

SOIL SURVEY BULLETIN NO. 39

A RECONNAISSANCE SOIL SURVEY OF THE WASE-IBI AREA,  
PLATEAU AND BENUE PROVINCES, NIGERIA.

by

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## PART I. INTRODUCTION

### A. PURPOSE

This survey was carried out for the purpose of investigating the soils of the plains in the Plateau and Benue Provinces north of the Benue and determining the extent and distribution of the soil types encountered, so as to obtain fundamental data for assessing soil capabilities and land use. The work is part of the reconnaissance soil survey programme being undertaken throughout the northern states of Nigeria.

### B. PREVIOUS WORK

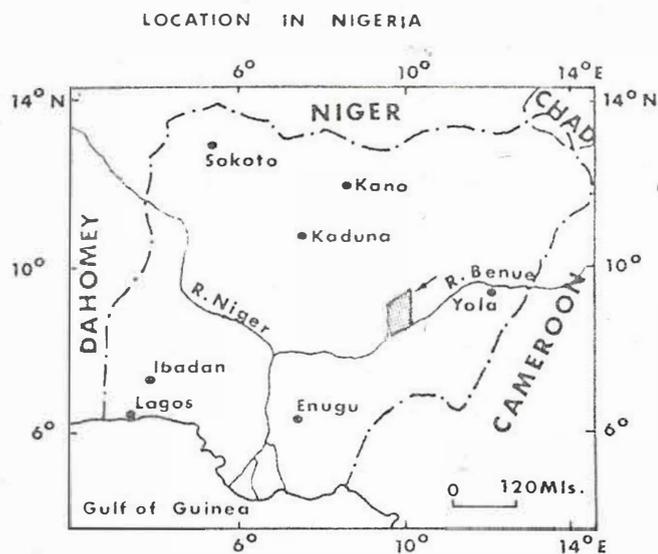
Clayton (1955) carried out an ecological survey of the Lowlands Experimental Farm, sited within the surveyed area, with the aim of correlating vegetation communities with known soil types. He extended this correlation to adjacent areas, making use of aerial photographs.

Tomlinson (unpublished report) investigated the soils of the Basement Complex located to the north of the area while Pullan (unpublished report) made a survey of the area south of the surveyed area and the Benue.

### C. LOCATION AND EXTENT

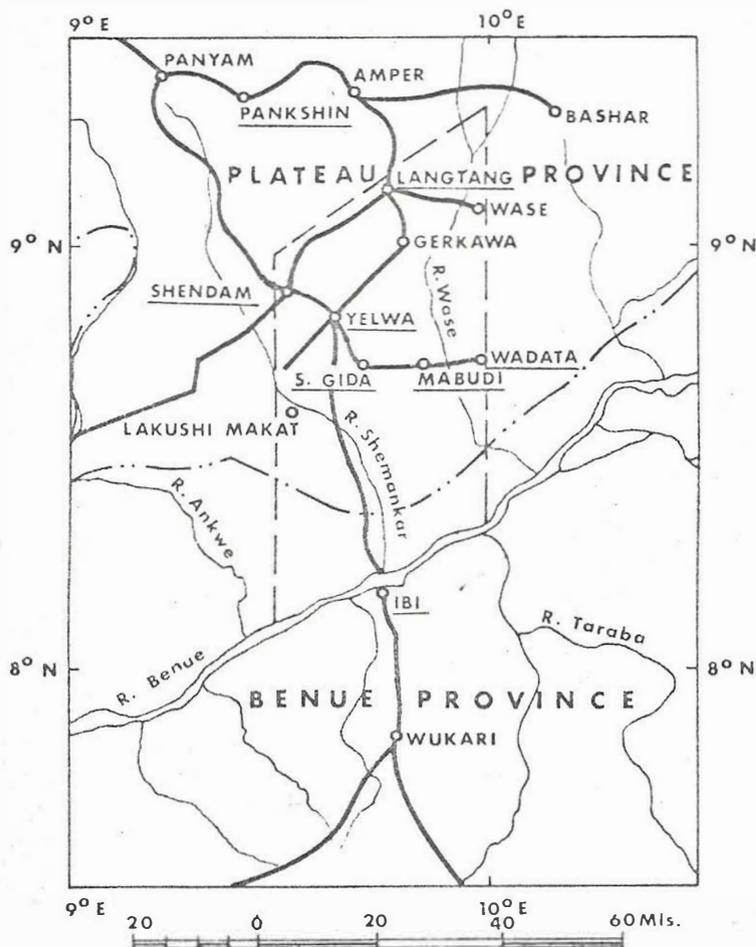
The location of the area is shown in Map 1. An all-season road connects Shendam, the most important town in the area, with Yelwa, Langtang, and Wase. A dry-season road links Yelwa with the north bank of the Benue opposite Ibi. Secondary roads interconnect the resettlement villages in the area (Map 2). The distance from Yelwa to Jos, the nearest large town is 120 miles.

MAP 1: LOCATION OF THE SURVEY AREA



(LOCATION OF THE SURVEY AREA IS INDICATED BY AN ARROW)

LOCATION IN PLATEAU AND BENUE PROVINCE



- TOWNS. . . . . ● ○
- ROADS. . . . . ———
- RIVERS. . . . . ~~~~~
- PROVINCIAL BOUNDARY. . . . . - - - - -
- BOUNDARY OF SURVEYED AREA. . . . . - · - · -

RAINFALL STATIONS UNDERLINED THUS "SHENDAM"

The surveyed area covers the greater part of Sheet 212 (Shendam) and a part of Sheet 191 (Wase) and Sheet 233 (Ibi) north of the River Benue.

D. STAFF

The survey was carried out in 1964 by two senior officers of the Soil Survey Section, Messrs. F.H. Hildebrand and J. Valette, assisted by 14 members of the technical staff of the Soil Survey Section. Both officers and three members of the technical staff arrived at Yelwa on 9th of February while the rest of the team arrived on 17th February. A labour force varying between 12 to 22 labourers were recruited at successive base camps which were set up at the following sites:

<u>Mr. J. Valette</u>	<u>Mr. F.H. Hildebrand</u>
9/2-7/3 Yelwa	9/2-4/3 Yelwa
8/3-21/3 Lakushi Makat	4/3-31/3 Mabudi
22/3-9/4 Gerkawa	1/4-7/4 Karkashi
10/3-18/4 Wase	8/4-12/4 Kuka
19/4-24/4 Yelwa	13/4-19/4 Shendam
	20/4-24/4 Gamnu

To speed up the survey, 4 technical staff were added to the team by early April. The team was back in Samaru on the 26th of the same month.

PART II. THE PHYSICAL ENVIRONMENT

A. CLIMATE

Rainfall data of stations within the area and those surrounding it are presented in Table 1. From these

Table 1: Mean monthly rainfall in Survey Area  
Records based on at least five years data from each station

Station	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total	
													inches	mm
Langtang	0.01	0.14	0.72	1.98	4.66	4.78	5.92	8.38	7.83	3.78	0.17	0.20	38.57	910
Pankshin	0.00	0.05	0.60	2.11	4.30	5.35	7.57	10.68	8.89	2.70	0.30	0.05	42.60	1,080
Wadata	0.00	0.17	0.61	3.25	4.39	7.05	6.34	8.53	9.20	3.49	0.68	0.17	43.88	1,110
Yelwa Insahar	0.00	0.00	0.76	2.67	5.43	8.22	4.83	7.85	7.62	5.01	0.14	0.00	42.53	1,050
Shendam D.O.	0.01	0.12	0.62	2.87	5.84	7.37	7.29	8.83	9.87	4.96	0.31	0.02	48.11	1,220
Sabon Gida	0.00	0.00	0.99	2.49	5.63	7.30	5.09	7.88	9.17	4.88	0.4	0.00	43.17	1,100
Lakushi Makat	0.00	0.04	0.76	3.72	5.06	7.01	6.20	9.11	9.49	4.19	0.25	0.10	45.93	1,160
Ibi Met.	0.05	0.19	1.17	3.52	6.48	7.18	5.47	6.31	8.66	5.42	0.42	0.19	45.06	1,140

	Altitude		Latitude	Longitude	Length of dry season
	ft	metres			
Langtang	-	-	9.45°	9.45°	5 months  See Map 1 for location of stations
Pankshin	-	-	9.20°	9.25°	
Wadata	600	183	8.45°	10.00°	
Yelwa Insahar	750	230	8.50°	9.37°	
Shendam D.O.	800	245	8.54°	9.28°	
Sabon Gida	550	168	8.40°	9.42°	
Lakushi Makat	500	152	8.35°	9.33°	
Ibi Met.	363	111	8.11°	9.45°	

records may be inferred that the annual rainfall is about 40 in. (1,040 mm) in the north and 45 in. (1,140 mm) in the south of the surveyed area.

The climate in the area is characterised by a single rainy season, which starts in April and ends in October and by high temperatures before the rains and a high humidity during a large part of the year.

#### B. GEOLOGY

The surveyed area is a part of the Benue Valley, which consists of broad and low platforms between 400 and 600 ft. These border the northern and southern escarpments which rise to upland plateaux at altitudes varying between 1,500 and 1,600 ft. The river is free from rapids and waterfalls which is due to the fact that it mainly flows over sedimentary rocks (Grove, 19 ).

The surveyed area is underlain by sedimentary rocks. The northern boundary coincides with the geological boundary between the sandstones and the rocks of the Basement Complex. It crosses the road from Shendam to Yelwa approximately halfway and runs in SW-NE direction, while slightly bending northwards. No geological information of the area is available and reference is made to the recent investigations of the comparable sandstone area between Gombe and Lau, located to the east of the surveyed area and extending into the latter. The sandstones underlying the surveyed area belong to the group of Bima Sandstones and Carter and al. (1963) explain their formation as follows:

"Sedimentation started late in the Upper Cretaceous. The oldest strata are a thick and widespread series of continental grits, sandstones and clays termed the Bima Sandstone which were laid down on an uneven surface of basement rocks and attained great thickness, especially in the Benue valley. Marine shales occur in the lower part of the formation. A widespread, shallow, marine transgression occurred during Turonian times, which persisted until the Maestrichtian. These marine conditions gradually gave way to deltaic and estuarine environments in which the Gombe Sandstone was deposited. A period of folding followed, resulting in the development of great anticlinal structures in the Cretaceous rocks. Sedimentation commenced in the Paleocene. The lowest members of the resistant grits and sandstones of the durable rocks of the Bima Sandstone forms the cores of the anticlines, while the overlying less resistant marine sediments are preserved in the synclinal troughs. In the early eocene intensive erosion of the land surface occurred resulting in the complete denudation of the Cretaceous Sediments over large areas. During the end-Tertiary a further uplift resulted in the sea and land levels which are found at present. The change in base level lead to the rejuvenation of rivers flowing into the sea such as the Benue." A simplified geological succession is shown below (Carter et al. 1963):-

Upper Cretaceous	{ Gombe Sandstone
	{ Marine Formations
	{ Bima Sandstone
Low Palaeozoic to Pre-Cambrian	Crystalline Basement

The sandstones were presumably derived from granitic terrain, constituting the crystalline basement north of the area surveyed. Cross-bedding is a ubiquitous feature of these sandstones, revealing fluvial or deltaic conditions during the deposition.

C. GEOMORPHOLOGY

The present landform is the result of many cycles of erosion and deposition which were lately accelerated by man's activities.

The sandstone rocks are more resistant than the shales and, wherever the latter occurs intercalated with the sandstones, gully erosion starts first on the shale bands giving rise to a parallel drainage pattern.

Surface and sub-surface lateritic ironpan which are of wide occurrence normally occur in situ in two situations. This was also observed by Jones in Sokoto, (1948).

- (1) As cappings on hills
- (2) As sheets on a plain.

Whenever blocks and or boulders of ironpan occur on hillsides or on level ground they are derived from higher lying areas or are remnants of an ancient ironpan.

A lateritic ironpan is best developed in shales and its development is promoted by the presence of an almost impermeable soil horizon situated not far below the soil surface. It will hold up the rainwater and retain it for sometime. Whenever this lateritic ironpan appears at the surface it retards erosion of the underlying rock (Jones,

1948). The lateritic ironstone, which was formed on the softer shales, originally occupied the lower lying parts of the terrain. In the process of landscape formation the resistant laterite capped shales become relatively elevated as compared with the surrounding less resistant sandstones (landscape inversion). In the case that the laterite-capped shales occupy a lower lying area (depression or valley bottom) the soils, overlying or accumulating on them from higher lying areas, tend to be carried away by accumulating run-off water as it unable to penetrate into the subsoil. Consequently the soils on the adjacent hillslopes become shallower to the valleys in contrast to the soils on sandstones which increase in depth towards the streams.

The occurrence of laterite capped hills and slightly elevated tablelands at concordant levels suggest that these are the remnants of an old erosion surface formed at an altitude of 350 ft in the south and rising to an altitude of approximately 800 ft in the north of the area. The landscape consisting of laterite capped hills and underlain by shales tend to be hilly. Undulating and level plains constitute the landscape consisting of soils over shales and underlain by secondary ironstone.

The surveyed area comprises two landscape regions: They are:-

Escarpment Region (E)<sup>\*</sup> - This consists of isolated hills and groups of hills in the north and west of the surveyed area.

Lowland Plain Region (L) - This consists of undulating or rolling terrain and occasionally

hilly terrain.

Floodplain Region (F) - This consists of level terrain comprising the floodplains and terraces along the main rivers. Depressions along streams are not included.

The present survey is mainly concerned with the Lowland Plain Region. It is subdivided into three Land Systems. Their location and extent are illustrated in Map 3.

#### LOWLAND PLAIN REGION (L)

Gerkawa Landsystem (LGe) - In the north of the surveyed area. Rolling and somewhat hilly terrain underlain by coarse grained sandstones. A number of volcanic plugs rise sharply from the plains. Altitudes vary between 750 and 850 ft.

Mabuui Landsystem (LMa) - In the centre of the surveyed area. Undulating to flat, but sometimes broken and somewhat hilly terrain with low scarps, mainly underlain by shales. Altitudes vary between 650 and 750 ft.

Fajul Landsystem (LFa) - In the south of the surveyed area. Undulating to rolling and occasionally broken terrain underlain by fine and medium sandstones alternated by shales bands. Altitudes vary between 350 and 650 ft.

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x The terms used in this report are explained in Appendix A.

#### D. WATER RESOURCES

The main rivers rising in the northern highlands, that is, the Wap, Shemankar and Wase cross the area and stream in approximately southerly direction. The Wase is seasonal and both others are perennial which is probably due to seepage from the Panyam basalts near the source.

Most parts of the area suffer from an acute shortage of water caused by the seasonal nature of the rainfall. Scarcity of water may be one of the main reasons for hampering the agricultural development of the area. In most cases water is obtained from tanks build on low sites near the villages and which filled up during the rainy season.

It was noticed that villages near the Wase obtained their water by digging holes to a depth of 2 to 3 ft in the dry coarse sandy riverbed. It therefore seems that even in the dry season a sub-surface flow is maintained. Wells were sunk to provide the villages with water, but many of the wells fail during the dry season. No information is available on groundwater in the area. The Bima Sandstones are known to possess considerable unconfined groundwater reservoirs.

### PART III. SOILS

#### A. SOIL CLASSIFICATION

The soils encountered in the area belong to three classes, that is, Raw Mineral Soils, Weakly Developed Soils, Ferruginous Tropical Soils and Hydromorphic Soils.

Each of these classes comprises one or more sub-classes, as shown in the legend of d'Hoore (Appendix B).

Raw Mineral Soils (1)<sup>+</sup>

Subclass: Ferruginous cuirasses (1a, ii).

Subclass: Rocks, not differentiated (1a, iii).

Weakly Developed Soils (2)

Soils with very weak differentiation of genetic horizons containing coarse elements and having solid rock within 12 in. depth.

Subclass: Lithosols on ferruginous crusts (2a, iii).

Subclass: Juvenile soils on riverine and lacustrine alluvium (2a, ii).

Ferruginous Tropical Soils (8)

Soils with an ABC profile of which some have an A<sub>2</sub> horizon and a textural B horizon showing blocky or weakly prismatic structure. Separation of iron oxides is indicated by mottling and concretions. Base saturation of the B horizon is higher than 40 per cent.

Subclass: Ferruginous tropical soils on sandy parent materials (8, i).

Hydromorphic Soils (12)

To this class belong all soils that have developed under conditions of a varying degree of wetness, which may be permanent or seasonal. The soils show marked

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+ Numerals refer to d'Hoore's legend (Appendix B)

evidence of water logging in the form of mottles and gleying around roots and root channels.

Subclass: Mineral Hydromorphic Soils (12, i).

In the following discussion the main attention will be given to the Ferruginous Tropical Soils. The Raw Mineral Soils and Weakly Developed Soils have little significance for farming and they are therefore only briefly mentioned. Mineral Hydromorphic Soils and Juvenile Soils are locally of wide occurrence. They will not be discussed.

#### THE SOIL ASSOCIATION

The soil pattern consisting of geographically associated soil series forms the soil association, which is the mapping unit employed in the survey. The location and extent of each soil association is illustrated in Map 4, and the series relationships within them are shown by the topographical cross-sections in Fig. 1, 2 and 3. The soil associations boundaries have been found to correspond with those of the Land Systems. The soil associations are discussed in Chapter III C.

#### THE SOIL SERIES

The series constitutes the lowest level of classification used in this report. The pedogenetic factors that have been selected in defining the series are in order of decreasing importance: Soil depth, texture, colour and mottling.

a) Soil depth is defined as the depth of the soil to bedrock or any other strongly contrasting non-conforming

rock material, including strongly cemented or indurated lateritic ironpan.

The following soil depth classes have been adopted:-

- (a) 0-12 in. very shallow
- (b) 12-36 in. shallow
- (c) 36-60 in. deep
- (d) > 60 in. very deep

b) Texture is defined according to the International System of Classification.

c) Soil Colour and Mottling to a certain measure reflect the drainage condition of the soil. An increase in grayish colours is usually accompanied by a tendency towards poorer drainage conditions and an increase in mottling. Soil colour and mottling are defined according to the Munsell Soil Colour Chart.

In the series definition soil texture and colour refer to the subsolum, that is, the body of soil between the topsoil and bedrock or any other non conforming rock material. The texture of the very deep soils in which the underlying rock material or ironpan lies well below 60 in. of the surface, is commonly taken as the part of the subsolum with the highest clay content, normally occurring between 2 and 5 ft of the surface. The soil series are described under the soil associations (Chapter III C).

## B. THE SOILS

Deep and very deep well drained soils are common on the coarse sandstones. Very shallow soils occur on hill-

tops and around the larger villages. The soils of the shales and fine sandstones tend to be shallow. Deep and very deep moderately mottled and concretionary soil may occur on lower and bottom pediments. They are partly formed by erosion and deposition from higher lying areas. Very deep soils occur on level terrain in the east of the surveyed area. The solum of the soils other than the very deep soils overlies moderately to strongly cemented lateritic ironpan or ferruginised weathering rock. The same material probably underlies the very deep soils.

Because erosion has affected most of the soils they tend to show a variation in texture over short distances. The soil texture as given in the series definition has therefore an average value. This in particular applies to the very shallow and shallow soils. The series are described in the following Chapter. A summary of the more important properties is given in Table 2.

### C. THE SOIL MAP

Prior to entering into the field an air photo interpretation was made of the area to be surveyed. The drainage pattern, major soil boundaries and other important features were indicated on the aerial photographs and transferred to a 1:100,000 standard sheet map. As no map of the area south of the Shendam sheet was available, a base map was constructed from aerial photographs. Both maps were reduced to a scale of 1:250,000. Most of the main and secondary roads were levelled and augered at convenient intervals and pits were dug at representative sites.

Table 2: Summary of main series characteristics.

Series Name	Phases	Depth	Colour (YR)	Texture	Mott.	CEC	BS	NNLC
<u>Gerkawa Association</u> - coarse to fine sand ratio is 3:1								
Kadi	G	very shallow	5/7.5	sandy loam to sand	-	25	50	IVS
Yashi	N	shallow	5/7.5	sandy loam	2C	30	50	IIIE
Kufai	N	deep	5/7.5	loamy sand	1A	35	50	IIe
Gerkawa	N	very deep	5/7.5	loamy sand	1A	35	60	I
Dongwan	N	very deep	10	sandy clay loam to sandy loam	2C	50	60	I
<u>Mabudi and Karkashi Associations</u> - coarse to fine sand ratio is about 1:1								
Chakai	GG	very shallow	7.5/10	sandy loam to sandy clay loam	-	-	-	IVS
Talbut	GG	shallow	10	clay loam to loam	3C	30	60	IIIS
Angwan	G	deep	10	sandy clay to sandy clay loam	2C	35	40	IIIW
Wall	G	very deep	5/7.5	loamy sand	2C	35	40	IIW
Timfun	N	very deep	5	sandy clay	2A	35	50	I
Wase	N	very deep	2.5/5	sandy clay loam to sandy loam	2C	15	80	IIW
<u>Karkashi Association</u> - coarse to fine sand ratio is 1:3 to 1:7								
Kadi	G	very shallow	10	loamy sand	-	-	-	IVS
Bolgan	NG	shallow	10	loamy sand to sandy loam	2C	40	50	IIIS
Kuka	N	deep	10	sandy clay loam	2C	30	50	IIe
Karkashi	N	very deep	10	sandy clay loam to sandy loam	1C	40	50	IIW

Mott: Mottles 1. Slightly mottled. 2. Moderately mottled. 3. Strongly mottled.  
A: Below 3 ft. B: Below 2 ft. C: Below 6-12 in. of the surface.  
C/F : Coarse to fine sand ratio.  
CEC : Cation Exchange Capability in meq/100 g clay.  
BS : Base Saturation Percentage.  
NNLC : Northern Nigeria Land Capability classes (Table 3).

Table 2 (contd.): Summary of main series characteristics.

Phase Symbols	N - normal	no gravel or stones
	GG - very gravelly	common or many gravels within 12. in. of the surface
	G - gravelly	common or many gravels from 12-36 in.

The soil association is the mapping unit used in this report. A subdivision into soil consociations is accepted. The following soil associations and soil consociations have been recognised. They are shown in Map 4.

Gerkawa Association	Ge
Mabudi Association	Ma
Mabu Consociation	Maa
Budi Consociation	Mab
Karkashi Association	Ka
Karka Consociation	Kaa
Kashi Consociation	Kab
Dutse Association	Du
Benue Association	Be

The Dutse and Benue Associations, corresponding with respectively the Escarpment Region and the Floodplain Region, and consisting of Raw Mineral Soils and Hydro-morphic Soils will not further be discussed.

A description of the soil associations and the definition of the series within each of the associations is given below.

#### The Gerkawa Association

Highly cultivated, rolling and occasionally hilly terrain. On hilltops erosion has stripped off the solum, leaving a thin layer of concretionary material overlying strongly cemented lateritic ironpan. The soils have a coarse sandy texture. Coarse sand to fine sand ratio is about 3:1. They are normally well drained and tend to be deep. In the western part of the association the terrain becomes somewhat more level and the soils more

shallow. Most of the older villages are located in this association. A schematic cross-section of the Gerkawa Association is given in Fig. 1.

#### Kadi Series

Very shallow, grey, sandy loam to sandy lithosol overlying lateritic ironpan on coarse sandstone.

The series occurs on slightly rounded and rounded hilltops. Average depth of the solum is 10 in.

#### Yashi Series

Shallow, reddish yellow to light brown (5/7.5 YR) sandy loam Ferruginous Tropical Soil, moderately mottled below one foot of the surface and overlying strongly cemented lateritic ironpan and/or ferruginised weathered coarse sandstone.

The series normally occurs on upper middle and upper slopes. Average depth of the solum is 30 in.

#### Kufai Series

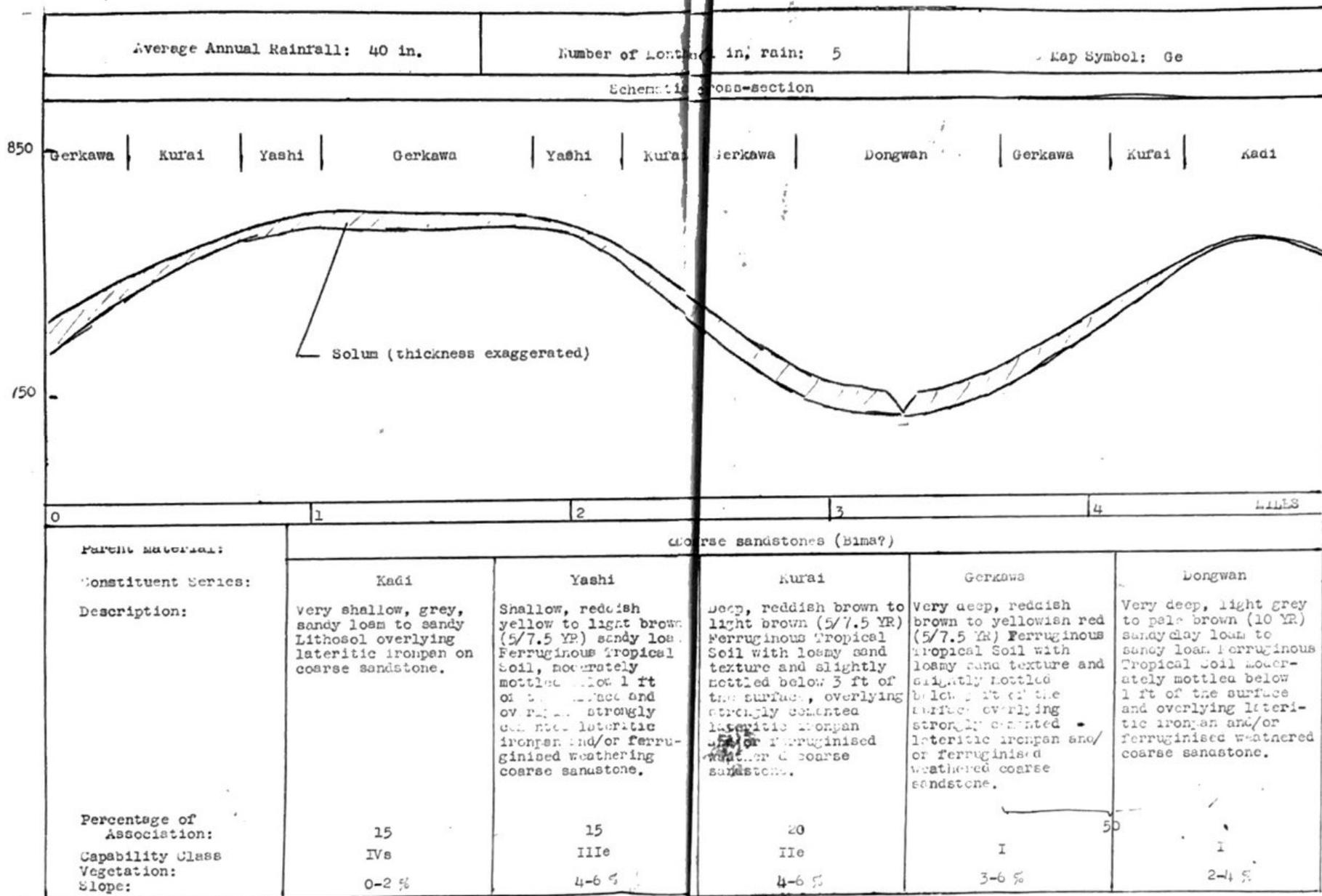
Deep, reddish brown to light brown (5/7.5 YR), Ferruginous Tropical Soil with loamy sand texture and slightly mottled below three feet of the surface, overlying strongly cemented lateritic ironpan and/or ferruginised weathered coarse sandstone.

The series mainly occurs on middle slopes. Average depth is 50 in.

#### Gerkawa Series

Very deep, reddish brown to yellowish red (5/7.5 YR)

Survey Area: Wase-ibi  
Gerkawa Association.



Ferruginous Tropical Soil with loamy sand texture and slightly mottled below 3 ft of the surface.

The series occurs mainly on lower slopes, but may also occupy level hilltops where erosion is negligible and drainage is somewhat impeded. Average thickness is 70 in.

#### Dongwan Series

Very deep, light grey to pale brown (10 YR), sandy clay loam to sandy loam Ferruginous Tropical Soil moderately mottled below one foot of the surface.

The series occurs mainly on bottom slopes and the flatter parts of the area bordering rivers. Average thickness of the solum is 60 in.

#### The Mabudi Association

Moderately cultivated, undulating to flat, but sometimes broken and hilly terrain underlain by shales and intercalated with fine sandstones. The solum of the soils formed on the shales overly variably cemented and strongly mottled lateritic ironpan. The solum of those formed on fine sandstones normally overly strongly ferruginised and hardened weathered rock.

On the whole the soils of this association have a fine texture, but the sandy nature seems to increase to the east. They tend to be shallow and the solum usually contains various amounts of gravel which often consists of concretionary material. Because of the shallow nature of the soils they are particularly vulnerable to sheet erosion as the difficultly permeable sub-soil holds up the

water leading to a rapid saturation of the solum. Excess rainwater then tends to flow at the surface carrying soil particles with it.

Deep and very deep soils normally occur on lower and bottom slopes of pediments which slope away from slightly elevated table lands and other higher lying terrain. Coarse to fine sand ratio is about 1:1.

In the northeast the Mabudi Association borders on the Basement Complex. A schematic cross-section of the Mabudi Association is given in Fig. 2.

The following series have been recognised: Chakai, Talbut, Angwan, Wali, Timfun and Wase. Their relationship within the association is shown schematically in Fig. 2.

Chakai Series (very gravelly phase)

Very shallow, brown to yellowish brown (7.5/10 YR) clay to sandy clay loam lithosol overlying strongly cemented lateritic ironpan on shales.

The series occurs on slightly rounded hilltops or ridge crests or level terrain.

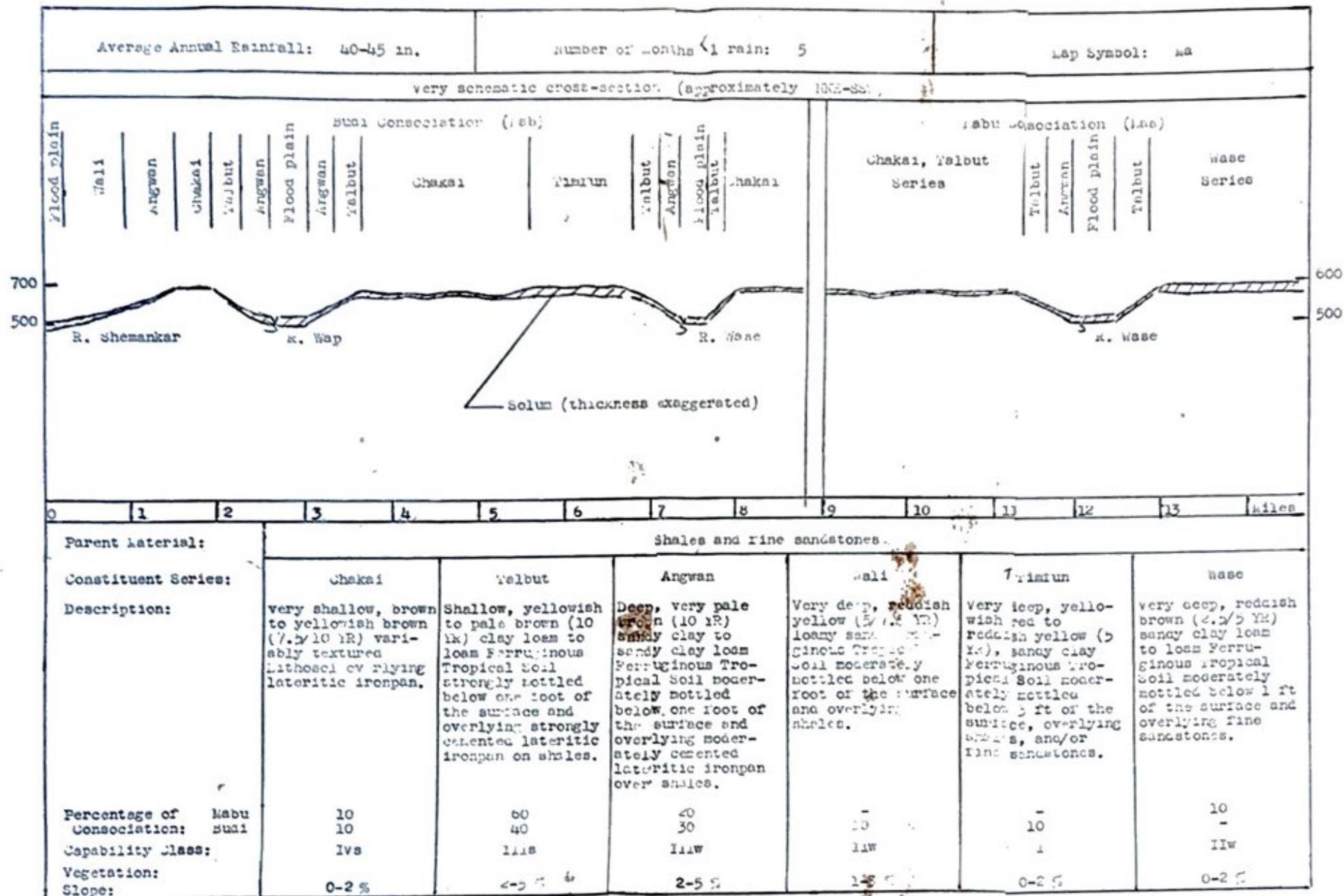
Talbut Series (very gravelly phase)

Shallow, yellowish to pale brown (10 YR) clay loam to loam Ferruginous Tropical Soil strongly mottled below one foot of the surface and overlying strongly cemented lateritic ironpan on shales.

The series occurs on upper slopes. The depth of the solum is very variable.

Survey Area: Yellow

Soil Association.



Angwan Series (gravelly phase)

Deep, very pale brown (10 YR) sandy clay to sandy clay loam Ferruginous Tropical Soil moderately mottled below one foot of the surface and overlying moderately cemented lateritic ironpan over shales.

The series occurs mainly on middle slopes.

Wali Series (gravelly phase)

Very deep, reddish yellow (5/7.5 YR) loamy sand Ferruginous Tropical Soil moderately mottled below one foot of the surface and overlying shales.

The series occurs on lower middle, lower and bottom slopes. It is mainly formed by erosion and deposition of sandy material from higher lying areas and elimination of the finer material.

Timfun Series (normal phase)

Very deep, yellowish red to reddish yellow (5 YR), sandy clay Ferruginous Tropical Soil moderately mottled below 3 ft of the surface, overlying shales or fine sandstones.

The series occurs on almost level terrain.

Wase Series (normal phase)

Very deep, reddish brown (2.5/5 YR) sandy clay loam to sandy loam Ferruginous Tropical Soil moderately mottled below one foot of the surface and overlying fine sandstones.

The series occurs mainly on level or gently sloping terrain.

The Mabudi Association is subdivided into two consociations. Their differentiation is based on the series distribution within each consociation.

#### Mabu Consociation (Maa)

Moderately cultivated, undulating and occasionally hilly terrain. This consociation is presumedly a transition between the soils formed on coarse sandstones in the north and those formed on shales and fine sandstones in the south of the surveyed area. West of the River Wase the soils are predominantly formed on shales and fine sandstones, whereas the amount of coarse material in the soils tend to increase to the east.

Very shallow and shallow soils (Chakai, Talbut Series) predominate in the west of the consociation. Deep soils (Angwan Series) may occur in the moderately sloping area west of the River Wase, while very deep soils (Wase Series) seem to be common in the east of this river, where the terrain tends to be level.

#### Budi Consociation (Mab)

Moderately cultivated, undulating to level terrain overlying shales mainly. The amount of fine sandy material in the soils tend to increase to the east.

Deep and very deep strongly mottled soils occur in the western part of the sub-unit (Angwan, Wali Series); the central part and the part east of the River Wase consist mainly of very shallow and shallow soils (Chakai, Talbut Series). Very deep, slightly mottled and well drained soils over incipient lateritic ironpan (Timfun Series) were found in the Talgwan-Timfun-Dadin Kowa area about northeast of

Mabudi. The sandy feeling and red colour of these soils is presumably due to the aggregation and binding of the clay particles by iron compounds (pseudo-sand formation) which dissolved from the old and more extended erosion surface of which at present only parts are left. These occur as "floating" boulders in the upper soil.

#### The Karkashi Association

Undulating to rolling and occasionally hilly terrain underlain by fine sandstones intercalated with shale bands.

The soils of this association have a fine sandy texture. Coarse to fine sand ratio varies between 1:3 and 1:7. The soils tend to be shallow and the solum normally overlies variably ferruginised and hardened weathering rock or lateritic ironpan.

Parts of the association is occupied by soils formed on clayey material. The clayey nature of these soils may be due to differential erosion along planes of weakness in the parent material, whereby the clay content in the soils is increased, giving it a heavier consistence and thus making it comparable in characteristics to soils formed on shales. The solum, which contains a fair amount of iron concretions, is moderately mottled and it is normally underlain by a weakly to moderately cemented lateritic ironpan.

The following series have been recognised: <sup>Kadi</sup> ~~Yamini~~, Bolgan, Kuka and Karkashi. Their relationship within the association is shown schematically in Fig. 3.

Kadi Series (gravelly phase)

Very shallow, pale brown to yellowish brown (10 YR)

loamy sand lithosol overlying ferruginised fine sandstone and/or strongly cemented lateritic ironpan.

The series occurs on hilltops and stretches or low lying areas underlain by shales or it occupies level areas where the soil is enriched in clayey material.

Bolgan Series (normal and gravelly phases)

Shallow, pale brown to yellowish brown (10 YR) loamy sand to sandy loam Ferruginous Tropical Soil moderately mottled below one foot of the surface and overlying ferruginised fine sandstone and/or strongly cemented lateritic ironpan.

The series normally occurs on upper and middle slopes.

Kuka Series (normal phase)

Deep, pale brown to grey brown (10 YR) sandy clay loam Ferruginous Tropical Soil moderately mottled below one foot of the surface and overlying ferruginised fine sandstones and/or moderately cemented lateritic ironpan.

The series occurs on middle and lower slopes but may also occupy upper slopes or level areas.

Karkashi Series (normal phase)

Very deep, pale brown to pinkish brown (10 YR) sandy clay loam to sandy loam Ferruginous Tropical Soil slightly mottled below one foot of the surface and overlying ferruginised fine sandstone and/or moderately cemented lateritic ironpan.

The series normally occurs on lower and bottom slopes,

but may also occupy hilltops. East of the River Wase in Wadata area it occurs on level terrain.

Within the Karkashi Association two consociations have been recognised. A schematic cross-section of this association is shown in Fig. 3.

#### Karka Consociation (Kaa)

Level to undulating terrain with very shallow and shallow soils (Kadi, Bolgan Series) over fine sandstones. Deep and very deep soils (Kuka, Karkashi Series) occur in the northeastern part of the consociation.

#### Kashi Consociation (Kab)

Rolling and somewhat dissected terrain with predominantly very shallow and shallow soils (Chakai, Talbut Series) on fine sandstones with a higher amount of fine (clay) material than in the soils of Consociation Kaa. Deep soils occupy small patches of more level terrain (Angwan Series, not indicated in Fig. 3).

### PART IV. PRESENT AND PROPOSED LAND USE

#### A. PRESENT LAND USE

The Gerkawa Association, of which the soils tend to be very deep, is intensively cultivated and most of the old villages are therefore located in the northern part of the area, whereas the newer villages were set up on the shales (Mabuđi Association) as these appear to be more fertile than the fine sandstone soils further to the south (Karkashi Association), which are practically un-

Fig. 3...

Soil Area: Wase-Ibi

Karkashi Association

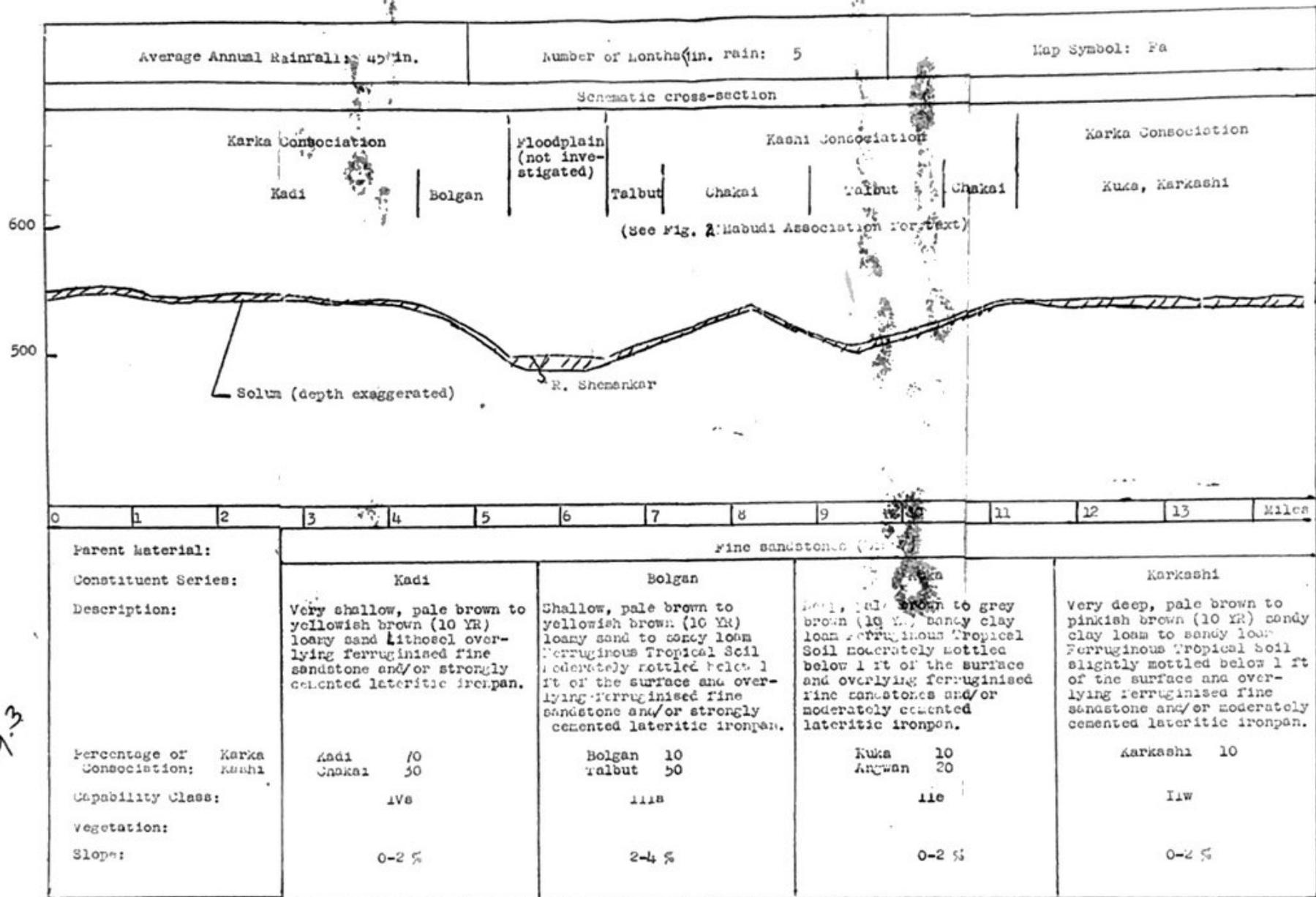


Fig. 3

inhabited. The reason may be due to historical factors, such as the expansion of the Jukun Empire and that of the Fulani during the last century. Further obstacles to resettlement are the density of the savanna woodland, the large areas of wet season land and the scarcity of water during the dry season (Grove, 19 ). The local movement of people from the over populated areas in the highland north of the surveyed area to the plains has in recent years caused shifting cultivation in the plains resulting in soil deterioration as erosion takes place readily where the natural vegetation is removed to clear the ground for farming. The soils of the Mabudi Association are moderately cultivated; cultivation is more intense in the area northeast of Mabudi where the soils tend to be very deep. The part of the Fajul Association consisting of shallow soils on fine sandstones is slightly cultivated; cultivation seems to increase in the southeast of the area and in localities where the soils are somewhat heavier and deeper.

In the surveyed area the Shendam Agricultural Development and Resettlement Scheme is situated. The objects of the scheme are:

- a) To save, by the establishment of clearly defined Resettlement areas, the large fertile expanses of uninhabited land, that lie in the Southern part of this Division, and to prevent uncontrolled immigration, with its resultant shifting cultivation.
- b) To settle within these areas, families from the escarpment and hill lands, where the fertility

of the soil is low, and where the existing population are finding it increasingly difficult to maintain a minimum standard of living.

- c) To encourage, and if necessary to enforce, improved agricultural practice, such as rotation of crops, mixed farming and soil conservation, etc.

The scheme was started in 1948 by Lowland Division Native Authority, and was established as Northern Region Development Corporation Project in 1950, which provided funds for the development of the scheme.

The scheme has included the construction of a new road system which is connected with the Jos road. In the Shemankar and Ajikemai river valley small scale experiments in mechanical rice production are being carried out.

Associated with the resettlement scheme is the Lowlands Experimental Farm, which lies 18 miles south of Shendam and 10 miles south of Yelwa.

## B. SOIL CAPABILITIES

To assess soil capabilities a system of capability classification is used which is based upon the United States Department of Agriculture Soil Conservation System and adjusted to Ghanaian environments. The figures indicating the capability classes in Table 3 (column 5) refer to the proposed land capability classification now in use in Northern Nigeria and shown in Table 4. The figures showing the percentage of each of the associations covered by the constituent series must be regarded as very approximate.

Table 3: Soil associations and capability classes of constituent series

Association and Consociation	Parent Rock.	Land Form	Constituent Series	Capability Classes	Percentage of Association	Topographic Position
Gerkawa (Ge)	coarse sandstone	rolling	Kadi	IVs	15	Rounded hilltops and ridge crests
			Yashi	IIIe	15	Upper-middle and upper slopes
			Kufai	Ile	20	Middle slopes
			Gerkawa Dongwan	I ) I )	50	Lower slopes, level hill-tops Bottom Slopes
Mabudi (Ma) Mabu (Maa)	mainly shales, sandier to east	undulating	Chakai	IVs	10	Slightly rounded or level terrain
			Talbut	IIIs	60	Upper slopes
			Angwan Wase	IIIw IIw	20 10	Middle slopes Level or gently sloping terrain
Budi (Mab)	Shales and free sandstone, more coarse sand to east	undulating to level	Chakai	IVs	10	Slightly rounded or level terrain
			Talbut	IIIs	40	Upper slopes
			Angwan	IIIw	30	Middle slopes
			Wali Tunfun	IIw I	10 10	Middle and lower slopes Level terrain
Karkashi (Ka) Karka (Kaa)	fine sandstones	level to undulating terrain	Kadi	IVs	70	Hilltops and level terrain
			Bolgan	IIIs	10	Upper and middles slopes
			Kuka	Ile	10	Middle and lower slopes, but also on level terrain
			Karkashi	IIw	10	Lower and bottom slopes, but also on level terrain
Kashi (Kab)	fine sandstones and shales	rolling terrain somewhat dissected	Chakai	IVs	30	Round hilltops and ridge crests
			Talbut Angwan	IIIs IIIw	50 20	Upper slopes Middle and lower slopes

### C. PROPOSED LAND USE

Natural erosion which maintains a balance between weathering, erosion and deposition, is the main contributory factor in building up the soil. In contrast soil erosion or accelerated natural erosion is responsible for removal and deterioration of the soil. With the high rainfall in the wet season the soil, stripped of its vegetation and often cultivated, is particularly sensitive to erosion and when accelerated to excess erosion can destroy in a single season an area of which the solum has taken a long time to build up. An understanding of soil erosion processes is therefore important in sound land use planning.

The most important internal factor promoting soil erosion is the formation of an impermeable layer in the soil. Depending on its depth below the soil surface it will prevent rainwater from penetrating into the deeper layers of the soil. Excess rainwater tend to flow at the surface carrying soil particle with it. Once this is started it proceeds with increasing rapidity and eventually the land is replaced by a bare surface. Rainfall is an external factor and its effect consists of beating and loosening the soil. Both these factors, single but mostly is combination, lead to the loss of fertility and structure of the soil. Maintaining these would therefore consist of measures to protect the soil against raindrop impact and preventing the formation of an impermeable layer in the soil. The former would include mulching, the use of organic manure and cultivation along the contours. The prevention of an impermeable layer in the subsoil means improving subsoil structure. This involves drainage and

deep cultivation to prevent the formation of the impermeable layer or to break it up once it is formed.

The improvement of fallow and the use of livestock should also be considered. Farming practices which lead to increased soil erosion like the construction of mounds should be discouraged and conservation farming techniques adopted.

On the whole the porous and open texture of the soils formed on the coarse sandstones (Gerkawa Association) are able to adsorb a fair proportion of the rainwater and erosion is therefore not making rapid progress.

Fine sandy and silty soils, when deprived of organic matter, seem particularly prone to pack and trade (Brian Wills, 1962). On the shales and fine sandstones cultivation has led to gully and sheet erosion and the accumulation of concretionary material in the solum. Because of the lower permeability of these soils greater care is made in the accurate alignment of drainage (or irrigation) furrows than in the soils on the coarse sandstones (Brian Wills, 1962).

#### D. SUMMARY

A soil survey of an area of 2,000 square miles located south of the Jos Plateau and north of the River Benue, in Plateau and Benue Provinces, was carried out to determine the extent and distribution of the soil types in order to assess their suitability for agricultural use. This area comprises rolling terrain on coarse sandstones in the north and gently undulating terrain on shales and fine sandstones in the centre and south.

The sedimentary rocks are reckoned to belong to the group of Bima Sandstones. Rainfall varies between 40 in. (1,040 mm) in the north and 45 in. (1,140 mm) in the south of the surveyed area.

The soils on the shales are affected by waterlogging due to a low permeability. The colour of these soils is greyish and mottling occurs in the lower horizons. Up-slope there may be <sup>an</sup> accumulation of coarser material on account of the finer material being washed away. The soils have usually been affected by process of lateritisation. The lateritic horizon is either heavily mottled and contains variably cemented iron concretions.

The soils formed on the shales and fine sandstones tend to be shallow and the subsoil normally consists of a lateritic ironpan or ferruginised weathering rock. The shallow soils are particularly vulnerable to sheet erosion as the difficulty permeable subsoil hold up the water whereby the solum soon is saturated. Excess rainwater tend to flow at the surface carrying soil particles with it. This process if ones started proceeds with increasing rapidity and eventually the land is replaced by a bare surface.

Deep, well drained and slightly mottled soils occur on the coarse sandstones. Deep and very deep soils occur in localities further to the south. They are mainly formed by transport and deposition from higher lying areas. Very deep, strongly mottled and seasonally <sup>undated</sup> ~~incubated~~ soils occupy the floodplains along the major rivers. These have not been investigated.

The soils have been grouped into the class of Ferruginous Tropical Soils. A fair number of samples however tend to show characteristics of Ferrisols. On the whole the soils on the coarse and fine sandstone in the north of the area are more favourable for farming than those in the central and southern part. They are intensively cultivated.

Soil erosion is the most important factor leading to soil degradation and in view of the increasing population pressure the maintenance of soil fertility and structure is of prime importance. Soil conservation should consist of protecting the soil against raindrop impact and preventing the formation of a compacted horizon in the soil, e.g. by mulching, application of organic matter to improve tilth, drainage and deep cultivation to prevent the formation of the impermeable layer or to break it up once it has been formed.

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Appendix A.

GLOSSARY OF TERMS

Base-saturation percentage - The extent to which the adsorption complex of a soil is saturated with exchangeable cations other than hydrogen. It is expressed as a percentage of the total cation exchange capacity. 1)<sup>x</sup>

Erosion cycle - The hypothetical sequence of changes or stages through which a land surface would pass in its reduction to base level by the process of soil erosion. 6)

Erosion surface - A landform planned by an erosional process, e.g. peneplanation. 6)

Landscape (geomorphological) region - A defined portion of the earth surface, as distinguished from other landscapes by contrasting physiographic features (e.g. plains versus hills) or altitude (e.g. lowland versus highlands). The division of an area into landscape regions has practical implications for agricultural systems as these should be adjusted to specific factors prevailing in each of the regions. Four geomorphological regions can be recognised:

- (a) Highland Region - Undulating rolling highland plateaux over 2,000 ft. Cool climate and high precipitation as compared with the lowlands.

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x) Numerals refer to the references.

- (b) Escarpment Region - Dissected or hilly terrain at widely variable altitudes. Serious erosion hazard and variable precipitation.
- (c) Lowland Region - Undulating, rolling and occasionally hilly terrain below 2,000 ft. Warm climate and less precipitation as compared to the highlands.
- (d) Floodplain Region - Flat terrain consisting of alluvial plains along the major rivers, normally at low levels. Waterlogging or flooding or both.

Landscape (geomorphic) System or Land System - A subdivision of the Landscape Region. Its recognition is based on a combination and recurrence of patterns of topography, soils and vegetation. The boundaries of a landscape system normally correspond with those of the soil association.

Lateritic ironpan - Used in the same sense as the term laterite proposed by Du Preez (1949) and defined by him as "a vesicular, concretionary, cellular, vermicular, slaglike, pisolithic and concrete-like mass consisting chiefly of ferric iron oxides with or without mechanically entangled quartz and minor quantities of alumina and manganese; it is of varying hardness but it is usually easily scattered when struck a sharp blow with a hammer. 3)

Lowland(s) - Low and relatively level land at a lower elevation than adjoining, hilly or mountainous areas.

Mottling (mottled) - Spots or blotches of different colour or shades of colour. 1)

Pediment (washslope) - Gently or moderately sloping plain with or without detritus that borders hills and ridges.

pH - The negative logarithm of the hydrogen-ion activity of a soil. The degree of acidity (or alkalinity) of a soil as determined by means of glass, quinhydrone, or other suitable electrode or indicator or a specified moisture content or soil-water ratio, and expressed in terms of the pH scale. 1)

Plain - An extensive area of level, rolling or undulating land, usually of low altitude. 4)

Plateau - An extensive level or mainly level area of elevated land. 4)

Soil - The unconsolidated mineral material on the immediate surface of the earth that serves as a natural medium for the growth of plants. 1)

Soil association - A group of defined and named taxonomic soil units occurring together in an individual and characteristic pattern over a geographic region, comparable to plant associations in many ways. 1)

Soil Consociation - The constituent parts of a soil association are provisionally called soil consociations. They have identical soils, but these occur in different proportions.

Soil horizon - Soil layer with features produced by soil-forming processes. 2)

A horizon - The uppermost layer of soil profile where accumulation of organic matter and eluviation commonly occur.

B horizon - Part of the soil profile below the A horizon;  
usually illuvial.

Soil phase - A variation in content of stones and/or  
gravel within the series. 1)

Soil profile (pit) - A vertical section of the soil through  
all its horizons and extending into the parent material.  
1)

Soil series - The basic unit of soil classification being  
a sub-division of a family and consisting of soils  
which are essentially alike in all major profile  
characteristics except the texture of the A-horizon. 1)

Soil texture - The relative proportions of the various  
soil separates in a soil as described by the classes  
of soil-texture described in the figure below. 5)

1. Clay
2. Silt clay
3. Silty clay loam
4. Silt loam
5. Silt
6. Sandy clay
7. Clay loam
8. Sandy clay loam
9. Loam
10. Sandy loam
11. Loamy sand
12. Sand

Solum - The upper and most weathered part of the soil  
profile; the A- and B-horizons. 1)

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## Appendix

DESCRIPTION OF AUGERLINES

Soil Survey Report No. 39 - Wase-Ibi Area

(Location of augerlines and profile pits, which were sampled and analysed, are shown on Map 3).

Number and Location of Augerlines	Serial No. of profile pits x)
WI 1 Inshar Rest House - Gerkawa-Wase	1, 2, 7, 10, 11, 15, 22, 23, 26, 27, 28, 29, 30
WI 2 Inshar Rest House - Inshar	36
WI 3 Inshar - Shemankar - Yamini	40, 41, 44, 47
WI 4 Inshar - Sabon Gida - Dorowa - Takalafia	53, 54
WI 5 Inshar - Shendam	65
WI 6 Inshar - Lakushi Makat	66, 67, 76, 79, 80, 81, 82, 83, 84, 85, 87
WI 7 Sabon Gida - Mabudi - Wadata (SG1)	90, 95, 97, 98, 99, 100, 102
WI 8 Mabudi - Gerkawa (G1)	107, 110, 113
WI 9 Nagane - Gamakai-Takalaria (M1)	115, 116, 118
WI 10 Junction near Zamban to Fajui (M2)	
WI 11 Northsouth Forest trace approx. 2 miles from Sabon Gida on the road to Mabudi and pits along road to Timbol.	121, 122, 123
WI 12 Road junction near Dorowa-Karkashi (T1)	124, 125, 128, 129, 130, 132
WI 13 Karkashi in direction of (TT1) Nasarawa	133, 134
WI 14 Karkashi - Magama (K1)	138
WI 15 Karkashi in direction of Magama (KK5) (repeated)	140
WI 16 Magama - Gidan Bowa (KM1)	143
WI 17 Riyam in direction of Gidan Bowa along footpath (R1)	144, 145, 146, 147
WI 18 Riyam along road to Sarkin Kudu (R2)	
WI 19 Riyam - Kuka - Yamini (R3)	
WI 20 Wase - Wadata (W)	168, 169, 172
WI 21 Gerkawa - Wase (SW)	174, 175, 176, 183, 184, 185, 186, 189

x) See Shendam file containing profile descriptions and analyses.

## Appendix

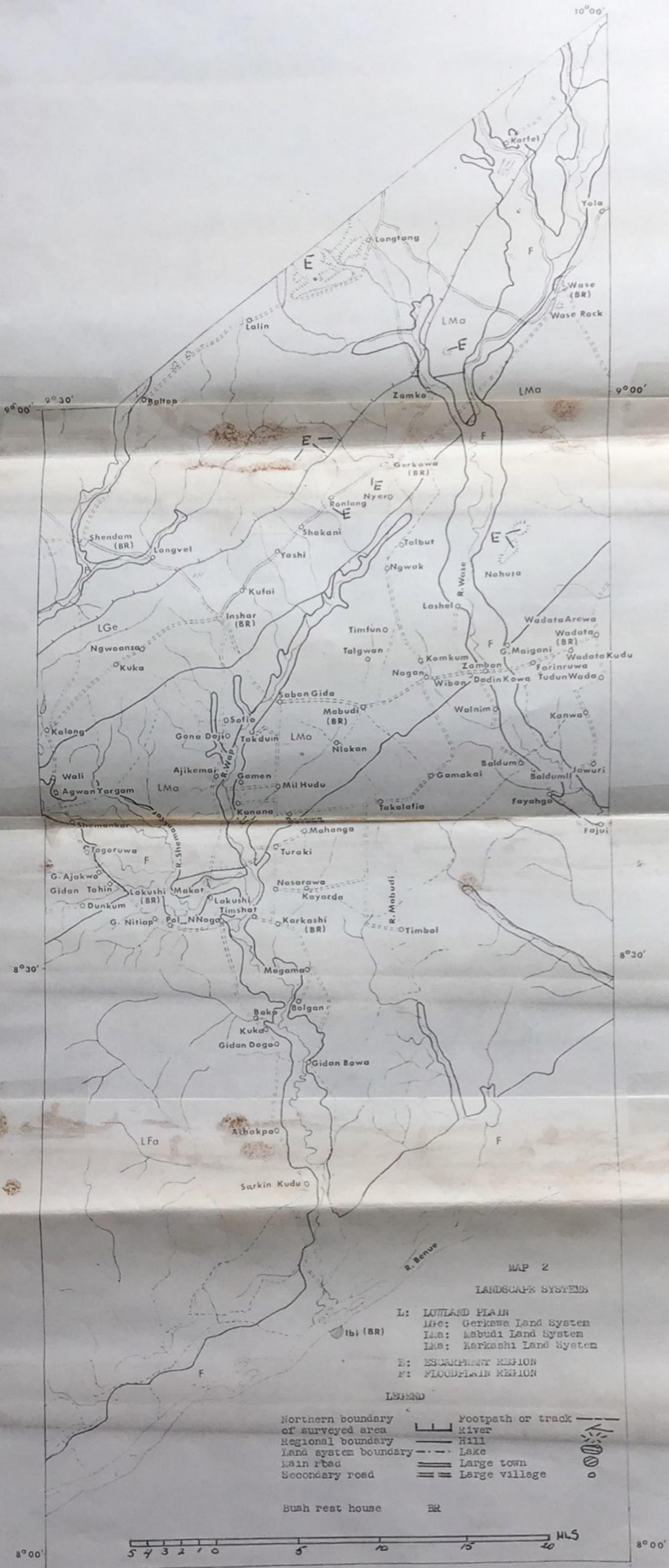
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WI 4 Inshar - Sabon Gida - Dorowa - Takalafia	53, 54
WI 5 Inshar - Shendam	65
WI 6 Inshar - Lakushi Makat	66, 67, 76, 79, 80, 81, 82, 83, 84, 85, 87
WI 7 Sabon Gida - Mabudi - Wadata (SG1)	90, 95, 97, 98, 99, 100, 102
WI 8 Mabudi - Gerkawa (G1)	107, 110, 113
WI 9 Nagane - Gamakai-Takalafia (M1)	115, 116, 118
WI 10 Junction near Zamban to Fajul (M2)	
WI 11 Northsouth Forest trace approx. (M4) 2 miles from Sabon Gida on the road to Mabudi and pits along road to Timbol.	121, 122, 123
WI 12 Road junction near Dorowa-Karkashi (T1)	124, 125, 128, 129, 130, 132
WI 13 Karkashi in direction of (TT1) Nasarawa	133, 134
WI 14 Karkashi - Magama (K1)	138
WI 15 Karkashi in direction of Magama (KK5) (repeated)	140
WI 16 Magama - Gidan Bowa (KML)	143
WI 17 Riyam in direction of Gidan Bowa (R1) along footpath	144, 145, 146, 147
WI 18 Riyam along road to Sarkin Kudu (R2)	
WI 19 Riyam - Kuka - Yamini (R3)	
WI 20 Wase - Wadata (W)	168, 169, 172
WI 21 Gerkawa - Wase (SW)	174, 175, 176, 183, 184, 185, 186, 189

x) See Shendam file containing profile descriptions and analyses.



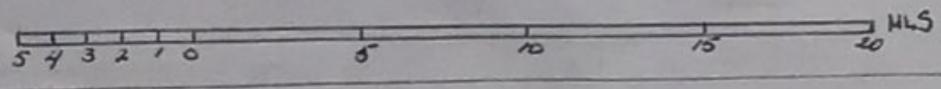
MAP 2

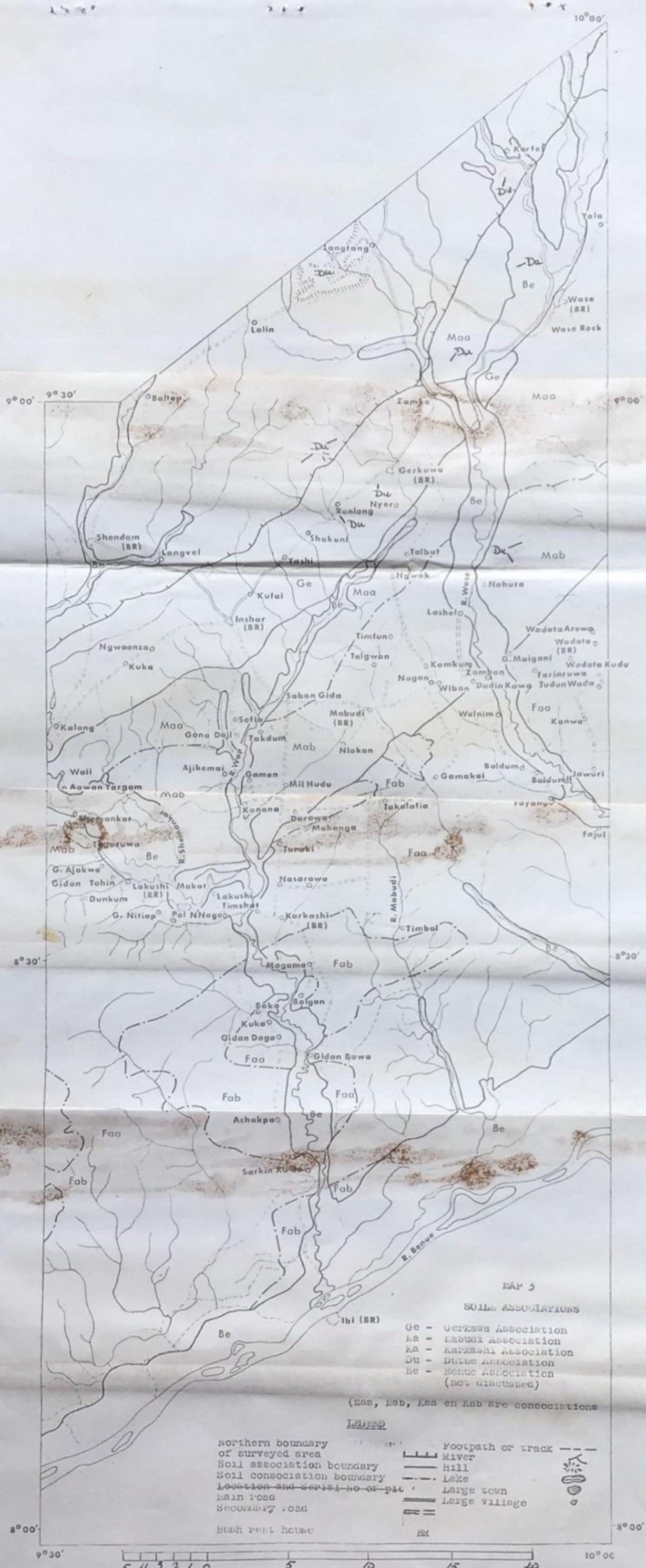
LANDSCAPE SYSTEMS

- L: LOTLAND PLAIN
- LGe: Gerkawa Land System
- LMa: Mabudi Land System
- LKa: Karkashi Land System
- E: ESCARPMENT REGION
- F: FLOODPLAIN REGION

LEGEND

- Northern boundary of surveyed area
- Regional boundary
- Land system boundary
- Main road
- Secondary road
- Bush rest house
- Footpath or track
- River
- Hill
- Lake
- Large town
- Large village





MAP 5  
SOIL ASSOCIATIONS

- Ge - Gerkawa Association
- Ka - Karkashi Association
- Du - Dutse Association
- Be - Benuue Association (not discussed)

(Ma, Mab, Ka on Mab are associations)

**LEGEND**

- Northern boundary of surveyed area
- - - Soil association boundary
- - - Soil conservation boundary
- o Location and serial no. of pit
- == Main road
- == Secondary road
- o Bush rest house
- Footpath or track
- River
- Hill
- Lake
- o Large town
- o Large village
- BR

