyparrhenia-Combretum bushed grassland with Hyparrhenia dissoluta, Loudetia arundinacea and Andropogon schinzii the dominant grasses and Combretum molle the dominant bush. The drainage ways support an Acacia-Combretum bushland. Remnant Brachystegia-Acacia woodland occurs in isolated areas.
- Features:** Sorghum, bananas and coffee are the main crops. About 40 percent of the unit is non-arable due to steep slopes and surface stones, but where the soils are deep there is good agricultural potential. At present the main limitation to development is the remoteness of the area.

Unit 320

- Physiography:** A rolling to hilly plateau, known as the Mwesi Highlands, that rises westwards into the Makari Mountains. The valleys are deep and drainage is rapid to Lake Tanganyika. The elevation ranges from 800 metres at lake level to 2400 metres on the Makari Mountains, but generally the elevation is 1400 - 1600 metres.
- Geology:** Metamorphic rocks that are mainly amphibolites, acid gneisses and granulites, but include some quartzites and granites.
- Rainfall:** Estimated 900 - 1400 millimetres.
- Soils:** Moderately deep, well drained, medium acid, dark red sandy clay loams on the upper slopes and deep, poorly drained, very dark brown loams over clay loams in the valleys. The soils are moderately fertile. Vesicular indurated plinthite is common at, or near the surface, on the lower slopes and many of the steeper slopes have shallow stony soils.
- Vegetation:** Medium Themeda-Protea bushed grassland on the plateau dominated by Themeda triandra, Hyparrhenia spp., Protea madiensis and Cussonia arborea. The valleys are Brachystegia-Pterocarpus woodland with Brachystegia longifolia, B. boehmii, Pterocarpus angolensis and Oxytenanthera abyssinica.
- Features:** Principal crops include bananas, coffee, sorghum, pulses and rice. Potatoes grow well in the upland valleys. Tsetse fly is present in the lower valleys. Agricultural potential is fair but the danger of severe erosion may be a limitation to mechanized agriculture.

Unit 321a^a

- Physiography:** Rolling to hilly with scattered large granite boulders on the slopes and in the valleys. Seasonal streams drain to the Kagera River. The elevation is 1400 - 1600 metres.
- Geology:** Grey biotite granites with associated quartzites, mica-schists and shales.
- Rainfall:** Estimated 800 - 1000 millimetres.
- Soils:** Moderately well drained, very dark brown sandy loams over sandy clay loams that have fine quartz gravel throughout the profile and frequent large red ironstone nodules in the subsoil. The valley soils are deep, very dark brown sandy clay loams.
- Vegetation:** Tall Hyparrhenia-Combretum bushed grassland dominated by Hyparrhenia dissoluta, Sporobolus pyramidalis and Combretum molle. Other species include Strychnos spinosa and Brachystegia spp.
- Features:** Maize, sorghum, cassava and bananas are the principal crops. The unit has a low to fair agricultural potential but its remoteness is a limitation to further development.

Unit 321b

- Physiography:** Rolling to hilly with well-defined seasonal streams and a few granite outcrops. The elevation is 1900 - 2000 metres.
- Geology:** Thin calcareous tuff over gneiss, schist and medium to coarse-grained granites.
- Rainfall:** Estimated 900 millimetres.
- Soils:** Deep, moderately well drained, dark reddish brown sandy loams over dark reddish brown clay loams that are often shallow and stony on the steeper slopes. In the valleys the soils are deep, dark brown sandy clay loams and sandy clays.
- Vegetation:** Tall Hyparrhenia-Acacia bushed grassland dominated by Hyparrhenia filipendula, Sporobolus pyramidalis and Themeda triandra grasses and Acacia hebecladoides. Throughout the unit there are areas of Acacia-Commiphora bushland dominated by Acacia tortilis, A. xanthophloea and Commiphora schimperi.
- Features:** This unit lies within the Serengeti National Park and is not open for agricultural development.

Unit 322

- Physiography:** This unit is composed of a number of areas characterized by steep, rounded hills surrounded by undulating footslopes. The elevation ranges from 1150 to 1800 metres.
- Geology:** Banded ironstone in association with acid and basic volcanics.
- Rainfall:** 900 - 1100 millimetres.
- Soils:** Moderately deep, well drained, dark reddish brown loams over dark red clay loams with few small red ironstone nodules throughout the profile. These soils have moderate fertility. Indurated plinthite appears at varying depths in the profile and is often exposed at the surface on the lower slopes.
- Vegetation:** West and south of Mwanza the vegetation is Brachystegia-Combretum woodland dominated by Brachystegia boehmii, B. spiciformis, Combretum obovatum and C. gondense. Other species include Lanea humilis, Grewia gilviflora and G. bicolor. Hyparrhenia spp. and Sporobolus spp. grasses cover the shallow soils underlain by indurated plinthite. The areas southeast and north of Mwanza have a medium Bothriochloa-Acacia bushed grassland that includes Bothriochloa insculpta, Sporobolus pyramidalis, Panicum maximum and Heteropogon contortus along with the bushes Acacia burttii, A. senegal, Combretum molle, Balanites aegyptiaca and Commiphora spp.
- Features:** Cotton, maize and sweet potatoes are the main crops. Agricultural potential is good but shallow soils due to indurated plinthite and susceptibility to erosion reduce the area suitable for mechanized agriculture.



Plate 16. - Banded ironstone hill showing indurated plinthite on the lower slope and mixed woodland on the upper slope - Unit 322.



Plate 17. - Banded ironstone hills (Unit 322) in the distance, looking across Hyparrhenia-Acacia bushed grassland footslopes.

Unit 323

- Physiography:** Rolling to hilly with long, steep-sided, flat-topped ridges of north-south orientation, separated by wide undulating valleys that have slow flowing streams. North of the Kagera River the unit is undulating with low ridges. The elevation is 1450 - 1750 metres.
- Geology:** Greyish brown shales interbedded with quartzites and fine-grained sandstones which, in some localities, have been intruded by granites.
- Rainfall:** 900 - 1200 millimetres.
- Soils:** Shallow, often exceedingly stony, well drained, dark reddish brown sandy loams over dusky red sandy clay loams on the hilltops and slopes. The valley soils are deep, moderately well drained, black loams over very dark grey clays. All soils have moderate fertility. Slight to moderate sheet and rill erosion occurs throughout the unit.
- Vegetation:** Acacia-Combretum bushland dominates the northern part with Acacia hebecladoides, A. macrothyrsa, Combretum molle, Psorospermum febrifugum, Protea angolensis and Lanea spp. The southern part is Terminalia-Brachystegia woodland of Terminalia mildbraedii and Brachystegia boehmii with an understorey of tall Hyparrhenia spp. grasses. Other species include Dombeya pedunculata and Uapaca spp. Throughout the whole unit Loudetia kagerensis-Hyparrhenia spp. grassland covers the hillsides.
- Features:** Maize, sorghum, pulses and bananas are the main crops. There is good agricultural potential on the lower slopes and in the valleys but about 55 percent of the unit is unsuitable for mechanized agriculture because of slopes, shallow soils and surface stones.

Unit 324a

- Physiography:** Rolling to hilly with massive sandstone escarpments of northwest-southeast orientation, separated by deep valleys which have slow flowing streams and small swamps. The elevation is 1150 - 1500 metres.
- Geology:** Fine to medium-grained white sandstone with interbedded quartzites and hard shale-like rocks.
- Rainfall:** 1300 - 2100 millimetres; varying with elevation.
- Soils:** On the lower slopes there are deep, moderately well drained, dark reddish brown sandy loams over yellowish brown sandy clay loams. At about 120 centimetres, small red ironstone nodules occur. In the profile the pH increases from medium acid to very strongly acid with depth. The upper slopes and ridge tops are fairly stony and the soils are often shallow. In the valleys the soils are deep, imperfectly drained, dark greyish brown sandy clay loams. The sandy loams have poor fertility while the valley soils have moderate fertility.
- Vegetation:** Tall to medium Hyparrhenia-Andropogon grassland with Hyparrhenia rufa, H. filipendula and Andropogon schinzii the dominant species. Urelytrum digitatum grass dominates the low lying areas. Imperata cylindrica, Digitaria scalarum and Eragrostis mildbraedii are weeds which appear on land left to fallow regrowth.
- Features:** The main crops, bananas, coffee, tea and groundnuts, are intensively grown by the dense population. The hillsides are used for grazing livestock. This area has low to fair agricultural potential depending upon slope.

Unit 324b

Physiography: Rolling to hilly with massive sandstone escarpments of north-south orientation, separated by deep valleys which have slow flowing streams and small swamps.
The elevation is 1150 - 1650 metres.

Geology: Fine to medium-grained white sandstone with interbedded quartzites and hard shale-like rocks.

Rainfall: 950 - 1600 millimetres; increasing from south to north.

Soils: Deep, well drained, medium acid, dark reddish brown fine sandy loams that become shallow and stony near the escarpments. The valley soils are deep, imperfectly drained dark greyish brown sandy clay loams. The sandy loams have poor fertility while the sandy clay loams have moderate fertility. Slight to moderate sheet and rill erosion occurs throughout the unit.

Vegetation: Brachystegia-Julbernardia woodland with areas of medium to tall Loudetia-Panicum grassland. The dominant trees are Brachystegia boehmii, B. microphylla, Julbernardia globiflora, Burkea africana and Uapaca spp. The areas of grassland are dominant in the northern part of the unit and are found on the hillsides where the soils are shallow and often stony. The main species are Loudetia simplex, Panicum maximum and Sporobolus pyramidalis.

Features: The northern part is densely populated and the main crops are bananas, coffee, tea and groundnuts. The hillsides are used for grazing livestock. The southern part of the unit is tsetse fly infested and is mostly forest reserve. The sandy loam soils have a low to fair agricultural potential depending upon slope, while the valley soils are limited by drainage to fair potential.

Unit 325

- Physiography:** Two rolling to hilly areas with some steeply dissected parts. The southern section drains directly into Lake Tanganyika while the northern section drains to the lake via the Malagarasi system.
The elevation ranges from 800 to 1600 metres in the south and 1200 to 1600 metres in the north.
- Geology:** Fine-grained reddish sandstones and ortho-quartzites that often have interbedded conglomerates. The southern section also has banded silty shales.
- Rainfall:** Estimated 1000 - 1400 millimetres.
- Soils:** Moderately deep to deep, well drained, slightly acid, dark reddish brown fine sandy loams over red sandy clay loams on the rolling part. The hilly and steeply dissected areas have shallow to moderately deep, well drained, slightly acid, dark reddish brown loamy fine sands over sandy loams. All soils have poor fertility. Moderate to severe sheet and rill erosion occurs on many slopes.
- Vegetation:** Short to medium Sporobolus-Hyparrhenia grassland dominated by Sporobolus marginatus, Hyparrhenia hirta and H. newtonii on the higher and steeper slopes. The lower slopes and valleys support a Brachystegia-Acacia woodland of Brachystegia boehmii, B. longifolia, Acacia hebecladoides, Combretum subvernicosum and C. zeyheri.
- Features:** Bananas, maize, sorghum and pulses are the main crops. Many people along the lake are fishermen. Steep slopes and susceptibility to erosion limit mechanized agriculture, but where slopes permit there is fair potential. Tsetse fly is present in the woodland.

Unit 326a

- Physiography:** Steeply dissected, often with slopes of 50 percent. The valleys are narrow with rapidly flowing seasonal streams. The elevation is 1300 - 1500 metres.
- Geology:** Grey to red shales, interbedded with quartzites and fine-grained sandstones.
- Rainfall:** 800 - 1000 millimetres.
- Soils:** Shallow dark reddish brown sandy clay loams over yellowish brown sandy clays. Steep slopes have exposed bedrock and are often exceedingly stony. Ironstone nodules form a continuous pan in small areas throughout the unit.
- Vegetation:** Brachystegia-Isobertinia woodland on the crests and in the valleys, and a Hyparrhenia rufa-Loudetia simplex grassland on the steep slopes. The dominant trees are Brachystegia boehmii, B. microphylla and Isobertinia angolensis. Other species include Dombeya pedunculata, Acacia abyssinica and Protea spp.
- Features:** This unit is not used for agriculture and has very low potential due to the shallow soils and steep slopes. The area is tsetse fly infested.

Unit 326b

- Physiography:** Steeply dissected with rounded hilltops, long ridges and deep valleys. Rapidly flowing streams drain to Lake Tanganyika. The elevation is 800 - 1700 metres.
- Geology:** Coarse-grained white siliceous orthoquartzites with frequent conglomerate horizons.
- Rainfall:** Estimated 1300 - 1400 millimetres.
- Soils:** Shallow, well drained dark reddish brown fine sandy loams and sandy clay loams which are often stony and severely eroded.
- Vegetation:** Short to medium Sporobolus-Hyparrhenia grassland dominated by Sporobolus marginatus, Hyparrhenia hirta and H. newtonii on the higher and steeper slopes. The lower slopes and valleys support a Brachystegia-Acacia woodland of Brachystegia boehmii, B. longifolia, Acacia hebecladoides and Combretum mossambicense.
- Features:** Bananas and other food crops are cultivated in the narrow valley bottoms and fishing villages are common along the lake. Steep slopes limit further agricultural development. The Gombe Stream National Park is included within this unit.

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SOIL PROFILE DESCRIPTIONS
AND ANALYTICAL DATA

Soil Profile Description

I. Information on the site:

- a. Profile Number: UK-30
- b. Unit Number: 308a
- c. Higher Category Classification: Ferrallitic Soil (D'Hoore).
- d. Date of examination: 22nd February 1969
- e. Authors: Wengell and Borden
- f. Location: Approximately 27 kilometres south of Tabora, on the Tabora-Sikonge road, Tabora District, Tanzania. Approximately 5°13'S. 32°45'E.
- g. Elevation: approximately 1200 metres.
- h. Land form:
 - i. physiographic position: lower convex slope
 - ii. surrounding land form: flat to almost flat
 - iii. microtopography: nil
- i. Slope on which profile is sited: Flat to almost flat(1%)
- j. Land use: The site was under Brachystegia-Julbernardia woodland with Brachystegia boehmii and Julbernardia globiflora the dominant species. There was an understorey of Hyparrhenia spp. Tobacco was being grown in a near by field at the time of examination.
- k. Climate: Data derived from Tabora Observatory, approximately 27 kilometres north of the site at elevation 1258 metres.

Average of 58 years

Monthly rainfall	J	F	M	A	M	J	J	A	S	O	N	D
in millimetres	134	132	168	132	26	2	0	1	6	17	104	171
Mean annual rainfall is 892 millimetres.												

Temperature average(°C) of 25 years

Monthly temperature	J	F	M	A	M	J	J	A	S
Mean maximum	27.8	28.3	28.2	28	28.3	28.4	28.5	29.6	31.4
Mean minimum	17.4	17.4	17.5	17.3	16.4	14.8	14.6	15.7	17.5
				O	N	D			
				32.3	30.6	28.5			
				18.9	18.7	17.7			

Climatic conditions at the site can be expected to be very similar. Note pronounced dry season May to October.

II. General Information on the soil:

- a. Parent Material: Derived from granitic rocks of the basement complex.
- b. Drainage: Class 2 - imperfectly drained.
- c. Moisture conditions in profile: moist throughout.
- d. Depth of groundwater: unknown.
- e. Presence of surface stones and rocks: Class 0 - none in each case.
- f. Evidence of erosion: none.
- g. Presence of salt or alkali: Class 0 - apparently free.
- h. Human influence: nil.

III. Brief Description of the Profile:

A dark brown loamy sand over a yellowish brown sandy loam that changes to a sandy clay loam and then to a sandy clay before it reaches a horizon of hard irregular red ironstone nodules at 179 centimetres. The profile is uniformly mottled, structure is weak and consistence is friable throughout. The surface horizon is medium acid while the subsoil is strongly acid. The entire profile is hard when dry.

IV. Profile Description:

- 0-10 cm. Dark brown (7.5YR4/2) loamy sand; fine granular; non-sticky, non-plastic, very friable, hard; common very fine pores; abundant fine and medium roots; clear smooth boundary; field pH 6.0.
- 10-20 cm. Light yellowish brown (10YR⁶/4) sandy loam; few medium prominent yellowish red (5YR⁵/8) mottles; weak medium subangular blocky; non-sticky, slightly plastic, friable, slightly hard; many very fine pores; very frequent fine and medium roots; clear smooth boundary; field pH 5.5.
- 20-43 cm. Reddish yellow (7.5YR⁶/6) sandy loam; few medium prominent yellowish red (5YR⁵/8) and many medium faint reddish yellow (7.5YR⁶/8) mottles; very weak medium subangular blocky; non-sticky, slightly plastic, friable, hard; many very fine pores; very frequent fine and medium roots; clear smooth boundary; field pH 5.5.

- 43-70 cm. Strong brown (7.5YR⁵/6) sandy clay loam; common fine and medium prominent yellowish red (5YR⁵/8) and common medium and coarse distinct light grey (10YR⁷/2) mottles; weak medium subangular blocky; slightly sticky, plastic, friable, hard; many very fine pores; common fine and medium roots; clear smooth boundary; field pH 5.5.
- 70-139 cm. Reddish yellow (7.5YR⁶/6) sandy clay loam; few fine prominent pinkish white (7.5YR⁸/2) mottles; weak medium subangular blocky; slightly sticky, plastic, friable, hard; many very fine and fine pores; few medium roots; gradual smooth boundary.
- 139-179cm. Pinkish grey (7.5YR⁷/2) sandy clay; common fine prominent yellowish red (5YR⁵/8) mottles; strong medium subangular blocky; sticky, plastic, firm, hard; few fine and medium roots; abrupt smooth boundary.
- 179-189+cm. Very frequent hard irregular red ironstone nodules.

V. Interpreted Characteristics of the Soil:

This soil is generally considered favourable for the growing of tobacco due to its coarse texture and (poor) fertility. The balance of bases is reasonable at the surface, except for potassium which is low. The subsoil is acutely short of both magnesium and potassium. The organic carbon and nitrogen levels are moderate to low. The slightly wider C/N ratio at the surface indicates possible responses to nitrogen fertilizers and trials bear this out(8). A naturally high water table and the higher clay content of the lower profile probably account for the imperfect drainage of what analytically appears to be a freely drained soil.

This soil was classified as a Ferrallitic Soil on the basis of colour, silt/clay ratio and C.E.C. even-though the base saturation is greater than 40 percent.

Unit 308a Analytical Data

Horizon Depth in cm.	0-10	10-20	20-43-	43-70	70-139
pH - 1:5 water	6.2	4.8	4.7	4.6	4.5
CaCO ₃ %	1.1	Nil	Nil	Nil	Nil
Conductivity - 1:5 mmohs/cm.	0.03	0.01	0.01	0.01	0.01
Exchangeable Bases - meq/100 gm.					
Ca	4.5	3.0	2.7	2.4	2.0
Mg	1.2	0.5	0.4	0.4	0.3
Na	0.10	0.05	0.06	0.03	0.04
K	0.14	0.08	0.06	0.04	0.03
Total	5.94	3.63	3.22	2.87	2.37
C.E.C. meq/100 gm.	7.5	-	-	-	10.3
Base Saturation %	79.0	-	-	-	23.0
Organic Carbon %	1.31	0.42	0.28	-	-
Nitrogen %	0.10	0.04	-	-	-
C/N ratio	13.1	10.5	-	-	-
Mechanical Analysis					
Coarse Sand %	60.4	58.1	48.1	45.7	45.9
Fine Sand %	23.7	18.7	17.2	25.6	21.7
Silt %	3.4	4.0	3.0	2.4	3.0
Clay %	9.1	15.2	25.7	24.2	26.0
Total	96.6	96.0	94.0	97.9	96.6

Soil Profile Description

I. Information on the site:

- a. Profile Number: UK-31
- b. Unit Number: 317b
- c. Higher Category Classification: Ferruginous Tropical
Soil (D'Hoore).
- d. Date of examination: 4 February 1969
- e. Authors: Wengell and Borden.
- f. Location: 12 kilometres northwest of Utegi, on the Utegi-Shirati road, North Mara District, Tanzania.
Approximately 1°18'S. 34°10'E.
- g. Elevation: approximately 1225 metres.
- h. Land form:
 - i. physiographic position: upper convex slope.
 - ii. surrounding land form: undulating.
 - iii. microtopography: nil.
- i. Slope on which profile is sited: gently sloping (3.5%).
- j. Land use: At the time of examination the site was under Panicum maximum and Hyparrhenia spp. grasses with Combretum zeyheri and Grewia bicolor bushes near-by. Crops of the area include sorghum, maize and cassava which are grown on ridges.
- k. Climate: Data derived from Shirati Mission, approximately 27 kilometres northwest of the site at elevation 1152 metres.

Average of 21 years

Monthly rainfall	J	F	M	A	M	J	J	A	S	O	N	D
in millimetres	51	60	99	170	110	37	20	31	29	51	112	70

Mean annual rainfall is 860 millimetres.

Rainfall at the site will be about the same.

II. General Information on the Soil:

- a. Parent Material: Derived from rocks of the basement complex, mainly granites.
- b. Drainage: Class 4 - well drained.
- c. Moisture conditions in profile: moist throughout.
- d. Depth of groundwater: unknown.
- e. Presence of surface stones and rocks: Class 0 - none in each case.
- f. Evidence of erosion: None at the site, but slight sheet erosion near-by.

- g. Presence of salt or alkali: Class 0 - apparently free.
h. Human influence: Very slight, confined to plough layer.

III. Brief Description of the Profile:

Well drained, dark reddish brown loamy sand over reddish brown to dark brown sandy loam with fine quartz gravel throughout. The entire profile is loose, porous and permeable, has good root distribution and neutral pH.

IV. Profile Description:

- 0-10 cm. Dark reddish brown (5YR²/2) loamy sand; weak medium granular; non-sticky, non-plastic, loose, loose; many very fine pores; few fine quartz gravel; abundant fine roots; abrupt smooth boundary; field pH 7.2.
- 10-33 cm. Very dark grey (5YR³/1) sandy loam; very weak fine subangular blocky; non-sticky, non-plastic, loose, loose; many very fine pores; few fine quartz gravel; abundant very fine roots; abrupt smooth boundary; field pH 7.5.
- 33-46 cm. Dark reddish brown (5YR³/2) sandy loam; very weak fine subangular blocky; non-sticky, non-plastic, loose, loose; many very fine pores; few fine quartz gravel; abundant very fine and few coarse roots; abrupt smooth boundary; field pH 7.0.
- 46-66+cm. Dark brown (7.5YR⁴/2) sandy loam; very weak fine subangular blocky; non-sticky, non-plastic, loose loose; many very fine pores; few fine quartz gravel; frequent very fine roots; field pH 7.2.

V. Interpreted Characteristics of the Soil:

This soil is mainly used for subsistence farming in a traditional crop-fallow rotation. The soil is weakly acid and has a very low C.E.C. and base content, though the balance of bases is fairly good. Potassium however, will be border-line for some crops. Organic carbon and nitrogen levels are moderate. The wide C/N ratio is indicative of economic responses to nitrogen

fertilizers on non-leguminous crops. Though phosphorus was not determined it seems likely that it is also in short supply. Fertilizer trials conducted by the Western Research Centre at Ukiriguru show a general response to ammonium sulphate and single superphosphate on granite soils, though the responses vary greatly from area to area. The general recommendation to farmers is 125 kilograms of each per hectare.

This soil was classified as a Ferruginous Tropical Soil on the basis of colour, high quartz content, silt/clay ratio, C.E.C. and the base saturation percentage of the subsoil.

Unit 317b Analytical Data

Horizon Depth in cm.	0-10	10-33	33-46	46-66
pH - 1:5 water	6.7	6.7	6.4	6.4
CaCO ₃ %	1.1	1.1	1.2	1.2
Conductivity - 1:5 mmohs/cm.	0.04	0.03	0.02	0.02
Exchangeable Bases - meq/100 gm.				
Ca	3.7	3.4	2.9	2.8
Mg	1.7	1.6	1.2	0.5
Na	0.07	0.18	0.12	0.10
K	0.27	0.24	0.20	0.17
Total	5.74	5.42	4.42	3.57
C.E.C. meq/100 gm.	6.2	-	-	4.3
Base Saturation %	92.0	-	-	83.0
Organic Carbon %	1.68	1.45	1.09	-
Nitrogen %	0.12	0.11	-	-
C/N ratio	14.0	13.1	-	-
Mechanical Analysis				
Coarse Sand %	69.0	58.7	54.5	61.7
Fine Sand %	19.3	23.5	29.1	28.5
Silt %	1.5	4.3	4.8	1.4
Clay %	7.2	9.0	9.4	7.0
Total	97.0	95.5	97.8	98.6

Soil Profile Description;

- I. Information on the site:
- a. Profile Number: UK-32
 - b. Unit Number: 311
 - c. Higher Category Classification: Ferrallitic Soil (D'Hoore).
 - d. Date of examination: 30 January 1969.
 - e. Authors: Wengell and Borden.
 - f. Location: 16 kilometres southwest of Nyalikungu, on the road to Lalago, Maswa District, Tanzania. Approximately 3°16'S. 33°52'E.
 - g. Elevation: approximately 1350 metres.
 - h. Land form:
 - i. physiographic position: crest of convex slope.
 - ii. surrounding land form: undulating.
 - iii. microtopography: nil.
 - i. Slope on which profile is sited: almost flat (1%).
 - j. Land use: The site was a cotton field the previous season but when examined supported a short grass cover of Bothriochloa insculpta and Chloris pilosa. Area crops include cotton, maize and cassava but no details of rotation, yields and management practices are known.
 - k. Climate: Rainfall data from meteorological station at Shanwa (elevation 1333 metres) approximately 17 kilometres northwest of the site.

Average of 39 years

Monthly rainfall	J	F	M	A	M	J	J	A	S	O	N	D
in millimetres	105	105	128	152	47	4	1	2	10	29	84	135

Mean annual rainfall is 803 millimetres.

Note the pronounced dry season from mid-May through October. Rainfall at the site can be expected to be comparable.

- II. General Information on the Soil:
- a. Parent Material: Derived from rocks of the basement complex, mainly granites.
 - b. Drainage: Class 4 - well drained.
 - c. Moisture conditions in profile: moist throughout.
 - d. Depth of groundwater: unknown.
 - e. Presence of surface stones and rocks: Class 0 - none in each case.

- f. Evidence of erosion: slight sheet and rill.
- g. Presence of salt or alkali: Class 0 - free.
- h. Human influence: confined to plough layer.

III. Brief Description of the Profile:

Deep, well drained, reddish brown sandy clay loam of weak subangular blocky structure. The second horizon has a noticeably higher clay content. Unconsolidated granitic bedrock underlies the profile at 106 centimetres.

IV. Profile Description:

- 0-20 cm. Reddish brown (5YR⁴/4) sandy clay loam; weak medium subangular blocky; non-sticky, non-plastic, very friable, loose; many medium pores; frequent fine quartz gravel; abundant medium roots; clear smooth boundary; field pH 7.0.
- 20-50 cm. Dark reddish brown (2.5YR³/4) sandy clay; weak medium subangular blocky; slightly sticky; plastic, friable, slightly hard; many medium pores; frequent fine quartz gravel; common medium roots; gradual smooth boundary; field pH 5.2.
- 50-106 cm. Red (2.5YR⁴/6) sandy clay loam; weak coarse subangular blocky; slightly sticky, plastic, friable, slightly hard; common fine pores; frequent fine quartz gravel; few medium and large roots; abrupt smooth boundary; field pH 5.0.
- 106+ cm. Unconsolidated granitic bedrock.

V. Interpreted Characteristics of the Soil:

This soil is used extensively for cotton and food crops and is suitable for mechanized agriculture. The soil is strongly acid with a marked fall in pH in the second horizon. The organic carbon and nitrogen levels are very low and the C/N ratio indicates that good responses to nitrogen fertilizers are likely, particularly in the presence of phosphorus, and fertilizer trials conducted by the Western Research Centre at

Ukiriguru verify this response. As the analytical data implies, potassium fertilizers did not give economic response.

This soil was classified as a Ferrallitic rather than a Ferruginous Tropical Soil on the basis of colour, structure, silt/clay ratio and C.E.C.

Unit 311 Analytical Data

Horizon Depth in cm.	0-20	20-50	50-106
pH - 1:5 water	5.5	4.9	5.5
CaCO ₃ %	Nil	Nil	Nil
Conductivity- 1:5 mmohs/cm.	0.02	0.01	0.01
Exchangeable Bases-meq/100gm.			
Ca	5.0	4.0	4.3
Mg	1.5	1.3	1.5
Na	0.18	0.10	0.16
K	0.64	0.40	0.17
Total	7.32	5.80	6.13
C.E.C. meq/100 gm.	13.8	-	11.1
Base Saturation %	53.0	-	55.0
Organic Carbon %	0.90	0.44	0.36
Nitrogen %	0.07	0.04	-
C/N ratio	12.9	11.0	-
Mechanical Analysis			
Coarse Sand %	51.1	49.4	45.5
Fine Sand %	18.3	14.6	13.7
Silt %	3.4	1.4	1.4
Clay %	22.5	31.0	36.5
Total	95.3	96.4	97.1

Soil Profile Description

I. Information on the site:

- a. Profile Number: UK-33
- b. Unit Number: 305
- c. Higher Category Classification: Calcimorphic Soil (D'Hoore).
- d. Date of examination: 29 November 1968.
- e. Authors: Reinsborough, Wengell and Borden.
- f. Location: 1.6 kilometres northwest of Mwamashele in Shinyanga District, Tanzania. Approximately 3°45'S. 33°49'E.
- g. Elevation: approximately 1100 metres.
- h. Land form:
 - i. physiographic position: mid convex slope.
 - ii. surrounding land form: flat to almost flat.
 - iii. microtopography: nil.
- i. Slope on which profile is sited: flat to almost flat(1.5%).
- j. Land use: At the time of examination the site was under the grasses Bothriochloa insculpta and Chloris pycnothrix. Adjacent to the site there was an old cotton field. Other crops grown in the area include maize and sorghum. Large numbers of livestock are also kept in the area.
- k. Climate: Data derived from meteorological stations at Mwadui Mine and Gulu Mission approximately 32 kilometres NW and 35 kilometres NNE of the site respectively. The elevation of both stations is 1212 metres.

Average monthly rainfall(millimetres)

	J	F	M	A	M	J	J	A	S	O	N	D
Mwadui	111	106	138	122	40	5	0	4	2	30	97	147
Gulu	101	98	122	86	41	1	0	0	7	14	57	115

Mean annual rainfall at Mwadui (15 year average) is 802 millimetres and at Gulu (13 year average) is 643 millimetres. Rainfall at the site can be expected to fall within this range. Note the pronounced dry season mid-May to October.

II. General Information on the Soil:

- a. Parent Material: Lacustrine deposits of silts and clays underlain by limestone.
- b. Drainage: Class 3 - moderately well drained.

- c. Moisture conditions in profile: dry throughout.
- d. Depth of groundwater: unknown.
- e. Presence of surface stones and rocks: Class 0 - none
in each case.
- f. Evidence of erosion: None at the site, but severe
gully erosion throughout the area.
- g. Presence of salt or alkali: Class 0 - apparently free.
- h. Human influence: severe overgrazing.

III. Brief Description of the Profile:

Moderately well drained, very dark brown clay loam over light brownish grey clay loam. Structure is massive throughout. The profile is sticky and friable and has frequent fine quartz gravel and hard irregular white calcareous nodules. pH is moderately alkaline. A shallow horizon of secondary calcium carbonate nodules directly overlies the limestone bedrock at 70 centimetres.

IV. Profile Description:

0-15 cm. Very dark brown (10YR²/2) moist and very dark grey (10YR³/1) dry, clay loam; few faint brown (7.5YR⁵/2) mottles; structureless, massive; sticky, plastic, friable, soft; few fine quartz gravel; very frequent small hard irregular white calcareous nodules; frequent fine roots; abrupt smooth boundary; field pH 7.6.

15-56 cm. Light brownish grey (10YR⁶/2) moist and dark greyish brown (10YR⁴/2) dry, clay loam; structureless, massive; sticky, plastic, friable, slightly hard; few fine quartz gravel; very frequent large hard irregular white calcareous nodules; frequent fine roots; clear smooth boundary; field pH 8.2.

56-70 cm. Dominant large hard irregular white secondary calcium carbonate nodules.

70+ cm. Decomposed limestone.

V. Interpreted Characteristics of the Soil:

This soil is good for a wide range of climatically

suited crops, especially cotton. Topography and soil structure make this area suitable for mechanized agriculture but the soils are shallow in some areas and highly erodable. The soil is strongly alkaline, and potassium is acutely deficient. The Ca/Mg ratio is very wide, therefore magnesium fertilizers may give some responses. The organic carbon and nitrogen levels are moderate and the C/N ratio is normal. Large economic responses to nitrogen fertilizers are not to be expected.

The soil has been classified as a Calcimorphic Soil because of colour, appreciable amounts of free calcium at all depths and a high content of bivalent cations, mainly calcium.

Unit 305 Analytical Data

Horizon Depth in cm.	0-15 .	15-50
pH - 1:5 water	8.5	8.6
CaCO ₃ %	12.0	15.4
Conductivity - 1:5 mmohs/cm.	0.08	0.09
Exchangeable Bases - meq/100 gm.		
Ca	62.4	68.3
Mg	3.8	3.4
Na	0.35	0.60
K	0.26	0.21
Total	66.81	72.51
C.E.C. meq/100 gm.	27.5	-
Base Saturation %	100.0	-
Organic Carbon %	1.73	1.28
Nitrogen %	0.14	0.12
C/N ratio	12.4	10.7
Mechanical Analysis		
Coarse Sand %	38.1	27.3
Fine Sand %	18.6	16.9
Silt %	7.4	11.4
Clay %	22.7	29.7
Total	86.8	85.3

8.5 8.6

12.0 15.4

0.08 0.09

Soil Profile Description

I. Information on the site:

- a. Profile Number: UK-34
- b. Unit Number: 302b
- c. Higher Category Classification: Vertisol of Topographic Depression (D'Hoore).
- d. Date of examination: 27 January 1969.
- e. Authors: Wengell and Borden.
- f. Location: Approximately 16 kilometres south of Mabuki, on the Mwanza-Shinyanga road, in Kwinba District, Tanzania. Approximately 3°05'S. 33°15'E.
- g. Elevation: approximately 1167 metres.
- h. Land form:
 - i. physiographic position: near bottom of convex slope.
 - ii. surrounding land form: flat to almost flat.
 - iii. microtopography: nil.
- i. Slope on which profile is sited: flat to almost flat(1.5-2%)
- j. Land use: At the time of examination the site was under Bothriochloa insculpta - Themeda triandra grass-land with some Sporobolus pyramidalis. Large numbers of livestock are kept in the area.
- k. Climate: Data derived from Ngudu meteorological station approximately 32 kilometres northeast of the site at an elevation of 1210 metres.

Average of 36 years.

Monthly rainfall	J	F	M	A	M	J	J	A	S	O	N	D
in millimetres	93	95	135	154	63	9	3	5	13	29	104	125

Mean annual rainfall is 828 millimetres.

The monthly mean maximum and minimum temperatures for a 28 year period are 29.1°C and 17.1°C respectively. Data derived from Kijima Mission station approximately 14 kilometres west of the site at elevation 1137 metres. The climate at the site should be comparable.

II. General Information on the Soil:

- a. Parent Material: Derived from sands and clays of lacustrine origin.
- b. Drainage: Class 3 - imperfectly drained.
- c. Moisture conditions in profile: moist to 38 centimetres.

- d. Depth of groundwater: unknown.
- e. Presence of surface stones and rocks: Class 0 -none
in each case.
- f. Evidence of erosion: slight rill.
- g. Presence of salt or alkali: Class 0 - none.
- h. Human influence: very slight, confined to surface
horizon.

III. Brief Description of the Profile:

Imperfectly drained, very dark brown clay over a very dark grey clay. The texture is uniform and structure is strong throughout. Fine quartz gravel and calcium carbonate nodules are found throughout the profile. Root distribution is normal, being concentrated in the top 30 centimetres. Unconsolidated granitic bedrock appears at 75 centimetres.

IV. Profile Description:

0-30 cm. Very dark brown (10YR²/2) cracking clay; strong fine subangular blocky; sticky, plastic, friable, hard; many very fine to fine vesicular pores; frequent fragments (1-4 millimetres) of quartz; few small hard irregular calcium carbonate nodules; few fine roots; clear smooth boundary; field pH 8.2.

30-75 cm. Very dark grey (7.5YR³/0) cracking clay; strong large prismatic; sticky, plastic, friable, extremely hard; few fine vesicular pores; frequent fragments (1-4 millimetres) of quartz; frequent small hard calcium carbonate nodules; few fine roots; abrupt smooth boundary; field pH 8.2.

75-85+cm. Unconsolidated granitic bedrock.

V. Interpreted Characteristics of the Soil:

The soil is suitable for the production of rice because of the very slow internal drainage, but adequate and controlled water supplies must be made available(6). Seasonal flooding could cause some hinderance to mechanized agriculture. The soil is strongly alkaline and

sodium increases with depth, but the level will not hinder most crops. Potassium is acutely short and the Ca/K ratio is very wide. Organic carbon and nitrogen are very low. The C/N ratio is slightly above normal. Responses to potassium, nitrogen and probably phosphorus fertilizers are likely but fertilizer trials at Western Research Centre, Ukiriguru do not verify this as economical.

This soil was classified as a Vertisol of Topographic Depression because of structure, dry season cracking, accumulations of calcium, slow internal drainage and a sodic horizon. Although the C.E.C. is below 50 percent it is saturated mostly with bivalent cations.

Unit 302b Analytical Data

Horizon Depth in cm.	0-30	50-75
pH - 1:5 water	8.4	9.0
CaCO ₃ %	2.3	3.0
Conductivity - 1:5 mmohs/cm.	0.06	0.13
Exchangeable Bases - meq/100 gm.		
Ca	35.6	36.1
Mg	3.6	3.9
Na	0.49	2.16
K	0.13	0.17
Total	39.82	42.33
C.E.C. meq/100 gm.	22.5	24.3
Base Saturation %	100.0	100.0
Organic Carbon %	0.90	0.56
Nitrogen %	0.07	-
C/N ratio	12.9	-
Mechanical Analysis		
Coarse Sand %	36.2	33.5
Fine Sand %	19.9	15.6
Silt %	8.4	10.4
Clay %	32.3	37.0
Total	96.8	96.5

Soil Profile Description

I. Information on the site:

- a. Profile Number: UK-35
- b. Unit Number: 318b
- c. Higher Category Classification: Ferruginous Ferrallitic Soil (D'Hoore).
- d. Date of examination: 26 October 1968.
- e. Authors: Reinsborough and Borden.
- f. Location: 13 kilometres west of Heru Juu on the main road, in Kasulu District, Tanzania. Approximately $4^{\circ}30'S$. $30^{\circ}E$.
- g. Elevation: approximately 1550 metres.
- h. Land form:
 - i. physiographic position: upper convex slope.
 - ii. surrounding land form: undulating to rolling.
 - iii. microtopography: nil.
- i. Slope on which profile is sited: moderately steep (19%).
- j. Land use: At the time of examination the site was under Hyparrhenia filipendula - Aristida atrovioacea grassland. The area around the site is mostly used for grazing and occasionally for small banana and coffee fields.
- k. Climate: Data derived from Heri Mission, approximately 20 kilometres west of the site, at elevation 1575 metres.

	Average of 10 years											
	J	F	M	A	M	J	J	A	S	O	N	D
Monthly rainfall in millimetres	152	150	210	252	89	11	0.5	5	35	96	177	185
Mean annual rainfall is 1362 millimetres.												
Note the short dry season from June to September. Rainfall at the site should be similar.												

II. General Information on the Soil:

- a. Parent Material: Derived in situ from reddish fine-grained flood basalts.
- b. Drainage: Class 4 - well drained.
- c. Moisture conditions in profile: dry throughout.
- d. Depth of groundwater: unknown.
- e. Presence of surface stones and rocks: Class 0 - none in each case.
- f. Evidence of erosion: none at the site but severe gully erosion throughout the area.

- g. Presence of salt or alkali: Class 0 - apparently free.
h. Human influence: nil.

III. Brief Description of the Profile:

Deep, well drained, dark red to red clay loam uniform in texture throughout. Structure is weak and ironstone nodules are found throughout the profile. Root distribution is normal with the majority of roots in the top 30 centimetres.

IV. Profile Description:

- 0-30 cm. Dark red (2.5YR³/6) moist and reddish brown (2.5YR⁴/4) dry, clay loam; weak medium crumb; slightly sticky, slightly plastic, friable, slightly hard; many fine pores; very few small hard irregular ironstone nodules; abundant fine roots; clear smooth boundary; field pH 6.0.
- 30-168 cm. Red (2.5YR⁴/8) moist and red (2.5YR⁴/6) dry, clay loam; weak fine subangular blocky; slightly sticky, slightly plastic, friable, slightly hard; common very fine pores; very few small hard ironstone nodules; frequent fine roots; clear smooth boundary; field pH 6.2.
- 168-185+cm. Yellowish red (5YR⁴/8) moist and yellowish red (5YR⁵/8) dry, clay loam; structureless, massive; slightly sticky, slightly plastic, friable, slightly hard; common very fine pores; few small hard irregular ironstone nodules; common fine roots; field pH 6.2.

V. Interpreted Characteristics of the Soil:

This soil is particularly susceptible to erosion, but where the slopes permit it is suitable for mechanized agriculture. High rainfall allows both temperate and sub-temperate crops to grow well. Much of the surrounding area is used for grazing livestock. The soil is freely drained and strongly acid at the surface, but slightly acid in the subsoil. It is deficient in potassium and possibly in calcium since the Ca/Mg ratio is very narrow in the subsoils. The organic carbon and

nitrogen levels are moderate to low. The C/N ratio is normal and thus large responses to nitrogen fertilizers would not generally be expected.

The soil has been classified as a Ferrallitic rather than a Ferruginous Tropical Soil because of the structure and texture of the second horizon and the apparent absence of 2:1 lattice clays even though the silt/clay ratio, C.E.C. and base saturation percentages are all high. ?

Unit 318b Analytical Data

Horizon Depth in cm.	.0-30	30-168	168-185
pH - 1:5 water	5.4	5.7	6.5
CaCO ₃ %	Nil	Nil	Nil
Conductivity - 1:5 mmohs/cm.	0.01	0.01	0.01
Exchangeable Bases - meq/100 gm.			
Ca	7.6	9.7	10.5
Mg	5.4	8.1	11.2
Na	0.15	0.23	0.20
K	0.18	0.12	0.15
Total	13.33	18.15	22.05
C.E.C. meq/100 gm.	24.7	-	24.5
Base Saturation %	54.0	-	90.0
Organic Carbon %	1.88	0.73	0.23
Nitrogen %	0.16	0.07	-
C/N ratio	11.8	10.4	-
Mechanical Analysis			
Coarse Sand %	16.5	10.7	9.5
Fine Sand %	14.9	15.7	29.0
Silt %	17.4	19.4	23.3
Clay %	43.5	49.7	33.0
Total	92.3	95.5	94.8

Soil Profile Description

- I. Information on the site:
- a. Profile Number: UK-36
 - b. Unit Number: 319
 - c. Higher Category Classification: Ferrallitic Soil (D'Hoore).
 - d. Date of examination: 2 February 1969.
 - e. Authors: Wengell and Borden.
 - f. Location: 17.7 kilometres past the Ruvuvu ferry crossing on the road to Ngara, Ngara District, Tanzania. Approximately 2°32'S. 30°34'E.
 - g. Elevation: approximately 1780 metres.
 - h. Land form:
 - i. physiographic position: crest of convex slope.
 - ii. surrounding land form: rolling.
 - iii. microtopography: nil.
 - i. Slope on which profile is sited: gently sloping (3-4%)
 - j. Land use: At the time of examination the site was under Hyparrhenia dissoluta and Loudetia arundinacea grasses with Combretum molle bushes near-by. Crops grown close-by include coffee, bananas and some cassava.
 - k. Climate: Data derived from Ngara recording station approximately 11 kilometres northeast of the site at elevation 1788 metres.

Average of 36 years

Monthly rainfall	J	F	M	A	M	J	J	A	S	O	N	D
in millimetres	99	109	122	186	100	12	5	19	64	75	125	113

Mean annual rainfall is 1027 millimetres.
The rainfall at the site should be similar.
Note the short dry season from June to August.
- II. General Information on the Soil:
- a. Parent Material: Derived in situ from interbedded shales and fine-grained sandstones.
 - b. Drainage: Class 4 - well drained.
 - c. Moisture conditions in profile: moist throughout.
 - d. Presence of surface stones and rocks: Class 0 - none in each case.
 - e. Depth of groundwater: unknown.
 - f. Evidence of erosion: slight to moderate rill erosion.
 - g. Presence of salt or alkali: Class 0 - apparently free.
 - h. Human influence: Very slight disturbance in surface horizon.

III. Brief Description of the Profile:

Deep, well drained profile, fairly uniform in appearance when moist. Texture changes from sandy clay loam to clay loam, then back to sandy clay loam. The whole profile is friable and root distribution is normal. Soft small red ironstone nodules appear at 64 centimetres.

IV. Profile Description:

- 0-23 cm. Dark reddish brown (5YR³/3) fine sandy clay loam; moderate crumb; non-sticky, non-plastic, very friable, soft; many fine pores; abundant fine and coarse roots; smooth abrupt boundary; field pH 7.0.
- 23-64 cm. Dusky red (2.5YR³/2) clay loam; weak fine sub-angular blocky; slightly sticky, slightly plastic, friable, slightly hard; common very fine pores; few coarse and common fine roots; smooth diffuse boundary; field pH 6.5.
- 64-150+cm. Dark reddish brown (2.5YR³/4) sandy clay loam; weak fine subangular blocky; non-sticky, non-plastic, very friable, soft; common very fine pores; few very fine roots; very few soft small red ironstone nodules; field pH 6.5.

V. Interpreted Characteristics of the Soil:

The soil is suitable for a variety of temperate and sub-temperate crops. There are areas of steep slopes, shallow soils and surface stones, but where the soils are deep, they are suitable for mechanized agriculture. The soil is moderately fertile, freely drained and medium to strongly acid. It is deficient in potassium and probably in magnesium since the Ca/Mg ratio is very wide in the deepest horizon. Organic carbon and nitrogen levels are high and the C/N ratio is normal.

The soil has been classified as a Ferrallitic Soil because of depth, structure, presence of iron oxide, apparent absence of 2:1 lattice clays, diffuse transition between horizons, silt/clay ratio and C.E.C.

Unit 319 Analytical Data

Horizon Depth in cm.	0-23	23-64	64-110
pH - 1:5 water	5.8	5.4	5.1
CaCO ₃ %	Nil	Nil	Nil
Conductivity - 1:5 mmohs/cm.	0.01	0.01	Nil
Exchangeable Bases - meq/100 gm.			
Ca	7.0	4.2	3.0
Mg	2.0	0.9	0.3
Na	0.20	0.14	0.12
K	0.13	0.10	0.08
Total	9.33	5.34	3.50
C.E.C. meq/100 gm.	16.4	-	8.6
Base Saturation %	57.0	-	41.0
Organic Carbon %	2.57	1.76	1.00
Nitrogen %	0.24	0.17	-
C/N ratio	10.7	10.3	-
Mechanical Analysis			
Coarse Sand %	33.2	30.2	16.0
Fine Sand %	12.1	13.9	17.9
Silt %	10.4	6.7	6.8
Clay %	40.9	45.0	52.4
Total	96.6	95.8	93.1

Soil Profile Description

I. Information on the site:

- a. Profile Number: UK-37
- b. Unit Number: 318a
- c. Higher Category Classification: Ferrallitic Soil (D'Hoore).
- d. Date of examination: 29 October 1968.
- e. Authors: Reinsborough and Borden.
- f. Location: Approximately 9.5 kilometres east of Tarime on Mara Hill road, in North Mara District, Tanzania. Approximately 1°23'S. 34°27'E.
- g. Elevation: approximately 1750 metres.
- h. Land form:
 - i. Physiographic position: upper convex slope.
 - ii. surrounding land form: undulating to rolling.
 - iii. microtopography: nil.
- i. Slope on which profile is sited: gently sloping (5%).
- j. Land use: At the time of examination the site was under Pennisetum polystachyon - Protea madiensis bushed grassland with some Digitaria scalarum.
- k. Climate: Data derived from Tarime meteorological station 9.5 kilometres west of the site, at elevation 1515 metres.

Average of 34 years

Monthly rainfall	J	F	M	A	M	J	J	A	S	O	N	D
in millimetres	84	106	164	229	163	79	46	74	88	127	150	129

Mean annual rainfall is 1439 millimetres.

Rainfall at the site should be the same.

II. General Information on the Soil:

- a. Parent Material: Apparently derived in situ on weathered basic basalts.
- b. Drainage: Class 4 - well drained.
- c. Moisture conditions in profile: moist throughout.
- d. Depth of groundwater: unknown.
- e. Presence of surface stones and rocks: Class 0 - none in each case.
- f. Evidence of erosion: none at the site, but slight to moderate rill erosion throughout unit.
- g. Presence of salt or alkali: Class 0 - free.
- h. Human influence: very slight, confined to plough layer.

III. Brief Description of the Profile:

Deep, well drained, dusky red clay loam that is very uniform in appearance, friable, porous and permiable throughout the profile. Root distribution is normal with the majority of roots in the top 50 centimetres. There is a medium acid reaction.

IV. Profile Description:

0-25 cm. Very dusky red ($10R^2/2$) clay loam; weak fine crumb; sticky, plastic, very friable, soft; many fine pores; abundant fine roots; diffuse smooth boundary; field pH 5.8.

25-

25-52 cm. Dusky red ($10R^3/4$) clay loam; structureless, massive, breaking very easily to very fine aggregates; sticky, plastic, friable, soft; ^{many} very fine to fine pores; frequent very fine roots; diffuse smooth boundary; field pH 5.6.

52-58+ cm. Dark red ($10R^3/6$) clay loam; structureless, massive, breaking easily to very fine aggregates; sticky, plastic, friable, slightly hard; common fine pores; few small hard spherical red iron-stone nodules; common very fine roots.

V. Interpreted Characteristics of the Soil:

The soil is suitable for a variety of temperate and sub-temperate crops. Rainfall is high and the soils are moderately fertile. It is suitable for mechanized agriculture where slopes, depth and absence of surface stones permit. The soil is freely drained and the balance of bases is normal. Economic responses to potassium are not probable. The C/N ratio is normal, therefore large responses to nitrogen fertilizers are not to be expected.

The soil was classified as a Ferrallitic Soil because of depth, presence of iron oxide, apparent absence of 2:1 lattice clays, silt/clay ratio and C.E.C. Also, the structural elements form a very friable and porous mass and the horizons are only slightly differentiated with diffuse transitions.

Unit 318a Analytical Data

Horizon Depth in cm.	0-25	25-52	52-85
pH - 1:5 water	5.6	5.2	5.2
CaCO ₃ %	Nil	Nil	Nil
Conductivity - 1:5 mmohs/cm.	0.05	0.02	0.01
Exchangeable Bases - meq/100 gm.			
Ca	6.4	5.1	5.0
Mg	2.4	1.9	1.7
Na	0.12	0.10	0.13
K	0.70	0.36	0.26
Total	9.62	7.46	7.09
C.E.C. meq/100 gm.	19.2	-	15.8
Base Saturation %	50.0	-	45.0
Organic Carbon %	2.31	1.74	1.20
Nitrogen %	0.21	0.17	-
C/N ratio	11.0	10.2	-
Mechanical Analysis			
Coarse Sand %	7.1	5.6	4.5
Fine Sand %	18.9	10.2	14.0
Silt %	18.0	15.6	10.0
Clay %	52.4	60.0	63.6
Total	96.4	91.4	92.1

0-25 . 25-52 . 52-85

Soil Profile Description

I. Information on the site:

- a. Profile Number: UK-38
- b. Unit Number: 313b
- c. Higher Category Classification: Ferruginous Tropical Soil (D'Hoore).
- d. Date of examination: 29 November 1968.
- e. Authors: Reinsborough, Wengell and Borden.
- f. Location: 13.6 kilometres north of Nyalikungu, on the road to Bariadi, Maswa District, Tanzania. Approximately 3°06'S. 33°52'E.
- g. Elevation: approximately 1335 metres.
- h. Land form:
 - i. physiographic position: gently convex midslope.
 - ii. surrounding land form: undulating.
 - iii. microtopography: nil.
- i. Slope on which profile is sited: gently sloping (2.5%).
- j. Land use: At the time of examination the site was a recently uprooted cotton field. The surrounding vegetation included Bothriochloa insculpta and Sporobolus spp. grasses and a few bushes of Acacia hebecladoides.
- k. Climate: Rainfall data recorded at Shanwa approximately 14 kilometres wouthwest of the site at 1333 metres elevation.

Average of 39 years

Monthly rainfall	J	F	M	A	M	J	J	A	S	O	N	D
in millimetres	105	105	128	152	47	4	1	2	10	29	84	135

Mean annual rainfall is 803 millimetres.

Rainfall at the site should be similar. Note the long dry season from May though October.

II. General Information on the Soil:

- a. Parent Material: Apparently derived in situ from deeply weathered rocks of the basement complex, mainly gneiss, but possibly influenced by volcanic ash deposits.
- b. Drainage: Class 4 - well drained.
- c. Moisture conditions in profile: moist to 30 centimetres.
- d. Depth to ground water: unknown.
- e. Presence of surface stones and rocks: Class 0 - none in each case.

- f. Evidence of erosion: slight sheet.
- g. Presence of salt or alkali: Class 0 - apparently free.
- h. Human influence: confined to plough layer.

III. Brief Description of the Profile:

Deep, well drained, dusky red sandy loam over dark red sandy clay loam. The profile is structureless, friable and permeable throughout with a few hard red ironstone nodules.

IV. Profile Description:

- 0-25 cm. Dusky red ($10R^3/4$) moist and red ($10R^4/6$) dry, sandy loam; structureless, massive; slightly sticky, non-plastic, friable, soft; slightly calcareous; smooth gradual boundary; field pH 7.5.
- 25-58 cm. Dark red ($10R^3/6$) moist and red ($2.5YR^4/6$) dry, sandy clay loam; structureless, massive; slightly sticky, slightly plastic, friable, slightly hard; very few hard red ironstone nodules; strongly calcareous; smooth gradual boundary; field pH 8.0.
- 58-137+cm. Dark red ($2.5YR^3/6$) moist and red ($2.5YR^4/8$) dry, sandy clay loam; structureless, massive; slightly sticky, slightly plastic, friable, slightly hard; few hard red ironstone nodules; strongly calcareous; few fragments of strongly weathered gneiss; field pH 8.0.

V. Interpreted Characteristics of the Soil:

The soil is used extensively for cotton and maize. Slope and soil structure make most of this unit suitable for mechanized agriculture. The soil is mildly to moderately alkaline, balance of bases is reasonable at the surface and the base content and C.E.C. are high. The organic carbon and nitrogen levels are very low, therefore nitrogen in the presence of phosphorus may give good responses to non-leguminous crops.

The soil has been classified as a Ferruginous Tropical Soil on the basis of free iron oxide, silt/clay ratio, C.E.C. and base saturation percent.

Unit 313b Analytical Data

Horizon Depth in cm.	0-25 .	25-58 .	58-100
pH - 1:5 water	7.6	8.2	8.3
CaCO ₃ %	1.0	1.5	2.2
Conductivity - 1:5 mmoha/cm.	0.08	0.14	0.15
Exchangeable Bases - meq/100 gm:			
Ca	18.0	30.0	29.6
Mg	3.0	2.6	3.9
Na	0.29	0.37	0.50
K	1.80	1.93	2.02
Total	23.09	34.90	36.02
C.E.C. meq/100 gm.	20.8	-	18.0
Base Saturation %	100.0	-	100.0
Organic Carbon %	0.66	0.23	0.11
Nitrogen %	0.08	0.04	-
C/N ratio	8.2	5.7	-
Mechanical Analysis			
Coarse Sand %	31.7	24.5	22.9
Fine Sand %	15.8	25.8	28.0
Silt %	12.3	20.9	25.4
Clay %	37.7	25.0	21.0
Total	97.5	96.2	97.3

Soil Profile Description

I. Information on the site:

- a. Profile Number: UK-39
- b. Unit Number: 322
- c. Higher Category Classification: Ferruginous Tropical Soil (D'Hoore).
- d. Date of examination: 12 March 1969.
- e. Authors: Wengell and Borden.
- f. Location: 24 kilometres west of Bwanga, on the road to Biharamulo, Biharamulo District, Tanzania. Approximately 2°53'S. 31°34'E.
- g. Elevation: approximately 1275 metres.
- h. Land form:
 - i. physiographic position: convex upper slope.
 - ii. surrounding land form: undulating.
 - iii. microtopography: nil.
- i. Slope on which profile is sited: gently sloping (4%).
- j. Land use: At the time of examination the site was under woodland. The dominant species were Brachystegia microphylla, Pterocarpus angolensis and Cussonia arborea with an understorey of Hyparrhenia dissoluta and Loudetia simplex grasses.
- k. Climate: Data derived from Runazi recording station approximately 15 kilometres northwest of the site at elevation 1394 metres.

Average of 12 years

Monthly rainfall	J	F	M	A	M	J	J	A	S	O	N	D
in millimetres	93	112	143	178	77	8	2	12	43	82	137	120

Mean annual rainfall is 1008 millimetres.

Rainfall at the site may be as low as 900 millimetres due to the lower elevation.

II. General Information on the Soil:

- a. Parent Material: Unconsolidated residual material of banded ironstone and metavolcanic origin.
- b. Drainage: Class 4 - well drained.
- c. Moisture conditions in profile: moist throughout.
- d. Depth of groundwater: unknown.
- e. Presence of surface stones and rocks: Class 0 - none in each case.
- f. Evidence of erosion: nil.

- g. Presence of salt or alkali: Class 0 - apparently free.
h. Human influence: nil.

III. Brief Description of the Profile:

Deep, well drained, dusky red sandy clay loam that is very uniform in structure and consistence throughout the profile. There is an extremely dense grass root mat in the top 15 centimetres.

IV. Profile Description:

- 0-8 cm. Dusky red (2.5YR³/2) sandy clay loam; moderate granular; sticky, plastic, very friable, hard; many fine pores; abundant fine roots; abrupt smooth boundary; field pH 7.8.
- 8-18 cm. Dark reddish brown (2.5YR³/4) sandy clay loam; moderate fine subangular blocky; sticky, plastic, very friable, slightly hard; many fine pores; abundant fine roots; abrupt smooth boundary; field pH 7.0.
- 18-38 cm. Dark red (2.5YR³/6) sandy clay loam; weak fine subangular blocky; very sticky, very plastic, very friable, slightly hard; many very fine pores; frequent fine to very fine roots; abrupt smooth boundary; field pH 6.0.
- 38-122+cm. Red (2.5YR⁴/8) sandy clay loam; weak fine subangular blocky; slightly sticky, slightly plastic, very friable, slightly hard; many fine pores; common very fine roots; field pH 5.5.

V. Interpreted Characteristics of the Soil:

The soil is suitable for a variety of crops, especially cotton, maize and sweet potatoes. Where soils are deep and slopes undulating the unit is suitable for mechanized agriculture. The soil is freely drained, fertile and the balance of bases is reasonable in the subsoil except for potassium. The organic carbon and nitrogen content and the C/N ratio is high. Data indicates possible responses to potassium and nitrogen fertilizers, but there is too little field data to verify this.

The soil was classified as Ferruginous Tropical Soil on the basis of structure, silt/clay ratio and C.E.C.

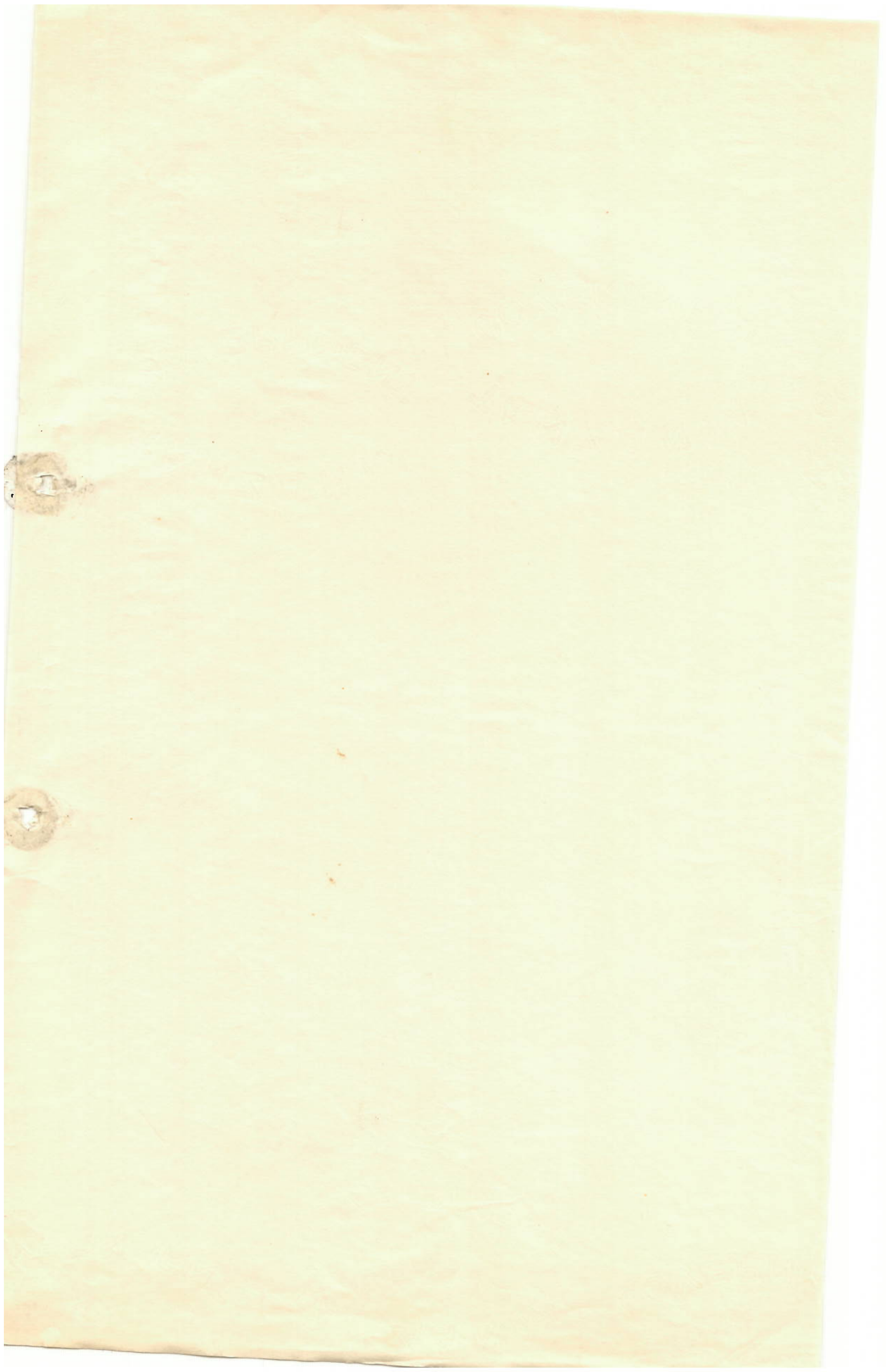
Unit 322 Analytical Data

Horizon Depth in cm.	0-8	8-18	18-38	38-90
pH - 1:5 water	7.4	5.6	5.3	5.1
CaCO ₃ %	1.1	Nil	Nil	Nil
Conductivity - 1:5 mmohs/cm.	0.03	0.01	0.01	0.01
Exchangeable Bases - meq/100 gm.				
Ca	-	3.5	2.8	2.2
Mg	-	1.4	0.8	0.5
Na	-	0.10	0.09	0.08
K	-	0.15	0.12	0.10
Total	-	5.15	3.81	2.88
C.E.C. meq/100 gm.	-	-	-	12.0
Base Saturation %	-	-	-	24.0
Organic Carbon %	2.03	1.68	1.05	-
Nitrogen %	-	0.12	-	-
C/N ratio	-	14.0	-	-
Mechanical Analysis				
Coarse Sand %	26.2	22.6	19.8	18.1
Fine Sand %	16.2	14.9	11.8	21.0
Silt %	14.4	9.7	9.4	8.0
Clay %	39.7	48.0	54.3	50.1
Total	96.5	95.2	95.3	97.2

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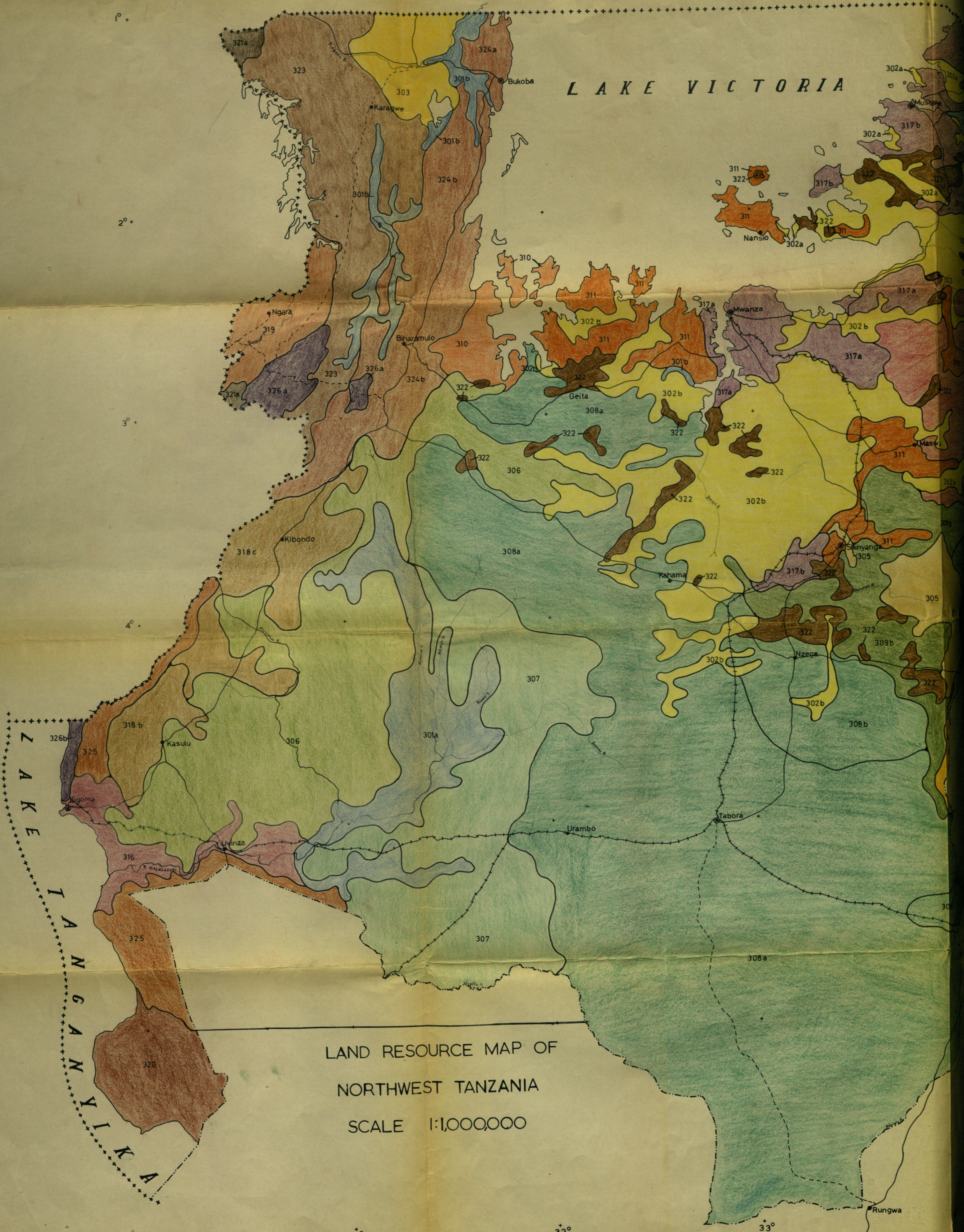
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LEGEND

Unit	Physiography	Soil	Vegetation
301	Flat swampland and adjacent floodplains.	a. Deep, black sandy clay loams overlain by deep organic matter; greyish brown sandy loams over sandy clays. b. Deep, black peaty clay loams over sandy clays overlain by deep organic matter.	<u>Vossia-Cyperus</u> permanent swamp; <u>Hyparrhenia-Panicum</u> grassland. <u>Cyperus-Vossia</u> permanent swamp; medium <u>Hyparrhenia-Panicum</u> grassland.
302	a. Flat to almost flat seasonally flooded valleys. b. Flat to almost flat with scattered granite outcrops.	Deep, calcareous, cracking, very dark grey to black clays; brown sandy loams over sandy clays. Deep, calcareous, cracking, very dark grey to black clays; grey sandy loams over sandy clays.	Tall <u>Hyparrhenia-Acacia</u> seasonally flooded bushed grassland; <u>Acacia-Combretum</u> bushland. Medium <u>Bothriochloa-Themeda</u> seasonally flooded grassland; <u>Acacia</u> bushland.
303	Flat to almost flat seasonally waterlogged plain.	Deep, very dark grey clays; dark reddish brown sandy clays over clays	Medium <u>Themeda-Acacia</u> bushed grassland; <u>Brachystegia-Acacia</u> woodland.
304	Flat to almost flat lake beds, floodplains and alluvial fans.	Deep, dark brown to brownish grey sandy loams over sandy clay loams; deep, dark brown silt loams over fine sandy loams; deep, saline black clays.	Short <u>Sporobolus-Acacia</u> bushed grassland; tall <u>Echinochloa</u> seasonally flooded grassland.
305	Flat to almost flat plain with occasional escarpments.	Very dark grey clay loams underlain by limestone.	Medium <u>Bothriochloa-Acacia</u> bushed grassland.
306	Flat to undulating with occasional small hills.	Deep, dusky red clay loams; shallow dark grey to black clays.	<u>Brachystegia-Julbernardia</u> woodland; short <u>Loudetia-Microchloa</u> grassland.
307	Flat to undulating with occasional low granite outcrops and a few volcanic cones.	Deep, calcareous, black sandy clay loams over sandy clays; moderately deep, red sandy clay loams over clay loams; grey sandy loams over sandy clays.	<u>Brachystegia-Julbernardia</u> woodland; medium to tall <u>Loudetia-Hyparrhenia</u> grassland.
308	Flat to undulating with occasional low granite outcrops.	a. Deep, dark greyish brown loamy sands and sandy loams over sandy clay loams; deep, dark red loams and sandy clay loams; deep, very dark brown sandy clays and clays. b. Deep, dark greyish brown sandy loams over sandy clay loams; deep, dark red sandy clay loams. c. Deep, light brownish grey sandy loams over sandy clay loams.	<u>Brachystegia-Julbernardia</u> woodland; tall <u>Hyparrhenia-Panicum</u> grassland. <u>Acacia-Commiphora</u> bushland. <u>Berhia-Bussea</u> bushland thicket; tall <u>Hyparrhenia-Acacia</u> bushed grassland.
309	Flat to undulating with occasional low granite outcrops.	a. Calcareous, very dark grey sandy clays over clays. b. Calcareous, dark grey sandy clay loams over clays.	<u>Acacia-Commiphora</u> bushland.
310	Undulating lowlands.	Deep, dark brown sandy loams over sandy clay loams; deep, calcareous, very dark grey clays.	<u>Brachystegia-Julbernardia</u> woodland; tall <u>Hyparrhenia-Acacia</u> bushed grassland.
311	Undulating with low granite outcrops.	Deep, reddish brown sandy loams over sandy clay loams; deep, very dark grey sandy clay loams over sandy clays.	<u>Acacia-Commiphora</u> bushland; short <u>Bothriochloa-Commiphora</u> bushed grassland; tall <u>Hyparrhenia-Pennisetum</u> grassland.
312	Undulating plain with occasional granite outcrops.	Deep, often calcareous, cracking, very dark brown to black sandy clays over clay loams; shallow, very dark brown sandy clay loams.	<u>Acacia-Commiphora</u> bushland; medium to tall <u>Hyparrhenia-Themeda</u> grassland.
313	Undulating plain with occasional massive granite outcrops.	a. Moderately deep, calcareous, dark reddish brown sandy clay loams over clay loams; calcareous, black clays. b. Deep, calcareous, dark reddish brown sandy loams over sandy clay loams; deep, calcareous, grey to black sandy clays.	<u>Acacia-Commiphora</u> bushland. Medium <u>Bothriochloa-Acacia</u> bushed grassland; <u>Acacia-Commiphora</u> bushland.
314	Undulating.	Moderately deep, dark greyish brown clay loams.	Tall <u>Hyparrhenia-Acacia</u> bushed grassland.
315	Undulating plain with granite and gneiss outcrops.	Moderately deep, calcareous, dark grey to very dark brown fine sandy loams and silty clay loams.	Medium to tall <u>Andropogon-Themeda</u> grassland.
316	Undulating to rolling with occasional low ridges and hills.	Deep, yellowish red fine sandy loams over sandy clay loams; deep, dark red sandy clay loams; deep, dark reddish brown to dark grey clay loams.	<u>Brachystegia-Julbernardia</u> woodland.
317	Undulating to rolling with numerous granite outcrops.	a. Moderately deep, reddish brown to grey loamy sands and sandy loams; moderately deep, greyish brown sandy loams over clay hardpan; deep, calcareous, cracking, black clays. b. Moderately deep, dark reddish brown loamy sands over sandy loams; deep, greyish brown sandy loams; deep, cracking, very dark brown clays. c. Moderately deep, dark reddish brown sandy loams; shallow, dark brown loams.	<u>Commiphora-Combretum</u> bushland; tall <u>Bothriochloa-Panicum-Hyparrhenia</u> grassland. Medium <u>Bothriochloa-Grewia</u> bushed grassland; <u>Grewia-Combretum</u> bushland. <u>Commiphora-Acacia</u> bushland.
318	Undulating to rolling plateaus.	a. Deep, dusky red clay loams. b. Deep, dark reddish brown to dark red clay loams and clays. c. Deep, dark red to dusky red sandy clay loams and clay loams.	Tall <u>Pennisetum-Protea</u> bushed grassland. Medium to tall <u>Hyparrhenia-Aristida</u> grassland; tall <u>Hyparrhenia-Combretum</u> bushed grassland. <u>Brachystegia-Pterocarpus</u> woodland; tall <u>Hyparrhenia-Combretum</u> bushed grassland.
319	Almost flat to rolling plateau.	Deep, dark reddish brown sandy clay loams over clay loams.	Tall <u>Hyparrhenia-Combretum</u> bushed grassland.
320	Rolling to hilly plateau.	Moderately deep, dark red sandy clay loams; deep, very dark brown loams over clay loams.	Medium <u>Themeda-Protea</u> bushed grassland; <u>Brachystegia-Pterocarpus</u> woodland.
321	Rolling to hilly with outcrops of granite.	a. Very dark brown sandy loams over sandy clay loams; deep, very dark brown sandy clay loams. b. Deep, dark reddish brown sandy loams over clay loams; deep, dark brown sandy clay loams and sandy clays.	Tall <u>Hyparrhenia-Combretum</u> bushed grassland. Tall <u>Hyparrhenia-Acacia</u> bushed grassland; <u>Acacia-Commiphora</u> bushland.
322	Steep, rounded hills surrounded by undulating footslopes.	Moderately deep, dark reddish brown loams over clay loams.	<u>Brachystegia-Combretum</u> woodland; medium <u>Bothriochloa-Acacia</u> bushed grassland.
323	Rolling to hilly with long steep-sided, flat-topped ridges.	Shallow, dark reddish brown sandy loams over sandy clay loams; deep, black loams over clays.	Medium <u>Loudetia-Hyparrhenia</u> grassland; <u>Acacia-Combretum</u> bushland; <u>Terminalia-Brachystegia</u> woodland.
324	Rolling to hilly with sandstone escarpments.	a. Deep, dark reddish brown sandy loams over sandy clay loams; deep, dark greyish brown sandy clay loams. b. Deep, dark reddish brown fine sandy loams; deep, dark greyish brown sandy clay loams.	Tall <u>Hyparrhenia-Andropogon</u> grassland. <u>Brachystegia-Julbernardia</u> woodland; medium <u>Loudetia-Panicum</u> grassland.
325	Rolling to hilly with some steeply dissected areas.	Moderately deep to deep, dark reddish brown fine sandy loams over sandy clay loams; shallow to moderately deep dark reddish brown loamy fine sands over sandy loams.	<u>Brachystegia-Acacia</u> woodland; short to medium <u>Sporobolus-Hyparrhenia</u> grassland.
326	Steeply dissected.	a. Shallow, stony, dark reddish brown sandy clay loams over sandy clays. b. Shallow, stony, dark reddish brown fine sandy loams and sandy clay loams.	<u>Brachystegia-Isobertinia</u> woodland; tall <u>Hyparrhenia-Loudetia</u> grassland. Short to medium <u>Sporobolus-Hyparrhenia</u> grassland; <u>Brachystegia-Acacia</u> woodland.

L A K E V I C T O R I A



LAND RESOURCE MAP OF
NORTHWEST TANZANIA
SCALE 1:1,000,000

7° 29'

30°

31°

32°

33°

Rungwa

L A K E V I C T O R I A



- | Unit | Physiography |
|------|---------------------------------------------------------------------------------------------------------------|
| 301 | Flat swampland and adjacent floodplains. |
| 302 | a. Flat to almost flat seasonally flooded valleys.
b. Flat to almost flat with scattered granite outcrops. |
| 303 | Flat to almost flat seasonally waterlogged plain. |
| 304 | Flat to almost flat lake beds, floodplains and alluvial fans. |
| 305 | Flat to almost flat plain with occasional escarpments. |
| 306 | Flat to undulating with occasional small hills. |
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| 310 | Undulating lowlands. |
| 311 | Undulating with low granite outcrops. |
| 312 | Undulating plain with occasional granite outcrops. |
| 313 | Undulating plain with occasional massive granite outcrops. |
| 314 | Undulating. |
| 315 | Undulating plain with granite and gneiss outcrops. |
| 316 | Undulating to rolling with occasional low ridges and hills. |
| 317 | Undulating to rolling with numerous granite outcrops. |
| 318 | Undulating to rolling plateaus. |
| 319 | Almost flat to rolling plateau. |
| 320 | Rolling to hilly plateau. |
| 321 | Rolling to hilly with outcrops of granite. |
| 322 | Steep, rounded hills surrounded by undulating footslopes. |
| 323 | Rolling to hilly with long steep-sided, flat-topped ridges. |
| 324 | Rolling to hilly with sandstone escarpments. |
| 325 | Rolling to hilly with some steeply dissected areas. |
| 326 | Steeply dissected. |

AND RESOURCE MAP OF
NORTHWEST TANZANIA
SCALE 1:1,000,000

32° 33° 34° 35°

L A K E V I C T O R I A



LAND RESOURCE MAP OF
NORTHWEST TANZANIA
SCALE 1:1,000,000

7° 29' 30° 31° 32° 33° 34° 35°