Land Resource Study

29 Land resources of central Nigeria Agricultural development possibilities Volume 2 B The Jos Plateau

Land Resources Development Centre, Ministry of Overseas Development

Land resources of central Nigeria
Agricultural development possibilities
Volume 2B The Jos Plateau

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Land Resources Development Centre

Central Nigeria Project Team

(ed. I D Hill)

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Land Resource Study 29

Land Resources Development Centre, Ministry of Overseas Development,
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1978

LAND RESOURCES DEVELOPMENT CENTRE*

The Land Resources Development Centre of the Ministry of Overseas Development assists developing countries in mapping, investigating and assessing land resources, and makes recommendations on the use of these resources for the development of agriculture, livestock husbandry and forestry; it also gives advice on related subjects to overseas governments and organisations, makes scientific personnel available for appointment abroad and provides lectures and training courses in the basic techniques of resource appraisal and development.

The Centre works in close cooperation with government departments, research institutes, universities and international organisations concerned with land resources assessment and development planning.

*The name of the former Land Resources Division was changed to Land Resources Development Centre in June 1978.

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Le Centre de Développement des Ressources de la Terre (l'un des organismes scientifiques du Ministère britannique de Développement Outremer) apporte son aide aux pays en voie de développement en matière de cartographie, recherche et évaluation des ressources de la terre et fournit des recommandations quant à l'exploitation de ces ressources pour le développement de l'agriculture, l'élevage et la sylviculture. Le Centre conseille également, dans les domaines annexes, gouvernments et organismes outremer, se charge de trouver du personnel scientifique pour les postes a pourvoir à l'étranger et orgánise des conférences et des stages de formation sur les techniques de base relatives à l'évaluation et la mise en valeur des ressources.

Le Centre travaille en étroite coopération avec services gouvernementaux, instituts de recherche, universités et organismes internationaux s'occupant d'évaluation des ressources de la terre et de plans de développement.

*L'ancienne Division des Ressources de la Terre (Land Resources Division) a été renommée Centre de Developpement des Ressources de la Terre (Land Resources Development Centre) en juin 1978.

List of volumes

Title: Land resources of central Nigeria: agricultural development possibilities. LRDC Central Nigeria Project Team (Eds I D Hill, J R D Wall)

Volume 1A	The Bauchi Plains, Executive Summary
Volume 1B	The Bauchi Plains
Volume 2A	The Jos Plateau, Executive Summary
Volume 2B	The Jos Plateau
Volume 3A	The Jemaa Platform, Executive Summary
Volume 3B	The Jemaa Platform
Volume 4A	The Benue Valley, Executive Summary
Volume 4B	The Benue Valley
Volume 5A	The Kaduna Plains, Executive Summary
Volume 5B	The Kaduna Plains
Volume 6A	The Kano Plains, Executive Summary
Volume 6B	The Kano Plains
Volume 7	An atlas of resource maps

NOTICE TO READERS

This published report is derived from a draft issued to the Nigerian Federal and State Authorities in 1977.

Readers concerned primarily with administrative or policy decisions in relation to agricultural development will find a summary of the various types of agricultural development considered and their location in the Jos Plateau in Volume 2A of this report, together with a precis.

The attention of readers requiring more detailed information is drawn to the section on the use of the report in Part 1 of this volume.

Throughout this report the word "agriculture" has been used in a broad sense to include crop production, range management and forestry.

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SEPARATE MAPS (in separate folder)

1. Land systems - the Jos Plateau

2. Present land use - the Jos Plateau

3. Areas with minimum environmental limitations to crop production - the Jos Plateau

4. Agricultural development possibilities - the Jos Plateau

MICROFICHES (inside back cover)

HILL I D & RACKHAM L J (1974) Interim report on the landforms, soils and vegetation of the Jos Plateau. Volumes 1, 2 and 3, Miscellaneous Report 153.

Abstract and keywords

ABSTRACT

The Jos Plateau area of the LRDC Central Nigeria Project is briefly described in terms of its climate, landform, geology, soils and natural vegetation. Present land use is described in relation to the intensity and distribution of cultivation, present farming systems, cattle production and forestry activities. This information is used to identify areas in which the environmental limitations are at a minimum for the growth of maize, millet, sorghum, groundnuts and cotton. Areas suitable for different types of agricultural development, including livestock and forestry, have been identified.

Microfiches of reports supplying additional data on the area are appended.

RÉSUMÉ

La région de Jos Plateau qui fait partie de l'aire étudiée par le Projet Nigéria da Centre est brièvement décrite en termes de climat, modelé, géologie, sols et végétation naturelle. On décrit l'utilisation de la terre par rapport à l'intensité et la distribution des cultures, les systèmes de cultivation, l'élevage du bétail et la sylviculture. Par moyen de cette information, on distingue les aires oú les limitations imposées par le milieu sont minimales en égard de la cultivation du maïs, du millet, du sorgho, des arachides, et du coton. Les aires qui conviennent aux divers types de la mise en valeur agricole, inclus l'élevage de bétail et la sylviculture, sont signalés.

Des microfiches fournissent des donnés additionelles sur la region.

DESCRIPTORS FOR COORDINATE INDEXING

Nigeria, Bauchi, climate, landform, soils, present land use, farming systems, livestock, forestry, agricultural development, maize, millet, sorghum, groundnuts, cotton, potatoes.

List of LRDC reports on the Jos Plateau

A full list is given below of the report of the Jos Plateau issued by the Land Resources Development Centre. They contain information for the specialist and are obtainable only with the agreement of the Nigerian Government. Selected specialist reports are reproduced as microfiches inside the rear cover of the present report.

BAWDEN M G & RACKHAM L J (1969) The physiography of the basement land province: interim report on the land resources of central Nigeria. Miscellaneous Report 75.

POSNETT N W, REILLY P M & WHITFIELD P (1971) Nigeria. Volumes 1-3. Land Resource Bibliography 2.

HILL I D, ALFORD M, RACKHAM L J & TULEY P (1974) Interim report on the landforms, soils and vegetation of the Jos Plateau. Volume 1, Landforms and soils. Volume 2, Climate and vegetation. Volume 3, The map units. Miscellaneous Report 153 (microfiches inside back cover).

BLAIR RAINS (1975) Livestock production in the Central Nigeria Project area. Miscellaneous Report 198.

HOWARD W J (1975) Rehabilitation of tin mining land on the Jos Plateau. Miscellaneous Report 213.

JONES R G B (1975) Central Nigeria Project: report on a soil conservation consultancy to study soil erosion problems on the Jos Plateau. Land Resources Report 6.

HOWARD W J (1976) Land resources of central Nigeria. Forestry. Land Resource Report 9.

GOSDEN P N (1978) Land resources of central Nigeria. Farming systems. Land Resource Report 17.

BLAIR RAINS A (1978) Land resources of central Nigeria. Rangeland and livestock production. Land Resource Report 18.

MANSFIELD J E (in preparation) Land resources of central Nigeria. The interpretation of environmental data in terms of limitation to crop growth. Land Resource Report 22.

Part 1

Part 1 Introduction

PREFACE

In June 1968 the Nigerian Government asked the British Government to investigate the land resources of parts of each of the six northern states of Nigeria. The investigations have been undertaken by the Land Resources Development Centre (then the Land Resources Division) of the British Government's Ministry of Overseas Development.

The project area covers approximately 230 000 km^2 (90 000 mi^2). Its western and eastern boundaries are marked approximately by 7° and 10° longitude and it extends from south of the Benue Valley northwards to the border with the Niger Republic (see Text Map 2.1).

Fieldwork was completed in 1976, and a draft of this report was distributed to the Nigerian Federal and State authorities in the following year. The results of the surveys and the draft reports for the Bauchi Plains, Jos Plateau, Jema'a Platform and Benue Valley were discussed in detail at a seminar held in Kaduna in February 1978. This seminar was opened by the Hon Mr Zakariya B Gaiya, Commissioner of Agriculture, Kaduna State and was attended by senior officials from Federal and State ministries and by staff members from several universities. Permission was subsequently received to publish this report for international distribution.

The many background and specialist reports on which the recommendations of the study are based are listed on p.xiii. Some are reproduced as microfiches inside the rear cover of this report.

OBJECTIVES

The objectives of the project were to investigate and describe the land resources with particular reference to their agricultural potential. More specifically, at the request of State and Federal authorities, an assessment has been made of the area's suitability for the growth of annual rainfed crops, maize, millet, sorghum, yams, rice, groundnuts and cotton together with its rangeland and forestry potential. Agricultural development in the more suitable areas has been considered in the context of improving and expanding existing agriculture and establishing new large-scale, capital-intensive schemes.

METHODS

From a study of aerial photographs the area was divided into units with similar landforms. Ground investigations of the soils and vegetation within these units, linked with climatic studies, enabled areas with the same pattern of climate, landform, soil and vegetation to be defined. Such areas are called land systems. These land systems are identified by numbers, are shown in Separate Maps 1-4 which accompany this report and are referred to whenever development possibilities are discussed.

The environmental data for each land system were interpreted in terms of suitability for various crops, grazing and forestry. This information, taken in association with studies of present land use was used to identify a number of development possibilities. More details of the methods used are contained in the reports listed on page xiii.

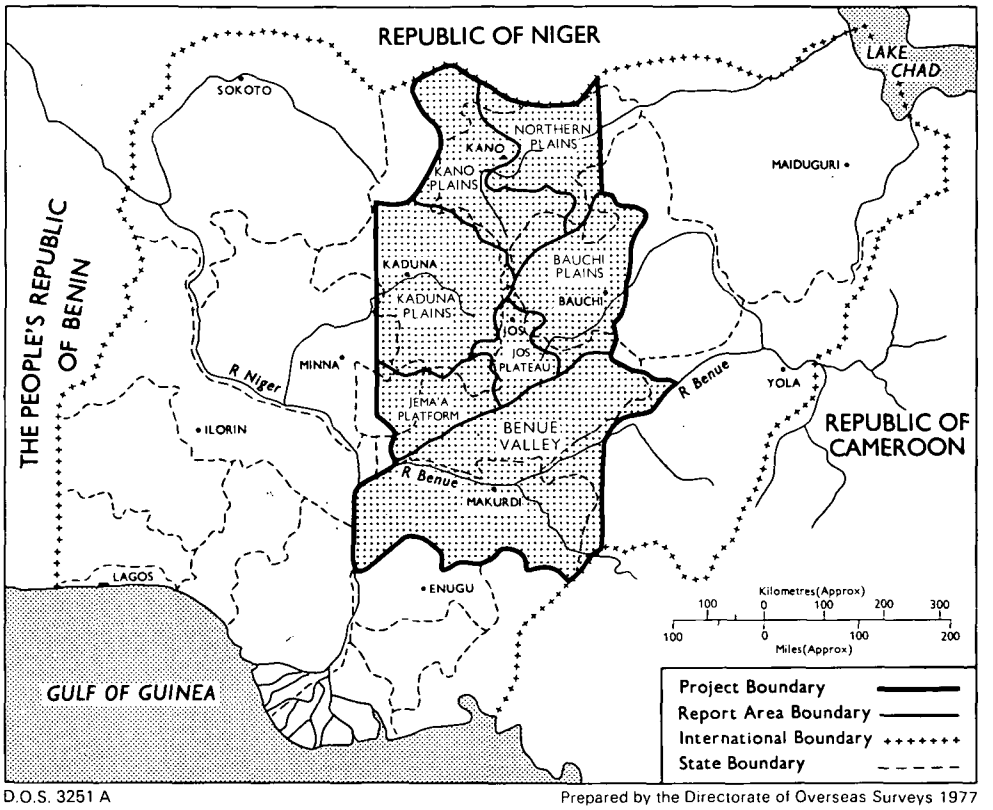
FIELDWORK AND TEAM COMPOSITION

Fieldwork started in January 1969 and continued until December 1976. Details of the progress of fieldwork have been given in six-monthly progress reports issued by the Land Resources Development Centre.

The project team included agriculturalists, ecologists, a forester, a range-land specialist, geomorphologists and soil scientists. Details of the team

TEXT MAP 2.1

LOCATION OF CENTRAL NIGERIA PROJECT



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composition and consultancies are given below.

Agriculture	J E Mansfield		1973–77	8? + ?
	P N Gosden		?	
Ecology	P Tuley	3	1969–72	
	R Rose-Innes	2	1975–77	11
	Mrs M Alford	5	1970–75	
	Dr R M Lawton	1	1975	
Forestry	W J Howard	3	1973–76	3
Rangeland	A Blair Rains	1	1975–76	2
	C R C Hendy	1	1975	
Geomorphology	M G Bawden	5	1968–73	
	L J Rackham	7	1970–77	15
	Mrs J A Jones	3	1970–73	
Soil Science	I D Hill	7	1969–76	
	A A Hutcheon	8	1969–77	
	A W Wood	4	1971–75	27
	J G Bennett	4	1973–77	
	W B Kerr	3	1974–77	
	J R D Wall	1	1976–77	
Soil erosion	R B Jones		1975	1
Consultants				
Agricultural economics	R Moyle		1975	1

ENV: 11 + 15 + 27 + 1 = 54
TECH: 8? + 3 + 2 = 13
ECON: 1 = 1

REPORTING

As the project area is so large it has been divided into six major physiographic regions, the Bauchi Plains, the Jos Plateau, the Jema'a Platform, the Benue Valley and the Kaduna and Kano Plains. These physiographic regions are shown on Text Maps 2.2a and 2.2b in relation to state boundaries. Each region has been reported on separately.

The agricultural development possibilities in each region are discussed in

separate volumes of this Land Resource Study: the six volumes are listed on page v. An executive summary has been prepared for each volume.

Environmental data collected during the survey for each of the major physiographic regions is contained in a series of reports published by this Division; those relating to the Jos Plateau are listed on page xiii. The list also includes reports dealing specifically with farming systems, rangeland and forestry for the whole project area.

USE OF THE REPORT

This report will be of use to technical and planning officers concerned with the formulation of plans or responsible for implementation of planning decisions. In it, environmental data have been summarised and an interpretation of these data as a number of development possibilities presented. The development possibilities have been assessed on environmental criteria: no attempt has been made to rank them in economic terms.

Readers requiring general information about the environment should turn to Part 2. Those requiring more detailed environmental and present land use information in relation to development possibilities are referred to Part 3. Part 4 dealing with actual agricultural development possibilities has, following discussions with Federal and State authorities, been structured so that it can be used in three ways.

1. Selection of areas for a particular type of agricultural development or project
2. Selection of areas for increasing the production of a given crop
3. Selection of the types of agricultural development for particular administrative units

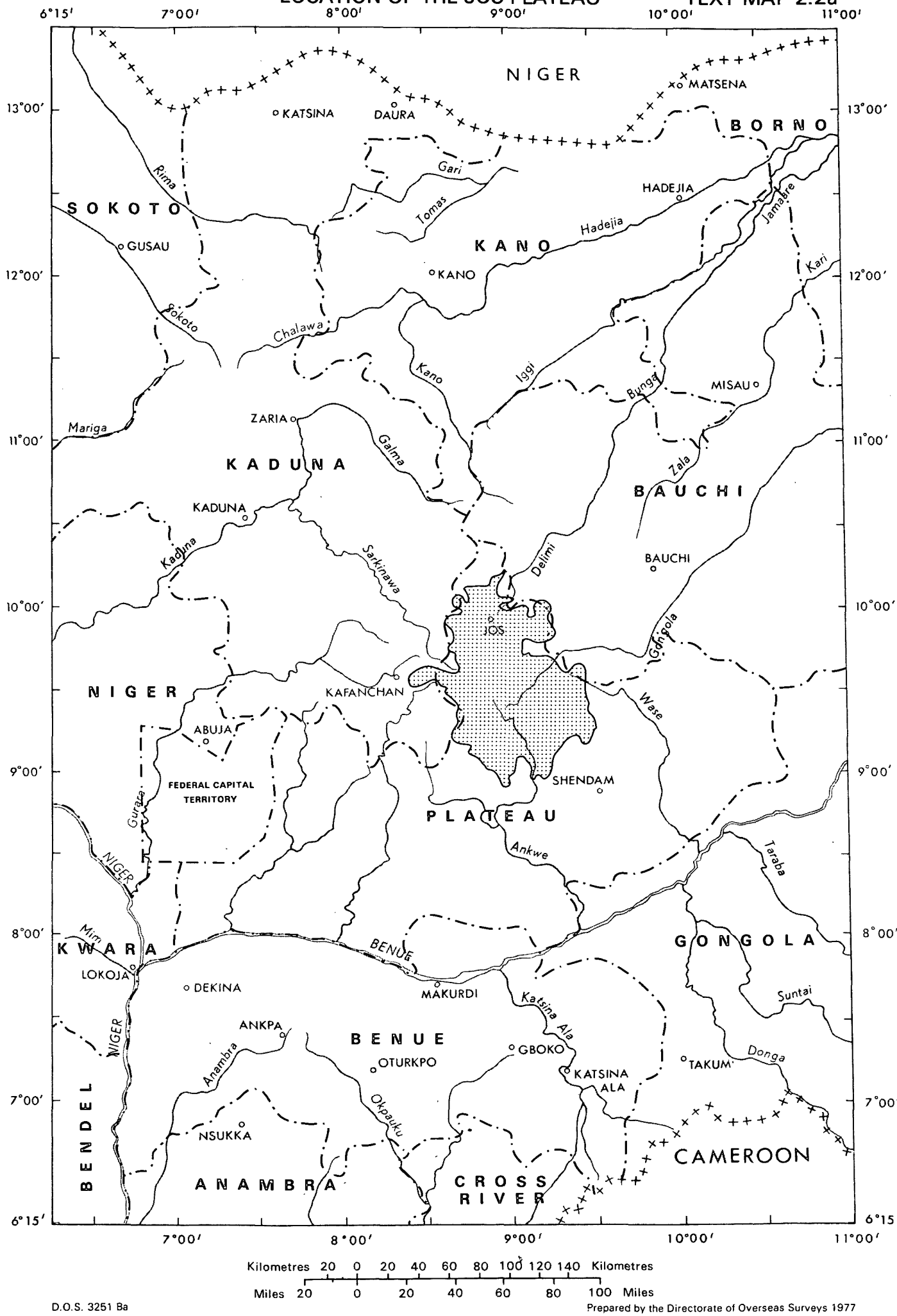
The report should be used mainly in conjunction with Separate Maps 3 and 4. Separate Maps 1 and 2 give information about the environment and present land use and are included for reference purposes.

1. Selection of areas for a particular type of agricultural development

The various type of development are defined in Part 4 of this report and

LOCATION OF THE JOS PLATEAU

TEXT MAP 2.2a



Kilometres 20 0 20 40 60 80 100 120 140 Kilometres

Miles 20 0 20 40 60 80 100 Miles

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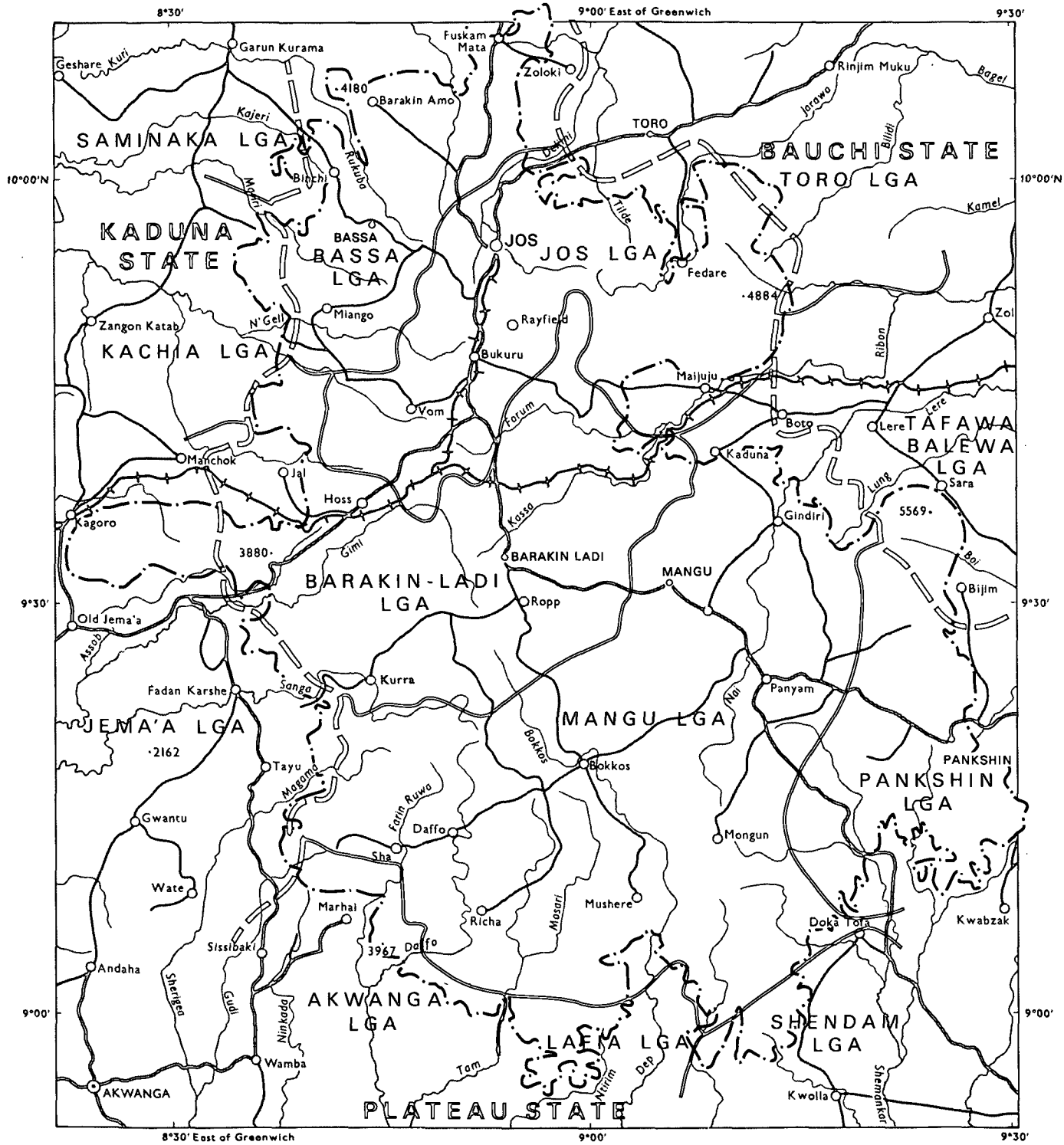
POST-1976 ADMINISTRATIVE BOUNDARIES OF THE JOS PLATEAU



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identified by a number. Given a decision on which type of development is to be followed, the most suitable areas for this type of development can be found by reference to Part 4. For example, if it has been decided that a cattle ranch is to be established somewhere on the Jos Plateau, Text Map 2.4 gives an indication of the areas in which such development could take place. These areas are also shown on Separate Map 4 and reference to Part 4 Table 47 shows that there are sites in Barakin Ladi, Mangu, Jos and Pankshin Local Government Areas in Land Systems 109, 117, and 120 in which there are few environmental limitations to the establishment of a ranch. These land systems can be identified on the separate maps.

2. Selection of areas for increasing the production of a given crop

Given a decision that the production of a given crop must be increased, the areas in which the environmental limitations are at a minimum for that crop can be obtained from Part 4, Table 48, and identified on Separate Map 3. For example, reference to Table 48 shows that there are no or only minor limitations to the growth of maize in Land Systems 109, 110, 115, 116, 117, 122, 123, 124, 129, 130 which occur in Barakin Ladi, Mangu, Pankshin and Jos Local Government Areas. Table 9 in Part 3 shows the number of crop options in each of these land systems and more detailed description can be obtained from Part 3. The geographical location of these land systems is obtained from Separate Map 3.

3. Selection of the types of development for particular administrative areas

The types of development that are possible in particular administrative units are discussed in Part 4 of this report. The administrative areas can be located on Separate Map 4 and symbols indicate the types of development for which the environmental limitations are at a minimum. For example, if it is decided that some form of development should take place in Pankshin Local Government Area, reference to Part 4, Table 47 and to Separate Map 4 shows the types of development for which there are few environmental limitations, and the areas within the Division in which they can take place. Further information about the area is obtained by reference to Part 3 of the report in the section dealing with areas with three crop options.

The decision as to which type of development should be undertaken or which crops should be grown, depends on economic and social factors that are outside the terms of reference of this project.

The report can also be used to determine the limitations to the growth of particular crops in areas chosen for development. For example, if it is decided that some form of development should take place in the Mangu Local Government area reference to Separate Map 3 shows that the area falls within Land System 127 and is considered to have soil limitations to the growth of crops. These limitations can be found by reference to the legend of Separate Map 1 or to the appropriate section of Part 3.

CROPS CONSIDERED

At the request of Federal and State authorities the following crops were considered:- maize, millet, sorghum, yams, rainfed rice, Irish potatoes, groundnuts and cotton. On the Jos Plateau climatic factors are severely limiting to the growth of cotton, so the area was not assessed in terms of soil limitations to this crop. Rainfed rice is a special case: water is probably the most important factor in its cultivation and water relationships will be most favourable in flood plain areas. On the Jos Plateau most of these have been disturbed by mining or gullying so no assessment was made for this crop either.

ADMINISTRATIVE UNITS

The boundaries of the new States announced in January 1976 have been derived from the Federal Surveys 1:1 500 000 map of Nigeria (1976). Data have been referred to Local Government Areas in all States. The boundaries of these Local Government Areas have been derived from the best available published maps.

ACKNOWLEDGEMENTS

We wish to thank the staff of the Federal and State Ministries of Agriculture and Natural Resources for assistance during the project. Thanks are also due

to the Director and staff of the Institute for Agricultural Research, Ahmadu Bello University, for help and cooperation in all stages of the survey and to the staff of the International Institute for Tropical Agriculture Ibadan for technical advise.

Part 2

Part 2 Aspects of the environment

The information presented here is summarised from the reports listed on page xiii which contains more detailed information and supporting bibliographies.

LOCATION

The area referred to here as the Jos Plateau forms a clearly defined highland area standing above the surrounding plains and is shown on Text Map 2.2a. It occupies 8 600 km^2 (3 300 mi^2) within the area marked by 8° 22' E and 9° 30' E and 8° 30' N and 10° 10' N.

Its boundary is marked for the most part by a steep fall to the surrounding plains, though it is more gradual in the east.

CLIMATE

Full climatological data published by the Nigerian Meteorological Service are available only for the town of Jos, but less comprehensive records are kept for other towns in the area.

Rainfall

The rainfall is highest in the south west corner of the Jos Plateau, with mean annual rainfall of about 1 600 mm (63 in). There is a gradual decrease north eastwards, and at Jos mean annual rainfall is about 1 400 mm (55 in). Higher rainfall may occur locally around the Shere Hills. The rains start in April and finish in October: little rain falls during the rest of the year.

Kowal and Knabe (1972) have defined areas thought to have similar temperature, rainfall and evapotranspiration regimes. These areas are shown as polygons, constructed around synoptic climatic stations in northern Nigeria: the polygons covering the Jos Plateau are shown on Text Map 2.9a and b and on Separate Map 3.

Variations within the polygons do occur, but as the climatic data needed to

quantify these variations are not available, zones of natural vegetation are taken as indicators of conditions that are wetter or drier than the average defined for a given polygon.

For each polygon Kowal and Knabe (1972) have defined a rainy period, which is the number of days between the start and the end of the rains. The length of the rainy period for the polygons on the Jos Plateau are shown in Table 1. This has been calculated using data grouped into ten day periods, so the actual length of the rainy period could be up to ten days shorter than shown. The dates for the start and the end of the rains are also shown in Table 1. During the rainy period crops are unlikely to suffer moisture stress long enough to affect yield significantly, so it can be considered as the safe growing period.

However, Benoit (1975) has shown that as the starting date of the rainy period may vary, the probabilities of the rainy period starting on the dates shown are only 50 and 30% for Jos and Bauchi.

TABLE 1 The length of the rainy period and the date of its start and finish in the polygons covering the Jos Plateau (Kowal and Knabe, 1972)

Polygon	Rainy period		
	Length (days)	Starting date*	Finishing date+
Jos	190	April 1 - 10	October 11 - 20
Bauchi	140	May 1 - 10	October 1 - 10

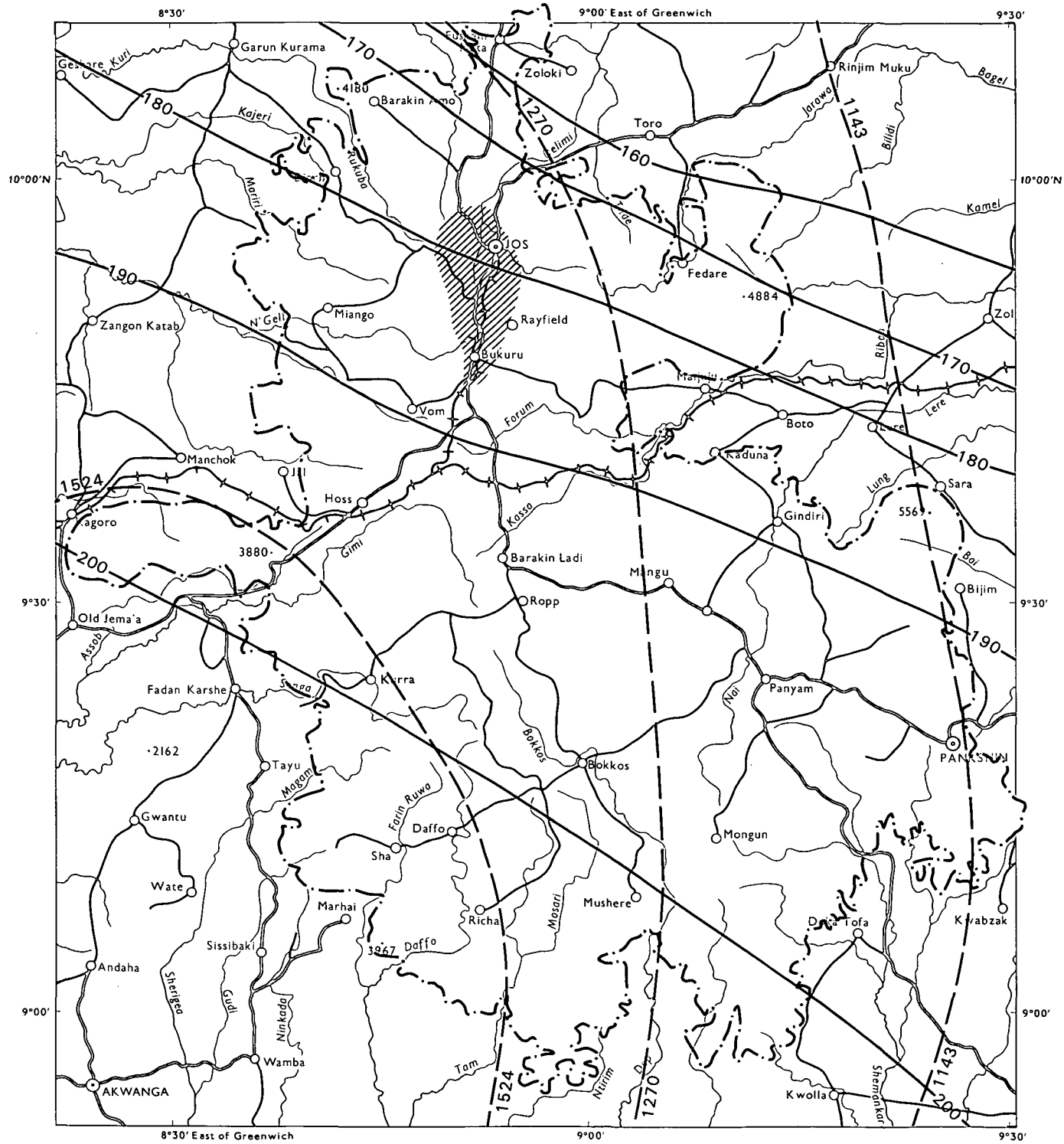
* First 10 day period in which rainfall (P) > 1.0 is followed by two 10 day periods in which P >0.5 ET (evapotranspiration)

\+ Last 10 day period in which P >0.5 in and P >ET previous 10 day period

Temperature

The range of daily maximum and minimum temperatures during the rainy season in the Jos polygon is given in Table 2.

ISOHYET MAP SHOWING MEAN ANNUAL RAINFALL AND LENGTH OF RAINY PERIOD



Jos Metropolitan Area

Kilometres 10 5 0 10 20 30 Kilometres

Miles 10 5 0 10 20 Miles

Length of the rainy period in days

Mean annual rainfall in mm

Boundary of Jos Plateau

Source: Agroclimatological Atlas of the Northern States of Nigeria (KOWAL and KNABE 1972)

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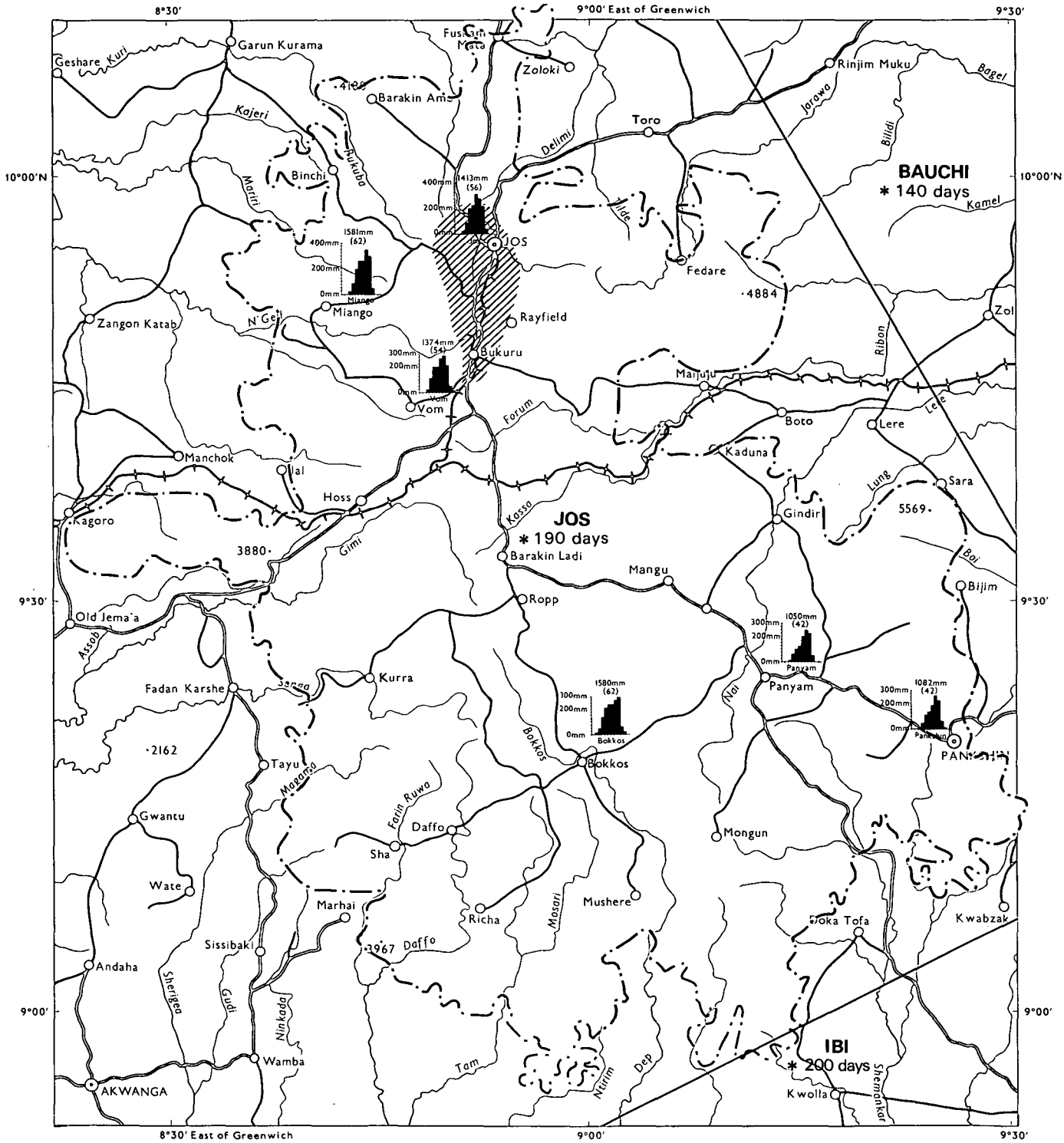
THIESSON POLYGON MAP SHOWING MEAN ANNUAL AND MONTHLY RAINFALL DISTRIBUTION AT SELECTED SITES (mm) AND LENGTH OF RAINY PERIOD (days)



Jos Metropolitan Area

Kilometres 10 5 0 10 20 30 Kilometres

Miles 10 5 0 10 20 Miles

—·— Boundary of Jos Plateau

* Length of rainy period (growing season)

Source: Agroclimatological Atlas of the Northern States of Nigeria (KOWAL and KNABE 1972)

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TABLE 2 Range of maximum and minimum temperatures during the rainy season in the Jos polygon

Polygon	Temperature range			
	Maximum		Minimum	
	°C	°F	°C	°F
Jos	23.5 - 30.9	74.3 - 87.6	26.6 - 28.5	61.9 - 65.3
Bauchi	28.4 - 34.9	83.1 - 94.8	19.6 - 22.8	67.2 - 73.0

The highest temperatures occur in March and April when the mean monthly temperatures reach 24.3°C (75.7°F). Mean monthly temperatures drop to 20.5°C (68.8°F) in December.

Global radiation and hours of sunshine

The range of mean daily global radiation and the range in mean actual hours of sunshine during the rainy period are given in Table 3 for the Jos polygon.

TABLE 3 Mean daily global radiation and the range in mean actual hours of sunshine during the rainy period for the Jos polygon

Polygon	Range	
	Mean daily global radiation $cal/cm^2/day$	Mean daily actual sunshine hours
Jos	301 - 424	3.71 - 7.20
Bauchi	349 - 488	4.86 - 8.88

RELIEF AND DRAINAGE

The relief of the Jos Plateau is shown on Text Map 2.10. The major relief characteristics of the Jos Plateau are closely related to the underlying rock

types. The resistant Younger and Older Granites have formed a resistant core throughout a long erosional history and still form the hill masses of the present landscape rising to over 1 500 m (5 000 ft), or the hilly broken country along parts of the dissected edges of the Plateau. The morphology of these hills is largely controlled by the joint pattern. Most of the Plateau surface lies between 1 050 - 1 370 m (3 800 - 4 500 ft). Lower lying areas within the Plateau are usually associated with migmatites whilst the Newer Basalt flows give flat to gently undulating terrain.

Over much of the rest of the Plateau the underlying rock is obscured by unconsolidated material and in detail the relief is largely controlled by the ironpan.

The drainage of the Jos Plateau is radial and the major drainage basins are shown on Text Map 2.11. The watersheds of the three major river systems of Nigeria meet on the Jos Plateau. The Delimi River drains to Chad, the Gongola River drains north eastwards before swinging to the Benue; the Wase, Shemankar, Ankwe and Mada Rivers drain directly to the Benue, whilst the Kaduna River drains to the Niger.

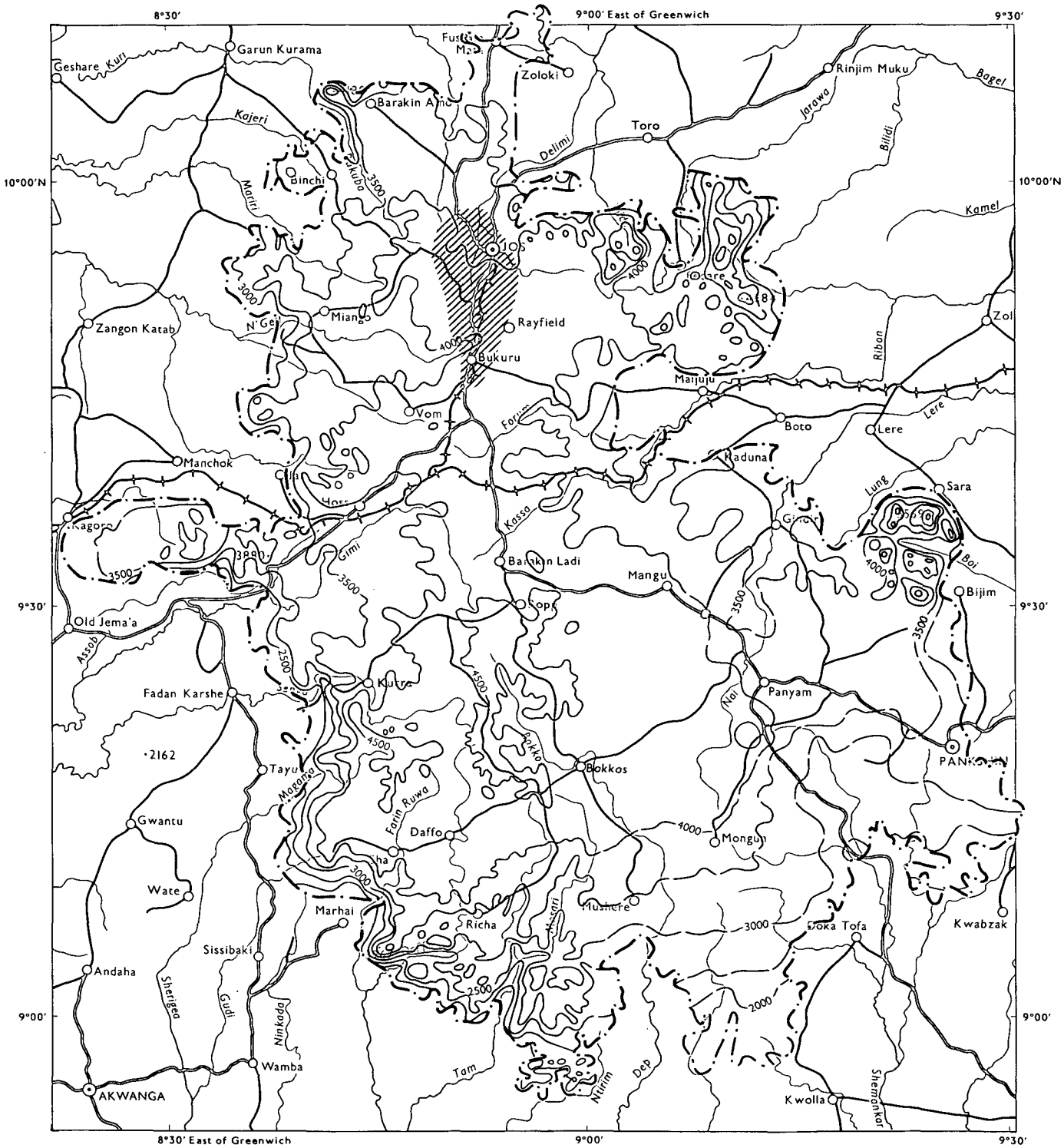
GEOLOGY

Macleod, Turner and Wright (1971) have most recently described the geology of the Jos Plateau. They have recognised Precambrian gneisses, migmatites and granites known in general as the Basement Complex rocks. Medium to coarse grained granites, known as the Younger Granites have been intruded into the Basement Complex and form a series of ring complexes: they are thought to be of Jurassic age. (Jacobson et al 1958)

The Jos Plateau has been affected by volcanic activity from Tertiary to recent times. Macleod, Turner and Wright (1971) have distinguished (a) Lateritised Older Basalts (b) Unlateritised Older Basalts, generally associated with (a) and (c) Newer Basalts that are typically large flows that can be traced to reasonably well preserved cones.

Erosion of the Lateritised Older Basalts has led to the formation of a secondary ironpan and deep unconsolidated deposits on the valley side slopes. Several phases of erosion and deposition appear to have taken place during the

RELIEF



Jos Metropolitan Area

Kilometres 10 5 0 10 20 30 Kilometres

Miles 10 5 0 10 20 Miles

Contour Interval 500ft

Contours — Formlines — Boundary of Jos Plateau

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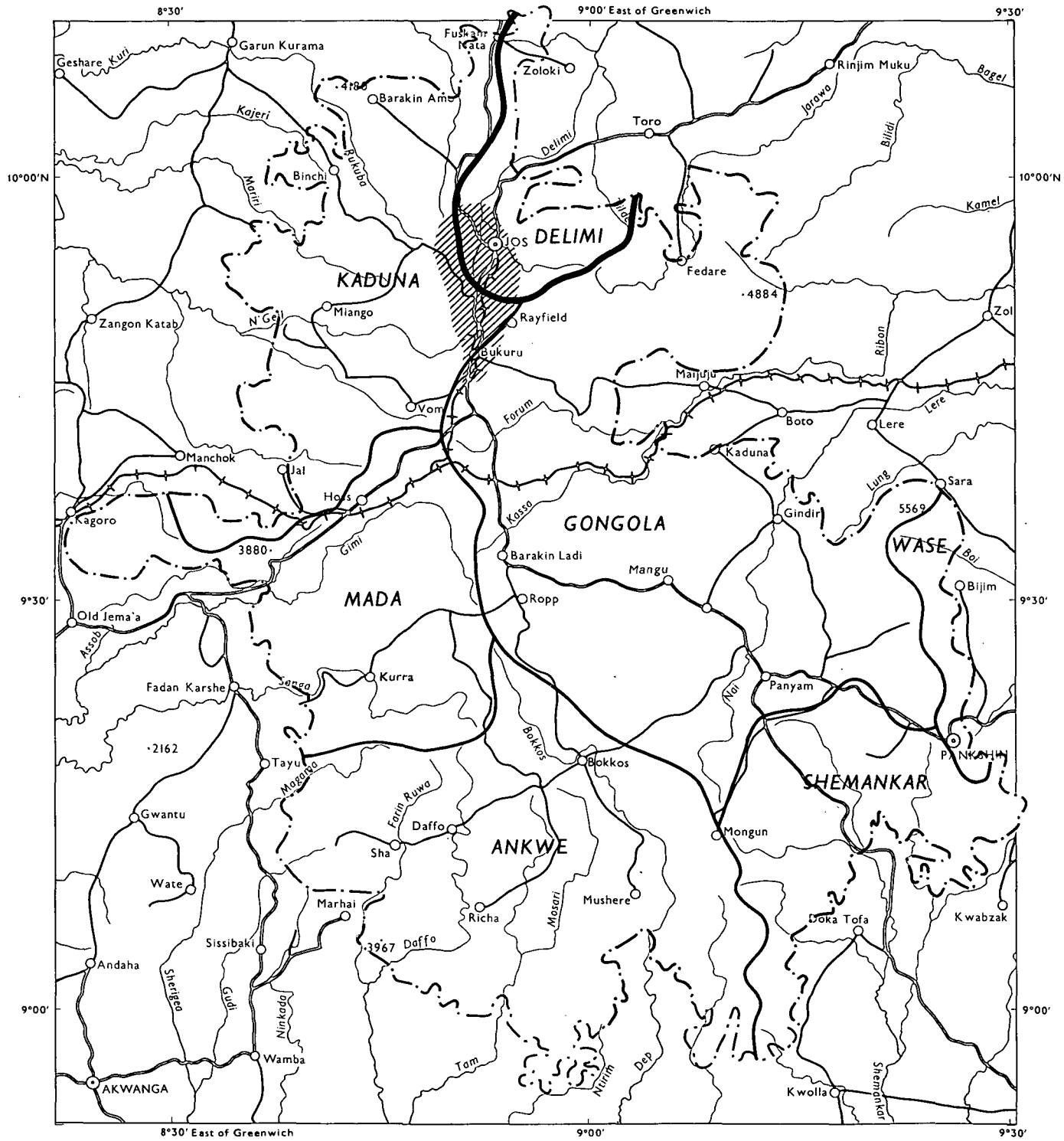
Prepared by the Directorate of Overseas Surveys 1977

DRAINAGE BASINS



Jos Metropolitan Area

Kilometres 10 5 0 10 20 30 Kilometres

Miles 10 5 0 10 20 Miles

Boundary of Chad Basin

Major watershed

Boundary of Jos Plateau

Prepared by the Directorate of Overseas Surveys 1977

Pleistocene and a number of different deposits, the Rayfield, Bokkos and Bisichi deposits have been recognised by Hill and Rackham (1974).

In more recent times a fine yellowish loamy material has been deposited over much of the area and Macleod, Turner and Wright (1971) have suggested that it is aeolian in origin.

LANDFORMS

Hill and Rackham (1973/4) have divided the Jos Plateau into three broad physiographic units, hills and mountains, dissected terrain and undulating terrain. (See Text Map 2.12).

Physiographic Unit i. Hills and mountains

This unit includes all the steep sided rugged hills within the area, whether they occur as isolated hills, groups of hills or mountain ranges.

Physiographic Unit ii. Dissected terrain

This unit occurs close to the edges of the Jos Plateau. It includes a variety of low rocky hills and rock outcrops and the intervening valleys which are frequently deeply incised. Slopes are usually steep but small pockets of flatter land occur.

Physiographic Unit iii. Undulating terrain

This unit occupies most of the main surface of the Plateau and has been divided into five sub-units reflecting various degrees of erosion and different parent materials. The least dissected is that developed on the Newer Basalts, whilst the Daffo-Pankshin area is slightly higher and less dissected than the sub-units lying to the north west and east.

SOILS

The physiographic units have been subdivided into another simpler landform units, each with a uniform pattern of landform. These landform patterns are the basis of the land systems shown on Separate Map 1.

Soil classification

The soils have been grouped into series (Hill and Rackham 1973/4), consisting of soils having soil horizons with similar characteristics and arrangement in the soil profile, and developed from a particular type of parent material (USDA, 1951). The series are defined primarily on morphological characteristics of depth, drainage, nature of the parent material, amount of gravel or other coarse material and texture of the B horizon: chemical characteristics are taken into account where necessary. These soil properties together with the texture of the surface horizons are thought to be significant to crop growth and are further discussed in Appendix 1.

Wherever possible the criteria used to define series conform to those used at higher levels of soil classification by international classification systems, in particular the Legend for the Soil Map of the World (FAO, 1974).

Soil genesis

The predominant parent materials are deep, unconsolidated deposits derived from weathered granites, Basement Complex rocks and Older Basalts. These materials have been modified by mild lateritisation resulting in pronounced mottling. In places concretionary gravels derived from the erosion of lateritic ironpan have been spread over the surface of the unconsolidated deposits. Elsewhere the soils are developed on Newer Basalts, on granites and their detritus, or on lateritic ironpan.

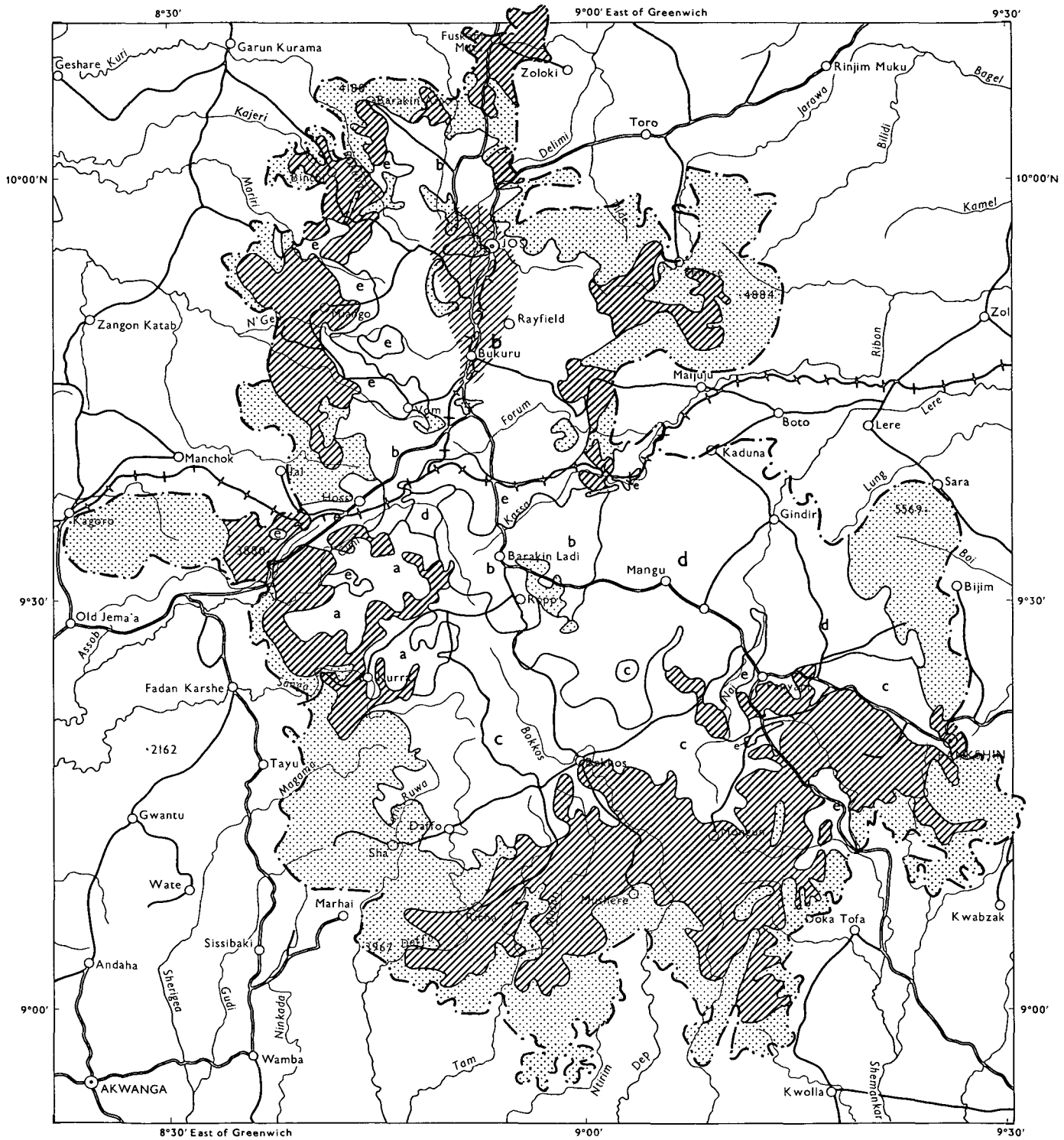
Fine loamy material thought by Macleod Turner and Wright (1971) to be aeolian affects the surface horizons of the soils.

Poor drainage may affect any of these parent materials, but due to the marked

JOS PLATEAU

TEXT MAP 2.12

PHYSIOGRAPHIC UNITS



Jos Metropolitan Area

Kilometres 10 5 0 10 20 30 Kilometres

Miles 10 5 0 10 20 Miles

Physiographic Unit i

Hills and Mountains

Physiographic Unit ii

Dissected terrain

Physiographic Unit iii Undulating terrain

a — iiia. The Sho-Kurra Area.

b — iiib. The Jos-Barakin Ladi Area.

c — iiic. The Daffo-Pankshin Area.

d — iiid. The Mongu Area.

e — iiie. The Newer Basalt Areas.

Boundary of Jos Plateau

D.O.S. 3251 M

Prepared by the Directorate of Overseas Surveys 1977

seasonal rainfall the water table fluctuates. The sandy surface horizons of many of the soils drain rapidly, particularly where underlain by gravelly material.

Soil patterns

The land systems shown on Separate Map 1 are soil associations in the sense that they are patterns of geographical associations of soils (Taylor and Pohlen, 1962). In most land systems the soil pattern is controlled by topography and they are toposequences of soils. Commonly occurring toposequences of soils are described below.

1. On unconsolidated deposits

Shallow soils associated with rock outcrops or lateritic ironpan commonly occur on interfluve crests. Downslope from the ironpan the soils often have a layer of concretionary gravel in the surface horizons. Mid and lower slopes carry deep, well to imperfectly drained, strongly mottled soils. The surface horizons may be of yellowish loamy material, possibly aeolian. In many valleys the lower slopes are not poorly drained, because the water table is at depth due to the deeply incised stream lines. Where drainage is restricted, poorer soil drainage is reflected in the greyer colours of the soil matrix.

2. On Newer Basalts

Deep, well drained, well structured soils occur on the footslopes of the volcanic cones associated with the Newer Basalt flows. Similar soils occur in other free draining sites on the Newer Basalt, usually where slopes are steeper than usual. Elsewhere on the surface of the flows soils may be shallow over slightly weathered rock or deep and strongly mottled. This may reflect the age of the flow. Soils with a high proportion of concretionary gravel in the surface horizons also occur.

3. On granitic material

Shallow soils rich in only slightly weathered minerals derived from the granite

occur close to many rock outcrops. In valleys in the dissected parts of the Jos Plateau accumulations of granitic material give rise to deeper soils, but their distribution is irregular.

Areas associated with mining in which the soils have been disturbed or completely destroyed occur commonly throughout the Jos Plateau. These areas are shown on Separate Map 1.

Soil fertility

Most of the soils on the Jos Plateau have a very poor nutrient status. The cation exchange capacity of the most commonly occurring soils is less than 8, except for the soils on basalt. pH is always less than 6 and frequently less than 5. The lower pH levels impose a limitation to the growth of all the crops considered. There are insufficient data to make generalisations about the levels of available phosphorus, but phosphorus availability can be related to pH. At the low pH of most of the soils there will be little phosphorus available for plant growth and this will provide an additional limitation to all the crops considered. The limitations to crop growth imposed by the various chemical characteristics for which data are available are given in Appendix 1 and the legend to Separate Map 3.

VEGETATION

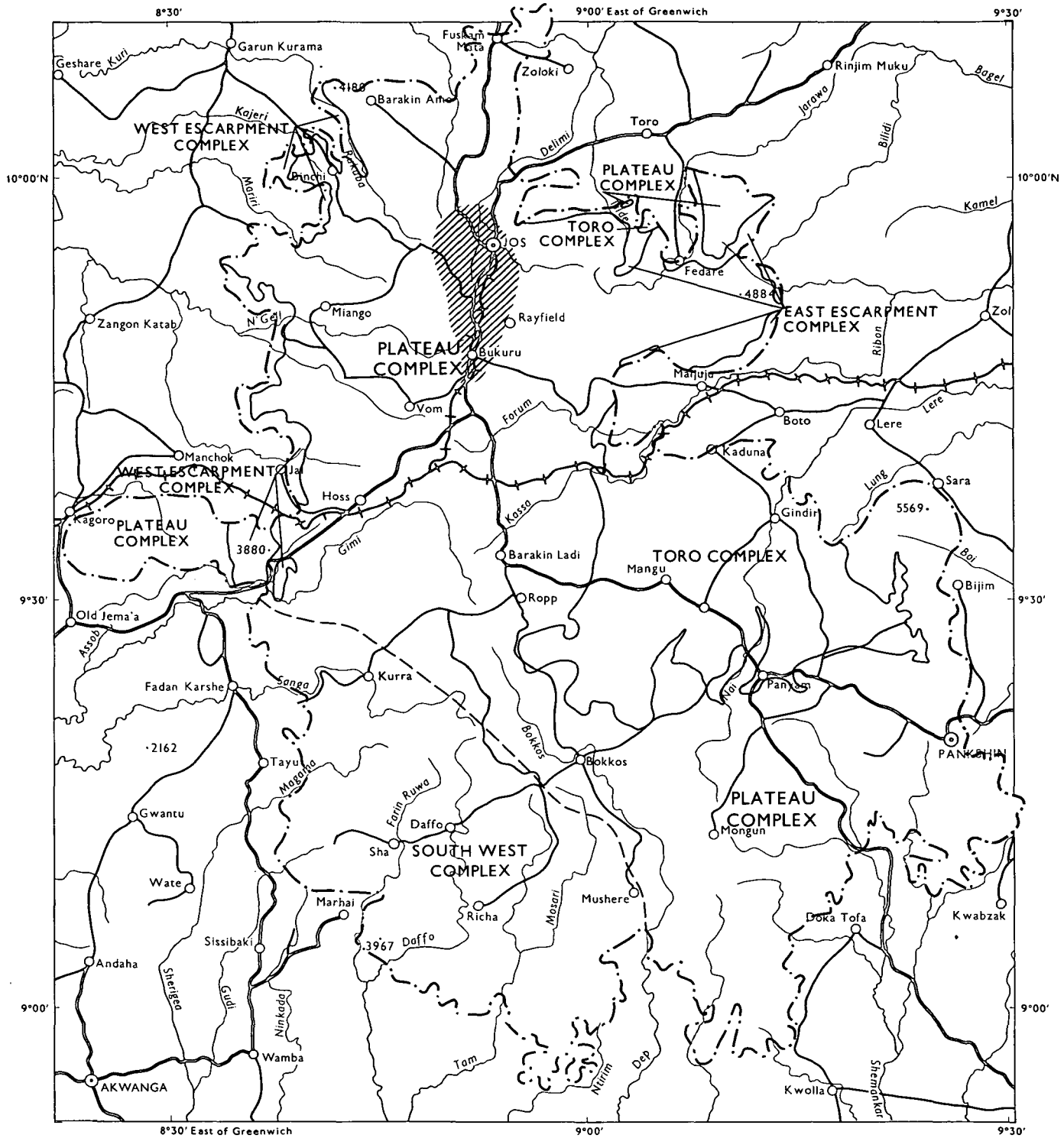
The vegetation of the Jos Plateau reflects interactions with climate, soil and the activities of man. Due to prolonged cultivation, little of the original vegetation remains and present day vegetation is mainly short duration fallow.

The vegetation has been described by Alford and Tuley (1974) as six complexes which broadly reflect climatic changes (see Text Map 2.13). The complexes provide a framework within which soil vegetation relationships are considered.

The Plateau Complex

This occurs over the central part of the plateau with mean annual rainfall of

VEGETATION



Jos Metropolitan Area

Kilometres 10 5 0 10 20 30 Kilometres

Miles 10 5 0 10 20 Miles

Vegetation boundary

Transitional vegetation boundary

Boundary of Jos Plateau

Prepared by the Directorate of Overseas Surveys 1977

1 270 - 1 524 mm (50 - 60 in). Andropogon pseudapricus grassland and Terminalia/Syzygium shrubland predominate in this complex. Rocky areas carry a Ficus/Euphorbia shrubland. On the shallow soils on ironpan there is a sparse grassland in which species of Loudetia, Ctenium, Microchloa and Sporobolus predominate. In more poorly drained sites Hyparrhenia rufa occurs whilst on the basalt derived soils species of Paspalum and Brachiaria are found.

The South-west Complex

This occurs in the south-western part of the plateau with a mean annual rainfall of 1 524 - 2 030 mm (60 - 80 in). Adenodolichos shrubland predominates with a riparian woodland in which species of Phoenix and Syzygium occur together with Cyathea dregei.

The West Escarpment Complex

Mean annual rainfall is lower than in the South-west Complex and conditions are more typical of the Southern Guinea zone. This is reflected by the Anogeissus/Vitex woodland, although riparian woodland and Adenodolichos shrubland similar to that in the south west also occurs.

The East Escarpment Complex

Mean annual rainfall is probably less than on the Plateau Complex and Isoberlinia/Monotes shrubland or woodland predominates. Adenodolichos occurs together with the riparian woodland found in the south west complex.

The Toro Complex

This occurs mainly on the Mongu Plains where the Plateau surface slopes gently down to the east. Mean annual rainfall is lower than on the Plateau and although much of the vegetation is similar to the Plateau Complex, a Combretum sericeum shrubland is found and a Parkia/Daniellia parkland in areas of intense cultivation.

The Alluvial Complex

This is characterised by Phoenix/Sysygium guineense riparian woodland.

PRESENT LAND USE

Density of cultivation

The density of cultivation was assessed from 1:40 000 scale aerial photographs taken in late 1971. Four percentage classes were distinguished, >60, 59 – 35, 34 – 10 and <10. The assessment was made within areas of 5 km^2 (1.95 mi^2) which are shown on Separate Map 2. Land lying within a field boundary was considered to be in the current cultivation cycle: no attempt was made to distinguish between land used for crops and short term fallow land.

Areas with more than >60% cultivation These are areas of intensive land use with little spare land. Population pressure is such that there is considerable land pressure. There is little grazing land available for grazing but nomadic herds may utilise some crop residues. The areas are considered unsuitable for the establishment of resettlement schemes, large mechanical cultivation farming projects or grazing and forest reserves because of problems associated with land tenure and the displacement of population.

Areas with 59 – 35% cultivation These are areas in which for the existing farming system there is a balance between population and available land. Any development in these areas will result either in a change in the farming system or increased pressure on the land, particularly a shortening of the fallow period. Although nomadic pastoralism is not impossible, there are likely to be severe problems associated with herding and damage to growing crops.

Areas with 34 – 10% cultivation These are areas with either a high proportion of land unsuitable for arable crops or there is unused land. Fallows are longer than in more intensively used areas. Land is available to support the nomadic pastoralists' herds and the establishment of more intensive forms

of agriculture where environmental conditions permit.

Areas with less than 10% cultivation These are areas of low population density with little pressure on the land: there is usually ample grazing land although, because of its present poor composition, it only provides satisfactory grazing during the wet season. Space is available for resettlement and mechanised farming schemes if other factors are favourable.

Distribution of cultivation

Separate Map 2 shows that much of the surface of the Plateau is intensively cultivated, with the heaviest cultivation density concentrated on the basalt flows at Vom, Miango, Riyom, and Panyam. Another area of dense cultivation occurs north and east of Mongu. The only extensive areas of land with less than 10% cultivation occur on the hills and mountains around the edges of the Plateau.

Present farming systems

Gosden (in press) described the agriculture of the Jos Plateau. It is characterised by rainfed upland farming, with small family farms cultivated by hand. The main food crop is the staple food grain, acha (Digitaria exiles) and the farming system has been defined as the Acha System.

The dominant crop acha is usually followed by transplanted long season bulrush millet (dauro), some finger millet (tamba) and sorghum. In the southern part of the Plateau maize is more important. Cocoyams, sweet potatoes and increasingly yams are grown for food. Surplus food crops are sold for cash and vegetables, a valuable source of income, are grown in wet areas including gully bottoms or with simple irrigation during the dry season. In the south, maize and Irish potatoes are frequently grown for sale.

Cultivation is almost entirely by hand, with only isolated use of draught animals and occasional limited use of government tractor hire services for land preparation. The acha is usually planted on the flat but dauro, tamba, Irish potatoes and maize are all grown on ridges. Yams, cocoyams and sweet potatoes are usually grown on large ridges though cocoyams are also grown on

large raised beds.

Cultivation is continuous or for long periods in the most intensively cultivated areas, such as Mba, Ra Hos, Katanya and Miango. Fallows do not exceed 2 years and cropping is often continuous. In less intensively cultivated areas fallows of about 4 to 5 years follow about 4 years cropping. Fertility is maintained by the combined use of short fallows, some cattle manure and fertiliser if available.

Cattle numbers are high all the year round on the Jos Plateau. Most of them are owned by nomadic or semi-nomadic Fulani though some farmers own a few beasts, usually Fulani breeds though there are some Muturu cattle. The farmers' cattle are often grazed with the Fulani herds, but are sometimes penned and fattened. Many of the Fulani herds move in the dry season to the floodplains of the Benue River and its tributaries.

Nomadic Fulani herds from Bauchi and Boruu cross the Jos Plateau in their seasonal migration to the Kafanchan and Abuja areas: small numbers of these cattle remain on the Plateau during the dry season.

Minor variations occur within the main farming system and are due to ethnic, climatic or physical differences. However, important distinctions can be recognised between below subsistance areas and areas with surplus food or cash crops.

In the below subsistance areas, in the northern parts of the Jos Plateau represented by sample villages Bomo/Katanye and Laminga/Forbor (see Separate Map 2) farm incomes have to be supplemented by outside employment, frequently in the tin mining industry. The low production of these areas may be due to intensive cultivation over a long period, of soils that have an inherently low fertility. As there has been little use of fertiliser the soils have become degraded. In subsistence areas farming supports the family but there is little surplus for sale. This type of farming occurs south of the below-subsistence areas from Miango to Gindiri and is represented by the sample villages of Miango, Gwaram/Rim, Ra Hos and Chemso (see Separate Map 2). In these areas much of the land is cultivated. The poor inherent fertility of most of the soils means that production is low. The short fallows and only limited use of fertilisers mean that there is little chance of improving the fertility status. In the south and south west of the Plateau in an area represented by the villages of Mbar and Mongun, crops such as maize, Irish

potatoes and dauro are produced in sufficient quantities to leave a surplus for sale.

The cultivation density is lower in these areas than further north and although the soils have a low fertility status, fallows are a little longer. As the grazing is better than in the northern areas there is probably a greater number of cattle and more use is made of manure for fertilisation.

Agricultural infrastructure

The agricultural services of Plateau State are organised according to administrative division. The Jos Plateau area described in this report lies within the former Jos and Pankshine Divisions. Available agricultural data are given by these Divisions but it should be borne in mind that there are parts of both Jos and Pankshin Divisions lying outside the area described here.

Data sources The data contained in the following tables are from Ministry of Natural Resources records. Records are incomplete for some administrative areas and some years.

Agricultural extension There is an Agricultural Officer in each Division responsible to headquarters in Jos. There are extension officers in each administrative district with field workers stationed in a number of the larger villages. The number of extension workers is given in Table 4.

TABLE 4 The distribution of agricultural workers, the numbers of farming families and the number of farming family per worker for Divisions≠ on the Jos Plateau

Administrative Division	No. of extension workers		No. of* farming families	No. of farming families/ extension workers	
	Field	Total		Field	Total
Jos	51	55	66 741	1 308	1 213
Pankshin	50	52	39 656	793	762

* Calculated from 1963 census figures up-dated by an estimated increase of 2.5% per annum and divided by 7. The urban population of Jos and Bukuru towns has not been included in these calculations

≠ Pre-1976 administrative areas are used in this table

Agricultural centres and institutions There is a farm centre at Riyom but no farm training centres or farm institutes. There is a fish farm at Panyam, and a mechanised farm at Bokkos, and schemes at Heipang and Batura. A small scheme provides irrigation for about 12 ha (30 ac) at Ganswuri and there are small soil conservation works at Miango and near Pankshin. There is storage for 2 000 tons of grain in Jos, and a central mechanical workshop in Bukuru, together with the Minesland Reclamation Unit.

Fertiliser Fertiliser is sold through the extension services and the latest available records of fertiliser sales are given in Table 5. As many of these data are from 1970/71 their value is questionable but are all that could be obtained.

TABLE 5 Sales of fertiliser in Jos and Pankshin Divisions*

Administrative Division	Year of records	Weight of fertiliser in tons	
		Superphosphate	Sulphate of Ammonia
Jos	72/3	228	200
Pankshin	70/1	310	350
	70/1	312	526
* Pre-1976 administrative units			

Agricultural chemicals These are mainly seed dressings sold through commercial outlets so no comprehensive records could be obtained. Demand is greatly in excess of supply.

Improved seed and planting material The distribution of improved seed in Jos and Pankshin Divisions is given in Table 6, and of tree crop seedlings which are mainly citrus in Table 7.

TABLE 6 The distribution of improved seed

Administrative Division*	Weight of seed kg (lb)				
	Maize	Sorghum	Groundnuts	Rice	Rame
Jos	3 810 (8 400)	-	218 (481)	181 (400)	18 (40)
Pankshin	45 459 (10 000)	136 (300)	1 000 (2 205)	-	-
* Pre-1976 administrative units					

TABLE 7 The distribution of tree crop seedlings

Administrative Division*	No. of seedlings			
	70/71	71/72	72/73	73/74
Jos	741	3 600	2 000	1 168
Pankshin	1 248	650	410	173
* Pre-1976 administrative units				

Mechanical cultivation The Ministry of Agriculture provides tractors for hire at subsidised rates. Operations are restricted to ploughing, ridging and harrowing. In December 1975 there were 7 tractors available for hire in Jos Division and 2 in Pankshin Division. Two other tractors belonging to the tractor hiring unit were listed as non-functional.

The areas cultivated by the tractor hiring units are given in Table 8. In addition 18 ha (44 ac) of fadama land were ploughed and harrowed in Pankshin Division.

TABLE 8 Area of land cultivated by tractor hiring units

Administrative Division*	Area cultivated, in ha (ac)								
	1972/3			1973/4			1974/5		
	P	H	R	P	H	R	P	H	R
Jos	26.3 (65)	4.8 (12)	3.6 (9)	72.8 (180)	- -	- -	226.2 (559)	21.8 (54)	22.3 (55)
Pankshin	72.0 (178)	193.4 (478)	10.5 (26)	197.1 (487)	163.3 (406)	- -	133.5 (330)	- -	2.8 (7)

P = Ploughing, H = Harrowing, R = Ridging
* Pre-1976 administrative units

These figures indicate that the tractors which represent a considerable capital investment are not fully utilised as in Jos in 1974/75 the average area cultivated by one tractor was only 38.6 ha (95.3 ac).

Rangeland

Rangeland and cattle production on the Jos Plateau have been described by Blair Rains (1975 and in press).

The Jos Plateau has special advantages for cattle production as it is tsetse free and has a higher rainfall than the surrounding plains, but intensive cultivation and widespread opencast mining activities seriously reduce the area available for pasture and rangeland production.

The main factors to be considered in the assessment of the potential of an area for livestock production are the natural vegetation and the ways in which man has modified it. Thus, it depends not only on the palatability and nutritive value of grasses and browse and the balance between herbaceous and woody vegetation, but also on the amount of cultivation, the availability of crop residues, the amount of grass that is burnt, the time of year it is burnt and the number of cattle that are in an area. It is important to recognise that the carrying capacity of an area is very different in the wet and dry seasons, and it is the dry season carrying capacity that determines year-round carrying capacity. (In some close farmed areas fodder resources are greater in the dry season than in the wet season).

Fodder resources

Grassland The natural vegetation of the Jos Plateau has been described in an earlier section of this report. Blair Rains (1975) in considering the carrying capacity has divided the Jos Plateau into northern and southern portions. In the north the grassland is degraded and only has species such as Eragrostis tremula, Rhynchelytrum repens, Michrochloa indica, Setaria spp. and Ctenium elegans: species such as Eragrostis atrovirens and Hyparrhenia rufa may occur in more poorly drained sites. Although most of these species are usually considered unpalatable and of low nutritive value they are all heavily grazed due to the high cattle population. The intensive grazing also means that herbage production is very low. In the southern part of the Plateau the species composition is better with Brachiaria jubata, Schizachyrium spp., Setaria anceps and Hyparrhenia spp.. However, herbage production is again very low because of the heavy grazing. Because of mining and dry season farming there is little flood plain grassland available for grazing.

Fodder trees The Jos Plateau is virtually treeless so fodder trees make no contribution to animal nutrition.

Crop residues Reference to Separate Map 2 shows that most of the main surface of the Plateau is intensively cultivated. The main crop residues are the straw and stubble from acha. The straw yields of acha are estimated at not more than 500 - 600 kilos/hectare (500 - 600 lb/ac) and the threshed straw is frequently burnt. Other crops commonly grown on the Plateau do not yield particularly useful residues.

Burning

Fire is not common on the Jos Plateau mainly because of the intensive cultivation: the short fallows and the heavy grazing result in an absence of material to burn. The vegetation growing in pockets of deeper soil in small valleys within rocky areas is frequently burnt to produce a flush of new growth.

Tsetse

The Jos Plateau is free of tsetse throughout the year.

Cattle population

The Jos Plateau has had a large livestock population since at least the early years of the century. The estimated cattle population of the Plateau is 400 000. The total area of the Plateau is 8 600 km^2 (3 300 mi^2) of which 4 404 km^2 (1 700 mi^2) is rocky hill country of limited use for grazing. This means that there is 1 animal per 1.04 ha (1:2.5 ac) on the main Plateau surface.

Carrying capacity

The high density of cultivation, the short fallows and the intensive grazing all result in a low herbage production, making it very difficult to make a realistic estimate of carrying capacity. However if cattle movements could be controlled to allow a longer interval between successive grazing of the same area, a much greater production of herbage of only slightly poorer quality would result. Carrying capacity would then be approximately 1:1.2 - 1.6 ha (1:3 - 4 ac) of grassland and older fallows, year round.

With the present cattle population there is already 1 animal per 1.04 ha (1:2.5 ac) and there is no control of cattle movement, production from the herds is low and the area is overgrazed: this is borne out by the condition of the natural grassland.

Forestry

Howard (1976) has discussed forestry activities on the Jos Plateau.

Most of the undulating surface is virtually treeless as the trees and shrubs have been removed by shifting cultivation and browsing cattle.

Forest reserves Most of the forest reserves have been sited on the dissected

country bounding the Plateau on the west and south: because of the shortage of land there are only six reserves on the Plateau surface. See Separate Map 2. The total area of reserves is 416 km^2 (157 mi^2). In addition to the forest reserves there are Communal Forest Areas (CFAs) usually planted with eucalypts, which are small areas of land set aside by the Local Authority to grow forest produce for the community: farming is forbidden except as a means of weeding the plantation. Mines Reclamation Areas (MRAs) are areas in which the Mines Land Reclamation Unit (MLRU) has levelled ground disturbed by open cast tin mining. Eucalypts are planted on the levelled mining spoil and so far 1 165 ha (2 879 ac) have been planted in 61 MRAs. Howard (1975) questions the practice of levelling the mining spoil using heavy equipment as the soil becomes compacted, thus reducing the growth of the trees. In recent years the MLRU has not been very active because of a lack of equipment.

Plantations Eucalypts are the most commonly planted trees as the elevation of 1 000 - 1 400 m (3 500 - 4 500 ft) and rainfall 1 400 mm (55 in) of the Jos Plateau provide an ideal environment. In 1958 there was a breakthrough in nursery technique with seedlings raised in polythene pots with dieldrin dust in the potting mixture. An irrigated nursery was established at Bukuru in 1960 to raise 600 000 seedlings per year. In recent years a total of 787 ha (1 945 ac) of eucalypts have been planted in forest reserves at Naraguta, Kuru, Jere and Heipang. Measurements of the growth rates of eucalypts on the Jos Plateau show mean annual increments of E camaldulensis ranging from 2 - 13 $m^3/ha/a$. The trees raised from local seed have poor form and suffer from gum exudation. Provenance trials of seed from Australia indicate that Katherine and Bullock Creek provenances provide trees of good form and high yield (Jackson 1974). Research is continuing into the provenance of eucalypts, the choice of species and fertiliser application.

Economic farm trees There is a tradition on the Plateau of preserving trees of economic importance, but these are usually found in the villages, often among rocks. Common species are Khaya grandifoliola and Canarium schweinfurthii. Many of the villages nowadays have eucalypts planted in the compounds and along the boundaries of the fields.

Mining

Reference to Separate Map 1 shows that there are 316 km^2 (122 mi^2) of land on the Jos Plateau that have been disturbed by open-cast tin mining.

In 1945 legislation was introduced requiring at least 70% reclamation by the mining company before a lease can be relinquished. There are a number of leases relinquished before 1945 that still require reclamation. There is also a large area of land that remains unreclaimed because the mining companies are unwilling to relinquish the leases even though they are at present not being worked. This is because there are residual deposits of tin that may become economic to work if the price of tin increases. The Minesland Reclamation Unit (MLRU) was set up to reclaim leases relinquished before 1945 and in conjunction with the Forestry Department rehabilitate all reclaimed mining land by planting with Eucalyptus. The MLRU has suffered from lack of staff and equipment and as a result there are large areas of disturbed land that have neither been reclaimed nor planted. Howard (1975) has shown that the policy of levelling the mining spoil with heavy equipment, leads to compaction and a reduced growth of the Eucalyptus. He has also distinguished a number of ecological zones within areas of mining spoil that might be utilised separately. In addition, the excavations form reservoirs for water which is at present mainly used by the mining companies themselves.

Erosion

Jones (1975) has reported on the special erosion problems on the Jos Plateau. He has identified and mapped approximately 7 250 km (4 500 mi) of gully representing a volume of 100 million tons of soil lost. The length of gully per square mile of each land system is shown on the legend accompanying Separate Map 1.

The gullying is brought about by the high natural soil erodibility, tin mining, overgrazing and cultivation methods. In addition to the gullying, sheet erosion is severe over much of the Plateau.

Part 3

Part 3 Environmental factors and present land use in relation to development

INTRODUCTION

In this part of the report we are presented the facts about the environment and present land use, from which the development possibilities given in Part 4 have been identified. The basic unit of description is the land system, but for convenience these have been grouped according to the number of crop options, that is to say the number of crops for which there are few environmental limitations: this grouping reflects the versatility of the land. The assessment of environmental factors in terms of limitation to particular crops is explained in Appendix 1. The groups are shown on Separate Map 3, in Table 9 and described in the following sections. As the groups have limitations in common due to climate these are discussed for the Jos Plateau as a whole.

CLIMATIC FACTORS IN RELATION TO CROP GROWTH

The climatic factors of major importance to crop growth are the length of the rainy period, maximum and minimum temperature, global radiation and the number of hours of sunshine during the growing season. The factors have been described in Part 2 and are considered here in terms of their effect on the production of maize, millet, sorghum, groundnuts, cotton, rice and yams.

TABLE 9 Land systems grouped according to the number of crop options

Administrative unit	Land systems grouped according to the number of crop options							
	6 crops	5 crops	4 crops	3 crops	2 crops	1 crop	Moderate or severe limitations to crops considered	Unsuitable for annual rainfed crops
Plateau State								
Bassa			LS113, 128	LS114, 121		LS108	LS107	LS1,2,101, 102,103, 104
Jos	LS110, 115		LS113, 128	LS114, 121		LS108, 120	LS107,119	LS1,1,101, 102,103, 104
Barakin Ladi	LS109, 110, 115, 116, 122, 130	LS129	LS128	LS112, 114, 131	LS125	LS120	LS107,111, 119	LS1,2,102, 103,104, 106
Mangu	LS109, 130	LS117, 129	LS123, 124, 128	LS131	LS125, 126		LS111,119, 127	LS1,2,102, 103,105, 106
Pankshin	LS130	LS117	LS123				LS127	LS1,2,101, 102,103, 105
Ankwanga							LS111	
Shendam								LS1,102
Lafia								LS1
Bauchi State								
Toro								LS1,104
Tafawa Balewa								LS1,101
Kaduna State								
Saminaka								LS1
Kachia			LS128					LS1
Jema'a							LS111	LS1,101

Over most of the Jos Plateau the rainy period is 180 days. As all the crops under consideration except rice have a growing season of less than 180 days the length of the rainy period is not a limitation. Upland rice requires a rainy period of at least 200 days so the crop is likely to suffer moisture stress and its cultivation is not considered on the Jos Plateau. Kowal and Knabe (1972) give a range of 16.6 - 18.5°C (61.9 - 65.3°F) as minimum temperatures during the growing season on the Jos Plateau. Temperature is considered a minor limitation to the growth of all the crops except for cotton for which it is a moderate to severe limitation and yams for which it is a moderate limitation. Global radiation and sunshine hours during the growing season are low, and this lack of photosynthetic energy forms a minor limitation to the growth of all crops except cotton: it presents a severe limitation to the growth of cotton. Because of the limitations due to temperature and radiation the climate of the Plateau is not considered suitable for cotton.

Improved varieties of dwarf sorghum developed at the Institute for Agricultural Research, Samaru, have not been successful on the Plateau. It is thought that this failure is due to adverse climatic factors though this needs further investigation.

LAND SYSTEMS WITH SIX CROP OPTIONS

This land occurs in Jos, Barakin Ladi, Mangu and Pankshin Local Government Areas and comprises seven land systems occupying 1 299 km^2 (502 mi^2). The main characteristics are summarised in Table 10 and discussed below.

Limitations to crop growth

1. Soil physical characteristics

All the land systems in this group have no or only minor limitations to the growth of six crops: the physical soil limitations are shown in Table 11.

TABLE 10 Summary of main characteristics of areas with six crop options

Land system no	Crop options	Occurrence	Density of cultivation	Present cropping		Draught animals	Erosion hazard	Communications	Rangeland and cattle production	Forestry
				Food	Cash					
109	Maize, Millet Sorghum, Groundnut, Yams, Potatoes	Mangu and Barakin Ladi LGAs	Sparse. Pocket of intensive cultivation west of Daffo	Acha, Cocoyam Maize, Dauro	Maize, Acha Potatoes	Nil	Moderate	Moderate to poor. Secondary roads cross northern and southern margins	Rangeland has good species composition. Wet and early dry season grazing	No forest resources. No natural vegetation for firewood
110	"	Jos and Barakin Ladi LGAs	Moderate to intensive	Acha, Dauro Yams	Very little vegetable Groundnuts Cassava	Nil	Moderate	Moderate to good	Mainly degraded rangeland. Intensive wet and dry season grazing	"
115	"	Jos and Barakin Ladi LGAs	Moderate to intensive	Acha, Tamba Sorghum, Dauro	Maize, Acha Potatoes	Nil	Moderate	Good. Main road passes through land system	"	"
116	"	Barakin Ladi LGA	Sparse	Acha, Tamba Sorghum	Small amount surplus food	Nil	Moderate	Poor	Rangeland has good species composition. Wet and early dry season grazing	"
122	"	Barakin Ladi LGA	Intensive	Acha, Tamba Dauro	Very little Dauro Sugar Cane	Nil	Slight	Good. Main road passes through land system	Degraded rangeland due to short fallows, intensive wet and dry season grazing	Very small area in Assob Bachit F.R.
130	"	Mangu Barakin Ladi and Pankshin LGAs	Intensive	Sorghum, Acha Maize, Dauro	Cassava, Sorghum Food crops Potatoes	Nil	Slight	Moderate. Secondary road crosses the centre of the land system	"	Forest Reserve at Langai/ Mongu

TABLE 11 Soil physical limitations to the growth of certain crops in areas with six crop options

Land system					% Soil limitation category (SLC) by crop in each land system with nature of limitation*																	
No	Total area		Area to which SLC data refer		Maize			Millet			Sorghum			Groundnuts			Yams			Potatoes		
	km^2	mi^2	km^2	mi^2	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation
109	139	54	131	51	1 3	30-59 10-29 10-29	Nil C Gully	2 3	30-59 10-29 10-29	t C Gully	1 3	30-59 10-20 10-29	Nil C Gully	2 3	30-59 10-29 10-29	t C Gully	1 3	30-59 10-29 10-29	Nil C Gully	2 3	30-59 10-29 10-29	t tC Gully
110	183	71	128	49	2	>60	w	2	>60	wt	2	>60	w	2	>60	t	1	>60	Nil	2	>60	t
115	235	91	241	93	2 3	30-59 10-29 10-29	w C Gully	2 3	30-59 10-29 10-29	wt tC Gully	2 3	30-59 10-29 10-29	w C Gully	2 3	30-59 10-29 10-29	t tC Gully	1 3	30-59 10-29 10-29	Nil C Gully	2 3	30-59 10-29 10-29	t tC Gully
116	42	16	38	15	1	>60 10-29	Nil Gully	2	>60 10-29	t Gully	1	>60 10-29	nil Gully	2	>60 10-29	t Gully	1	>60 10-29	Nil Gully	2	>60 10-29	t Gully
122	89	34	73	28	1	>60	Nil	2	>60	t	1	>60	Nil	2	>60	t	1	>60	Nil	2	>60	t
130	611	236	470	181	2 3 4	30-59 10-29 10-29	w C Wtc	2 3 4	30-59 10-29 10-29	t tC Wc	1 3	30-59 10-29	Nil wtc/C	2 3	30-59 10-29	t wc/tC	1 3	30-59 10-29	Nil C	2 3	30-59 10-29	t Wc/tC

*Limitations

Depth	Drainage	Texture	Coarse material
D Severe	W Severe	T Severe	C Severe
D Moderate	W Moderate	T Moderate	C Moderate
d Minor	w Minor	t Minor	c Minor

Alternative limitations are separated by an oblique stroke

TABLE 12 Dominant soil chemical characteristics assessed as limitations to crop growth for land systems with six crop options (top 50 cm of soil profile only)

Land system	CEC* meq %	Exch K ** meq %	pH	Limitations due to pH for						
				Maize	Millet	Sorghum	Groundnuts	Yams	Potatoes	P availability ≠
109	10.5	0.4	4.6	Sev	Min	Mod	Mod	Min	Min	Sev
110	4.5	0.2	4.9	Sev	Min	Mod	Mod	Min	Nil	Sev
115	3.9–4.5	0.2–0.6	5.3–4.9	Mod–Sev	Nil–Min	Min–Mod	Min–Mod	Nil–Min	Nil	Mod–Sev
116	7.6	0.5	5.0	Sev	Nil	Min	Min	Nil	Nil	Mod
122	12.4	0.6	5.4	Mod	Nil	Min	Min	Nil	Nil	Mod
130	8.1	0.4–0.6	6.0–5.3	Nil–Min	Nil	Nil–Min	Nil	Nil	Nil	Mod

* CEC meq % soil: >8 Suitable for intensive agriculture, 2.0–7.9 Requires a high rate of fallow to crops, <2.0 Unsuitable for intensive production of annual arable rainfed crops (Adetunji, 1974).

** K meq at pH >4.5: >0.10 Adequate <0.10 Deficient

≠ P availability related to pH:

pH	Limitations
6.5–7.5	Nil
6.0–6.49 7.51–8.0	Minor
5.0–5.9 8.1–8.5	Moderate
<5.0	Severe

There are minor drainage limitations to most of the crops considered in Land Systems 110 and 130 and minor limitations due to coarse material or texture in 109, 115 and 130. There are appreciable areas of gullied land in Land Systems 109, 115 and 116 in which there is either no soil development or the soil is eroded and disturbed.

2. Soil chemical characteristics

The chemical characteristics for which data is available are shown in Table 12 and assessed as limitations to the growth of the crops considered.

Limitations to mechanical cultivation

The predominant slopes in these areas are given in Table 13 together with the range of slopes found on the major facets of each land system.

TABLE 13 Dominant slopes and slope range on major facets in areas with six crop options

Land system	Slopes of major facets			
	Percent		Degrees	
	Dominant	Range	Dominant	Range
109	5.2	3.5 – 10.5	3	2 – 6
110	5.2	1.7 – 7.9	3	1 – 4
115	3.5	1.7 – 5.2	2	1 – 3
116	4.4	3.5 – 7.9	$2\frac{1}{2}$	2 – 4
122	1.7	0.9 – 3.5	1	$\frac{1}{2}$ – 2
130	2.6	1.7 – 5.2	$1\frac{1}{2}$	1 – 3

These figures show that land systems 122 and 130 will require some conservation measures: all other land systems will require strict conservation measures and because of the complexity of the layout it is unlikely that mechanised farming

will be economic except for high value crops.

There are commonly small rocky hills and outcrops in Land Systems 110 and 122 which may be additional limitations to mechanical cultivation.

Density and distribution of cultivation

Reference to Separate Map 2 and Table 14 shows that Land Systems 122 and 130 are intensively cultivated. Although Land Systems 110 and 115 are less intensively used, there is little spare land. Land System 109 has only a moderate cultivation density, though there are pockets of intensive cultivation to the north of Daffo.

Farming systems

The acha farming system predominates in these areas but there are variations in the level of crop production corresponding to below subsistence, subsistence and subsistence-plus farming.

1. Mainly below subsistence

Main characteristics Land System 110 found to the east of Jos and Bukuru generally supports a rather poor below-subsistence type of farming. There is some mining disturbance, and farmers reported soil fertility to be very low due to the inherently low fertility aggravated by intense cultivation in the past. Acha, dauro, yams and cassava are the main food crops. Where possible vegetables, groundnuts and cassava, are cultivated for sale but many people have to rely on outside employment to supplement farm incomes. The land is cultivated for 3 - 7 years followed by a similar period of fallow. No cattle ownership is practiced by the arable farmers. Though there is a local settled Fulani population they appear to be reluctant to part with their cattle manure.

Constraints to production This area suffers particularly from the weed Striga and from a shortage of domestic water.

TABLE 14 Density of cultivation in areas with six crop options

Land system	Total area		Local government area	Areas (km^2) occupied by density of cultivation (percentage) class				% of <10% density class in forest reserves
	km^2	mi^2		>60%	59–35%	34–10%	<10%	
109	139	54	Barakin Ladi			5	4	
			Mangu	43		63	24	
110	183	71	Jos	7	11	73	25	4
			Barakin Ladi	29	20	18		
115	235*	91	Jos	4	9	8		
			Barakin Ladi	112	16	86		
116	42	16	Barakin Ladi			28	14	
122	89	34	Barakin Ladi	17	56	9	7	
130	611	236	Pankshin	34	3	1	5	
			Barakin Ladi		23			
			Mangu	222	245	57	21	95

* Recomputation. Area different to that on Separate Map 1

Rangeland Due to intensive grazing the grassland is degraded. Valley bottoms are either disturbed by mining or gullied so there is no flood plain grassland and little crop residue for dry season feeding.

Forestry There are no forest reserves and no natural vegetation to provide firewood.

2. Mainly subsistence

Main characteristics Land Systems 115, 116, 122, 130 generally support farming on a subsistence level. The Acha farming system predominates but towards the east in the Gindiri area (Land System 130) sorghum becomes increasingly important. Various food crops are sold; sweet potatoes and cocoyam in Land System 122, some grain crops and a limited amount of Irish potatoes in many places. Some sorghum is sold in the Gindiri area. Cropping is almost continuous in Land System 122, with only about 4 years fallow after 20 - 30 years In Land System 116 land is cropped for 2 - 4 years followed by about 6 years fallow. Elsewhere, about 4 years fallow follows the same period of cropping. Some of the arable farmers own cattle and there is a large population of settled Fulani. Nomadic herds come from Bauchi during the dry season. The value of manure is appreciated and often paid for in cash or kind.

Rangeland Because of the intensive grazing the grassland is degraded in all these land systems except 116. In the densely cultivated Land Systems 122 and 130 there is little spare land available for grazing.

Forestry There are forest reserves at Mongu and Langai in Land System 130, but elsewhere no natural vegetation to provide firewood.

3. Mainly subsistence-plus

Main characteristics In Land System 109 in the south west of the Jos

Plateau farmers produce surplus crops for sale. As well as the food crops acha, dauro, cocoyams and yams, appreciable amounts of maize and Irish potatoes are grown for sale. Fallows of up to 7 years, follow 4 years under crops. Some of the arable farmers own cattle which they graze with the local Fulani herds and sheep are commonly kept in this area.

Rangeland The grassland in this area has a good species composition and intensive grazing maintains a close sward of palatable grass. It is used for both wet and dry season grazing.

Forestry There are no forest reserves and no natural vegetation to provide firewood.

LAND SYSTEMS WITH FIVE CROP OPTIONS

This land occurs in Mangu, Barakin Ladi and Pankshin Local Government Areas and is made up of two land systems occupying 300 km^2 (116 mi^2). The main characteristics are summarised in Table 15 and discussed below.

Limitations to crop growth

1. Soil physical characteristics

The land systems in this group have no or only minor limitations to the growth of five of the crops considered: the soil limitations are shown in Table 16. Drainage is a limitation to all crops except yams grown on mounds in Land System 129 and shallow soils a limitation in Land System 117.

2. Soil chemical characteristics

The chemical characteristics for which data are available are shown in Table 17 and assessed as limitations to the growth of the crops considered.

Limitations to mechanical cultivation

The predominant slopes in these areas are given in Table 18 together with the range of slopes found on the major facets of each land system.

TABLE 18 Dominant slopes and slope range on major facets in areas with five crop options

Land System	Slopes of major facets			
	Percent		Degrees	
	Dominant	Range	Dominant	Range
117	5.2	3.5–10.5	3	2–6
129	3.5	1.7– 7.9	2	1–4

TABLE 15 Summary of main characteristics of areas with five crop options

Land system no.	Crop options	Occurrence	Density of cultivation	Present cropping		Draught animals	Erosion hazard	Communications	Rangeland and cattle production	Forestry
				Food	Cash					
117	Maize Sorghum Groundnuts Yams Potatoes	Pankshin and Mangu LGAs	Sparse	Acha Dauro Maize	Dauro Potatoes	Nil	Moderate	Moderate to poor. Secondary road passes close to the northern edge of the land system	Rangeland has good species composition. Intensive wet season grazing	No forest reserves No natural vegetation for firewood
129	"	Barakin Ladi and Mangu LGAs	Intensive	Sorghum Acha Maize Dauro	Cassava Sorghum Potatoes Food crops	Nil	Moderate	Poor	Degraded rangeland due to short fallows and intensive wet and season grazing	"

TABLE 16 Soil physical limitations to the growth of certain crops in areas with five crop options: crop options indicated by shading

Land system					% Soil limitation category (SLC) by crop in each land system with nature of limitation*																			
No.	Total area		Area to which SLC data refer		Maize			Millet			Sorghum			Groundnuts			Yams			Potatoes		
	km^2	mi^2	km^2	mi^2	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation
117	167	64	142	55	1 2	10–29 30–59 10–29	Nil w Gully	2 4	30–59 10–29 10–29	wt Dc Gully	1 4	30–59 10–29 10–29	Nil Dtc Gully	2	> 60 10–29	t Gully	1 3	30–59 10–29 10–29	Nil tc Gully	1 2	10–29 30–59 10–29	Nil t Gully
129	133	51	105	40	1 3	30–50 30–50	Nil wt	2 3	30–50 30–50	t W	1 2	30–50 30–50	Nil wt	2	> 60	w/t	1 3	30–50 30–50	Nil t	2 3	30–50 30–50	t W

*Limitations

Depth	Drainage	Texture	Coarse material
D Severe	W Severe	T Severe	C Severe
D Moderate	W Moderate	T Moderate	C Moderate
d Minor	w Minor	t Minor	c Minor

Alternative limitations are separated by an oblique stroke

TABLE 17 Dominant soil chemical characteristics assessed as limitations to crop growth for land systems with five crop options (top 50 cm of soil profile only)

Land system	CEC* meq %	Exch. K** meq %	pH	Limitations due to pH for						
				Maize	Millet	Sorghum	Groundnuts	Yams	Potatoes	P availability †
117	4.5	0.2	4.9	Sev	Min	Mod	Mod	Min	Nil	Sev
129	3.9–5.2	0.1–0.6	5.3–5.5	Min	Nil	Min	Min	Nil	Nil	Mod

*CEC meq %: >8 Suitable for intensive agriculture; 2.0–7.9 Requires a high ratio of fallow to crops, <2.0 Unsuitable for intensive agriculture (Adetunji, 1974)

**K meq % for soils of pH > 4.5: >0.10 Adequate; <0.10 Deficient

†P availability related to pH:

pH	Limitations
6.5–7.5	Nil
6.0–6.49) 7.51–8.0)	Minor
5.0–5.9) 8.1–8.5)	Moderate
<5.0	Severe

These figures show that both land systems would require elaborate conservation measures to prevent erosion under mechanical cultivation: the complexity of the lay-out would prevent the economic running of machinery, except for high value crops.

Density and distribution of cultivation

Reference to Separate Map 2 and Table 19 shows that Land System 117 is only sparsely cultivated. Most of Land System 129 is densely cultivated.

Farming systems

The acha farming system predominates in these areas which can be divided into subsistence and subsistence plus farming.

1. Mainly subsistence

Main characteristics In Land System 129 acha is the predominant crop but sorghum is of considerable importance. Maize, dauro, and some root crops such as cassava, sweet potatoes and cocoyams are also grown. Cassava, sorghum, Irish potatoes and other surplus food crops are sold. Four years' cropping is usually followed by about 4 years' fallow. Many farmers own their own cattle as well as a number of goats, sheep and poultry, and there is a large population of settled Fulani with their herds, augmented by nomadic herds from Bauchi in the dry season. The value of manure is appreciated and often paid for in cash or kind.

Constraints to production This area suffers from particularly poor communications.

Rangeland The high density of cultivation, relatively short fallows and high cattle population mean that the grassland is degraded.

TABLE 19 Density of cultivation in areas with five crop options

Land system	Total area		Local government area	Areas (km^2) occupied by density of cultivation (percentage) class				% of <10% density class in forest reserves
	km^2	mi^2		>60%	59–35%	34–10%	<10%	
117	167	64	Pankshin			4		
			Mangu	13	4	78	68	1
129	133	51	Mangu	6	59	2		
			Barakin Ladi	8	50	8		

Forestry There are no forest reserves and no natural vegetation to provide firewood.

2. Mainly subsistence plus

Main characteristics Land System 117 is mainly sparsely cultivated but some of the population were reported to be leaving the area. Acha, dauro and maize are produced for food with lesser amounts of cocoyam and sweet potatoes. Surpluses are sold together with potatoes. About 4 years' cultivation is follow by up to 7 years' fallow. Muturu cattle are often kept, penned in a walled enclosure at the back of the family compound. The District Council has established District Grazing Areas, which are moved every few years: the manured area is then cultivated. There is a settled population of Fulani with their herds, and nomadic herds come from Bauchi and Gombe at harvest time passing on to Akwanga and Abuja and returning at the start of the rains.

Rangeland The grassland has a good species composition and intensive grazing maintains a close sward of palatable grasses. The area is used for both wet and dry season grazing.

Forestry There are no forest reserves and no natural vegetation to provide firewood.

LAND SYSTEMS WITH FOUR CROP OPTIONS

This land occurs in Bassa, Jos, Mangu, Pankshin, Barakin Ladi and Kachia Local Government Areas and is made up of four land systems occupying 437 km^2 (170 mi^2). The main characteristics are summarised in Table 20 and discussed below.

Limitations to growth

1. Soil physical characteristics

The land systems in this group have no or only minor limitations to the growth of four crops: the soil limitations are shown in Table 21. Drainage is a moderate limitation to the growth of maize in Land System 113. In Land System 123 there are appreciable areas of shallow, poorly drained soils which are limiting to the growth of most of the crops considered: these soils are not thought to be limiting to the growth of yams as this crop is grown on mounds which provide extra depth and better drainage. Land System 113 has areas of severe gullying in which there is either no soil development or the soils are eroded and disturbed.

2. Soil chemical characteristics

The chemical characteristics for which data are available are shown in Table 22 and assessed as limitations to the growth of the crops considered.

Limitations to mechanical cultivation

The predominant slopes in these areas are given in Table 23 together with the range of slopes found on the major facets of each land system.

TABLE 20 Summary of main characteristics of areas with four crop options

Land system no	Crop options	Occurrence	Density of cultivation	Present cropping		Draught animals	Erosion hazard	Communications	Rangeland and cattle production	Forestry
				Food	Cash					
113	Millet Groundnuts Yams Potatoes	Jos & Bassa LGAs	Moderate to intensive	Acha Dauro Yams	Very little vegetables Cassava Groundnuts	Nil	Moderate	Good. Main roads pass through the land system	Degraded rangeland due to short fallows and intensive grazing	Forest reserves at Naraguta and Radung
123	Maize Sorghum Yams Potatoes	Mangu & Pankshin LGAs	Intensive	Acha Dauro Maize	Millet Potatoes Sweet potatoes Cocoyams	Nil	Slight	Good. Main and secondary roads cross the land system	"	No forest reserves No natural vegetation for firewood collection
124	Maize Sorghum Yams Potatoes	Mangu LGA	Intensive	Most of land system occupied by Bokkos Farm						
128	Millet Sorghum Yams Potatoes	Bassa Jos Mangu Barakin Ladi Kaehia LGAs	Intensive to moderate	Acha Dauro Maize Cocoyams	Maize Dauro Potatoes Food crops	Nil	Slight to moderate	Moderate. Secondary roads cross the land system	Degraded rangeland due to short fallows and intensive grazing	Forest reserves at at Chawal Escarpment. Little natural vegetation for firewood collection elsewhere

TABLE 21 Soil physical limitations to the growth of certain crops in areas with four crop options: crop options indicated by shading

Land system					% Soil limitation category (SLC) by crop in each land system with nature of limitation*																	
No	Total area		Area to which SLC data refers		Maize			Millet			Sorghum			Groundnuts			Yams			Potatoes		
	km²	mi²	km²	mi²	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation
113	162	63	148	57	3 5	30–59 10–29 10–29	W/wt DC Gully	2 3	30–59 10–29 10–29	w Wt Gully	2 5	30–59 10–29 10–29	wt DC Gully	1 3	30–59 10–29 10–29	Nil wt Gully	1 4	30–59 10–29 10–29	Nil C Gully	1 3	30–59 10–29 10–29	Nil wt Gully
123	92	36	85	33	1 5	30–59 30–50	Nil DWc	2 5	30–59 30–50	t DW tc	1 5	30–59 30–50	Nil DWc	2 5	30–59 30–50	t DWtc	1	⩾ 60	Nil	2 4 5	30–59 10–29 10–29	t Wt D
124	83	32	71	27	1 3	30–50 30–50	Nil C	2 3	30–50 30–50	t tC	1 3	30–50 30–50	Nil C	2 3	30–50 30–50	t tC	1 3	30–59 30–50	Nil C	2 3	30–59 30–50	t tC
128	100	39	81	31	1 3 5	10–29 30–50 10–29	Nil wc D/DC	2	⩾ 60	tc	1 2 5	10–29 30–50 10–29	Nil c D/DC	2 3 5	10–29 30–50 10–29	t tc D/DC	1	⩾ 60	Nil	2	⩾ 60	t

*Limitations

Depth	Drainage	Texture	Coarse material
D Severe	W Severe	T Severe	C Severe
D Moderate	W Moderate	T Moderate	C Moderate
d Minor	w Minor	t Minor	c Minor

Alternative limitations are separated by an oblique stroke

TABLE 22 Dominant soil chemical characteristics assessed as limitations to crop growth for land systems with four crop options (top 50 cm of soil profile only)

Land system	CEC* meq %	Exch. K** meq %	pH	Limitations due to pH for						
				Maize	Millet	Sorghum	Groundnuts	Yams	Potatoes	P Availability †
113	4.5	0.2	4.9	Sev	Min	Mod	Mod	Min	Nil	Sev
123	12.4	0.6	5.4	Min	Nil	Min	Min	Nil	Nil	Mod
124	4.6–5.8	0.3	4.8–5.0	Sev	Min	Mod	Mod	Min	Nil	Sev
128	4.6–5.8	0.3	4.8–5.0	Sev	Min	Mod	Mod	Min	Nil	Sev

*CEC meq %: >8 Suitable for intensive agriculture; 2.0–7.9 Requires a high ratio of fallow to crops, <2.0 Unsuitable for intensive agriculture (Adetunji, 1974)

**K meq % for soils of pH >4.5:>0.10 Adequate; <0.10 Deficient

†P availability related to pH:

pH	Limitations
6.5–7.5	Nil
6.0–6.49) 7.51–8.0)	Minor
5.0–5.9) 8.1–8.5)	Moderate
< 5.0	Severe

TABLE 23 Dominant slopes and slope range on major facets in areas with four crop options

Land system	Slopes of major facets			
	Percent		Degrees	
	Dominant	Range	Dominant	Range
113	3.5	1.7–7.9	2	1–4
123	1.7	0 –3.5	1	0–2
124	3.5	1.7–5.2	2	1–3
128	2.6	1.7–5.2	1½	1–3

These figures show that Land Systems 113 and 124 require strict conservation measures and although Land Systems 123 and 128 have gentler slopes they will still require conservation practices.

The presence of small rock outcrops in all the land systems and ironpan in Land System 113 will be an additional limitation to mechanical cultivation. The complexity of the erosion control measures would prevent the economic running of machinery except for high value crops.

Density and distribution of cultivation

Reference to Separate Map 2 and Table 24 shows that Land System 123 is densely cultivated. Land Systems 113 and 128 are less cultivated but there is little spare land. Land System 124 is mainly occupied by the Bokkos Farm.

Farming systems

The acha farming system predominates in these areas and they can be divided into below subsistence and subsistence-plus farming.

TABLE 24 Density of cultivation in areas with four crop options

Land system	Total area		Local government area	Areas (km^2) occupied by density of cultivation (percentage) class				% of <10% density class in forest reserves
	km^2	mi^2		≥60%	59–35%	34–10%	<10%	
113	162	61	Bassa	30	12	19	6	
			Jos	12	5	44	17	35
123	92	36	Pankshin	19		15	9	
			Mangu	12	23	9	5	
124	83	32	Mangu	44	21	18		
128	100	39	Mangu	30	25	11	2	
			Jos		3			
			Bassa	12	7	1		
			Barakin Ladi	3	2	1		66
			Kachia				3	66
Area different to that in key on Separate Map 1. Mining spoil and ironpan areas now excluded								

1. Mainly below subsistence

Main characteristics In Land System 113 the cultivation density is high but there is a considerable amount of mining disturbance and agricultural production is well below subsistence level. Acha, dauro, sweet potatoes and finger millet are the food crops, but there is little produced for sale and employment other than farming is essential. Cropping is almost continuous, though 1 year fallow may follow 3–6 years cropping. There are no locally owned cattle but a high population of both settled and nomadic Fulani cattle.

Rangeland The species composition of the grassland is poor and intensive grazing and short fallow periods have caused severe degradation.

Forestry Part of Land System 113 is covered by the Naraguta Forest Reserve. There is no natural vegetation to provide firewood in the rest of the Land System which is densely cultivated.

2. Mainly subsistence-plus

Main characteristics In Land Systems 123, and 128 acha, dauro, maize and cocoyams are the main food crops and dauro, maize and Irish potatoes grown for sale. In the most intensively cultivated areas cultivation is continuous but elsewhere, fallows of about 4 years follow 4 years cropping. Muturu cattle are kept penned for fattening by the local farmers, and there is a large population of Fulani owned cattle.

Rangeland As these areas are mainly intensively cultivated with short fallows the grassland is degraded.

Farming Part of the Chawal Escarpment Forest Reserve occurs in Land System 128. Elsewhere there is little natural vegetation to provide firewood.

3. Land System 124

Most of this Land System is occupied by the Bokkos Farm Project.

LAND SYSTEMS WITH THREE CROP OPTIONS

This land occurs in Bassa, Jos, Barakin Ladi and Mangu Local Government Areas and includes four land systems totalling 603 km^2 (235 mi^2) in area. The main characteristics are summarised in Table 25 and discussed below.

Limitations to crop growth

1. Soil physical characteristics

The land systems in this group have no or only minor limitations to the growth of three crops: the soil limitations are shown in Table 26. In Land System 114 there are appreciable areas of gullied land in which there is either no soil development or the soils are eroded and disturbed. Texture is a moderate limitation for the growth of yams in Land Systems 114 and 151. Drainage and coarse material are limitations to the growth of maize and millet and to a lesser extent groundnuts and potatoes in Land Systems 121 and 131.

2. Soil chemical characteristics

The chemical characteristics for which data are available are shown in Table 27 and assessed as limitations to the growth of the crops considered.

Limitations to mechanical cultivation

The predominant slopes in these areas are given in Table 28 together with the range of slopes found on the major facets of each land system.

TABLE 25 Summary of main characteristics of areas with three crop options

Land system	Crop options	Occurrence	Density of cultivation	Present cropping		Draught animals	Erosion hazard	Communications	Rangeland and cattle production	Forestry
				Food	Cash					
112	Sorghum Yams Potatoes	Barakin Ladi LGA	Sparse	Acha, Tamba Sorghum	Little Foodcrops Potatoes	Nil	Moderate	Moderate to poor. Secondary road crosses northern part of land system	Mainly degraded rangeland due to intensive wet and dry season grazing	No forest reserves. No natural vegetation for firewood collection
114	Millet Groundnuts Potatoes	Barakin Ladi, Bassa and Jos LGAs	Moderate to intensive	Acha, Dauro Sorghum, Tamba	Very little foodcrops Potatoes vegetables	Nil	Slight to moderate	Moderate. Secondary road crosses northern part of land system	Moderately good species composition of rangeland but is degraded in intensively cultivated areas. Wet and dry season grazing	"
121	Millet Yams Potatoes	Jos and Bassa LGAs	Very intensive	Acha, Dauro Sorghum, Tamba	Little foodcrops Sugarcane Potatoes Vegetables	Nil	Slight	Moderate. Secondary road passes through the land system	Degraded rangeland due to short fallows and intensive grazing	"
131	Groundnuts Yams Potatoes	Mangu and Barakin Ladi LGAs	Intensive	Acha, Sorghum, Dauro	Dauro, Potatoes Foodcrops	Nil	Moderate	Moderate. Main road crosses northern part of land system	Rangeland has good species composition but is degraded in intensively cultivated areas. Wet and dry season grazing	"

TABLE 26 Soil physical limitations to the growth of certain crops in areas with three crop options: crop options indicated by shading

Land system					% Soil limitation category (SLC) by crop in each land system with nature of limitation*																	
No	Total area		Area to which SLC data refers		Maize			Millet			Sorghum			Groundnuts			Yams			Potatoes		
	km²	mi²	km²	mi²	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation
112	176	68	162	62	2 5	30–59 10–29 10–29	w DC Gully	2 5	30–59 10–29 10–29	t DtC Gully	1 5	30–59 10–29 10–29	Nil DC Gully	2 4	30–59 10–29 10–29	t tC Gully	1 4	30–59 10–29 10–29	Nil C Gully	2 4	30–59 10–29 10–29	t tC Gully
114	159	61	116	45	2	30–59 10–29	t Gully	1	30–59 10–29	Nil Gully	2	30–59 10–29	t Gully	1	30–59 10–29	Nil Gully	3	30–59 10–29	T Gully	1	30–59 10–29	Nil Gully
121	127	49	105	41	1 3 4	10–29 10–29 30–50	Nil tC/wc wC	2 3 4	30–50 10–29 30–50	t C wCt	1 3 4	10–29 10–29 30–50	Nil tC/wc wC	2 3	30–50 30–59	t tC/tc	1 3	30–59 30–59	Nil tC/C	2 3	30–59 30–59	t tC
131	245	95	174	67	3	>60	Wt/wtc	3	>60	W/wc	2 3	10–29 30–59	wt wtc	2	>60	w/c	1 3	30–59 10–29	Nil T	1 3	30–59 10–29	Nil W

*Limitations

Depth	Drainage	Texture	Coarse material
D Severe	W Severe	T Severe	C Severe
D Moderate	W Moderate	T Moderate	C Moderate
d Minor	w Minor	t Minor	c Minor

Alternative limitations are separated by an oblique stroke

TABLE 27 Dominant soil chemical characteristics assessed as limitations to crop growth for land systems with three crop options (top 50 cm of soil profile only)

Land system	CEC * meq %	Exch. K** meq %	pH	Limitations due to pH for						
				Maize	Millet	Sorghum	Groundnuts	Yams	Potatoes	P Availability ≠
112	5.1–7.6	0.5	5.0–5.3	Min–Mod	Nil	Min	Min	Nil	Nil	Mod
114	4.5	0.2	4.9	Sev	Min	Mod	Mod	Min	Nil	Sev
121	10.9	0.1	5.7	Nil	Nil	Nil	Nil	Nil	Nil	Mod
131	5.2–8.1	0.1–0.4	5.5–6.0	Nil	Nil	Nil	Nil	Nil	Nil	Mod

*CEC meq %: >8 Suitable for intensive agriculture; 2.0–7.9 Requires a high ratio of fallow to crops, <2.0 Unsuitable for intensive agriculture (Adetunji, 1974)

**K meq % for soils of pH >4.5: >0.10 Adequate; <0.10 Deficient

≠P availability related to pH:

pH	Limitations
6.5–7.5	Nil
6.0–6.49) 7.51–8.0)	Minor
5.0–5.9) 8.1–8.5)	Moderate
<5.0	Severe

TABLE 28 Dominant slopes and slope range on major facets in areas with three crop options

Land system	Slopes of major facets			
	Percent		Degrees	
	Dominant	Range	Dominant	Range
112	5.2	3.5–10.5	3	2–6
114	2.6	1.7–3.5	$1\frac{1}{2}$	1–2
121	0.9	0 –3.5	$\frac{1}{2}$	0–2
131	4.4	1.7–7.9	$2\frac{1}{2}$	1–4

These figures show that Land Systems 112 and 131 require strict conservation measures to prevent erosion and the complexity of the lay-out would prevent the economic running of machinery except for high value crops. Less elaborate conservation measures would be required in the other land systems.

Density and distribution of cultivation

Reference to Separate Map 2 and Table 29 shows that all these land systems except 112 are intensively used and there is little spare land.

Present farming systems

The acha farming system predominates throughout these areas though sorghum is of importance in the east. They can be divided into mainly subsistence and subsistence-plus farming.

1. Mainly subsistence

Main characteristics Land Systems 112, 114 and 121 support a mainly subsistence agriculture, with acha, dauro, finger millet and sorghum grown for

TABLE 29 Density of cultivation in areas with three crop options

Land system	Total area		Local government area	Areas (km^2) occupied by density of cultivation (percentage) class				% of <10% density class in forest reserves
	km^2	mi^2		>60%	59–35%	34–10%	<10%	
112	148*	57	Barakin Ladi	10	9	69	60	
114	136*	53	Bassa	20	24	5		
			Jos	17	42	11	15	
			Barakin Ladi				2	
121	127	49	Bassa	32	37	15	4	
			Jos	9	25	5		
131	192*	76	Barakin Ladi	8	12	10	4	
			Mangu	90	19	42	7	

* Areas different to those in key on Separate Map 1. Area distrubed by mining and those with ironpan now excluded

food. Small surpluses are sold and some Irish potatoes. Cropping in the densely cultivated Land Systems 114 and 121 is for up to 10 years with only 2 years' fallow, but in the less cultivated Land System 112 cropping is for 2 to 6 years with 4 to 6 years' fallow. Local farmers in these land systems seldom own cattle but there is a high population of settled Fulani herds with an influx after harvest of nomadic herds from Bauchi or Zaria. Residents accuse cattle of trampling and consolidating the soil and damaging the crops.

Rangeland In the densely cultivated areas the grassland is degraded by intensive grazing and short fallows. In Land System 112 the grassland has a good species composition.

Forestry There are no forest reserves and little natural vegetation to provide firewood.

2. Mainly subsistence-plus

Main characteristics In Land System 131 acha, dauro, maize, sorghum and root crops are grown, and surplus food crops, especially maize and Irish potatoes are sold. Cropping periods of about 4 years are followed by 4 years fallow. Local farmers are often cattle owners and there also are many local and nomadic Fulani cattle.

Rangeland The intensive cultivation and high cattle population mean that much of the grassland is degraded.

Forestry There are no forest reserves and little vegetation to provide firewood.

TABLE 30 Summary of main characteristics of areas with two crop options

Land system	Crop options	Occurrence	Density of cultivation	Present cropping		Draught animals	Erosion hazard	Communications	Rangeland and cattle production	Forestry
				Food	Cash					
125	Yams Potatoes	Mangu and Barakin Ladi LGAs	Moderate to intensive	Acha Cocoyam Maize	Maize Acha Potatoes	Nil	Moderate	Moderate. Secondary road crosses part of land system	Rangeland has good species composition. Intensive grazing maintains a close sward	Forest reserve at Richa. Elsewhere little natural vegetation for firewood collection
126	Yams Potatoes	Mangu LGA	"	"	"	Nil	"	"	"	"

TABLE 31 Soil physical limitations to the growth of certain crops in areas with two crop options: crop options indicated by shading

Land system					% Soil limitation category (SLC) by crop in each land system with nature of limitation*																	
No.	Total area		Area to which SLC data refers		Maize			Millet			Sorghum			Groundnuts			Yams			Potatoes		
	km^2	mi^2	km^2	mi^2	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation
125	249	96	202	78	1	10–29	Nil	2	30–59	t	1	10–29	Nil	2	10–29	t	1	>60	Nil	2	30–59	t
					3	10–29	wc				2	10–29	c	3	10–29	tc						
					4	10–29	W	4	30–50	Wt/tC	4	10–29	C	4	30–59	W/tC				4	30–50	tC/Wt
126	108	42	84	32	1	10–29	Nil	2	30–50	wt	1	10–29	Nil	2	30–50	t	1	30–59	Nil	2	30–50	t
					2	10–29	w				2	10–29	w				3	10–29	tC			
					4	30–59	WtC/C	4	30–50	WCt/C	4	30–59	WtC/C	4	30–50	wtC/C	4	10–29	C	4	30–50	tC/WC

*Limitations

Depth	Drainage	Texture	Coarse material
D Severe	W Severe	T Texture	C Severe
D Moderate	W Moderate	T Moderate	C Moderate
d Minor	w Minor	t Minor	c Minor

Alternative limitations are separated by an oblique stroke

TABLE 32 Dominant soil chemical characteristics assessed as limitations to crop growth for land systems with two crop options (top 50 cm of soil profile only)

Land system	CEC* meq %	Exch. K** Meq %	pH	Limitations due to pH for						
				Maize	Millet	Sorghum	Groundnuts	Yams	Potatoes	P availability ≠
125	4.6–11.8	0.3–0.6	4.6–5.0	Sev	Min	Mod	Mod	Min	Min–Nil	Sev
126	4.6–13.5	0.3–0.6	4.8–5.8	Sev–Nil	Min–Nil	Mod–Nil	Mod–Nil	Min–Nil	Nil	Sev–Mod

*CEC meq % : >8 Suitable for intensive agriculture; 2.0–7.9 Requires a high ratio of fallow to crops, <2.0 Unsuitable for intensive agriculture (Adetunji, 1974)

**K meq % for soils of pH > 4.5 : > 0.10 Adequate; < 0.10 Deficient

≠ P availability related to pH:

pH	Limitations
6.5–7.5	Nil
6.0–6.49) 7.51–8.0)	Minor
5.0–5.9) 8.1–8.5)	Moderate
< 5.0	Severe

LAND SYSTEMS WITH TWO CROP OPTIONS

This land occurs in Mangu and Barakin Ladi Local Government Areas. It includes two land systems totalling 341 km^2 (132 mi^2) in area. The main characteristics are summarised in Table 30 and discussed below.

Limitations to crop growth

1. Soil physical characteristics

The land systems in this group have no or only minor limitations to the growth of two crops: the soil limitations are shown in Table 31. Poor drainage or coarse material are the main limitations to the growth of crops.

2. Soil chemical characteristics

The chemical characteristics for which data are available are shown in Table 32 and assessed as limitations to the growth of the crops considered.

Limitations to mechanical cultivation

The predominant slopes in these areas are given in Table 33 together with the range of slopes found on the major facets of each land system.

TABLE 33 Dominant slopes and slope range on major facets in areas with two crop options

Land system	Slopes of major facets			
	Percent		Degrees	
	Dominant	Range	Dominant	Range
125	3.5	1.7- 5.2	2	1–3
126	3.5	1.7–10.5	2	1–6

These figures show that both land systems require elaborate conservation measures which would lead to uneconomic running of machinery except for high value crops.

In addition common small ironpan outcrops occur in both land systems and rocky hills in Land System 125 which would be additional limitations to mechanical cultivation.

Density and distribution of cultivation

Reference to Separate Map 2 and Table 34 shows that both land systems are only moderately to sparsely cultivated.

Present farming systems

The Acha farming system predominates in these areas and production is sufficient for subsistence plus farming.

1. Mainly subsistence-plus

Main characteristics In Land Systems 125 and 126 the main crops are acha, cocoyams, maize and dauro. Maize, acha and Irish potatoes are often produced for sale. Where the cultivation is very intensive, cropping is continuous with little or no fallow. In less intensively farmed areas up to 4 years cropping is followed by 4 years fallow. Cattle and sheep ownership is common and the animals are often grazed with the settled Fulani herds. Some of the Fulani cattle move to the south and east for the dry season.

Rangeland The grassland has a good species composition and intensive grazing maintains a close sward of palatable grasses.

Forestry There is a forest reserve at Richa in part of Land System 125. Elsewhere there is little vegetation to provide firewood.

TABLE 34 Density of cultivation in areas with two crop options

Land system	Total area*		Local government area	Areas (km^2) occupied by density of cultivation (percentage) class				% of <10% density class in forest reserves
	km^2	mi^2		>60%	59–35%	34–10%	<10%	
125	237	92	Barakin Ladi			33	4	
			Mangu	190	5	81	4	25
126	104	40	Mangu	35		60	9	38

* Area different to that on Separate Map 1. Area under mining spoil excluded

TABLE 35 Summary of main characteristics of areas with one crop option

Land system	Crop options	Occurrence	Density of cultivation	Present cropping		Draught animals	Erosion hazard	Communications	Rangeland and cattle production	Forestry
				Food	Cash					
108	Yams	Bassa and Jos LGAs	Sparse	Acha Dauro Sweet potatoes Tamba	Almost nil	Nil	Slight	Moderate	Rangeland has poor species composition. Further degraded by intensive wet and dry season grazing	No forest reserves No natural vegetation for firewood collection
120	Yams	Jos and Barakin Ladi LGAs	Intensive	Acha Tamba Sorghum Dauro Maize	Maize Acha Potatoes	Nil	Slight	Good. Main road crosses the land system	Moderately good species but degraded by intensive grazing. Cattle ranch established	"

TABLE 36 Soil physical limitations to the growth of certain crops in areas with one crop option: crop options indicated by shading

Land system					% Soil limitation category (SLC) by crop in each land system with nature of limitation*																	
No.	Total area		Area to which SLC data refers		Maize			Millet			Sorghum			Groundnuts			Yams			Potatoes		
	km²	mi²	km²	mi²	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation
108	144	55	129	50	3	30–59	W/C	3	30–59	W/tC	2	10–29	wt	3	30–59	W/Ct	1	30–59	Nil	3	30–59	tC
											3	10–29	C									
					4	10–29	W	4	10–29	Wt	4	10–29	W	4	10–29	W	3	10–29	tC	4	10–29	tC/Wt
120	119	46	102	39	3	10–29	wc	2	10–29	tc	2	10–29	c	2	10–29	t	1	60	Nil	2	10–29	t
					4	10–29	Dw	3	10–29	D	3	10–29	D	3	10–29	tc						
					5	30–59	DWc	5	30–59	DWtc	5	30–59	DWc	4	30–59	Wt				4	30–59	Wt

* Limitations

Depth	Drainage	Texture	Coarse material
D Severe	W Severe	T Severe	C Severe
D Moderate	W Moderate	T Moderate	C Moderate
d Minor	w Minor	t Minor	c Minor

Alternative limitations are separated by an oblique stroke

TABLE 37 Dominant soil chemical characteristics assessed as limitations to crop growth for land systems with one crop option (top 50 cm of soil profile only)

Land system	CEC* meq %	Exch. K** meq %	pH	Limitations due to pH for						
				Maize	Millet	Sorghum	Groundnuts	Yams	Potatoes	P availability ✓
108	3.9–8.7	0.2–0.6	4.9–5.3	Sev–Min	Min–Nil	Mod–Min	Mod–Min	Min–Nil	Nil	Mod–Severe
120	8.3–9.1	0.6–0.7	5.5–5.7	Nil	Nil	Nil	Nil	Nil	Nil	Moderate

*CEC meq % : > 8 Suitable for intensive agriculture; 2.0–7.9 Requires a high ratio of fallow to crops, < 2.0 Unsuitable for intensive agriculture (Adetunji, 1974)

**K meq % for soils of pH > 4.5 : >0.10 Adequate; <0.10 Deficient

✓P availability related to pH:

pH	Limitations
6.5–7.5	Nil
6.0–6.49) 7.51–8.0)	Minor
5.0–5.9) 8.1–8.5)	Moderate
<5.0	Severe

LAND SYSTEMS WITH ONE CROP OPTION

This land occurs in Bassa, Jos and Barakin Ladi Local Government Areas and comprises two land systems which occupy an area of 263 km^2 (101 mi^2). The main characteristics are summarised in Table 35 and discussed below.

Limitations to crop growth

1. Soil physical characteristics

The land systems in this group have no or only minor limitations to only one crop: the soil limitations are shown in Table 36. Drainage and coarse material are limitations to all crops except yams grown on mounds in both the land systems. In addition there are shallow soils in Land System 120 which are limiting to all crops except yams grown on mounds or ridges.

2. Soil chemical characteristics

The chemical characteristics for which data are available are shown in Table 37 and assessed as limitations to the growth of all the crops considered.

Limitations to mechanical cultivation

The predominant slopes in these areas are given in Table 38 together with the range of slopes found on the major facets of each land system.

TABLE 38 Dominant slopes and slope range on major facets in areas with one crop option

Land system	Slopes of major facets			
	Percent		Degrees	
	Dominant	Range	Dominant	Range
108	2.6	1.7–5.2	1½	1–3
120	1.7	0 –3.5	1	0–2

These figures show that some conservation measures are required in Land Systems 108 and 120. The presence of ironpan in both land systems may prove an additional limitation to mechanical cultivation.

Density and distribution of cultivation

Reference to Separate Map 2 and Table 39 shows that Land System 120 is densely cultivated. There is less cultivation in Land System 108 and it is more widely scattered throughout the land system, though it tends to be concentrated on the ridges and around rocky hills.

Present farming systems

The acha farming system predominates in these areas though in Land System 120 most of the cultivation has been displaced by the new Jos airport and the Jos Cattle Ranch at Heipang. In the remaining areas farming is mainly below subsistence.

1. Mainly below subsistence

Land System 108 has appreciable areas disturbed by mining and soils with low fertility so the farming is well below subsistence level. Many of the farmers have recently spread into this area from the nearby rocky hills and often still farm land there as well. Acha, dauro, sweet potatoes and finger millet (tamba) are grown for food and very little is available for sale. Land is farmed for between 3 and 6 years, after which it may be rested for a year before being used again. No cattle or sheep are kept by the local farmers, their only livestock being some goats and a few poultry. There are a few settled Fulani and nomadic herds pass through from Bauchi after harvest.

Rangeland The species composition of the grassland is poor and it is degraded by intensive grazing.

Forestry There are no forest reserves and little natural vegetation to provide firewood.

TABLE 39 Density of cultivation in areas with one crop option

Land system	Total area		Local government area	Areas (km^2) occupied by density of cultivation (percentage) class				% of <10% density class in forest reserves
	km^2	mi^2		>60%	59–35%	34–10%	<10%	
108	144*	55	Bassa	13	6	29	14	7
			Jos	13	5	56	8	7
120	119	46	Barakin Ladi	26	50	9		
			Jos	8	26			

* Area different to that in key on Separate Map 1. Excludes area distrubed by mining

AREAS WITH MODERATE OR SEVERE LIMITATIONS TO ARABLE CROPS

These are areas with a high proportion of land in which the soil present moderate or severe limitations to the growth of the crops considered. They occur throughout the Jos Plateau and the four land systems total 983 km^2 (378 mi^2). The main characteristics are summarised in Table 40 and discussed below.

Limitations to crop growth

1. Soil physical characteristics

The physical soil limitations are given in Table 41. Shallow soils and a high proportion of rock and mining spoil limit crop growth in Land System 107. In the other land systems, depth, drainage and the presence of coarse material may all limit crop growth. Land Systems 119 and 127 are badly affected by gullying.

2. Soil chemical characteristics

The soil chemical characteristics for which data are available are given in Table 42 and assessed as limitations to the growth of all the crops considered.

Limitations to mechanical cultivation

The predominant slopes in these areas are given in Table 43 together with the range of slopes found on the major facets of each land system.

TABLE 40 Summary of main characteristics of areas with moderate or severe limitations to arable crops

Land system	Crop options	Occurrence	Density of cultivation	Present cropping		Draught animals	Erosion hazard	Communications	Rangeland and cattle production	Forestry
				Food	Cash					
107	Nil	Bassa, Jos, Barakin Ladi LGAs	Sparse to moderate	Acha, Dauro, Yams, Cassava	Very little foodcrops	Nil	Moderate	Good. Main road passes close to the land system	Rangeland is degraded by intensive wet and dry season grazing	No forest reserves No natural vegetation for firewood collection
111	"	Akwanga, Jema'a, Mangu and Barakin Ladi LGAs	Sparse	Acha, Cocoyams, Maize, Dauro	Very little foodcrops	"	Moderate to severe	Poor	Rangeland has good species composition. Used for wet and dry season grazing	Forest reserves at Richa and Marahai
119	"	Jos Mangu and Barakin Ladi LGAs	Sparse	Acha, Dauro, Sweet potatoes, Finger millet	Very little foodcrops	"	Moderate	Variable but mainly poor	Moderately good species composition. Degraded by grazing	No forest reserves No natural vegetation for firewood collection
127	"	Pankshin and Mangu LGAs	Moderate to intensive	Acha, Dauro, Maize, Sorghum	Very little foodcrops	"	Moderate	Moderate to poor	Poor species composition Degraded by intensive grazing	"

TABLE 41 Soil physical limitations to the growth of certain crops in areas with moderate or severe limitations to arable crops

Land system					% Soil limitation category (SLC) by crop in each land system with nature of limitation*																			
					Maize			Millet			Sorghum			Groundnuts			Yams			Potatoes		
No.	Total area		Area to which SLC data refers		SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation	SLC	%	Nature of limitation
	km²	mi²	km²	mi²																		
107	244	94	276	107	2	10-29	w	2	10-29	t	1	10-29	Nil	2	10-29	t	1	10-29	Nil	2	10-29	t
					5	10-29	DtC	5	10-29	DC	5	10-29	DtC	4	10-29	C	4	10-29	tC	4	10-29	C
						30-59	Mining spoil		30-59	Mining spoil		30-59	Mining spoil		30-59	Mining spoil		30-59	Mining spoil		30-59	Mining spoil
						10-29	Rock		10-29	Rock		10-29	Rock		10-29	Rock		10-29	Rock		10-29	Rock
111	393	151	363	140	2	10-29	t	1	10-29	Nil	2	10-29	t	1	10-29	Nil	3	30-50	T/C	1	10-29	Nil
					4	10-29	wc	3	10-29	tC	3	10-29	wC	3	10-29	tc	4	10-29	tC	3	10-29	C
						30-59	D/DC	5	30-59	D/DC	5	30-59	D/DC	5	30-50	D	5	30-50	TC	5	30-50	D
119	130	50	No data		1	10-29	Nil	2	10-29	t	1	10-29	Nil	2	10-29	t	1	10-29	Nil	2	10-29	t
					4	30-59	C	4	30-59	tC	4	30-59	C	4	30-59	tC	4	30-59	tC	4	30-59	tC
						10-29	Gully		10-29	Gully		10-29	Gully		10-29	Gully		10-29	Gully		10-29	Gully
127	216	83	194	75	2	10-29	w	2	10-29	t	1	10-29	Nil	2	10-29	t	1	10-29	Nil	2	10-29	t
					3	10-29	C	3	10-29	tC	3	10-29	C	3	30-50	tC	3	10-29	C	3	30-50	tC
					5	10-29	DtC	5	10-29	DC	5	10-29	DCt		10-29	Gully	5	10-29	TC		10-29	Gully
						10-29	Gully		10-29	Gully		10-29	Gully					10-29	Gully			

*Limitations

Depth	Drainage	Texture	Coarse material
D Severe	W Severe	T Severe	C Severe
D Moderate	W Moderate	T Moderate	C Moderate
d Minor	w Minor	t Minor	c Minor

Alternative limitations are separated by an oblique stroke

TABLE 42 Dominant soil chemical characteristics assessed as moderate or severe limitations to arable crops (top 50 cm of soil profile only)

Land system	CEC* meq %	Exch. K** meq %	pH	Limitations due to pH for						
				Maize	Millet	Sorghum	Groundnuts	Yams	Potatoes	P availability ≠
107	4.2	0.4	4.9	Sev	Min	Mod	Mod	Min	Nil	Sev
111	3.9–4.5	0.2–0.6	4.9–5.3	Sev–Mod	Min–Nil	Mod–Min	Mod–Min	Min–Nil	Nil	Sev–Mod
119	4.6	0.3	4.8	Sev	Min	Mod	Mod	Min	Nil	Sev
127	4.2–5.8	0.3–0.4	4.9–5.0	Sev	Min	Mod	Mod	Min	Nil	Sev

*CEC meq % : >8 Suitable for intensive agriculture; 2.0–7.9 Requires a high ratio of fallow to crops, <2.0 Unsuitable for intensive agriculture (Adetunji, 1974)

**K meq % for soils for pH > 4.5 : >0.10 Adequate; <0.10 Deficient

≠ P availability related to pH:

pH	Limitations
6.5–7.5	Nil
6.0–6.49) 7.51–8.0)	Minor
5.0–5.9) 8.1–8.5)	Moderate
< 5.0	Severe

TABLE 43 Dominant slopes and slope range on major facets in areas with soil limitations to crop growth

Land system	Slopes of major facets			
	Percent		Degrees	
	Dominant	Range	Dominant	Range
107	5.2	1.7–10.5	3	1–6
111	7.9	3.5–12.3	4	2–7
119	5.2	1.7– 7.9	3	1–4
127	3.5	1.7– 5.2	2	1–3

These figures show that all the land systems in this group would require elaborate conservation measures to prevent erosion under mechanised cultivation. In addition the presence of ironpan in Land Systems 111, 119 and 127, of rocky outcrops in Land Systems 107, 111 and 119 and of mining spoil in Land System 107 would be additional limitations to mechanical cultivation. These factors would prevent the economic running of machinery except for high value crops.

Density and distribution of cultivation

Reference to Separate Map 2 and Table 44 shows that Land Systems 107, 111 and 119 are not densely cultivated though there are patches of denser cultivation throughout. Land System 127 is more intensively cultivated.

Present farming systems

The acha farming system predominates in all these areas and can be considered as mainly below subsistence and mainly subsistence farming.

TABLE 44 Density of cultivation in areas with limitations to crop growth

Land system	Total area		Local government area	Areas (km^2) occupied by density of cultivation (percentage) class				% of <10% density class in forest reserves
	km^2	mi^2		>60%	59–35%	34–10%	<10%	
107	244*	94	Barakin Ladi	5	1	42	8	
			Bassa	16	10	30	2	
			Jos	23	12	90	5	
111	393*	151	Barakin Ladi				4	
			Mangu	17		98	156	3
			Akwanga			5	32	43
			Jema'a			10	71	
119	130*	50	Barakin Ladi	4	3	12	30	
			Mangu	29		35	8	
			Jos	7	1			
127	216	83	Mangu	47	30	37	5	
			Pankshin	54	36	7		

* Area different to those in the key on Separate Map 1. Excludes areas distrubed by mining

1. Mainly below subsistence

Main characteristics Land Systems 111 and 119 are dissected or hilly areas with small patches of cultivation, and Land System 107 is badly disturbed by mining. Acha, dauro, sweet potatoes and finger millet are the main food crops, with no surplus for sale. Small areas of vegetables are grown in the dry season. Cultivation is nearly continuous. In Land System 107 cattle owning by the local farming community is rare. There are some resident Fulani herds with nomadic herds passing through after harvest. In the Land Systems 111 and 119 more local farmers keep cattle and the total cattle population is high.

Rangeland The grassland in Land System 107 is badly degraded, but further south in Land Systems 111 and 119 the species composition is better and a palatable sward is maintained by grazing.

Forestry There are forest resources at Richa and Marahai in Land System 111. Elsewhere there is little natural vegetation to provide firewood.

2. Mainly subsistence

Main characteristics In Land System 127 the main crops are Acha, dauro, maize and sorghum, with some maize and Irish potatoes; surplus food crops are sold. The intensively cultivated areas have long periods under crop, with very short fallows, if any.

In other areas 4-5 years' cropping is followed by about 4 years fallow. Cattle are often kept by the local farmers, and there is a high population of scattered and nomadic herds as well. Manure is appreciated and used.

Rangeland The intensive cultivation, very short fallows and high cattle population mean that the land is degraded.

Forestry There are no forest reserves and little vegetation to provide firewood.

AREAS UNSUITABLE FOR ARABLE CROPS

These are areas that are unsuitable for arable crops because they have a high proportion of bare rock, steep slopes, or shallow or gravelly soils. Hills and mountains are included; also complex areas of low rock or ironpan outcrops interspersed with pockets of soil.

These areas occur throughout the Jos Plateau and particularly on its margins. They include Land Systems 1, 2, 101, 102, 103, 104, 105, 106 and total 4 004 km^2 (1 546 mi^2).

Limitations to crop growth

The absence of soil or its shallow gravelly nature over most of these areas, precludes the growth of crops. Small patches of deeper soils do occur in valleys and between rock outcrops.

Density and distribution of cultivation

Reference to Separate Map 2 and Table 45 shows that most of these areas are uncultivated but small patches are intensively cultivated on the slightly deeper soils.

TABLE 45 Density of cultivation in areas unsuitable for arable crops

Land system	Total area		Local government area	Areas (km^2) occupied by density of cultivation (percentage) class				% of <10% density class in forest reserves
	km^2	mi^2		>60%	59–35%	34–10%	<10%	
1	2 178	841	Barakin Ladi	25	1	39	115	23
			Mangu	4	1	50	250	9
			Bassa	7	2	25	99	63
			Pankshin	5		82	203	
			Jos	13	2	144	347	57
			Kachia			1	23	5
			Lafia				146	
			Shendam			1	67	
			Akwanga			1	108	23
			Jema'a			5	162	19
			Tafawa Balewa				120	4
			Toro				115	1
			Samanika			8	7	
2	221	85	Barakin Ladi	8	6	8	3	
			Mangu	23	1	23	10	
			Bassa	9		7	37	
			Pankshin	3		7	9	
			Jos	3	2	30	31	67
			Kachia				1	
101	62	24	Mangu				1	
			Bassa			2	13	29
			Pankshin	12	12		3	
			Jos			3	9	67
			Jema'a				2	
			Tafawa Balewa				5	
102	325	125	Barakin Ladi	5	2	24	78	54
			Mangu	5		65	59	
			Bassa	1	1	2	18	70
			Pankshin			21	9	
			Jos	1		2		
			Kachia				3	100
			Shendam			6	22	
			Akwanga				1	
103	261	101	Barakin Ladi	1	3	3	11	
			Mangu	3		13	8	
			Bassa	43	12	58	24	50
			Pankshin	11	2	32	14	
			Jos	2	3	1		
			Kachia			1	11	100
			Lafia				1	
			Saminaka			4		
104	226	87	Barakin Ladi	18	5	12	1	
			Bassa	24	1	49	16	66
			Jos	20		58	12	
			Toro				5	
			Saminaka			5		
105	589	227	Mangu	11	11	108	337	1
			Pankshin	4		55	63	
106	142	55	Barakin Ladi	4		33	91	16
			Mangu			6	7	
			Jema'a				1	100

Part 4

Part 4 Agricultural development possibilities

TYPES OF AGRICULTURAL DEVELOPMENT

Different types of agricultural development have been considered with reference to the Third National Development Plan 1975 - 80 and discussions with Federal and State authorities and the staff of research institutes in Nigeria. The definitions given in Table 46 and in the following sections of this report are based on these discussions and experience of similar developments projects in Nigeria. The areas in which the various types of development could take place are shown in Table 47 in relation to both administrative units and land systems. Similarly Table 48 shows areas in which the environmental limitations for particular crops are at a minimum in relation to both administrative units and land systems. It must be emphasised that the various development possibilities have been assessed on environmental criteria. No attempt has been made to rank them in economic terms.

ASSESSMENT OF AREAS FOR PARTICULAR TYPES OF DEVELOPMENT

Any particular form of development should result in increased agricultural production almost anywhere in the Jos Plateau, but to be most effective it should be located in areas where environmental and present land use limitations are at a minimum. In assessing whether an area is suitable for a particular type of development the following factors have been considered within the framework of land systems:

Climate
Size and distribution of the land system
Soil limitations to crop growth
Slopes in relation to erosion hazard
Distribution and intensity of present cultivation
Present farming systems
Existing extension coverage
Present grazing status and cattle movements
Existing forestry activities
Communications

The criteria used to assess the suitability of an area for the types of agricultural development are summarised in Table 48A. The page numbers given in the first column refer to the pages in which the development is described.

The Jos Plateau has particular advantages of climate as compared with other parts of Nigeria for certain types of development. Crops such as Irish potatoes can be grown and there are especially favourable conditions for cattle production. Vegetable production particularly in the dry season is very profitable on small irrigated plots and this production could be expanded. However investigation of this form of irrigated agriculture was not possible within this reconnaissance survey: more detail studies are necessary.

There are also particular disadvantages on the Jos Plateau for agricultural development. The large area (316 km^2/122 mi^2) disturbed by mining and the presence of deep active gullies present severe limitations to agricultural development. These factors have been taken into account in the discussion of agricultural development on the Jos Plateau.

1. INTEGRATED AGRICULTURAL DEVELOPMENT PROJECTS

An integrated rural development project involves the concentration of agricultural, medical and educational resources in selected areas with associated improvements in communications. In this report only the agricultural aspects of such a project are discussed, but it must be emphasised that they cannot be considered in isolation, as successful development is dependent on improvements in the whole range of rural services.

TABLE 46 Types of agricultural development

Type of development		Summary definition of development
1. Integrated agriculture	(a) In densely cultivated areas	Establishment of integrated agricultural development projects aimed at increasing existing agricultural production per ha by improving infrastructure (communications, supply of agricultural inputs, produce marketing, credit facilities and extension service coverage). Run by a semi-autonomous project authority and making use of self-help wherever possible. Allied to general improvement of social services.
	(b) In sparsely cultivated areas	As above but also able to increase production by increasing the area under cultivation and/or introducing 'mixed farming'.
2. Mechanised farming		Establishment of large mechanised farms (> 1 000 ha) requiring a high level of management expertise and mechanisation of all stages of production from land preparation to harvest. Good planning and adequate conservation measures are essential. Limited to sparsely cultivated areas.
3. Traditional grazing		Improvement of traditional grazing including control of flock numbers, the elimination of unregulated pruning and the introduction of forage species into natural grassland. These measures, together with the establishment of grazing reserves and the allocation of grazing rights, are components of a suggested programme to be organised at inter-State level. Limited to sparsely cultivated areas.
4. Grazing reserves		Establishment of reserves in the major traditional wet and dry season grazing areas and along migration routes, with additional reserves within areas free or being freed of tsetse by the eradication programme. Provision of adequate water supplies, veterinary services and improved natural grassland, coupled with strict control of stock numbers. Limited to sparsely cultivated areas.
5. Cattle ranches and dairy farming		Establishment of ranches for 'growing out' cattle drawn from Fulani herd. Stock numbers restricted to 2 000 head until the viability of the ranch is established. Area not less than 1 600 ha per 1 000 head of cattle, with 1 500 ha for wet season and early dry season grazing and 80 ha for fodder grass to provide additional dry season roughage. Supplementary dry season feeding by cottonseed, cottonseed cake, groundnut cake, brewers grains or molasses as available. Limited to sparsely cultivated areas. Establishment of dairy herds of not more than 100 milking cows. Total area not less than 250 ha, with 160 ha improved pastures for wet and dry season grazing and 36 ha to provide additional dry season feed, supplemented by locally available concentrates and crop residues.
6/7. Production forestry	6. Development for production of timber	Development financed and managed by Government and covering a few to 100 ha in one location, usually for sawn timber production for local use, alternatively by a commercial company at minimum annual planting rate of 400 ha for sawn timber or pulp. Confined to forest reserves.
	7. Development for production of firewood and poles	(a) Production by State and Federal Departments in forest reserves.
		(b) Production by farmers on small woodlots, backed by extension service.
		(c) Extraction from areas of natural vegetation in forest reserves.
8. Protection forestry, reservation to protect areas against erosion or strict conservation resources		Protection of existing and establishment of new forest reserves in areas with slopes greater than 10% (6°) where conservation is required.
		Protection required only in parts of area.

TABLE 47 Agricultural development possibilities in relation to administrative units and land systems on the Jos Plateau

Administrative unit	Land systems* suitable for different types of development											
	1. Integrated agriculture		2. Mechanised farming	3. Traditional grazing in		4. Grazing reserves	5. Cattle ranches and dairy farms	7. Firewood & poles production from			8. Protection forestry	9. Minesland reclamation	10. Erosion control
	(a) In densely cultivated areas	(b) In sparsely cultivated areas		(a) Intensively cultivated areas with at least 3 year fallow	(b) Less intensively cultivated areas			(a) Forest reserves		(b) Farmers wood lots			
								Name	LS				
Plateau State Bassa	LS113,114,121, 128 (1),(107)			LS107,108,113, 114,121,128 (1),(104),(118)	LS107,108,113, 114,121 (104)			Rumfan Governor Rukuba	(1)	LS103,107,113, 114,121 128	LS1,2,101, 102,103,104 (110)	All land systems but particularly part of LS103, 106,107,108,110, 113,115,119,131	All land systems
Jos	LS114,121	LS110,113		LS107,108,113, 114,121	LS110,113,119, 120	LS119,120	LS119,120	Radung Naraguta Jarawa Hill Rajin Bauna South	(104) (1),(113) (1),(2) (110) (1)	LS107,108,110, 113,115	LS1,2,101, 104 (110)	All land systems but particularly part of LS103, 106,107,108,110, 113,115,119,131	All land systems
Barakin Ladi	LS110,115, 122,129,131 (1)	LS112,116,122 (106),(119)		LS110,115,122, 129,130,131 (1)	LS106,110,112, 119,120,122, 125	LS112,119, 120,122 (110)	LS110,112,119, 120,122	Rahama NE Escarpment Assob Bachit Kurra Jekko	(1) (1) LS122 LS102 (1),(106)	LS110,112,115, 116,122,125, 129,131 (1)	LS1,102,103, 106 pts 118 (110)	All land systems but particularly part of LS103, 106,107,108,110, 113,115,119,131	All land systems
Mangu	LS109,123,124, 128,129,130,131 (1),(2),(119)	LS109,130,131 (2)		LS109,119,123, 124,125,127, 128,129,130,131 (1),(2),(118)	LS109,111,117, 119,125,126, 127,128,130, 131 (2)	LS109,111, 117,119	LS109,117, 119	Langai FR Mongu FR Richa FR	LS130 LS130 (1)	LS109,113,118, 119,123,124, 125,126,128, 129,130,131	LS1,2,101, 102,103,105, 106,117,118, 119	All land systems but particularly parts of LS112, 115,119,131	All land systems
Pankshin	LS130 (2),(101),(117)	LS130		LS127 (2).(101),(117)	LS130 (2)					LS127,130 (2),(101),(117)	LS1,2,101, 102,103,105, 118	All land systems but particularly parts of LS112, 115,119.131	All land systems
Akwanga					LS111	LS111		Marahai	LS(1), (111)		LS1,102,111	All land systems but particularly parts of LS112, 115,119,131	All land systems
Shendam											LS1,102	"	"
Lofia											LS1,103	"	"
Bauchi State Toro											LS1		"
Tafawa Balewa											LS1,101		"
Kaduna State Saminaka											LS1,103,104		"
Kachia								Chawal Escarpment Rahama FR	LS103,128 (1)				"
Jema'a								North East Escarpment FR	LS(1)		LS1,111		"

* There Are no areas suitable for timber production on the Jos Plateau

/ Land system (LS) numbers in brackets are unsuited to the type of development shown but are not differentiated on Separate Map 4 because of their small size

TABLE 48 Land systems with few limitations to the growth of particular crops in relation to administrative units

Administrative unit	Land systems with few limitations to the growth of					
	Maize	Millet	Sorghum	Groundnuts	Yams	Potatoes
Plateau State						
Bassa		LS113,114,121, 128	LS128	LS113,114	LS108,113,121, 128	LS113,114,121, 128
Jos	LS110,115	LS110,113,114, 115,121,128	LS110,115,128	LS110,113,114, 115	LS108,110,113, 115,120,121, 128	LS110,113,114, 115,121,128
Barakin Ladi	LS109,110,115, 116,122,129, 130	LS109,110,114, 115,116,122, 128,130	LS109,110,112, 115,116,122, 128,129,130	LS109,110,114, 115,116,122, 129,130,131	LS109,110,112, 115,116,120, 122,125,128, 129,130,131	LS109,110,112, 114,115,116, 122,125,128, 129,130,131
Mangu	LS109,117,123, 124,129,130	LS109,128,130	LS109,117,123, 124,128,129, 130	LS117,129,130, 131	LS109,117,123, 124,125,126, 128,129,130, 131	LS109,117,123, 124,125,126, 128,129,130, 131
Pankshin	LS117,123,130	LS130	LS117,123,130	LS117,130	LS117,123,130	LS117,123,130
Akwanga	-	-	-	-	-	-
Shendam	-	-	-	-	-	-
Lafia	-	-	-	-	-	-
Bauchi State						
Toro	-	-	-	-	-	-
Tafawa Balewa	-	-	-	-	-	-
Kaduna State						
Saminaka	-	-	-	-	-	-
Kachia		LS128	LS128		LS128	LS128
Jema'a	-	-	-	-	-	-

These projects can be established either in intensively cultivated areas or in areas where there is room for the expansion of the area under cultivation. The structure of the project can be similar in both cases, but in the former any increase in agricultural production must come from increased yields and intensification of the present farming system.

Such projects should be administered by a semi-autonomous project authority and involve the improvement of infrastructures, concentration of extension services and creation of farmers' organisations. They also include some degree of mechanisation, supply of agricultural inputs, provision of credit and marketing arrangements as well as associated services such as water supply and health. Obviously project proposals must be fully explained to the local population and located only where their full cooperation is ensured.

Due to the special climatic advantages enjoyed by the Jos Plateau the cultivation of crops such as Irish potatoes and vegetables should be encouraged. These factors are discussed below.

Project authority A semi-autonomous project authority should be established to coordinate and implement all aspects of the development programme. It should include local farmer representation from the beginning and have the long-term, objective of becoming entirely run by local people with government advice.

Infrastructure Roads, water supplies, marketing and storage facilities should be provided before the full scale injection of agricultural inputs, though some inputs should be made available to establish credibility with the farming community.

Staffing Trained and experienced extension staff should be located in the villages. Initially the ratio of extension staff to farming families should not exceed 1:500. Once new techniques have been accepted the ratio can be increased, and extension staff made available for similar projects elsewhere, or the expansion of the project area itself.

TABLE 48A Criteria used to assess the suitability of an area for particular types of agricultural development

Type of agricultural development	Crop options	Slope %	Gullying	Rock or ironpan outcrops	Trypanosomiasis hazard	Cultivation density %	Minimum size of unit, ha*	Other factors
1. Integrated agricultural development (p.80) a.	3 +	< 10	Nil to slight	Nil to few	-	> 35	-	-
b.	3 +	< 10			-	< 35	-	
2. Mechanised farming (p.86)	3 +	< 3	Nil to slight	Nil to few	-	< 35	1 000	Not unduly fragmented by drainage lines
3. Traditional grazing (p.89)	-	< 10	Nil to mod. if protected	-	Nil to slight	< 35	-	-
4. Grazing reserves (p.92)	-	< 10	"	-	"	"	-	-
5. Cattle ranches (p.94)	-	< 10	Nil to slight	-	Nil to slight	< 35	1 000	-
Dairy farms (p.94)	-	< 10	"	-	"	< 35	260	-
6. Production of timber (p.98)	-	-	-	-	-	-	5-100	Limitations due to edaphic factors. Gazetted forest reserves
7. Production of firewood and poles (p.98) a.	-	-	-	-	-	-	"	" "
b.	-	-	-	-	-	> 35	-	-
c.	-	-	-	-	-	< 35	-	-
8. Protection forestry (p.102)	-	> 10	-	-	-	-	-	-

*The minimum size of unit has been justified in the report but, for cartographic reasons, the smallest area shown on the map is approximately 1 500 ha.

Special crops Irish potatoes can be produced on the Jos Plateau as a rain fed crop. Presently available varieties, with a 3 month growing period, should be planted in late April or in May depending on the start of the rains. Spraying with Duter fungicide using ultra low volume (ULV) sprayers is necessary to control fungal diseases and should be started in the third week in June and repeated every 10–15 days until harvest. The crop should be harvested before the heaviest rains in August when lack of sunshine and late blight adversely affect yields. The six year old seed stocks presently being used should produce 14.8–24.7 t/ha (6–10 tons/ac) provided fertiliser is used at the rate of 100 kg of superphosphate and 50 kg sulphate of ammonia/ha (89 and 45 lb/ac): fresh imported seed should produce at least 24.7 t/ha/a (500 lb/ac/a) for the first two years. The crop should only be grown on the same plot of land once every four years. Seed requirements are about 446 kg/ha/a (500 lb/ac/a). 105 ha (260 ac) of land have been obtained at Heipang for production of seed potatoes and about 26 ha (65 ac) of this should be in production in any one year, with yields of seed potatoes of about 14.8 t/ha (5 tons/ac). This should produce enough seed for about 631 ha (1 560 ac).

Other crops such as vegetables should be encouraged; also wheat if suitable varieties can be found.

Size of holding The farm should be large enough to enable the farmer to make a minimum income that will counter the attraction of urban life. Mansfield (in press) has suggested that this requires a minimum net annual income of about ₦900 corresponding to the income of many daily paid government employees, Norman (1972) has shown that most farmers derive about 22% of their total income from off-farm activities during the dry season, so farmers would have to derive about ₦740 from the farm.

Socioeconomic studies of potato growing on the Jos Plateau are needed before definite suggestions can be made about optimum size of holdings. However it is thought that one family should be able to cultivate about 2 acres of potatoes without additional labour. As the crop should not be grown on the same plot more than once in every four years, a minimum holding of 8 acres is required. Yields should be in the order of 5–10 tons/acre and the price to the farmers is 5–6 kobo/lb, so potatoes should form a valuable cash crop providing more than the suggested minimum income.

For other crops the minimum size of holding needed to produce an income of ₦740 has been calculated using data from IAR socio-economic studies. The size of holding has been calculated for farms using hand labour only, and for farms

using family labour, oxen and herbicides. Maize, sorghum, groundnuts and cowpeas have been considered as the main cash crops. The various farm sizes are given in Appendix 3 and more details of the calculations by Mansfield (in press).

The figures show that the minimum size of holdings using only hand labour range from 5.5-7.5 ha (13.8-18.5 ac): this includes some fallow and assumes the farmer hires additional labour. Holdings using oxen must be much larger. In practice actual farm sizes will be even larger than these theoretically calculated sizes as the farmer does not grow simple cash crops.

Yams are a special case as they are grown on mounds and mechanisation presents difficulties. It has been calculated that with a 4 year fallow and hand cultivation the size of holding required is 4.2 ha (10.4 ac) and with a 7 year fallow the size of holding would be 5.8 ha (14.3 ac). These figures are based on likely yields on the Jema'a Platform and in the Benue Valley.

The farm sizes for crops other than yams are calculated using data collected in the Jema'a area so details may differ for the Jos Plateau, but the size of holding is unlikely to be significantly lower. Consequently, in many of the densely cultivated areas of the Plateau that have a high population, there is not enough land for each farmer to have a holding big enough to generate an income equal to that earned by many daily paid government employees. This re-emphasises the need to grow a high value crop such as Irish potatoes.

Storage Conveniently situated storage facilities are necessary for all crops, but for potatoes a store with fan assisted ventilation and storage trays is necessary. This should enable potatoes to be safely stored for 3-4 months after harvest. However, as the crop is bulky and can suffer bruising if improperly handled, there are difficulties in collecting the crop from widely scattered small producers. These can be minimised by siting the cool store centrally to a block of potato growing farms. The marketing could be under-taken by producer societies with their own cool store.

Oxenisation Throughout Nigeria the term 'mixed farming' describes the use of animals for draught and this has usually been restricted to ploughing or ridging. Mixed farming has always been envisaged as the integration of crop and animal husbandry involving the feeding of crop residues, the cultivation of fodder crops,

the use of manure and the use of animals for a variety of draught purposes. Implements for cultivating and planting and carts are available; the best equipment is simple to adjust and can be maintained by village blacksmiths.

In areas where the cultivation density is less than 35% and spare land for larger holdings is available, an improved system based on a 10–12 ha (25–30 acre) farm size enables the bulk of the bulls' food to be produced on the farm.

Mechanisation with tractors To make the use of tractors economic they must be used for most of the farming year. This means that most farming operations are mechanised and necessitates clean stumping with an associated increase in the risk of erosion. Farms must also be organised into large blocks. All this involves a complete change in the farming system and experience in other areas shows that the farmer becomes less involved and less enthusiastic. Full mechanisation is therefore more appropriate to large mechanised farms.

If tractors are used primarily for land preparation to eliminate the drudgery of hand cultivation and to enable planting to take place earlier, then it is unlikely that the tractors can be operated economically. Even if farms are organised into blocks, the tractors will remain idle for a large part of the year together with the drivers and maintenance staff so that government subsidy of the service is essential. More efficient use of equipment might be achieved by commercial contractors who use the tractors for other work during the rest of the year. If this type of subsidised cultivation is undertaken erosion control measures are necessary in areas with slopes greater than 1%.

Credit and marketing Seasonal loans should be provided to enable farmers to obtain improved seed, fertiliser, agricultural chemicals, equipment and tractor hire services. Marketing should be controlled by project authority. Loan recovery is more difficult with crops that can be marketed locally, and may depend on refusing further credit and services to debt defaulters and by making bad debts a community responsibility.

Other agricultural inputs Inputs such as fertilisers, herbicides, pesticides, implements, improved seed and planting material should be available to the farmers at the correct time. Credit may be necessary so supplies should be available where crops are marketed.

Implementation schedule As it is unlikely that the whole area can be developed at once, development should be phased to keep pace with the build up of staff and infrastructure. After the initial establishment of the Project Authority each phase should be scheduled as follows:-

Year 1

i Survey of present potato growers, their distribution and size of holdings.

ii In the light of findings at (i), a decision on the best centres for the establishment of producer societies.

iii Provision of a limited supply of inputs to establish credibility with the farming community.

iv Intensive publicity and formation of farmers' groups, followed by their involvement in development of infrastructural needs, including roads, housing and water supplies, as well as the establishment of soil and water conservation works. Assistance would be given in such matters as materials, bridge and culvert construction, road alignment and technical advice on layout and design.

v The establishment of seed multiplication units for an initial period until these can be run by the farmers.

vi Provision of a guaranteed but limited supply of inputs to establish credibility with the farming community.

vii Recruiting and training of new staff and orientation courses for existing staff at agricultural centres.

Year 2

i Continuation of publicity and formation of farmers' groups.

ii Extension staff move to their villages and start work on demonstration plots. These are possibly sited on their own individual farms (for which they are solely responsible) and on which they carry out the manual work involved with assistance from their family. These are to act as a practical demonstration to the

Year 2 ii farmers and would help to build up their standing within the farming community.

iii Continuation of the build-up of the infrastructure, with the population involved at all stages. Concentrating on the building of stores, including cool storage facilities for potatoes and mechanical workshops for mechanisation.

iv Establishment of distribution, marketing and credit organisation. The ordering and delivery of all agricultural inputs required for Year 3.

Year 3 The project becomes fully operational. All the required inputs are available to farmers, through their group organisations, together with extension advice on the way to use them.

Location of integrated rural development projects on the Jos Plateau

Only areas with three or more crop options have been considered suitable for the establishment of integrated rural development projects as a choice of crops is considered essential. Suitable areas occur in all Local Government Areas but almost all are already intensively cultivated: only Land System 109 in the south west of the Plateau is sparsely cultivated. The location of the sites is shown on Text Map 2.3, on Separate Map 4 and is given in Table 49 in relation to administrative units.

TABLE 49 Location of integrated agricultural development projects on the Jos Plateau

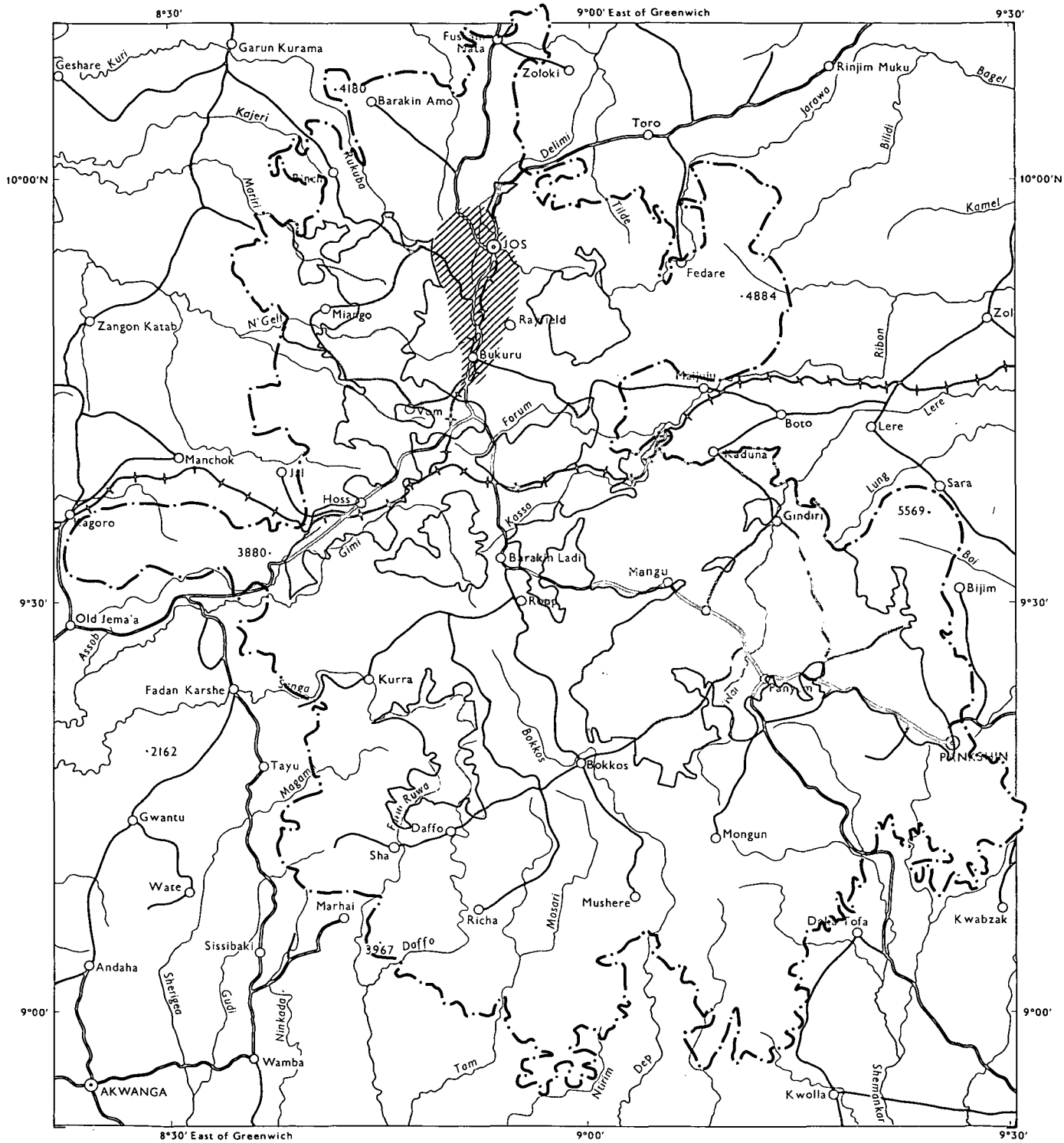
Administrative unit	Land systems suitable for integrated rural development projects	
	Densely cultivated areas	Sparsely cultivated areas
Plateau State		
Bassa	LS113,114,121,128,(1), (107)	
Jos	114, 121	LS110,113
Barakin Ladi	LS110,115, 122,129,131,(1)	LS112,116, 122, (106), (119)
Mangu	LS109,123,124*,128,129,130,131, (1),(2),(119)	LS109,130,131,(2)
Pankshin	(2), (101), (117), 130	LS130

Land system numbers in brackets refer to small pockets unsuitable for this type of development but within the generalised area on the map

* LS124 is mainly ocupied by the Bokkos Farm

AREAS SUITABLE FOR INTEGRATED AGRICULTURAL DEVELOPMENT PROJECTS

(based on environmental and present land use factors only)



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Effect on other types of development

The establishment of an integrated rural development project can mean an increase in the area under cultivation and a reduction in the area available for grazing. However, there will be an increase in crop residues and if these are made available to cattle, they should offset the loss of dry season grazing. The increase in cultivation also means a loss of wet-season grazing.

2. LARGE MECHANISED FARMS FOR PRODUCTION OF RAINFED ANNUAL CROPS

In Nigeria these farms have been established by government for the production of large quantities of food crops or as seed multiplication centres. On the Jos Plateau only Land Systems 114, 121 and 130 have suitable soils and slopes for such schemes but they are already intensively cultivated. Establishing a large mechanised farm in one of these areas would mean displacement of a large number of people: consequently this type of development is not considered appropriate for the Jos Plateau. A large mechanised farm has already been established at Bokkos mainly on Land System 124 with dominant slopes of more than 3%. Severe erosion has already taken place on parts of the farm.

3. IMPROVEMENT OF TRADITIONAL GRAZING

Traditional grazing on the Jos Plateau involves the use of uncultivated land, fallow land or crop residues by a large number of settled Fulani herds and some nomadic herds crossing the Plateau on the way to dry season grazing areas near Keffi and Abuja. The intensive cultivation, the lack of trees and the high cattle population mean that improvement of grazing on the Jos Plateau poses special problems. However, the climate presents special advantages for the introduction of the perennial legume Stylosanthes guyanensis which could make a significant improvement to the fodder resources of the Plateau. Stylo grows most vigorously at the end of the rainy season and is readily eaten during the dry season. The heavy grazing of the competing grasses ensure good seedling development, and the legume will be spread by seed passing undigested through the gut of the grazing animal. Like other leguminous plants, it is necessary for the symbiotic rhizobium (bacterium) to be present in the roots, and a cowpea - type rhizobium is usually present in most soils of the

Plateau. Stylo has already been successfully established on the Jos Plateau at Miango, Batura and Kumbul.

Any improvement of the grazing by planting stylo involves the following:-

1. The production of seed. This should be obtained from existing stands of the legume on the Plateau and not imported from overseas. An attractive price for seed would encourage its production by local farmers.

2. Stylo should be established in areas of natural grassland by oversowing in cultivated areas with at least three to four year fallow. Plants should appear from seed in the soil even after three years cropping. It is unlikely that stylo could be successfully established in areas with shorter fallows or longer cultivation periods.

3. The seed can be successfully planted by hand, with the seed dropped in a shallow groove scratched with a stick. Alternatively, a simple seeder mounted on an ox drawn tool bar could be used. Heavy tractor mounted equipment is available but it should not be necessary to use this in the initial stages.

4. A dressing of 700 kg/ha (5 cwt/ac) of ground rock phosphate and elemental sulphur should be applied using broadcasting equipment. The rock phosphate would have a beneficial effect for about five years. On land being fallowed for at least three years, farmers should be encouraged to plant stylo, in return for which their land would be given a dressing of rock phosphate by the State.

5. These measures would need to be associated with an intensive campaign, mounted to make the pastoralist aware of the deterioration of the grassland that results from overgrazing.

Location of areas for improvement of traditional grazing

The improvements discussed in the previous section could be applied to most parts of the Jos Plateau.

Those areas which are intensively cultivated but have a three year fallow in which stylo could be established are distinguished from areas with less

intensive cultivation. These areas are shown on Text Map 2.4, on Separate Map 4 and in Table 50 in relation to administrative units and land systems.

TABLE 50 Location of areas suitable for improvement of traditional grazing in relation to land systems and administrative units

Administrative unit	Land systems	
	(a) Intensively cultivated areas with at least 3 years fallow	(b) Less intensively cultivated areas
Plateau State		
Bassa	LS107,108,113,114, 121,128,(1),(104),(118)	LS107,108,113,121 (104)
Jos	LS107,108,113,114, 121	LS110,113,119,120
Barakin Ladi	LS110,115,122,129, 131, 130 (1)	LS106,110,112, 119,120,122,125
Mangu	LS119,123,125,127,124 128,129,130,131, 109 (1),(2),(118)	LS109,111,117,119, 125,126,127,128, 130, 131 (2)
Pankshin	LS127 (2),(101),(117)	LS130 (2)

Land systems number which are bracketed are those of small areas found within generalised development area on the map but not suitable for proposed development

Effect on other types of development

Traditional grazing may be improved without major changes to other existing forms of agricultural activity but it should be planned in relation to them.

4. ESTABLISHMENT OF GRAZING RESERVES

The Grazing Reserve Law 1965, provides for the establishment of grazing reserves ultimately to achieve the settlement of nomadic pastoralists. On the Jos Plateau there are already numbers of settled Fulani as well as nomadic herds crossing the Plateau. Transhumance is practised for the benefit of the stock, in terms of adequate fodder and avoidance of disease; because these needs cannot be met immediately by settling pastoralists attempts should be made to improve rather than eliminate the system of seasonal movement. This could be done by establishing grazing reserves in the main wet and dry season "home" areas of the nomadic herds: there are the Bauchi and Keffi/Abuja areas for most of the nomadic cattle crossing the Plateau. Grazing reserves

established along the main migration routes could act as staging posts to canalise and slow down the movement and such staging posts could be established on the Plateau. Reserves should also be established to ensure long term grazing for the settled herds.

The requirements of such reserves on the Jos Plateau are listed below.

1. The establishment of an inter-State body to coordinate policy as it cannot be applied to one area in isolation.

2. The reserves should have fencing, adequate supplies of water and veterinary facilities.

3. Stock movements should be controlled within the reserve.

4. Pasture improvement should be undertaken by
   i) the elimination of overgrazing but avoiding selective grazing
   ii) the introduction of Stylosanthes by oversowing the existing grassland
   iii) fertilisation with ground rock phosphate using a dressing of 700 kg/ha (5 cwt/ac) once every five years. The fertiliser should be applied using a spinner or other broadcasting equipment.

5. Payment for the use of the reserve must be charged; payment could be in stock but should NOT be in milk.

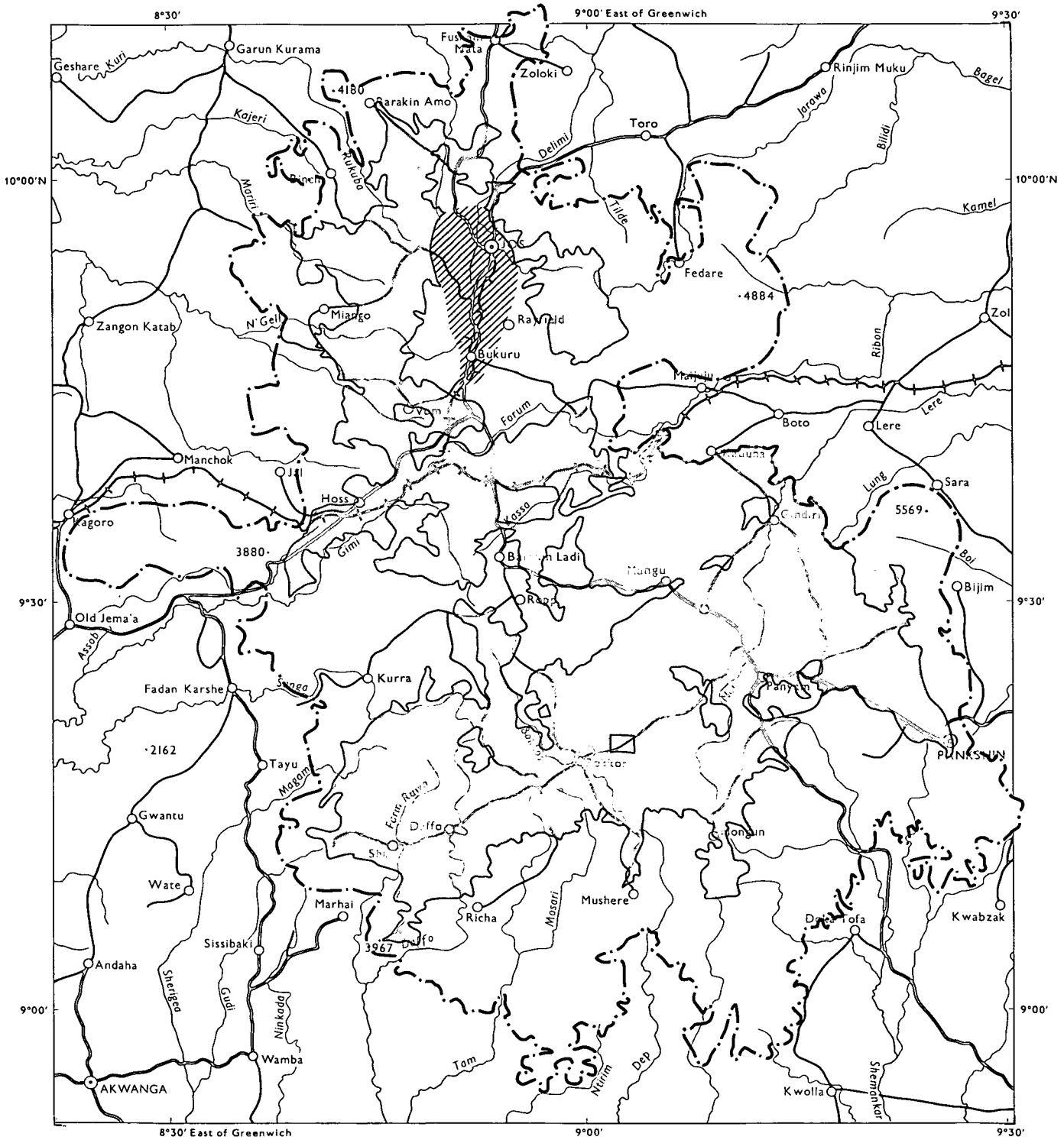
6. Ranches for "growing out" cattle might be associated with the reserves.

Location of grazing reserves on the Jos Plateau

Areas suitable for the establishment of grazing reserves occur in Jos, Barakin Ladi, Mangu LGAs. However, as virtually all parts of the Plateau are cultivated to some extent, the establishment of a grazing reserve will mean the displacement of some people. The establishment of reserves has therefore only been considered for areas in which the cultivation density is low. These areas are shown on Text Map 2.5, Separate Map 4 and in Table 51 in relation to administrative units and land systems.

AREAS SUITABLE FOR IMPROVEMENT OF TRADITIONAL GRAZING

(based on environmental and present land use factors only)



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AREAS SUITABLE FOR ESTABLISHMENT OF GRAZING RESERVES

(based on environmental and present land use factors only)

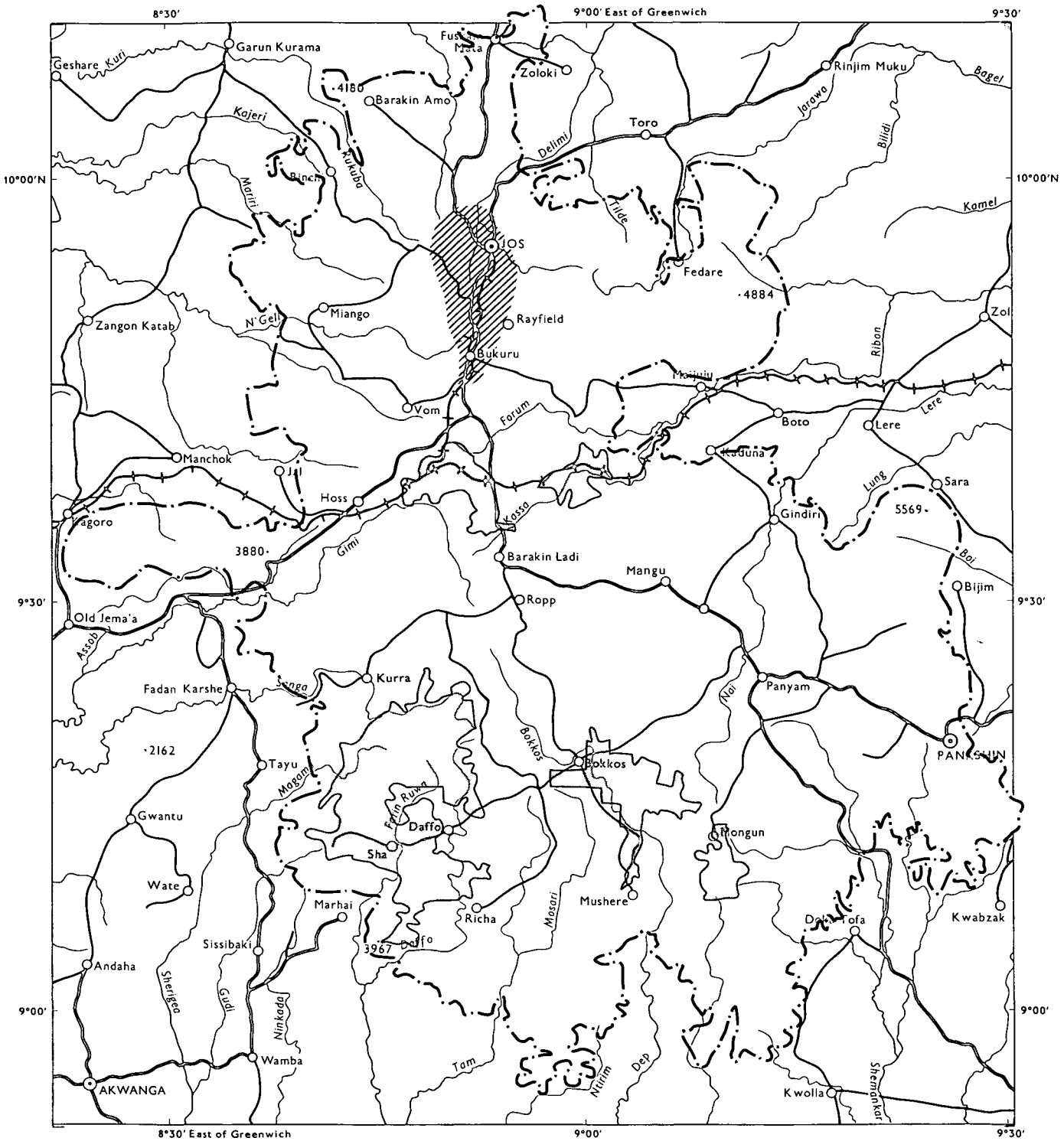

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TABLE 51 Location of grazing reserves

Administrative unit	Land systems	
	Suitable for grazing reserves	In small pockets within generalised area on map but not suitable for proposed development
Plateau State		
Jos	LS119,120	
Barakin Ladi	LS112,119,120,122,	LS110
Mangu	LS109,111,117,119	

Effect on other types of development

The establishment of grazing reserves reduces the land available not only for cultivation and forestry but also for traditional grazing: it does not necessarily mean that the cattle population can be increased by the numbers accommodated in the reserve.

5. ESTABLISHMENT OF CATTLE RANCHES AND DAIRY FARMS

The Jos Plateau is a relatively disease free environment with climatic advantages for livestock enterprises including milk production. In spite of these advantages, both growing out* ranches and dairy farms require a high level of management; the exotic breeds recommended for milk production are particularly demanding. Successful dairy farming largely depends on the skill of the stockmen.

Much of the detailed information has been obtained from the staff of the Federal Veterinary Research Institute.

Cattle ranches

The ranches will 'grow out' over a period of 5–10 months semi-mature cattle purchased from Fulani herds; some animals might be obtained by way of payment for the use of grazing reserves (in several African countries government ranches provide grazing and veterinary care for cattle which remain the

* The proposed system cannot be termed 'fattening' but growth and weight increase are implied.

property of the owners who pay a monthly fee: the cattle must go to slaughter after six to eighteen months on the ranch).

Herd size The number of cattle on the ranch will fluctuate but should not exceed 2 000 until experience has been gained and the economic viability of ranching has been established. Stock will be purchased mainly in the second half of the dry season; there should be a regular off take of cattle for slaughter and numbers would be at a minimum prior to the main purchasing period.

Wet season feeding Natural grassland should provide fairly satisfactory grazing during the wet season.

Dry season feeding The improvement of the grassland by the introduction of Stylosanthes guyanensis should provide fairly satisfactory grazing for two or three months of the dry season.

To reduce dependence on supplementary feeding stuffs such as cottonseed, cottonseed cake, groundnut cake or brewers grains, it will be desirable to provide suitable fodder. Stands of either guinea grass (Panicum maximum) or elephant grass (Pennisetum purpureum) or, on favourable sites, sugar cane could be established and during the dry season cut daily and mechanically chopped before feeding.

Area of the ranch The area of a ranch for a unit of 1 000 head is given in Table 52 during certain periods of the years numbers will be lower

TABLE 52 Cattle Ranch Area per 1 000 head

Category	Yield		Area	
	t/ha	tons/ac	ha	ac
Improved grassland	15*	6*	1 500	3 700
Dry season fodder			80	205
Building yards			70	173
Total			1 650	4 078
*Green material				

It may be found profitable to fatten suitable animals for 3–4 months prior to slaughter; it is anticipated that the costs of this practice will limit it to small numbers of animals which could attract a premium at slaughter.

Dairy farms

Herd size Because of the lack of commercial dairy farm operating experience, it is recommended that farms be initially restricted to 100 milking cows, which with herd replacements corresponds to 160 livestock units.

Breed The herd should consist of Friesians which have been kept successfully at Vom and at Batura. They should yield approximately 2 270 kg (5 000 lb) per lactation compared to Bunaji (White Fulani) 910 kg (2 000 lb) and cross bred Bunaji – Friesian 1 640 kg (3 600 lb).

Wet season feeding Grassland improved by the introduction of *Stylosanthes guyanensis* should provide maintenance for mature and semi-mature stock for 7–8 months or even longer. Milk production will be based on concentrates which will also be fed to down calvers and to young stock during the second half of the wet season.

Dry season feeding Silage should be fed generously (adult cattle eat approximately 8.9 kg (18–20 lb) of dry matter per day). Good quality hay is useful for calves and also for sick animals; if it is not possible to purchase leafy cowpea haulms then a legume such as *Glycine javanica* or *Stizolobium deeringianum* should be grown for hay. Grass from unimproved grassland does not make satisfactory silage (Miller *et al* 1963) and it is desirable to ensile a purpose grown cereal crop such as maize or sorghum.

These crops must be ensiled during the late flowering stage. Timely harvesting of a large area may be difficult and it is therefore recommended that trials of species such as elephant grass or guinea grass for ensiling be undertaken; the necessary additional silage would be made from the more suitable of these fodder grasses to which fertiliser should be applied.

Concentrate should be fed to milking cows according to yield and to immature stock. It is recommended that the rations be compounded on the farm from purchased materials.

Area of farm The farm size required for 160 livestock units is given in Table 53.

TABLE 53 Dairy farm: area per 100 cows plus followers

Category	Yield		Area	
	t/ha	t/ac	ha	ac
Improved grassland			162	400
Legume hay	3.8*	1.5*	12	30
Cereal for silage	25**	10**	16	40
Fodder grass for silage	10**	4**	20	50
Buildings yards etc			34	85
Total			244	605
* Dry matter ** Green material				

Location of cattle ranches or dairy farms on the Jos Plateau

Suitable areas* for the establishment of cattle farms or ranches occur in Jos, Barakin Ladi and Mangu Local Government Areas. The intensity of cultivation restricts these areas to the land systems shown on Text Map 2.6, on Separate Map 4 and in Table 54 in relation to administrative units.

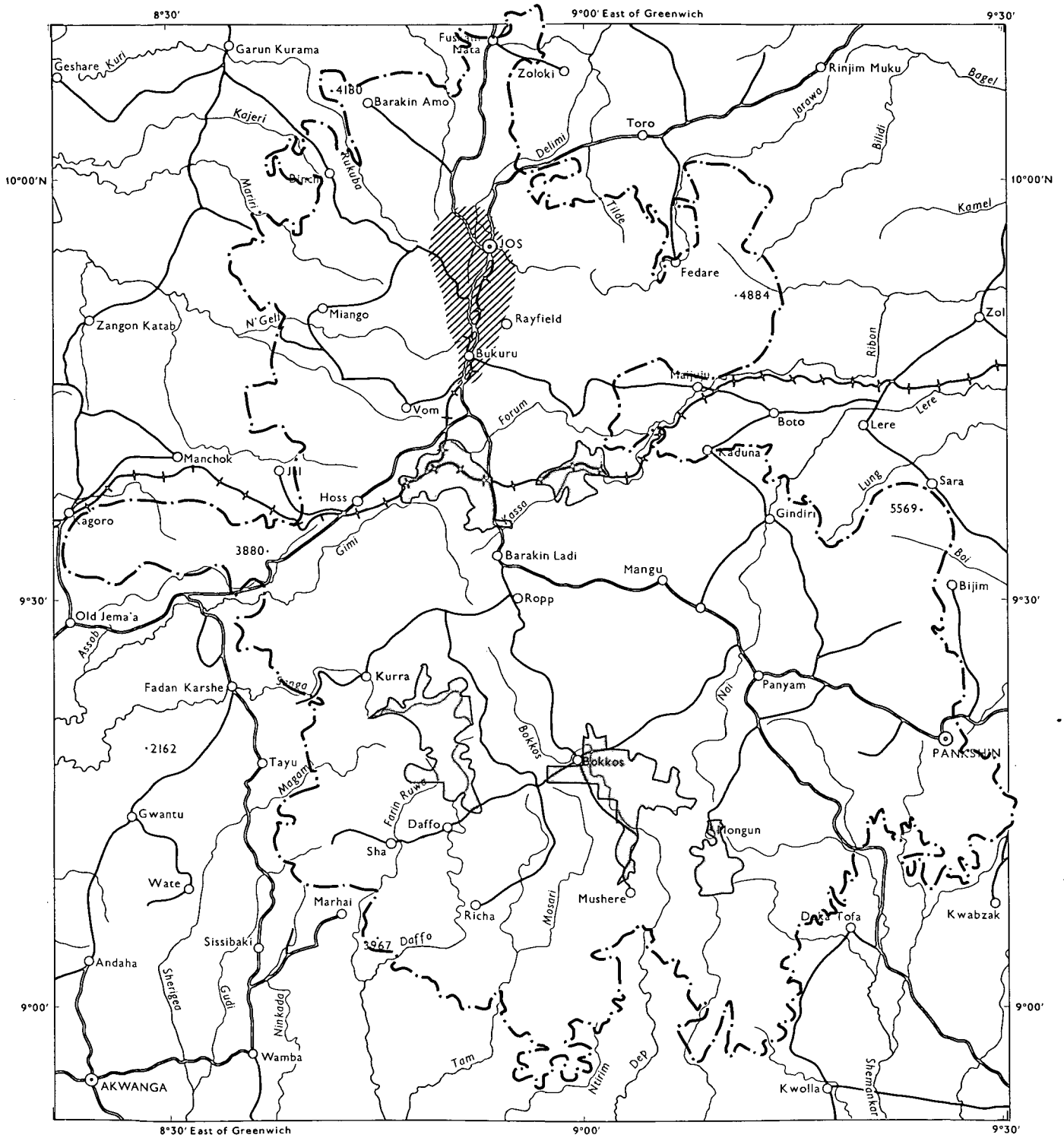
TABLE 54 Areas for the establishment of cattle ranches or dairy farms

Administrative unit	Land systems
Jos	119, 120
Barakin Ladi	110, 112, 120, 119, 122
Mangu	109, 117, 119

* Easy access is necessary in the location of dairy farms.

AREAS SUITABLE FOR CATTLE RANCHES OR DAIRY FARMS

(based on environmental and present land use factors only)



Jos Metropolitan Area

Kilometres 10 5 0 10 20 30 Kilometres

Miles 10 5 0 10 20 Miles

Boundary of Jos Plateau

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Effect on other types of development

The establishment of cattle farms reduces the area of land available for cultivation and forestry. The effect of the production from these farms on local markets for meat and dairy products is not known but it is likely that demand presently exceeds supply.

6. FORESTRY DEVELOPMENT FOR THE PRODUCTION OF TIMBER

The main obstacle to growing timber on the Jos Plateau is the shortage of land. If land were available, eucalypts and pines could be grown to timber size as shown by trial plantings in several localities. Timber is grown over a long rotation compared to firewood and poles, so for its economic production it is necessary to have good soils to ensure good growth rates. As cultivation is most intensive on the good soils it is unlikely that land will be available for production of timber on the Jos Plateau and this type of development has not been considered further.

7. FORESTRY DEVELOPMENT FOR PRODUCTION OF FIREWOOD AND POLES

Firewood and poles can be produced by (a) State and Federal Departments in forest reserves, (b) farmers growing small woodlots, backed by a forestry extension service, and (c) extraction from areas of natural vegetation.

7a. Production of firewood and poles by State and Federal Departments

This type of forest production has the following characteristics:-

1. The plantation is financed and managed by Government.

2. A few hectares to 100 ha (250 ac) are planted in one location.

3. The production is usually directed towards meeting a local requirement for firewood and poles.

4. The work has an element of research in it and so the costs are

not critical. Alternatively the plantation is established for social reasons even though it is not economically viable.

Location of areas for production of firewood and poles by State and Federal Authorities

Production on the Jos Plateau takes place either within forest reserves shown on Separate Map 2 or within Communal Forest Areas (CFA). The Forestry Department is disheartened by the difficulties of achieving proper forest management in the CFAs as these are not under their control.

Increased production of firewood and poles could be achieved by increasing the area of planting within the reserves; the growth potential of eucalypts is given in Table 55 for those reserves for which information is available. These are shown on Text Map 2.7 and on Separate Map 4. The method of assessing the growth potential is given in Appendix 4.

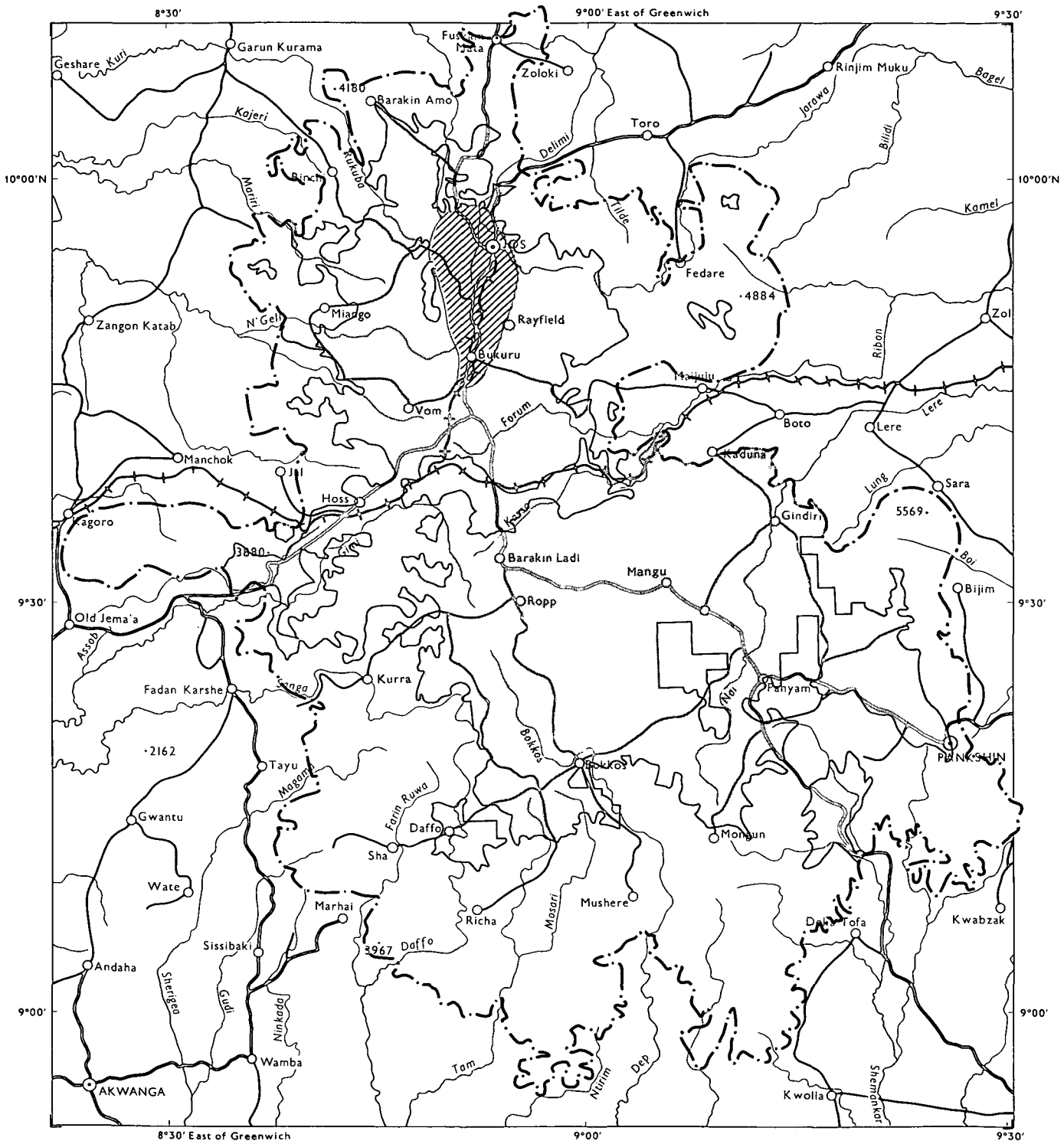
TABLE 55 Growth potential of eucalypts in forest reserves on the Jos Plateau

Administrative unit	Forest reserve	Land system	Growth potential $m^3/ha/a$
Jos	Naruguta	113	10–15
Mangu	Richa	105	5–9
		125,126	10–15
	Langai/Mongu	130	10–15
Barakin Ladi	Kurra Jekko/Abak River	106	5–9
	North East & Assob Escarpments	102	5–9
Kachia	Chawal Escarpment	103	5–9
		128	10–15

Firewood and poles could also be produced in the reserves recommended for areas in need of conservation that are discussed in a later section.

Effects on other types of development As production takes place within forest reserves, the effect on other types of development is limited.

FOREST RESERVES FOR PRODUCTION OF FIREWOOD AND POLES, AND AREAS REQUIRING EXTENSION FORESTRY



LAND SYSTEMS SHOWN

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7b. Production of firewood, poles and economic farm trees by farmers

The development of this type of forestry which has been described in greater detail by Howard (1976) should include the following:-

1. A forestry extension service should be formed using Government and local authority field staff to encourage the protection of farm trees and planting of indigenous and exotic trees.

2. Seedlings should be raised in a nursery and distributed to the farmers who pay a subsidised price for them.

3. Equipment such as pig wire should be supplied to the farmer, possibly at a subsidised price, to protect trees from goats.

4. The farmer should do the planting, weeding, fire tracing and felling, advised and encouraged by the forestry extension worker.

Species recommended for economic farm trees are cashew, Anacardium occidentale, avocado pear Persea gratissima, Canarium schweinfurthii, Mangifera indica and Vitex doniana. Eucalyptus are recommended for use in woodlots for firewood and poles.

Location of areas for production of firewood, poles and economic farm trees by farmers This type of development is needed and could be established over the whole of the Jos Plateau.

Effect on other types of development The production of firewood and poles by farmers becomes necessary whenever a high density of cultivation occurs over such large areas that farmers cannot collect firewood from nearby natural vegetation. It is therefore relevant to developments aimed at increasing the area of cultivation. The production of economic farm trees could be integrated with farming systems.

7c. Extraction of firewood and poles from natural vegetation

As the Jos Plateau is virtually treeless there is little scope for cutting firewood.

8. ESTABLISHMENT OF FOREST RESERVES FOR PROTECTION AGAINST EROSION

Forest reserves should be established in areas with slopes mainly in excess of 10% (6°) or which are severely gullied. Grazing should be prohibited until the forest reserves are well established and then strictly controlled so that the grass cover is not eliminated and the effectiveness of the erosion control reduced. If the areas are not reserved the strictest conservation measures must be enforced.

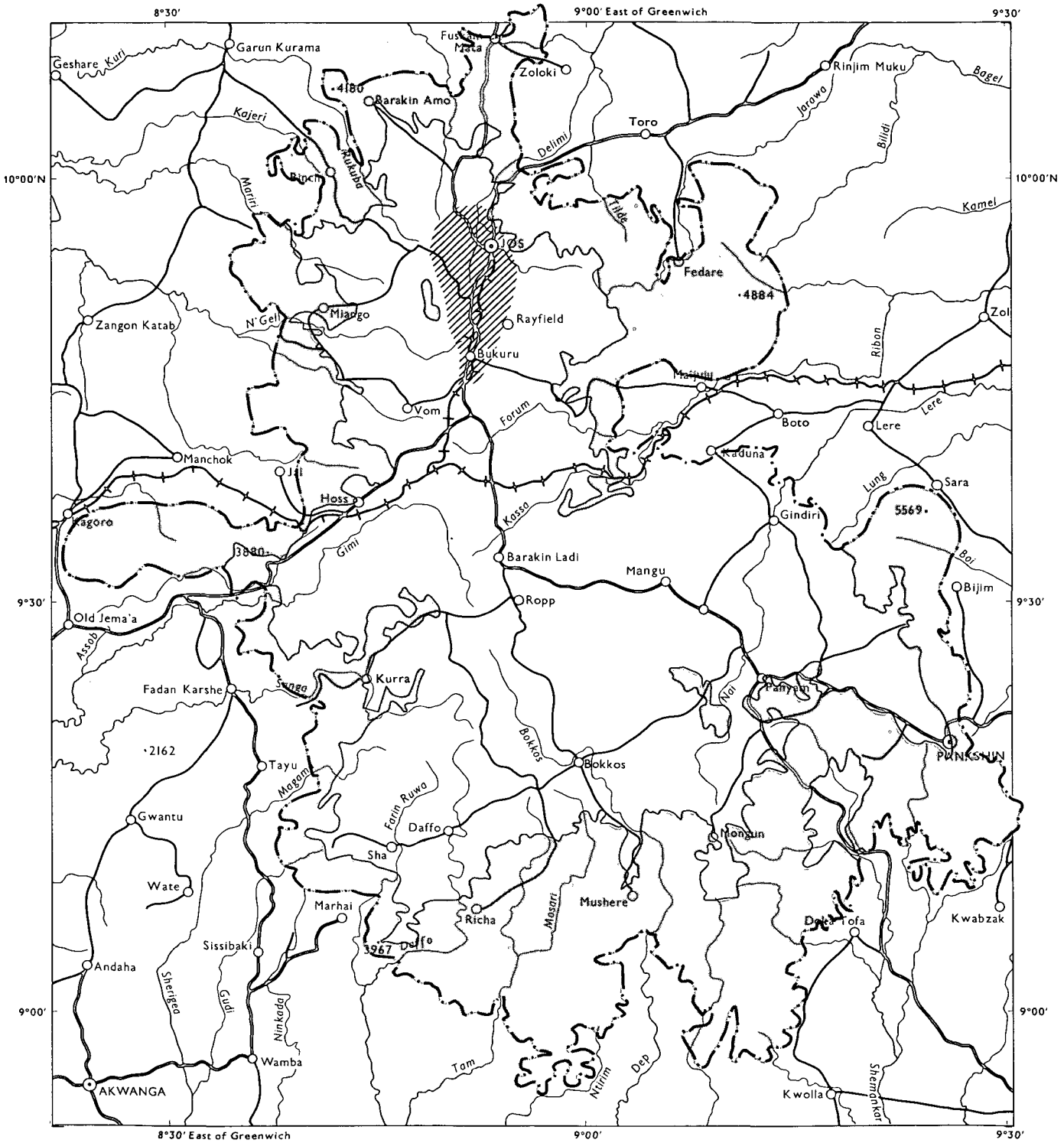
Location

Areas requiring protection against erosion occur throughout the Jos Pleateau but particularly around the margins where rocky and hilly country predominates. The land systems requiring conservation are listed in Table 56 and are shown on Text Map 2.8 and on Separate Map 4. Gullies occur in many other land systems but protection with forest reserves is not thought practicable.

TABLE 56 Areas requiring protection against erosion

Administrative unit	Land system
Plateau State	
Bassa	LS1,2,101,102,103,104,(110)
Jos	LS1,2,101,104,(110)
Barakin Ladi	LS1,102,103,106, parts 118, (110)
Mangu	LS1,2,101,102,103,105,106, parts 117,118,119
Pankshin	LS1,2,101,102,103,105,pts 118
Akwangu	LS1,102,part 111
Shendam	LS1,102
Lafia	LS1,103
Bauchi State	
Toro	LS1
Tafawa Balewa	LS1,101
Kaduna State	
Saminaka	LS1,103,104
Jema'a	LS1, parts 111

AREAS REQUIRING RESERVATION OR STRICT CONSERVATION



Jos Metropolitan Area

Kilometres 10 5 0 10 20 30 Kilometres

Miles 10 5 0 10 20 Miles

Boundary of Jos Plateau

Prepared by the Directorate of Overseas Surveys 1977

9. MINESLAND RECLAMATION

The large areas of land disturbed by mining pose special problems in reclamation and agricultural development. The present policy is to level the mining spoil with heavy equipment and plant with Eucalyptus. Howard (1975) has shown that the growth of Eucalyptus is poor on much of this reclaimed land, probably because of the compaction of the spoil. However, even this policy is not being implemented, as the Minesland Reclamation Unit lack staff and equipment.

Further research is needed in the utilisation of the mined areas. The following aspects need investigation.

1. The optimum use of the various ecological zones within the mining spoil distinguished by Howard (1975): it may be possible to use some without any reclamation.

2. Methods of reducing the compaction of the levelled mining spoil, either by mechanical means or by those of soil conditioners.

3. The use of the excavations as reservoirs for small scale irrigation of vegetables grown either on the surrounding undistrubed land or on parts of the disturbed areas.

Location of areas for reclamation

The areas disturbed by mining are shown on Separate Map 1. All these areas will eventually require reclamation and rehabilitation, but there are two areas with a particularly high concentration of disturbed land which are distinguished on Separate Map 4. One occurs in the north of the Plateau around and between Jos and Bukuru, the other further south in the Barakin Ladi and Ropp area.

The disturbed and undisturbed land in these two areas form a complex interrelated pattern. In consequence the other forms of development discussed in this report will be difficult to apply or will be inapplicable.

10. EROSION CONTROL

The problems of erosion control have been discussed by Jones (1975) and can be summarised as follows.

1. Erosion due to cultivation

i) Simple erosion control measures should be used in the general farming areas prohibiting cultivation downslope on streambanks and road verges, by revival of old N.A. (Control of Erosion) laws.

ii) Farmers should be re-educated before the enforcement of legislation.

iii) A conservation inspectorate should be set up to police reactivated erosion control measures.

iv) Conservation education should be introduced in schools.

v) Capital intensive conservation should be restricted to large scale farming schemes.

vi) Cultivation should not be permitted on slopes of 10% (6°) or more.

2. Erosion due to grazing

Overgrazing and overstocking result in trampling and compaction of the top soil, and the loss of the vegetative cover which leads to increased run-off of rain water and increased gullying. The risk of erosion is particularly high when the overgrazing occurs close to the banks of watercourses and gullies. Control of these malpractices is dependent on regulation of the whole livestock population of the Plateau.

3. Erosion due to tin mining

Tin mining excavations may trigger off extensive gully erosion so the control of the erosion is closely related to the reclamation and rehabilitation of the mined areas. A particular problem is presented by those leases that have been worked in the past and have not been reclaimed because there may be residual deposits of tin. Conservation should be enforced to prevent gullies forming around these leases.

CONSTRAINTS ON AGRICULTURAL DEVELOPMENT

The Third National Development Plan, 1975-80, discusses the constraints on agricultural development as follows:

"The constraints are several but the most serious are

i. Shortage of qualified manpower in key areas
ii. Inadequate supplies of agricultural inputs
iii. Inadequate extension service
iv. The poor condition of feeder roads and other transport facilities
v. Inadequate or lack of effective supporting services such as farm credit, marketing facilities, etc
vi. The problem of land ownership imposed by the land tenure system in most parts of the country
vii. The problem of diseases and pests
viii. The problem posed by labour shortage in the rural areas in consequence of rural-urban migration
ix. Lack of appropriate or complete packages of technology for many food crops
x. Drudgery in farm work and low returns from agriculture which forces rural youth to migrate to urban areas rather than go into farming"

Interviews with farmers in 8 villages scattered throughout the Jos Plateau (see Separate Map 2) confirmed that these factors are indeed constraints to agricultural development. Those factors for which data are available are discussed below and more fully by Gosden (1978).

"i. Shortage of qualified manpower in key areas and iii. Inadequate extension services"

1. The ratio of field agricultural extension workers to farming families ranges from 1:1 300 in Jos Division to 1:790 in Pankshin Division. Existing integrated rural development projects in Nigeria are aiming at a ratio of 1:400.

2. There is one range management officer based in Jos. Although there are three assistants they are based in Wase, off the Jos Plateau.

3. With any extension service, whether it be for crop production, pasture improvement, forestry or soil conservation, there is a conflict between the need to encourage and advise the population and the need for policing to eliminate malpractices. The two functions should be kept separate and policing done by special inspectors. Jones (1975) has suggested having a special soil conservation inspectorate.

"iv. The poor condition of feeder roads and other transport facilities"

Reference to the legend of Separate Map 1 shows the length of main road, secondary roads and track in each land system on the Jos Plateau, though the figures must be considered in relation to the total area of each land system. They show that in most parts of the Jos Plateau there is an adequate network of roads and tracks.

"viii. The problem posed by labour shortage in the rural areas in consequence of rural urban migration"

Gosden (1978) has produced farming calendars for a number of localities on the Jos Plateau that show that shortage of labour is a common restraint to production, particularly at weeding time. Lack of money at this time prevents additional labour being hired, even if this is available.

Additional constraints

1. The lack of effective farmers organisations which would enable farmers to request and benefit from more effective extension advice, bulk purchases of inputs and handling of produce, credit facilities and tractor hiring units.

2. The low level of soil fertility is a severe constraint to production. This is partly due to inherently low soil fertility, and partly to intensive cultivation over the past 70 years with little addition of fertiliser.

3. Disturbance by mining. This not only renders large areas (316 km^2/ 122 mi^2) virtually useless for agriculture but often triggers off gullying and erosion. This has been fully discussed by Jones (1975).

RESEARCH NEEDS

A long-term programme of research should be established to answer some of the problems to be encountered during development. Topics needing investigations are summarised below.

1. Trials to test varieties, fertiliser treatments and cultivation practices related to specific soils on the Jos Plateau. For example, many of the soils have a low pH, other large amounts of coarse material and, with present technology, are considered to present limitations to the growth of crops. Research should be aimed at producing varieties or technologies that will overcome or at least reduce these limitations.

2. The long term effects of intensive crop production on the often infertile and poorly structured soils of the area need study: in particular the long term effects of mechanised agriculture in relation to differing management practices and rotations.

3. Trials to test the varieties of wheat vegetables and high yielding dwarf sorghum most suited to the special climate of the Jos Plateau.

4. Cool storage facilities for potatoes need to be designed and tested for Plateau conditions together with temporary storage arrangements on the farm.

5. The most effective way of utilising or reclaiming land disturbed by mining needs study. In particular the utilisation of the two areas with a high proportion of disturbed land needs shown on Separate Map 4 needs investigation.

6. Methods of adopting pasture improvement techniques to wide scale implementation need investigation.

7. Practical methods of improving the nutrition of young stock in the ordinary nomadic herd need to be devised.

8. A socioeconomic study of Fulani practices and attitudes is needed, particularly of those on the Bauchi to Abuja axis.

9. Trials should be made of species for planting out in farmers woodlots,

together with investigations of techniques for protection of the growing plant and investigation as to the best methods of gaining the cooperation and involvement of the farmers.

10. Small scale plantations of pines and eucalypts are necessary to test the reaction of species to different soil and site conditions. This could be done by establishing the plantations on a toposequence of soils extending from crest to valley bottom.

11. Seed orchards should be established to provide sufficient seed of pines and of the best provenances of Eucalypts. Jackson (1974) suggests using grafts to obtain fruiting material as soon as possible.

Part 5

Part 5 References

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Appendixes

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INTERPRETATION OF SOIL DATA IN RELATION TO THE GROWTH OF MAIZE, MILLET, SORGHUM, GROUNDNUTS AND COTTON A1

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Appendix 1 Interpretation of soil data

INTERPRETATION OF SOIL DATA IN RELATION TO THE GROWTH OF MAIZE, MILLET, SORGHUM, GROUNDNUTS AND COTTON

The soil physical properties of depth, drainage, texture of the surface 50 cm and the amount of coarse material are considered to have an important effect on crop production. They are all properties that cannot be modified without major soil improvement programmes. They have been divided into classes and given a coded annotation: each class has been assessed as a nil, minor, moderate or severe limitation to the growth of maize, millet, sorghum, groundnuts or cotton.

In addition to soil physical properties, certain chemical properties may be limiting to crop growth. Data are available for pH, CEC, levels of potassium and available phosphorus, and each of these has also been divided into classes and assessed as a limitation to the growth of the crops considered.

Each of the soil properties is discussed below. The classes into which they have been divided, and their coded annotation, are given in the tables, together with the assessment of each class as a limitation to the growth of the crops considered.

In the project area* yam, Irish potatoes and rainfed rice are grown under special conditions which are discussed separately at the end of this Appendix.

Depth

The effective depth of the soil is considered to be that depth beyond which roots will not readily penetrate due to the presence of rock, ironpan or a permanent high water table. The depth classes and codes are given in Table 1 and assessed as limitations to the growth of crops.

*Yam cannot be grown as a rainfed crop in the Bauchi Plains, Kano Plains and northern Kaduna Plains. Irish potatoes can only be grown on the Jos Plateau.

TABLE 1 Depth classes and codes assessed as limitations to the growth of certain crops

Depth class cm	Soil code	*Limitation to the growth of					
		Maize	Millet	Sorghum	Groundnut < 140 day rainy period	Groundnut > 140 day rainy period	Cotton
> 150	DO	Nil	Nil	Nil	Nil	Nil	Nil
150-100	Dl	Nil	Nil	Nil	Nil	Nil	Nil
100-50	D2	Nil	Nil	Nil	Nil	Nil	Mod.
50-25	D3	Mod.	Mod.	Mod.	Mod.	Nil	Sev.
25	D4	Sev.	Sev.	Sev.	Sev.	Sev.	Sev.

*Depth not limiting to yams on large ridges or mounds unless <25 cm, when severe limitation

Shallow soils limit root development, thus inhibiting nutrient and moisture uptake which results in low yields. Shallowness is least limiting to shallow rooting crops such as groundnuts. Even soils of 50-25 cm depth impose no limitations to groundnuts if the rainy period is greater than 140 days, as significant periods of water stress are unlikely. Shallowness is most limiting for cotton which is a deep-rooting crop that also requires soil moisture after the end of the rainy season for optimum yields.

Drainage

Soil drainage has been assessed on the basis of soil colour, with pale colours being correlated with poor drainage. The criteria used are similar to those given in the Legend to the Soil Map of the World (FAO 1974). Imperfectly drained soils have been subdivided and the soil codes W2-W4 represent a seasonal water table increasingly closer to the surface. The only certain way of determining the drainage characteristics of a soil is to record seasonal watertable fluctuations, but this was not possible over such a large area: the drainage classes should therefore be considered as tentative.

The drainage classes and codes are given in Table 2 and the assessment of these classes as limitations of the growth of crops in Table 3.

TABLE 2 Drainage classes defined on the basis of colour

Drainage class	Colour criteria and depth	Soil code
Well drained	Soils lacking properties of codes W1-W5	WO
Well drained imperfectly drained	Gleyic horizon colour or > 20% gley spot mottle at 100-150 cm	W1
" "	> 20% gley spot mottles at 50-100 cm	W2
" "	Gley horizon matrix colours at 50-100 cm	W3
" "	> 10% gley spot mottles or imperfect matrix colours at < 50 cm	W4
Poorly drained	Gleyic horizon matrix colours at < 50 cm	W5

TABLE 3 Soil drainage assessed as limitations to the growth of certain crops

Soil Code	Limitation to the growth of//					
	Maize	Millet	Sorghum	Groundnut ≤ 140 day rainy period	Groundnut > 140 day rainy period	Cotton
WO	Nil	Nil	Nil	Nil	Nil	Nil
W1	Nil	Nil	Nil	Nil	Nil	Min.
W2	Min.	Nil	Nil	Nil	Nil	Mod.
W3	Min.*	Min.	Min./	Min	Nil	Mod.**
W4	Mod.	Mod.	Min.	Mod.	Min.	Sev.
W5	Sev.	Sev.	Sev.	Sev.	Sev.	Sev.

* For maize if this degree of limitation is found in combination with two others, one of which is texture, it is treated as a moderate limitation

/ For sorghum as for *

** For cotton as for * & / but treated as a severe limitation under these conditions

// Drainage not limiting for yams grown on large ridges or mounds

Impeded drainage is a limitation to the growth of all the crops considered because they will not tolerate the anaerobic conditions of water-saturated soils: groundnuts, cowpeas and other legume crops are particularly adversely affected by waterlogging. Shallow-rooting crops such as groundnuts are less affected by waterlogging in the lower part of the soil profile, whilst deep-rooting crops such as cotton are most affected. Although sorghum and maize have similar rooting habits, the former is more tolerant of wet conditions in the later stages of growth. The limitations imposed by drainage shown in Table 3 reflect the fact that the soil codes WO-W5 are thought to represent seasonal water saturation increasingly near the surface.

A complicating factor in assessing the limitation imposed by imperfectly drained soils is that in a dry year, such soils support better crop growth. This is offset by the fact that in a year of above average rainfall soils may be even more limiting than is shown in Table 3.

Texture

Texture of the surface 50 cm only is considered because most of the feeding roots of annual crops are concentrated there.

Four broad textural groups have been defined corresponding in general to clayey, loamy, sandy and coarse sandy soils. The textural classes in each group are shown in Table 4, together with the assessment of these groups as limitations to the growth of certain crops.

TABLE 4 Groups of textural classes and soil codes assessed as limitations to the growth of certain crops

Texture class	Soil code *	Limitation to the growth of						
		Maize	Millet	Sorghum	Groundnut	Cotton	Yam (on large ridges or mounds)	
							//180-199	>200
Cl,C,SC,SiCl,SiC	T1	Nil	Min.	Nil	Min.	Nil	Nil	Nil
L,SCl,SiL,Si	T2	Nil	Min.	Nil	Min.	Nil	Nil	Nil
S,fS,L$,LfS,SL,fSL	T3	Min.	Nil.	Min.	Nil	Min./	Mod.	Min.
cS,cLS,cSL	T3c	Min.	Nil	Min.	Nil	Mod.	Mod.	Mod.

* Where appropriate a subscript + is given to those profiles where 10-20 cm has a finer texture.
Where appropriate a subscript - is given to those profiles where 10-20 cm has a coarse texture

/ For cotton T3 + is a minor limitation (t), T3 is treated as a moderate limitation (Ta) with regard to Soil Category 2 but as a minor limitation when considering effect of texture in Categories 3, 4 or 5.

//Rainy period in days

C = clay, L = loam, S = sand, Si = silt, f = fine, c = coarse.

The four textural groups reflect differences in available waterholding capacity (Williams and Joseph, 1970). This is of particular significance in assessing the limitations presented by any soil to the growth of cotton

and late planted millet which require a minimum of 11.8 cm (4.6 in) and 7.2 cm (2.8 in) of available soil water after the end of the rainy period respectively.

Calculation of the mean depths of soil required for various textural groups to hold the above amount of water indicates that, apart from CS, C1S, CSL (T3C group), the differences are less than 20 cm and the variation in AWC (available water capacity) due to texture has little practical significance for most rainfed crops.

Nutrient availability and aeration are also related to texture so maize, sorghum and cotton require medium and fine textured soils for optimum yields but millet and groundnuts will yield adequately on coarser textured soils. In the case of groundnuts this is an indirect effect as they will grow well on heavier soils, but are difficult to harvest. Management of heavy clay soils, particularly of montmorillonitic clays, may also be a limitation because of their physical characteristics: (a) they become sticky and puddle when wet, (b) they crack on drying out which may cause rupture of roots, (c) rain water flows rapidly down the cracks with little moisture retained near the surface: when the cracks close water tends to stand on the surface.

Coarse material

This includes all the hard soil particles greater than 2 mm in diameter; they may be rock fragments, mineral grains or concretions. Both the amount of coarse material and the depth over which it occurs are significant to crop growth, and in Table 5 various combinations of percentages of coarse material and the depths at which they occur are used to define seven classes shown as C0 to C6. The percentage of coarse material is assessed in the field as a volume percentage.

TABLE 5 Percentages of coarse material in various depth ranges in seven classes represented by codes CO to C6

Mean coarse material percentages	Depth ranges over which coarse material occurs	Soil code
<20	0-100 cm	CO
<20 20-40	0-50 cm 50-100 cm	C1
20-40	0-100 cm	C2
20-40 40-60	0-50 cm 50-100 cm	C3
<40 >60/Rock/Hardpan	0-50 cm from 50 cm	C3(s)
40-60	0-100 cm	C4
40-60 >60	0-50 cm 50-100 cm	C5
40-60 Rock/Harpan	0-50 cm 0-100 cm	C5(s)
>60	0-100 cm	C6
>60 >60	0-50 cm 50-100 cm	C6
(s) shallow		

The assessment of these classes as limitations of certain crops is given in Table 6.

TABLE 6 Coarse material soil codes assessed as limitations to the growth of certain crops

Soil code	Limitation to the growth of					
	Maize	Millet	Sorghum	Groundnut	Cotton	Yam*
CO	Nil	Nil	Nil	Nil	Nil	Nil
C1	Nil	Nil	Nil	Nil	Min.	Nil
C2	Min.	Min.	Min.	Min.	Min.	Nil
C3	Min.	Min.	Min.	Min.	Mod.	Nil
C3s	Min.	Min.	Min.	Min.	Sev.	Nil
C4	Mod.	Mod.	Mod.	Mod.	Mod.	Mod.
C5	Mod.	Mod.	Mod.	Mod.	Sev.	Mod.
C5s	Mod.	Mod.	Mod.	Mod.	Sev.	Mod.
C6	Sev.	Sev.	Sev.	Sev.	Sev.	Sev.
*On large ridges or mounds						

Coarse material reduces available waterholding capacity by reducing the volume of soil so its effect is most pronounced on cotton which requires moisture after the end of the rains to give maximum yields. This also adversely affects the yields of maize, millet and sorghum but to a lesser extent. Coarse material also affects the root penentration and reduces overall nutrient status. Large amounts of coarse material in the surface horizons of soils may make cultivation more difficult and thus has an indirect effect on crop production.

Soil chemical properties

Low levels of certain soil chemical properties can limit crop yields. The most important for which data from routine soil analyses is available are considered to be 1. Soil pH (water), 2. Phosphorus, 3. Potassium, and 4. Cation exchange capacity (CEC).

1. pH (water) The limitations due to pH are shown in Table 7.

TABLE 7 Limitations imposed by pH to the growth of certain crops

Crop	pH range (water)	Limitation
Maize	5.5-7.5	Nil
	5.2-5.4	Minor
	4.5-5.1 or 7.6-8.0	Moderate
	<4.5 or >8.0	Severe
Sorghum	5.5-7.5	Nil
	5.0-5.4	Minor
	4.5-4.9 or 7.6-8.0	Moderate
	<4.5 or >8.0	Severe
Millet	5.0-6.5	Nil
	4.5-4.9 or 6.6-7.0	Minor
	4.0-4.4 or 7.1-8.0	Moderate
	<4.0 or >8.0	Severe
Rice (Swamp)	4.5-7.0	Nil
	3.0-4.4 or 7.1-7.5	Minor
	7.6-8.0	Moderate
	<3.0 or >8.0	Severe
Cotton	5.0-6.0	Nil
	4.5-4.9 or 6.1-6.5	Minor
	4.0-4.4 or 6.6-7.5	Moderate
	<4.0 or >7.5	Severe
Groundnuts	5.5-6.5	Nil
	5.0-5.4 or 6.6-7.0	Minor
	4.5-4.9 or 7.1-7.5	Moderate
	<4.5 or >7.5	Severe
Yam (on large ridges or mounds)	5.0-7.0	Nil
	4.5-4.9 or 7.1-7.5	Minor
	4.0-4.4 or 7.6-7.8	Moderate
	4.0 or >8.0	Severe

2. Phosphorus There are not sufficient data on phosphorus availability as determined by the Truog method to make generalisations related to land systems. Phosphorus availability is related to pH and the limitations due to phosphorus availability were assessed as in Table 9.

TABLE 8 Limitations due to phosphorus availability related to pH

pH		Limitation
6.5-7.5		Nil
6.0-6.49	7.51-8.0	Minor
5.0-5.9	8.1-8.5	Moderate
<5.0		Severe

3. Potassium The assessment of different levels of potassium in terms of plant needs is given below.

a) At pH > 4.5

0.15 meq/100 gm soil		Luxury
0.1-0.15	" " " "	Adequate
< 0.1	" " " "	Deficient

b) At pH < 4.5 the assessment is based on the potassium saturation percentage: where this is > 2, levels are thought to be adequate, where it is < 2 levels are thought to be deficient.

4. Cation exchange capacity (CEC) Little is known about critical levels of CEC with respect to retention of potassium, calcium and magnesium cations under leaching conditions of intensive rainfall. Adetunji (1974) related CEC levels to the ability of a soil to withstand intensive cultivation. These levels are given below, based on his classification.

CEC > 8 meq/100 gm soil		Suitable for intensive agriculture
2-7.9	" " " "	Requires a high ratio of fallow or grass legume pasture to crops
< 2	" " " "	Unsuitable for production of annual, arable, rainfed crops

Soil limitation categories (SLC)

Limitations due to any of the factors discussed above may occur in soils in a variety of combinations. For example, reference to Tables 1, 5 and 6 shows that a soil of 25-50 cm depth with a high percentage of coarse material would have two severe limitations to the growth of any of the crops considered, whilst a soil of similar depth and no coarse material is considered to have only one severe limitation (due to depth) for cotton and only a moderate limitation for maize or millet or sorghum.

Various combinations of nil, minor, moderate and severe limitations have been used to define five soil limitation categories (Table 9) based only on the limitations due to the physical characteristics.

No attempt has been made to consider the interrelationships of the physical and chemical soil characteristics. A soil is placed in a soil limitation category on the basis of its physical characteristics; any limitation due to chemical characteristics is noted separately.

As the soil characteristics are interpreted differently for different crops it follows that the limitation category is specific to a given crop.

Soil limitation categories in relation to crop yields

An attempt was made to check whether the soil limitation categories are related to actual crop production. The yields of a variety of crops grown on State demonstration plots were collected. However, differences in yield due to climatic or management factors were so great that it was not possible to correlate differences in yields with soil differences. In other experiments done in the project area information about the soils is generally inadequate.

The soil limitation categories must therefore be considered tentative. However they have been defined after discussion with a wide range of research workers and practising agriculturalists in Nigeria. They can therefore be considered as a consensus opinion of the limitations imposed by soil characteristics to the growth of crops.

TABLE 9a Nature and degree of limitations shown in Table 9b

Nature of limitation	Letters used to denote the degree of limitation			
	Nil	Minor	Moderate	Severe
Depth (D)	O	N/A	D	D
Drainage (W)	O	w	W	W
Texture (T)	O	t	Ta, tb*	N/A
Coarse material (C)	O	c	C	C

*Ta or Tb are treated as a moderate limitation for Categories 1 and 2 only. For Categories 3, 4 and 5 they are treated as a minor limitation

TABLE 9b Combinations of the degrees of limitation acceptable in each soil limitation category for rainfed maize, millet, sorghum, groundn cotton and yam (grown on mounds or large ridges)

1	2	3	4	5
O	w	D	Dw	DW + or - c, t, or Ta
	t	wt	Dt	DWC + cr - t, or Ta
	c	wTa	DTa	DWC + or - t, or Ta
	wt *	wtc/	Dwt/	DWC
	tc *	wTac	DwTa	DC + or - t, Ta or Tb
		wc	Dtc	DC + or - t, Ta, or Tb
		W	DTac	D + or - any combination
		Wt	Dc	WC + or - t, or Ta
		WTa	wC	WC + or - t, or Ta
		tc	wtC/	WC + or - t, or Ta
		tC	wTaC	TbC
		TaC	wtC**	TbC
		Ta	WTac**	
		Tb	Wc	
		C	WC	
			W	
			WTa	
			Wtc	
			Wc	
			tC	
			TaC	
			C	

* These combinations only permitted for sorghum and millet

/ for Maize if drainage code is W3(w) for this combination the drainage becomes a moderate limitation W
for Sorghum if drainage code is W3(w) for this combination the drainage becomes a moderate limitation W

** for Cotton if drainage code is W3(W) for this combination the drainage becomes a severe limitation W
Therefore in both cases / and ** the limitation category for that soil would go down one

Ta Texture limitation applicable to cotton only

Tb Texture limitation applicable to Yam only when grown in areas with 180-199 day rainy period

Soil limitation categories in relation to land systems

The land systems shown on Separate Map 1 are defined in terms of their landform, soils and vegetation. The soils are grouped according to depth, drainage, texture of the surface 50 cm and amount of coarse material; the groups are represented by codes as discussed in previous sections of this appendix.

An estimate is made of the percentage of each land system occupied by soils of a given code. The area of each facet in each land system is first measured on representative aerial photographs. Many land systems have a number of small facets, so, to simplify the estimate, only facets occupying a mean 18% (11-25% range) or more of a land system are considered further: These facets usually make up more than 70% of the unit.

The soils on any facet have been described by a number of soil pits and each soil is given a code. The number of pits of a given code, as a percentage of the total number of pits on the facet, is taken as the percentage of the facet occupied by soils of that code. As these percentages are only indicative they are given in percentage classes of <10, 10-29, 30-50 and/or 30-59 and >60.

Soils of a given code can be assigned to one of the five limitation categories defined in the previous section. A land system can therefore be defined in terms of percentages of various limitation categories by summing the relative proportions of facets.

For example, in Land System X (Table 10) the soils are in three groups. 30-59% of the land system has soils coded as D_2W_0 T_3 + C_2 i.e. soils of 50-100 cm depth, well drained, coarse textured surface horizons and 20-40% coarse material scattered throughout the soil profile. Shallow depth, free drainage and coarse texture are not limiting to the growth of millet, but the coarse material is considered as a minor limitation. (See Tables 1, 3, 4 and 6.) As the soil has only one minor physical limitation for millet, it is classed as limitation category 2. (See Table 9.) In the case of maize, the texture and the coarse material are both considered as minor limitations and by reference to Table 9 the soil is placed in soil limitation category 3.

TABLE 10 Percentage of soils of various codes in Land System X and their relationship to soil limitation categories for certain crops

Land system	Soil code				% of land system in each code	Soil limitation category by crop						
	D	W	T	C		Maize	Millet	Sorghum	G'nut	Cotton	Yams*	Rice
X	2	0	3+	2	30-59	3	2	2	2	4	1	5
	2	0	3+	5	10-29	3	3	3	3	5	3	5
	1	0	3+	0	10-29	2	1	2	1	3	1	5

*On large ridges or mounds

Ranking of land systems

Land systems with the highest proportion of SLC 1 land have least limitations to the growth of a given crop. If two land systems have a high proportion of SLC 1 land, the one in which the remaining land is SLC 2 or 3 can be considered to be better than the one in which the remaining land is SLC 4 or 5.

A land system is considered especially favourable for the production of a crop if it has one of the following combinations of SLCs:

- at least 30-50% SLC 1 + any other SLC
- $\geq$ 60% SLC 2
- at least 30-50% SLC 2 + 10-29% SLC 1
- 30-59% SLC 2 + 10-29% SLC 3
- 10-29% SLC 1 + 10-29% SLC 2 + 10-29% SLC 3.

Land systems with these combinations of Soil Limitation Categories are shown on the legend of Separate Map 3. The legend of Separate Map 1 shows the percentages of the Soil Limitation Categories in all the land systems in the area.

INTERPRETATION OF SOIL DATA IN RELATION TO THE GROWTH OF YAMS

This crop is grown either on mounds or large ridges within the project area. This method has a number of advantages over 'on-the-flat' cultivation practiced in other parts of Nigeria - mainly on free draining, deep, alluvial sandy loams with little, if any, coarse material and a relatively high fertility.

Observational trials carried out on the Jos Plateau (Pankshin area) have shown that higher yields are obtained from mound cultivation as opposed to ridge cultivation. The following soil conditions achieved by mound/ridge cultivation are considered to be advantageous to the development of yam tubers:

1. The soil is broken up into a relatively friable medium and finer textured soils do not present the same 'resistance' to tuber expansion as would be the case with 'on-the-flat' cultivation

2. In areas suffering from seasonal waterlogging, mounds raise the tubers above the level where anaerobic conditions occur and in fact produce the free draining conditions required for optimum tuber development

3. The depth of the soil is artificially increased enabling yams to be grown on soils which would be too shallow to 'on-the-flat' cultivation

4. The presence of a layer of coarse material within the growing depth for the tuber has been shown at IITA, Ibadan, to distort tuber development, preventing further downward growth. When mounds or ridges are used, the coarse material is evenly distributed throughout the heap or mound and is likely to have much less impedance on tuber development. It is considered that a mean of up to 20% coarse material by volume is not limiting when the crop is grown on mounds or ridges.

5. The crop is relatively easy to harvest

The only possible disadvantage of mounds or ridges could be the increased rate of drying out of the soil due to the larger surface area exposed to the sun, ridges being worse in this respect than mounds. In the project area and particularly in the Benue Valley with its longer rainy season and reliable rainfall this effect is considered to be of little importance, even when coarse-textured soils (which can dry out more rapidly) are considered

To summarise the above, provided 25 cm depth of soil is available, soil depth is not a limitation for yams grown on ridges. There is no limitation imposed by poorly drained soils. Variations in soil texture are of only minor importance and the adverse effect of coarse material is lessened.

INTERPRETATION OF SOIL DATA IN RELATION TO THE GROWTH OF IRISH POTATOES (JOS PLATEAU ONLY)

As these are grown on 25-30 cm high ridges, many of the comments made about yams are relevant to Irish potatoes. Depth is not limiting unless it is less than 25 cm which is considered severe (D4). Drainage only becomes significant when the seasonal watertable is less than 50 cm. The best development of tubers occurs on coarse-textured soils which also assists in obtaining clean tubers when lifting. Coarse-textured soils T3(+), therefore, are the only ones

permitted in category 1 (Table 11). Irish potatoes have similar responses to coarse material as yams. Up to C3s is treated as no limitation.

TABLE 11 The range of code numbers permitted for key soil characteristics in each soil limitation category for Irish potatoes grown on 25-30 cm ridges on the Jos Plateau

Category	Degree of limitation	D	W	T	C
1	O	O/1/2/3	O/1/2/3	T3(+)	O/1/2/3/3s
2	t	O/1/2/3	O/1/2/3	T1 or 2	O/1/2/3/3s
3	W	O/1/2/3	4	T3(+)	O/1/2/3/3s
3	Wt	O/1/2/3	4	T1 or 2	O/1/2/3/3s
3	C	O/1/2/3	O/1/2/3	T3(+)	4/5/5s
3	Ct	O/1/2/3	O/1/2/3	T1 or 2	4/5/5s
4	W(t)	O/1/2/3	5	Any	O/1/2/3/3s
4	C(t)	O/1/2/3	O/1/2/3	Any	6
4	CW(t)	O/1/2/3	4	Any	4/5/5s
5	D*	4	Any	Any	Any
5	WC(t)	O/1/2/3	5	Any	4/5/5s
5	WC(t)	O/1/2/3	4	Any	6
5	WC(t)	O/1/2/3	5	Any	6

*Any other combination

INTERPRETATION OF SOIL DATA IN RELATION TO THE GROWTH OF RAINFED RICE

In the project area the crop can be grown on three main drainage positions:-

1. Shedding sites, such as crest, upper, middle and planar or convex slope which are dependant entirely on the direct rainfall which enters the soil. They may either have (a) free draining soils, or (b) soils with imperfect drainage usually associated with shales or hardpan near the surface giving rise to a perched watertable.

Free draining soils require reliable rainfall distributed evenly over the growing season (ideally at least 5 mm/day). A drought of 10 days duration on

soils with a low water-holding capacity, either at the early stages of growth, or between the beginning of flowering and the milky (soft) grain stage can reduce yield by up to 80%.

Upland rice on free-draining soils is becoming an increasingly important cash crop in the Benue Valley south of the Benue River. The area appears to have a northern limit which coincides with the mean 1 300 mm (50 in) rainfall isohet as drawn by Kowal and Knabe (1972). It is assumed that areas south of this line are unlikely to suffer from significant drought periods during the growing season. Rice can, therefore, be grown on free-drainage soils in these areas, providing the same site is only used once in 5 years with an intervening fallow to enable the build up of organic matter and hence soil waterholding capacity.

Elsewhere in the project area such sites are considered unsuitable for rainfed rice production unless perched watertable conditions prevail which would probably enable the crop to be unaffected by drought periods of up to 15 days without loss of yield.

2. Receiving sites, such as concave lower slopes and valley heads. These sites not only receive water from direct rainfall but also water passing through soils from areas further up the slope. Such sites also receive run-off water which is usually transient.

3. Flooding sites, such as valley bottoms, floodplains and lower river terraces. The sites receive direct rainfall water passing through the soil from higher up the interfluve, run-off water and possibly flood water.

Sites 2 and 3 are considered the most suitable areas on which to grow rainfed rice over most of the project area. Such areas are usually minor facets of the land system (less than 10%) of the total area and are, therefore, not usually considered in our overall assessment of land systems which excludes soils data relating to minor facets.

The specific soil limitations for the crop are coded in Table 12.

TABLE 12 The range of code numbers permitted for key soil characteristics in each soil limitation category for rainfed rice

a. In areas <1 300 mm rainfall and < 200 day rainy period

These areas have a risk of water stress when soil has no limitations.

b. Varieties with 100-200 day growing period

Category	D	W	T	C
1	O/1/2/3	5	1/2	O/1/2/3
	O/1/2	4	1/2	O/1/2
2	O/1/2/3	5	3/3+	O/1/2/3
	3	5	1/2	3s
	O/1/2	4	3/3+	O/1/2
3	3	5	3/3+	3s
	O/1/2	4	1/2/3/3+	3
4	O/1/2/3	5	Any	4
	O/1/2	4	Any	4
	O/1/2	3	1/2	O/1/2/3
5	3	4	Any	3s
	O/1/2	Any	Any	5/6
	O/1/2/3	O/1/2	Any	Any
	O/1/2	3	3/3+	Any
	O/1/2/3	3	1/2	4
	3	3	1/2	3s
	4	Any	Any	Any

Categories 1, 2 and 3 are only likely to occur in lower slope or valley bottom situations or when conditions give rise to a perched watertable. Categories 1 and 2 includes 1-, 2+ or 2-.

Appendix 2 Assessment of erosion hazard

Erosion hazard has been assessed on the assumption that open field clean cultivation techniques are to be used. Three main factors are then considered to affect the degree of erosion to which an area is subjected, the length and steepness of slope, the duration and intensity of rainfall and the infiltration characteristics of the soil.

Slope is taken as the most important variable in the assessment of erosion hazard. Four slope categories have been defined.

a) <1% (0.5°) These areas should not require mechanical protection works. The use of grass strips and contour ploughing should give adequate erosion control.

b) 1-3% (0.6-1.75°) These areas require normal mechanical protection works which include graded terraces and grassed protected waterways. Contour ploughing and strip cropping should be practised. Mean contour intervals should range between 240-127 ft.

c) 3.1-10% (1.76-6°) These areas require normal mechanical protection works organised on a catchment rather than an individual farm basis. They should not be used for large scale mechanical farming schemes based on the rainfed crops considered in this report: the short inter-terrace intervals and complexity of the layout mean that economic running of machinery is extremely difficult and is only worthwhile for high value crops such as tobacco.

d) >10% (6°) These areas have a high erosion hazard and intensive conservation measures such as bench terracing are required. They are more suited to tree crops than arable crops. Total protection is recommended.

Data are not available for the project area on the duration and intensity of rainfall, but the start of the rainy season is characterised by short, heavy, violent rainstorms, having a high erosive power. It was not possible to subdivide the area according to the rainfall pattern.

Most of the soils in the project area rapidly form a capping which reduces infiltration: trampling by cattle may add to the problem. No quantitative measurements have been made so there has been no attempt to rank the soils according to their infiltration characteristics.

Appendix 3 Minimum size of economic farm units (provisional)

It has been suggested by Mansfield (in press) that a farm should produce a minimum net income of ₦ 900 per annum, corresponding to that of many daily paid government employees. Norman (1972) has shown that most farmers derive about 22% of their income from off-farm activities so farmers would have to derive ₦ 740 from the farm.

It has been assumed that

1. The farming system is based on annual rainfed crops

2. The farmer grows only one cash crop which is the one that brings him the highest net return per unit area and has the least environmental limitations to growth

3. All farmers used improved practices such as early planting, improved seed, fertiliser and insecticidal sprays.

The minimum size of farm unit has been calculated for farms on which the main cash crop is one of the following:

maize, sorghum, groundnuts, cowpeas and cotton. It has been calculated for three types of farm:

Type 1 Hand labour only
Type 2 Family labour and draught oxen
Type 3 Family labour + draught oxen and herbicides to control inter-plant weed growth

For Type 1, labour must be hired in order to cultivate the amount of land required to produce the minimum income.

The theoretically calculated farm sizes are given in Table 1 for farms with no fallow and farms where one third of the farmed area is under fallow.

TABLE 1 The minimum size of farm unit required to produce an annual income of ₦ 740 of various types of farm and with various cash crops

Farm type	Cash crop	Minimum farm size			
		No fallow		1/3 fallow	
		ac	ha	ac	ha
1. Hand labour only	Maize	12.35	5.00	18.53	7.50
	Groundnuts	9.18	3.22	13.77	5.57
	Cowpeas	9.59	3.88	14.93	6.04
	Cotton	10.21	4.13	15.23	6.16
2. Family labour + draught oxen	Maize	38.05	15.40	46.73	18.91
	Sorghum	31.41	12.71	36.76	14.88
	Groundnuts	26.13	10.57	28.84	11.67
	Cowpeas	28.77	11.64	32.81	13.28
	Cotton	23.35	9.45	24.67	9.98
3. Family labour + draught oxen + herbicides	Maize	44.51	18.01	56.41	22.83
	Sorghum	35.05	14.18	51.72	20.93
	Groundnuts	26.78	10.84	29.83	12.07
	Cowpeas	28.39	11.49	32.24	13.05
	Cotton	31.57	12.78	37.00	14.97

In practice, actual farm sizes will need to be larger because the farmer does not grow a single cash crop.

Appendix 4 Evaluation of the growth potential of forest reserves

The extent to which a particular soil property is limiting to a plantation species is estimated by relating measured sample plots to the characteristics of the underlying soil and from a knowledge of the species' site requirements. Many soil limitations such as depth and coarse material inhibit the growth of practically all species, but some species flourish in conditions that might inhibit the growth of others; for example Eucalyptus spp. tolerate poorly drained soils whereas teak, Gmelina and neem do not.

The classes and codes for depth, drainage, texture and coarse material content of a soil, used to assess limitations to the growth of various crops, are also used for tree species. In Table 1 these classes are ranked and given a score for teak, Gmelina, Eucalyptus, neem and Dalbergia. For any given soil the total limitation score for a species is obtained by adding the code values that affect that species.

Facets of the land systems are allocated limitation scores according to the predominant soil series. This information is obtained from the description of the soil series given in Hill and Rackham (1974). If a facet has dominant soil series with different limitation scores the percentage that the facet occupies in the land system is divided between the scores. For example:

1. In Maigama Reserve on the Bauchi Plains, Facet i occupies 21% of Land System 36 (Table 2a) *. There are three dominant soil series, Gyangyan, Kurba and Zaranda. The first two have soil limitation scores for Eucalyptus of 1 and Zaranda has a score of 3. The 21% is therefore divided between the 0-2 and 3-4 limitation score classes.

2. In Naraguta Reserve, on the Jos Plateau, Facet iv occupies 7% of Land System 113 (Table 2b) *. There are two dominant soil series, Mushere and Vwang. Mushere has a soil limitation score for Eucalyptus of 4 and Vwang has a score of 1. The 7% is therefore divided equally between the 0-2 and 3-4 limitation score classes.

*The forest reserve relevant to this volume only is shown as Table 2.

3. In Nimbia Reserve on the Jema'a Platform, Facet iii occupies 35% of Land System 218 (Table 2c). There are two dominant soil series, Mailafia and Jenta. Mailafia has a soil limitation score for teak of 1 and Jenta has a score of 3. The 35% is therefore divided equally between the 0-2 and 3-4 limitation score classes.

4. In Shangev Tiev in the Benue Valley, Facet ii occupies 34% of Land System 501 (Table 2d). Of the two dominant soil series, one has a limitation score for teak and Gmelina of 1 and the other of 2. The 34% is therefore allocated to the 0-2 limitation score class.

The limitation score for any land system is obtained by adding the percentages in the three classes 0-2, 0-3 and 5-6. This is intended as a very general guide to the growth potential of a land system for plantation forestry. In Table 2 the limitation scores for the land systems in the above forest reserve relevant to this volume are given.

In the forestry report, Howard (1976) has related the increment of the major plantation species (teak, Gmelina, Eucalyptus and neem) to the soil limitation score. This information is used to provide the growth potential for the forest reserves. If the land system has more than 50% land with a score of 0-2, the overall score is taken as 0-2. If the score is 5-6 over more than 60%, the score is taken as 5-6 and the land considered unsuitable for plantation forestry. Land systems with intermediate scores are treated as having a score of 3.

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*The forest reserve relevant to this volume only is shown as Table 2.

TABLE 1 Soil Limitation Scores for teak, Gmelina, Eucalyptus, neem and Dalbergia

Soil property			Soil limitation score (SLC)				
Heading	Description	Code	Teak	Gmelina	Eucalyptus	Neem	Dalbergia
Depth (D)	150 cm	0					
	150-100 cm	1	1	1	1	1	1
	50-100 cm	2	2	2	2	2	2
	25- 50 cm	3	3	3	3	3	3
	25 cm	4	4	4	4	4	4
Drainage (W)	Free draining to 150 cm	0					
	Imperfect at 100 cm	1				1	
	Imperfect at 100-50 cm	2				1	
	Poor at 100-50 cm	3	1	1		1	
	Imperfect at 50 cm	4	1	1		1	
	Poor at 50 cm	5	1	1		1	
Texture (T) Top 50 cm	Fine	1				1	
	Medium	2					
	Coarse	3					
Texture (T) 50-150 cm	Fine	1				1	
	Medium	2					
	Coarse	3	1	1			
Coarse C material	None	0					
	low	1	1	1	1	1	1
	high	2	2	2	2	2	2

Example: A coded soil description might be $D_2W_3T_3T_1C_2$

This soil would have a limitation score of 2(D) + 1(W) + 2(C) = 5 for teak, Gmelina or neem and a score of:-

2(D) + 2(C) = 4 for Eucalyptus or Dalbergia

TABLE 2 How the soil limitation scores for the land systems in a forest reserve are worked out (Naraguta Reserve on the Jos Plateau)

Land system	Facet	% of L.S.	Major soil series	Soil limitation score	Series as % of L.S.	Summary % of L.S. occupied by each limitation group
1	Mostly bare rock					100% unsuitable for planting
113	i	30	Vwang	1	30%	
	ii	7	Madaki	5	7%	
			Karashin	5		
	iii	7	Shen	2	7%	
	iv	7	Mushere	4	3.5%	
			Vwang	1	3.5%	75% 0-2
	v	14	Gwafan	1	14%	4% 3-4
	vi	7	Vwang	1	7%	21% 5-6
			Gwafan	1		
	vii	14	Vwang	1	14%	
			Gwafan	1		
	viii	7	No soil	6	7%	
	ix	7	Dutsin	6	7%	

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