LAFIA AGRICULTURAL DEVELOPMENT PROJECT, LAFIA, PLATEAU STATE, NIGERIA

SOILS OF ASSAIKIO, AWE, DOMA, KEANA, LAFIA AND OBI FARMS

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SECTION I

1. INTRODUCTION

At the request of the Lafia Agricultural Development Project, soil surveys were carried out in the Seed/Research farm at Lafia and in the District Demonstration farms at Assaikio, Awe, Doma, Keana and Obi. One demonstration farm is sited in each of the five districts which lie within the boundaries of the project (Fig. 1). The extent of each farm is as follows:-

Seed/Research farm	50.80 ha
* Assaikio farm	16.95 ha
Doma farm	61.25 ha
Obi farm	34.46 ha
Keana farm	50.40 ha
Awe farm	37.03 ha
Total =	250.89 ha

Over a period of eight weeks between November 1980 and March, 1981, detailed studies were carried out in the Seed/Research farm and the five demonstration farms.

The objectives of the study were to (i) characterize and classify the soils of the farms and (ii) make vital recommendations on the appropriate uses of the soils of the farms for agricultural production.

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* The farm is at Tsakuwa which is roughly halfway between Lafia and Assaikio

2. PHYSICAL SETTING

2.1 General

The headquarters of the Project is at Lafia in the southern part of Plateau State. The Project itself, is located on a number of flat to gently undulating plains lying between the escarpment and dissected hilly areas marking the southern boundary of the Jos Plateau to the north and the floodplains of the River Benue to the south. The general altitude of the plains within the project area is 120 - 180m (400 - 600ft). The vegetation is open woodland with a southern Guinea Savanna species composition. The mean annual rainfall is around 1300mm (50.5").

2.2 Methodology

A 200m x 100m grid format was used in carrying out the field work. In each area soil surveyed, traverses 200m apart were laid out at right angles to the general slope of the land. At 100m intervals along each traverse, auger samples were taken to a maximum depth of 120cm. In addition soil changes were observed along each traverse and the points of change marked as natural soil boundaries.

By the procedures above the natural boundaries among the various soils were identified and plotted on base maps. The soil mapping unit is the soil series, denoted 1, 2, 3, 4 etc on the basic soil maps that accompany this report.

One profile pit was dug in each of the major mapping units (soil series) recognized. The soil pits were described according to the guidelines laid down in the FAO (1973) publication. Bulk soil samples were collected from the natural horizons recognized in the soil pits for laboratory characteristics studies. The following analyses were performed on the soil samples following the necessary sample preparation procedures:

- Particle size analysis by the hydrometer method
- pH in water (1:1 soil: water ratio)
- Organic carbon content by the Walkley-Black method (wet combustion method involving the oxidation of soil organic matter with potassium dichromate)
- Exchangeable cations (Ca, Mg, K, Na) in 1N NH_4 OAc (pH 7) soil extracts; Ca and Mg determined by atomic absorption spectrophotometry, and Na and K determined by flame photometry.
- cation exchange capacity (CEC) by saturating soil with 1N NH_4OAc (pH 7) followed by the direct distillation and determination of adsorbed ammonia.

- total nitrogen by the macro-Kjeldahl method.
- Available phosphorus by Bray I method (1N NH_4F - 0.5N HCL mixture).
- Electrical conductivity (EC) by use of the Conductivity Bridge.
- Base saturation by dividing the sum of bases (Ca, Mg, K and Na) by the CEC.

Based on the overall soil properties observed in the field and measured in the laboratory, a basic soil map with soil series as the mapping unit and a land capability map based on the interpretation of the soil properties was prepared for each farm at a scale of 1:5000.

3. SOILS

In this section will be discussed the general characteristics of the soils of each of the demonstration farms and Seed/Research farm. The morphological data and the physical and chemical data in support of the soil characteristics outlined for each soil are in Section II of this report.

3.1 Assaikio

The Assaikio demonstration farm is 22 km from Lafia along the Shendam road. It is situated south of the Akuni stream and adjacent to the carp farm of the fisheries unit. Part of the stream forms the northern boundary of the farm. The farm extends to 16.95 ha (See Map 1).

The general slope of the land surface is from the higher elevations at the southern end of the farm down towards the Akuni stream. Most of the uplands are flat to gently sloping. Approaching the stream the slope gradient increases and there is usually a clear break of slope where the uplands meet the flat valley floor. In the eastern part of the farm the valley floor is in the form of a shallow depression lying between the uplands and a narrow band of slightly more elevated land along the northern boundary of the farm. Toward the west the area of low lying land between the uplands and the stream is slightly more extensive. However most of this flat land lies between the northern boundary of the farm and the stream and therefore does not form part of the farm.

The Akuni stream is perennial with a good flow even in the height of the dry season. It is a tributary of the River Tsakuwa

which at one point flows close to the western boundary of the farm.

Upland areas make up the bulk of the farm. The upland soils have been mapped into two soil series identified as Soil Series 1 and Soil Series 2. Soil series 1 consists of the upper slope soils which make up about 50% of the soils of the area and which include deep well-drained, very strongly acidic yellowish red clay loamy to clay soils. A few subrounded ironstone concretions are present in the upper part of the soils and soft, subrounded black concretions in the lower part of the soils. The presence of the subrounded concretions throughout the soil profile would suggest that the soils have formed in transported material. The high ratio of fine sand to coarse sand also supports this idea. The soils are very strongly acid. Of the exchangeable bases, the level of magnesium (Mg) is moderate while the levels of calcium (Ca), potassium (K) and sodium (Na) are low. Cation exchange capacity (CEC) is moderate to high. Base saturation is low.

Soils of soil series 2 are deep well-drained yellowish red, sandy clay loam soils occupying the lower middle slope positions. They differ from the soils of soil series 1 in being lighter in texture, mottled below 100cm and lacking hard ironstone concretions within the upper 50cm. They occupy about 30% of the area.

The soils are strongly acid except in the top 20cm where soil reaction is moderately acid to slightly acid. Exchangeable Ca and Mg are moderate, Na is low and K is very low. CEC is moderate. Base saturation is moderate in the subsoil and high in the topsoil.

Soils of soil series 3 are imperfectly drained, deep, reddish-yellow sandy clay loam soils in lower slope positions. They are very minor in the farm. They have formed in alluvial and colluvial materials.

Soils of soil series 4 have also formed in alluvial materials bordering the Tsakuwa and Akuni streams. They are poorly drained brown to gray, clay loams to clays. They are gleyed below 100cm. The soils occur in the valley bottom lands adjoining the streams.

Soils of soils series 3 and 4 are very strongly acid. The levels of exchangeable Na, K and Ca are low while Mg level is moderate. Base saturation is moderate.

Summarily, the majority of the soils of the farm are well-drained fine-texured (clay loam to clay) soils that are capable of holding adequate water for plant use. Their fertility level is rated low as the levels of Na, K, Ca, are low and organic matter is low to moderate generally. Slope conditions are favourable for mechanical cultivation. Soil erossion will be minimal as

most of the land surfaces are flat or nearly flat. The relevant data of soil descriptions, and physical and chemical characteristics of the soils are on P. 42-53 of Section II.

3.2 Awe

The farm is about one kilometer east of "New" Awe on the road to Kyekwura. The Tabagutu stream cuts through the south-east quadrant of the farm. At first it follows a north-westerly course and then abruptly changes direction towards the south-west. The stream is perennial but the flow during the late dry season is minimal. Where it enters the farm, the stream is bordered by a narrow band of fringing forest for about 200m. The stream then enters a fadama area without the fringing forest type vegetation. The fadama continues almost to the Awe-Kyekwura road. A dry season water course enters the stream on the right bank above the fadama and another smaller water course joins the fadama on the same side further down stream.

The overall slope is towards the stream. In the south-east corner of the farm the land surface is flat, then a gentle to moderate dip occurs towards the stream. From the western boundary towards the fadama the slope is long and gradual. From along the

northern boundary towards the stream the slopes are still gentle but slightly steeper than in the western part of the farm. Between the stream and the more northerly of the two water courses, the land is generally low lying.

The soils of Awe farm have formed in residuum from shale and/or sandstone and colluvium derived there from. The best drained soils are the imperfectly drained soils of soil series 5 (see map 2) which occupy about 14% of the land. The soils are deep loamy sands becoming more clayey with depth. They do not have mottles in the upper 60cm from the soil surface. Mottling below 60cm is probably due to the clayey material which underlies the sandy superficial materials in which the soils have formed. The clayey substratum occurs at 2 to 3 metre depth and appears to inhibit water percolation. The soils are moderately acid. The level of Na is low and K very low. Ca and Mg are low to moderate. CEC is very low and base saturation is moderate to high.

Soil series 6 occurs further down the slope and includes soils which are less well-drained compared with the soil series 5. Mottles and soft black concretions are present in the soils. The soils have developed in sandy colluvial parent material possibly overlying residuum from shale which is responsible for the more clayey horizons at deeper depths in the soils.

Soil series 6 are sandy clay loam to sandy clay soils with sandy loam topsoil. They are moderately acid in reaction. The level of exchangeable Na is low in surface horizons and moderate in the subsurface horizons. Exchangeable K is very low in the surface horizons and low in the subsurface horizons. Mg is low in the surface horizons and moderate in the subsurface horizons. Ca is moderate to high especially in the subsurface horizons. CEC is low to moderate while base saturation is moderate to high. Soil series 6 occupies about 12% of the land.

In the northwest part of the farm occurs soil series 7 consisting of shallow, imperfectly to poorly drained sandy loam soils over ironpan or a concretionary layer. The series occupies about 10% of the land. The soils of the series are strongly acid. Exchangeable Na and K are low while Mg and Ca are moderate. CEC is low and base saturation is high.

Downslope after soil series 7 occurs soil series 8. The soils are deep, imperfectly drained sandy clay loam to clay soils with sandy loam topsoil. They are mottled from the surface down. Ironstone concretions or soft black and red concretions are present in the subsurface horizons. The soils are strongly acidic in the surface horizon becoming moderately acid with depth.

Exchangeable Na is low, K moderate, Mg and Ca moderate to high. The deeper horizons apparently developed in shale residuum have more of each of the exchangeable bases compared with the upper soil horizons developed in colluvial material. CEC is low to high and base saturation is moderate to high.

Soil series 8 occupies about 20% of the land and next to soil series 9 are the most extensive soils.

Soils of the lower slopes and alluvial flats adjoining the Tabagutu stream define soil series 9. The soils are the most extensive in the farm occupying about 40% of the land. They are deep olive brown, imperfectly drained to poorly drained sandy clay loam to clay soils with sandy loam topsoil. Ironstone concretions are present in the upper soil horizons. The soils are moderately acid to slightly acid. The level of exchangeable Na is low but high in the bottom horizon forming in shale residuum. In the latter horizon exchangeable Ca, Mg and K are also high. The cations Ca, Mg and K are moderate in amount in the upper horizons. CEC and base saturation are moderate to high.

Summarily the soils of the Awe farm, with the exception of soils of soil series 5, have a good water holding capacity due to their sandy clay loam to clay texture. Their fertility level can be rated moderate. Majority of the soils are underlain by the

shale residuum which has an adequate weathering potential as shown by the high levels of exchangeable Ca, Mg, K and Na in the horizons formed from it. The latter soils particularly soil series 8 and 9 (accounting for 60% of the land) are likely to supply adequate nutrients for crop growth through nutrient recyding. However, the major obstacle to the use of the soils for growing-a variety of crops is the imperfect to poor drainage. Mottling right to the surface in the soils suggests a high water table or impeded drainage.

3.3 Doma

The demonstration farm is located about one kilometre north of Doma town. The roads to Mudu and Brumbrum form the western and easter boundaries respectively. At the southern end of the farm the Adurogya stream flows along part of the boundary fence. The farm extends to 61.25 ha.

The general landscape is a gently undulating plain underlain by medium to coarse grained sandstones. Broad interfluves with gently convex slopes are separated by narrow valleys with perennial streams or dry water courses. A water course bisects the farm from north to south into two unequal parts. The slope from the uplands towards the Adurogya stream is very gentle. The slopes

from the uplands towards the water course are steeper with the slope gradient increasing from north to south.

In the southern part of the farm the sandstone rock weathers to form hard subrounded to platy fragments which give the surface a stony appearance. In the lower slopes bordering the water course the sandstone rock is covered by alluvial/colluvial material washed down from the upper slopes.

Where the water course enters low lying land bordering the Adurogya stream, the area is marshy during the wet season and water logged during the rains. The lower slope soils bordering the southern part of the water course are also influenced by a high wet season water table. Soils of the Doma farm have formed in residuum from sandstone or colluvium derived there from. Deep, well drained red loamy soils of soil series 10 are found on the upper slope in the southern part of the farm. The soils account for about 13% of the land area (see Map 3). The residential quarters are located on these soils. Texturally, the soils are sand to a depth of 75cm below which they become heavier, being sandy clay loam. They are moderately acid in the surface horizon and strongly acid in the subsurface horizon. Exchangeable Na level is low, K moderate, Ca low to very low and Mg low. CEC is very low to low and base saturation is moderate to high (Table 10).

The marked increase in clay content below 75cm depth is likely to improve the water holding capacity of the soils. The good physical properties of the soils make them suitable for arable crops but the sandy topsoils can easily erode and therefore would require protection.

Soils of soil series 11 which cover about 62% of the land area are the most extensive soils. They are well-drained and red like the soils of soil series 10 but are sandier in texture. The texture is sand to about 100cm with loam beneath. Some soils contain a few weathered sandstone fragments in upper horizons. The soils are strongly acid. The level of exchangeable Na is very low to low, K very low, and Ca and Mg very low. CEC is very low and base saturation moderate (Table 11).

Water holding capacity of the soils is considered low in the upper 100cm.

Shallow soils overlying weathered sandstone and mapped as soil series 12 mantle the upper slopes leading to the water course in the southern half of the farm. The soils occupy about 20% of the area of the farm. They are deep reddish brown to reddish yellow well-drained soils. Faint mottling is present in the subsurface horizons which is due to the differential weathering in the sandstone rock. Texture is loamy sand grading to sandy

clay loam with depth. The soils are strongly acid. Exchangeable Na is low, K moderate, Ca low to very low and Mg low. CEC is low and base saturation is moderate (Table 12).

Many of the soils have a stony surface, the stones being indurated sandstone fragments scattered on the soil surface. Slope conditions are gently sloping to sloping.

Occupying the bottom lands a e the soils of soil series 13 which are deep, gray poorly drained loamy sands. Mottling occurs within 14cm of the soil surface. The water table at the end of the dry season was about 150cm from the surface. In the wet season the soils are waterlogged.

Soils of soil series 13 are strongly acid in the upper horizons and very strongly acid at depth. The level of exchangeable Na is very low, K very low, Ca very low and Mg very low to low. CEC is very low and base saturation moderate (Table 13). The soils occupy about 3% of the farm area.

The small fadama which occurs in the south eastern corner of the farm toward the Adurogya stream has parmanently waterlogged soils. The fadama occupies about 2% of the farm area.

Summarily the majority of the soils of Doma farm are well drained sands of low fertility on a flat to gently sloping topography. Some of the soils have a stony surface. The poorly drained soils are subject to water logging in the rainy season.

3.4 Keana

The demonstration farm is about 3 kilometers west of Keana on the Giza road. The River Ome forms the northern and eastern boundaries of the farm and the Keana-Giza road the southern boundary.

The river has a seasonal flow. A few pools exist well into the dry season and are used by nomadic herdsmen to water their cattle. As the stream winds its way from the north-west corner of the farm towards the road, it becomes more deeply incised. Near the road there is a height difference of about 30 m between stream bed and stream bank.

The low lying land bordering the stream is not extensive but is variable in width. In the southern part of the farm the land surface is flat to gently sloping. The northern half of the farm has a more irregular topography. The north facing slopes leading down to the stream are gently sloping to undulating with a few rock outcrops.

Soils of the uplands predominate. They include soil series 14, 15 and 16 (see Map 4). Soil series 14 occupies about 18% of the land and consists of very deep, pink to pinkish gray, well-drained sandy loams with a sand to loamy sand topsoil. The soils have few ironstone concretions. Patches of concretionary gravel outcrop at the surface. The soils are slightly acid with low levels of exchangeable Na and Mg, and very low levels of K and Ca. Exchangeable Mg tends to be high, however, below 130cm. CEC is

very low but base saturation is very high (Table 14).

Soil series 15 occupying about 28% of the farm consist of deep, reddish yellow well-drained sandy loams or sandy clay loams with loamy sand topsoil. The soils possess few ironstone conc. etions and generally overlie ironpan. Patches of ironstone gravel outcrop at the surface in a number of places. Some of the larger patches have been indicated with a symbol in Map 4. The soils of soil series 15 are moderately acid. Their level of exchangeable Na is low, K very low, Ca low and Mg moderate. CEC is very low. Base saturation is high (Table 15). The ironpan over which the soils occur is occasionally within 100cm of the surface and therefore, may interfere with the root development of some crops.

Soil series 16 occupying another 18% of the farm area consists of shallow, yellowish red, well-drained sandy loams, with loamy fine sand topsoil. Weathering and unweathered sandstone often occur close to the surface or outcrop at the surface. Included in this mapping unit are the soils with mottled olive clay subsoil. The subsoil horizons of the latter soils are believed to be formed from shale which occasionally occurs as bands within the

sandstone. Such shale bands were observed within the sandstone in a road cutting a few miles east of the farm. The soils are moderately to slightly acid. Exchangeable K and Na are low to very low; Ca low and Mg moderate. The CEC is low to moderate and base saturation is moderate (Table 16).

Soil series 17 consists of deep, well-drained, red sandy clay loam soils with a loamy fine sand topsoil. The soil series occupies about 18% of the farm area. The soils are moderately acid above 30cm and strongly acid below this depth. Exchangeable Na is low, K is low to very low, Ca low and Mg low to moderate. The CEC is low to moderate while the base saturation is moderate (Table 17).

Soil series 18 consists of imperfectly drained to poorly drained loams and clays derived from alluvial deposits. They occur in the northern and eastern parts of the farm and trail the course of River Ome.

Summarily the majority of the soils of Keana farm are deep to moderately deep sandy loams with a lighter textured (loamy sand) topsoil. They occur on level to gently sloping surfaces. They should have a fairly good water holding capacity. The fertility of the soils is low. The CEC is low suggesting a low capacity to retain nutrients. The imperfectly to poorly drained soils

are loams and clays with a good water holding capacity.

3.5 Lafia

The Lafia Seed/Research farm is about 2 kilometers from Lafia along the Makurdi road. It is situated south of the road and at one time part of it was the farm centre of the State Ministry of Agriculture. The Lafia - Makurdi road forms the northern boundary of the farm and the Angoro steam marks the southern boundary. The area surveyed was 50.80ha.

The general slope is from the road towards the stream. Initially the land surface is flat or very gently sloping but about half way towards the stream the slope becomes more pronounced.

The northern part of the farm is level to nearly level. The very deep, red, well-drained soils are similar to those at Doma and mapped as series 10. The soil texture is a sandy loam grading to sandy clay loam with increasing depth. Ironstone concretions are absent. The soils are moderately acid. The organic matter content is very low (Table 18). Exchangeable Na is low, K very low, Ca low and Mg low to moderate. CEC is low but base saturation is high. The soils occupy about 60% of the farm.

The deep red soils on the upper slopes give way to deep pinkish gray soils, soil series 19, on gently sloping surfaces. The soils have a sandier surface horizon compared with the upper slope red soils. They have faint mottling; however, they are moderately well-drained. They are free of concretions except for a few soft concretions in the deeper horizons. They are very similar to the upper slope red soils in their chemical properties (Table 19). The soils occupy about 20% of the farm area.

Below soil series 19 in the topography and occupying the lower slope positions are imperfectly drained, deep, reddish yellow soils similar to those at Assaikio which are mapped as soil series 3. The texture is loamy sand in the topsoil and sandy clay loam in the subsoil. Iron oxide concretions are common in the subsoil. The soils are strongly acid. Exchangeable Na and Ca are low; K very low and Mg low to moderate. CEC and base saturation are both low to moderate (Table 20). The soils occupy about 15% of the farm area.

Adjacent to the Angoro stream are deep, dark brown to gray poorly drained sandy loam soils with few ironstone concretions throughout their depths. The soils, soil series 20, are mottled from the surface. The water table in the soils was at a depth of 84cm at the end of the dry season (April). The presence of pot

cherds indicates a disturbed site. The fine sand fraction is dorminant in the soil. The silt fraction is higher than in the upland soils. Both properties tend to indicate the alluvial origin of the soil parent material. The soils are strongly acid. The exchangeable Na, Mg, Ca and K are low, particularly K. CEC is low and base saturation is moderate (Table 21).

Summarily the majority of the soils of the Lafia Seed/Research Farm are deep, well drained and moderately well-drained sandy loam to sandy clay loam soils. The water holding capacity of the soils should be good. However, the fertility status is poor as shown by the low levels of exchangeable bases. Slope conditions are favourable to cultivation, being flat to gently sloping mainly. The low CEC is indicative of a poor ability of the soils to retain nutrients. Added nutrients in fertilizers would probably be rapidly leached owing to the poor nutrient retention capacity of the soils.

3.6 Obi

The farm is a few kilometers south of Obi on the road to Keana. The largest part of the farm, Farm B, lies to the west of the road and has the Kpabu stream flowing through it along the northern

end. Farm A is situated east of the road and has the Kpabu stream flowing alongside but beyond the northern boundary of the farm. Farm B extends to 33.37 ha and Farm A to 1.09 ha.

In Farm B the highest elevation is along the southern boundary. South of the stream a dry season water course bisects the farm from north to south. The slopes leading down to the water-course are gentle to fairly steep. The steeper slopes are located where the water course reaches the more level ground bordering the stream. The area north of the stream is almost flat.

The Kpabu stream is ephemeral. A few pools of water are present during the late dry season but these are usually due to excavations made in the stream bed by the local people.

The soil parent materials are sandstones and shales.

Soils series 21 (see Map 6) occupies the upper to middle slopes of the uplands. Along the upper positions the slope is flat but away from the crest and towards the Kpabu stream, the slope is gently to fairly steep. The soil series comprise deep, yellow to gray imperfectly drained clay soils with sandy clay loam topsoil. The imperfect drainage is due to impeded drainage resulting from the clayey texture of the soils, the nature of the clay and the compact underlying concretionary layer. The soils are strongly acid to very strongly acid. The levels of exchangeable N and K are moderate, Ca low and Mg moderate to high.

CEC is high and base saturation is low (Table 23).

The soils occupy about 25% of the farm area.

Soil series 22 occupying another 25% of the farm area occurs in the flat crest area in the southeastern part of the Farm B. The soils are very deep, light grayish, imperfectly drained clay loams. The imperfect drainage is due to the clay loam texture of the soils and the nature of the clay. The soils crack in the dry season but the cracks are not deep. The soils are strongly acid in the surface horizons and moderately acid in the subsurface horizons. The levels of exchangeable Na and K are low to moderate, Ca low and Mg moderate to hgih. CEC is moderate and base saturation is low (Table 23).

Soil series 23 occupies the middle to lower slopes below soil series 21 or soil series 22. It consists of deep, olive brown poorly drained clays. The soil surface cracks in the dry season, but the cracks are not wide or deep. The soils are strongly acid. The levels of exchangeable Na and K are moderate in the surface horizons and low in the subsurface horizons. Exchangeable Ca is moderate to high while Mg is high. CEC is high and base saturation is high. The high Mg level is likely to create problem in soil management and for crop growth (Table 24).

Soil series 24 is found adjacent to Kpabu stream in the northern part of Farm B, and in all of Farm A. It consists of very deep, gray, imperfectly drained sandy clay loam soils with sandy loam texture in the lower horizons (below 70cm depth). The soils are strongly acid. The level of exchangeable Na is low, K low to very low, Ca and Mg low to moderate. CEC is moderate and base saturation is very low to low (Table 25).

Summarily, the majority of the soils of Obi farm are deep, and imperfectly drained, the imperfect drainage being due to impeded drainage promoted by the heavy texture of the soils as well as the possible presence of montmorillonite in the clay fraction. The moderate to high CEC lends support to the presence of montmorillonite in the clay fraction of the soils. The soils are strongly acid. Their fertility level is moderate to high. However, there is Ca/Mg imbalance in soil series 22 and 23 which may pose a serious problem in nutrient uptake by plants. The imperfect drainage of the lower slope soils and the poor drainage of the bottomland soils could limit the range of crops that can be grown. Erosion is likely to be a problem in the area occupied by soil series 21 where soil slope is fairly steep toward the lower ground.

4. SOIL SURVEY INTERPRETATION AND RECOMMENDATIONS

Based on soil surface characteristics on the one hand and the morphological, physical and chemical properties of the soils on the other hand, the soil series recognized in each farm have been grouped into land capability classes for land use and soil management recommendations. A land capability map has been produced for each farm which shows the land capability classes or soil areas suitable for a specified use and requiring the same management. The land capability classification adopted in formulating the land classes is the proposed land capability classification for northern Nigeria derived from that modified for use in Ghana from the USDA land capability classification. Mechanical cultivation of land and the growth of arable crops are the basic criteria for formulating the land capability classes. The detail of proposed land capability classification for northern Nigeria is given in Section III (Table 26) of this report.

Topographic or soil characteristics likely to have adverse effects on the mechanical cultivation of soils and/or the growth of arable crops are considered as "limitations" and used to define the subclasses in each of the land capability class. Small postcript letters, e, w and s are used to emphasize the nature of

limitations, e being for erosion hazard on sloping land, w for wetness and s for adverse soil characteristics.

In formulating the land capability classes for the various farms, the kinds of crops that are adapted to the areas and that most farmers grow in the areas are taken into consideration. These arable crops are maize, cassava, yams, beans, rice and sorghum to name the major ones. It is felt that a demonstration farm should aim at working on the crops that farmers in the areas grow in order to educate the farmers about improved farming practices for increased yields from cultivated land.

The land capability classes of each farm and land use recommendations are briefly discussed below.

4.1 Assaikio Farm

4.1.1 Land Use

The **dominant** land class including the best soils of the farm is class II land. Soil series 1 and 2 fall in this class. The soils are deep well-drained soils with clay loam to clay texture. They are on flat to gentle slopes with little or no hazard. However the low fertility of the soils qualify them

for the subclass IIs. The soils are suitable for maize, cassava and sorghum.

The deep well-drained to imperfectly drained, sandy clay loam soils on sloping surfaces (Soil series 3) are in the subclass IIe owing to the slope condition which is likely to promote the erosion of the soils under cultivation. Sorghum, groundnut and cowpea can be grown on the soils. However, adequate erosion control measures will have to be adopted to use the soils. Contour ploughing and ridging are recommended as erosion control measures.

The poorly drained clay loam to clay soils in flat valley bottomlands are in the subclass IIw. The soils are best suited to tree crops, vegetables (to be grown under irrigation) and rice. If soil drainage is improved then the soils can be used for a wider range of crops such as cassava, yams, vegetables, cowpeas etc.

4.1.2 Liming

This soils of Assaikio farm have strongly acid to very strongly acid reaction which is not very favourable for good plant growth and, hence, good crop yield. It is common knowledge that for good

crop performance the pH of the soils should be 5.5 and above (range of 5.5 to 7.5). Below pH 5.5 aluminium toxicity in crops becomes a serious problem. The net effect is poor crop performance and depression of crop yield. Therefore, liming of the soils to pH 5.5 is recommended to offset aluminium toxicity. For the well drained to imperfectly drained soils the application of lime at the rate of 1ton/ha is recommended. For the poorly drained soils, the artificial drainage of the soils should improve their oxidation state and subsequently decrease soil acidity. However some application of lime to the latter soils may be necessary following their drainage because of the low levels of exchangeable bases in them.

4.1.3 Fertilizer requirement

The nutrient elements that are deficient in the soils are K, and Ca. To these should be added N and P which have been proved in an earlier study to be deficient in the soils. Fertilizers should be applied to the soils to bring to favourable levels the amounts of K, Ca, N and P that crops can extract from the soils. Calcium ammonium nitrate (CAN) to supply N and Ca, potash (K_2O) to supply K and single superphosphate to supply P are the recommended

fertilizers. The recommended rates of application are 100-120kg/ha N, 50-125kg/ha K and 40kg/ha P for calcium ammonium nitrate, potash and single superphosphate, respectively.

4.2 Awe farm

4.2.1 Land use

The land capability subclasses in the farm are IIs, IIw, IIIs and IVw. Subclass IIs consists of deep sandy loam to sandy clay loam soils (Soil series 5 & 6) which are imperfectly drained. They are on flat to gently sloping surfaces where erosion hazard is expected to be small. The imperfect drainage is the limitation of the soils. The soils are suitable for groundnut, cassava and cowpea. Subclass IIw is the dominant land class in the farm. It includes areas occupied by soil series 8 and 9 which are sandy clay loam to clay soils. They are imperfectly to poorly drained. The main limitations to their use is their poor drainage. They are presently suitable for shallow rooted crops such as vegetables (dry season) and cowpea but with improved drainage they can support cassava, maize and sorghum in addition.

The subclass IIIs consists of the shallow soils over ironpan or compact concretionary layers, notably soil series 7. The land surface is gently sloping so that there should be little or no erosion hazard in the soils. It is suggested that the soils of subclass IIIs be left under grass or pasture. Subclass IVw includes the imperfectly to poorly drained sandy clay loam to clay soils (wetland soils) which occupy the lower slopes and alluvial flats in the farm. The soils are subject to waterlogging and as such could only support paddy rice and vegetables (dry season) It is recommended that the soils be reserved for the above crops.

If the soils of Awe farm are to be used to produce a range of crops including maize, guinea-corn, yams, cowpea etc, then majority of the soils which are imperfectly to poorly drained, must be drained artificially.

4.2.2 Fertilizer requirement

Being recently cleared land it is not surprising that the nutrient status of the soils of the Awe farm is reasonably good as can be judged from the moderate to high amounts of exchangeable Ca and Mg in the subsoils. K seems to be low to very low in the better drained soils that may have been cultivated periodically in

recent years. The fertilizers that are likely to be required are those to supply N, P and K. The fertilizers recommended for the Assaikio soils to supply elements above are also recommended for the Awe soils.

Soil pH is favourable for good plant growth. Therefore, liming is not required.

It should be noted that fertilizers to supply Ca and Mg may be required to be added to the soils after one or two growing seasons.

4.3 Doma Farm

4.3.1 Land use

The land subclasses recognized in the Doma farm are IIe, IIIs, IIIws and IVw. The subclass IIe is dominant including red deep well-drained sandy loam to sandy clay loam soils with lighter textured topsoil. The land surface is flat to sloping. There is the possiblility of erosion on the steeper sloping surfaces. The soils are suitable for cover crops such as groundnut and cowpeas but if adequately protected from erosion, they can support maize and cassava also. Land subclass IIIs includes shallow to moderately deep, well-drained sandy loam to sandy clay loam soils on gently

slopes. The soils are better suited to grazing than cultivation. If cultivated, adequate erosion control measure will be needed to protect the soils. Only shallow rooted crops like groundnut will be suitable for the soils. The land subclass IIIws have wetness and shallowness of soils as limitations. The proper land use for the soils is the same as that for the sublcass IIIs mentioned above. The subclass IVw includes poorly drained sandy soils subject to waterlogging. The soils are better suited to sugarcane and vegetables (dry season). The very poorly drained and permanently waterlogged soils should be left in natural vegetation.

4.3.2 Liming

Since the soil reaction is strongly acid, the soils may require some liming to raise pH to 5.5. The recommendation on liming rate is already given above.

4.3.3 Fertilizer requirement

In general the soils of Doma farm are deficient in all the elemental nutrients required by crops for good growth. The levels of exchangeable Na, K, Ca, and Mg are low to very low. Also N and P are low in thesoils as revealed by a previous study. The

recommended fertilizers for the soils are calcium ammonium nitrate (CAN), potash, single superphosphate and magnesium sulphate. The recommended rates of the fertilizers have been given previously except for magnesium sulphate which should be applied at the rate of 40-60kg/ha Mg.

If dolomite limestone is used as the liming material for the soils then it will not be necessary to use magnesium sulphate fertilizer.

4.4 Keana Farm

4.4.1 Land use

The dominant land class is the land subclass IIs. Others are IIw and IIIs. Land subclass IIs consists of deep, well-drained sandy loams and largely sandy clay loams on flat to gently sloping surface. The limitation of the soils is the low fertility. The soils are suitable for maize, cassava, cowpea, sorghum and groundnut. The subclass IIw consists of soils with imperfect drainage to poor drainage. They are suitable for groundnut, vegetables, and cowpea on the better drained soils but with improved drainage they can support maize and cassava also. The land subclass IIIs includes shallow to moderately deep well-drained

sandy loam underlain by weathered sandstone at shallow depths. The land surface is sloping so that erosion is a limitation to the use of the soils. Using appropriate erosion control measures, the soils can be cultivated to groundnut and cowpea or they can be reserved for pasture in their present state.

4.2.2 Fertilizer requirement

Except for Mg, all the exchangeable bases are low in the soils suggesting the need for applying fertilizers to the soils. N and P are also low in amount in the soils as indicated by previous study. The fertilizer requirement of the soils is the same as that for Assaikio soils. Calcium ammonium nitrate, potash, and single superphosphate are the required fertilizers.

4.5 Lafia Farm

4.5.1 Land use

The best soils on the farm are Class I soils consisting of the very deep, well drained, sandy loams to sandy loams on flat surfaces for a variety of crops including maize, sorghum, cassava, groundnut, and cowpea. Class IIs soils are the deep, imperfectly drained,

sandy clay loam soils with sand to loamy sand topsoil. They are on gently sloping to sloping surfaces. The sandy surface horizons of the soils make them susceptible to erosion. The soils are low in plant nutrients. Maize and cassava are suitable crops to be grown on the soils. Also groundnut and cowpea can be grown on them. However, erosion control measure is essential to protect the soils. The deep poorly drained sandy loam soils of soil series 20 make up the land capability subclass IIw. They are on alluvial flats and gently sloping lower slopes. The soils are suitable for tree crops and vegetables (dry season). With improved drainage, they can be suitable for other crops such as cowpea, sorghum, and maize.

4.5.2. Fertilizer requirement

The soils of Lafia Seed/Research Farm are characterised by low levels of plant nutrients. Calcium ammonium nitrate, potash, magnesium sulphate, and single superphosphate are the recommended fertilizers to be applied of the soils.

4.6 Obi Farm

4.6.1 Land Use

A greater proportion of the soils of the Obi farm are Class IIs. They are the imperfectly drained soils with clayey texture (days and clay loams). There is little or no erosion hazard because the soils are on flat to gently sloping surfaces. However, the imperfect drainage due to impermeability of the clay soils limits the growing of sorghum, maize and cassava to the better drained soils. With adequate drainage, the soils should support most of the arable crops.

Subclass IIe are clayey soils (clays) on sloping surfaces. Erosion is likely to affect the soils under cultivation. To use the soil areas adequate erosion control measures must be established. The soils can support the same crops as the subclass IIs soils. The subclass IIIw soils include the deep imperfectly drained soils that are loamy in texture. The land surface is flat to very gently sloping. The soils should be suitable for upland rice, vegetables and sugarcane. If drained, then crops like maize and cassava can be grown. The rest of the soils of the farm are subcalss IIw which are poorly drained soils that are clayey in texture and crack when dry. The land surface is steep to

sloping. The soils may be difficult to cultivate but should be suitable for rice, sugarcane and vegetables.

4.6.2 Fertilizer requirement

Generally the fertility of the soils is moderate to high. However, the Ca/Mg imbalance resulting from the moderate to high levels of exchangeable Mg has been mentioned earlier. To correct the imbalance Ca - supplying fertilizer must be applied. Calcium ammonium nitrate and potash are the two fertilizers recommended for the soils.

4.7 Other Crops

Yams can be grown on sites where the soils are deep, well drained and have a loamy texture. As yams cannot be fitted into a mechanised cropping system, no site recommendations have been made for this crop. Cotton grown under rain-fed conditions does best in a heavy loam soil. Like cassava it does not tolerate waterlogged conditions. In the Lafia area cotton has to compete with yams and as the cash return from growing yams is more advantageous to the local farmers virtually no cotton is grown.

Yams, as well as being a cash crop, are also a highly desirable foodcrop. Cowpeas did not appear to do well possibly owing to poor management but local beans give good yields in some areas.

4.8 Land Clearing

At the time of the survey the farms at Keana and Awe had only partially been cleared of trees and at Obi there were still mounds of felled timber and brushwood scattered over the lower lying parts of the farm.

Land cleafing at Obi was done with machines. The soil cover was probably thin on the upper slopes prior to the removal of the tree cover. During clearing operations the sandstone soils of the upper slopes have had their surface cover stripped off resulting in the underlying ironstone concretions being exposed at the surface. With time an indurated crust is likely to form making these soils unsuitable for cropping.

Some spoil heaps have been flattened and where the more clayey materials from the mounds have spread out over the surface of the ground this will probably hinder crop growth. Land clearing has been carried out too close to the Kpa'au stream and parts of the waterway have been partially blocked. Removal of the protective vegetative cover along the stream banks will increase the erosion haz

At Awe the land has been cleared by hand. Hand felling and stumping is the better method when minimum disturbance of the soil is required. This is particularly true for the area along the western boundary of the farm where the upper slope soils are shallow and generally concretionary. The fringing forest along the stream banks should not be removed otherwise the water table will fall below the land surface during the dry season.

The planting of suitable trees along perimeter fences, as has been done on some of the farms, enhance the appearance of the landscape as well as providing shelter from sun and rain. Strategically placed small shelter belts would minimise erodion on the sandier soils.

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SECTION II

Soil Series 1

Brief Description

The soils are very deep, yellowish red in colour and well drained. The texture is clay loam to clay throughout. A few small rounded ironstone concretions are present in all horizons except the surface horizon.

Site

Crests and upper slopes

Parent Material

Colluvial material derived from sandstone

Present Land Use

Cultivated to sorghum

Profile Description

Ap--0-15cm; dark reddish-gray (5YR 4/2) sandy clay loam; moderate medium, subangular blocky structure; dry, slightly hard; many, fine, woody roots; clear smooth boundary.

Bt1--15-31cm; dark gray (5YR 4/1) clay; moderate, medium, subangular blocky structure; dry, hard; few, fine, rounded ironstone concretions; moist, firm; few medium woody roots and few, fine fibrous roots; clear, smooth boundary.

Bt2--31-54cm; yellowish-red (5YR 5/6) and reddish-yellow (7.5YR 6/6); clay; strong, medium subangular blocky structure; dry, hard and moist, firm; common, fine, rounded ironstone concretions; few medium, fibrous roots; clear, smooth boundary.

BC1--54-80cm; yellowish-red (5YR 5/6) and reddish-yellow (7.5YR 6/6) clay loam; strong, medium subangular block structure; dry, hard and moist, firm; few, fine, rounded ironstone concretions; few cutans in root channels, few, medium, fibrous roots; diffuse, smooth boundary.

BC2--80-118cm; yellowish-red (5YR 5/8) and reddish yellow (7.5YR 6/6); clay loam; moderate, medium, subangular blocky structure; moist, firm to friable; few, round, black concretions and few soft red concretions; few cutans in roots channels, few, fine to medium-fibrous roots; diffuse, smooth boundary.

C--118-170cm; light yellowish-brown (10YR 6/4) and brown (7.5YR 5/4) clay; weak to moderate, medium, subangular blocky structure; moist, firm; few, soft dark red ironstone concretions and few black to reddish concretions.

Table 1. Physical and chemical data of soil series 7 in Asseikio Farm

Characteristics	Horizon Depth (in cm)					
	0–15	15–31	31–54	54–80	80–118	118–170
Horizon designation	Ap	Bt1	Bt2	BC1	BC2	C
Particle size (in mu)						
Clay 2	26	48	54	34	34	48
Fine silt 2–20	8	6	4	24	24	5
Coarse silt 20–50	12	6	2	4	6	7
Fine sand 50–200	40	31	32	32	30	33
Coarse sand 200–2000	14	9	8	6	6	7
pH 1:2.5 H_2O	5.4	5.0	4.9	4.7	4.4	4.5
% Organic carbon	1.20	.63	.53	.38	.29	.21
Exch. Na meq/100g soil	.13	.15	.16	.10	.11	.15
Exch. K meq/100g soil	.17	.23	.23	.21	.17	.17
Exch. Ca meq/100g soil	7.30	4.40	3.10	2.50	3.30	1.75
Exch. Mg meq/100g soil	3.54	2.55	1.85	2.06	1.77	1.48
TEB meq/100g	11.14	7.33	5.34	4.87	5.35	3.46
CEC meq/100g	16.7	25.5	23.2	24.5	25.0	25.5
Base saturation %	68	29	23	20	21	14

mu = micrometre, TEB = Total exchangeable bases

Brief Description

The soils are very deep, yellowish - red to reddish - yellow in colour and well drained. The texture is sany clay loam. Mottles and ironstone concretions are present below 100cm.

Site

Lower middle slope

Parent Material

Colluvial material delived from sandstone

Present Land Use

Cultivated to sorghum

Profile Description

Ap---0-16cm; dark greyish-brown (10YR 4/2), loamy sand; weak angular blocky structure; dry, slightly hard; common, fine, fibrous roots; clear, smooth boundary.

Bt1---16-47cm; brown (7.5YR 5/4); sandy clay loam; weak angular blocky structure; dry, slightly hard; common termite nests; few, fine, fibrous roots; gradual, smooth boundary.

Bt2-47-90cm; yellowish-red (5YR 5/6) sandy clay to clay; few, faint reddish mottles; weak subangular blocky structure; dry hard; few, fine, fibrous roots; clear, smooth boundary.

Bt3---90-135cm; reddish-yellow (5YR 5/8) sandy clay loam; yellowish-red (5YR 4/6) common, medium, distinct mottles; weak

subangular blocky structure; dry, very hard; common, medium soft ironstone concretions and few, fine soft black concretions.

Table 2: Physical and chemical data of soil series 2 in Assakio Farm

Characteristics	Horizon Depth (in cm)			
	0–16	16–67	47–90	90–135
Horizon designation	Ap	Bt1	Bt2	Bt3
Particle size (in mu)				
Clay 2	6	30	44	34
Fine silt 20–20	6	6	6	6
Coarse silt 20–50	8	4	6	6
Fine sand 50–200	45	35	31	31
Coarse sand 200–2000	35	25	13	23
pH 1:2.H_2O	6.4	5.7	5.2	5.2
% Organic carbon	.90	.38	.25	.17
Exch. Na meq/100g soil	.15	.12	.13	.12
Exch. K meq/100g soil	.54	.19	.18	.14
Exch. Ca meq/100g soil	10.80	6.0	6.30	4.10
Exch. Mg meq/100g soil	1.93	2.88	2.47	2.01
TEB meq/100g	12.70	9.69	9.08	6.37
CEC meq/100g	12.0	11.2	16.7	16.7
Base saturation	100	87	54	38

mu = micrometre; TEB = Total exchangeable bases

Brief Description

The soils are very deep, reddish-yellow grading to pale brown in colour, and imperfectly drained. The texture is a sandy clay loam. Mottles and ironstone concretions are present within 50cm of the surface.

Site

Lower slope

Parent Material

Alluvial deposits

Present Land Use

Cultivated but presently under fallow

Profile Description

Ap1--0-26cm; gray (10YR 5/1); loamy sand; weak crumb structure; dry slightly hard; many, fine, fibrous roots; clear, smooth boundary.

Ap2---26-42cm; pinkish gray (7.5YR 6/2); loamy sand; weak, prismatic structure; dry, slightly hard; few red ironstone concretions; common, fine fibrous roots; abrupt, smooth boundary.

B1--42-71cm; strong brown (7.5YR 5/6); sandy clay loam; yellowish red (5YR 5/6) few, medium, distinct mottles; weak subangular blocky structure; dry, hard; common medium ironstone concretions; common termite nests; few, fine fibrous roots; clear, smooth boundary.

B2---71-96cm; reddish-yellow (5YR 6/8); yellowish red (5YR 5/6) common, medium distinct mottles; sandy clay loam, weak subangular blocky structure; dry, very hard, many black concretions, few, fine fibrous roots; gradual, smooth boundary.

BC--96-131cm; pale brown (10YR 6/3) sandy clay loam; yellowish-red (5YR 5/6) common to many, medium, distinct mottles; weak subangular blocky structure; dry, very hard; many red ironstone concretions; few fine, fibrous roots; diffuse, smooth boundary.

C--131-152cm; pale brown (10YR 6/3); sandy clay loam; yellowish red (5YR 5/6) many, medium distinct mottles, weak subangular blocky structure; dry, very hard.

Table 3: Physical and chemical data of soil series 3 in Assaikio Farm

Characteristics	Horinson Depth (in cm)					
	0–26	26–42	42–71	71–96	96–131	131–152
Horizon designation	Ap1	Ap2	B1	B2	BC	C
Particle size (in mu)						
Clay 2	7	8	33	34	30	30
Fine silt 2–20	4	3	8	10	6	8
Coarse silt 20–50	9	10	5	2	4	4
Fine sand 50–200	37	31	38	29	29	37
Coarse sand 200–2000	43	41	23	25	31	21
pH 1:2.5H_2O	6.2	6.2	6.2	5.2	5.4	5.2
% Organic carbon	1.0	.33	.34	.16	.19	.13
Exch. Na meq/100g soil	.15	.13	.13	.19	.13	.10
Exch. K meq/100g soil	.30	.12	.18	.28	.16	.15
Exch. Ca meq/100g soil	7.00	3.30	5.00	3.30	3.90	2.50
Exch. Mg meq/100g soil	1.89	.94	4.11	1.48	2.71	1.32
TEB meq/100g	9.34	4.49	9.42	5.25	6.90	4.07
CEC meq/100g	6.5	5.5	15.2	13.5	15.0	10.7
Base saturation	100	82	62	39	46	38

mu = micrometre; **TEB = Total exchangeable bases**

Soil Series 4

Brief Description

The soils are deep, dark brown to grey in colour and poorly drained. The texture is a clay loam to clay. Mottles and a few black concretions are present below 30cm and below 112cm the soil is gleyed.

Site

Level area close to stream

Parent Material

Alluvium

Present Land Use

Grassland

Profile Description

Ap---0-18cm; light gray (10YR 6/1); clay loam; weak angular blocky structure; dry, slightly hard; medium, fine, fibrous roots; clear, smooth boundary.

Bt1---18-32cm; dark gray brown (10YR 4/2); clay loam to clay; weak prismatic structure; slightly hard; common, fine fibrous roots; clear, smooth boundary.

Bt2---32-65cm; brown to dark brown (7.5YR 4/2) clay loam to clay; brown (7.5YR 5/4) few, fine, faint mottles; weak

prismatic structure; dry; slightly hard; few black concretions; few, fine, fibrous roots; gradual, smooth boundary.

BC--65-112cm; gray (7.5YR 5/0) clay; brown (7.5YR 5/4) common, medium, distinct mottles; weak prismatic structure; dry, slightly hard; clear, smooth boundary.

C--112-144cm; gray (7.5YR 5/0) clay loam; dark reddish-brown (5YR 3/3) many, medium to coarse, distinct mottles; gleyed; weak prismatic structure; moist, friable.

Table 4: Physical and chemical data of soil series 4 in Asseikio Farm

Characteristics	Horizon Depth (in cm)				
	0–18	18–32	32–65	65–112	112–144
Horizon designation	**Ap**	**Bt1**	**Bt2**	**BC**	**C**
Particle size (in mu)					
Clay 2	32	40	40	44	28
Fine silt 2–20	20	20	16	18	26
Coarse silt 20–50	8	8	8	10	10
Fine sand 50–200	37	30	34	27	28
Coarde sand 200–2000	3	2	2	1	8
pH 1:2.5H_2O	5.1	4.6	4.6	4.8	4.8
% Organic carbon	1.96	1.30	.19	.23	.17
Exch. Na meq/100g soil	.20	.17	.20	.25	.32
Exch. K meq/100g soil	.24	.21	.21	.23	.24
Exch. Ca meq/100g soil	5.05	2.78	1.80	0.38	1.75
Exch. Mg meq/100g soil	3.21	1.85	1.15	0.74	1.83
TEB meq/100g	8.70	5.01	3.36	1.60	4.14
CEC meq/100g	28.0	36.5	29.0	26.0	28.0
Base saturation	31.	14	12	6	15

mu = micrometre ; **TEB = Total exchangeable bases**

Soil Series 5

Brief Description

The soils are deep, light yellowish brown to light grey and imperfectly drained. The texture is a loamy sand in the surface horizons and a sandy loam to sandy clay loam in the subsurface horizons. The lower part of the profile is mottled.

Site

Upper slope

Parent Material

Weathered colluvium or residiuum from shale

Present Land Use

Cultivated. Under cowpea

Profile Description

Ap1---0-20cm; grayish brown (10YR 5/2) loamy sand; very weak subangular blocky structure; dry, soft; common, medium, fibrous roots and few, fine fine woody roots; clear, smooth boundary.

Aps---20--43cm; light gray (10YR 7/2) loamy sand; structureless; dry; soft; common, medium fibrous roots and few, fine to medium woody roots; clear, smooth boundary.

AB---43-64cm; light yellowish brown (2.5Y 6/4) sandy loam; yellowish red (5YR 5/8) few, fine, faint mottles; weak subangular

blocky structure; dry, hard; few, fine soft red concretions; few termite holes; few fine to medium woody roots; gradual, wavy boundary.

B1--64-103cm; light gray (2.5Y 7/2) sandy loam to sandy clay loam; yellowish red (5YR 5/8) few, faint, distinct mottles; weak to moderate subangular blocky structure; dry, hard; few, fine to medium soft red concretions; few termite holes; few, fine, woody roots; gradual, smooth boundary.

B2--103-163cm; light gray (2.5Y 7/2) sandy clay loam; yellowish red (5YR 5/8) common, fine to medium distinct mottles; weak to moderate subangular blocky structure; common, fine to medium soft red concretions; few termite holes,

Table 5: Physical and chemical characteristics of soil series 5 in Awe farm

Characteristics	Horizon Depth (in cm)				
	0-20	20-43	43-64	64-103	103-163
Horizon designation	Ap1	Aps	AB	B1	B2
Particle size (in mu)					
Clay 2	2	7	7	20	24
Fine silt 2-20	4	5	6	6	6
Coarse silt 20-50	8	10	10	7	6
Fine sand 5-200	39	36	36	34	40
Coarse sand 200-2000	47	42	42	33	24
pH 1:2.5 H_2O	6.0	6.0	5.9	6.0	5.6
% Organic carbon	.45	.16	.15	.12	.08
Exch. Na meq/100g soil	.11	.12	.14	.18	.34
Exch. K meq/100g soil	.11	.05	.07	.09	.12
Exch. Ca meq/100g soil	3.40	1.80	3.50	5.20	5.88
Exch. Mg keq/100g soil	.72	.46	.90	1.32	1.64
TEB meq/100g	4.34	2.43	4.65	6.79	7.98
CEC meq/100g	5.2	3.7	8.7	10.7	13.7
Base saturation	83	66	53	63	58

mu = micrometre, TEB = Total exchangeable bases

Soil Series 6

Brief Description

The soils are very deep, brownish gray to gray in colour, and imperfectly drained. The texture is a sandy loam in the surface horizons and sandy clay loam to sandy clay in the subsurface horizons.

Site

Lower slope

Parent Material

Colluvium from shale

Present Land Use

Cultivated under maize

Profile Description

Ap—0-31cm; pinkish gray (7.5YR 6/2) loamy sand; reddish yellow (5YR 6/8) few, fine, distinct mottles; structureless; common, fine, fibrous roots; clear, smooth boundary.

AB—31-66cm; light reddish brown (5YR 6/3); sandy loam; reddish yellow (5YR 6/8) few, fine, distinct mottles; weak to moderate subangular blocky structure; dry, slightly hard; few, fine to medium ironstone concretions; few termite holes; few, fine to medium woody roots; clear, smooth boundary.

B1---66-95cm; light brownish gray (2.5Y 6/2), sandy loam; reddish yellow (5YR 6/8) common, fine, distinct mottles; moderate subangular blocky structure; moist, firm; few, fine to medium ironstone concretions; few, fine woody roots; clear, smooth boundary.

B2---95-118cm; gray (5Y 6/1) sandy clay loam; reddish yellow (5YR 6/8) common, fine, distinct mottles; moderate subangular blocky structure; few, soft black concretions; clear smooth boundary.

B3---118-150cm; light gray (5Y 7/1) sandy clay; reddish yellow (5YR 6/8) common, fine, distinct mottles; moderate subangular blocky structure; moist, very firm; few, fine to medium soft black concretions; few termite holes.

Table 6: Physical and chemical characteristics of soil series 6 in Awe farm

Characteristics	Horizon Depth (in cm)				
	0–31	31–66	66–95	95–118	118–150
Horizon designation	Ap	AB	B1	B2	B3
Partical size (in mu)					
Clay 2	6	13	15	32	40
Fine silt 2–20	4	4	5	6	6
Coarse silt 20–50	10	10	6	4	4
Fine sand 50–200	38	35	33	25	24
Coarse sand 200–2000	42	38	41	33	26
pH 1:2.5 H_2O	6.0	5.8	5.8	6.0	6.2
% Organic carbon	.24	.19	.15	..19	.07
Exch. Na meq/100g soil	.15	.16	.18	.42	.74
Exch. K meq/100g soil	.08	.07	.10	.21	.24
Exch. Ca meq/100g soil	2.20	3.85	4.50	7.25	14.50
Exch. Mg meq/100g soil	.49	.77	.89	1.48	2.86
TEB meq/100g	2.32	4.85	5.67	9.36	18.34
CEC meq/100g	5.0	9.7	11.0	19.0	25.2
Base saturation	46	50	51	49	73

mu = micrometre; TEB = Total exchangeable bases

Soil Series 7

Brief Description

The soils are shallow, pinkish gray in colour, and imperfectly drained to poorly drained. The texture is sandy loam. A layer of concretionary gravel at 26cm is underlain by ironpan.

Site

Upper slope

Parent Material

Sandy deposit over ironpan

Present Land Use

Uncultivated. Recently cleared woodland

Profile Description

Ap1---0--9cm; gray (5YR 6/1) sandy loam; yellowish red (5YR 5/8) common, fine, distinct mottles; structureless; dry, slightly hard; few, fine, fibrous roots and few, fine woody roots; clear, wavy boundary.

Ap2---9--26cm; pinkish gray (5YR 7/2) sandy loam; yellowish red (5YR 5/8) common, fine, distinct mottles; dry, slightly hard; few, fine, soft yellowish conncretions; few, fine, woody roots; clear, smooth boundary.

C1---26-41cm; pinkish gray (7.5YR 7/2) sandy loam; structureless; dry; hard; common, fine to medium black and yellowish red concretions; few, fine, woody roots; clear, wavy boundary.

2C2--41-52cm; concretionary gravel

2C3--52cm + ironpan containing small rounded ironstone concretions in pockets.

Table 7: Physical and chemical characteristics of soil series 7 in Awe farm.

Characteristics	Horizon Depth (in cm)				
	0-9	9-26	26-41	41-52	52 +
Horizon designation	Ap1	Ap2	C1	2C2	2C3
Particle size (in mu)					
Clay 2	8	10	12		
Fine silt 2-20	5	7	8		
Coarse silt 20-50	19	17	14		
Fine sand 50-200	50	49	48		
Coarse sand 200-2000	18	17	18		
pH 1:2.5 H_2O	5.5	5.2	5.5		
% Organic carbon	.59	.33	.23		
Exch. Na meq/100g soil	.15	.20	.17		
Exch. K meq/100g soil	.09	.09	.12		
Exch. Ca meq/100g soil	2.83	2.50	3.00		
Exch. Mg meq/100g soil	.95	1.03	1.15		
TEB meq/100g	4.02	3.82	4.44		
CEC meq/100g	5.5	5.2	5.5		
Base saturation	73	73	80		

Mu = midrometre; TEB = Total exchangeable bases.

Soil Series 8

Brief Description

The soils are deep, yellowish to olive in colour and imperfectly drained. The texture is sandy loam in surface horizons grading through sandy clay loam to clay in the subsurface horizons.

Site

Middle slope

Parent Material

Colluvium over residuum from shale

Present Land Use

Uncultivated. Woodland.

Profile Description

A--0-14cm; gray (5YR 6/1) sandy loam; yellowish-red (5YR 5/6) common, fine, distinct mottles; dry; slightly hard; few, fine fibrous roots; clear, smooth boundary.

AB--14-35cm; light reddish brown (5YR 6/3) sandy loam; yellowish red (5YR 5/6) many, fine distinct mottles; dry, hard; few termite holes; few, woody roots; abrupt, smooth boundary.

B1---35-47cm; reddish yellow (7.5YR 6/6) sandy loam; yellowish red (5YR 5/6) many, fine distinct mottles; dry, very hard many, fine to medium red and black ironstone concretions; few, fine woody roots; clear, smooth boundary.

B2---47-65cm; brownish yellow (10YR 6/6) sandy clay loam; yellowish red (5YR 5/6) few, fine, distinct mottles; weak subangular blocky structure; dry, slightly hard; few, fine, to medium soft red and black ironstone concretions; few, fine roots; gradual smooth boundary.

B3---65-88cm; light olive brown (2.5Y 5/4) sandy clay loam; yellowish red (5YR 5/6) few, fine, distinct mottles; weak, subangular blocky structure; dry, hard; common, fine to medium roots; gradual, smooth boundary.

2C1---88-105cm; light olive brown (2.5Y 5/4) clay; yellowish red (5YR 5/6) common, fine, distinct mottles; weak subangular blocky structure; moist, firm; few, fine, ironstone concretions; few, fine, woody roots; clear, smooth boundary.

2C2---105-116cm; light olive brown (2.5Y 5/6) clay; yellowish red (5YR 5/6) few, fine, faint mottles; moderate subangular blocky structure; moist, firm; few, fine, soft black concretions

Table 8: Physical and chemical characteristics of soil series 8 in Awe farm.

Characteristics	Horizon Depth (in cm)						
	0–14	14–35	35–47	47–65	65–88	88–105	105–116
Horizon designation	A	AB	B1	B2	B3	2C1	2C2
Particle size (in mum)							
Clay 2	10	13	13	23	28	45	47
Fine silt 2–20	8	9	7	7	11	7	8
Coarse silt 20–50	14	13	7	8	9	6	6
Fine sand 50–200	45	39	31	37	32	27	28
Coarse sand 200–2000	23	26	42	25	20	15	11
pH 1:2.5 H_2O	5.2	5.2	5.4	5.4	5.8	6.0	6.4
% Organic carbon	.63	.37	.28	.30	.22	.27	.13
Exch. Na meq/100g soil	.16	.20	.28	.20	.37	.83	.91
Exch. K meq/100g soil	.11	.14	.11	.13	.21	.34	.55
Exch. Ca meq/100g soil	3.75	3.25	3.00	5.00	8.63	14.75	18.25
Exch. Mg meq/100g soil	1.07	1.07	1.07	2.14	2.96	5.35	7.32
TEB meq/100g	5.09	4.66	4.46	7.47	12.17	21.27	26.83
CEC meq/100g	6.9	6.8	7.6	14.7	18.2	26.5	30.5
Base saturation	74	69	59	51	67	80	88

mu = micrometre; TEB = Total exchangeable bases

Soil Series 9

Brief Description

The soils are deep, olive brown in colour and imperfectly drained to poorly drained. The texture is sandy loam on the surface grading through sandy clay loam and sandy clay to clay at 100cm.

Site

Middle to lower slope

Parent Material

Residuum from shale

Present Land Use

Uncultivated. Recently clearly woodland

Profile Description

A---0-14cm; pinkish-grey (7.5YR 6/2), sandy loam; reddish-yellow (7.5YR 6/6) few, fine, faint mottles; dry, slightly hard; few, fine to medium ironstone concretions; few, fine, fibrous roots; abrupt, smooth boundary.

AC---14-35cm; concretionary horizon. Many ironstone concretions.

2C1---35-74cm; light olive brown (2.5Y 5/4) sandy clay; massive structure; dry, very hard; many, fine to medium ironstone concretions; few, fine woody roots; abrupt, smooth boundary.

2C2---74-93cm; olive brown (2.5Y 4/4) clay; weak, platy structure; dry, hard.

Table 9. Physical and chemical characteristics of soil series 9 in Awe farm.

Characteristics	Horizon Depth (in cm)			
	0–14	14–35	35–74	74–93
Horizon designation	A	AC	2C1	2C2
Particle size (in mu)				
Clay 2	11	32	46	40
Fine silt 2–20	14	12	4	10
Coarse silt 20–50	22	6	2	6
Fine sand 50–200	36	26	23	22
Coarse sand 200–2000	17	24	25	22
pH 1:2.5 H_2O	5.8	6.0	6.0	6.2
% Organic carbon	1.26	.63	.26	.14
Exch. Na meq/100g soil	.23	.34		2.13
Exch. K meq/100g soil	.19	.25		.34
Exch. Ca meq/100 gsoil	6.10	9.80	4.85	24.00
Exch. Mg meq/100g soil	2.10	3.29	1.20	12.34
TEB meq/100g	8.53	13.68		38.81
CEC meq/100g	18.5	29.5		44.0
Base saturation	46	46		88

mu = micrometre; TEB = Total exchangeable bases /

Soil Series 10

Brief Description

The soils are very deep, yellowish red in colour and well drained. The texture is sand overlying sandy clay loam.

Site

Upper slope

Parent Materials

Residuum from sandstone overlain by a sandy colluvium

Present Land Use

Cultivated but presently under fallow

Profile Description

A—0-17cm; pale brown (10YR 6/3) sand; weak subangular blocky structure; dry, slightly hard; common fine, fibrous roots; clear, smooth boundary.

AB—17-42cm; Light brown (7.5YR 6/4) sand; weak subangular blocky structure; dry slightly hard; few termite nests; few, fine, fibrous roots and few, medium to coarse woody roots; gradual, smooth boundary.

B—42-76cm; yellowish red (5YR 5/8) sand; weak subangular blocky structure; dry, hard; few termite nests; few, fine to medium roots; gradual, smooth boundary.

Bt1—76–110cm; yellowish red (5YR 5/8) sandy clay loam; weak subangular blocky structure; dry, hard; few, medium termite nests; few, fine, woody roots; diffuse, smooth boundary.

Bt2—110–156cm; yellowish red (5YR 5/8) sandy clay loam; weak subangular blocky structure; dry, hard; few pieces of sandstone ; few, fine woody roots.

Table 10. Physical and chemical characteristics of soil series 10 in Doma farm

Characteristics	Horizon Depth (in cm)				
	0–17	17–42	42–76	76–110	110–156
Horizon designation	A	AB	B	Bt1	Bt2
Particle size (in mu)					
Clay 2	2	2	2	23	33
Fine silt 2–20	2	2	3	2	2
Coarse silt 20–50	6	4	2	2	3
Fine sand 50–200	35	31	32	26	23
Coarse sand 200–2000	55	61	61	46	39
pH 1:2.5 H_2O	5.9	5.9	5.4	5.2	5.2
% Organic carbon	.45	.22	.18	.18	.13
Exch. Na meq/100g soil	.11	.09	.09	.11	.12
Exch. K meq/100g soil	.09	.05	.05	.06	.07
Exch. Ca meq/100g soil	2.50	1.20	2.13	1.13	2.13
Exch. Mg meq/100g soil	0.66	0.33	0.58	0.58	0.70
TEB meq/100g	3.36	1.67	2.85	1.95	3.02
CEC meq/100g	3.5	2.6	3.3	6.1	6.4
Base saturation	96	64	86	32	47

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 11

Brief Description

The soils are very deep, reddish-yellow in colour and well drained. The texture is sand overlying sandy loam.

Site

Middle slope

Parent Materials

Coarse sandstone residuum.

Present Land Use

Cultivated Under cassava

Profile Description

Ap--0-10cm; yellowish brown (10YR 5/4) sand; weak subangular blocky structure; dry, soft; few fine, fibrous roots; clear, smooth boundary.

Bw1--41-68cm; light reddish brown (5YR 6/4) sand; weak subangular blocky structure; dry, slightly hard; few termite nests; few, fine woody roots; gradual, smooth boundary.

Bw2--68-103cm; reddish yellow (5YR 6/6) sand; weak subangular blocky structure; dry, hard; few termite nests; few, fine woody roots; gradual, smooth boundary.

Bt1--103-146cm; reddish yellow (5YR 6/8) loamy sand to sandy loam; moderate, subangular blocky structure; dry, hard; few termite nests; few fine to medium woody roots; clear, smooth boundary.

Bt2--146-168cm; reddish yellow (5YR 6/8) and pinkish gray (5YR 7/2) sandy loam; weak subangular blocky structure; dry, hard.

Table 11: Physical and chemical characteristics of soil series 11 in Doma farm.

Characteristics	Horizon Depth (in cm)					
	0-18	18-41	41-68	68-103	103-146	146-168
Horizon designation	Ap	AB	B1	B2	Bt1	Bt2
Particle size (in mu)						
Clay 2	0	2	4	6	12	18
Fine silt 2-20	2	2	0	0	2	2
Coarse silt 20-50	4	4	4	4	4	4
Fine sand 50-200	30	32	32	33	28	31
Coarse sand 200-2000	64	60	60	57	54	45
pH 1:2.5 H_2O	5.4	5.2	5.1	5.2	5.2	4.9
% Organic carbon	.22	.17	.15	.14	.11	.12
Exch. Na meq/100g soil	.09	.10	.09	.11	.10	.11
Exch. K meq/100g soil	.03	.06	.05	.06	.07	.05
Exch. Ca meq/100g soil	1.03	.95	.45	2.00	.75	.50
Exch. Mg meq/100g soil	.35	.25	.16	.30	.30	.23
TEB meq/100g	2.50	1.36	.75	2.47	1.22	.89
CEC meq/100g	2.2	2.5	2.5	2.9	3.3	5.0
Base saturation	100	54	30	85	37	18

mu = micrometre ; TEB = Total exchangeable bases.

Soil Series 12

Brief Description

The soils are deep, light reddish brown to reddish yellow in colour and well drained. The faint mottling present is due to differential weathering in the sandstone rock. The texture is loamy sand grading into sandy clay loam with increasing depth. Shallower than Soil Series 10.

Site

Middle slope

Parent Material

Residuum from coarse grained sandstone

Present Land Use

Cultivated but presently under fallow

Profile Description

Ap---0-19cm; light brownish gray (10YR 6/2) coarse sand; weak subangular blocky structure; dry, slightly hard; few weathered rock fragments; common, fine, fibrous roots; clear, smooth boundary.

AB---19-38cm; yellowish brown (10YR 5/4) sand to loamy sand; weak subangular blocky structure; dry, slightly hard; common weathered rock fragments; common, fine, fibrous roots and few, fine woody roots; gradual, smooth boundary.

Bw—38-57cm; light reddish brown (5YR 6/4) loamy sand; weak, subangular blocky structure; dry, slightly hard; few, hard, sandstone concretions; few, fine to medium, woody roots; gradual, smooth boundary.

Bt1—57-96cm; reddish yellow (5YR 6/8) sandy clay loam; red (2.5YR 5/8) few, fine, distinct mottles; subangular blocky structure; dry, hard; few, fine woody roots; diffuse, smooth boundary.

Bt2—96-128cm; reddish yellow (5YR 6/8) sandy loam to sandy clay loam; red (2.5YR 5/8) few, fine, distinct mottles; dry, hard; few, fine woody roots.

Table 12: Physical and chemical characteristics of soil series 12 in Doma farm.

Characteristics	Horizon Depth (in cm)				
	0–19	19–38	38–57	57–96	96–128
Horizon designation	**Ap**	**AB**	**Bw**	**Bt1**	**Bt2**
Particle size (in mu)					
Clay 2	2	4	6	28	20
Fine silt 2–20	4	2	2	4	2
Coarse silt 20–50	6	6	4	4	4
Fine sand 50–200	34	33	31	25	26
Coarse sand 200–2000	54	55	57	39	48
pH 1:2.5 H_2O	5.2	5.3	5.1	5.3	5.2
% Organic carbon	.34	.26	.07	.21	.11
Exch. Na meq/100g soil	.14	.08	.08	.11	.10
Exch. K meq/100g soil	0.5	.05	.05	.09	.07
Exch. Ca meq/100g soil	4.10	1.25	1.00	2.50	1.10
Exch. Mg meq/100g soil	1.07	0.31	0.15	1.03	0.64
TEB meq/100g	5.36	1.69	1.28	3.73	1.91
CEC meq/100g	3.5	2.4	2.4	6.9	6.7
Base saturation	100	70	53	54	29

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 13

Brief Description

The soils are very deep, gray in colour and poorly drained. The texture is a loamy sand throughout.

Site

Valley bottom

Parent Material

Mainly alluvial deposits

Present Land Use

Cultivated Under cassava

Profile Description

Ap—0-14cm; gray (5YR 6/1); loamy sand; weak subangular blocky structure; dry, slightly hard; many, fine to medium fibrous roots; clear, smooth boundary.

AC—14-35cm; light yellowish-brown (10YR 6/4) loamy sand; yellowish red (5YR 5/8) common, fine, distinct mottles; weak subangular blocky structure; dry; slightly hard; common, fine to medium fibrous roots; gradual, smooth boundary.

C1—35-64cm; pinkish gray (7.5YR 7/2) loamy sand; yellowish red (5YR 5/8) many, fine, distinct mottles; medium, subangular blocky structure; dry; slightly hard; few soft concretions; few, fine, fibrous roots; gradual, smooth boundary.

2C2--64-101cm; light gray (2.5Y 7/2) loamy sand; yellowish red (5YR 5/8) common, fine, distinct mottles; structureless mbist friable; soft, black, rock fragments; few, fine, fibrous roots; clear, smooth boundary.

2C3---101-128cm; light olive brown (2.5Y 5/6) loamy sand; yellowish red (5YR 5/8) common, fine, distinct mottles; structureless; moist, friable; soft, black rock fragments; abrupt, smooth boundary.

2Cg---128-198cm; gray (2.5Y 6/0) gleyed loamy sand; structureless moist, very friable.

Table 13: Physical and chemical characteristics of soil series 13 in Doma farm

Characteristics	Horizon Depth (in cm)					
	0–14	14–35	35–64	64–101	101–128	128–198
Horizon designation	Ap	AC	C1	2C2	2C3	2Cg
Particle size (in mu)						
Clay 2	3	6	12	8	6	9
Fine silt 2–20	5	2	2	0	6	3
Coarse silt 20–50	12	8	6	8	12	3
Fine sand 50–200	36	38	40	39	37	32
Coarse sand 200–2000	44	46	40	45	45	53
pH 1:2.5 H_2O	5.2	5.2	5.0	5.0	4.9	4.6
% Organic carbon	.52	.21	.28	.15	.09	.12
Exch. Na meq/100g soil	.11	.07	.11	.08	.09	.10
Exch. K meq/100g soil	.12	.03	.07	.04	.05	.07
Exch. Ca meq/100g soil	1.50	1.88	2.50	.75	1.15	.70
Exch. Mg meq/100g soil	.39	.25	.39	.14	.14	.12
TEB meq/100g	2.12	2.23	3.07	1.01	1.43	.99
CEC meq/100g	4.0	3.1	4.8	2.4	2.4	2.4
Base saturation	53	72	64	42	60	41

mu = micrometre; TEB = Total exchangeable bases

Soil Series 14

Brief Description

The soils are moderately deep, pink to pinkish gray in colour and well drained. The texture is sand changing to sandy loam at 130cm.

Site

Lower slope

Parent Material

Medium to coarse grained sandstone

Present Land Use

Uncultivated. Recently cleared woodland

Profile Description

A—0-12cm; pinkish gray (5YR 6/2) fine sand; dry, loose; few, fine, ironstone concretions; common, fine fibrous roots; clear, wavy boundary.

AC1—12-41cm; pinkish gray (5YR 7/2) fine sand; weak subangular blocky structure; dry, soft; few, fine, ironstone concretions; few, fine fibrous roots and few, fine, woody roots; clear, wavy boundary.

AC2—41-85cm; pink (5YR 7/3) loamy fine sand; weak subangular blocky structure; dry, soft; few, fine to medium ironstone concretions; few, fine, woody roots; abrupt, wavy boundary.

C1r--85-130cm; pink (5YR 7/4) medium sand; structureless; moist, friable, many fine to medium, ironstone concretions, many, weathered sandstone fragments, few, fine fibrous roots and few, fine, woody roots; gradual, wavy boundary.

C2r--130-199cm; pinkish gray (7.5YR 7/2) fine, sandy loam; structureless; moist, firm, many, fine to medium ironstone concretions; common, weathered sandstone fragments.

Table 1.4: Physical and chemical data of soil series 14 in Koana Farm.

Characteristics	Horizon Depth (in cm)				
	0–12	12–41	41–85	85–130	130–199
Horizon designation	A	AC1	AC2	C1	C2
Particle size (in mu)					
Clay 2	2	2	4	2	6
Fine silt 2–20	3	3	4	3	8
Coarse silt 20–50	7	7	12	7	12
Fine sand 50–200	55	56	56	49	53
Coarse sand 200–2000	33	32	24	39	21
pH 1:2.5 H_2O	6.4	6.0	6.2	6.1	6.4
% Organic carbon	.28	.20	.07	.08	.06
Exch. Na meq/100g soil	.16	.14	.13	.18	.22
Exch. K meq/100g soil	.07	.07	.07	.05	.12
Exch. Ca meq/100g soil	1.10	1.40	1.60	1.50	3.35
Exch. Mg meq/100g soil	.44	.69	.90	.67	1.92
TEB meq/100g	1.77	2.30	2.70	2.40	5.61
CEC meq/100	2.3	2.7	2.7	2.2	6.3
Base saturation	77	85	100	100	89

mu = micrometre; TEB = Total exchangeable bases.

Brief Description

The soils are reddish yellow in colour and well drained. The texture is sandy loam to sandy clay loam. Ironpan underlies the soils at about 100cm.

Site

Crest and upper slope

Parent Material

Medium to coarse grained sandstone residuum

Present Land Use

Cultivated. Under fallow

Profile Description

Ap1---0-17cm; pinkish gray (5YR 6/2) loamy sand; weak angular blocky structure; dry, soft; common, fine fibrous roots and few fine, woody roots; clear, wavy boundary.

Ap2---17-43cm; light reddish brown (5YR 6/4) loamy sand; structureless; moist, friable; few, fine, fibrous roots and few, fine to medium woody roots; gradual, wavy boundary.

C1---43-68cm; reddish yellow (5YR 6/6) sandy loam; structureless; moist, firm; few, fine woody roots; clear, wavy boundary.

C2---68-102cm; reddish yellow (5YR 6/8) sandy loam to sandy clay loam; moderate, angular blocky structure; moist, firm; few, fine, soft, red ironstone concretions; few, fine, woody roots.

2Cm---120cm + Ironpan.

Table 15: Physical and chemical data of soil series 15 in Keana Farm.

Characteristics	Horizon Depth (in cm)			
	0–17	17–43	43–68	68–102
Horizon designation	Ap1	Ap2	C1	C2
Particle size (in mu)				
Clay 2	6	3	17	20
Fine silt 2–20	2	4	3	6
Coarse silt 20–50	16	13	11	12
Fine sand 50–200	62	62	54	47
Coarse sand 200–2000	14	18	15	15
pH 1:2.5 H_2O	6.1	5.8	5.4	5.8
% Organic carbon	.61	.11	.20	.15
Exch. Na meq/100g soil	.12	.12	.13	.13
Exch. K meq/100g soil	.14	.08	.17	.18
Exch. Ca meq/100g soil	3.35	1.25	2.10	2.30
Exch. Mg meq/100g soil	1.02	.46	1.05	1.15
TEB meq/100g	4.63	1.91	3.45	3.76
CEC meq/100g	4.7	2.8	5.9	6.4
Base saturation %	99	68	58	59

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 16

Brief Description

The soils are shallow, yellowish-red in colour and well drained. The texture is fine sandy loam.

Site

Upper slope

Parent Material

Medium to coarse grained sandstone residuum

Present Land Use

Cultivated. Yam farm

Profile Description

Ap---0-16cm; reddish brown (5YR 5/3) loamy fine sand; weak, angular blocky structure; dry, soft; few sandstone fragments; few termite nests; few, fine, fibrous roots; clear, smooth boundary.

Bt1---16-41cm; yellowish red (5YR 5/8) loamy fine sand; weak angular blocky structure; moist, friable; many, fine to medium sandstone nodules; few termite channels; few, fine to medium woody roots; clear, smooth boundary.

Bt2---41-68cm; yellowish red (5YR 5/8) fine sandy loam; weak to moderate angular blocky structure; moist, friable; few, sandstone nodules; few termite nests; few, fine woody roots; clear, wavy boundary

Cr1---68-93cm; strongly weathered sandstone rock.

Cr2---93-112cm; slightly weathered sandstone rock.

Table 16: Physical and chemical data of soil series 16 in Keana Farm.

Characteristics	Horizon Depth (in cm)				
	0–16	16–41	41–68	68–93	93–112
Horizon designation	Ap	Bt1	Bt2	Cr1	Cr2
Particle size (in mu)					
Clay 2	7	8	13	6	2
Fine silt 2–20	6	4	5	5	3
Coarse silt 20–50	7	8	8	9	8
Fine sand 50–200	58	49	45	50	51
Coarse sand 200–2000	22	31	29	30	36
pH 1:2.5 H_2O	5.9	6.0	6.0	6.0	6.2
% Organic carbon	.68	.24	.20	.09	.05
Exch. Na meq/100g soil	.14	.17	.16	.18	.22
Exch. K meq/100g soil	.21	.17	.20	.22	.17
Exch. Ca meq/100g soil	5.00	3.85	4.15	3.50	4.28
Exch. Mg meq/100g soil	1.58	1.48	2.43	2.45	3.62
TEB meq/100g	6.93	5.67	6.94	6.35	8.29
CEC meq/100g	15.7	9.5	12.7	11.5	14.2
Base saturation %	44	60	55	55	58

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 17

Brief Description

The soils are deep, red in colour and well drained. The texture is sandy clay loam.

Site

Middle slope

Parent Material

Residuum from medium to coarse grained sandstone

Present Land Use

Cultivated. Yam farm

Profile Description

Ap--0-10cm; reddish brown (5YR 5/3) loamy fine sand; weak subangular blocky structure; dry; soft; few termite holes; common, fine, fibrous roots; clear, wavy boundary.

Ap2--10-19cm; reddish brown (5YR 4/4) loamy fine sand; weak subangular blocky structure; dry, soft; few, fine, fibrous roots and few, fine to medium, woody roots; claar, smooth boundary.

Ap3-19-30cm; light reddish brown (5YR 6/4) loamy fine sand; weak subangular blocky structure; dry, slightly hard; few, fine to medium woody roots; clear, wavy boundary.

Bt1--30-67cm; red (2.5YR 4/6) sandy clay loam; brownish yellow (10YR 6/6) common, fine, distinct mottles; weak, subangular blocky structure; moist, firm; few, fine, woody roots; gradual smooth boundary.

Bt2—67-113cm; red (2.5YR 4/8) sandy clay loam; weak subangular blocky structure; moist, firm; few termite holes; few, fine woody roots; diffuse, smooth boundary.

Bt3—113-142cm; red (2.5YR 4/8) sandy clay loam, weak subangular blocky structure; moist, firm.

Table 17. Physical and chemical characteristics of soil series 17 in Keana Farm

Characteristics	Horizon Depth (in cm)					
	0–10	19–19	19–30	30–67	67–113	113–143
Horizon designation	**Ap**	**Ap2**	**Ap3**	**Bt1**	**Bt2**	**Bt3**
Particle size (in mu)						
Clay 2	2	4	6	33	28	25
Fine silt 2–20	4	3	3	4	2	4
Coarse silt 20–50	13	10	11	5	9	7
Fine sand 50–200	59	56	55	44	46	48
Coarse sand 200–2000	22	27	25	14	15	16
pH 1:2.5 H_2O	6.1	6.0	6.0	5.3	5.4	5.4
% organic carbon	.98	.37	.31	.34	.14	.15
Exch. Na meq/100g soil	.12	.10	.11	.16	.16	.17
Exch. K meq/100g soil	.18	.12	..13	.26	.20	.18
Exch. Ca meq/100g soil	4.00	2.40	2.00	4.00	4.85	4.80
Exch. Mg meq/100g soil	1.07	.61	.69	1.30	1.38	1.32
TEB meq/100g	5.87	3.23	2.93	5.72	6.59	6.47
CEC meq/100g	9.7	6.0	5.5	16.2	15.0	12.7
Base saturation	55	54	53	53	44	51

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 10

Location: Lafia Seed/Research Farm

Brief Description

The soils are very deep, red in colour and well drained, The texture is sandy loam grading to sandy clay loam with increasing depth. There are no concretions or mottles present.

Site

Crests and upper slopes

Parent Material

Residuum from coarse to medium grained sandstone

Present Land Use

Cultivated. Under cassava

Profile Description

Ap---0 -21cm; brown (7.5YR 5/4) fine sand; weak subangular blocky structure; dry, slightly hard; common, fine fibrous roots; clear, smooth boundary.

BA---21-33cm; reddish brown (5YR 5/4) sand to loamy sand; weak subangular blocky structure; dry slightly hard; few, fine fibrous roots; gradual, smooth boundary.

Bt---33-61cm; yellowish red (5YR 5/6) sandy loam, weak to moderate subangular blocky structure; dry, hard; few, fine to medium fibrous roots; diffuse, smooth boundary.

Bt2—61-108cm; red (2.5YR 5/6) sandy loam; moderate angular blocky structure; dry, hard; few fine woody roots; diffuse, smooth boundary.

Bt3—108-186cm; red (10R 4/6) sandy clay loam; moderate subangular blocky structure; moist, friable; few, fine fibrous roots.

Table 13: Physical and chemical data of soil series 10 at Lafia Seed Farm.

Characteristics	Horizon Depth (in cm)				
	0–21	21–33	33–61	61–108	108–186
Horizon designation	**Ap**	**BA**	**Bt1**	**Bt2**	**Bt3**
Particle size (in mu)					
Clay 2	3	6	17	19	28
Fine silt 2–20	4	5	3	2	7
Coarse silt 20–50	4	2	2	4	3
Fine sand 50–200	49	48	47	45	40
Coarse sand 200–2000	40	39	30	30	22
pH 1:2.5 H_2O	5.8	6.0	5.8	5.8	5.6
% Organic carbon	.43	.32	.19	.16	.11
Exch. Na meq/100g soil	.14	.13	.24	.14	.13
Exch. K meq/100g soil	.08	.07	.17	.08	.06
Exch. Ca meq/100g soil	3.10	3.40	2.10	3.00	2.30
Exch. Mg meq/100g soil	.76	.90	.99	1.15	1.07
TEB meq/100g	4.08	4.50	3.50	4.37	3.56
CEC meq/100g	4.1	4.3	5.6	5.9	6.0
Base saturation %	100	100	63	74	59

mu = micrometre; TEB = Total exchangeable bases

Soil Series 19

Brief Description

The soils are deep, pinkish gray in colour and moderately well drained. The texture is fine sand to loamy sand in the surface horizons and sandy clay loam in the subsoil. Mottles are common below 60cm.

Site

Middle slopes

Parent Material

Residuum from coarse to medium grained sandstone

Present Land Use

Cultivated. Under maize

Profile Description

Ap--0-17cm; gray (10YR 5/1) sand; weak subanggular blocky structure; dry, slightly hard; common, fine fibrous roots; clear, smooth boundary.

BA--17-33cm; pinkish gray (5YR 6/2) sand; weak to moderate subangular blocky structure; dry, slightly hard; few fine fibrous roots; gradual, smooth boundary.

B--33-63cm; light reddish brown (5YR 6/3) loamy sand; reddish yellow (5YR 6/6) few, fine and faint mottles; weak to

moderate subangular blocky structure; dry, slightly hard; few, fine woody roots; gradual, smooth boundary.

Bt--63-106cm; pinkish gray (7.5YR 7/2) sandy clay loam; red (10YR 4/8) common, medium and distinct mottles; weak subangular blocky structure; dry, hard; few, fine woody roots; gradual, smooth boundary.

Btg--106-133cm; light gray (7.5YR 7/0) sandy clay loam; red (10YR 4/8) to yellow (10YR 7/8) common, fine and distinct mottles; weak subangular blocky structure; dry, hard; few soft concretions; few, fine woody roots.

Table 19: Physical and chemical data of soil series 19 in Lafia Seed Farm.

Characteristics	Horizon Depth (in cm)				
	0–17	17–33	33–63	63–106	106–133
Horizon designation	**Ap**	**BA**	**B**	**Bt**	**Btg**
Particle size (in mu)					
Clay 2	2	3	5	29	29
Fine silt 2–20	2	2	3	1	3
Coarse silt 20–50	6	7	6	8	7
Fine sand 50–200	44	46	43	35	34
Coarse sand 200–2000	46	43	43	27	27
pH 1:2.5 H_2O	5.6	5.8	5.9	5.2	5.0
% Organic carbon	.47	.24	.12	.18	.08
Exch. Na meq/100g soil	.11	.10	.19	.11	.11
Exch. K meq/100g soil	.09	.09	.07	.14	.09
Exch. Ca meq/100g soil	4.00	3.10	1.10	4.00	2.80
Exch. Mg meq/100g soil	.68	.67	.41	1.48	1.19
TEB meq/100g	4.88	3.96	1.77	5.73	4.19
CEC meq/100g	3.9	3.1	2.2	14.5	7.0
Base saturation %	100	100	80	40	60

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 3

Location: At Lafia Seed/Research Farm

Brief Description

The soils are deep, reddish yellow in colour within 100cm of the surface and light gray below that depth. The soil is mottled below 40cm, the mottles being red to yellowish red in colour indicating imperfect drainage conditions. The texture is loamy sand in the topsoil and sandy clay loam in the subsoil. Ironstone concretions are common in the subsoil but absent in the surface horizons.

Site

Lower middle slopes

Parent Material

Residuum from coarse to medium grained sandstone

Present Land Use

Cultivated. Under maize

Profile Description

Ap—0-19cm; light brownish gray (10YR 6/2) loamy sand; weak angular blocky structure to structureless; dry, slightly hard; common, fine fibrous roots; abrupt, smooth boundary.

AB—19-39cm; light brownish gray (10YR 6/2) loamy sand; weak angular blocky structure; dry, slightly hard; few, fine woody roots; clear, smooth boundary.

Bt1—39-66cm; reddish yellow (7.5YR 6/6) sandy clay loam; reddish yellow (5YR 6/8) few, fine, faint mottles; weak angular blocky structure; dry, hard; few ironstone concretions; few termite nests; few, fine woody roots; abrupt, wavy boundary.

Bt2—66-81cm; reddish yellow (7.5YR 7/8) sandy clay loam; reddish yellow (5YR 6/6) common, fine, faint mottles; weak angular blocky structure; dry, very hard; many medium ironstone concretions; abrupt, smooth boundary.

Bt3—81-108cm; reddish yellow (7.5YR 7/8) sandy clay loam; red (2.5YR 5/6) to light gray (2.5Y 7/2) many, medium distinct mottles; weak subangular blocky structure; dry, hard; few ironstone concretions; common termite nests; gradual, smooth boundary.

Bt4—108-167cm; light gray (2.5Y 7/2) sandy clay loam; red (2.5YR 4/8) to light yellowish brown (10YR 6/4) many, medium distinct mottles; weak angular blocky structure; dry, hard, few ironstone concretions; occasional termite nests.

Table 20: Physical and chemical data of soil series 3 in Lafia Seed Farm.

Characteristics	Horizon Depth (in cm)					
Horizon designation Particle size (in mu)	0–19 **Ap**	19–39 **AB**	39–66 **Bt1**	66–81 **Bt2**	81–108 **Bt3**	108–167 **Bt4**
Clay 2	4	4	34	29	28	32
Fine silt 2–20	2	5	5	4	6	8
Coarse silt 20–50	8	11	6	11	12	9
Fine sand 50–200	52	53	43	38	45	39
Coarse sand 200–2000	34	27	12	18	9	12
pH 1:2.5 H_2O	6.0	5.8	4.9	5.2	5.2	5.4
% Organic	.57	.39	.38	.17	.14	.08
Exch. Na meq/100g soil	1.3	.11	.15	.14	.14	.15
Exch. K meq/100g soil	.13	.09	.17	.13	.15	.13
Exch. Ca meq/100g soil	4.30	3.00	3.50	2.90	4.60	4.10
Exch. Mg meq/100g soil	.82	.74	1.11	.99	1.68	1.65
TEB meq/100g	5.38	3.94	4.93	4.16	6.57	6.03
CEC meq/100g	6.6	4.6	15.0	15.0	7.4	12.5
Base saturation%	82	86	33	28	89	48

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 20

Brief Description

The soils are deep, dark brown in colour and poorly drained. The texture is a sandy loam. A few ironstone concretions are present in all horizons. The concretions in the topsoil are hard and those in the subsoil are soft.

Site

Lower slopes and valley bottoms

Parent Material

Alluvial deposits

Present Land Use

Cultivated. Under fallow

Profile Description

Ap—0-20cm; very dark gray brown (10YR 3/2) sandy loam; strong brown (7.5YR 5/6) many, fine and distinct mottles; weak, medium subangular block structure; dry, slightly hard, moist friable; few, fine to medium red ironstone concretions; red stains in root channels, many fine fibrous roots; diffuse, wavy boundary.

AB—20-30cm; dark brown (10YR 3/3) and brown (7.5YR 4/2) sandy loam; strong brown (7.5YR 5/8) few, fine and faint

mottles; weak, medium subangular blocky structure; dry, hard moist firm; few fine, hard red ironstone concretions; few potchards; many fine fibrous roots, common medium woody roots; diffuse, wavy boundary.

BC--30-58cm; brown to dark brown (10YR 4/3) sandy loam; brown to dark brown (7.5YR 4/4) common, medium and distinct mottles; weak, medium subangular blocky structure; dry hard, moist firm; few, medium hard red ironstone concretions; potchards; many fine fibrous roots, common medium woody roots; diffuse, wavy boundary.

BC--58-84cm; brown to dark brown (10YR 4/3) sandy loam; brown to dark brown (7.5YR 4/4) common, medium and distinct mottles; structureless; moist and firm; few, fine soft red ironstone concretions; potchards; few, fine to medium woody roots; clear smooth boundary.

C--84-140cm; gray (10YR 5/1) wet sandy loam; brownish yellow (10YR 6/8) many fine to medium, distinct mottles; structureless; wet and sticky; few, fine soft red ironstone concretions; few fine to coarse woody roots.

Table 21: Physical and chemical data of soil series 20 in Lafia Farm.

Characteristics	Horizon Depth (in cm)				
	0–20	20–30	30–58	58–84	84–100
Horizon designation	**Ap**	**AB**	**BC**	**BC**	**C**
Particle size (in mu)					
Clay 2	11	19	17	19	17
Fine silt 2–20	14	7	7	7	7
Coarse silt 20–50	14	14	16	13	11
Fine sand 50–200	49	43	44	44	47
Coarse sand 200–2000	12	17	16	17	18
pH 1:2.5 H_2O	5.2	5.2	5.2	5.2	5.2
% Organic carbon	.97	.49	.25	.20	.16
Exch. Na meq/100g soil	.13	.14	.14	.13	.13
Exch. K meq/100g soil	.11	.10	.10	.11	.09
Exch. Ca meq/100g soil	2.50	2.40	2.50	2.10	2.30
Exch. Mg meq/100g soil	.41	.58	.74	.82	1.07
TEB meq/100g	3.15	3.22	3.48	3.16	3.59
CEC meq/100g	7.7	12.7	7.5	6.9	7.7
Base saturation %	41	25	46	46	47

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 21

Brief Description

The soils are deep, yellowish to gray in colour and imperfectly drained. The texture is sandy clay loam over clay.

Site

Upper slopes

Parent Material

Rediduum from sandstone and shale

Parent Land Use

Cultivated. Under sorghum

Profile Description

Ap--0-10cm; pale brown (10YR 6/3) sandy clay loam; weak medium, subangular blocky structure; dry, hard; few, fine fibrous roots; clear, smooth boundary.

Bt1--10-26cm; brownish yellow (10YR 6/6) clay; yellowish red (5YR 5/6) few, fine, faint mottles; weak subangular blocky structure; dry, hard; few fine, soft black concretions; few, fine fibrous roots and few, fine to medium woody roots; gradual, smooth boundary.

Bt2--26-74cm; olive yellow (2.5Y 6/6) clay; yellow h red (5YR 5/6) common, fine, distinct mottles weak, subangular blocky

structure; dry, hard; few, fine to medium soft black concretions and common, fine to medium ironstone concretions; few termite nests; few, fine to medium woody roots; gradual, smooth boundary.

Bc--74-104cm; pink (7.5YR 7/4) gravelly, sandy clay loam; structureless; dry, hard; common, fine to medium soft black concretions; few, fine woody roots; gradual, smooth boundary.

C--104-135cm; light gray (2.5Y 7/2) gravelly sandy clay loam; structureless; dry, hard; common, fine to medium soft Black concretions and many fine to medium yellowish red ironstone concretions; strongly cemented.

Table 22: Physical and chemical data of soil series 21 in Obi Farm.

Characteristics	Horizon Depth (in cm)				
	0–10	10–26	26–74	74–104	104–135
Horizon designation	Ap	Bt1	Bt2	BC	C
Particle size (in mu)					
Clay 2	24	40	44	30	32
Fine silt 2–20	4	12	10	8	8
Coarse silt 20–50	6	8	8	6	6
Fine sand 50–200	29	31	30	27	29
Coarse sand 200–2000	37	9	8	29	25
pH 1:2.5 H_2O	4.8	4.8	5.2	5.4	5.8
% Organic carbon	.11	1.15	.58	.33	.19
Exch. Na meq/100g soil	.11	.18	.27	.65	.38
Exch. K meq/100g soil	.05	.33	.30	.41	.37
Exch. Ca meq/100g soil	.50	3.38	1.78	2.10	1.96
Exch. Mg meq/100g soil	.28	2.55	2.71	4.61	4.93
TEB meq/100g	.94	6.44	5.06	7.77	7.64
CEC meq/100g	6.3	27.0	28.5	32.3	28.5
Base saturation					

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 22

Brief Description

The soils are very deep, light grayish in colour, and imperfectly drained. The texture is clay loam.

Site

Level crest

Parent Material

Residuum from fine sandstone and the overlying colluvium

Present Land Use

Cultivated. Under maize

Profile Description

Ap---0--23cm; light olive brown (2.5Y 5/4) loam; moderate subangular blocky structure; dry, slightly hard; few, reddish soft concretions; few fine, fibrous roots and few, coarse woody roots; clear smooth boundary.

Bt1---23-38cm light yellowish brown (2.5Y 6/4) clay loam; reddish yellow (5YR 6/8) common, fine, distinct mottles; weak subangular blocky structure; dry, slightly hard; few fine, soft black concretions; few termite nests; few, fine, fibrous roots and few medium woody roots; clear, smooth boundary.

Bt2---38-81cm; pinkish gray (7.5YR 7/2) clay loam; reddish yellow (5YR 6/8) common, fine to medium, distinct mottles; weak subangular blocky structure; dry, hard; few fine to medium soft black concretions; few termite nests; few, fine woody roots; gradual, smooth boundary.

Btg1---81-116cm; light gray (5YR 7/1) clay loam; reddish yellow (5YR 6/8) common, fine to medium, distinct mottles; weak subangular blocky structure; dry, hard; common, fine to medium, soft black concretions; gradual, smooth boundary.

Btg2---116-141cm; light gray (5Y 7/1) clay loam; reddish yellow (5YR 6/8) common, fine to medium, distinct mottles; weak subangular blocky structure; dry, hard; many, fine to medium, soft black concretions; diffuse, smooth boundary.

Btg3---141-193cm; light gray (5Y 7/2) clay loam; red (10YR 4/8) many, fine to medium, distinct mottles; moderate subangular blocky structure; moist, firm; few, fine, soft black concretions.

Table 23: Physical and chemical data of soil series 22 in Obi Farm.

Characteristics	Horizon Depth (in cm)					
	0–23	23–38	38–81	81–116	116–141	141–193
Horizon designation	**Ap**	**Bt1**	**Bt2**	**Btg1**	**Btg2**	**Btg3**
Particle size (in mu)						
Clay 2	24	30	36	34	34	39
Fine silt 2–20	24	19	17	13	12	11
Coarse silt 20–50	15	14	18	11	13	10
Fine sand 50–200	31	30	22	30	30	29
Coarse sand 200–2000	6	7	7	10	11	11
pH 1:2.5 H_2O	5.4	5.0	5.4	5.8	6.1	6.1
% Organic carbon	1.23	.61	.35	.27	.17	.12
Exch. Na meq/100g soil	.18	.18	.23	.34	.41	.52
Exch. K meq/100g soil	.25	.21	.50	.28	.29	.31
Exch. Ca meq/100g soil	3.75	2.25	2.15	2.63	2.75	3.25
Exch. Mg meq/100g soil	3.87	2.61	2.62	3.87	4.24	4.90
TEB meq/100g	8.05	5.25	5.50	7.12	7.69	8.98
CEC meq/100g	22.0	20.5	24.5	24.3	23.0	18.8
Base saturation	37	26	22	29	33	48

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 23

Brief Description

The soils are deep, olive brown in colour and poorly drained. The texture is clay.

Site

Middle slopes.

Parent Material

Residuum from shale

Present Land Use

Uncultivated. Recently cleared woodland

Profile Description

A1—0-18cm; grayish brown (2.5Y 5/2) sandy clay loam; medium subangular blocky structure; dry, hard; few, fine, fibrous roots and few, fine to medium, woody roots; **surface cracks;** clear, smooth boundary.

Bc—18-34cm; light reddish brown (5YR 6/3) clay; structureless; dry, loose; common, fine to moderate soft reddish brown concretions and few, fine, ironstone concretions; few, fine, fibrous roots and few, fine woody roots; clear, smooth boundary.

Bt1—34-47cm; light olive brown (2.5Y 5/4) clay; yellowish red (5YR 5/8) common, fine to medium, faint mottles; moderate

subangular blocky structure; dry, hard; few, fine to medium, ironstone concretions; few, fine, woody roots; clear, smooth boundary.

Bt2---47-119cm; olive brown (2.5Y 4/4) clay; yellowish red (5YR 5/8) common, fine to medium, faint mottles; moderate to strong subangular blocky structure; dry, very hard; few; fine to medium soft concretions; few, fine, woody roots; clear, smooth boundary.

Bt3---119-140cm; light gray (5Y 7/2) clay; yellowish red (5YR 5/8) common, fine to medium, distinct mottles and red (2.5Y 4/8) common, fine, distinct mottles; weak, platy structure; dry, slightly hard; few, black weathered rock fragments.

Table 24: Physical and chemical characteristics of soil series 23 in Obi Farm

Characteristics	Horizon Depth (in cm)				
Horizon designation	0–18 A1	18–34 BC	34–47 Bt1	47–119 Bt2	119–140 Bt3
Particle size (in mu)					
Clay 2	28	48	60	62	56
Fine silt 2–20	18	18	9	11	13
Coarse silt 20–50	10	4	5	3	4
Fine sand 50–200	37	23	23	22	24
Coarse sand 200–2000	7	7	3	2	3
pH 1:2.5 H_2O	5.5	5.4	5.4	5.4	5.2
% Organic carbon	2.40	.86	.56	.41	.07
Exch. Na meq/100g soil	.28	.34	.41	1.35	2.09
Exch. K meq/100g soil	.38	.40	.82	1.02	1,02
Exch. Ca meq/100g soil	6.50	3.50	4.58	6.88	33.75
Exch. Mg meq/100g soil	9.70	7.40	11.51	18.09	22.20
TEB meq/100g s	16.86	11.64	17.32	27.34	57.06
CEC meq/100g	40.2	32.8	28.7	20.7	38.0
Base saturation	42	35	60	100	100

mu = micrometre; TEB = Total exchangeable bases.

Soil Series 24

Brief Description

The soils are very deep, gray in colour and imperfectly drained. The texture is sandy clay loam in the upper horizons and sandy loam in the lower horizons.

Site

Flat bottom land

Parent Material

Alluvial

Present Land Use

Cultivated. Under sorghum

Profile Description

Ap--0-12cm; grayish brown (2.5Y 5/2) loam; weak; subangular blocky structure; dry, hard; common, fine to medium fibrous roots and few, fine, woody roots; clear smooth boundary.

Bt1--12-42cm; light olive brown (2.5Y 5/4) sandy clay loam; brownish yellow (10YR 6/8) common, fine, distinct mottles; weak, subangular blocky structure; dry, slightly hard; few to common, soft, black concretions; few, fine fibrous roots; clear, smooth boundary.

Bt2--42-77cm; gray (5YR 6/1) sany clay loam to clay loam; brownish yellow (10YR 6/8) common, fine, distinct mottles; weak, subangular blocky structure; moist firm, common, fine to medium, soft black concretions; few, fine woody roots; diffuse, smooth boundary.

2BC---77-126cm; light gray (5YR 7/1) sandy loam; brownish yellow (10YR 6/8) common, distinct mottles; weak subangular blocky structure; moist, firm; common, fine to medium, soft black concretions, common ironstone concretions; few fine, woody roots; diffuse, smooth boundary.

2C--126-158cm; light gray (5YR 7/1) sandy loam; brownish yellow (10YR 6/8) common, fine, distinct mottles; weak subangular blocky structure; moist, firm; many, fine to medium, soft black concretions, common ironstone concretions; few, fine woody roots.

Table 25: Physical and chemical data of soil series 24 in Obi Farm

Characteristics	Horizon Depth (in cm)				
	0–12	12–42	42–77	77–126	126–158
Horizon designation	Ap	Bt1	Bt2	2BC	2C
Particle size (in mu)					
Clay 2	30	23	32	15	17
Fine silt 2–20	10	17	13	5	7
Coarse silt 20–50	14	13	11	19	16
Fine sand 50–200	39	38	35	50	50
Coarse sand 200–2000	7	9	9	11	10
pH 1: 2.5 H_2O	5.0	5.1	5.2	5.3	5.3
% Organic carbon	.28	2.15	.26	.07	.10
Exch. Na meq/100g soil	.19	.27	.20	.17	.35
Exch. K meq/100g soil	.15	.29	.16	.15	.21
Exch. Ca meq/100g soil	1.63	5.80	1.30	1.30	1.90
Exch. Mg meq/100g soil	0.77	3.22	0.67	0.84	1.89
TEB meq/100g	2.74	9.58	2.33	2.46	4.35
CEC meq/100g	18.8	29.5	21.8	13.3	14.8
Base saturation %	15	32	11	18	29

mu = micrometre; TEB = Total exchangeable bases.

SECTION III

Proposed Land Capability Classes: Northern Nigeria (after Ghana Modified from USDA Soil Conservation System)

Definition	Class and Sub Class Chafacteristics		
ry good land with nor or no physical mitations to mechanical ltivation.	One class only - no sub classes Deep to very deep Well drained Medium textured Nearly level to gently sloping Moderately permeable		Moderate to high water holding capacity Medium inherent fertility Good capacity for fertiliser utilisation Slight erosion No damaging overflows
derate to high productivity can be sustained with a few but good management practices such as 1) maintenance of fertility ulching, manuring, [illegible] addition of fertilisers, establishment of a legume in the rotation 2) contour ploughing.			
derate to good land with w physical limitations to chanised cultivation but ich can be corrected.	IIe Moderate to high erosion hazard Sloping or undulating topography Gravelly or stony texture	IIw Imperfect to poor internal drainage Excessive wetness Heavy textures Presence of salts Occasional to moderate overflow hazard	IIs Moderate to shallow depth Low or moderate water holding capacity Either very slow or very rapid permeability Low inherent fertility Fair or low capacity to utilise added fertiliser
derate productivity can be maintained by following recommendations for Class I with additional water control measures such as ass waterways, close stripcropping based on contour terraces or bunds.			
ir to good land, best ited for perennial vege- tion, that can be chanically farmed with eat care. Hand culti- tion or bullock farming n be practised.	IIIe Moderate to high erosion hazards Sloping to hilly topography Very gravelly or stony texture	IIIw Poor to excessively drained soils Heavy textured soils Moderate overflow hazard	IIIs Shallow depth, to bedrock, ironpan concretions or clays Poor drainage Light textured and/or gravelly or stony soils Either very rapid or very slow permeability Low water holding capacity Low inherent fertility Low capacity to utilise added fertilisers
e productivity of these soils may be maintained by following intensely the same practices recommended for II soils but rotations be practised should include long periods of forage or tree crop production			

	IVe	IVs
Land not suited to mechanical cultivation but suited for limited clearing, grazing and hand cultivation for the production of perennial crops. These soils commonly occur on hilly or steep topography and are subject to moderate or severe erosion.	Moderate to severe erosion hazard Steep or rocky slopes Excessive drainage Very shallow depth and stoniness	Extremes in texture, very light or very heavy Rapid or slow permeability Low or very low moisture holding capacity Low inherent fertility Fair or poor capacity to utilise added fertilizers

The productivity of these soils for perennial crops can best be maintained by raising their fertility level through mulching, application of manure and/or the inclusion of a leguminous crops in the rotation. The establishment of stringent erosion control practices is essential even when such soils are hand cultivated.

These lands have a severe erosion hazard and are too steep, too stony, too dry or too wet to be suitable for any type of mechanical cultivation. With care, limited clearing and very limited hand cultivation may be carried out. Perennial tree crops, forestry, controlled grazing, recreation and watershed protection are recommended.

Moderately alkaline	7.9 – 8.4
Strongly alkaline	8.5 – 9.0

Glossary

Soil Colour — The colours are for dry soil. If two colours are given the first is the dominant colour.

Soil Depth

0–30cm	Very shallow soil
30–90cm	Shallow soil
90–150cm	Deep soil
150cm +	Very deep soil

Soil Texture — According to Soil Survey Manual

Sandy soils	Sands, loamy sands
Loamy soils	(Sandy loam. Loam (Silt loam. Silt (Clay loam. Sandy clay loam
Clayey soils	(Sandy clay. Silty clay (Clay

Soil Reaction — pH

Extremely acid	4.5
Very strongly acid	4.5 – 5.0
Strongly acid	5.1 – 5.5
Moderately acid	5.6 – 6.0
Slightly acid	6.1 – 6.5
Neutral	6.6 – 7.3
Slightly alkaline	7.4 – 7.8
Moderately alkaline	7.9 – 8.4
Strongly alkaline	8.5 – 9.0
Very strongly alkaline	9.0

Organic Matter

Very low	0.4%C
Low	0.4 - 1.0%C
Moderate	1.0 - 1.5%C
High	1.5 - 2.0%C
Very high	2.0%C

CEC

Very Low	6meq/100g soils
Low	6 - 12 meq/100g soil
Moderate	12 - 25 meq/100g soil
High	25 - 40 meq/100g soil
Very high	40 meq/100g soil

Base Saturation

Very low	0 - 20%
Low	20 - 40%
Moderate	40 - 40%
High	60 - 80%
Very high	80 - 100%

The limitation imposed by pH to the growth of certain crops is given in Land Resources of Central Nigeria. Agricultural development possibilities Vol. 4B. The Benue Valley. Ed. I. D. Hill. Land Resources Development Centre, Tolworth, Surrey England.

S E C T I O N IV

ADDITIONAL INFORMATION ON YAM CULTIVATION AND ITS MECHANISATION.

1. Growth Habit of Yams

Four growth phases (the duration of each varies according to the species) have been identified for yams. Each phase is characterised by an organ or sets of organs exhibiting a greater relative growth than others.

Phase 1: Root Development

This lasts from sprouting to about 6 weeks after sprouting. It is marked by an extensive growth and development of the roots and vine. There is little or no leaf growth. The plant survives by absorbing or utilizing food reserves in the planted sett.

Phase II: Foliage Development

Foliage development starts from about the 6th week from sprouting. The canopy is fully established by the 10th week. After 13 weeks from sprouting there is little or no more increase in leaf area, although root and vine growth continues with less vigour in the 2nd phase and marks the transition period from dependancy on food stored in the sett to complete autotrophy. Tuber initiation therefore occurs during this phase as early as the 8th week but usually about the 10 - 11th week. Flowering may also begin.

Phase III: Tuber Bulking

This phase is marked by rapid tuber bulking as a result of food manufacture by the large canopy of leaves and vines.

Phase IV: Senescence

Large scale senescence of the shoot begins in the 4th phase and may be accompanied by some decrease in tuber dry weight. Although some diseases may accelerate the senescence and dying back of the shoot, it is thought to be under photoperiodic control. The tuber enters the dormancy period which may last for 2 - 3 months but varies with species and cultivars. There is no sprouting of the tuber during dormancy.

It will be remarked that while the vines of D. rotundata, D. alata, D. cayenensis twine to the right (ie clockwise); D. dumentorum, D. bulbifera and D. esculenta, twine to the left ie anti-clockwise.

2. Yam Species and Cultivars

D. rotundata, Poir (white yam) is the most widely cultivated in terms of hectrage in the world. It is characterised by a wingless stem, which is roughly circular in cross section.

Spines are present but the extent is dependent on cultivars. The leaves are cordate simple with pointed tip and are opposite in arrangement. The tuber generally is cyclindrical and the flesh is white. It has large and ovoid starch grains. Several cultivars are recognised but there is yet no universally accepted names for them. Meanwhile the cultivars continue to be called their local names. At the National Root Crops Research Institute, Umudike, 488 accessions were maintained in the germ plasm based on their floral and tuber characteristics. D. rotundata topped the list.

Species of Yam	Cultivar name (local)	Number of Accessions	
D. rotundata (white yam)	Igwe	261	
	Nwopoko	90	
	Ekpe	22	
	Abi	5	389
	Okwoha	7	
	Ukom	4	
D. cayensis (yellow yam)		27	
D. alata (water yam)		54	
D. dumentorum (bitter or trifoliate yam)		12	
D. bulbifera (aerial yam)		6	
D. esculenta (chinense yam)		2	

3. Cultivation

The yam plant can be established by

(i) Tuber

(ii) bulbils

(iii) Seeds

(iv) Vine cuttings

(v) Tissue culture

The commonest and the most important commercially is by the use of tuber. Small whole tubers called seedyams may be used. In the alternative, cut tuber pieces called setts which are derived from the head, middle or tail portions of the tuber are used. It is established that whole tubers which have protective layer against rot organisms are better planting materials than cut setts. Sett cuts which is from the head region establish faster than those from the middle or tail regions. The rate of sprouting of setts from middle and tail portions are similar. "Minisetts" used for production of seed yams behave similarly with respect to the portion of the tuber from which they are derived.

To produce yams in commercial quantity setts weighing 150-300g (mean 200g) should be used. Although it is recognised that larger setts (300 - 500g) produce bigger yams per stand, tuber yield per unit weight of planted material decreases as the sett weight increases.

However, for specialist production of very large tubers, large setts of up to 4.5kg have been used but this is not for routine commercial production of ware yams.

For commcercial production of seed yams, minisetts as small as 25g have been successfully recently used to establish a seed yam plantation at Umudike and have resulted in the production of seed-yams of which 79 - 87% weighed more than 200g. Thus from one tonne of planting material it is possible to produce 13.6 tonnes of seed yam/ha as against 4 tonnes/ha to produce the same yields by normal farming practices for seed yam production utilizing 100g setts. Setts as small as 2.5g have sprouted and produced seed yams. The basis of the "minisett" technique for rapid propagation of seed yams developed recently at the National Root Crop Research Institute, Umudike, exploits the fact that any part of the yam tuber can be made to sprout.

The size of sett to plant is therefore dependent on the aim of the project. eg. for commercial ware yam production, setts of about 200 - 300g are used.

For commercial seed yam production, setts as little as 25g may be used. More information on this technique - minisetts - may be obtained by visiting the National Root Crop Research Institute at Umudike. For D. alata, the minisett technique has led to the production of even ware yams.

It is also recognised that late planting of yam of sett size 100g will produce only seed yams when spaced 50 - 60 cm on 1m ridges.

B. Seed bed preparation

Yams require loose soils for easy penetration of tuber. Thus good seed bed preparation is an essential factor in successful yam cultivation. While mounds and holes are used by local farmers, ridges and sometimes flats (after ploughing and harrowing) are common in partly mechanised farm. Although mounding has produced the largest yields of tuber per stand, it is a very tedious operation and not mechanisable. Ridges of 1 - 1.2 m apart are recommended. In areas subject to severe erosion, larger size ridges (1.2 m) are preferred to avoid exposing the tuber later in the season. Exposed tubers develop chlorophyll and are slightly bitter to the taste. They are also subject to destruction by pests.

C. Planting Time

The time of planting depends on the locality. In northern part of the forest zone of Nigeria, dry season yam (early yam) are planted in October - November but they won't sprout untill January or February.

Rainy season planting (at onset of the rains) is preferred. Yams planted in February or March (late Yam) yield most even

though rains are not steady till late March or early April. The later the planting, the lower the yield. The shorter growing season available to late planting plus a possible effect of photoperiodicity may account for this.

D. Population and planting depth

A population of 10,000 stands/ha for ware yam production and 40,000 stand/ha for seed yam production by the minisett technique is so far recommended subject to further investigation. Later plantings utilizing 100g setts for seed yam are placed at 20,000 stands/ha. This means planting distance (intra - row) of 1 m, 0.5 m and 25 m for ware yams, normal seed yam production and seed yam production by minisett technique, respectively. While ware yams may be planted 10 cm below soil surface, minisetts can be placed about 5 cm below soil surface.

D. Mulching

This is essential particularly for dry season planting to protect planted yams from excess heat and subsequent dessication. Later plantings after the rains have become steady have less need for mulching. Materials to be used for mulching should not contain weed seeds or be very prone to termite attacks.

E. Staking

Yam yields are significantly increased by staking but this is one major operation in yam cultivation that increases cost of production and hinders mechanisation of some operations.

Several methods and types of stakes are used (individual, pyramidal, trellis etc; stakes from acioa, Indian bamboo, Raffia, oil palm fronds, Elephant grass stalks etc). Some stakes may cost as much as 30 - 50 k/stake. The use of maize, sorghum, millet as intercrops which may substitute for conventional stakes is gaining top priority in our present research efforts and has been successfully tested for seed yam produced by the minisett technique. This will drastically cut down production costs for seed yam.

Also whereas at least 4 normal yams (ware) can be staked onto a stand, 8 minisett can be supported conveniently by a stand.

4. Weed Control

The use of pre-emergence herbicides is advocated for commercial yam production especially if mechanisation is to be adopted. In Nigeria, diuron, ametryne or linuron each at 3 kg a.i/ha have been found to suppress weeds for the 1st 3 months after planting.

Application of such herbicides before yams are planted followed by a good, clean seed bed preparation mechanically has a great future in commercial yam production. If the need arises, only one supplementary hand weeding may be necessary because weeds will reappear after 3 months. However yields are no longer drastically reduced since the critical period of weed interference is the 1st 3 months from planting. The practices of inter planting yams with melon, maize etc. make it more difficult to select suitable herbicide for such mixed cropping. However, there are indications that premetra, and atrazine plus alachlor have promise especially where melon is intercropped and protected by the use of activated chaircoal mixed with soil before planting melon at 30 - 50 kg/ha. It should be stated that in Nigeria the importance of weed science is newly being recognised, and herbicide technology is therefore in its infancy.

5. Fertilizers

Yam requires high soil fertility, hence it is traditionally grown as the first crop in a rotation to open a fallow. Response to N and K (nitrogen and phosphorus) are most common in Nigeria while response to P is very slight. The existing recommendations are as follows:

1. For Ware yam production

Northern States 25 kg N as sulphate of Ammonia

South Eastern States 400 - 600 kg/ha of 15 : 15 : 15 or 300-400 kg/ha of 12: 12 : 17 : 2.

Western States 300kg/ha of 12 : 12 : 17 : 2. (acid soils)

S. Western States 50 kg N/ha and 60 kg K_2O/ha

2. For yams grown for minisetts.

Results in the South Eastern States suggest 50 kg N, 50 kg P_2O_5, 75 kg K_2O and 10 kg MgO be mixed and applied. A supplementary dressing of FYM/poultry manure at a rate of 4 - 8 tonnes/ha will produce very high yields.

The fertilizers should be applied at about 8 weeks after planting but not later than one month after planting when the plant changes from dependence on the setts to true autotrophy. Placement in circles or holes 15 cm away from the base of the vine and 3 - 5 cm deep is normally recommended. Under large scale cultivation, P and K and half the N can be harrowed in during field preparation while the second half of N may be top dressed a month from planting.

Although sulphate of ammonia and compound fertilizers (15 : 15 : 15 or 12 : 12 : 12 : 17 :2) have not been recommended for the soils of the project area, these fertilizers have been proved to be particularly beneficial to yams.

Soils and Yield

About 7 - 12 tonnes/ha is obtained under farmers condition as against 25 - 30 tonnes/ha possible with good management but this depends on the location (soils), variety, and cultural practice.

Difference in soil physical conditions have been thought to influence yields of yam. Soils with fine texture and total porosity of 46 - 56% have been known to favour yam growing in Anam and Abakaliki. Good yam soils are medium textured or loamy soils (Sandy loams to sandy clay loams). Therefore, except for the sandy soils of Doma area, most of the soils of the project areas are good yam soils since they are sandy loams, sandy clay loams and clay loams. Sandy soils or coarse textured soils (sands and loamy sands) are poor yam soils. Good yams soils also should contain enough Ca, Mg and potassium to improve yields. Yams have performed well on soils with exchangeable Ca, of 1.9 meq/100g and above 1.5 meq/100g of Mg and 0.22 meq/100g of K.

Possibility for yam mechanization

Large scale production of yam in the future is only possible if most of the operation can be mechanised. The intention of the Lafia Agricultural Project to mechanise yam production is, therefore, a right step in this direction. As at now, it would be difficult to achieve complete mechanisation of all operations in yam cultivation.

1. Land preparation can be fully mechanised - ploughing, harrowing and ridging.
2. Weed control can be mechanised partly as mechnical spraying of recommended herbicides can be done with a boom sprayer attached to a tractor or moving landdrover. This can be done after harrowing or before ridging. This will achieve weed control for the first 3 months of planting.
3. Fertilizer application can be done to a large extent mechanically by drilling the fertilizer P, K, and $\frac{1}{2}$ N, harrowing them during field preparation. Manure application can similarly be harrowed in. Only a top dressing of $\frac{1}{2}$ N may be needed when the canopy of the crop is at maximum.
4. The possibility of designing and constructing a seed yam planter cannot be ruled out but this will take some time to achieve.

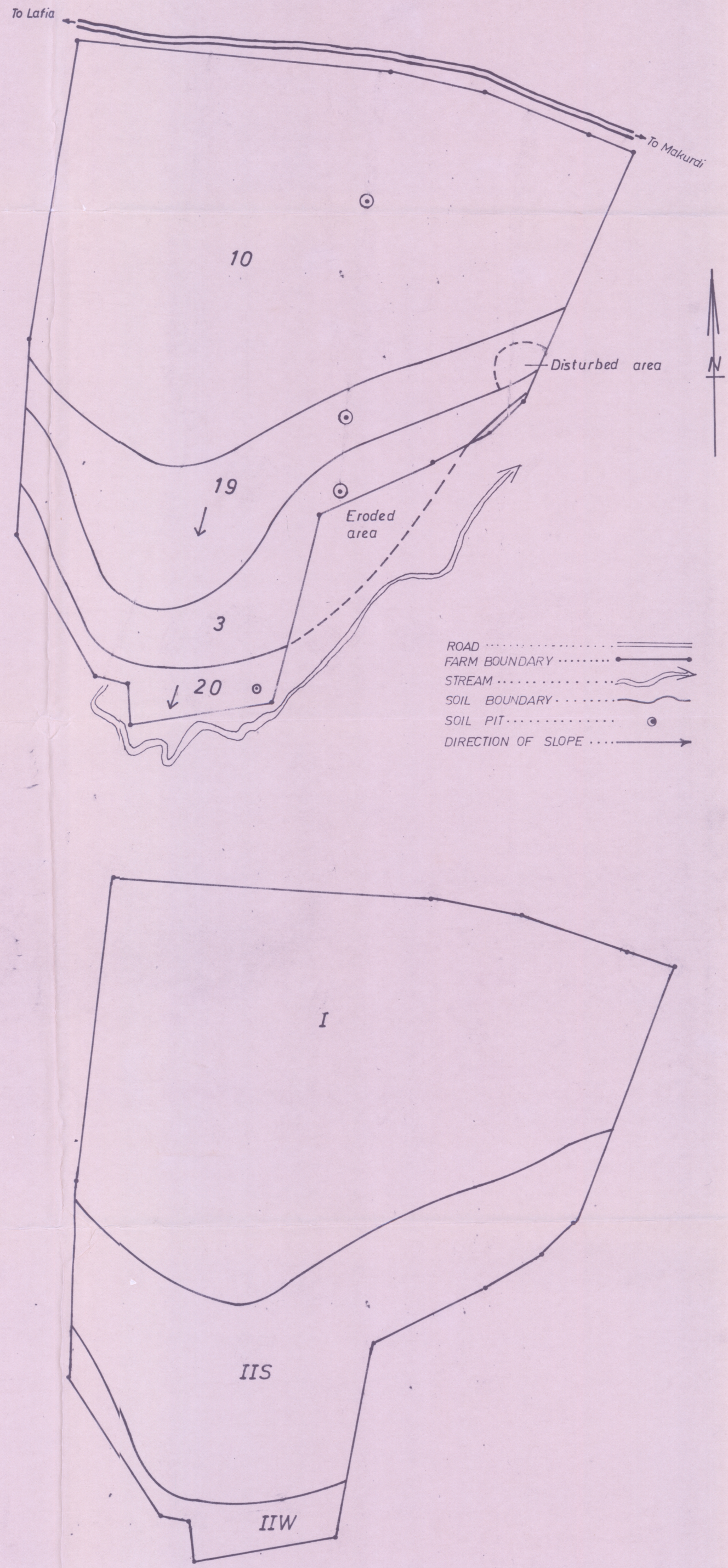
5. Seed yam harvesting can be mechanized especially if there is no staking or after stakes are removed. Harvesting of ware yams will be more difficult because they grow deep into the soil and are often branched. D. esculenta is well adapted for mechanical harvesting which suggests that some species or cultivars will lend themselves to mechanical harvesting better than others. The potato lifter has been used for D. esculenta and such equipment can be modified for seed yam harvesting. Advances in this direction have been made in the West Indies and Ivory Coast.

Disease

Anthracnose disease of water yam is becoming very important as it severely affects some cultivars of D. alata. Resistant cultivars to this disease should be planted eg. Um 680.

SOIL MAP OF SEED/ RESEARCH FARM LAFIA

MAP5



LEGEND

SOIL SERIES

UPPER SLOPE SOILS

10 DEEP, WELL DRAINED, SANDY CLAY LOAM

MIDDLE SLOPE SOILS

19 DEEP, IMPERFECTLY DRAINED, SANDY CLAY LOAM

3 DEEP, IMPERFECTLY DRAINED, CONCRETIONARY SANDY CLAY LOAM

LOWER SLOPE SOILS

20 DEEP, POORLY DRAINED, SANDY LOAM

0 100 200m

LAND CAPABILITY CLASS

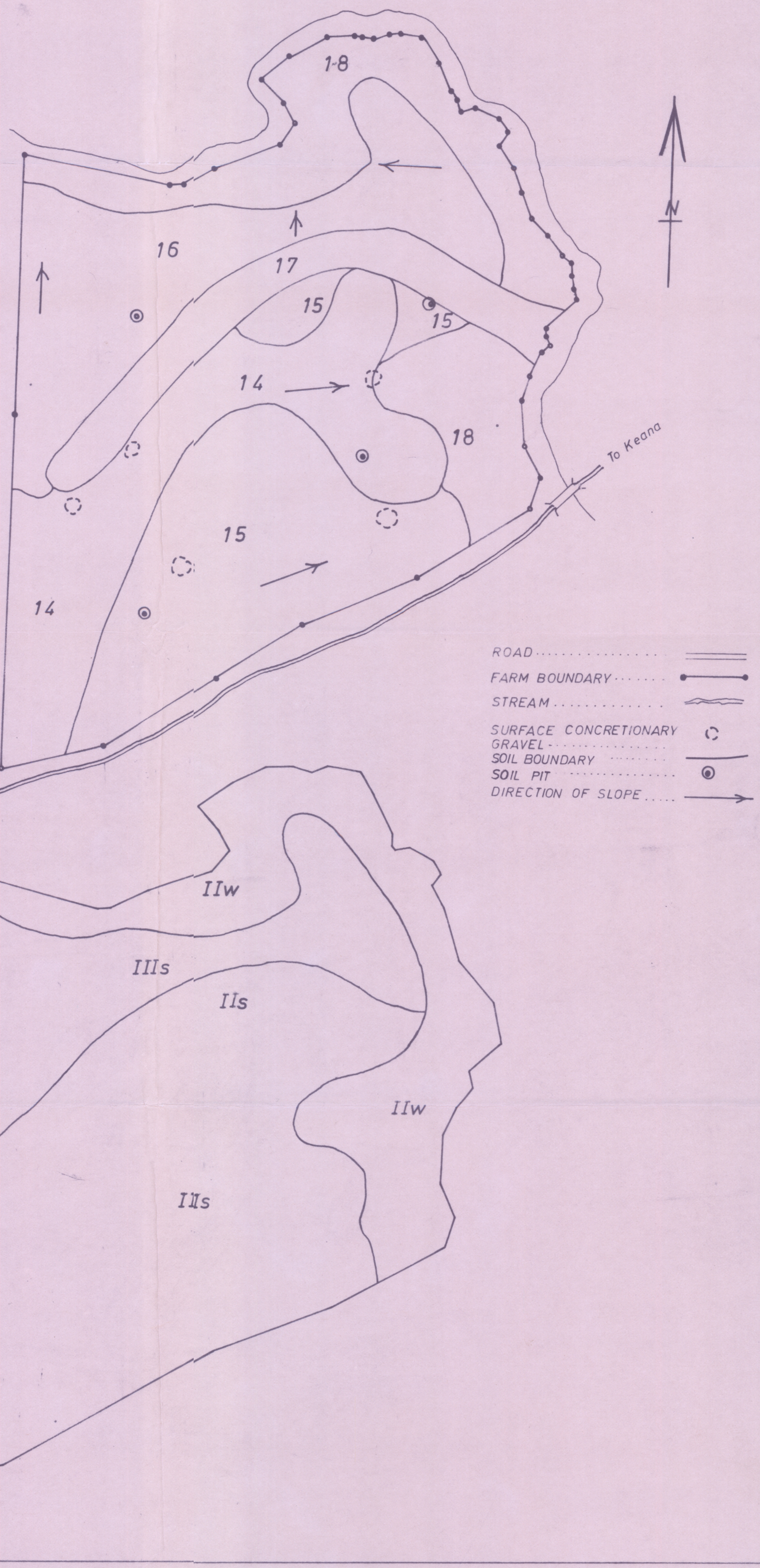
I MEDIUM INHERENT FERTILITY

IIS LOW INHERENT FERTILITY

IIW IMPERFECT TO POOR INTERNAL DRAINAGE

DISTRICT DEMONSTRATION FARM KEANA

MAP 4



LEGEND

SOIL SERIES

UPPER AND MIDDLE SLOPE SOILS

14 — VERY DEEP, WELL DRAINED, LOAMY SAND TO SANDY LOAM WITH FEW CONCRETIONS

15 — DEEP, WELL DRAINED, SANDY LOAM TO SANDY CLAY LOAM

MIDDLE TO LOWER SLOPE SOILS

16 — SHALLOW, WELL DRAINED, SANDY LOAM OVER WEATHERED ROCK

17 — DEEP WELL DRAINED SANDY CLAY LOAM

LOWER SLOPE SOILS

18 — DEEP, IMPERFECTLY TO POORLY DRAINED, LOAMS AND CLAYS

0 100 200m

LAND CAPABILITY CLASS

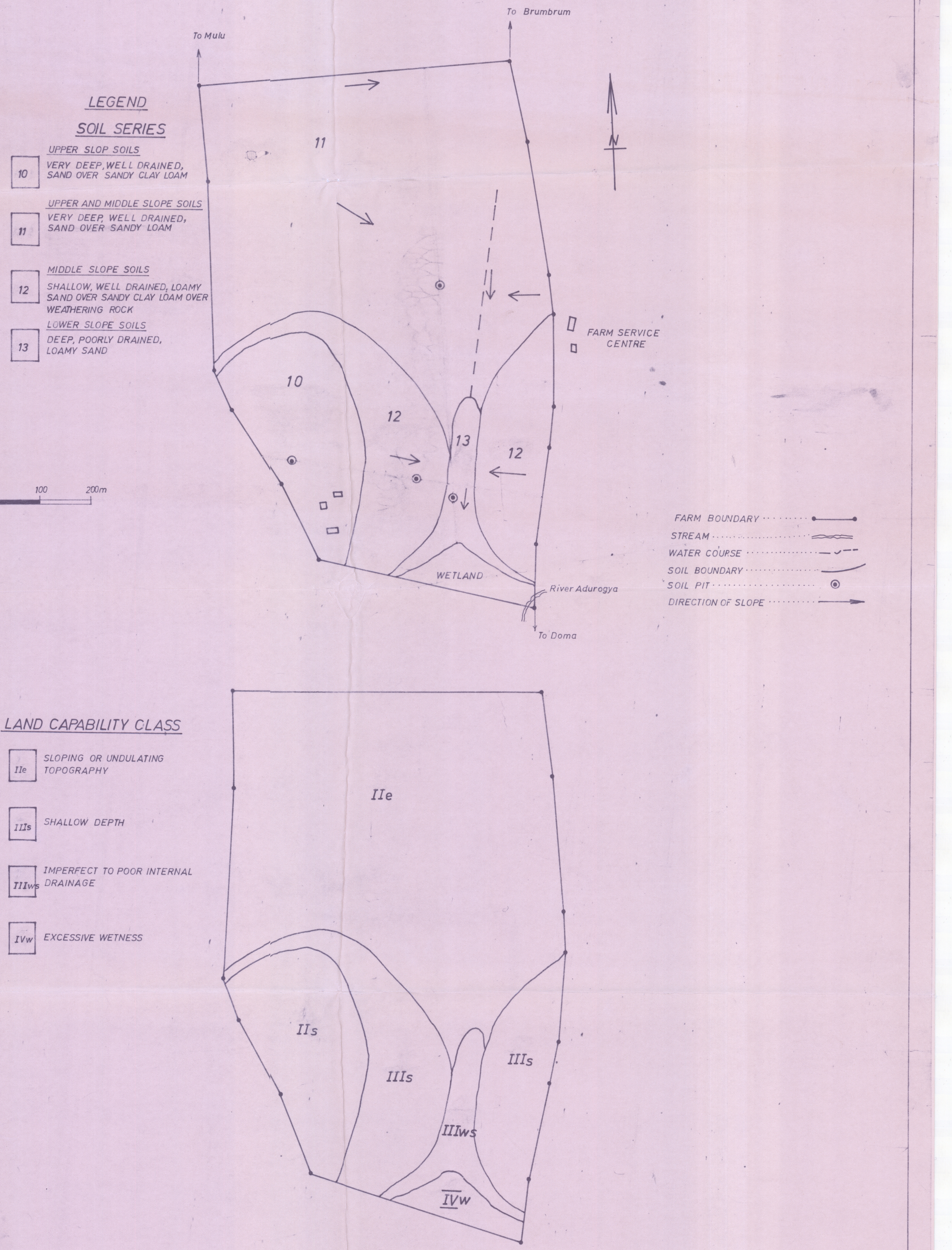
IIs — LOW INHERENT FERTILITY

IIw — HEAVY TEXTURES AND POOR INTERNAL DRAINAGE

IIIs — MODERATE TO SHALLOW DEPTH

DISTRICT DEMONSTRATION FARM
DOMA

MAP 3



DISTRICT DEMONSTRATION FARM
AWE

MAP 2

LEGEND

SOIL SERIES

UPPER SLOPE SOILS

5 — DEEP, IMPERFECTLY DRAINED, SANDY LOAM TO SANDY CLAY LOAM

7 — SHALLOW, IMPERFECTLY DRAINED, SANDY LOAM OVER IRONPAN OR IRONSTONE CONCRETIONS

MIDDLE SLOPE SOILS

6 — VERY DEEP, IMPERFECTLY DRAINED, SANDY CLAY LOAM TO SANDY CLAY

8 — DEEP, IMPERFECTLY DRAINED, CONCRETIONARY SANDY CLAY TO CLAY

MIDDLE AND LOWER SLOPE SOILS

9 — DEEP, IMPERFECTLY TO POORLY DRAINED, SANDY CLAY LOAM TO CLAY

ROAD .....
FARM BOUNDARY .....
STREAM .....
WATER COURSE .....
SOIL BOUNDARY .....
SOIL PIT .....
DIRECTION OF SLOPE .....

0 100 200m

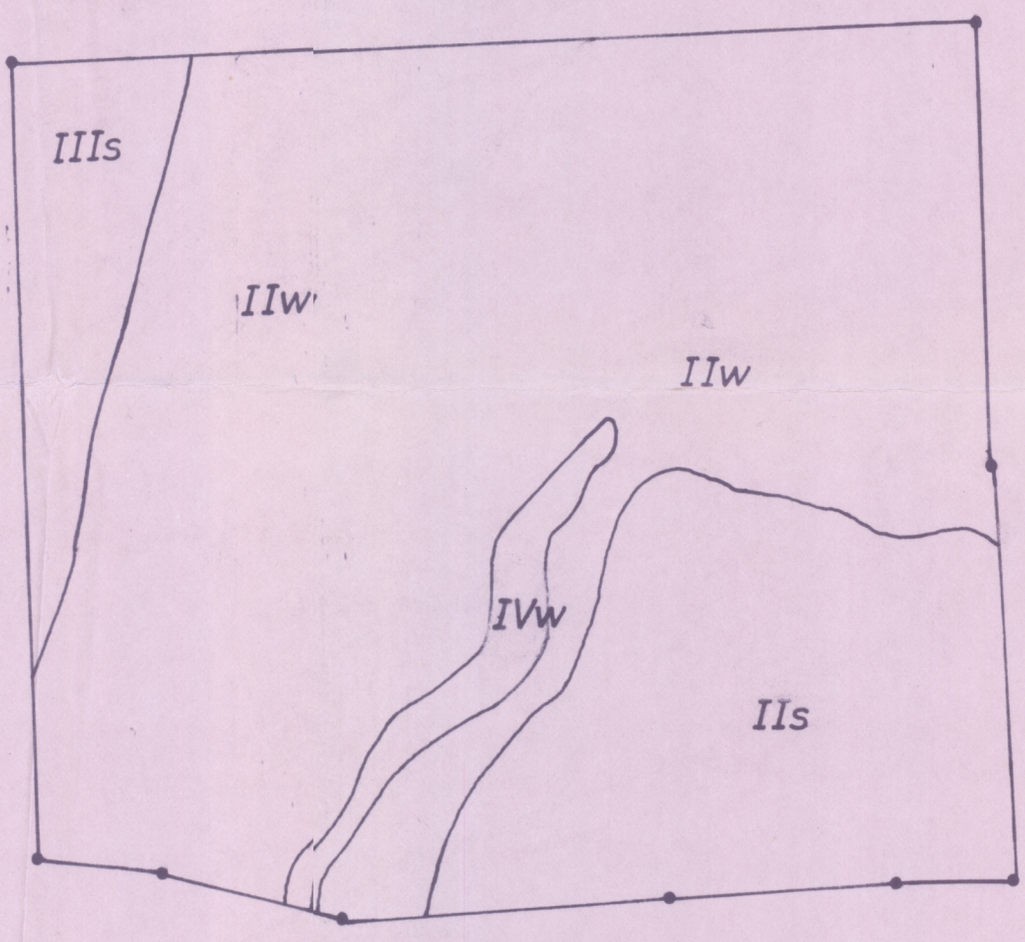
LAND CAPABILITY CLASS

IIs — LOW OR MODERATE WATER HOLDING CAPACITY

IIIs — SHALLOW DEPTH TO IRONPAN OR TO CONCRETIONS

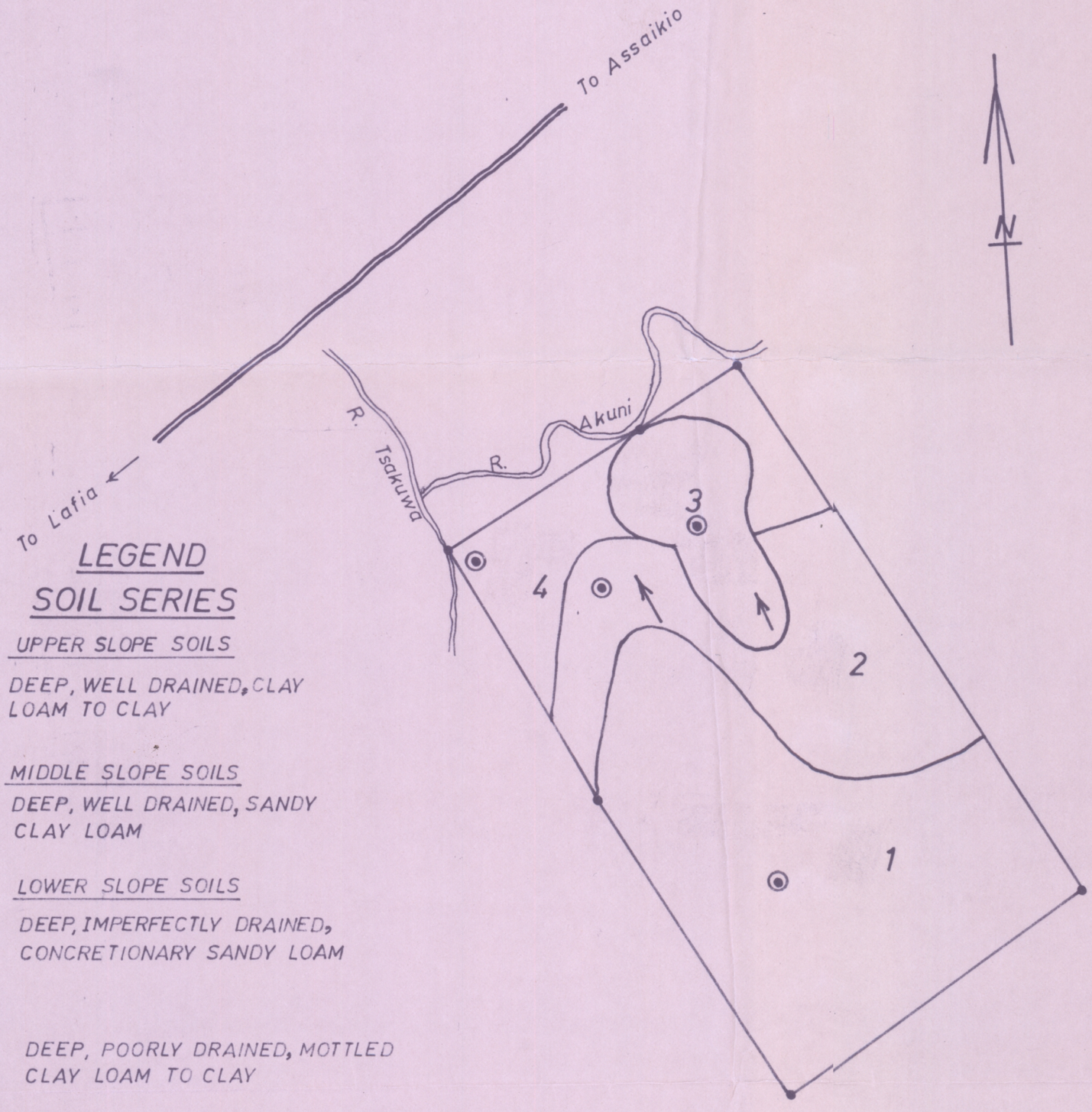
IIw — IMPERFECT TO POOR INTERNAL DRAINAGE

IVw — WETLANDS



DISTRICT DEMONSTRATION FARM ASSAIKIO (TSAKUWA)

MAP 1



LEGEND
SOIL SERIES

UPPER SLOPE SOILS

1 — DEEP, WELL DRAINED, CLAY LOAM TO CLAY

MIDDLE SLOPE SOILS

2 — DEEP, WELL DRAINED, SANDY CLAY LOAM

LOWER SLOPE SOILS

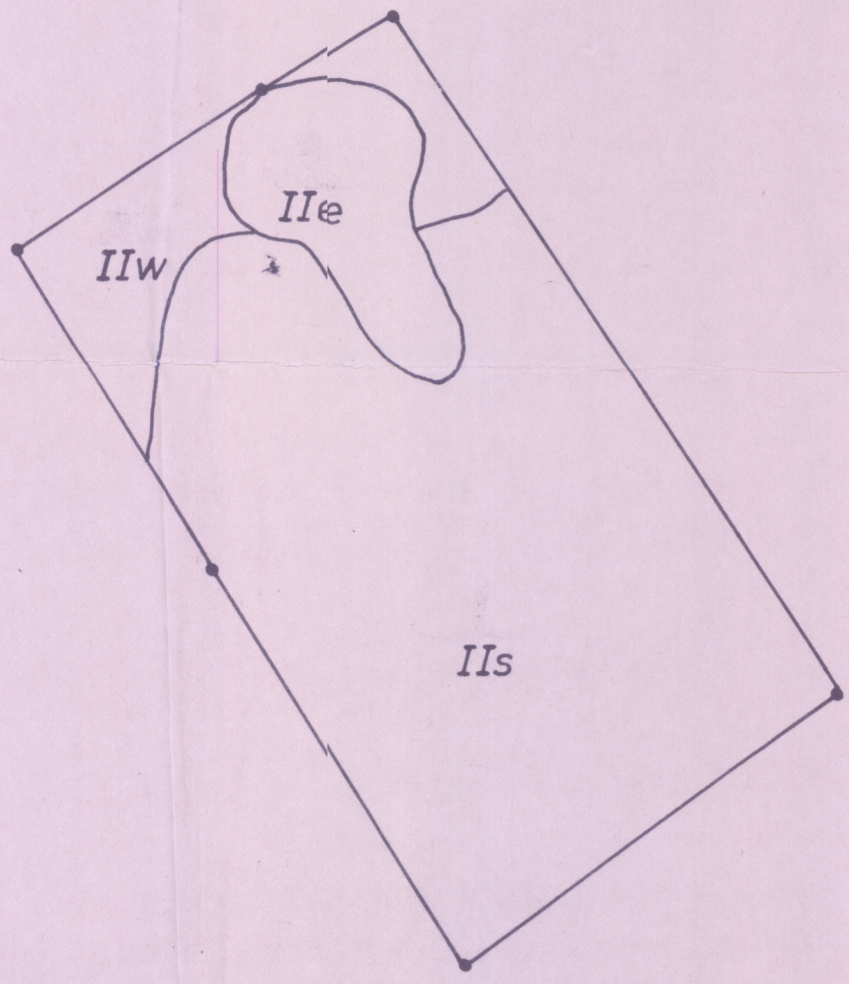
3 — DEEP, IMPERFECTLY DRAINED, CONCRETIONARY SANDY LOAM

4 — DEEP, POORLY DRAINED, MOTTLED CLAY LOAM TO CLAY

0 100 200m

ROAD
FARM BOUNDARY
STREAM
SOIL BOUNDARY
SOIL PIT
DIRECTION OF SLOPE

LAND CAPABILITY CLASS



IIs — LOW INHERENT FERTILITY

IIe — GRAVELLY OR STONY NATURE

IIw — IMPERFECT TO POOR INTERNAL DRAINAGE

28316-6
35 x 45

DISTRICT DEMONSTRATION FARM
OBI

MAP 6

LEGEND
SOIL SERIES

UPPER SLOPE SOILS

21 — DEEP, IMPERFECTLY DRAINED, MOTTLED SANDY CLAY LOAM TO CLAY

22 — VERY DEEP, IMPERFECTLY DRAINED, CLAY LOAM

MIDDLE SLOPE SOILS

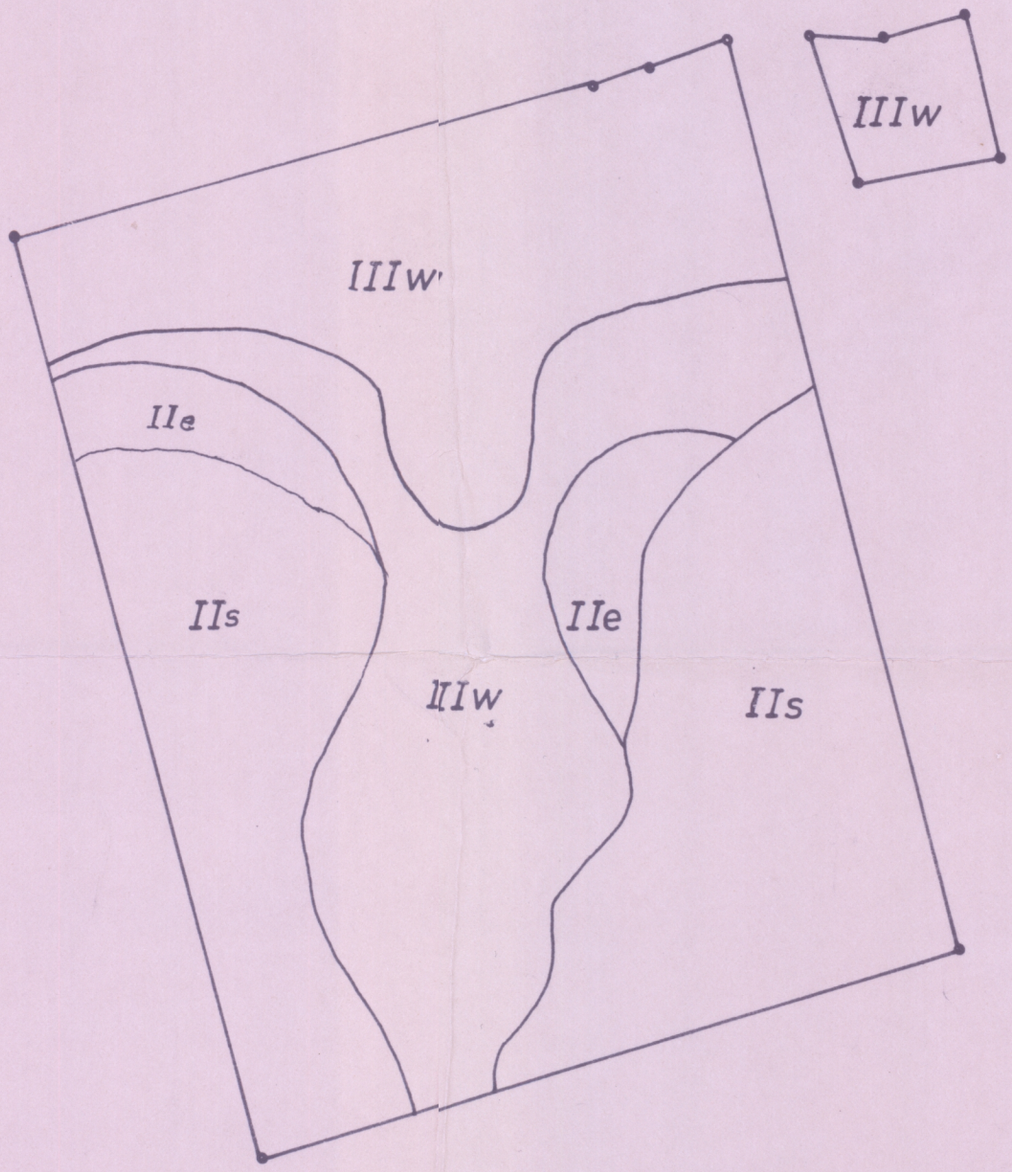
23 — DEEP, POORLY DRAINED, CLAY

LOWER SLOPE SOILS

24 — VERY DEEP, IMPERFECTLY DRAINED, CLAY

0 100 200m

LAND CAPABILITY CLASS



IIs — SOILS WITH IMPEDED DRAINAGE (CLAYS AND CLAY LOAMS)

IIe — GENTLY TO STEEPLY SLOPING CLAY SOILS SUBJECT TO EROSION

IIIw — POOR INTERNAL DRAINAGE

IIw — OCCASIONAL TO MODERATE OVERFLOW HAZARD