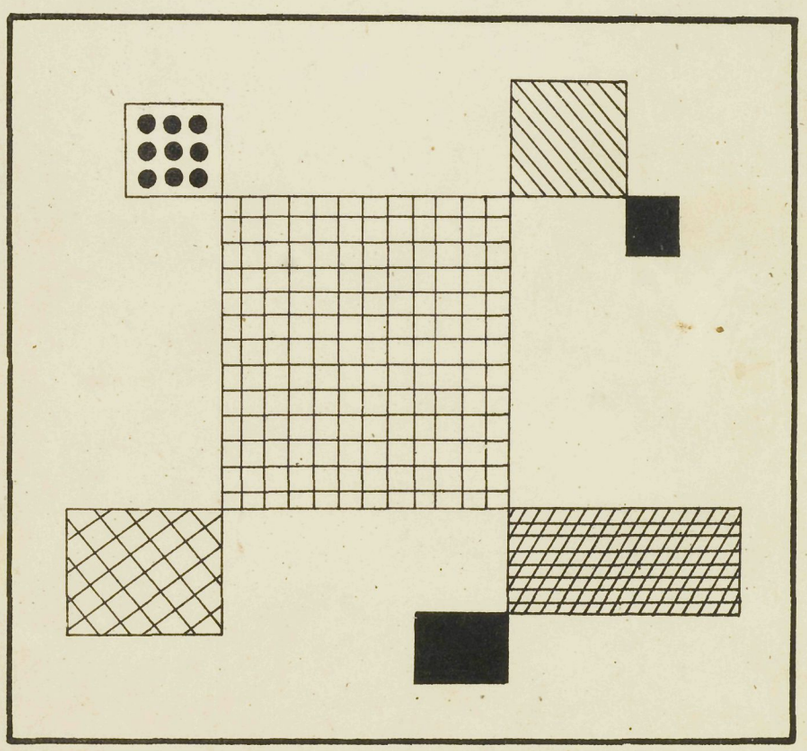
Land Resources Survey

Sierra Leone

AG: DP/SIL/73/002
Technical Report 1

land in sierra leone: a reconnaissance survey and evaluation for agriculture



United Nations Development Programme

Food and Agriculture Organization of the United Nations

Freetown, 1979

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Land Resources Survey
Sierra Leone

LAND IN SIERRA LEONE: A RECONNAISSANCE SURVEY AND EVALUATION FOR AGRICULTURE

Report prepared for the
Government of Sierra Leone
by
The Food and Agriculture Organization of the
United Nations acting as executing agency for the
United Nations Development Programme

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based on the work of

C J Birchall — *Soil Scientist*
P Bleeker — *Land Evaluation Expert*
in collaboration with
C Cusani-Visconti — *Land Suitability Agronomist*

UNITED NATIONS DEVELOPMENT PROGRAMME
FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Freetown, 1979

7832

This technical report is one of a series of reports prepared during the course of the UNDP/FAO project identified on the title page. The conclusions and recommendations given in the report are those considered appropriate at the time of its preparation. They may be modified in the light of further knowledge gained at subsequent stages of the project.

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FOREWORD

Developing and increasing the productivity of the land, while at the same time protecting or restoring the overall environment, cannot be adequately carried out without a number of prerequisites, among which land classification is essential.

Such exercises involve two major phases, namely: an inventory of the various land resources available, followed by an integrated analysis of their potential expressed in terms of land suitability.

The Land Resources Survey Project established in Sierra Leone in 1975, was fortunate enough to take advantage of the latest developments in land classification.

Firstly, it was possible to select and acquire the most appropriate remote sensing tool available to serve as a basis for its field and mapping activities, ie a recent and homogeneous national coverage of high flight aerial photography. Secondly, with local modifications, the project could also valuably make use of the guidelines for land evaluation and, more recently, of the methodology on agro-ecological studies, both developed by FAO.

The present study, carried out by a multi-disciplinary team of specialists with the full support and involvement of national counterpart staff and management, is an early practical application at country level of the latest land evaluation systems developed to date. It enabled the production of the first national integrated survey of the land resources of Sierra Leone and led to a broad but specific qualitative evaluation of their respective potential for agricultural development,

It is believed that this study constitutes a most useful reference for national land use planners and policy makers as well as to bilateral and international assistance or investment programmes willing to contribute to the agricultural development of this country. At the same time it may serve as a model for the undertaking of similar vital studies in other countries.

D C Schwaar
FAO Project Manager
Freetown, Sierra Leone

March, 1979

FAO. Land in Sierra Leone: a reconnaissance survey and evaluation for agriculture, based on the work of C J Birchall and P Bleeker in collaboration with C Cusani-Visconti, Freetown 1979. 246 pages, 21 tables 13 figures, 6 plates, 4 separate plates and 1 multi-colo map. AG:DP/SIL/73/002 T R 1.

ABSTRACT

This report describes the environment and land suitability of Sierra Leone. Its findings are based on reconnaissance survey carried out with the aid of high flight aerial photography. An appraisal is given of the soils, climate, vegetation and land use of forty four broad physiographic units in terms of suitability for eight specific crops under conditions of sustained cultivation at improved traditional management level.

The results of the survey indicate that, because of poor soil conditions, upland areas are suitable only for low demanding arable and tree crops, while the relatively more fertile swamps have a good potential for paddy rice and short-cycle arable crops. It is concluded that the present system of farming will be unable to support the rapidly increasing population and that more intensive forms of cultivation will be necessary if Sierra Leone is to avoid becoming dependent on food imports.

Recommendations are given for further studies and survey necessary both to refine the land evaluation methodology and to provide a more detailed basis for the future planning and implementation of agricultural development. The need for further research and extension activities geared towards intensifying agricultural production, whilst at the same time maintaining the ecological balance, is stressed.

ACKNOW

RESUME

Ce rapport passe en revue divers aspects de l'environment de la Sierra Leone liés à l'aptitude des terres pour la production agricole. Les résultats obtenus s'appuient sur des cartes thématiques à l'échelle de reconnaissance établies sur le terrain avec l'aide de photographies aériennes à haute altitude. Quarante quatre grandes unités physiographiques oné été ainsi identifiées selon leurs types de sol, de climat, de végétation naturelle et d'utilisation agricole. L'évaluation du potentiel respectif de chacune de ces unités est donnée pour huit cultures spécifiques importantes considérées à un niveau amelioré d'exploitation traditionnelle garantissant une production soutenue.

Les résultats de cette étude démontrent que, en raison de la médiocrité générale des sols, les terres en sec ne conviennent qu'à des cultures annuelles et pérennes peu exigeantes, tandis que les terrains marécageux relativement plus fertiles offrent des conditions favorables à la culture du riz ainsi qu'aux récoltes à cycle de croissance courte. Le rapport arrive à la conclusion que, au rythme auquel ou la population s'accroît, le système agricole actuel sera incapable d'assurer les besoins alimentaires du pays et qu'il est des lors indispensable de mettre en oeuvre des pratiques culturales plus intensives si l'on veut éviter que la Sierra Leone ne soit dépendante des marchés alimentaires extérieurs.

Ce rapport recommande par ailleurs d'entreprendre des études supplementaires tant pour affiner la méthodologie d'évaluation des terres mise au point jusqu'ici, que pour constituer une base de référence plus complète et détaillée lors des phases ultérieures de planification et de mise en valeur du secteur agricole. On y souligne aussi les besoins en recherche et vulgarisation agricoles qu'exige une production intensifiée capable tout à la fois de maintenir l'équilibre écologique ambiant.

ACKNOWLEDGEMENTS

The Food and Agriculture Organization is greatly indebted to all those who assisted in the implementation of the project by providing information, advice and facilities. Special thanks are extended to management and staff of the Land Resources Survey Project, without whose encouragement and untiring support this study would never have been completed. Project staff who participated directly in the study are listed in Part 1. Gratitude is also expressed to the numerous farmers and local government officials who so willingly co-operated with the survey team during the countrywide treks.

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Land suitability: 1:1 000 000 scale maps in 4 plates

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UNITS AND CONVERSION FACTORS

(1) Metric units	*(2) English units*	*To convert column (1) into column (2) multiply by:-*
Length		
millimetres (mm)	inches	0.0394
centimetres (cm)	inches	0.394
metres (m)	yards	1.094
kilometres (km)	miles	0.621
Area		
hectare (ha)	acres	2.471
square kilometres (km^2)	square miles	0.386
Mass		
kilograms (kg)	pounds	2.205
kilograms (kg)	bushels	0.039
metric tonnes (MT)	pounds	2205.0
metric tonnes (MT)	bushels	39.37
metric tonnes (MT)	English tons	0.984
Yield		
kilograms per hectare (kg/ha)	pounds per acre	0.891
kilograms per hectare (kg/ha)	bushels per acre	0.016
metric tonnes per hectare (MT/ha)	pounds per acre	892.35
metric tonnes per hectare (MT/ha)	bushels per acre	15.92
metric tonnes per hectare	English tons per acre	0.398
Temperature		
degrees celsius (^oC)	degrees Fahrenheit	1.8 and add 32
Rate		
cubic metres per second (m^3/s)	cubic feet per second	35.35

Others

mmhos/cm - millimhos per centimetre
meq % - millequivalents percent
ppm - parts per million

GLOSSARY

alluvium : material carried in suspension by rivers and deposited in sluggish water beyond the influence of the swiftest current.

argillic horizon : a soil horizon in which clay, washed down from the horizons above, has accumulated.

backplain : that part of a river floodplain, between the levee and the backswamp, normally flooded for several months each year.

backswamp : the lowest lying part of a river floodplain experiencing prolonged flooding.

bench : a relatively level part of a hillslope between the crest and the footslope, resulting from earlier erosion cycles.

boli : see drainage depression

bush fallow : the period of rest into which land is left to allow for natural processes to restore soil fertility levels. Bush fallow differs from shifting cultivation in that the land is occupied and the cultivated fields are rotated around a fixed settlement rather than the settlement itself being moved.

catch crop : a crop grown on an otherwise unutilised piece of land during the life cycles of two main crops grown on that land.

colluvium : soil material deposited by unconcentrated surface runoff or sheet erosion usually at the base of a slope.

cover crop : a crop grown on a piece of land with the main purpose of giving protection from atmospheric agents to an otherwise barren soil surface.

crest : the highest, usually relatively level, part of a hill or interfluve.

drainage depression : featureless saucer-shaped depression drained by a seasonal stream.

ferralitic soil : a strongly weathered tropical soil with few or no weatherable minerals, a complementary enrichment with quartz and the oxides of iron and aluminium and predominantly 1:1 lattice clays.

gley : grey or neutral colours resulting from prolonged periods of reduction in the soil profile.

hydromorphic soil : a soil in which the effects of poor drainage is the main factor in determining its morphology, giving rise to a predominance of gley colours.

interfluve : the relatively undissected upland or ridge between two adjacent valleys containing streams that flow in the same general direction.

ironstone : see laterite.

irregular interfluves or hillslopes : an interfluve or hillslope with a highly variable airphoto pattern, usually resulting from the presence of rocks and boulders at or near the surface.

kaolinite : a clay mineral with the formula $Al_2Si_2O_5(OH)_4$. It forms specifically as a result of weathering of feldspars and micas under humid tropical conditions.

land facet : the smallest relatively uniform unit in terms of landform, parent material, soil and vegetation which can be described in a land system.

land factor (also known as land characteristic) : an attribute of land that distinguishes different kind of land and can be measured or estimated.

land quality : a complex attribute of land which acts in a distinct manner in its influence on the suitability of land for a specific kind of use (FAO 1976a).

land system : an area, or group of areas, throughout which there is a recurring pattern of topography, soils and vegetation (Christian and Stewart 1953).

laterite : cemented soil or weathered rock material. A laterite sheet is a continuous body of laterite.

levee : that part of a river floodplain closest to the river and above the main floodplain level, built up by the deposition of relatively coarse textured material which settles first when the river overflows its banks.

ley : a fallow period, usually one year or shorter.

major floodplain : a broad floodplain adjacent to a main river, showing characteristic floodplain features eg levees, terraces and backswamps.

minor floodplain : a narrow, rather featureless, area of alluvial land adjacent to a perennial stream which floods only periodically.

mottle : a spot or small area of different colour and composition from the surrounding soil material or matrix.

nodule	: any hardened soil material; in this case iron or manganese-rich mottles which have become hardened but can still be broken between the fingers.
pisolitic ironstone	: ironstone consisting of gravel sized material cemented together by iron oxides.
plinthite	: an iron-rich, humus-poor mixture of clay with quartz and other diluents. It commonly occurs as soft red mottles or harder nodules in a grey or yellow matrix. It hardens irreversibly to laterite on exposure to the atmosphere.
potential evapotranspiration	: the maximum possible loss of soil moisture under a given climatic condition, by transpiration through the leaves of plants and by direct evaporation.
saddle	: a relatively level piece of land between two summits on a hill ridge.
saprolite	: a soft, earthy, clay-rich, thoroughly decomposed rock, formed in place by chemical weathering of gneiss and metamorphic rocks.
scroll complex	: a sequence of levees and abandoned river channels on a river floodplain, formed as a result of the river gradually changing its course.
short cycle crop	: a crop which, from sowing to harvesting, occupies the land for a period of less than 3 months.
soil family	: a group of soil series having many characteristics in common.
soil series	: soils which are essentially alike in all their major characteristics.
terrace	: an area of land adjacent to or within a river or stream valley but above the level of the valley bottom. Formed from colluvium or alluvium deposited during previous erosion cycles.
valley swamp	: a narrow, level, valley bottom which is drained only by a sluggish seasonal stream and which is waterlogged for much of the year.

ABBREVIATIONS

ACRE	-	Adaptive crop research and extension
ADB	-	African Development Bank
AWC	-	Available water capacity
B & W	-	Black and white (photography)
CEC	-	Cation exchange capacity
C/N	-	Carbon-nitrogen ratio
CSIRO	-	Commonwealth Scientific Industrial Research Organisation
CSO	-	Central Statistics Office
EC	-	Electrical conductivity
ECD	-	European Commission for Development
EDF	-	European Development Fund
FAO	-	Food and Agricultural Organisation of the United Nations
GDP	-	Gross domestic product
GNP	-	Gross national product
GOSL	-	Government of Sierra Leone
IADP	-	Integrated Agricultural Development Project
IBRD	-	International Bank for Reconstruction and Development
IDA	-	International Development Agency
IFAD	-	International Fund for Agricultural Development
IITA	-	International Institute of Tropical Agriculture, Ibadan
IRC	-	Infra-red colour (photography)
ma	-	million years
MAF	-	Ministry of Agriculture and Forestry
MANR	-	Ministry of Agriculture and Natural Resources
n.a.	-	not available
NDB	-	National Development Bank
NUC	-	Njala University College
SLPMB	-	Sierra Leone Produce Marketing Board
TCP	-	Technical co-operation programme
UNDP	-	United Nations Development Programme
UNESCO	-	United Nations Education, Scientific and Cultural Organisation
USAID	-	United States Agency for International Development
USDA	-	United States Department of Agriculture
var.	-	variable
VE	-	vertical exaggeration
WARDA	-	West African Rice Development Association

Part 1
BACKGROUND INFORMATION

INTRODUCTION

This report presents the results of a reconnaissance land resources study of the whole of Sierra Leone (72 326 km^2) undertaken between February 1976 and July 1977, as part of the regular programme of activities of the Land Resources Survey Project, SIL/73/002. The study was restricted to a qualitative evaluation of physical factors affecting the agricultural potential of the country: no attempt has been made at this stage to appraise the socio-economic aspects of land development. It is intended, however, that quantitative land evaluation, based on both physical and socio-economic factors, will form the main emphasis in the future work of the project at more detailed levels of investigation.

BACKGROUND TO PROJECT

The Land Resources Survey Project was set up in the Ministry of Agriculture & Natural Resources (MANR)[1] in June 1975 with UNDP as the funding and FAO as the executing agencies respectively. The project is scheduled to last until December 1980, by which time it will have been incorporated into the Ministry as a permanent Land and Water Resources Department.

The project is designed to assist Government, at planning and implementation levels, in improving the productivity of agricultural land in Sierra Leone through the increased production of staple foods, other foodstuffs and cash crops, and by the more effective use of soil, water and climate resources. Project activities are centred on the execution of land resources surveys at various levels of intensity, the setting up of networks to monitor hydrological and climatological resources and the in-service training of counterpart staff in modern techniques of integrated land and water appraisal.

OBJECTIVE OF STUDY

One of the objectives of the project is to provide the Ministry of Agriculture & Forestry of the Government of Sierra Leone with data on the agricultural resources of the country on which to base planning decisions. The lack of any such survey hitherto covering the whole of Sierra Leone has meant that the first phase of project activities was orientated towards a resources inventory at reconnaissance level. This study seeks partly to fulfil the above objective by giving a qualitative

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[1] *Reorganised as the Ministry of Agriculture & Forestry (MAF) in July 1978.*

assessment of land in Sierra Leone and an indication of its potential for a number of selected crops. It was carried out at the same time as a complementary study of the vegetation and land use of Sierra Leone.

PREVIOUS STUDIES AND SURVEYS

The first attempt at a systematic investigation of the agricultural resources of the country was carried out from 1949 to 1950 by the Soil Conservation and Land Utilisation team of the then Ministry of Agriculture (Waldock *et al*, 1951). Although the description and mapping of soils and land potential in this study were rudimentary, due to lack of specialised techniques (eg aerial photographs) at the time, many of the team's findings and recommendations are still of interest and relevance today.

Between 1958 and 1972 a number of agricultural resources surveys were carried out in specific areas of Sierra Leone, prior to the commencement of the present study. These took the form of soil surveys and most included some kind of land evaluation: either a general land capability assessment, a specific rating for selected crops, or a combination of both. These surveys, summarised in Table 1, cover between 10 and 11% of Sierra Leone and are confined to the centre, south and east of the country.

Data from all but one of these surveys (Stobbs, 1963) were collated by researchers working at Njala University College (NUC) and published in Odel *et al*, 1974. This is a thorough investigation into the morphology, properties, classification and adaptability of some of the more important soils in the country, to which the specialised reader should refer for more detailed information on specific areas.

In 1966, the University of Sierra Leone published a series of maps with short accompanying texts on many aspects of the geography of the country (Clarke, 1966). Although this text is of a rather broad nature and contains no information on soils or land potential, it gives, nevertheless, a useful background for the general reader. The work was revised in 1969 and is due to be revised again shortly to incorporate new data which have become available during the last 10 years.

In 1973, a survey of the swamps in the proposed Northern Area Integrated Agricultural Development Project was carried out to determine their suitability for paddy rice (Roberts, 1973). This work was approached from the point of view of the cost of developing the swamps using drainage and irrigation. For this purpose the swamps were classified according to soil texture, water regime, slope, channel morphology, vegetal cover and surface morphology.

Numerous other papers and minor reports have been written on various aspects of soils and crops in Sierra Leone, many of which are no longer readily obtainable. Where cited, reference have been quoted in the text; for a more comprehensive bibliography reference should be made to Dijkerman (1976).

Table 1 - Summary of previous soil surveys

Location	Km^2	Scale	Date	Author(s)	Unit of soil

Table 1 - Summary of previous soil surveys

Location	*Km²*	*Scale*	*Date surveyed*	*Author(s)*	*Unit of soil classification*	*Basis for grouping soil units*	*Mapping unit*	*Correlation*	*Land Appraisal*
Bolilands	2600	1:50,000	1958-1960	Stobbs	Soil series	Parent material, landform and soil forming process	Sub-divisions of great soil groups based on parent material and landform	None	None
Eastern Province	5406	1:100,000	1963-1966	Sivarajasingham	Soil families	Parent material, gravel content and drainage	Soil associations based mainly on landform	USA, Belgium, French	8 land capability classes
Eastern Province	*2600	1:50,000	1967	Stark	Soil units	Parent material, gravel content and drainage	Soil associations based mainly on landform	USDA	General statement on suitability. Specific comments on suitability for cocoa
Makeni	105	1:50,000	1968	Van Vuure and Miedema	Soil series	Parent material, landform and drainage	Soil associations based on landform	USDA	8 land capability groups with 4 subclasses. Ratings from 1-10 for swamp rice, irrigated and non-irrigated
Torma Bum	176	1:50,000	1969	Dijkerman and Westerwald	Soil series	Parent material and landform (drainage inferred)	Soil series and associations based mainly on landform and drainage	USDA	8 general soil suitability classes. 3 classes of suitability for sugar cane
Njala	58	1:25,000	1966-1972	Soil Survey staff Njala University College	Soil series	Landform, gravel content and drainage	Soil series and phases	USDA	7 land capability classes and a specific rating for paddy rice

*Included within area of Sivarajasingham's survey

SURVEY PROGRAMME

The survey team assembled in Freetown early in 1976. Field activities took place during the dry seasons of 1976 and 1977, while the survey data were collated and the report written throughout 1977, 1978 and the early part of 1979. The locations where soil and site observations were made are shown in Fig 1. The detailed work programme was as follows:

Jan - Feb 1976

Pre-interpretation, on 1:40 000 scale photographs, of land form units at selected sites along four E-W traverses across the country, chosen to represent the main physiographic and agricultural regions.

Mar - May 1976

Orientation survey along the above traverses. Field observations made at 300 sites.

June - Jul 1976

Systematic photo-interpretation of land systems[1] on new, high flight, B & W aerial photography at scale 1:120 000, aided by previous field orientation. Freehand transfer of detail on to uncontrolled photo-mosaics for checking of boundaries and mapping consistency only (not an intermediate cartographic step). Compilation of summary descriptions for each of 48 provisional land systems. Selection of representative type areas for subsequent facet breakdown.

Aug 1976

Transfer of theme on to 1:250 000 base maps using an optical pantograph. Fair drawing of provisional land system map with descriptive legend.

Aug - Nov 1976

Systematic interpretation of one representative type pattern for each of the land systems, using 1:40 000 scale photographs, with descriptions of the morphology of their constituent land facets.[1]

Nov - Dec 1976

Planning of field operations and observation sites for 1976/77 dry season after careful consideration of system and facet distribution and access.

Dec 1976 - May 1977

Systematic sampling of land systems for landform, soils and agricultural practices on a further 650 sites and checking of the provisional map boundaries in the field.

May - Jul 1977

Interpretation of field data from a total of 950 sites. Revision of the land system map and type pattern breakdown in the light of field experience. Comprehensive draft description of the final 44 land systems and their constituent facets, in terms of landform, soils and vegetation/land use. Qualitative evaluation of these units, based on physical factors, in terms of land suitability for selected crops.[2]

Aug - Nov 1977

Fair drawing of revised land system map at 1:250 000 scale, hand colouring and area measurement of mapping units.

Nov 1977 - Mar 1979 (intermittent)

Finalisation of land system descriptions and consolidation into report on reconnaissance survey phase.

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[1] *See glossary.*

[2] *Initially, suitability classification was carried out for broader crop groups but these were later modified in favour of 8 specific crops, (see Part 5).*

Fig. 1

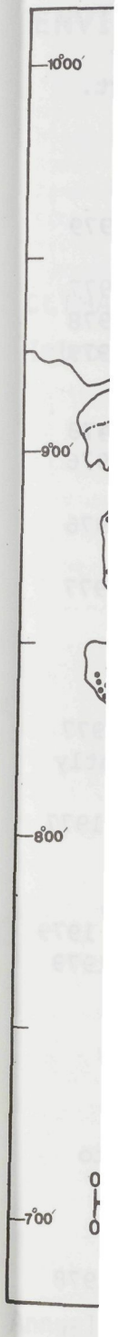
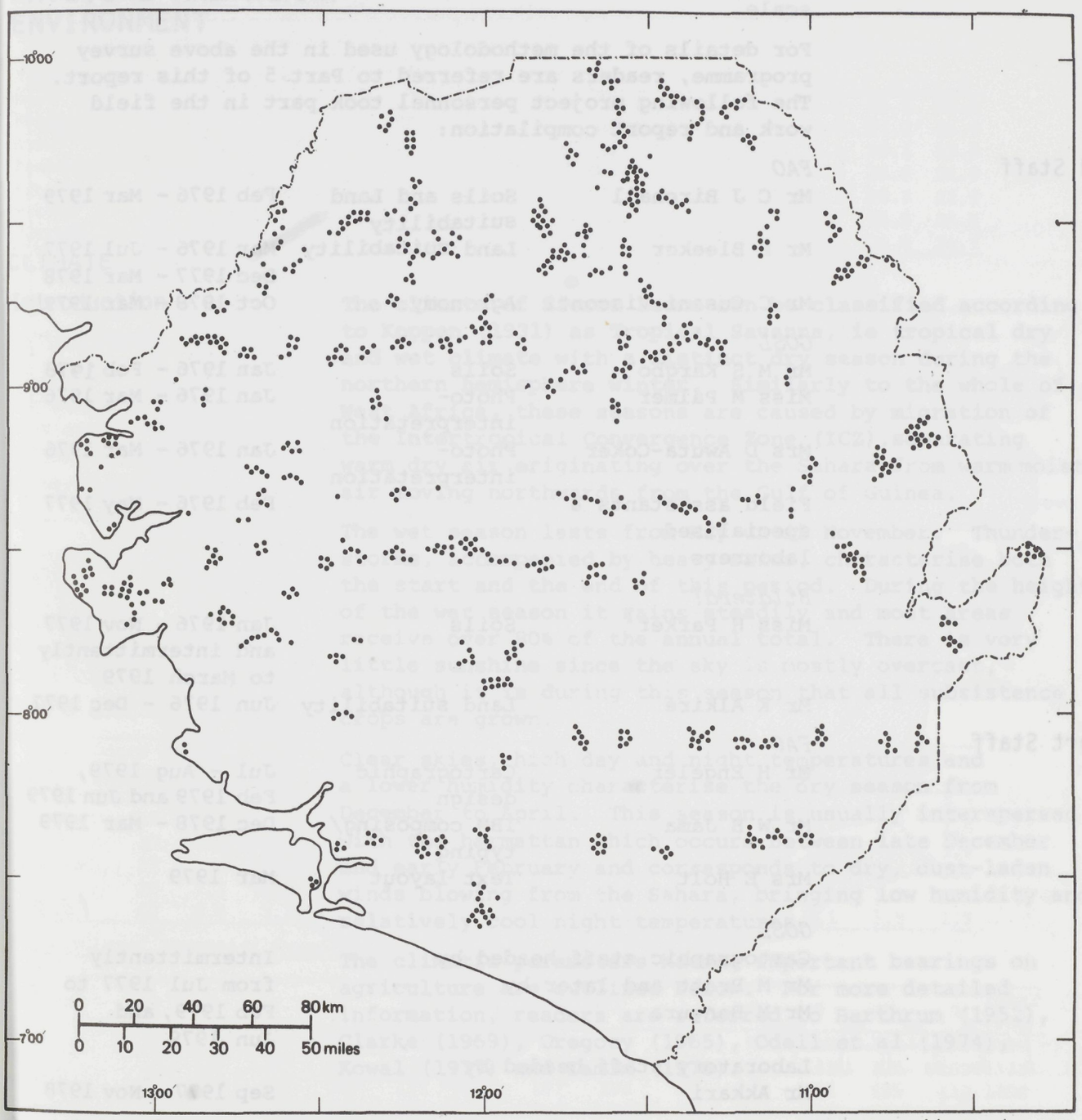


Fig. 1 Location of Soil and site observation points



Cartographic Section 1979

Production of colour printed land system map at 1:500 000 scale and derived land suitability maps at 1:1 000 000 scale.

For details of the methodology used in the above survey programme, readers are referred to Part 5 of this report. The following project personnel took part in the field work and report compilation:

Field Staff	*FAO*		
	Mr C J Birchall	Soils and Land suitability	Feb 1976 - Mar 1979
	Mr P Bleeker	Land suitability	Mar 1976 - Jul 1977 Dec 1977 - Mar 1978
	Mr C Cusani-Visconti	Agronomy	Oct 1978 - Mar 1979
	GOSL		
	Mr M S Kargbo	Soils	Jan 1976 - Feb 1978
	Miss M Palmer	Photo-interpretation	Jan 1976 - Mar 1976
	Mrs D Awuta-Coker	Photo-interpretation	Jan 1976 - Mar 1976
	Field assistants & specialised labourers		Feb 1976 - May 1977
	Bilateral		
	Miss H Parker[1]	Soils	Jan 1976 - Nov 1977 and intermittently to March 1979
	Mr K Alkire	Land suitability	Jun 1976 - Dec 1977
Support Staff	*FAO*		
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Part 2
PHYSICAL AND HUMAN ENVIRONMENT

CLIMATE

Introduction

The climate of Sierra Leone can be classified according to Koppen (1931) as Tropical Savanna, ie tropical dry and wet climate with a distinct dry season during the northern hemisphere winter. Similarly to the whole of West Africa, these seasons are caused by migration of the Intertropical Convergence Zone (ICZ), separating warm dry air originating over the Sahara from warm moist air moving northwards from the Gulf of Guinea.

The wet season lasts from May until November. Thunderstorms, accompanied by heavy rains, characterise both the start and the end of this period. During the height of the wet season it rains steadily and most areas receive over 80% of the annual total. There is very little sunshine since the sky is mostly overcast, although it is during this season that all subsistence crops are grown.

Clear skies, high day and night temperatures and a lower humidity characterise the dry season from December to April. This season is usually interspersed with the harmattan which occurs between late December and early February and corresponds to dry, dust-laden winds blowing from the Sahara, bringing low humidity and relatively cool night temperatures.

The climatic parameters having important bearings on agriculture are outlined below. For more detailed information, readers are referred to Barthrum (1952), Clarke (1969), Gregory (1965), Odell *et al* (1974), Kowal (1977) and Lamin (1978).

Annual rainfall

The distribution of mean annual rainfall is shown in Fig 2. The coastal areas experience the highest rainfall with a precipitation of 3000 mm or more. However, there is also another area of relatively high rainfall located in the middle of Sierra Leone with Magburaka as its centre. Towards the northeast, the rainfall gradually decreases to 2000 mm or less in the Musaia-Falaba area.

Fig 3 shows water budget relationships of stations with ten or more years of records. These are discussed in more detail below.

Temperature

Table 2A shows the mean monthly temperatures at selected stations in Sierra Leone. December/January and March/April/May tend to be respectively the coolest and warmest periods of the year, but the annual temperature range of

TR1

Fig. 2 Distribution of mean annual rainfall

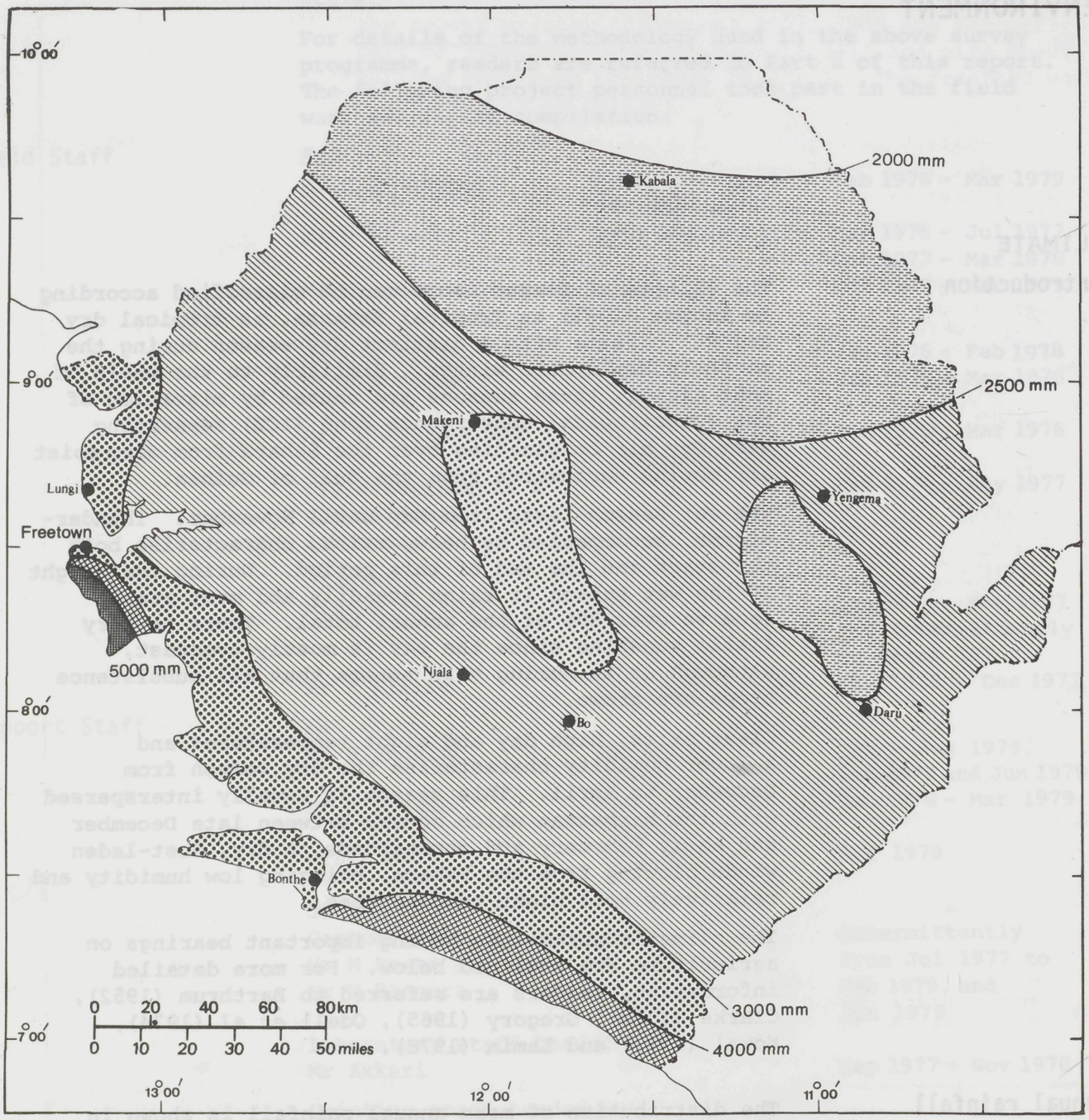

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Table 2 - Selected climate data

A *Mean Monthly Temperature (°C)*

Station	Years of Record	J	F	M	A	M	J	J	A	S	O	N	D
Bo	37	25.9	27.2	27.9	27.7	27.7	26.2	25.1	24.8	25.2	26.1	26.4	25.8
Bonthe	34	26.9	27.7	28.2	28.2	27.7	26.4	25.4	25.2	25.7	26.5	27.2	26.9
Daru	29	25.2	27.0	27.6	27.4	27.2	26.4	25.3	24.9	25.7	26.1	26.1	25.3
Freetown	35	26.8	27.1	27.5	27.8	27.5	26.7	25.7	25.2	25.9	26.4	26.8	26.9
Kabala	20	24.6	26.8	27.7	27.2	26.3	25.0	24.1	23.8	24.4	25.1	25.3	23.9
Makeni	34	26.2	27.5	28.5	29.1	27.7	27.0	25.9	25.4	25.9	26.7	26.9	26.2
Yengema	36	24.4	26.2	27.5	27.5	26.8	26.3	25.3	24.9	25.8	26.0	26.0	24.7

B *Mean Monthly Vapour Pressure (mbs)*

Station	Years of Record	J	F	M	A	M	J	J	A	S	O	N	D
Bo	21	25.2	25.2	26.7	27.7	28.7	28.0	27.2	27.1	27.7	27.7	28.2	26.6
Bonthe	24	28.3	28.9	28.9	29.5	30.3	29.4	29.3	28.1	29.0	29.3	29.7	29.2
Daru	29	23.6	25.1	26.6	27.4	28.0	27.5	26.6	26.6	27.0	27.0	27.0	25.0
Freetown	30	17.4	27.5	28.3	29.1	30.2	29.8	28.7	28.7	29.2	29.3	30.0	28.5
Kabala	20	15.5	17.5	20.4	23.6	25.7	25.5	25.0	25.1	25.3	25.4	24.6	18.5

C *Mean Monthly Hours of Bright Sunshine*

Station	Years of Record	J	F	M	A	M	J	J	A	S	O	N	D
Bonthe	35	6.3	6.5	6.3	5.7	5.0	5.0	3.9	2.2	1.9	2.7	4.9	5.7
Daru	22	6.0	6.4	6.7	5.9	5.7	4.7	3.0	2.5	3.6	5.3	5.9	5.7
Freetown	35	7.8	8.0	7.9	7.2	6.4	5.2	3.0	2.5	4.2	6.2	6.7	7.2
Kabala	15	8.1	8.4	8.3	7.7	6.9	5.6	4.5	3.4	4.8	6.2	7.0	7.4
Njala	34	7.2	7.3	6.7	6.1	6.0	5.1	2.9	2.0	3.5	5.6	6.1	6.4

Tormbum C_2
Njala C_1

D *Mean Monthly Wind Speed at 10 Metre Level (m/s)*

Station	Years of Record	J	F	M	A	M	J	J	A	S	O	N	D
Bo	15	1.5	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1
Bonthe	37	1.5	1.5	1.5	1.5	1.5	2.1	1.5	1.5	1.5	1.5	1.5	1.6
Daru	37	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	2.1	1.5	1.5	1.9
Freetown	27	2.6	3.1	3.7	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6	2.6
Lungi	29	3.1	4.1	4.1	4.1	4.1	3.6	3.6	3.6	3.6	3.1	3.1	3.1
Kabala	22	2.6	3.1	3.1	2.6	2.6	2.1	2.6	2.6	2.1	2.1	1.5	1.5

C_1 - Subhumid
C_1
B — Humid
D_1/C_2
C_2 Subhumid
— D_1 Savanna

E *Calculated Potential Evapotranspiration (mm)* Penman

Station	J	F	M	A	M	J	J	A	S	O	N	D	Total Year
Bo	114	115	113	126	117	99	90	90	94	109	105	108	1300 — C_1
Daru	110	118	135	124	120	105	96	94	101	112	104	102	1322 — B
Kabala	126	131	149	137	127	107	103	97	103	111	105	112	1408
Freetown	118	118	138	131	124	107	96	94	102	115	108	113	1365
Lungi	117	118	140	136	126	110	97	94	100	114	107	109	1366 — C_2

Source: Lamin (1978)

TR1

24°C to 28°C is in fact rather small. The seasonal range is smaller along the coast, where the Atlantic Ocean has a moderating influence on temperature, than it is inland.

The diurnal temperature range is more pronounced, but shows a similar pattern to the annual range. Diurnal ranges of 5°C to 7°C are typical along the coast, whereas inland they can reach 15°C during the harmattan period.

Relative humidity

Table 2B indicates that there is a considerable decrease in vapour pressure during the dry season harmattan period, giving a marked drop in humidity. During the rainy season, the relative humidity is in the range of 70 - 90%, but this falls to a range of 50 - 80% in the dry season. Along the coast this seasonal variation is less marked than in the northern parts of the country.

Sunshine

Table 2C shows mean monthly sunshine hours for five stations, based on readings from Cambell Stokes sunshine recorders. There is a marked variation in monthly sunshine hours between the wet and dry seasons and also a variation between the south and the north of the country. The total monthly hours of sunshine in the dry months from January to April range from 180 (6 h/d) to 240 (8 h/d). During the rains, from June to September, the totals fall to between 120 (4 h/d) and 60 (2 h/d).

Wind

Table 2D indicates mean monthly wind speeds recorded 10 m above ground surface at six stations. Most of the country experiences light winds all the year round, with minimum speeds during the early part of the dry season. Wind speeds along the coast, however, are higher, as a result of a greater exposure to the prevailing westerlies, and reach a maximum at the end of the dry season. At the start and end of the rains strong squalls, associated with thunderstorms, can cause damage to buildings and trees, especially in areas adjacent to hills.

Evapotranspiration

There is a lack of reliable data on evapotranspiration in Sierra Leone. There is no data available on pan evaporation and the data recorded at nine stations using a Piche evaporimeter are dubious and incomplete. The potential evapotranspiration figures shown in Table 2E are based on computer calculations (Penman) carried out by FAO using data relating to latitude, time of year, rainfall, mean daily sunshine hours and wind speed.

Evapotranspiration rates over the country vary with latitude and are in the range 1300 to 1400 mm per year. There is also a seasonal variation, with higher rates in the dry season from December to May than in the rainy season from June to November, with a minor peak in October. Although average rainfall far exceeds evapotranspiration, the combination of relatively high evapotranspiration rates coupled with negligible rainfall in th dry season leads to severe soil moisture stress during this period particularly in the north of the country. This is discussed in more detail below.

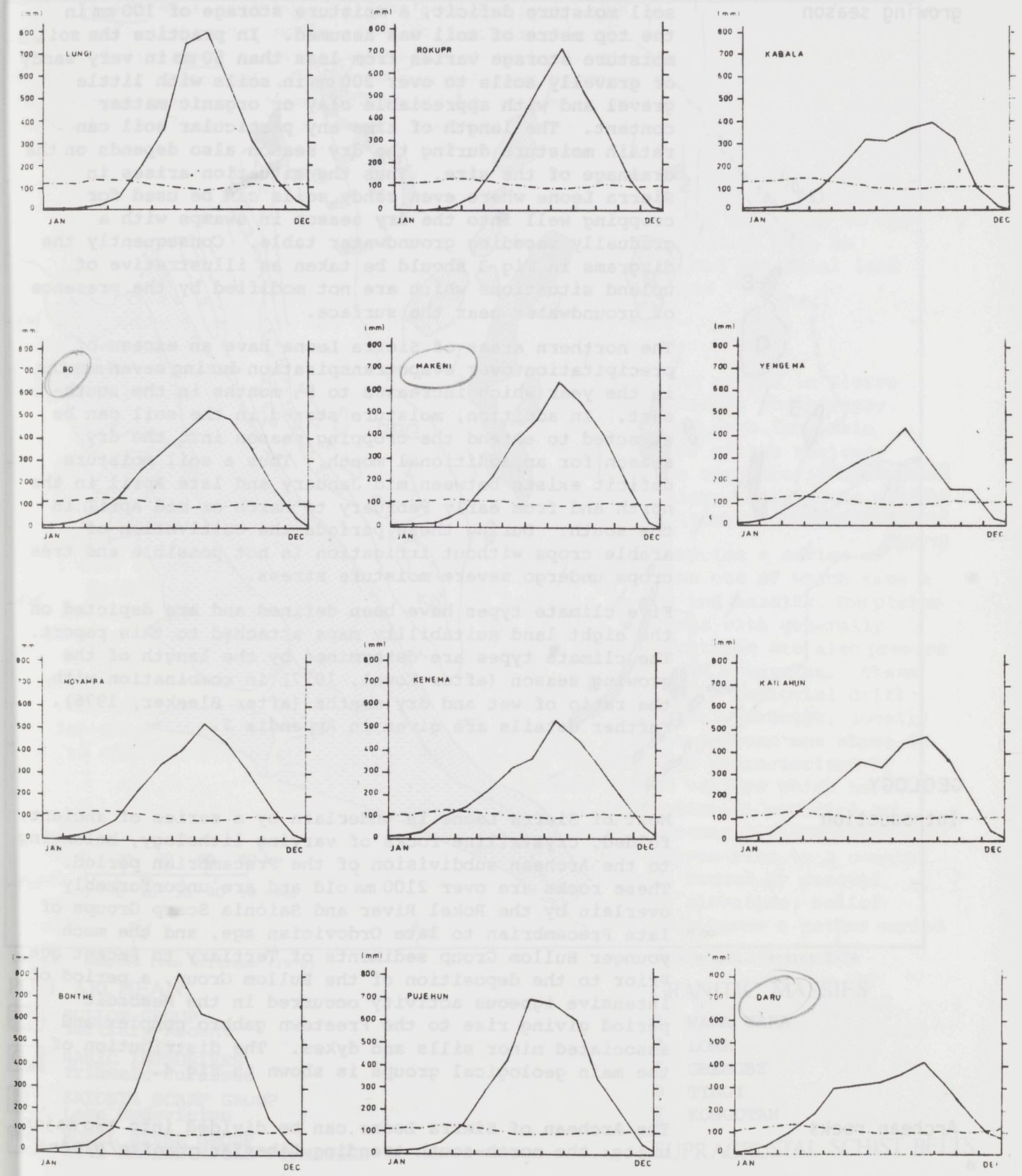
Fig. 3



Sour

TR 1

Fig. 3 Evapotranspiration – rainfall relationships



rainfall — evapotranspiration

Source: Lamin 1978

Soil moisture deficit and length of growing season

Fig 3 illustrates the relationship between potential evapotranspiration and rainfall for selected stations in Sierra Leone. In determining the period of dry season soil moisture deficit, a moisture storage of 100 mm in the top metre of soil was assumed. In practice the soil moisture storage varies from less than 50 mm in very sandy or gravelly soils to over 200 mm in soils with little gravel and with appreciable clay or organic matter content. The length of time any particular soil can retain moisture during the dry season also depends on the drainage of the site. Thus the situation arises in Sierra Leone where even sandy soils can be used for cropping well into the dry season in swamps with a gradually receding groundwater table. Consequently the diagrams in Fig 3 should be taken as illustrative of upland situations which are not modified by the presence of groundwater near the surface.

The northern areas of Sierra Leone have an excess of precipitation over evapotranspiration during seven months in the year which increases to 8½ months in the south-east. In addition, moisture stored in the soil can be expected to extend the cropping season into the dry season for an additional month. Thus a soil moisture deficit exists between mid January and late April in the north and from early February to March or mid April in the south. During these periods the cultivation of arable crops without irrigation is not possible and tree crops undergo severe moisture stress.

Five climate types have been defined and are depicted on the eight land suitability maps attached to this report. The climate types are determined by the length of the growing season (after Kowal, 1977) in combination with the ratio of wet and dry months (after Bleeker, 1976). Further details are given in Appendix 2.

GEOLOGY

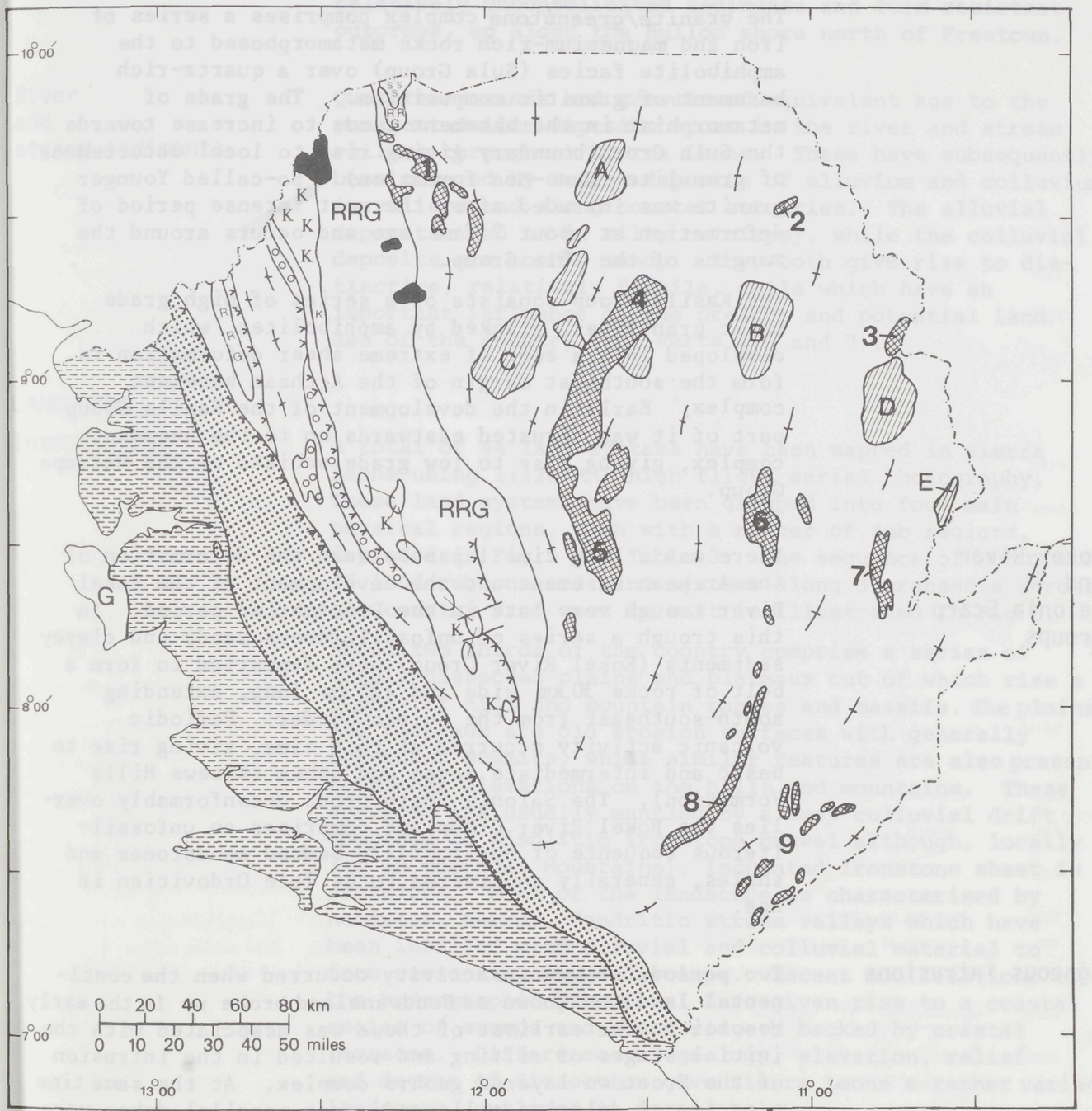
Introduction

Most of Sierra Leone is underlain by a series of ancient, folded, crystalline rocks of varying lithology, belonging to the Archean subdivision of the Precambrian period. These rocks are over 2100 ma old and are unconformably overlain by the Rokel River and Saionia Scarp Groups of late Precambrian to late Ordovician age, and the much younger Bullom Group sediments of Tertiary to Recent age. Prior to the deposition of the Bullom Group, a period of intensive igneous activity occurred in the Mesozoic period giving rise to the Freetown gabbro complex and associated minor sills and dykes. The distribution of the main geological groups is shown in Fig 4.

Archean rocks

The Archean of Sierra Leone can be divided into two major units: the north-south trending Liberian granite/green-

Fig. 4 Geology



Source: Adapted from Williams (1978)

Cartographic Section 1979

POST ARCHEAN

- BULLOM GROUP Tertiary-Recent
- G BASIC INTRUSIVES Triassic-Jurassic
- SSS SSS SAIONIA SCARP GROUP Late Ordovician
- RRG K ROKEL RIVER GROUP with KASEWE HILLS FORMATION

ARCHEAN

- YOUNGER GRANITE
- SULA GROUP
- KASILA GROUP
- MARAMPA GROUP
- GRANITIC MIGMATITE COMPLEX
- THRUST

GRANITIC MASSIFS

A WARA WARA
B LOMA
C GBENGBE
D TINGI
E KONGOTAN

SUPRACRUSTAL SCHIST BELTS

1 LOKO HILLS
2 SANKARAMA
3 SEREKOLIA
4 SULA MOUNTAINS
5 KANGARI HILLS
6 GORI HILLS
7 NIMINI HILLS
8 KAMBUI HILLS
9 MANO-MOA GRANULITES

stone complex and the northwest-southeast trending Kasila Group (Williams, 1978).

The granite/greenstone complex comprises a series of iron and magnesium-rich rocks metamorphosed to the amphibolite facies (Sula Group) over a quartz-rich basement of granitic composition. The grade of metamorphism in the basement tends to increase towards the Sula Group boundary giving rise to local occurrences of granulite (Mano-Moa formation). So-called Younger granite was intruded after the most intense period of deformation at about 2.7 ma ago and occurs around the margins of the Sula Group.

The Kasila Group consists of a series of high grade basic granulites, flanked by amphibolites, which developed into a zone of extreme sheer deformation to form the southwest margin of the Archean basement complex. Early in the development of the Kasila Group part of it was thrusted eastwards on to the basement complex, giving rise to low grade schists of the Marampa Group.

Rokel River and Saionia Scarp Groups

There was a long time lapse between the deformation of the Archean basement and the development of the Rokel River trough very late in the Precambrian period. In this trough a series of unfossiliferous sandy and clayey sediments (Rokel River Group) were deposited to form a belt of rocks 30 km wide and 225 km long, extending south-southeast from the Guinea border. Periodic volcanic activity occurred at this time, giving rise to basic and intermediate lavas and ashes (Kasewe Hills Formation). The Saionia Scarp Group unconformably overlies the Rokel River Group and comprises an unfossiliferous sequence of horizontally bedded sandstones and shales, generally considered to be late Ordovician in age.

Igneous intrusions

Two periods of igneous activity occurred when the continental land mass known as Gondwanaland broke up in the early Mesozoic. The earliest of these was associated with the initial stages of rifting and resulted in the intrusion of the Freetown layered gabbro complex. At the same time a series of dolerite sills and coast-parallel dykes were intruded. The sills cap Bintumani and the Saionia Scarp, while the dykes are very numerous in a zone trending east-southeast through Bo. The second period of igneous activity was the intrusion of Kimberlite dykes and pipes about 90 ma ago. These are found mainly in the eastern part of the country, particularly at Tongo and Yengema, where they are the source of Sierra Leone's alluvial diamond deposits.

Bullom Group

Also associated with the continental dislocation was the deposition of Tertiary Bullom Group deposits, which occupy a belt up to 45 km wide bordering the Sierra Leone coastline. These deposits rest uncomformably on the Kasila Group and the Freetown gabbro and comprise nearly

horizontal beds of marine, estuarine and fluvial gravels, sands and clays. Locally, laterites occur within the relatively unconsolidated sediments and form resistant outcrops, eg along the Bullom shore north of Freetown.

River and stream sediments

Quaternary sands and gravels of equivalent age to the youngest Bullom deposits occur in the river and stream valleys throughout Sierra Leone. These have subsequently been covered by Recent deposits of alluvium and colluvium in valleys and along coastal estuaries. The alluvial deposits tend to be silty or clayey, while the colluvial deposits are mostly sandy. They both give rise to distinctive, relatively fertile, soils which have an important influence on the present and potential land use of the country (see Parts 4,6 and 7).

LANDFORM

Introduction

A total of 44 land systems have been mapped in Sierra Leone using 1:120 000 high flight aerial photography. These land systems have been grouped into four main physical regions, each with a number of sub regions, depicted in Fig 5 and Table 3. The sequence of occurrence of land regions and land systems along 3 transects across the country from west to east is illustrated in Fig 6.

About two thirds of the country comprise a series of highly dissected plains and plateaux out of which rise a number of hill and mountain ranges and massifs. The plains and plateaux are old erosion surfaces with generally accordant summits, while similar features are also present at higher elevations on the hills and mountains. These surfaces are usually mantled by a deep colluvial drift composed of pisolitic ironstone gravel although, locally (eg in the Sula Mountains), indurated ironstone sheet is prevalent. Much of the landscape is characterised by numerous, narrow, dendritic stream valleys which have been infilled with alluvial and colluvial material to form seasonally flooded swamps. Recent modifications of the hydrographic base level have given rise to a coastal region of swamps and beach ridges, backed by coastal terraces. Differences in geology, elevation, relief and degree of dissection give Sierra Leone a rather varied landscape, outlined in detail below.

Coastal plains

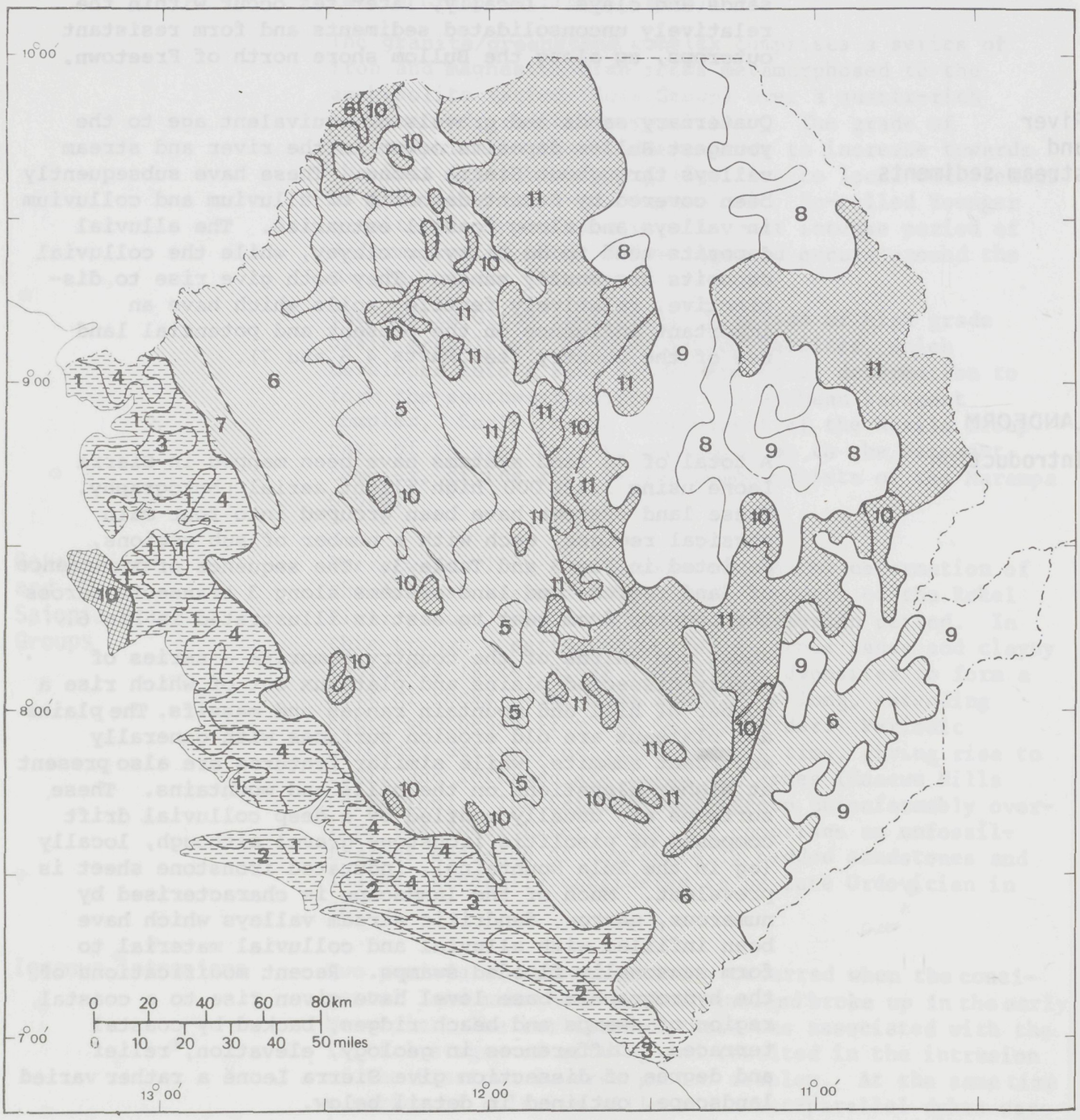
The Coastal Plains region covers an area of 10 444 km^2 (15% of the land surface of Sierra Leone). It comprises four sub regions, each with a distinctive morphology as follows:

Coastal terraces

The most extensive of the sub regions, comprising about half of the total, are the coastal terraces formed on Bullom sediments and lying at elevations between 2 and 40 m (7).[1] The relatively unconsolidated nature of the

[1] *The figures between brackets in this section refer to the corresponding numbering of the land system mapping units on the map and its legend.*

Fig. 5 Main physical regions



Source: Lamin 1978

Cartographic Section 1979

COASTAL PLAINS
1 estuarine swamps
2 beach ridges
3 alluvial plains
4 coastal terraces

INTERIOR PLAINS
5 boliland
6 undulating plains
7 low plateaux

PLATEAUX
8 undulating high-lying plains
9 rolling plains and hills

HILLS AND MOUNTAINS
10 on basic and ultra basic rocks
11 on acid rocks

Table 3 - Land regions, sub regions and systems

Land Region and Sub-Region	Land System		Area (km^2)
COASTAL PLAINS			10444
Estuarine Swamps			
Complex of cultivated coastal estuaries and river floodplains	1	Scarcies	801
Tidal coastal mangrove swamps	2	Tasso	1546
Beach Ridges			
Coastal beach ridges	3	Turner	382
Inland beach ridges	4	Sherbro	472
Degraded beach plains	5	Bonthe	579
Alluvial Plains			
Coastal floodplains	6	Torma Bum	1404
Coastal Terraces			
Dissected terraces	7	Newton	5159
Slightly dissected terraces	8	Hastings	101
INTERIOR PLAINS			31418
Bolilands			
Seasonally flooded basins	9	Mabole	1254
Seasonally flooded grassland swamps	10	Senehun	869
Colluvial terraces and seasonally flooded basins	11	Rokel	1013
Undulating Plains			
Dissected plains and terraces	12	Njama	1404
Dissected plains with broad valley swamps	13	Lunsar	2896
Intricately dissected plains with rare isolated hills and broad valley swamps and terraces	14	Laia	262
Dissected plains with isolated small hills and common terraces	15	Blama	6569
Dissected plains	16	Moyamba	2411
Rather variable dissected plains	17	Yonibana	3467
Intricately dissected plains with isolated small hills	18	Bo	5876
Complex of dissected plains and terraces	19	Wari	1381
Dissected plains with savanna vegetation	20	Borompo	1009
Dissected plains with rare isolated hills	21	Makondu	779
Rather variable dissected plains with isolated hills	22	Kamakwie	672
Dissected plains with common rocky hills	23	Kamabai	875
Low Plateaux			
Dissected low plateaux with savanna vegetation	24	Port Loko	681

Land Region and Sub-Region	Land System		Area (km^2)
PLATEAUX			15741
Undulating High-lying Plains			
Complex of plains and terraces associated with major rivers and their tributaries	25	Musaia	292
Intricately dissected plains with isolated rocky hills and narrow wooded valleys	26	Wadu	1054
Irregularly dissected plains with isolated rocky hills	27	Koidu	1955
Strongly dissected plains with isolated hills	28	Kailahun	1511
Intricately dissected with isolated hills	29	Kombile	1552
Intricately dissected plains with isolated rocky hills and narrow wooded valleys	30	Kamaron	1327
Rolling Plains and Hills			
Intricately dissected association of plains and pointed hills	31	Bendugu	1515
Variably dissected association of plains and rocky hills	32	Sandaru	4080
Hills			
Dissected flat-topped gravelly hills with common footslopes	33	Kabala	1156
Dissected rocky hills with common footslopes	34	Haffia	1299
HILLS AND MOUNTAINS			14723
On Basic and Ultra Basic Rocks			
Flat-topped hills and high ridges	35	Saionia	628
Remnant hills with extensive footslopes	36	Kasewe	333
Dissected hill ridges with extensive laterite capping	37	Sula	419
Dissected escarpment and hill ranges	38	Kangari	1425
Strongly dissected hill range	39	Regent	326
On Acid Rocks			
Dissected flat-topped gravelly hills	40	Quantamba	1342
Complex of rocky hills	41	Kulufaga	4181
Intricately dissected faulted hills	42	Saiama	2246
Massive dissected rocky hills and peaked hill ridges	43	Tonkolilini	2844
Dissected hills and mountains	44	Loma	979

sediments has led to an extremely intricate pattern of dissection by minor streams, especially along the seaward margin of the terraces. Included in this sub region are higher lying terraces surrounding the Peninsula Mountains in the Freetown area (8). These lie at elevations up to 70 m and have level terrace surfaces, capped extensively by laterite sheets. Deeply incised streams, flowing swiftly from the mountains dissect the terraces in places.

Estuarine swamps

At the foot of the coastal terraces lie estuarine swamps, resulting from the deposition of silt and clay along major river channels. Mangrove vegetation typifies these swamps which are subject to tidal flooding (2). In places, especially along the Great and Little Scarcies Rivers, the mangrove has been extensively cleared for paddy rice cultivation (1).

Alluvial plains

Deposition of alluvium has taken place in a freshwater environment along the Little Scarcies and Sewa Rivers, giving rise to extensive grassland plains (6). These lie up to 15 m above sea level and much of the area is flooded during the rainy season when the rivers overflow their banks.

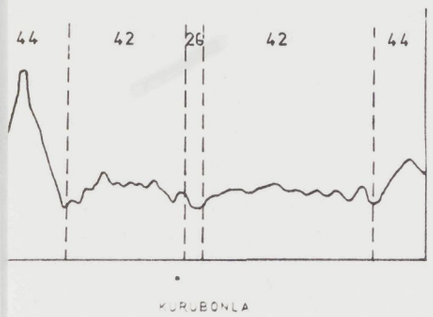
Beach ridges

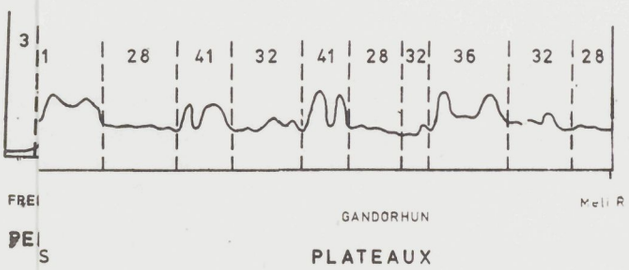
Fringing the coastal plains along their seaward side is a zone of beach ridges of varying age. These are most extensive in the Turner's Peninsula area where they attain widths of up to 20 km. Adjacent to the coast the ridges are elongated and have caused the deflection of major rivers (3 and 4). Most notable of these are the Waanji and the Sewa which have joined in their lower reaches to flow parallel to the coast for some 50 km, before reaching the sea near Sherbro Island. Further inland the beach ridges become more dissected and do not exhibit such a striking parallelism (5). Between Sherbro and the Guinea border, the beach ridges are discontinuous and narrow and attain widths of only a few kilometres.

Interior plains

The Interior Plains are the most extensive physiographic region in Sierra Leone, covering 31,418 km^2 (43% of the total area). The plains rise gently from west, where they merge almost imperceptibly with the coastal terraces and lie at about 40 m elevation, to east where they lie at elevations of up to 200 m. They are separated from the Plateaux region by a distinct escarpment. Although the Interior Plains have a uniformly low relief there are significant variations in morphology resulting from differences in the rock types on which they have formed. They comprise two main sub regions: 1) an extensive area of low relief dissected undulating plains, stretching from the Guinea border in the north to the Liberia border in the south and attaining a maximum width of 100 km in the centre of the country, and 2) an area of seasonally

lion Vertical exaggeration: 10





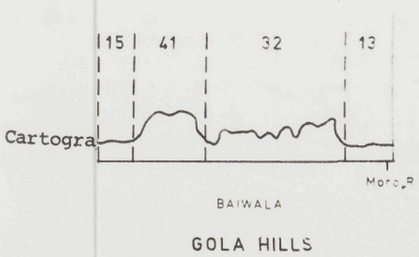
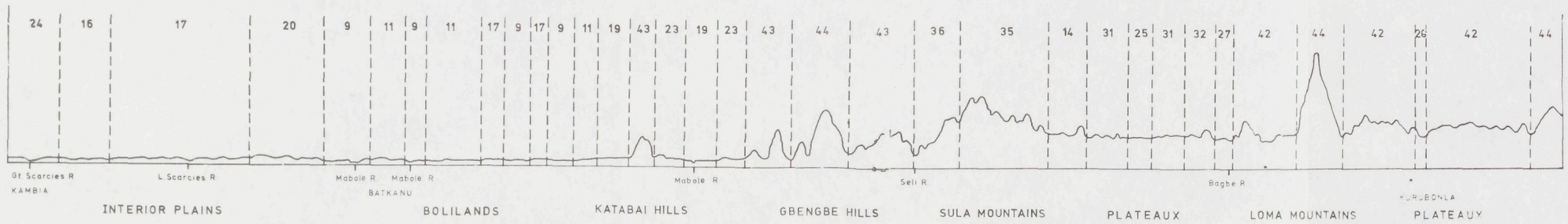


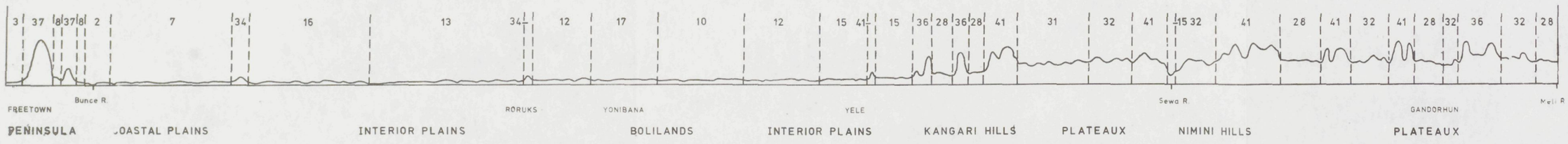
Fig.6 Topographical cross-sections

Scale: approx. 1:1million Vertical exaggeration: 10

Northern



Central



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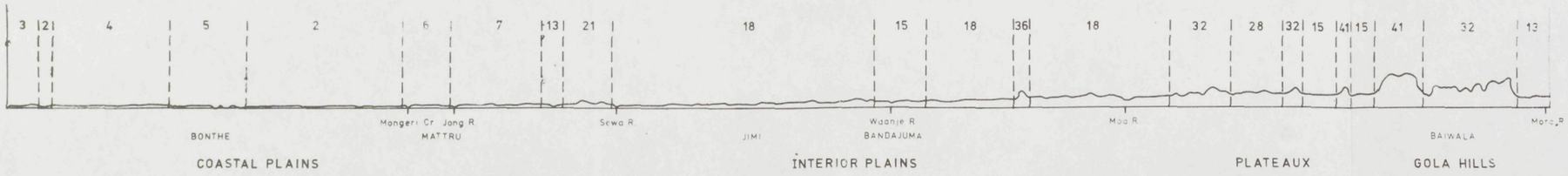


Cartographic Section 1979

flooded swamps and associated terraces of negligible relief (known locally as the Bolilands), associated with the Rokel River Group sediments.

Undulating plains

In the west, granulites of the Kasila Group and schists of the Marampa Group have given rise to undulating plains which have predominantly gentle slopes mantled by a thick layer of densely packed pisolitic ironstone gravel (16, 17,20). The swamps are narrower and occur at lower densities than on the plains further east; low isolated hills occur locally (21). In the northwest the plains are bordered by a flat topped low plateaux with distinctive E-W trending incised valleys (24).

In the central part of the Interior Plains, undulating plains have developed on resistant sediments of the Rokel River Group (10, 12). Here the slopes are more subdued, extensive terraces are locally present and the swamps often broaden into featureless depressions (bolis). Parts of the plains also occur in a complex association with the Bolilands sub region where they have been cut back to such an extent that they form subdued isolated remnants (part of 17).

In the east, undulating plains have formed on a complex of granitic rocks. Typically slopes are very gentle, the density of narrow swamps increases and isolated hills are scattered throughout the area (14,15,18,19,22). Footslope terraces are normally present and locally become common (eg along the eastern edge of land system 18 and 19). In the north, at the foot of the fringing escarpment, the proportion of gentle slopes increases and low, predominantly rocky, hills become more frequent (23). Further west a zone of granitic rocks occurs between the Kasila granulites and the Rokel River sediments. Here the plains have very subdued relief, isolated hills are rare and the swamps, usually associated with terraces, are broad (13).

Bolilands

The Bolilands attain a maximum width of 50 km west of Magburaka. They are an intricate association of depressions and low terraces along the Rokel and Mabole Rivers and their tributaries (9,10,11). Flooding is widespread during the rainy season, resulting both from the poor drainage of the low lying terrain and overflow from rivers and streams.

Plateaux

The Plateaux region covers 15 741 km^2 (22% of the country) in the northeast and southeast and lies at altitudes between 300 and 700 m. Although formed almost exclusively on granitic rocks, a varied landscape has developed due to difference in dissection and relief.

Undulating high-lying plains

The eastern part of the Plateaux is composed mainly of undulating plains, similar in morphology to the Interior

Plains but lying at higher elevations (26,27,29,30). Low isolated hills are scattered across the plains.

Rolling plains and hills

The western and southern parts of the Plateaux comprise dissected hills of low to moderate relief with broad footslopes (31,32,33,34), broken in places by undulating plains (28). Adjacent to the main rivers (eg the Mongo) narrow alluvial plains occur (25). In the south the hills are covered by a thick layer of colluvial ironstone gravel, but towards the north the weathering granite is at a shallower depth and rock outcrops become more common.

Hills and mountains

The high relief land of Sierra Leone can be grouped into 2 sub regions: 1) hills developed on predominantly basic and ultrabasic rocks and 2) hills developed on acid rocks The region covers 14 723 km^2 (20% of the country).

Hills on basic and ultrabasic rocks

These rocks are generally rather resistant to erosion and have given rise to highly dissected hill ridges of moderate to high relief. In addition, the relatively high proportion of iron and aluminium in the rocks is conducive to the formation of laterite, either in the form of surface crusts or as densely packed ironstone gravel. Gravelly hill ridges, at elevations between 470 m and 890 m, are a conspicuous feature of both the Freetown Peninsula (39) and the escarpment bordering the Plateaux on its western and southern sides (38). The Sula Mountains rise out of the Plateaux to elevations of 900 m and are covered by a laterite crust (37). Along the Guinea border, in the northwest, the Saionia Scarp forms a prominent, laterite-capped ridge rising to 800 m. Remnant ridges and isolated hills, with broad laterite covered footslopes, occur on the Interior Plains in the southwest of the country (36).

Hills on acid rocks

Hills formed on granitic material have eroded to give a higher proportion of gentle slopes and rock outcrops than those developed on the more basic rocks. Along the margins of the Plateaux, granitic hills rise to 1000 m and exhibit a variety of scenery, ranging from rather massive, faulted hills to rocky hill complexes (40,41,42 and 43). In the escarpment area these hills have been strongly dissected by rivers flowing from the Plateaux on to the Interior Plains through deep, often fault controlled, gorges. This dissection has given rise to the occurrence of granitic hill outliers along the eastern and northern edges of the Interior Plains (part of 41 and 43).

The hills formed on the Younger granite exhibit some of the most spectacular scenery in Sierra Leone, culminating at the 1945 m dolerite capped peak of Bintumani in the Loma Mountains (44).

DRAINAGE

Fig 7 depicts the rivers and river basins of Sierra Leone. The respective area and discharge of the main basins are shown in Table 4.

Table 4 - Area, discharge and runoff of main river basins

Basin	*Area (km^2)*	[1]*Discharge (m^3/sec) Min*	*Max*	[1]*Annual runoff (mm)*	*Location of Station*	*Year*
Little Scarcies	12,870	5.1	1801	1787	Mange	1971
Seli/Rokel	10,620	1.7	416	782	Bumbuna	1971
		2.2	784	1112	"	1972
Pampana/Jong	7,511	3.1	389	1275	Magburaka	1972
Sewa	14,140	12.4	771	1028	Jaiama	1972
		4.8	601	860	"	1973
Moa	9,220	34.5	978	511	Kenema	1971

[1]*Except for the Scarcies, these figures refer to a part of the basin only.*
Source: Clarke (1969) and UNDP (1975).

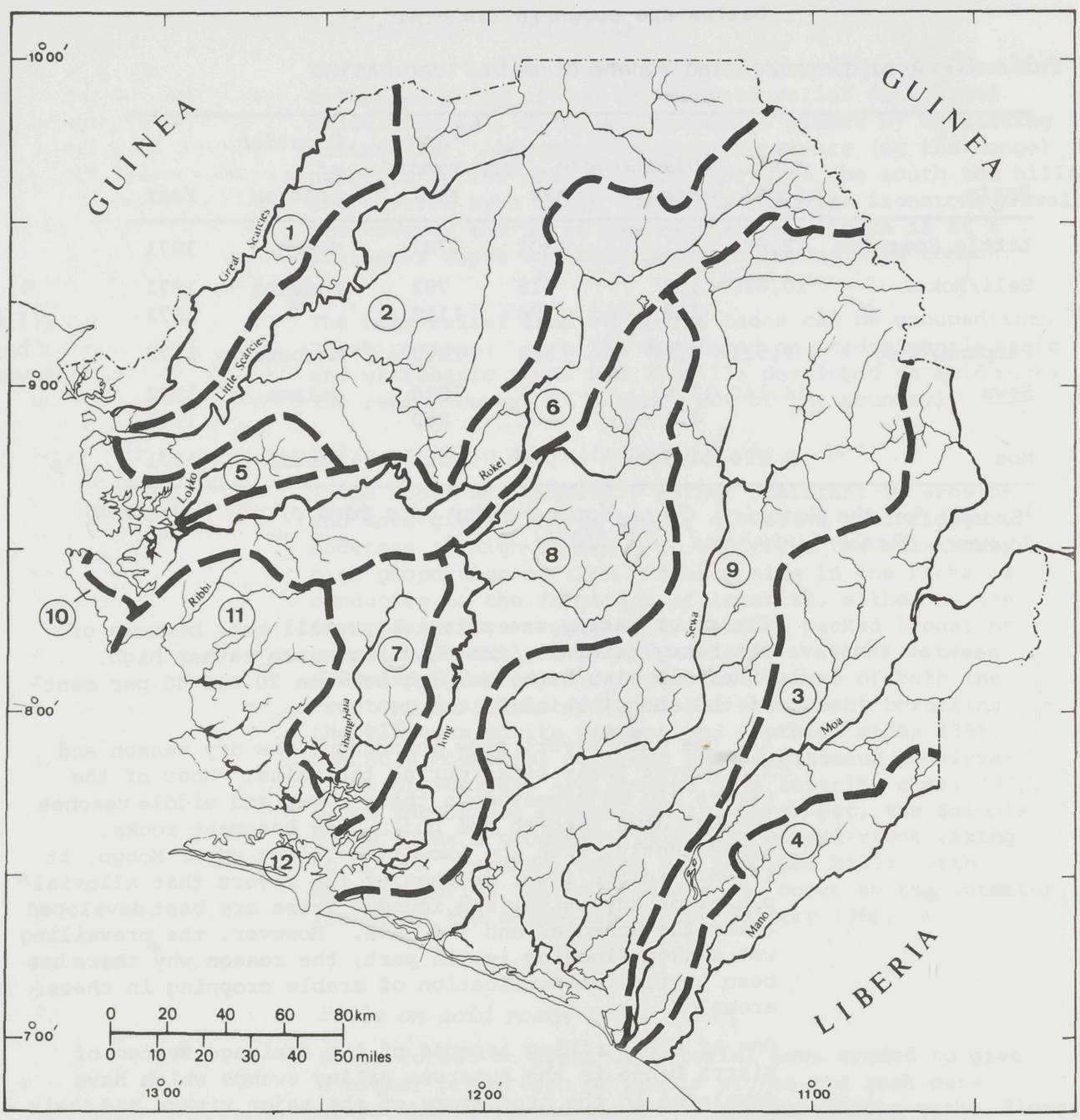
The river basins are relatively small but, because of the heavy rainfall, the discharges are rather high. Runoff is also high, varying between 20 and 40 per cent of the annual rainfall total.

All the main rivers flow throughout the dry season and flood over their banks during the rains. Most of the rivers are rejuvenated in their upper and middle reaches and cut down through the underlying basement rocks. Consequently, with the exception of the upper Mongo, it is only in the lower reaches of the rivers that alluvial plains of any extent are found. These are best developed along the Scarcies and the Sewa. However, the prevailing wet season flooding is, in part, the reason why there has been little intensification of arable cropping in these areas.

One of the striking aspects of the drainage system of Sierra Leone is the numerous valley swamps which have developed in the headwaters of the major rivers and their tributaries. These appear to have resulted from a regional tilting of the land surface which has caused a damming up of streams and their subsequent infill with alluvial and colluvial material. The resulting flat-bottomed narrow valleys are drained only by sluggish seasonal streams and are usually swamped for over 6 months of the year. In their lower reaches the streams tend to flow faster however and are often bordered by narrow, alluvial plains, which flood only periodically and are better drained.

Another feature of note is the Bolilands area, already described above. This complex of seasonal swamps seems to have developed as a result of the silting up of a former delta common to the Mabole, Rokel and Pampana Rivers which, during a period of higher sea level, probably

Fig.7 Drainage and river basins



Cartographic Section 1979

Watershed Boundary

river basins

1	Great Scarcies Basin	7	Gbangbaia Basin
2	Little Scarcies Basin	8	Jong Basin
3	Moa Basin	9	Sewa Basin
4	Mano Basin	10	Western Water Resources Area
5	Lokko Basin	11	Ribbi/Thauka Water Resources Area
6	Rokel Basin	12	Sherbro Water Resources Area

flowed into the sea north of their present estuaries. The drainage system of the Bolilands is extremely variable and the extent and degree of flooding in the area is a major constraint to the development of more intensive forms of agriculture.

VEGETATION AND LANDUSE

Introduction

The original vegetation of Sierra Leone was probably moist high forest, except in the extreme north, where drier and less humid conditions would have given rise to deciduous woodland. Due to the activities of man, however, this pattern has been greatly modified so that mosaics of forest regrowth, secondary forest and derived savanna, resulting from bush fallow cultivation practices, now cover much of the upland area of the country. In the coastal and inland swamps specific vegetation patterns have developed due to the influences of tidal and fresh-water inundation respectively. Here too, considerable modification of the climax vegetation has taken place due to the cultivation of paddy rice.

In a complementary study to that reported here the vegetation and land use patterns of Sierra Leone have been mapped from 1975/76 infra-red colour transparencies (Gordon *et al*, 1979). Fig 8, indicating the main vegetation and land use types, is a simplification of this work. The main types are discussed briefly below, while in Part 3 additional details are given on farming practices and crops.

Forest

Closed forest

Primary high forest now only occurs as remnants over about 5% of the country, mainly on hill slopes in the more inaccessible parts. Most of these areas are reserved, although cultivation continues to encroach in places. Secondary, immature forest also occurs as remnants, mainly in the east and south, in association with tree crop cultivation.

Forest regrowth

Just over half of Sierra Leone has a typical association of vegetation types resulting from bush fallowing (see glossary and Part 3), which can conveniently be termed forest regrowth. The association comprises an intricate mosaic of annual crops, grassland, thicket and regrowth forest, usually with localised remnants of closed forest. In the south of the country the closed forest becomes more common and usually contains an understorey of tree crops. Wild oil palm (*Elaeis guineensis*), left because of their productive value, rise out of the regrowth forest.

Savannas

In the drier northern 25% of the country, forest regrowth gradually gives way to savanna. In places this comprises a fairly closed canopy of gnarled trees with

Fig. 8 Vegetation and land use



Cartographic Section 1979

1 Closed Forest
2 Forest Regrowth and Farmland
3 Savanna Woodland
4 Mixed Tree Savanna
5 Complex of Lophira Tree Savanna and Boliland Swamps
6 Upland Grassland
7 Montane Grassland and Rock Outcrop
8 Mangrove Swamp Forest
9 Association of Coastal Forests and Swamp Grasslands
10 Continuous Upland Cultivation
\+ Oil Palm/Rubber Estate

tall grasses, while elsewhere the trees are scattered and grass predominates. On the higher lying parts of the Boliland area, and also on the low plateaux east of Port Loko, a savanna dominated by *Lophira lanceolata* occurs. Dry season burning of the savannas by Foulah herdsmen is rife, leading to a gradual spread of fire resistant grass and tree species. Cane grass *(Chasmopodium caudatum)* is dominant over much of the northern part of the country, whereas the more palatable forage grasses such as guinea grass *(Panicum maximum)* and napier grass *(Pennisetum purpureum)* have all but disappeared in many parts. In some areas repeated burning is leading to a replacement of savanna by more or less pure stands of *Lophira* with an impoverished understorey of annual weeds.

Coastal upland communities

Infertile sandy soils of the beach ridge areas of Sherbro Island and Turner's Peninsula support a less luxuriant vegetation than that of adjacent uplands. The dominant tree is *Parinari macrophylla* and this occurs in association with thicket or short grasses. The area is only scantily cultivated, cassava being the main crop grown.

Swamp communities

The natural vegetation of the tidal coastal swamps is mangrove forest and thicket composed of *Rhizophora* and *Avicennia spp*. *Avicennia* appears to grow in sandier, less waterlogged areas than *Rhizophora* (Tomlinson, 1957 a, Hesse, 1961 a, Hesse and Jeffrey, 1963). In addition, soils under *Rhizophora* tend to be more fibrous and more susceptible to acidification when drained than those under *Avicennia*. Most of the mangrove in the northern coastal areas has been cleared for rice cultivation, whereas in the Sherbro area very little clearing has taken place.

Uncultivated valley swamps support a thicket vegetation dominated by *Raphia vinifera*. After cultivation (which has increased considerably in recent years) grasses, aquatic herbs and low shrubs colonise the swamps.

In the seasonally flooded areas of the Bolilands and the alluvial plains a number of different grassland communities occur depending on the frequency and depth of flooding. On the higher lying sites cane grass such as *Chasmopodium caudatum* is common. Boli depressions are dominated by *Anadelphia* and *Rhytachne spp*, while in the deep flooded areas of the Sewa floodplain floating *Echinoclea spp* are found. Severe invasion by lalang grass *(Imperata cylindrica)* is common in the more intensively cultivated parts.

Continuous upland cultivation

About 2% of Sierra Leone, mainly around the main towns and villages, is continuously cultivated for rainfed arable crops. In the south perennial tree crops are common. Other areas of permanent cultivation include some 6 500 ha of oil palm plantation scattered across the southern half of the country and 2 100 ha of rubber in Pujehun district.

POPULATION

Total population

Between 1963 and 1974 the population of Sierra Leone increased by 20 per cent from 2.28 to 2.74 million, with an increase in density from 31.5 to 38 per km^2. This is a fairly rapid increase in a country which is already one of the most densely populated in Africa. Thomas (1978) estimates the present population to be 3.2 million with a growth rate of 2.4%. Assuming that no acceleration of population growth occurs it can be predicted that Sierra Leone's population will double in the next 25 to 30 years a possibility which has serious implications with regard to the country's future land use (see Part 7).

Population distribution

The population of Sierra Leone is unevenly distributed, as indicated in Fig 9 and Table 5. Areas of highest population density are related to a) migration to urban and mining centres and b) cultivation of cash crops. The lowest population densities occur in areas with hilly or seasonally flooded terrain.

The Western Area, which includes greater Freetown, is the most densely populated part of the country with 457 persons per km^2. This is followed by the diamond mining areas of Kono district where four of the chiefdoms have over 100 persons per km^2. Chiefdoms containing the larger district towns (ie Makeni, Bo and Kenema) also have densities of over 100.

The most populated rural chiefdoms are in the vegetable growing and mangrove swamp rice areas of Kambia and Port Loko districts, whose proximity to the Freetown market has given rise to a rural economy based on cash crops. Inland from the Bullom coast, two distinct zones of relatively high rural population occur on the Interior Plain: one stretching east and southeast from Kambia and Port Loko towards Makeni and Njala, and the other associated with the moister, coffee and cocoa growing areas of the southern plains from Bo, through Kenema, to Kailahun.

Areas of low rural population occur along the southern coast, from the Sierra Leone River to the Liberian border, and inland as far as Moyamba and Pujehun. Population density is also low in the seasonally flooded Boliland area and on the Plateaux.

Population change

Fig 10 indicates the percentage change in chiefdom populations between 1963 and 1974. Several distinct trends of population change are discernible.

a) 2 to 4 fold population increases are associated with migration into the diamond mining areas of Kono district, while in the rutile and bauxite mining areas of Moyamba and Bonthe districts the population nearly doubled over the same period.

b) The populations of Freetown, Makeni, Magburaka, Kabala, Sefadu, Bo and Kenema have all increased significantly faster than the national average.

Fig. 9 Population density 1974, by chiefdom

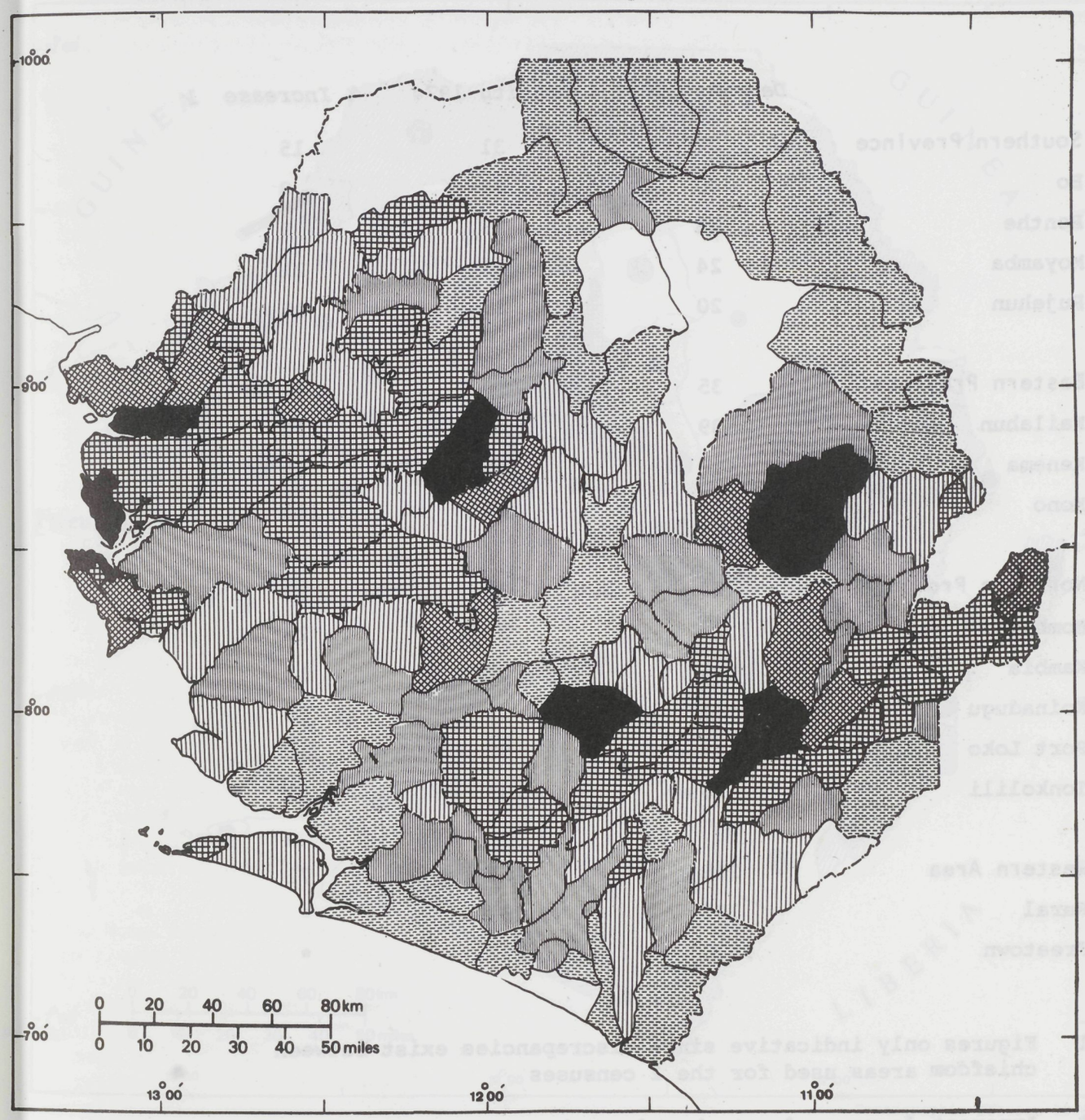


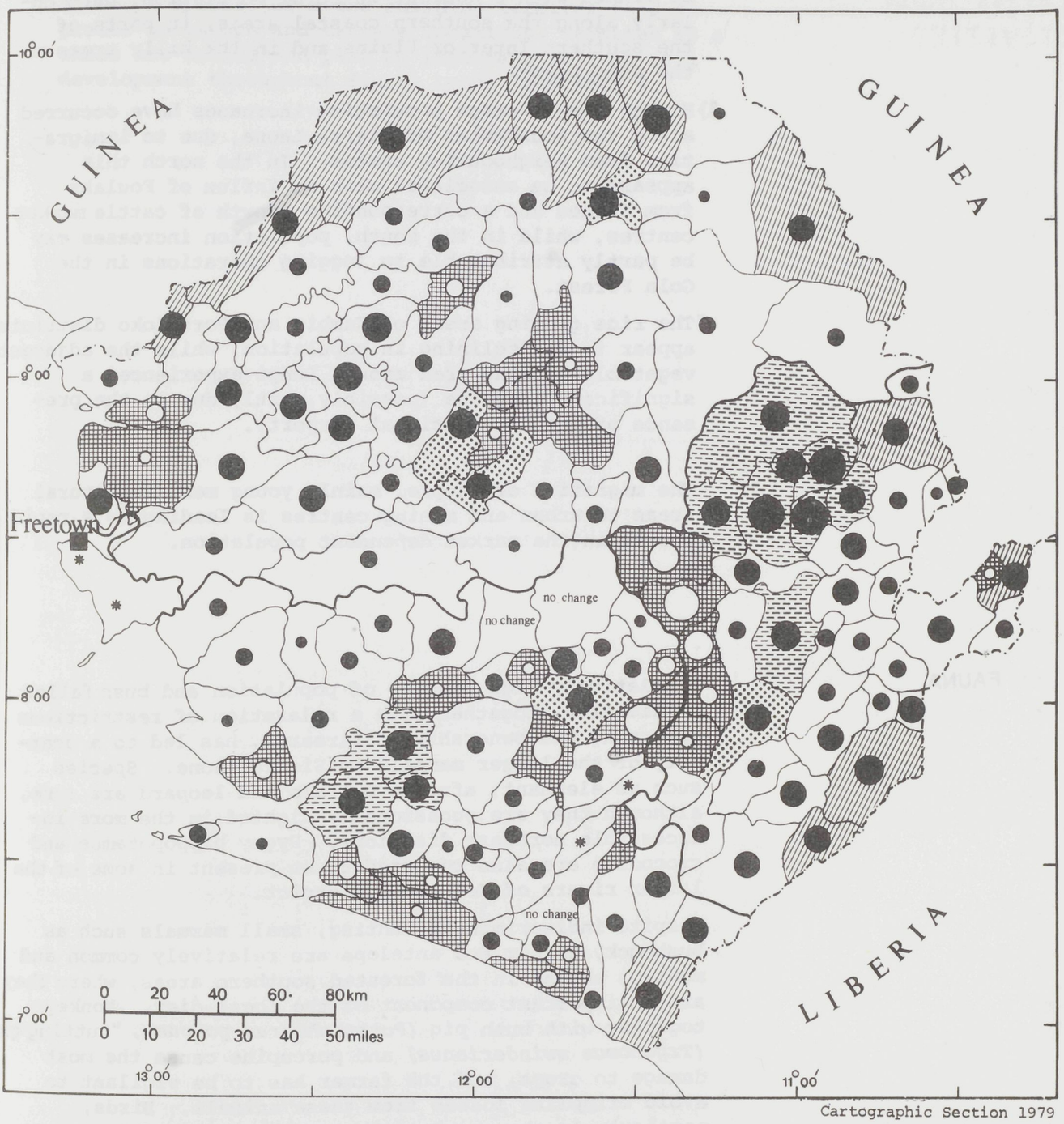
Table 5 - Population density and percentage increase for 1963 and 1974, by province and district (per km^2)

	Density 1963	*Density 1974*	*% Increase 1*
Southern Province	27	31	15
Bo	40	43	8
Bonthe	23	25	9
Moyamba	24	29	21
Pujehun	20	25	25
Eastern Province	35	50	43
Kailahun	39	46	18
Kenema	38	44	16
Kono	30	64	113
Northern Province	25	30	20
Bombali	24	30	25
Kambia	46	52	13
Koinadugu	11	13	18
Port Loko	44	50	14
Tonkolili	26	33	27
Western Area	268	457	71
Rural	103	67	*
Freetown	9878	4292	*

1 Figures only indicative since discrepancies exist between chiefdom areas used for the 2 censuses

* Apparent decrease due to boundary changes

Fig. 10 Population change between 1963 and 1974, by chiefdom



c) The increase in urban and mining population appears to be linked with a decline in rural population, particularly along the southern coastal areas, in parts of the southern Interior Plains and in the hilly areas of the escarpment.

d) Higher than average population increases have occurred along the boundaries of Sierra Leone, due to immigration from neighbouring states. In the north this appears to be associated with an influx of Foulahs from Guinea and a corresponding growth of cattle market centres, while in the south, population increases may be partly attributable to logging operations in the Gola Forest.

e) The rice growing areas of Kambia and Port Loko districts appear to be declining in population, while the adjacent vegetable growing area around Lungi experienced a significant increase (possibly partly due to the presence of the international airport).

The migration of people, mainly young men, from rural areas to urban and mining centres is leading to a rapid growth in the market dependent population.

FAUNA

A relatively high density of population and bush fallow cultivation, together with a relaxation of restrictions governing the ownership of firearms, has led to a scarcity of the larger mammals in Sierra Leone. Species such as elephant, african buffalo and leopard are rare, although they are occasionally sighted in the more inaccessible northern districts. Pygmy hippopotamus and crocodile are also reported to be present in some of the larger rivers of Koinadugu district.

Despite indiscriminate hunting, small mammals such as bushbuck, duiker and antelope are relatively common and monkeys abound in the forested southern areas, where they are an important component of the local diet. Monkeys, together with bush pig *(Potamochoerus porcus)*, "cutting gra *(Tryonomus swinderianus)* and porcupine cause the most damage to crops, and the farmer has to be vigilant to avoid crippling losses from these animals. Birds, particularly the weaver, also cause considerable damage to crops, especially rice.

Insect damage to crops in the field appears to be limited to infestation of upland rice by stem borers and army worms and attack by grasshoppers on cassava, vegetables and citrus. However, storage losses of crops such as rice and groundnuts due to attack by weevils and beetles are considerable. Tsetse fly is present in the country and is a possible constraint to the introduction of new breeds of cattle.

Of all the soil fauna, termites are the most important. Although species of mound building termites tend to prefer footslope and terrace locations, termites as a whole are active and play an important role in soil development throughout Sierra Leone (see Part 4).

Part 3
AGRICULTURAL ACTIVITIES

SOCIO-ECONOMIC FACTORS

The economy

The economy has two main sectors: agriculture and mining. The agricultural sector provides a livelihood for 80% of the population and contributes 33 per cent of GDP and 44 per cent of current export earnings. Coffee and cocoa are by far the most important export crops and, although the total production is relatively low, high prices over recent years have led to a trebling of the sector's contribution to export earnings. The mining sector employs about 4% of the working population and contributes 10% of GDP and 40% of current export earnings. The proportion of export earnings from mining fell by half in recent years due to a depletion of the more easily exploitable iron ore reserves and a fall in the price of diamonds in 1975. However, a recent increase in the price of diamonds has again stimulated mining exports.

The agricultural sector

According to the 1974 National Census, 80% of the population of Sierra Leone are rural, ie directly dependent on the land for their livelihood. The share of the population indirectly connected with agriculture (agro-business, agro-industry etc) is unknown but it can be estimated as very small. In 1970/71 there were approximately 286 000 farmers in the country, plus some 20 000 cattle raisers, mainly semi-nomadic Foulah. Out of a total land area of about 7.2 million ha, approximately 0.5 million ha are cultivated (CSO, 1970/71). About 80% of the cultivated area is on upland (non-flooded areas) under traditional bush fallow cultivation methods.

Average farm size in 1970/71 was estimated at about 1.8 ha, with farms in the east tending to be larger than those in the south and north. Unpublished census data (CSO, 1974) puts the figure at about 1.5 ha, while a recent fallow period survey estimated average farm size to be 1.33 ha (LRSP, 1979a).

Despite the significant improvement in export earnings from coffee and cocoa, the agricultural sector has a growth rate of only about 1% and remains weakly developed. Table 6 indicates the area, yield and production of the main crops. Rice, either rainfed or paddy, is by far the most important crop and is grown by 70% of farmers. Of these only

TR1

Table 6 - Cultivated area, yield and production of principal crops, 1970/71

Crop	*Cultivated Area* Ha	%	*Yield* (MT/ha)	*Production* MT	%
Rice					
Upland Rice	243,302	45.6	1.33	323,592	43.5
Swamp Rice	83,758	15.7	1.50	125,637	16.9
		61.3			60.4
Grain Crops					
Guinea Corn	4,754	0.9	1.25	5,943	0.8
Fundi	1,371	0.3	0.67	919	0.1
Millet	5,707	1.1	1.12	6,392	0.9
Maize	10,486	2.0	1.01	10,591	1.4
		4.3			3.2
Pulses/Oil crops					
Groundnut	13,822	2.6	1.10	15,204	2.0
Broad Beans	317	0.1	1.12	355	0.1
Benniseed	1,794	0.3	0.49	879	0.1
		3.0			2.2
Root Crops					
Cassava	16,678	3.1	4.95	82,556	11.1
Cocoyam	4,452	0.8	4.95	22,037	3.0
Sweet Potato	7,022	1.3	2.65	18,608	2.5
Chinese Yams	412	0.1	3.92	1,615	0.2
		5.3			16.8
Export Crops					
Coffee	71,311	13.3	0.28	19,967	2.7
Cocoa	45,059	8.4	0.15	6,759	0.9
		21.7			3.6
Other Crops	23,665	4.4	4.34	102,706	13.8
Total	533,910	100%		743,760	100%

Note: 70% of total acreage under cultivation is under mixed cropping i.e. a combination of crops cultivated within the same field and usually harvested at different times.

Source: Agricultural Statistical Survey of Sierra Leone, 1970/71 (Central Statistics Office)

22% have a rice surplus to sell in the market. However, the majority of farmers have excess production of one or more other crops which are bartered or sold for cash. While the average per capita income in Sierra Leone in 1975 was $160, the average rural income was only about $50 (IBRD, 1975). This varied between $30 in the north and $60 in the southeast. These differences reflect mainly better agro-ecological conditions in the south-east, enabling the cultivation of export earning tree crops.

Food consumption and imports

Rice is the major component of the Sierra Leone diet with, in 1973, an average annual per capita consumption of about 120 kg. This is one of the highest in Africa. An increasing food shortage has developed in recent year due to a rapidly increasing population and near subsistence level of production. As a consequence, Sierra Leone has in the last decade and a half, been utilising its foreign exchange earnings from mining to import between 20 000 and 40 000 MT of rice per annum (CSO, 1970/ Between 1976 and 1977 food imports amounted to 18% of total imports, of which one quarter was rice (FAO, 1978a This has partly been responsible for the worsening balan of payments position and growing foreign debt burden of recent years.

Agricultural development policy

In order to improve the situation the current National Development Plan aims at:-

a an increase in rice production to a level of national self sufficiency

b an increase in production of the main export crops to give increases in foreign exchange earnings and revenues from export taxes.

c correcting regional income disparities, particularly between north and south.

Short term production increases for rice and export crops are being sought through a more enlightened pric-ing policy and evidence suggests that farmers are responding to the higher rice price established since mid 1974. Longer term production objectives are being achieved through development projects supplying extensi and credit facilities to farmers, as well as the necessary field inputs to increase productivity.

Uplan

TRADITIONAL UPLAND FARMING

Bush fallow cultivation

In this system of traditional rainfed upland farming an area of bush which has been lying fallow for some years (previously 15-20 but now, with increasing population pressure, 5-12) is felled and burnt. Crops are grown for one or two years before the farmer moves on to fell another, usually adjacent area of bush, and so the cyc is repeated. The traditional system can be characteris as follows:

- short periods of cropping alternating with long fallow periods necessary to restore soil fertility. This results in a low intensity of cultivation.
- few or no inputs apart from land, labour and, occasionally, improved seed.
- manual labour, often by women and children, using rudimentary tools (hoes and cutlasses).
- mixed planting of between 6 and 20 crops. This allows for a better distribution of labour, a more sufficient use of land and water, easier control of weeds, pests and diseases and provision of a varied diet.

Much criticism has been levelled against the traditional methods of tropical farmers in that they appear primitive, wasteful of resources and labour, and even destructive of vegetation and soils. Nevertheless such practices have supported African populations for thousands of years and therefore can be regarded as a delicate adjustment to environmental, economic and human conditions (Morgan, 1969). However, when these conditions change, for instance through changing climate or population increase, the equilibrium of the system is upset and yields begin to fall below their already low levels. It has been suggested that, under normal conditions of traditional farming in Africa, degradation of the soil and vegetation is bound to occur when the population density exceeds 25 per km^2 (Hauck, 1974). This figure has already been reached in many of the rural areas of Sierra Leone and as a consequence the fallow period is decreasing.

A recent survey carried out by the project estimates the average fallow period to be about 9 years (LRSP, 1979a), with only a third of farmers leaving land fallow for over 10 years. There appears to be a good correlation between the length of fallow and the land available to the farmer. Sixty seven per cent of farmers interviewed on the survey reported that present yields are lower than those of the past, while those reporting higher yields tended to be cultivating newly developed swamps or recently cleared forest reserves. The fallow period in areas around forest reserves was higher than average, reflecting a tendency for some farmers to counteract falling yields by clearing virgin land.

Upland crops

Three quarters of the cultivated upland area is under food crops, the remainder under perennial tree crops. Rainfed rice is by far the most important crop, accounting for about half the area. Although average yields in 1970/71 were estimated at 1300 kg/ha (CSO, 1970/71) it is probable that most farmers attain yields of only half this figure (Roberts, 1973).

Other crops planted in mixed stands with rice include maize, guinea corn (sorghum), millet, sesame (benniseed) and pigeon pea. The ratio of rice to the other grain crops decreases with decreasing rainfall towards the north. Groundnuts, normally cultivated by women, and cassava are often planted in the previous year's rice plot

and both these crops are more common in the north than in the south and east. Yams are planted in heaps on the most fertile areas around the homestead or in the remains of previous years' trash heaps. Yields of all these crops are low.

Vegetables, eg pepper, okra, spinach, garden egg, potato leaf and tomato, are also grown around the homestead, as are fruits such as citrus, mango, banana, avocado, pine-apple, breadfruit and guava. In parts of Koinadugu district, particularly around Kabala, vegetables are often grown in upland fields which are furrowed down the slope to facilitate runoff during high intensity downpours. Such practices are inevitably leading to accelerated soil erosion. In the south and east, coffee and cocoa are important cash crops, while wild oil palm is harvested in all parts of the country, except the driest northern parts.

SWAMP CULTIVATION

The FAO/LRSP TR 2 (1979) indicates that cultivated swamp cover 209 000 ha, mainly along the coast and in the Boliland areas. This figure does not include the cultivated valley swamps scattered over the Interior Plains and Plateaux, too small to be shown at reconnaissance mapping scale; nor does it represent the annually cultivated area, since the swamps mapped contain recent fallow and inclusions of swamp grassland.

In 1970/71 the area of cultivated swamp was estimated at about 84 000 ha, an increase of 36.5% since 1965/66. Swamp cultivation has undoubtedly further increased in the 8 years since the CSO survey, but unfortunately reliable up to date figures are not available. However, it is probable that less than 10% of the total swamp area is at present cultivated.

The cultural practices carried out in the swamps differ from those of the uplands. The fallow period is normally only 1 or 2 years and in some areas, notably the mangrove swamps, continuous cultivation is practiced. Although paddy rice is the main crop, short cycle catch crops, eg groundnuts, sweet potato and vegetables, are also grown in some areas. Rice is normally broadcast or sown, transplanting being limited to mangrove swamps and locally to valley swamps. Under traditional methods inputs are limited to labour and water control is not practiced. Consequently yields, averaging 1 400 kg per ha, are low.

There are four main swamp environments summarised in Table 7 and briefly described below.

Mangrove

The areas of mangrove swamp cultivation occur mainly along the Great and Little Scarcies Rivers, where rice has been grown since the turn of the century (land system 1). In view of the low population increase in this area it is probable that the cultivated area is remaining fairly static. The soils are inherently fertile but remain difficult to cultivate because of a

Table 7 - Major environments of paddy rice cultivation

Environment	*Flooding regime*	*Cultivation practices*	*Total area (ha) (1)*	*Cultivated area 1970/71 (ha) (2)*	*Average yields (MT/ha)(3)*	*Other crops grown*	*Remarks*
Mangrove	Tidal to depths of 60cm.	One crop of paddy rice per year, planting time varies with onset of rains and distance from sea	213,900	15,411	1.1-1.5	None	Dry season salinity. Soils acidify when drained.
Boliland	Prolonged rainy season flooding to depths of 1m.	One crop of paddy rice per year, land locally mechanically prepared	115,500	3350	0.9-1.3	Sweet potato	Extremely acid soils of low fertility
Riverain Grassland	Variable rainy season flooding to depths of ½ to 2m.	One crop of paddy or floating rice per year, land mechanically prepared	110,000	7120	1.2-2.4	None	Difficulties of flood control along major rivers.
Inland valley swamp(4)	Short to prolonged rainy season flooding to depths of ½ to 1m.	One or two crops of paddy rice depending on degree of flood control or drainage	675,000	57,877	1.1-1.8	Vegetables, groundnuts, maize, sweet potato	Relatively fertile soils. Easily reclaimed by hand methods.

(1) Based on land facet estimates
(2) Central Statistics Office, 1970/71
(3) Traditional level of management
(4) Includes areas referred to as minor flood plains in other parts of this report

seasonal high salt content and a tendency for the more fibrous soils to acidify when not fully saturated (see Part 5). During the rains there is sufficient fresh water to flush the topsoil free of salt and tall, long duration, rice varieties are transplanted as soon as salinity levels fall. Rice is the only crop grown and the land is left fallow during the dry season. Yields compare well with the other swamp environments and it is generally considered that they could be doubled with appropriate fertilizer use.

Bolilands

Seasonal flooding in the Bolilands (land system 9,10 and 11) is limited to the large saucer-shaped depressions (referred to in this report as backswamps and drainage depressions but known locally as "bolis") which comprise between 20 and 50 per cent of the Boliland area. The pattern of flooding is complex, resulting from both the seasonal overflowing of the larger rivers and streams and runoff and seepage from surrounding uplands; consequently water control in these areas is difficult. Paddy yields are low due to a number of factors, including extremely acid soils of low fertility (see Part 5), lack of proper water control, poor tillage and sowing practices and heavy weed infestation (ten Have, 1975). The relatively large size and level nature of the bolis make them ideal for mechanical cultivation. Despite the involvement of Government for many years in subsidised tractor hire schemes there has been little improvement in rice production from these areas. Indeed there is evidence to suggest that mechanical ploughing and harrowing operations, followed by the traditional practice of hand broadcasting, only worsen the weed problem, thereby reducing yields. Because of the problems associated with the cultivation of the bolis, it is unlikely that the acreage under production is increasing.

Riverain grasslands

The term riverain grassland is used to describe extensive alluvial plains along the Sewa, Waanji and to a lesser extent, Little Scarcies Rivers (land system 6). About 70% of the area is seasonally flooded, the depth of flooding being related to variations in topography. Along the higher lying levees, close to the rivers, water collects to depths of about 50 cm whereas in the lowest parts of the plains, eg near the confluence of the Sewa and Waanji, flooding to depths of 2 m occurs at the height of the rains. In the latter parts floating rice is grown and constitutes about 12% of the area's total rice acreage (CSO, 1970/71). Soils are relatively fertile, being heavy textured with a thick surface humus layer (see Part 5).

Mechanical cultivation was started in the deep flooded areas by Government in 1948 as a means to assist farmers in controlling the rhizomes of wild rice, thereby enabling an increase in both area under cultivation and rice yield. Ploughing was later extended to the levees, but in recent years the scheme has been running into difficulties, due to inadequate funds for the maintenance of equipment.

TR1

This has led to a drop in the rice acreage which now may be as low as 2 000 ha. Average yields are among the highest in Sierra Leone and maximum yields of 3 MT/ha have been recorded (FAO, 1976b). In 1978 a Netherlands Government assisted project was started in the Torma Bum area with a view to increasing the mechanised production of rice in the deep flooded areas.

Valley swamps

Narrow, flat-bottomed, seasonally flooded valleys (known locally as inland valley swamps) occur throughout the upland areas of Sierra Leone, as already mentioned in Part 2. They constitute between 8 and 20% of the landscape and vary in size from about 10 ha to over 200 ha, depending on the land system.

Typically the swamps are drained only by a sluggish stream and flood for 3 to 6 months, during the rains. Locally, however, a perennial stream exists and in such cases (termed minor flood plains in this report) flooding is not so severe. The dense natural vegetation of the swamps has led to relatively fertile soils with a thick, humic topsoil. The subsoils, however, are generally rather infertile and may be locally sandy (see Part 5).

Despite the higher natural fertility of the valley swamps, the traditional farmer prefers to cultivate the adjacent upland. This is due to a number of factors: the main being difficulties in the initial clearance of the swamp vegetation, preference for upland rice in the local diet and the unhealthy working conditions of the swamps. Due to the emphasis placed on swamp development by Government in recent years the area under cultivation is increasing rapidly, particularly in the south and east. Under traditional methods of cultivation yields from the valley swamps are relatively low. However, considerable progress has been made in raising the yields from these areas under improved forms of cultivation (see Part 7).

CASH CROPS

The most important agricultural products exported by Sierra Leone are coffee, cocoa, oil palm kernels, ginger and kolanut. Other cash crops, of which the production is consumed internally, are tobacco and citrus, while prospects appear favourable for the introduction of cashew and sugar cane. A brief summary of the distribution and yield of these crops is given below.

Coffee (*Coffea robusta and liberica*)

Coffee is grown over 70 000 ha in the south and east of the country where more than half of the farmers cultivate it. Ninety eight per cent of the coffee trees belong to the species robusta, and only two per cent to liberica. Yield data are either unavailable or widely varying, but it is generally accepted that they are very low by international standards and in the order of 230 kg/ha. This can be ascribed to low yielding varieties, poor cultivation and processing practices and low plant population.

Cocoa
(Theobroma cacao)

Due to the well defined growth requirements of cocoa, cultivation is restricted to gravel free soils in the moist southeastern part of the country. Estimates of the area under cocoa vary considerably between 16 000 and 47 000 ha and there are no commercial plantations. The level of management is very low and this is reflected in low yields: some 120 kg/ha compared with 450 - 500 kg/ha in Ghana and Nigeria.

Oil palm
(Elaeis guineensis)

Wild oil palms are widespread in all parts of the country except the extreme north and along the coast. The total area is estimated to exceed 4 million ha. They are not felled during the bush clearing operations and possess a degree of fire resistance which enables them to survive burning.

Only about 30% of the wild oil palms are harvested for oil, with an extraction rate of 45% by local methods. (CSO, 1970/71). A similar number are tapped for palm wine; the rest remain unexploited. Since the wild palms are widely scattered and low yielding, their harvesting is profitable only for traditional farmers.

High yielding varieties have recently been introduced from Ivory Coast, and are at present grown mainly on the Daru and Gambia-Mattru schemes. The new varieties start yielding kernels in their 4th year and it would appear that ample scope exists for improvement in the management and production of this crop.

Raphia palm or piassava
(Raphia vinifera)

This grows wild in cultivated freshwater swamps particularly in the southern coastal area. Piassava and raphia products are respectively obtained by stripping the trunk and the frond stems. No attempts have yet been made to grow or farm these palms commercially. Therefore raphia cannot be defined as a "crop" but rather as an "agricultural product" which nevertheless has over the years accounted for a sizeable proportion of the agricultural export earnings.

Ginger
(Zingiber officinale)

Ginger is a well established crop which has made a small but consistently useful contribution to the export earnings of Sierra Leone (MANR, 1978b). Although production has been on the decline, recent price increases have led to a renewed interest in the crop by farmers. Yields, at 3 to 4 MT/ha, are low by world standards. Ginger is grown in the Moyamba - Bo area and in the Kambia district. It is a convenient crop for many farmers since it can be planted, usually in May/June, on any well drained slope and usually harvested after 6 months to 1 year, although it can be cropped for up to 5 years.

Kola nut
(Cola spp)

Kola trees are scattered throughout the coffee and cocoa areas in the southeast of the country, particularly near villages. The nuts are usually sold on the local market. As an export crop it is declining in importance, due to the low demand on the international market. No data on production are available.

Tobacco *(Nicotiana tabacum)*

Until recently the whole national consumption had to be imported, at a rate of some 2 000 MT per year. In the early seventies, Government assisted projects promoted tobacco growing by farmers, particularly in the Makeni - Kamakwie area. Although recent data are not available, it can be assumed that the 1974 production of 150 MT has slightly increased of late. Prospects for the expansion of this crop appear to be very favourable, particularly in the central areas of the Interior Plain (see Part 7).

Rubber *(Hevea brasiliensis)*

Exploitation of this crop is limited to a few small scattered plantations in Pujehun district. Exports of crepe rubber in 1961 amounted to 680 MT (Gunawardene,1970). Yields are low compared with neighbouring Liberia and this has been ascribed to a lack of skilled labour and incompetent management. Plans are being drawn up for the expansion of rubber production, involving both a nucleus estate and small holders, in the Potoru area.

Coconut *(Cocos nucifera)*

Coconut grows throughout Sierra Leone except in some of the driest northern areas. A large concentration of coconut palms is found along the coastal belt while inland the trees are found scattered around homesteads. The area under coconut is estimated at about 1800 ha (Gunawardene, 1970). It is assumed that at least 60% of production, estimated at 1 700 MT per year (CSO, 1970/71), is consumed in the farm or village, the rest being sold in neighbouring towns or the capital. The possibilities for increasing coconut production on Turner's Peninsula are currently under investigation.

Cashew nut *(Anacardium occidentale)*

Cashew nut was grown on an experimental basis at Newton as long ago as 1937. More recently 10 trial plots were established south of Port Loko but these have subsequently been neglected. Cashew appears to be a promising crop for Sierra Leone because of its tolerance of poor soil conditions and its great demand and high price on the world market. Consequently it is intended to further investigate prospects for production, processing and marketing of cashew as part of the Northwestern Integrated Agricultural Development Project.

Sugarcane *(Saccarum officinale)*

At the present time all of Sierra Leone's sugar requirement, some 25 000 MT per year, is imported. Project identification studies (Tate and Lyle, 1978) have indicated that an area near Pendembu in the southeast of the country may be suitable for a rainfed sugar estate capable of supplying 75% of the country's future requirement; feasibility studies to verify this have been started. Also, an irrigated scheme of about 1350 ha is being developed at Magbas near Magburaka, by a team from the Peoples Republic of China.

Citrus

Citrus is widely grown all over the country, and is especially common in the drier northern districts. Very few examples of estate cropping are to be found and

generally the management of this crop is very poor. Improved varieties, in terms of quantity and quality of produce, are not common. Due to the recent interest shown by Government for this crop, production schemes for feeding a canning factory near Makeni are being implemented.

LIVESTOCK

Per capita consumption of meat, estimated at 5 kg per annum, is very low throughout the country and only one third of fish consumption. Cattle belong almost exclusively to the Ndama breed which is small, slow growing, and gives a very low abattoir return. They are, however very hardy and well adapted to local conditions, having developed good qualities of resistance to pests and diseases, particularly to trypanosomiasis.

Cattle raising is mainly carried out in the Northern Province by semi-nomadic Foulahs, who migrate with their herds in search of water and grazing land. Normally they stay in one area for 2 or 3 years before moving their settlement, probably not returning for 15 to 20 years (Murray, 1958). The Foulahs also cultivate small areas of food crops: mainly groundnuts, rice, cassava, millet, maize and sweet potato.

Although the Foulahs obtain grazing and water rights from local settled farmers, disputes are common due to the pollution of drinking water supplies and damage to crops by their animals. The Foulah's practice of burning the savannas at the height of the dry season to produce a flush of young shoots is leading to a progressive impoverishment of the natural vegetation and a predominance of unpalatable grass species (see Part 2). Early attempts at settling Foulahs on a scheme near Gberia Timbako were reported to have met with initial success (Touchberry, 1967), but within ten years it failed due to lack of acceptance by the herdsmen of a sedentary way of life and poor organisation and management (Holt, 1976)

Table 8 - Livestock population

	Cattle	*Sheep*	*Goats*	*Pigs*	*Poultry*
1946	70,000	n.a.	n.a.	n.a.	n.a.
1964	127,000	n.a.	n.a.	n.a.	n.a.
1967	204,000	n.a.	n.a.	n.a.	n.a.
1971	207,000	47,000	109,000	16,700	1,330,000
1976	300,000	50,000	120,000	17,000	1,800,000

Source: Central Statistical Office (unpublished data)

Table 8 indicates that there was a 50% increase in cattle population between 1971 and 1976. This increase can be

partly attributed to migration of Foulahs from Guinea into Koinadugu district, particularly in the areas around the border market towns such as Gbentu, Gbindi and Gberia Fotombu. These towns have increased dramatically in size during the past decade and the surrounding areas have become severely overgrazed. Nevertheless, local animals account for only 37% of Sierra Leone's beef requirements (CSO, 1970/71), the deficit (some 7 500 head) being imported on the hoof, mainly from Guinea. On the other hand, the demand for sheep, goats and poultry is mostly met from local production.

An ongoing study into the livestock sector (Huntings, 1979) has estimated the present cattle population at about 325 000. Significant increases in cattle population are reported in the Kambia and Port Loko districts and in the hills northeast of Sefadu.

FORESTRY

The area of constituted forest reserves is approximately 285 200 ha. The largest of these are the high forest areas of the Gola, Kambui, Nimini Hills and the Peninsula and Loma Mountains. An additional 34 000 ha are proposed which, if reserved, will bring the total to about 3 190 km^2, or 4.4 per cent of the country. A further 12 000 ha is under protected forest, mainly in relatively small plantation blocks.

The forest reserves are being exploited for hardwood timber and prior to 1977 about 15 000 m^3 were milled annually. Since then the volume of sawn timber has doubled due to the expansion of logging activities in the Gola Forest. In many places inadequate control of farming activities along the borders of the reserves has led to an encroachment of cultivation into the forests.

Very little planting of forest trees has been carried out in recent years. *Pinus caribaea* was planted on a trial basis on 250 ha of the gravel free coastal terraces in Moyamba district prior to 1975. Although the tree is growing successfully and could constitute a valuable source of softwood timber, exploitation of this crop on an industrial scale has been hindered by shortage of land and finance (Smart, 1977). Other plantings have been limited to small areas of *Gmelina, Terminalia* and *Eucaluptus spp* as fuel wood mainly for domestic use and tobacco curing.

INLAND FISHERIES

Although fish is the most important source of protein in Sierra Leone the harvesting of fish is limited to coastal waters. The inland swamp areas, particularly the valley swamps, are suitable for fish farming provided the soils are heavy textured and there is a perennial flow of good quality water. *Tilapia nilotica* is the most favoured species for use in commercial freshwater fish farming, since it is fast growing and disease resistant (Mazainis, 1977).

EXTERNALLY FUNDED AGRICULTURAL PROJECTS

Improvements to the traditional farming system have come about in recent years through the implementation of a number of projects, indicated in Fig 11 and summarised in Table 9.

Table 9 - Summary of agricultural development projects

Project	*External Financing Agency*	*Phasing*	*Total Area (Km^2)*	*No. of Farmers*	*Project Components*	
					Crop	*Area (Ha)*
Eastern Area Phases 1 & 2	IDA	1972-1979	11,140	7,000	Swamp rice	4,795
					Upland rice	485
					Cocoa	740
Eastern Area Phase 3	IDA	1980-1982	17,350	12,000	Swamp rice	1,620
					Upland rice	46,575
					Cocoa	4,050
					Coffee	4,050
					Oil palm estate	810
					Oil palm outgrowers	1,620
					Rubber estate	2,835
					Rubber outgrowers	605
Northern Area	IDA	1976-1979	3,445	8,000	Swamp rice	1,215
					Upland rice	10,125
					Groundnuts	4,050
Koinadugu	EDF	1978-1982	5,600	4,500	Swamp(rice, onions, tomatoes and groundnuts)	2,430
					Upland rice	405
					Livestock (4 ranches)	8,100
North Western	EDF	1980-1984	6,700	4,500	Swamp rice (mangrove)	5,265
					Cassava	565
					Off-shore fisheries research	
					Cashew and pentadesma	
Gambia/Mattru	ADB	1974-1979	3,038	1,000	Oil palm estate	1,820
					Oil palm outgrowers	1,215
Moyamba	ADB	1980-1984	3,070	5,750	Swamp rice	2,330
					Upland rice	8,745
					Cash crops (ginger, maize, benniseed, groundnuts, oil palm, coconut)	1,745
Magbosi	-	1980-1985	3,110	5,300	Swamp rice	3,240
					Upland crops (rice, maize, pigeon pea, cassava)	6,480

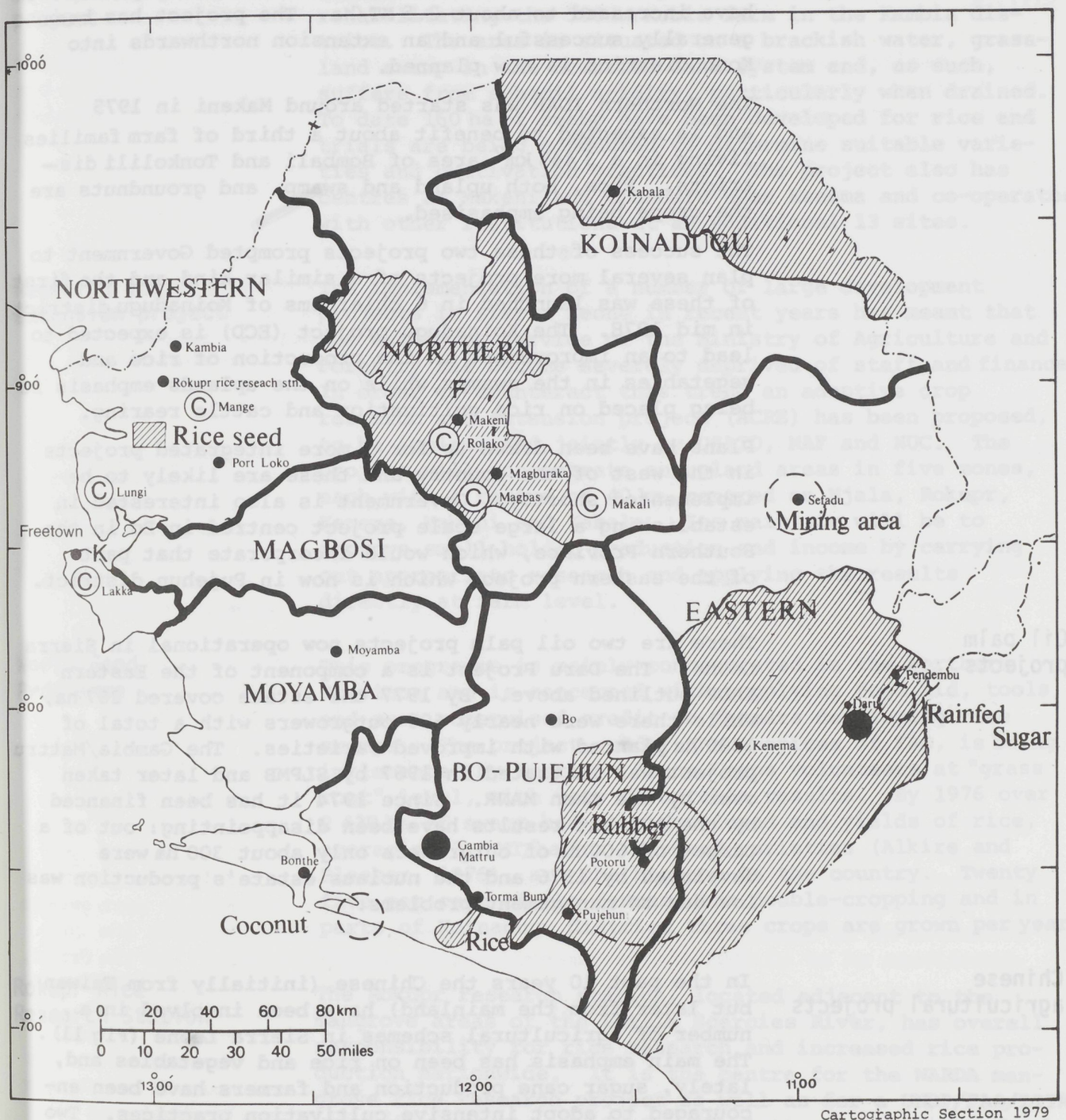
Fig. 11

Integrated agricultural development projects

There are at present three ongoing integrated agricultural development projects in the country.

The Eastern IADP started in 1972 and is now benefitting 10% of farm families in 1,140 km^2 of Kenema, Kailahun

Fig. 11 Agricultural Development Projects



integrated agricultural development project boundary July 1982)

project under implementation

project under investigation

Ⓒ projects sponsored by the People's Rep. of China

● oil palm nucleus estate

K palm kernel mill

F fruit canning factory

and Pujehun districts. Emphasis has been placed on swamp rice, cocoa and oil palm development and paddy yields have increased to about 2.5 MT/ha. The project has been generally successful and an extension northwards into Kono district is now planned.

The Northern IDAP was started around Makeni in 1975 and is expected to benefit about a third of farm families living in a 3 445 km^2 area of Bombali and Tonkolili districts. Rice, both upland and swamp, and groundnuts are the crops being emphasised.

The success of these two projects prompted Government to plan several more projects of a similar kind and the first of these was launched in 6 chiefdoms of Koinadugu district in mid 1978. The Koinadugu project (ECD) is expected to lead to an improvement in the production of rice and vegetables in the swamps, while on the uplands emphasis is being placed on rice cultivation and cattle rearing.

Plans have been drawn up for 3 more integrated projects in the west of the country and these are likely to be implemented shortly. Government is also interested in establishing a large scale project centred in Bo in the Southern Province, which would incorporate that part of the eastern project which is now in Pujehun district.

Oil palm projects

There are two oil palm projects now operational in Sierra Leone. The Daru Project is a component of the Eastern IADP outlined above. By 1977 the estate covered 207 ha, while there were nearly 600 outgrowers with a total of 1380 ha planted with improved varieties. The Gambia/Mattru project was initiated in 1967 by SLPMB and later taken over by the then MANR. Since 1974 it has been financed by the ADB but results have been disappointing: out of a target of 600 ha of outgrowers only about 300 ha were developed by 1976 and the nucleus estate's production was low due to management problems.

Chinese agricultural projects

In the past 10 years the Chinese (initially from Taiwan but later from the mainland) have been involved in a number of agricultural schemes in Sierra Leone (Fig 11). The main emphasis has been on rice and vegetables and, lately, sugar cane production and farmers have been encouraged to adopt intensive cultivation practices. Two of the sites, Mange and Makali, are also currently used for agro-technician training by MAF.

Torma Bum rice scheme

In 1976 an FAO mission undertook an appraisal of the alluvial plains around Torma Bum for increased paddy rice production. 3 700 ha of levee land were identified as suitable, of which 20% was on the more accessible east bank of the Sewa. A subsequent appraisal by a Dutch team formulated an alternative proposal for the development of the deep flooded areas near the Waanji/Sewa confluence for the mechanical cultivation of floating rice. This second proposal is now being implemented, financed jointly by NDB and the Netherlands Government.

Rice seed multiplication project

In 1978 a West German funded project within the Ministry of Agriculture and Forestry commenced operations in rehabilitating the 500 ha Kobia farm in the Kambia district. The area is situated on a brackish water, grassland swamp in the Scarcies land system and, as such, suffers from subsoil acidity, particularly when drained. To date 160 ha of swamp have been developed for rice and trials are being conducted to determine suitable varieties and cultivation practices. The project also has centres at Makeni and Gbenderu near Kenema and co-operates with other institutions at an additional 13 sites.

Research and extension project

The implementation of a number of large development projects in Sierra Leone in recent years has meant that the extension service of the Ministry of Agriculture and Forestry has become severely deprived of staff and finance. In order to counteract this trend an adaptive crop research and extension project (ACRE) has been proposed, to be implemented jointly by USAID, MAF and NUC. The project will concentrate on upland areas in five zones, each with a radius of 40 km, centred on Njala, Rokupr, Kenema, Makeni and Kabala. Its main aim will be to improve small holder production and income by carrying out appropriate research and applying the results directly at farm level.

World Food Programme

This programme is mainly concentrated in the Northern Province and is concerned with supplying food aid, tools and some supervised credit to farmers developing rice swamps. The project, under the auspices of FAO, is being implemented by American Peace Corps volunteers at "grass root" level, with very favourable results. By 1976 over 2 430 ha of swamp had been developed and yields of rice, averaging 2.8 MT/ha for improved varieties (Alkire and Bleeker, 1976), are the highest in the country. Twenty five per cent of the farmers are double-cropping and in parts of Koinadugu district three crops are grown per year.

Rokupr Rice Research Station

The Rokupr research station, located adjacent to the mangrove areas of the Little Scarcies River, has overall responsibility for rice research and increased rice production nationwide. It is the centre for the WARDA mangrove rice research project as well as for a UNDP/FAO/IITA extension research project. The latter has been involved in a TCP funded adaptive research programme of rice trials on farmers fields at approximately 600 sites. The sites were selected and their soils identified, in collaboration with LRSP, with a view to determining the response of selected rice varieties to various fertilizer applications, according to different soil and landform units.

Projects under investigation

A number of projects are currently under investigation. These are concerned with the increased production of cash crops, notably coconut, rubber and sugar cane in the Southern and Eastern Provinces.

Part 4
SOILS

SOIL FORMING PROCESSES

A number of processes combine to influence soil development in Sierra Leone and give rise to differences in soil morphology. These are discussed briefly below. For a more discoursive treatment of this topic readers are referred to Odell *et al* (1974).

Weathering

The ancient crystalline rocks underlying much of the country weather rapidly in the warm humid climate. The silicate rock minerals breakdown into silica, bases (Ca, Mg, K, Na), aluminium and iron. The silica and aluminium have combined to form 1:1 lattice clays of the kaolinite type, with a low capacity for holding nutrients. Resistant minerals, particularly quartz, remain in the soil to dominate the sand fraction, while excess iron and aluminium tend to combine in insoluble mineral forms. Aluminium may also enter the soil exchange complex, where it has a deleterious affect on the soil water and nutrient balances. In general the dark coloured basic rocks in Sierra Leone - schists, amphibolites and gabbros - weather to release more iron and aluminium and less quartz than do the light coloured acid granites and gneisses.

Weathering is strongest in the south and west where the rainfall is highest and the slopes relatively more gentle and stable. In these areas deep subsoils with low contents of weatherable minerals predominate. In the drier more steeply sloping areas of the Plateaux weathering is taking place at a slower rate. This, combined with increased rates of erosion, has led to younger, often truncated soils containing weathered rock fragments. In other areas, notably the Bolilands and some of the larger river floodplains, the soils are strongly weathered because the parent material itself has passed through a previous weathering cycle.

Leaching

Mineral bases released by weathering are readily leached from the soil in areas where precipitation for much of the year is far in excess of evaporation. Consequently most of the soils in Sierra Leone are under-saturated with bases and there is a complementary enrichment of iron, aluminium and quartz. There has also been a slight movement of clay down the profile in many of the soils, giving rise to weakly developed argillic horizons, although this is usually difficult to confirm in the field due to termite activity and high gravel contents. In the most permeable soils, iron, aluminium and

organic matter have been leached to form bleached topsoils.

Oxidation and reduction

About 85% of Sierra Leone soils are well drained and contain iron in an oxidised form. However, most of the swamplands are flooded for long periods each year and contain soils which have undergone various stages of reduction. Those that are more or less permanently saturated with water are completely reduced and have grey or neutral colours, while those that are saturated for only part of the year are alternately reduced and oxidised to give a mottling of grey and red colours. When the cycles of wetting and drying are intense, as is the case in Sierra Leone, the concentrations of oxidised iron in subsoil red mottles may start to harden into nodules. This material irreversibly hardens when exposed to air and is known as plinthite. During prolonged cycles of erosion, plinthite becomes transformed into indurated ironstone gravel, which is a characteristic feature of many Sierra Leone soils.

Organic matter accumulation

From the point of view of agriculture, the presence or absence of appreciable levels of organic matter in the soil is of particular interest. The recycling of nutrients by the incorporation of organic wastes in the topsoil is an important counteraction to the leaching effect of rainfall. Furthermore, organic matter, because of its colloidal nature, donates a significant proportion of the soil exchange complex (CEC). This is particularly the case where clays with low exchange capacity predominate. The existing pattern of bush fallow on uplands to some extent preserves the organic matter content of the topsoil, thus maintaining an equilibrium between human activity and natural soil fertility. However, this system can rapidly breakdown if there is a shortening of the fallow period due to increased pressure on the land, a fact that has important implications if an intensification of agricultural activities is to be considered.

In contrast to the uplands, the swamps generally have rather high organic matter levels. This is partly due to the slow rate of decomposition of plant material in the swamps and also because of preference by local farmers for the upland cultivation of rice, thereby leaving a high proportion of the swamps under natural vegetation.

Animal activity

Soil fauna, particularly termites, play an important role in soil development in Sierra Leone. *Macrotermes spp* collect gravel free material from the subsoil for the construction of their mounds. During its period of habitation, the mound tends to become enriched with bases compared with the surrounding subsoil, leading to a corresponding increase in pH and CEC (Miedema and van Vuure, 1977). When the termites desert the mound this material erodes and spreads over the ground surface, leading to a gravel free top layer which, initially at least, is relatively fertile.

Non mound-building species of termite also inhabit Sierra Leone soils and these, together with other insects such as ants, contribute significantly to the incorporation of organic material into the soil and to the development of soil structure and porosity. In the moister valley sites, earthworms are very active and play a similar role.

SOIL MAPPING AND CORRELATION

Prior to the setting up of the Land Resources Survey Project in 1975 a total of 97 soil families and series had already been established in Sierra Leone, (Odell *et al* 1974). These were mapped in 16 soil provinces according physiography, parent material and drainage. Those families and series for which detailed analytical data were available, about one third of the total, were correlated with three international systems, namely: the USDA Soil Taxonomy, the FAO/UNESCO world soil map legend and the French system.

It was beyond the scope of the present study to define new soil series or families in hitherto unsurveyed parts of the country. Nor was it possible in the time availabl to develop a full taxonomic framework for soil classification and mapping, suitable for local conditions. Nevertheless it was considered desirable to update the existing small scale soil province map of Odell *et al*, using as a basis the land system breakdown and the results of countr wide field observations. However, the production of a soil map at 1:2 000 000 scale, in addition to that of land systems at 1:500 000 scale, could only be justified if its legend was based predominantly on soil, rather than physiographic, criteria. When selecting suitable units for use in the soil map legend a number of factors were relevant:

a) Sierra Leone lacks a local hierarchic soil classification framework suitable for soil mapping at a variety of scales.

b) The use of the USDA soil taxonomy for mapping and classification purposes in Sierra Leone is unsatisfactory since many of the soils are near the boundary between oxisols and ultisols or ultisols and cambisols. The oxisols and ultisols are difficult to distinguish because, although most of the soils are highly weathered and have oxic properties, many appear also to have an argillic horizon which can normally only be identified under the microscope. Similarly, lack of data on the quantity and composition of weatherable minerals makes the distinction between oxisols and cambisols difficult. The FAO/UNESCO map legend, based on similar diagnostic criteria, has the same deficiencies.

c) Because of the generalised nature of the survey and the resulting small scale of mapping, the legend units had to be broad. In view of b) above, it was desirable that they should reflect those local soil attributes which have an important bearing on land suitability and which can be easily and consistently measured in the field. In this respect the quantity and type of gravel in the upland soils and the degree of hydromorphism in the valley bottom soils are considered to be

of prime significance, at least for land evaluation purposes if not from a purely soil classification viewpoint.

The soil map (Fig 12) depicts 12 soil associations which are described in the legend in terms of dominant soil types. Soils occupying less than 20 per cent of the association are not listed but are discussed below. In order that the map may have more than purely local significance, Table 10 gives a correlation of the main soil types with three international systems.

SOIL DISTRIBUTION

In the following paragraphs the main characteristics of 12 associations are outlined, while correlations with established soil series are given in brackets. Table 11 summarises the properties of the principal soil types for which analytical data are available. For more detailed descriptions of the soils of each of the land facets reference should be made to the land system tables in Part 6 of this report.

Association 1 *Weakly developed muds and hydromorphic clays*

This association covers an area of 2 347 km^2, on the estuarine swamps along the coast. The soils are poorly drained and differ in morphology according to the extent of tidal flooding.

Weakly developed muds subjected to daily flooding by brackish sea water are dominant (Rokupr series). In the rainy season the effects of brackish water incursions are lessened by the heavy discharge of fresh runoff water. As a consequence the salt content of the soil varies during the year so that the EC ranges from 1 or 2 mmhos/cm in the wet season to up to 30 mmhos/cm in the dry season (WARDA, 1977).

The natural fertility of the muds is quite high, with organic carbon contents in the 2 - 6% range, a CEC of between 8 and 20 meq % and relatively high levels of bases, particularly K.

In their natural state the muds are completely reduced and concentrations of sulphur compounds from sea water remain in the sulphide form to give a pH in the neutral range. When drained however, the sulphides oxidise to sulphates and sulphuric acid forms, giving a drop in pH of 2 or 3 units, at which stage the soils are termed "cat clays". At the same time phosphorus becomes tied up with unavailable forms of iron and manganese, and the intense acidity liberates aluminium. The fertility relationships of these soils, with particular reference to rice growing, has been the subject of intensive studies, (Hart, 1959, Tomlinson, 1957b , Jeffrey, 1960 and 1963, Hesse, 1961b, 1962 and 1963) to which the reader is referred for more detailed information.

In association with the muds, on slightly elevated areas which are not tidally flooded, hydromorphic clays occur which have already undergone a degree of acidification. These soils have a thin organic topsoil overlying a very impermeable gleyed subsoil. The pH is usually below 5 and levels of plant nutrients are low.

Inclusions in this association comprise variably textured undifferentiated hydromorphic soils of the fresh water floodplains and saline soils developed along the swamp margins.

Association 2
Undeveloped to weakly developed sands

This association occurs on the coastal beach ridges and covers an area of 1 433 km^2. The soils are sandy, highly permeable and very low in plant nutrients.

Undeveloped sands are dominant on the younger beach ridges (Sahama series). A thin organic topsoil is present (<1% organic carbon) over uniform bleached coarse sand. The CEC is usually less than 3 meq % and levels of bases so low that the exchange complex is less than 50% saturated.

Soils on the older beach ridges exhibit a greater degree of profile development, either due to the leaching of iron and organic matter down the profile (Gbamani series) or through the segregation of iron compounds in the subsoil as a result of a fluctuating water table (Hahun series). The levels of topsoil organic matter may be locally higher, particularly in the swales, but the overall fertility of the soils is still extremely low. Inclusions of poorly drained sands occur in the swales (Mani series).

Association 3
Hydromorphic clays and gravel free ferralitic soils

The riverain grassland plains along the coast of Sierra Leone are characterised by an association of soils formed on highly weathered river alluvium, covering 1 404 km^2.

Poorly drained clays are dominant and are typical of the lower lying sites subjected to prolonged wet season flooding (Torma Bum & Gbehan series). Although organic matter levels tend to be high in the surface horizons (2 to 5% organic carbon) to depths of about 30 cm, subsoil fertility is rather low. The CEC is normally between 10 and 20 meq % and percent base saturation is less than 50. The clays are strongly acid with a pH in the range 4.5 to 5.0.

Higher lying backplains and levees are characterised by well drained to imperfectly drained gravel free ferralitic soils with less organic matter and a rather poor nutrient status (Taso series). Locally the better drained soils are highly leached and have a very unfavourable nutrient status.

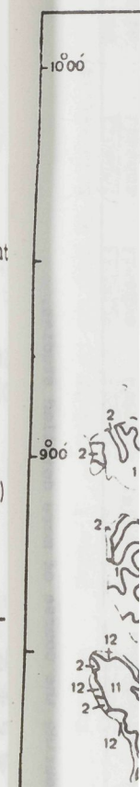
Included in this association are strongly weathered ferralitic soils which occur on the higher terraces (Bali series).

Association 4
Gravel free ferralitic soils

This association of predominantly gravel free soils occurs on the coastal terraces and extends over 5 159 km^2.

The interfluves are characterised by deep, well drained, strongly weathered, yellowish brown sandy loams to sandy clay loams (Newton series). Clay content gradually increases with depth and averages about 30% in the subsoil. The soils are strongly acid with a CEC of between 5 and 10 meq % and a low base saturation (<20%).

Fig. 12



Map Symbol | Soil
1 | Weakly morphi estua
2 | Undeve sands
3 | Hydrom ferral plains
4 | Gravel coasta
5 | Gravel hydrom terrace
6 | Very gr colluvi plains
7 | Gravell weather colluvi interio

Fig. 12 Soil associations



Cartographic Section 1979

Map Symbol	Soil Association	Land System(s)	Area (Km^2)	Map Symbol	Soil Association	Land System(s)	Area (Km^2)
1	Weakly developed muds and hydromorphic clays along coastal river estuaries	1,2	2347	8	Gravelly nodular ferralitic soils over weathered granitic basement on northern interior and plateau plains	14,19,22 25,29,30	5486
2	Undeveloped to weakly developed sands on coastal beach plains	3,4,5	1433	9	Stony and gravelly ferralitic soils over weathered granitic basement or colluvial gravel on low to moderate relief hills	23,31,32 33,34,40	10267
3	Hydromorphic clays and gravel free ferralitic soils on coastal floodplains	6	1404				
4	Gravel free ferralitic soils on coastal terraces	7	5159	10	Stony and gravelly ferralitic soils with shallow soils on moderate to high relief hills formed from predominantly acid rocks	35,41,42 43	9899
5	Gravelly ferralitic and plinthic hydromorphic soils on inland terraces, depressions and floodplains	9,10,11	3136				
6	Very gravelly ferralitic soils over colluvial gravel on western interior plains	12,13,16 17,20,21 24	12647	11	Very gravelly ferralitic soils with shallow soils on moderate to high relief hills formed from basic and ultrabasic rocks	36,38,39	2084
7	Gravelly ferralitic soils over weathered granitic basement or colluvial gravel on southern interior and plateau plains	15,18,26 27,28	16965	12	Shallow soils on plateau mountains and lateritic hills and terraces	8,37,44	1499

Table 10 - Correlation of the main soil types with units of the USDA, FAO/UNESCO and French systems and with selected soil families and series

Soil type	*Main occurrence (map unit)*	*USDA Soil Taxonomy*	*FAO/UNESCO World soil map legend*	*French classification system*	*Soil family/series (1)*
Weakly developed muds	1	Typic Sulphaquents	Thionic Fluvisols	Sols minéraux bruts d'apport marin	Rokupr
Hydromorphic clays	3	Ochraquox, Umbraquox, Tropaquept	Dystric or Humic Gleysols	Sols hydromorphes minéraux à gley de surface	Gbehan, Torma Bum, Sangama
Hydromorphic soils with plinthite	5	Plinthic Tropaquepts, Plinthic Paleaquults	Plinthic Acrisols, Plinthic Gleysols	Sols hydromorphes minéraux à gley de surface	Mankane, Pelewahun, Taiama, Massimo, Rokel, Kontobe
Undifferentiated hydromorphic soils	As inclusions in 4-12	Typic Psammaquents, Typic Fluvaquents, Typic or Plinthic Tropaquepts	Dystric or Humic Gleysols, Dystric or Gleyic Cambisols	Sols hydromorphes minéraux à gley de surface au profondeur	Keya, Panlap, Khifa*
Undeveloped to weakly developed sands	2	Typic Quartzipsamments, Tropohumods	Dystric Regosols, Humic Podzols	Sols peu évolués non climatiques d'apport-iso-humiques, podzols humo-ferrugineux	Sahama, Gbamani
Moderately weathered alluvial soils	As inclusions in 6-12	Aquic Fluventic Dystro-pepts, Oxic Dystropepts	Ferralic or Gleyic Gambisols	Sols ferrallitiques moyennement désaturés en B pénévolués hydromorphes	Moa, Mongo*, Falaba*
Gravel free ferralitic soils	4 & as inclusions in 5-10	Umbriorthox, Haplorthox, Paleudults, Palehumults	Humic or Xanthic Ferralsols, Humic or Ferric Acrisols	Sols ferrallitiques fortement désaturés en B	Benikoro*, Masheka, Masuba, Kania, Taso, Nyawama, Newton*, Mabang
Slightly gravelly ferralitic soils	4 & 7-12	Paleudults, Palehumults, Haplorthox, Dystropepts	Humic or Ferric Acrisols, Orthic Ferralsols, Ferralic Cambisols	Sols ferrallitiques fortement désaturés en B	Baoma, Bonjema, Bosor, Gbindi* Koinadugu* Mabassia, Mankahun, Segbwema, Tubum
Very gravelly ferralitic soils	6-9,11	Paleudults, Palehumults, Umbriorthox, Haplorthox	Humic or Ferric Acrisols, Orthic or Humic Ferralsols (petric phases)	Sols ferrallitiques fortement désaturés en B	Batkanu, Gbentu* Makonte, Makeni, Manowa, Yisimaia*
Stony and very gravelly ferralitic soils	9-12	Typic Dystropepts	Dystric or Ferralic Cambisols (petric phases)	Sols ferrallitiques moyennement désaturés en B	Yagala*
Shallow soils	10-12	Lithic Dystropepts	Lithosols and Ferralic Cambisols (lithic phases)		Vaahun, Wara-Wara*

(1) For detailed descriptions see Odell et al (1974)

* Soil families provisionally established by the Land Resources Survey Project during the course of more detailed studies.

Table 11 - Summary of soil properties

Soil type and occurrence	*Estimated proportion of association(%)*	*Munsell colour of subsoil (1)*	*Subsoil drainage*	*Texture topsoil(2)*	*subsoil*	*Topsoil organic carbon(%)*	*pH(1:1H$_2$0) topsoil*	*subsoil*	*CEC(Meq %) topsoil*	*subsoil*	*Base sat.(%) topsoil*	*subsoil*	*No. of sites*

(1) For detailed descriptions see Odell et al (1974)

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Association 1									
Weakly developed muds on tidal flats	50	N3	Water-logged	SiC-C / SiC-C	4.0	5.2 / 2.8 (3)	14.6 / 16.5	42 / 53	2
Hydromorphic clays on terraces	30	10YR 5/1, mottled	Very poorly drained	SiL-C / CL-C	2.3	4.6 / 4.5	5.9 / 3.1	31 / 55	1
Association 2									
Undeveloped to weakly developed sands on recent and old beach ridges	80	10YR 6/1-2.5Y 5/6	Excessively well drained	S-CoS / S-CoS	0.9	5.3 / 4.8	2.3 / 3.5	46 / 10	2
Association 3									
Hydromorphic clays on backplains, back-swamps and alluvial flats	50	10YR 6/2-2.5Y 7/2, mottled	Poorly drained to very poorly drained	L-CL / C	3.2	4.6 / 4.8	22.0 / 12.0	13 / -	5
Gravel free ferralitic soils on levees and terraces	45	10YR 6/4, locally mottled	Well drained to imperfect-ly drained	SCL-CL / SCL-C	2.7	5.4 / 5.2	17.0 / 9.4	12 / -	4
Association 4									
Gravel free ferralitic soils on interfluves	80	10YR 5/4-7.5YR 5/6	Well drained	LS-SL / SCL	2.6	5.1 / 5.1	9.8 / 3.5	17 / -	8
Undifferentiated hydromorphic soils in valley swamps and on minor floodplains	13	10YR 4/1-6/1, generally mottled	Poorly drained to waterlogged	LS-SL / SL-SC	4.5	5.0 / 5.1	17.8 / 8.3	7 / 8	2
Association 5									
Very gravelly ferralitic soils over collu-vial gravel on rises and high terraces	35	7.5YR 5/6-5YR 5/6	Well drained	SL-gL / vgSCL-vgSC	2.3	4.8 / 5.3	4.0 / 4.2	18 / 16	2
Gravel free ferralitic soils over gravel on high terraces	25	10YR 5/4-7.5YR 5/6	Well drained to imperfectly drained	SL-L / gSCL-gSC	2.1	5.2 / 5.2	6.1 / 5.4	18 / 19	9
Gravel free ferralitic soils with subsoil plinthite on levees and low terraces	20	10YR 6/4-7.5YR 5/6	Well drained to imperfectly drained	SL-SiL / SCL-SiCL	3.3	4.8 / 5.3	16.4 / 8.9	12 / 14	4
Hydromorphic soils with subsoil plinthite in drainage depressions and on floodplains	20	10YR 5/2-5/6, mottled	Poorly drained to waterlogged	LS-SCL / SCL-SC	1.2	4.7 / 4.8	4.0 / 6.0	19 / 24	7

Table 11 (Continued)

Association 6									
Very gravelly ferralitic soils over colluvial gravel on interfluves	70	7.5YR 5/6-5YR 5/8	Well drained	SL-vgL / vgCL-vgC	2.3	5.2 / 5.4	12.5 / 7.3	18 / 17	15
Gravel free ferralitic soils on footslopes, terraces and locally on interfluves	18	10YR 6/6-7.5YR 5/8	Well drained	SL-SCL / SCL-SC	2.0	4.7 / 4.9	6.8 / 4.7	17 / 9	6
Undifferentiated hydromorphic soils in valley swamps and drainage depressions	10	10YR 4/2-7/1, generally mottled	Poorly drained to waterlogged	Variable / Variable	2.2	5.8 / 5.3	8 / -	19 / -	45
Moderately weathered alluvial soils on minor floodplains	2	10YR 6/6-7.5YR 5/6, locally mottled	Well drained to locally imperfectly drained	L-SCL / SCL-C	2.7	5.2 / 5.4	18.0 / 8.7	18 / 14	4
Association 7									
Very gravelly ferralitic soils over colluvial and residual gravel on interfluves	60	7.5YR 5/6-5YR 5/6	Well drained	SL-gSCL / vgSCL-vgSC	2.5	5.0 / 5.0	9.5 / 7.5	25 / 15	13
Slightly gravelly ferralitic soils over weathered bedrock, on isolated hills and locally on interfluves	15	7.5YR 5/6-2.5YR 4/6	Well drained	SL-SCL / gSCL	2.0	5.3 / 5.2	8.3 / 5.1	24 / 15	8
Undifferentiated hydromorphic soils in valley swamps	14	10YR 4/1-2.5Y 6/2, generally mottled	Poorly drained to waterlogged	variable / variable	2.9	5.1 / -	13.6 / 6.1	26 / -	4
Gravel free ferralitic soils on footslopes, terraces and locally on interfluves	5	10YR 5/6-6/8	Well drained to imperfectly drained	SL-SCL / SCL-SC	1.8	5.1 / 4.8	8.4 / 5.4	16 / 14	7
Association 8									
Slightly gravelly ferralitic soils over weathered bedrock, on interfluves and locally on footslopes and terraces	45	7.5YR 4/4-5YR 5/6	Well drained	SL-CoSCL / gCoSCL	2.0	4.9 / 4.8	7.9 / 4.2	21 / 21	15
Very gravelly ferralitic soils over weathered bedrock, on interfluves and locally on footslopes and terraces	30	7.5YR 5/6-5YR 5/6	Well drained	gSL-gSCL / vgCL-gSC	-	5.0 / 5.2	8.7 / 6.4	16 / 17	10
Gravel free ferralitic soils on footslopes and terraces and locally on interfluves and major floodplains	10	10YR 5/4-7.5YR 5/6	Well drained	SL / SCL	-	4.5 / 4.5	7.8 / 4.6	19 / 21	4
Undifferentiated hydromorphic soils on floodplains and in valley swamps	10	10YR 4/1-5Y 7/1, generally mottled	Poorly drained	variable / variable	2.1	4.8 / 5.0	12.2 / 7.0	-	14
Moderately weathered alluvial soils on floodplains	5	10YR 5/2-7.5YR 5/6,	Well drained to	SL-SiL / SiCL-C	3.4	4.7 / [illegible]	19.3 / [illegible]	-	12

Table 11 (Continued)

Association 9

Moderately weathered alluvial soils on floodplains	5	mottled 10YR 5/2-7.5YR 5/6,	Well drained to	SL-SiL	3.4	4.7	19.3	-	12

Table 11 (Continued)

Association 9									
Stony and very gravelly ferralitic soils over weathered bedrock or colluvial gravel on hillslopes, hillcrests and footslopes	70	7.5YR 4/6-2.5YR 4/4	Well drained	SL-gCL / stvgCL-gC	1.7	5.1 / 5.1	8.2 / 3.4	25 / 14	12
Slightly gravelly ferralitic soils over weathered bedrock on hillslopes and footslopes	20	7.5YR 5/6-5YR 5/6	Well drained	SL-SCL / gCoSCL-gC	2.4	5.4 / 5.1	13.8 / 6.2	28 / -	3
Moderately weathered alluvial soils on floodplains	5	10YR 7/1-7.5YR 4/4, usually mottled	Well drained to imperfectly drained	SL-CL / variable	2.0	4.9 / 5.1	10.8 / -	10 / 15	4
Undifferentiated hydromorphic soils on floodplains and in valley swamps	5	10YR 4/1-2.5Y 6/2, generally mottled	Poorly drained	variable / variable	3.0	4.0 / 4.3	15.7 / 23.2	16 / 24	4
Association 10									
Stony and very gravelly ferralitic soils over weathered granitic basement on hillslopes	55	7.5YR 4/4-5YR 3/4	Well drained	SL-gCL / StvgCL-gC	2.7	6.0 / 5.7	10.7 / 8.1	9 / 10	3
Slightly gravelly ferralitic soils over weathered granitic basement on steep hillslopes	15	7.5YR 5/6-5YR 3/4	Well drained	SL-SCL / gCoSCL-gC	2.4	5.4 / 4.9	13.7 / 7.3	25 / 17	7
Association 11									
Very gravelly ferralitic soils over colluvial gravel or weathering bedrock on hillslopes and footslopes	70	7.5YR 5/6-2.5YR 4/4	Well drained	gL-vgCL / vgCL-vgC	1.5	5.4 / 4.8	12.1 / 8.6	29 / 16	10
Association 12									
No data									

Footnotes

(1) Indicative of drainage condition
(2) Defined here as any humic horizon above 50cm
(3) Analysed after drying

NB Only those soils for which reasonably reliable analytical data are available are listed.

Texture symbols

C	-	clay	g	-	gravelly
L	-	loam	vg	-	very gravelly
S	-	sand(y)	st	-	stony
Si	-	silt(y)	Co	-	coarse

denotes incomplete data

Inclusions comprise very strongly weathered, gravel free soils locally on the interfluves, with a CEC of less than 5 meq % and a strongly acid reaction (pH about 4.5), very gravelly soils locally on the steeper slopes and variably textured, undifferentiated hydromorphic soils in the valley swamps. The swamps have higher topsoil levels of organic matter than the uplands (2-12% organic carbon) which in turn give a higher CEC to the surface soil layers. However, nutrient levels in the swamps are very low and the exchange complex is less than 10% saturated.

Association 5
Gravelly ferralitic and plinthic hydromorphic soils

The Bolilands have a complex association of soils ranging from free draining gravels on the higher lying areas to poorly drained clays in the seasonally flooded depressions (bolis). The area covered is 3 136 km^2.

Very gravelly ferralitic loams to clays (30-80% ironstone gravel throughout) dominate the rises and also occur on the higher parts of the terraces (Batkanu series). These pass laterally into sandy loams to sandy clay loams which are gravel free to between 30 and 100 cm but have very gravelly subsoils (Mankahun series).

On the lower terraces and levees well drained to imperfectly drained gravel free, ferralitic soils with subsoil plinthite occur (Mabang series). In the lowest lying areas of the backplains and drainage depressions hydromorphic soils predominate. Coarse to medium textured topsoils overlie, at relatively shallow depths, strongly gleyed clays with hardening plinthite (Rokel, Kontobe and Massimo series). Soil drainage in these areas is generally poor, but may be locally imperfect.

Drainage variations within the Bolilands are reflected in soil colour which ranges from reddish to brownish on the rises, through yellowish on the terraces, to greyish in the depressions.

Although soil fertility is generally very low, the terrace soils appear to have higher than average fertility. The rather low levels of organic matter in the more poorly drained soils of the depressions are possibly due to the fairly intensive rice cultivation which is carried out there.

Association 6
Very gravelly ferralitic soils

This association of very gravelly soils occurs along the western edge of the Interior Plains on predominantly basic rocks which have weathered to produce a deep mantle of colluvial ironstone gravel. It extends over 12 647 km^2

The dominant soils, occurring over 70% of the area on the elevated interfluves, are ferralitic and contain between 50 and 80% densely packed detrital gravel, with or without a thin gravel free topsoil (Njala series). Gravel free ferralitic soils are only locally present on the broader interfluve crests and plateaux surfaces but are dominant on the footslopes and terraces and major floodplains, where plinthite often occurs at depth (Bonjema, Nyawama and Kania series).

Well drained to imperfectly drained, moderately weathered alluvial soils occur adjacent to minor streams, while the swamps and lower lying parts of the floodplains contain undifferentiated hydromorphic soils of variable texture.

Soil fertility in this association is generally low, although the gravels appear to have a slightly higher nutrient status than the upland soils of either the coastal terraces or the Bolilands. The gravel free footslope and terrace soils have a very low fertility however; they are strongly acid and have a CEC of less than 10 meq which is only 10% saturated. The minor floodplain soils are the most fertile, especially in their surface layers, whereas the swamp soils, from the data available, appear to have a lower nutrient status than elsewhere.

Associati
Gravelly
ferraliti

Association 7
Gravelly ferralitic soils

The moister southern parts of the interior and plateaux plains are characterised by an association of gravelly ferralitic soils which have developed over weathered granitic basement. The association extends over 16 965 km^2.

The dominant soils are well drained, reddish to yellowish sandy clay loams to sandy clays, containing high proportions (50-80%) of densely packed, colluvial ironstone gravel (Manowa family). These occur on the interfluves. In the southeast of the country, very gravelly soils are reported to cover between 90 and 95 per cent of the interfluves, (Stark, 1968), although for the association as a whole the proportion is estimated to be about 60 per cent. On the more level interfluve crests a thin gravel free topsoil is normally present, while on the slopes sheet erosion has exposed gravel at the surface. Generally the gravel content decreases with depth, where colluvial gravel is replaced by softer residual gravel overlying weathered bedrock.

Slightly gravelly and gravel free ferralitic soils occur as inclusions in this association. The former have gravel contents of between 10 and 50 percent and occur on the slopes of isolated hills and locally on the interfluves, especially on the concave lower slopes. They have a higher proportion of residual ironstone gravel than the very gravelly soils and often contain fragments of weathered bedrock in the subsoil. On the steeper slopes the soils are reddish and have truncated profiles with gravel in the upper layers (Segbwema family), while on the concave slopes variable depths of yellowish, gravel free, colluvial material occur over gravel (Tubum, Bosor and Mabassia series). Yellowish gravel free soils occur on the footslopes and terraces and usually contain hardening mottles in the subsoil (Pendembu family and Masuba series). Other inclusions comprise moderately weathered alluvial silty clays on major river floodplains, (Moa family) variably textured undifferentiated hydromorphic soils in valley swamps (Keya family) and shallow soils on isolated hills (Vaahun family).

Associati
Stony and
gravelly
soils

Soil fertility in this association is low. The ferralitic upland soils have a CEC of between 5 and 10 meq % and are strongly acid. Soils on the steep slopes are

reported to be slightly more fertile (Dijkerman, 1969) due to the presence of weatherable minerals, while the gravel free footslope and terrace soils appear to be appreciably lower in plant nutrients. The floodplain and swamp soils have a relatively high fertility in the topsoil due to high levels of organic matter, while the subsoils are rather infertile.

Association 8
Gravelly nodular ferralitic soils

This association occurs on the drier northern interior and plateaux plains and extends over 5 486 km^2. Provisional findings of a recent survey carried out in part of Koinadugu district (LRSP, 1979b) indicate that the association comprises a variety of ferralitic soils with reddish and yellowish subsoil mottles hardening into iron rich nodules.

Slightly gravelly soils, occuring on interfluves, are dominant (Gbindi family). The gravel - a mixture of detrital and residual ironstone, quartz and weathering gneiss - usually occurs in the upper parts of the soil profile, often in thin layers. The subsoil is generally gravel free. On the steeper side slopes, soils with over 50% ironstone gravel are common and where sheet erosion is severe, gravel has become exposed on the ground surface. ((Gbentu family). These soil families have gritty subsoils, with high contents of fine angular quartz gravel and coarse quartz sand derived from the weathering of the granitic basement rocks. Nodules are forming in situ as a result of seasonal fluctuations in the water table and in places these have become hardened and form a continuous indurated layer.

Gravel free ferralitic soils occur as inclusions in this association on terraces where they are brownish and medium textured and locally on interfluves where they are reddish and gritty. (Benikoro family). Silty ferralitic soils with strongly mottled nodular subsoils are found on the older alluvial terraces (Musaia family) adjacent to major rivers. On the younger floodplains moderately weathered, well drained to imperfectly drained, alluvial soils occur (Mongo and Falaba families). The valley swamps are characterised by poorly drained loams to clays (Khifa family)and locally by sandy or organic soils.

The fertility of this association is generally similar to that of association 7. The upland soils are strongly acid and leached of nutrients. However, because of the savanna vegetation and repeated burning, organic matter levels are slightly lower and there is a corresponding decline in topsoil CEC. The floodplain and swamp soils with high levels of organic matter are more fertile than those of the uplands.

Association 9
Stony and gravelly ferralitic soils

This association, occurs on low to moderate hills in the plateaux region areas and extends over 10 267 km^2. The hills are typified by moderately sloping, often rocky slopes which locally steepen and rise to broad, gravel covered crests. Footslopes and floodplains/ swamps comprise respectively 40 and 10 per cent of the landscape. Terraces are rather rare.

Ferralitic soils containing varying amounts of gravel and stones are dominant in this association. Erosion is common on steep slopes leading to truncated topsoils low in organic matter.

Soils with high contents of colluvial ironstone gravel and stones occur on broad hill crests, footslopes and locally on hillslopes (Yisimaia family). In the more rocky areas, soils contain residual ironstone and granite gravel over weathered bedrock at variable depth (Yagala family). On the steepest slopes deep, red soils with lower gravel contents occur (Koinadugu family). The valley swamps have variably textured, poorly drained, undifferentiated hydromorphic soils, while better drained moderately weathered alluvial loams to clays occur on the floodplains.

The fertility of the upland soils is low although, where weathering bedrock occurs at shallow depth, nutrient levels, especially K, tend to be slightly higher.

Association 10
Stony and gravelly ferralitic soils with shallow soils

This association occurs on the rocky, predominantly granitic, moderate to high relief hills and covers 9 899 km^2. It is similar to association 9 except that the proportion of very gravelly soils is lower, while shallow soils (<50 cm to weathering bedrock) comprise an estimated 25% of the association. The proportion of swamp and floodplain soils is estimated at about 5%.

Association 11
Very gravelly ferralitic soils with shallow soils

This association occurs on the moderate to high relief hills formed from basic and ultrabasic rocks and covers 2 084 km^2. Soils containing over 50% densely packed detrital ironstone gravel and rich in iron are dominant. On the more gentle slopes this gravel is exposed on the ground surface together with scattered laterite boulders. On the steeper slopes erosion has exposed bedrock and stony shallow soils become common. Shallow soils are also common on the broader footslopes where laterite sheets occur on the ground surface. Pockets of deeper, less gravelly soils containing fragments of weathering rock are locally present. In the broader valleys, floodplain and swamp soils are found but comprise only 1-2% of the association. The fertility of the slope soils is generally low, although the floodplain soils appear to be rather fertile.

Association 12
Shallow soils

This association occurs over an area of 1 499 km^2 on the rocky high relief granitic mountains and on laterite covered hills and terraces. Shallow soils are dominant, although pockets of deeper soils are locally present.

SOIL CHARACTERISTICS IN RELATION TO LAND SUITABILITY

The poor physical and chemical condition of most of the soils in Sierra Leone, particularly those of the uplands, is the major factor limiting the suitability of land in the country. The main soil characteristics in this respect are discussed below.

Texture

Most of the upland soils are medium to heavy textured with clay contents, which gradually increase with depth, in the range 20 to 50 per cent. Sandy surface horizons are only locally present, while soils which are sandy throughout are restricted to the coastal beach ridges. However, gravel of one kind or another is present in an estimated 95 per cent of upland soils and in about a third of these it comprises between 50 and 80 per cent of the soil mass. For any given volume of soil, a high content of gravel reduces the volume of the fine earth fraction, thereby limiting the capacity of the soil to hold moisture and nutrients. In addition gravel, if present on the surface, inhibits seed germination and it can also restrict the rooting capacity of crops, particularly if it occurs in a compacted form in the subsoil. The valley bottom soils have more favourable textural characteristics than the upland soils, being generally gravel free and higher in clay and silt content. Locally however, sandy soils occur in the swamps and these drain rather rapidly and do not hold plant nutrients well.

Structure and consistence

Soil structure is generally weak and, in the uplands, is combined with a high degree of friability. The friable consistence of the upland soils is beneficial for drainage and root penetration and serves to lower the erosion hazard on cultivated slopes. The rather compacted gravelly subsoils common in many areas inhibit crop rooting depth.

Drainage

Well drained upland soils account for about 80 per cent of the total. The remainder are saturated to a greater or lesser extent for long periods during the rainy season. An estimated 5 per cent of soils, mainly in the estuarine and valley swamps, are continuously waterlogged. Drainage has an important influence on the suitability of land for agriculture since few crops are adapted to anaerobic soil conditions (Table 12).

Available water capacity

Soil AWC affects the length of dry season moisture stress, as already discussed in Part 2. In general the upland soils have a low AWC, in the range 5 to 15% by volume, due to high contents of gravel, low levels of organic matter and only moderate amounts of clay. These figures correspond to an extension of the growing period beyond the end of the rains of about 15 to 45 days respectively. In the most gravelly soils and the beach sands the AWC is less than 5%. The heavier textured swamp soils have an AWC of between 15 and 30%, while in the sandier swamp soils it is less than 10%.

Organic matter and nitrogen

The level of organic matter in soils has an important influence on crop growth through a) its high capacity for holding plant nutrients and b) its breakdown through microbial activity to release nitrogen. Thus soils with high levels of organic matter can be considered to be appreciably more fertile than soils with little organic matter.

Topsoil organic carbon levels in the upland soils are generally low, varying between less than 1% in soils under annually burnt savanna in the north and 2 to 4% in soils under secondary regrowth or forest in the south. The topsoil is normally less than 30 cm deep and organic carbon levels decrease sharply below this. Nitrogen levels are correspondingly low and the C/N ration is in the range 7 to 13, indicating a rapid breakdown of organic matter in the humid climate.

The seasonally flooded valley bottom soils have relatively high organic matter contents in the range 3 to 10%. In the estuarine muds organic matter is distributed fairly evenly through the profile; in most of the swamp and the floodplain soils it is concentrated in the surface layers. The Boliland soils have rather low levels of organic matter with only 1 to 2% organic carbon in the topsoil. In general the swamps have higher nitrogen levels than the uplands, while the slower rate of breakdown of organic matter is reflected in higher C/N ratios.

Soil reaction

Many crops grow best at weakly acid to neutral pH, since extremes of acidity or alkalinity inhibit the uptake of certain nutrients. However, the majority of crops are adapted to a range of soil pH, while some are tolerant of extreme conditions (Table 12). Most of the soils in Sierra Leone are strongly acid, with a pH below 5.5. In some of the poorly drained soils, particularly those of the Bolilands, the pH falls to 4.5. In the coastal mangrove areas the soils are neutral to slightly alkaline when waterlogged by saline or brackish water but, as already discussed, become extremely acid when drained. Soils affected by recent burning are also neutral to alkaline for short periods, due to the rapid release of bases from combusted plant residues.

Salinity

High levels of soluble salts in the soil profile are restricted to the tidally flooded mangrove areas along the coast. Since these soils are continuously waterlogged, salinity affects land suitability only in as much as it restricts the cropping of paddy rice to the rainy season.

Exchange complex

The ability of a soil to retain plant nutrients is reflected in its cation exchange capacity, which itself is a function of soil texture, clay mineral type and organic matter content. Since organic matter has between 8 and 15 times the CEC of the kaolinite clay dominant in Sierra Leone soils, the level of organic matter becomes crucial with respect to soil fertility. Most of the upland soils have very low CEC in the range 5 to 10 meq %.

This falls to below 5 meq % in the sandy, humus poor soils of the beach ridges. The more organic valley bottom soils on the other hand have a rather high topsoil CEC in the range 15 to 25 meq %, although these levels drop sharply in humus-poor subsoils.

Nutrients

The high rate of leaching affecting most soils in Sierra Leone has led to a deficiency in most plant nutrients, while at the same time the rocks are weathering to release large quantities of aluminium. Exchangeable sodium, potassium, magnesium and calcium are generally all at a very low level and the exchange complex is often only about 20% saturated. The total contents of potassium and magnesium are similarly low, in the range 100 to 1500 and 30 to 300 ppm respectively. Phosphorus is deficient, rarely exceeding 20 ppm in its available form and with total contents generally less then 100 ppm. From the few analytical data available, trace element deficiency can be expected in many of the soils, particularly the more acid types. Levels of copper and zinc rarely exceed 100 ppm, while those of manganese are in the 50 to 100 ppm range.

In general, nutrient status is lowest in the soils of associations 2,4 and 5 and in the more weathered gravel free soils of the terraces. The moderately weathered floodplain soils have a relatively high nutrient status. particularly in the drier northern areas. The gravelly upland soils are rather variable in their nutrient contents, although fairly high levels can be expected in those with weathering bedrock in the subsoil.

Iron and alluminium toxicity

The contents of iron and aluminium are high in Sierra Leone soils. Total Fe_2O_3 ranges from 7 to 20 per cent in the well drained soils but falls to between 1 and 8 percent in soils which are saturated for long periods of time (Odell *et al*, 1974). Iron toxicity can occur in the swamps due to the accumulation of iron over long periods in the presence of high levels of easily decomposable organic matter (Moorman, 1977).

Exchangeable aluminium exceeds 1 meq % in many soils and higher levels are reached in those which are highly weathered. Aluminium toxicity to crops can be expected when the pH falls to around 4.5 or if the ratio Ca + Mg to Ca + Mg + Al is below 0.1.

Part 5
LAND EVALUATION METHODOLOGY

THE LAND SYSTEM APPROACH

The technique of using land systems to provide a reconnaissance description and classification of land is based on the concept that units of the natural landscape occur in patterns. These landscape patterns are reflecte in and can be mapped from corresponding patterns on aerial photographs. Each unit has its own characteristic association of features relating to topography, water regime, soils and vegetation within broad climatic types, which govern the optimum use of the land. A grouping of like units will thus bring together areas with similar land suitabilities or potential. The approach was pioneered in Australia just after the Second World War and subsequently applied in a number of different tropical countries by a variety of survey organisations. It was considered that the approach could be successfully applied to reconnaissance resources inventory in Sierra Leone as a basis for the collection of essential terrain and soil data.

A land system is an area with reasonably similar and recurring characteristics of climate, vegetation, geology, topography, soils and land use. The constituent parts of a land system are termed land facets. Land facets are relatively small units of land, reasonably homogeneous in their natural characteristics. When mapping land systems and facets at reconnaissance scale some simplification and consolidation is inevitable. Some land systems such as the Peninsula Mountains near Freetown or the mangrove swamps along the sea coast have well-defined boundaries. However, many others have diffuse boundaries and one system may gradually merge into its neighbour. Although most of the facets can be clearly identified from aerial photographs the morphology of some is masked by dense vegetation or complicated cultivation patterns, giving rise to difficulties in mapping.

The 44 land systems recognized in Sierra Leone have been named after the area where they are best represented. For each land system a representative type pattern area of 16 km^2 was selected for more detailed mapping of facets (Fig 13 and Part 6). The area range of each facet within each system was determined from a combination of:

a) measurements of the type pattern mapping units and

b) estimations of the variation of facet proportions throughout the land systems.

While most of the facets have a simple and unique morphology, about 25% are complex in nature and comprise

two or more simple facets combined. Each land system has between 2 and 8 facets and a total of 58 facets recur throughout the systems.

AERIAL PHOTOGRAPHY

High flight aerial photography at two scales, using two emulsions (1:120 000 scale B & W panchromatic and 1:70 000 scale infra-red colour) were selected as a basis for reconnaissance resources survey in Sierra Leone. The reasons for this decision have been discussed elsewhere FAO/LRSP TR 4 (1979). Ninety nine per cent of Sierra Leone was flown from December 1975 to January 1976; the remainder was completed in January 1978. In addition to this a complete coverage exists of panchromatic B & W 1:40 000 scale imagery, flown in a series of missions between 1951 and 1964.

When selecting the appropriate imagery for the land system mapping programme, several important factors had to be considered:

a) Land system mapping requires the recognition, grouping and classification of complex stereo image keys, necessitating a high reference level for the photo-interpreter.

b) As the reconnaissance survey of the whole country had to be completed in two field seasons, it was imperative that the preparatory land system mapping be completed quickly.

c) The 1:120 000 B & W coverage consists of 350 prints and was approximately half the intended field map scale of 1:250 000. The 1·70 000 IRC coverage comprises over three times as many transparencies.

d) While the 1:120 000 B & W imagery was available as two sets of prints (from one of which an uncontrolled mosaic could be assembled) the 1:70 000 IRC photography was in the form of a unique set of transparencies (funds at the time not being available for prints).

e) The infra-red transparencies were ideal material for the complementary vegetation and land use mapping and survey programme.

f) Whichever of the small scale imagery was chosen for the land system mapping, larger scale photography was necessary for the breakdown of systems into their constituent facets. In the absence at the time of enlargements from the 1975/76 coverage the old 1:40 000 scale photographs were used.

With the above considerations in mind, the 1:120 000 B & W imagery was selected for the land system mapping and the 1:70 000 retained for interpretation of vegetation and land use.

FIELD OBSERVATIONS

The reference units for field observations were the constituent facets of the land systems. Once defined from type patterns, these facets could then be fairly readily identified anywhere within the land system and observed where access was most advantageous.

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During the survey the aim was to make several observations on every facet of every system, so that its range of characteristics could be quantified. In practice, a few inaccessible facets of mountainous systems could not be observed at all, whereas frequent observations were made on accessible facets with a higher potential for agricultural development.

The following parameters were measured at each observation site and recorded on specially designed data sheets.

a) Slope (using an Abney level).

b) Percent rockiness and stoniness (visual estimates).

c) Soil colour, including mottling (using Munsell Colour Chart).

d) Soil texture (estimation of sand, silt and clay proportions by feel and percent gravel content by visual estimation).

e) Soil consistence at field moisture state.

f) Depth and arrangement of soil horizons.

g) Soil reaction of main horizons (using a Truog field kit).

h) Incidence of flooding (from field observations and interviews with farmers).

i) Depth of water table (if within 150 cm).

j) Vegetation or landuse.

All soil observations were made with a soil auger and approximately 340 selected sites were sampled for laboratory analysis. Generally these sites were sampled at 2 or 3 depths, from the surface to below 50 cm.

LAND SUITABILITY EVALUATION

With the publication in 1976 of soils bulletin No 32 "A framweodk for land evaluation" (FAO, 1976a), a major initiative was taken in the establishment of a comprehensive methodology for the evaluation of land for agricultural use. This methodology was further developed in the FAO agroecological zones project, the findings of which for Africa have recently been published (FAO, 1978b). One of the fundamental principles embodied in the framework is that land suitability can only be properly assessed with respect to specified kinds of land use and that this use should be on a sustained basis. Specified use on a sustained basis implies a given crop (or group of crops with very similar requirements and tolerances) grown under a given level of management, without undue environmental degradation.

The method of land suitability evaluation used in this study is a modification of a system devised for Sierra Leone (Bleeker, 1976), based on work carried out in Papua New Guinea (Haantjens, 1969 and Bleeker, 1975). Land evaluation, at reconnaissance scale, has been carried out for eight specific crops, grown under conditions of improved traditional management. Physical land factors

TR1

only have been taken into account, making the study a qualitative one; quantification of the suitability classification through the incorporation of crop yield and economic data will require further studies.

The criteria used in the suitability evaluation are defined and elaborated upon in the following paragraphs. Further details of the land factor classes, the land quality groupings and crop requirements are given in Appendices 2 and 3.

Land factors and land qualities

A land factor (also known as a land characteristic) is an attribute of land which can be measured or estimated. The data collected during the course of this survey were sorted, according to 11 land factors, into 58 classes (see Appendix 2), each factor having between 4 and 6 classes.

A land quality is a complex attribute of land which acts in a distinct manner on the suitability of land for a specific kind of use (FAO, 1976a). The presence or absence of favourable land qualities for a selected crop in any given area determines the area's suitability for that crop. Land qualities influence suitability through the interaction of land factors, either singly or in combination. Five land qualities were used in the assessment and the relationship between land qualities and land factors is indicated below:

Land quality	*Land factors*
Rooting space (r)	Effective soil depth *(d)*
Soil fertility (f)	Nutrient status *(n)* Salinity *(c)* Soil reaction *(a)*
Availability of moisture (m)	Available water capacity *(x)* Climate type *(z)*
Availability of oxygen (o)	Drainage *(w)** Flooding *(fl)** Permeability *(p)**
Resistance to erosion (e)	Slope steepness *(s)* Surface stones and rocks *(y)*

Selection of crops

The number of crops for which suitability was systematically evaluated for all facets and presented in map form was kept at 8 due to time, manpower and budgetary considerations. The crops chosen after consultation with officials of the Planning Unit of the Ministry of Agriculture and Forestry were *cashew, cassava, citrus, coconuts, coffee (robusta) groundnut, maize and paddy rice*. These crops are among those for which government has most interest in expanding production at the present time: further details of the reasons for their selection are given in Appendix 3.

**Also used in the assessment of moisture availability for paddy rice.*

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Management level

The improved traditional level of management was selected for use in the evaluation, since it is this level towards which Government is directing the main thrust of its development efforts in the agricultural sector. Suitability studies at the traditional and intensive management levels were initially considered but later rejected. The first, by definition, precludes any possibility of development and is therefore of little interest to Government while, with a few specific exceptions, the second is not considered attainable in the foreseable future. In such cases, intensive agricultural ventures should be evaluated on an individual basis and will require more detailed comprehensive studies.

When used in this context the term improved traditional management denotes a more advanced form of the present farming system. It is characterised as follows:

a) Permanent cultivation of well defined holdings involving short fallow periods and planted leys.

b) Pure stands of crops grown in rotation, together with perennial tree crops and, possibly, livestock.

c) Use of improved seed, fertilizer, pest and disease control measures, improved hand and animal drawn tools and simple methods of irrigation and flood control.

d) Access to credit facilities, extension advice and effective market organisation.

Improved traditional management does not, in this context, involve fully mechanised forms of cultivation, nor large scale drainage or irrigation works.

Suitability classification

Land suitability evaluation requires the matching of crop requirements with the physical characteristics of land and climate, either measured or inferred. This produces the suitability classification of a given tract of land for a given use (crop and management). Such an exercise is bound to contain an element of subjectivity, particularly when reliable soil-relatable, crop yield data are not available. In addition, small scale variations in soil properties cannot be adequately evaluated at broad reconnaissance level, even though these may have an important influence on crop growth. However, within the limits imposed by scale and available data, every effort was made to put the rating on as sound and scientific basis as possible.

Table 12 gives the method by which the 8 crops used in the evaluation, together with other crops of possible interest to planners, are scored according to their specific requirements and tolerances. The most limiting land factor or factors, with respect to the eleven consider determines the land suitability class. The suitability sub class is determined by the land qualit or qualities causin the limitation.

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Table 12 The rati

LAND QUALITIES	
LAND FACTORS	
LAND FACTOR CLASSES (See appendix 2 for ranges)	
CROPS	
Avocado	
Banana & Plantain	
Beans	
Cashew Nut*	
Cassava* (6)	
Citruses*	
Cocoa **	
Coconut*	
Coffee*	
Cotton	
Forest: Humid	
Dry	
Ginger	
Grasses: Humid, acidic	
Dry, alkaline	
Groundnut* (6)	
Legumes: Pulses**	
Dry cover/forage	
Humid cover/forage	
Maize*	
Millet**	
Oil Palm**	
Pepper, Spice	
Piassava	
Potato, Sweet	
Rice: Upland	
Rice: Lowland*	
Rubber**	
Sesame	
Sorghum**	
Soybean	
Sugar Cane	
Tobacco	
Vegetables (7)	
(8)	
(9)	
Yams	

NOTES

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**Crops whose suitabi

(1) A depth class of for tree crops wh

(2) When using this t should be upgrade fertilizer will b not apply to cash class of 4.

(3) Since the minimum in Sierra Leone i factor class does rating of arable of pests and dise nounced in the mo evaluation of thi reconnaissance le

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Table 12 The rating of selected crops with respect to land factor classes

LAND QUALITIES	Rooting space (r)						Soil fertility (f)							Availability of moisture (m)								Availability of oxygen (o)					Resistance to Erosion (e)										
LAND FACTORS	*Effective Soil Depth* (1)						*Soil Reaction*						*Nutrient Status* (2)						*Soil Salinity*						*Climate Type* (3)						*Available Water Storage capacity*						*Soil Drainage*					*Flooding* (4)					*Soil Permeability*						*Slope Steepness* (5)						*Surface Stones and Rocks*					
	d						*a*						*n*						*c*						*z*						*x*						*w*					*fl*					*p*						*s*						*y*					
LAND FACTOR CLASSES (See appendix 2 for ranges)	Very deep	Deep	Moderately deep	Moderately shallow	Shallow	Very shallow	Extremely acid	Strongly acid	Weakly acid	Neutral	Alkaline		High	Moderate	Low	Very low	Extremely low		Non saline	Weakly saline	Saline	Strongly saline			B	Cl	C2	D1	D2		Very high	High	Moderate	Low	Very low	Extr. low		Well	Imperfect	Poor	Very poor	Water logged		Absent	Short duration	Medium duration	Long duration	Permanent		Very rapid	Rapid	Moderate	Slow	Very slow		Level	Very gentle	Gentle	Moderate	Steep	Very steep		Absent	Slight	Moderate	Pronounced	Very pronounced	Extreme
	0	1	2	3	4	5	1	2	3	4	5		0	1	2	3	4		0	1	2	3			1	2	3	4	5		0	1	2	3	4	5		0	1	2	3	4		0	1	2	3	4	5		1	2	3	4	5		0	1	2	3	4	5		0	1	2	3	4	5
CROPS																																																																									
Avocado	+	+	0	:	x	x	x	-	+	0	:		+	0	-	:	:		+	:	x	x			+	0	-	:	:		+	+	0	-	~	:		+	:	x	x	x		-	0	+	0	:		+	+	0	-	:	x		+	+	0	-	:	x
Banana & Plantain	+	+	+	0	-	x	x	:	+	+	-		+	0	-	:	:		+	0	:	:			+	0	-	:	:		+	+	0	-	:	:		+	0	-	:	x		+	-	x	x	x		-	0	+	0	:		+	+	+	0	x	x
Beans	+	+	+	-	:	x	x	-	0	+	0		+	+	-	-	:		+	-	:	x			-	+	+	-	-		+	+	0	-	:	:		+	0	:	:	x		+	:	x	x	x		-	-	+	0	~		+	+	+	0	x	x
Cashew Nut*	+	+	+	0	x	x	x	0	0	+	0		x	+	0	0	-		+	0	:	x			-	+	0	0	-		+	+	+	0	~	:		+	-	:	:	x		+	:	x	x	x		0	+	+	:	~		+	+	+	0	:	x
Cassava* (6)	+	+	0	-	x	x	-	0	+	0	:		+	+	0	-	:		+	-	:	x			-	+	+	0	0		+	+	+	0	0	:		+	-	:	:	x		+	x	x	x	x		0	+	+	-	:	x		+	+	0	-	:	x
Citruses*	+	+	0	-	x	x	x	:	0	+	0		+	+	-	:	:		+	0	:	x			-	+	+	-	~		+	+	+	0	~	:		+	-	:	:	x		+	x	x	x	x		-	0	+	0	:		+	+	+	0	x	x
Cocoa **	+	+	:	x	x	x	-	0	+	:	x		+	+	:	:	x		+	x	x	x			+	-	:	:	x		+	+	0	-	x	x		+	0	-	:	x		+	-	x	x	x		-	+	+	0	:		+	+	+	-	x	x
Coconut*	+	+	0	:	:	x	-	0	+	+	-		+	+	0	-	-		+	0	:	:			+	0	-	:	:		+	+	0	0	-	-		+	-	:	:	x		+	:	x	x	x		-	+	+	:	:		+	+	0	0	-	:	x
Coffee*	+	+	0	-	x	x	-	0	+	-	x		+	+	-	:	x		+	x	x	x			+	0	:	:	:		+	+	0	0	:	:		+	-	:	:	x		+	x	x	x	x		-	+	+	0	~		+	+	+	0	:	:
Cotton	+	+	0	-	:	x	x	:	0	+	0		+	+	-	:	:		0	+	0	:			:	-	+	0	0		+	+	+	0	-	:		+	0	-	x	x		+	x	x	x	x		0	+	+	-	~		+	+	+	0	x	x
Forest: Humid	+	+	0	0	:	:	+	+	0	-	:		+	+	0	-	:		+	-	x	x			+	+	+	0	-		+	+	+	0	-	:		+	0	:	:	x		+	0	+	0	~		0	+	+	0	-		+	+	+	+	x	-
Dry	+	+	0	0	:	:	x	:	0	+	+		+	+	0	-	:		+	0	-	-			x	-	0	+	0		+	+	+	0	-	-		+	-	:	:	x		+	0	+	0	~		0	+	+	0	-		+	+	+	0	-	:
Ginger	+	+	+	0	-	x	x	0	0	+	-		+	+	0	0	:		+	-	x	x			-	0	+	-	:		+	+	0	0	-	:		+	-	:	x	x		+	x	x	x	x		0	+	+	-	:		+	+	+	0	:	x
Grasses: Humid, acidic	+	+	+	0	0	-	~	+	+	0	:		+	+	0	0	:		+	:	x	x			+	+	0	-	:		+	+	+	0	-	:		+	+	+	-	~		+	0	-	:	:		0	+	+	0	-		+	+	+	0	-	:
Dry, alkaline	+	+	+	0	-	:	x	:	-	+	+		+	+	+	-	:		+	0	0	:			:	+	+	-	-		+	+	+	0	-	:		+	+	0	-	~		+	0	-	:	x		+	0	+	0	-		+	+	+	0	-	:
Groundnut* (6)	+	+	0	0	:	x	x	-	0	+	0		+	+	-	:	x		+	0	:	x			-	0	+	+	+		+	+	0	0	-	:		+	+	0	-	~		+	0	:	x	x		0	+	+	0	-		+	0	0	-	x	x
Legumes: Pulses**	+	+	0	0	-	:	x	:	0	+	+		+	+	-	:	:		+	0	:	x			-	0	+	+	+		+	+	+	0	-	-		+	0	-	:	x		+	x	x	x	x		0	+	+	0	-		+	0	-	:	x	x
Dry cover/forage	+	+	0	-	:	x	x	:	-	+	+		+	+	-	:	:		+	0	0	-			:	+	+	0	-		+	+	+	+	0	-		+	0	-	:	x		+	x	x	x	x		0	+	+	0	-		+	+	+	+	:	-
Humid cover/forage	+	+	+	0	:	:	:	0	+	+	-		+	+	0	:	x		+	x	x	x			-	+	0	+	-		+	+	+	0	0	-		+	+	0	-	:		+	0	-	x	x		+	+	+	0	0		+	+	+	0	0	0
Maize*	+	+	0	0	:	x	x	-	0	+	0		+	+	-	-	:		+	+	-	-			+	+	0	0	-		+	+	+	0	-	-		+	0	:	:	x		+	x	x	x	x		0	+	+	0	-		+	0	0	+	+	x
Millet**	+	+	+	0	-	:	x	-	0	+	0		+	+	0	-	:		+	+	0	-			:	+	+	+	+		+	+	+	+	0	-		+	0	:	:	x		+	x	x	x	x		+	+	+	0	0		+	0	0	:	x	x
Oil Palm**	+	+	+	-	:	x	x	-	+	+	:		+	+	0	:	x		+	0	x	x			+	0	x	x	x		+	+	+	0	-	:		+	0	-	:	x		+	0	:	x	x		-	+	+	0	-		+	+	+	~	:	x
Pepper, Spice	+	+	+	-	:	x	-	+	+	-	x		+	+	+	-	:		+	:	x	x			+	0	:	x	x		+	+	+	+	-	:		+	+	0	0	-		+	0	0	-	:		+	+	0	0	~	x	x
Piassava	+	+	+	+	0	:	-	+	+	+	0		+	+	+	0	-		+	+	-	x			+	+	0	:	x		0	0	+	+	+			:	+	+	0	0		-	0	0	+	+		+	0	:	x	x	x
Potato, Sweet	+	+	+	+	0	:	x	-	+	+	0		+	+	0	-	:		+	-	x	x			~	+	0	-	-		+	+	+	0	-	:		+	-	:	:	x		+	:	x	x	x		:	0	+	0	:		+	+	-	:	x	x
Rice: Upland	+	+	+	+	-	x	:	0	0	+	0		+	+	-	:	x		+	0	-	x			~	+	+	0	0		+	+	+	0	-	-		0	+	+	+	+		+	0	0	0	0		0	0	+	+	+		+	0	-	:	x	x
Rice: Lowland*	+	+	+	+	-	x	:	0	0	+	0		+	+	-	:	x		+	+	-	x			+	+	+	+	+		0	+	+	+	+			+	+	0	0	0		0	0	+	+	+		x	x	-	+	+		+	:	x	x	x	x
Rubber**	+	+	~	:	x	x	0	+	+	-	x		+	+	-	x	x		+	x	x	x			+	:	x	x	x		+	+	0	:	:	x		+	0	-	:	x		+	0	x	x	x		:	-	+	-	:		+	+	+	+	:	:
Sesame	+	+	0	:	x	x	x	0	+	+	0		+	+	0	-	:		+	0	:	x			~	+	+	0	0		+	+	0	:	:	x		+	+	0	:	x		+	:	:	x	x		+	+	0	:	x		+	+	0	:	x	x
Sorghum**	+	+	+	0	:	:	x	0	+	+	+		+	+	+	-	:		+	+	0	:			:	0	0	+	+		+	+	+	0	-	:		+	0	-	:	x		+	x	x	x	x		0	+	+	0	-		+	0	+	0	:	x
Soybean	+	+	+	-	:	x	x	0	+	+	:		+	+	-	:	x		+	0	x	x			~	+	+	0	0		+	+	+	0	-	:		+	0	:	x	x		+	-	x	x	x		0	+	+	-	:		+	0	-	x	x	x
Sugar Cane	+	+	+	-	:	x	x	0	+	+	:		+	+	-	:	x		+	0	x	x			~	+	+	0	0		+	+	+	:	:	x		+	0	:	:	x		+	-	x	x	x		-	-	+	0	-		+	0	-	:	x	x
Tobacco	+	+	+	0	:	x	x	0	+	0	+		+	0	-	:	x		+	0	x	x			~	+	+	0	0		+	+	+	:	:	x		+	:	:	x	x		+	x	x	x	x		0	+	0	:	x		+	0	-	:	x	x
Vegetables (7)	+	+	+	0	:	x	x	:	+	+	x		+	+	-	:	x		+	:	x	x			-	+	+	+	+		+	+	+	0	-	:		+	-	:	:	x		+	x	x	x	x		-	+	+	:	x		+	0	-	:	x	x
(8)	+	+	+	0	:	x	x	:	+	+	0		+	+	-	:	x		+	0	:	x			+	-	:	x	x		+	+	+	0	-	:		+	-	:	:	x		+	x	x	x	x		-	+	+	-	:		+	0	:	x	x	x
(9)	+	+	+	0	x	x	x	-	0	+	0		+	+	:	:	x		+	0	x	x			+	0	-	:	:		+	x	x	x	x			+	x	x	x	x		-	0	+	-	:		+	0	-	:	x	x		+	0	:	x	x	x
Yams	+	+	+	0	:	x	x	+	+	+	-		+	+	0	:	:		+	:	x	x			-	+	+	0	-		+	0	-	:	x			+	0	-	:	x		+	-	x	x	x		-	~	0	+	0		+	+	0	0	:	x

NOTES

*Crops for which a suitability map accompanies this report.
**Crops whose suitability can be inferred from a related crop map.

(1) A depth class of 3 has no effect on the rating for tree crops when due to high gravel content.

(2) When using this table the nutrient status class should be upgraded by 1, on the assumption that fertilizer will be used. However, this should not apply to cashew or for soils with a nutrient class of 4.

(3) Since the minimum length of the growing season in Sierra Leone is about 240 days, the climate factor class does not significantly affect the rating of arable crops. Although the incidence of pests and disease will tend to be most pronounced in the moister climate types no evaluation of this has been carried out at reconnaissance level.

(4) When the flooding *(fl)* class is 1 or 2 it has been assumed that the growth cycle of arable crops will be adjusted to coincide with the season in which flooding does not occur, thus nullifying the above ratings.

(5) Slope rated severely due to rainfall pattern.

(6) Soils with very gravelly surface layers were assumed to have a depth class of 3 and 4 when rating for cassava and groundnuts respectively.

(7) Raddish, celery, greenbeans

(8) Tomato, cauliflower, lettuces

(9) Onion, carrot, cucumber, spinach, rape, peppers.

Suitability scoring

+	optimal condition
0	good condition
-	fair condition
:	poor condition
x	prohibitive condition

Suitability class

S1	high to moderate	highest and good yields
S2	low	low yields
S3	very low	very low yields
N	Nil	nil or negligible yields

For each of the eight crops selected for map presentation, the suitability of every land system was determined from the suitabilities of their constituent facets at improved traditional level of management. This information is shown in Plates 7 to 10, i e coffee and maize (Plate 7); coconut and citrus (Plate 8); groundnut and paddy rice (Plate 9); cashew and cassava (Plate 10). For each crop two map presentations are given:

The *dominant land suitability*, shown for all crops except rice, indicates the prevalent suitability classes of all land systems based on percentages, ie more than 50% whenever there is one dominant class, or from 40% to 60% if two dominant suitability classes are present. This does not necessarily imply that relatively large areas of better suited land do not exist within the various mapping units (see opposite map).

In the case of paddy rice, most of the land systems are by their very nature unsuitable; nevertheless, they usually contain significant percentages of various types of drainage depressions with higher suitabilities. The map shows, for this particular crop only, land areas rated according to their combined percentages of class one and class two suitabilities (S1 + S2).

The *best suitability* for all crops except citrus, is expressed according to percentage categories of class one suitability (S1). This does not necessarily imply that the crop considered cannot be grown in the remaining parts or the whole of those areas, although under less favourable conditions.

For *citrus*, the land qualities prevailing in Sierra Leone do not warrant the rating of any land facet of any land system under class one suitability (S1) nor under class two (S2). However, since this crop is here primarily considered as a plantation crop (ie with a higher level of inputs), it was possible to show the potentially better suited areas by giving less weight to soil fertility limitations. This allowed, in most cases, the upgrading of S3 suitability class to S2. Therefore, for citrus only, the map shows the best suited land expressed in terms of class two suitability (S2). It does not necessarily imply that citrus cannot be grown in the remaining parts or tne whole of those areas, although under less favourable conditions.

For more details readers are referred to land system tables 1 to 44, pp. 86-173.

Part 6
DESCRIPTION AND EVALUATION OF LAND SYSTEMS AND FACETS

Introduction

This section contains, in tabular form, a detailed description and evaluation of each of the 44 land systems and their constituent facets. It should be read in conjunction with the land system map accompanying this report. The left hand page of each table gives a broad description of the morphology of the land system with general comments on its land suitability. The right hand page contains details of the land facets within each system, together with their evaluation for the 8 selected crops. For details of the land factor classes listed in the right hand page table, reference should be made to Appendix 2, while Table 12 gives details of the suitability matching.[1]

Fig 13, indicates the location of the type pattern areas used for detailed mapping of land facets while page 81 contains an index to the land systems. Plates 1 to 6 show illustrative views of selected land systems.

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[1] *It should be noted that for crops adversely affected by topsoil gravel, eg cassava and groundnuts, the suitability class cannot necessarily be derived directly from the effective soil depth rating listed in the facet tables. This is because, in the calculation of the depth rating, the proportion of gravel in the soil profile only was used and no allowance was made for the depth at which the gravel occurs. To offset this deficiency, interfluve facets within soil associations 7 and 8 were taken as having 50% of soils with sufficient topsoil gravel to justify down-grading the rating for cassava and groundnuts to S2 and S3 respectively.*



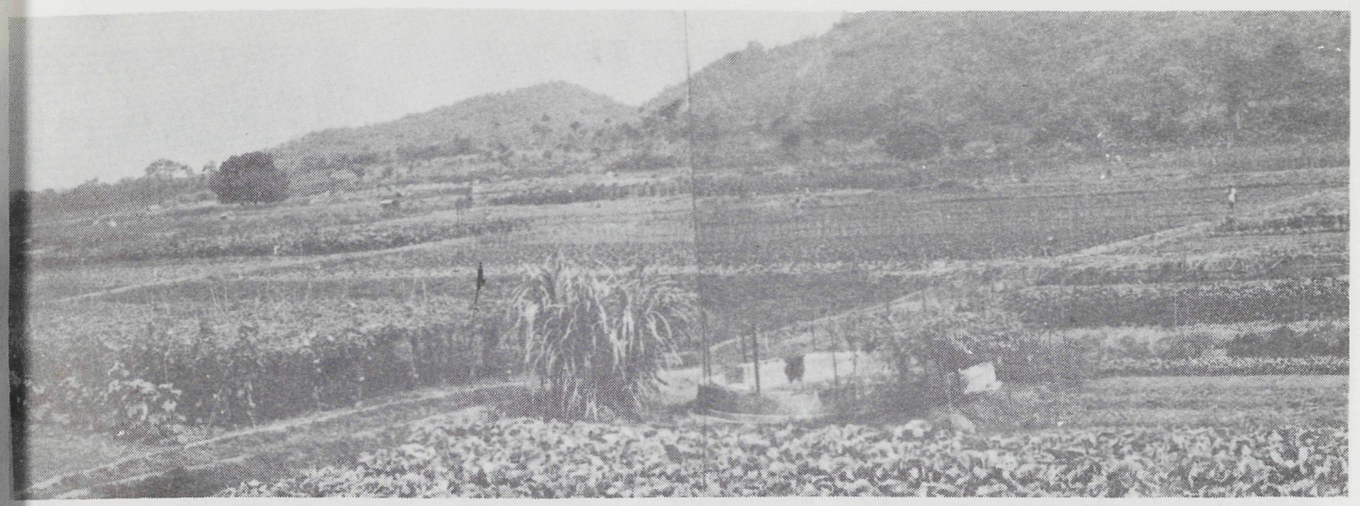
Cultivated tidal flats of Scarcies land system near Mambolo.



Sampling a sandy soil on an old beach ridge of Turner land system near Bonth



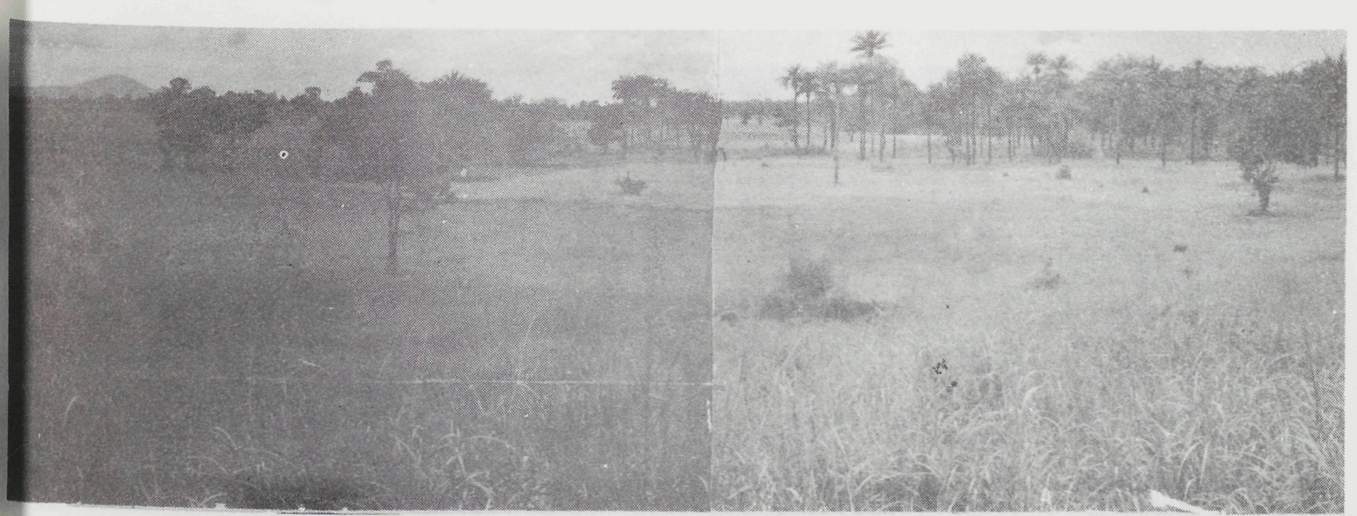
Sewa river and flooded backplains of Torma Bum land system.



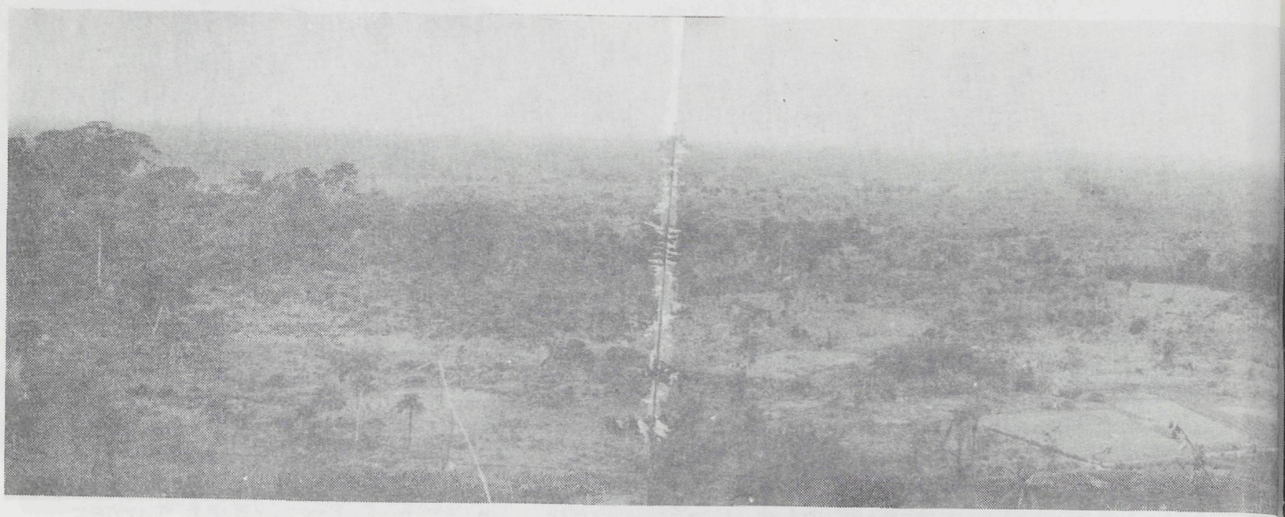
Intensive, irrigated vegetable cultivation on alluvial flats of Turner land system near Freetown.



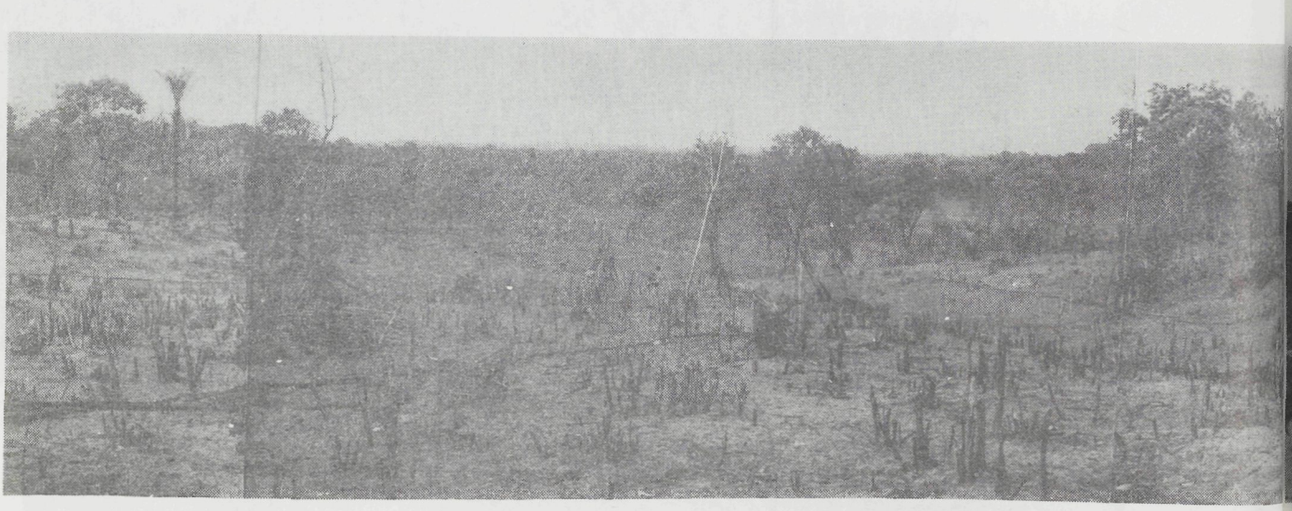
Gallery forest and banana grove on minor flood plain of Moyamba land system. Hand-watered vegetables are grown beneath the bananas.



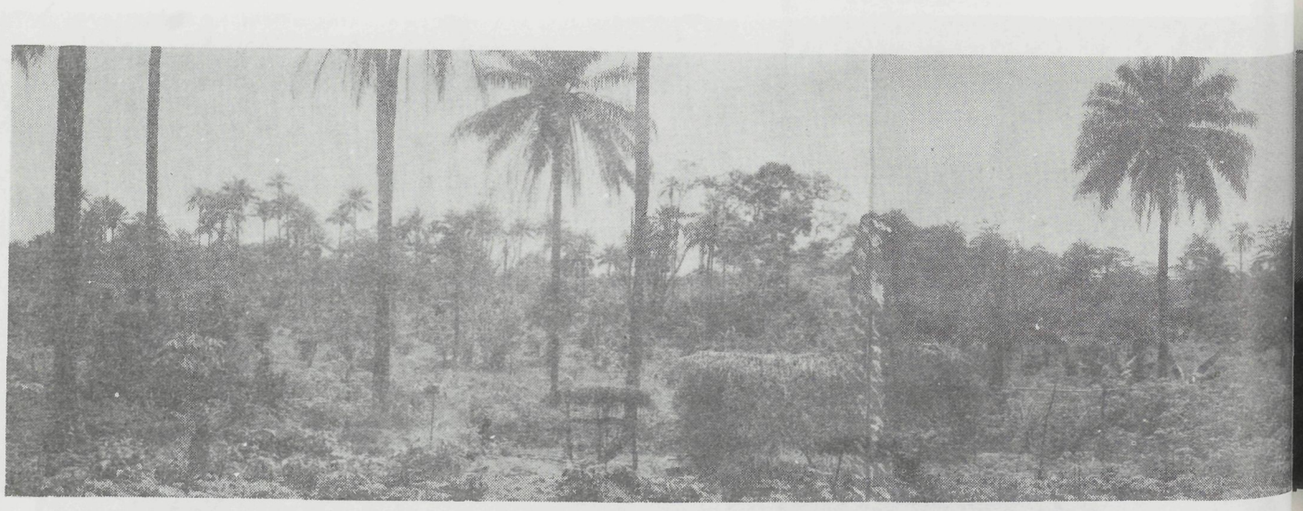
View over Mabole land system showing a recently harvested boli, flanked by terraces and remnant plains of Yonibana land system.



View over interior plain showing mosaic of bush-fallow regrowth and secondary forest. The swamp in the right foreground has been drained and is used for paddy rice and vegetable cultivation.



Gently sloping interfluve of Yonibana land system cleared for upland rice and groundnuts. Both gully and sheet erosion have occured on this slope, exposing ironstone gravel on the ground surface.



Cassava field on a gravel free terrace soil in Bo land system, with a rice swamp in the middle distance.



Partially cleared valley swamp in Blama land system. Paddy rice has just been harvested from the left hand side of the swamp, while the remainder is reverting to thicket.



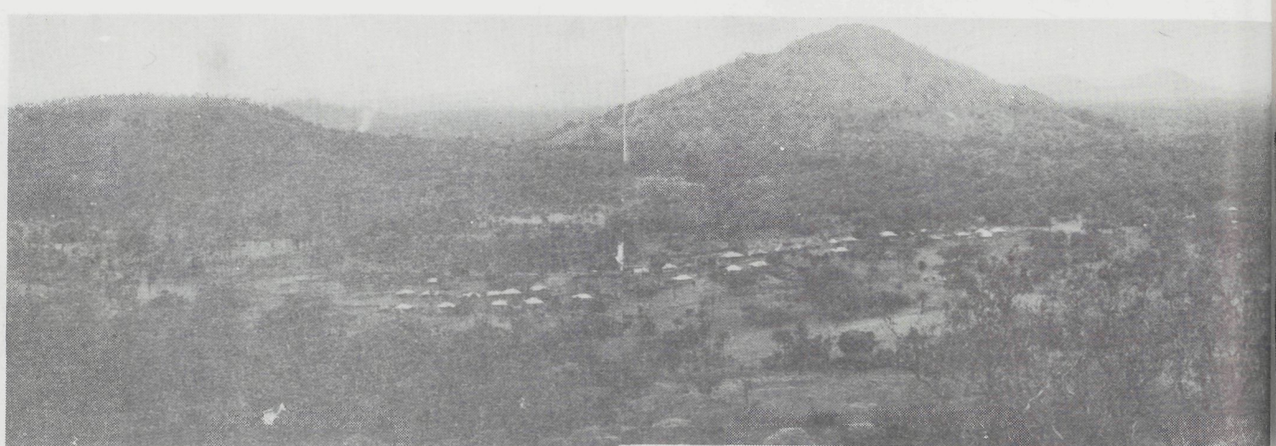
Self-help swamp development in Bo land system. 6.5 ha of swamp have been recently cleared and drained and work has started on the construction side of bunds and irrigation canals.



Fully developed WFP swamp in Musaia land system. Up to 3 crops of paddy a year can be grown on this 20 ha farm, with yields per crop as high as 4 MT/ha. In the dry season onions and vegetables are also grown



Steep hillslope of Kulufaga land system cleared for upland rice. On the plain below tree crops are cultivated under a canopy of secondary forest.

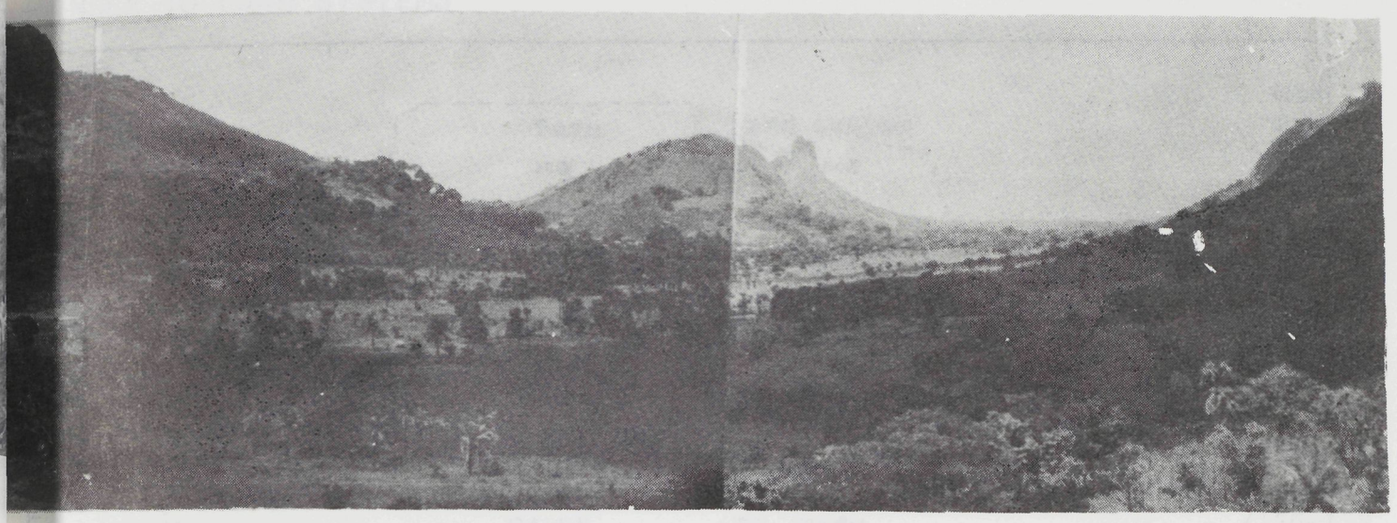


View over hill outliers on interior plain north of Makeni.



View of Kangari land system south of Kabala, with traditional upland farming on the hillslopes and improved cultivation of paddy rice in the swamp.

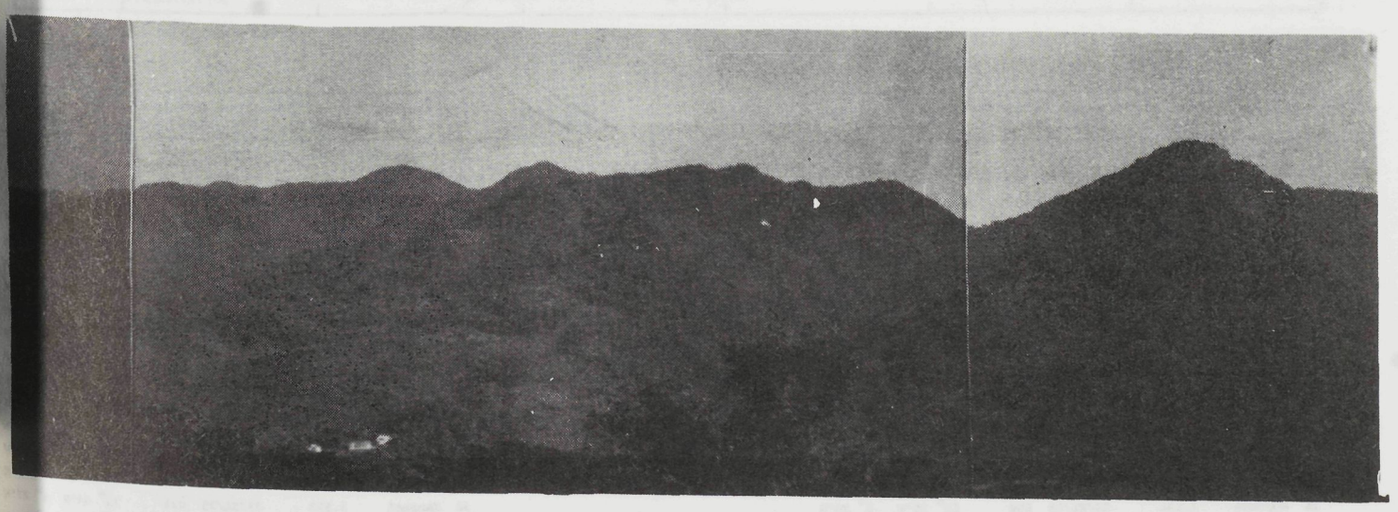
Plate 6



View of the fertile Bumban valley in Wari land system, flanked by the rocky slopes of Tonkolili land system.

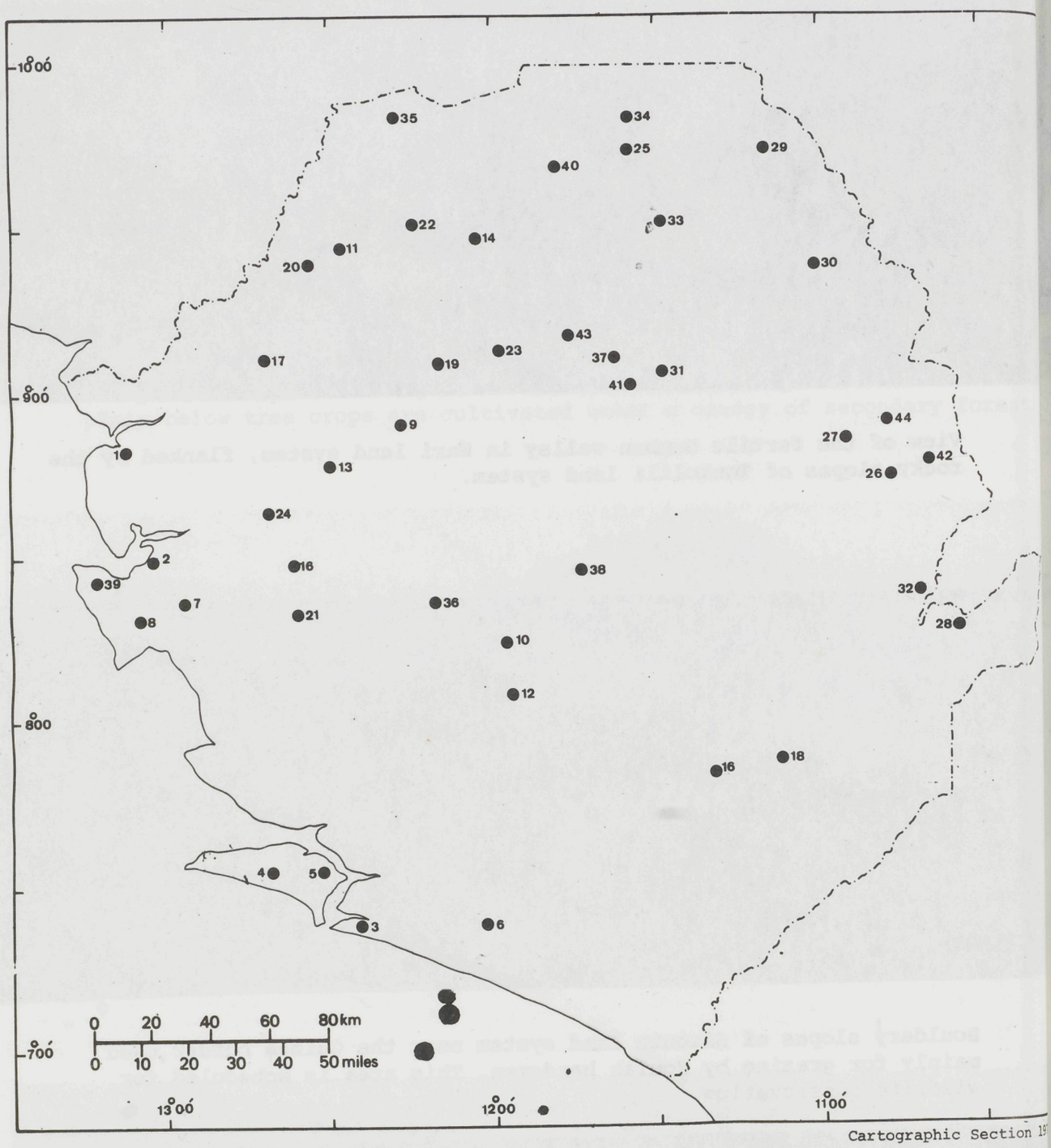


Bouldery slopes of Siaonia land system near the Guinea border, used mainly for grazing by Foulah herdsmen. This area is scheduled for wildlife conservation.



Reserved forest on the slopes of Regent land system, Freetown Penninsula.

Fig 13 Location of land system type patterns



	Land System	Aerial Photograph Reference 1975/76	1951 - 1964		Geographical co-ordinates
1	Scarcies	2.493	33/SL/3	043	13° 07'W 8° 50'N
2	Tasso	3.829	33/SL/10	013	13° 01'W 8° 31'N
3	Turner	6.1692	61/SL/3	012	12° 25'W 7° 23'N
4	Sherbro	4.1281	46/SL/13	015	12° 35'W 7° 32'N
5	Bonthe	4.1278	46/SL/13	019	12° 31'W 7° 32'N
6	Torma Bum	6.1686	61/SL/3	025	12° 01'W 7° 23'N
7	Newton	3.818	33/SL/11	008	12° 57'W 8° 24'N
8	Hastings	4.1289	33/SL/11	042	13° 04'W 8° 19'N
9	Mabole	2.473	33/SL/9	154	12° 17'W 8° 54'N
10	Senehun	3.802	39/SL/11	029	11° 57'W 8° 15'N
11	Rokel	1.189	33/SL/7	023	12° 28'W 9° 27'N
12	Njama	2.746	39/SL/22	056	11° 58'W 8° 05'N
13	Lunsar	2.504	33/SL/2	022	12° 30'W 8° 47'N
14	Laia	1.120	46/SL/10	003	12° 04'W 9° 30'N
15	Blama	3.879	39/SL/18	094	11° 20'W 7° 52'N
16	Moyamba	3.836	33/SL/14	008	12° 39'W 8° 29'N
17	Yonibana	2.399	33/SL/9	083	12° 43'W 9° 07'N
18	Bo	3.881	39/SL/21	039	11° 08'W 7° 58'N
19	Wari	2.362	46/SL/1	066	12° 09'W 9° 07'N
20	Borompo	1.187	33/SL/10	046	12° 33'W 9° 34'N
21	Makondu	3.812	39/SL/10	039	12° 35'W 8° 22'N
22	Kamakwie	1.118	33/SL/6	044	12° 14'W 9° 30'N

	Land System	Aerial Photograph Reference 1975/76	1951 - 1964		Geographical co-ordinates
23	Kamabai	2.358	33/SL/9	059	11° 59'W 8°
24	Port Loko	2.501	33/SL/8	030	12° 41'W 8°
25	Musaia	1.067	61/SL/4	018	11° 35'W 9°
26	Wadu	1.277	23/SL/21	030	10° 49'W 8°
27	Koidu	2.450	23/SL/17	033	10° 57'W 8°
28	Kailahun	3.1048	39/SL/7	103	10° 35'W 8°
29	Kombile	1.073	61/SL/4	032	11° 10'W 9°
30	Kamaron	1.213	46/SL/10	066	11° 01'W 9°
31	Bendugu	2.350	46/SL/1	041	11° 29'W 9°
32	Sandaru	3.1047	39/SL/5	075	10° 41'W 8°
33	Kabala	1.131	46/SL/10	124	11° 30'W 9°
34	Haffia	1.067	46/SL/12	079	11° 36'W 9°
35	Saionia	1.099	39/SL/1	066	12° 18'W 9°
36	Kasewe	3.806	39/SL/9	063	12° 12'W 8°
37	Sula	2.352	46/SL/1	083	11° 37'W 9°
38	Kangari	2.623	39/SL/25	021	11° 44'W 8°
39	Regent	4.1293	33/SL/10	010	13° 12'W 8°
40	Quantamba	1.063	46/SL/9	067	11° 48'W 9°
41	Kulufaga	2.352	46/SL/2	011	11° 35'W 9°
42	Saiama	1.275	23/SL/17	055	10° 40'W 8°
43	Tonkolilini	2.355	46/SL/8	010	11° 47'W 8°
44	Loma	1.258	23/SL/16	062	10° 46'W 8°

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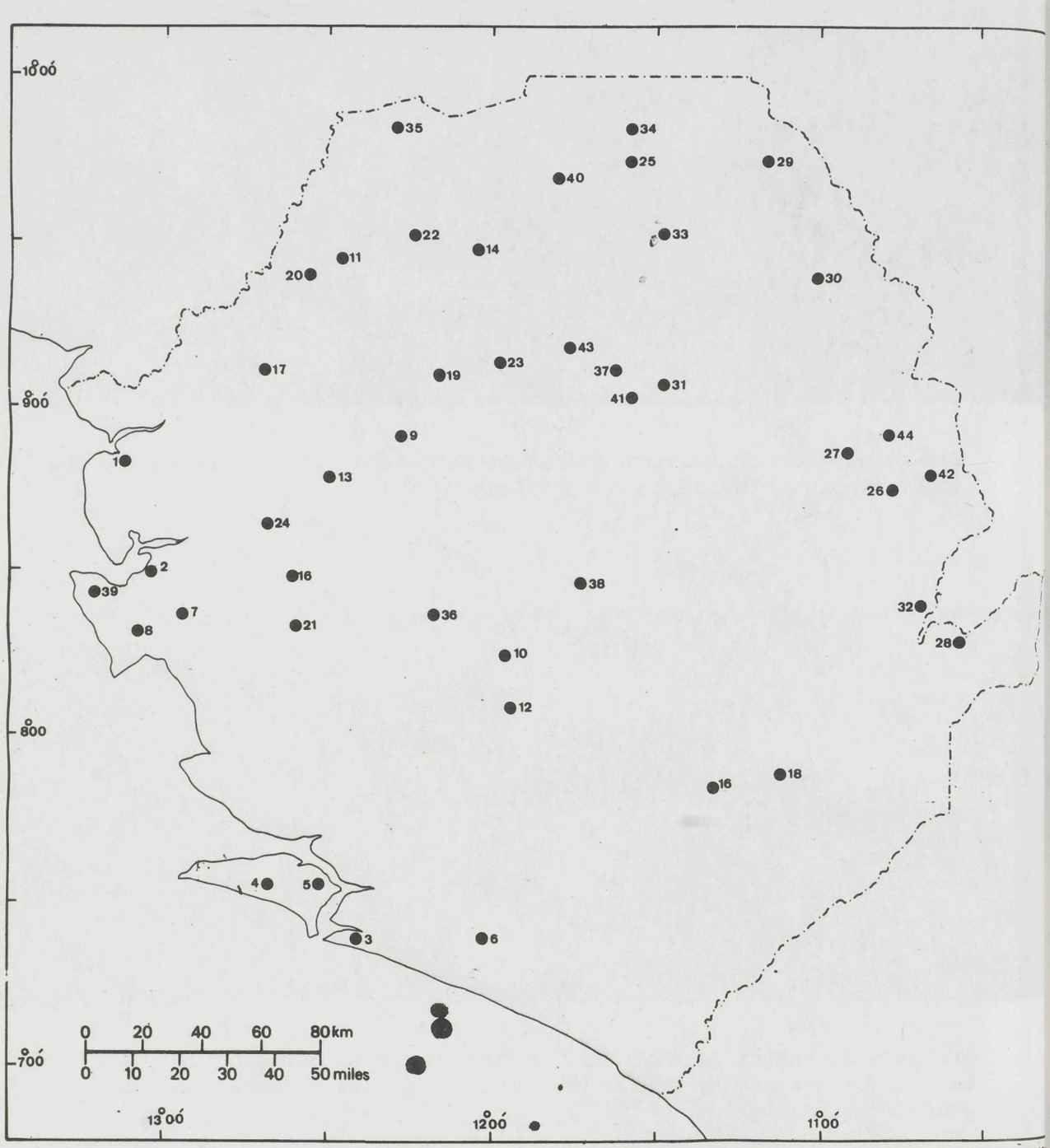
Fig 13 Location of land system type patterns



Cartographic Section 19

	Land System	Aerial Photograph Reference 1975/76	1951 - 1964		Geographical co-ordinates	
1	Scarcies	2.493	33/SL/3	043	13° 07'W	8° 50'N
2	Tasso	3.829	33/SL/10	013	13° 01'W	8° 31'N
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4	Sherbro	4.1281	46/SL/13	015	12° 35'W	7° 32'N
5	Bonthe	4.1278	46/SL/13	019	12° 31'W	7° 32'N
6	Torma Bum	6.1686	61/SL/3	025	12° 01'W	7° 23'N
7	Newton	3.818	33/SL/11	008	12° 57'W	8° 24'N
8	Hastings	4.1289	33/SL/11	042	13° 04'W	8° 19'N
9	Mabole	2.473	33/SL/9	154	12° 17'W	8° 54'N
10	Senehun	3.802	39/SL/11	029	11° 57'W	8° 15'N
11	Rokel	1.189	33/SL/7	023	12° 28'W	9° 27'N
12	Njama	2.746	39/SL/22	056	11° 58'W	8° 05'N
13	Lunsar	2.504	33/SL/2	022	12° 30'W	8° 47'N
14	Laia	1.120	46/SL/10	003	12° 04'W	9° 30'N
15	Blama	3.879	39/SL/18	094	11° 20'W	7° 52'N
16	Moyamba	3.836	33/SL/14	008	12° 39'W	8° 29'N
17	Yonibana	2.399	33/SL/9	083	12° 43'W	9° 07'N
18	Bo	3.881	39/SL/21	039	11° 08'W	7° 58'N
19	Wari	2.362	46/SL/1	066	12° 09'W	9° 07'N
20	Borompo	1.187	33/SL/10	046	12° 33'W	9° 34'N
21	Makondu	3.812	39/SL/10	039	12° 35'W	8° 22'N
22	Kamakwie	1.118	33/SL/6	044	12° 14'W	9° 30'N

	Land System	Aerial Photograph Reference 1975/76	1951 - 1964		Geographical co-ordinates	
23	Kamabai	2.358	33/SL/9	059	11° 59'W	9°
24	Port Loko	2.501	33/SL/8	030	12° 41'W	8°
25	Musaia	1.067	61/SL/4	018	11° 35'W	9°
26	Wadu	1.277	23/SL/21	030	10° 49'W	8°
27	Koidu	2.450	23/SL/17	033	10° 57'W	8°
28	Kailahun	3.1048	39/SL/7	103	10° 35'W	8°
29	Kombile	1.073	61/SL/4	032	11° 10'W	9°
30	Kamaron	1.213	46/SL/10	066	11° 01'W	9°
31	Bendugu	2.350	46/SL/1	041	11° 29'W	9°
32	Sandaru	3.1047	39/SL/5	075	10° 41'W	8°
33	Kabala	1.131	46/SL/10	124	11° 30'W	9°
34	Haffia	1.067	46/SL/12	079	11° 36'W	9°
35	Saionia	1.099	39/SL/1	066	12° 18'W	9°
36	Kasewe	3.806	39/SL/9	063	12° 12'W	8°
37	Sula	2.352	46/SL/1	083	11° 37'W	9°
38	Kangari	2.623	39/SL/25	021	11° 44'W	8°
39	Regent	4.1293	33/SL/10	010	13° 12'W	8°
40	Quantamba	1.063	46/SL/9	067	11° 48'W	9°
41	Kulufaga	2.352	46/SL/2	011	11° 35'W	9°
42	Saiama	1.275	23/SL/17	055	10° 40'W	8°
43	Tonkolilini	2.355	46/SL/8	010	11° 47'W	9°
44	Loma	1.258	23/SL/16	062	10° 46'W	8°

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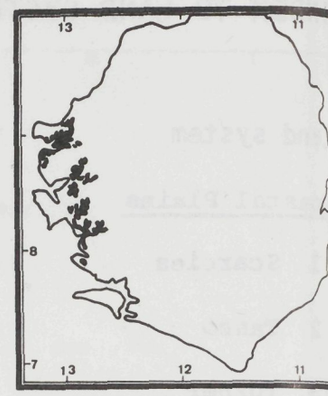
SCARCIES LAND SYSTEM 1



(801 KM^2)

GENERAL DESCRIPTION

Complex of cultivated coastal estuaries and river floodplains.

GEOLOGY

Recent alluvial silts and clays.

GEOMORPHOLOGY

Complex of low terraces, tidal flats and brackish swamps which inland grade into floodplains. Typically, in the Scarcies area, low seasonally flooded terraces fringe remnants of Songo land system. These merge into upper and lower tidal flats, the latter being intensively cultivated for swamp rice and drained by meandering tidal creeks. Where the tidal influence becomes less, brackish grassland swamps have developed. Upstream along major rivers and their tributaries these grade into floodplains subject only to fresh water inundation.

TERRAIN PARAMETERS

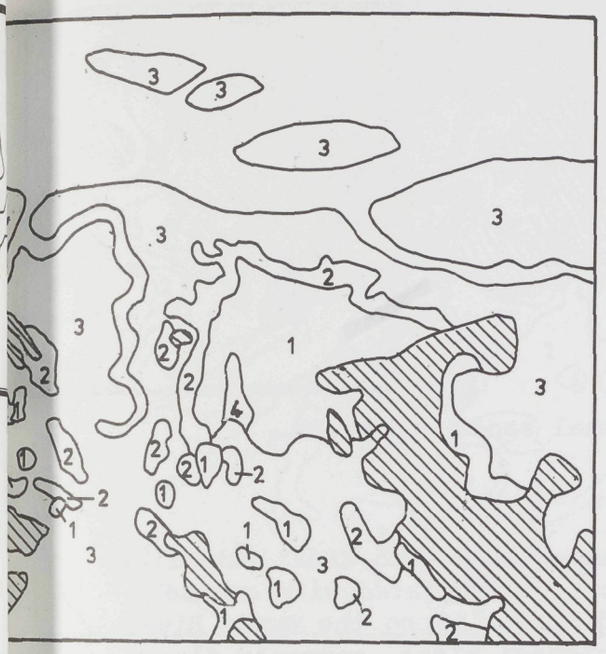
Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
-1	2	Negligible	Level	n.a.	Estuarine	n.a.

CLIMATE TYPE C_2 and D_1

GENERAL LAND SUITABILITY

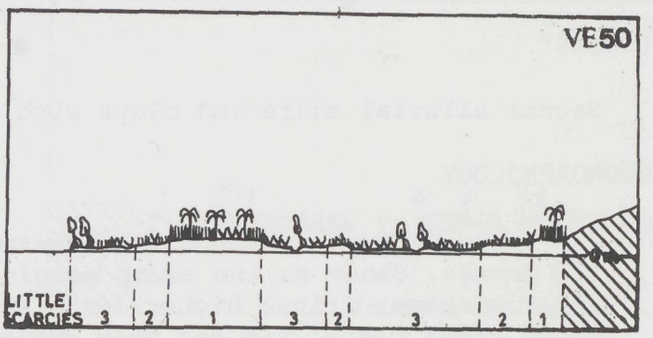
Because of tidal flooding and saline soils, most of this land system is suitable only for paddy rice and, locally, for tree crops tolerant of short duration flooding. Although soil fertility is relatively high, the pattern of flooding by salty and brackish water is such that rice growing is possible only during the rains when salts are flushed away from a shallow layer of the topsoil. The resulting limited rooting space leads to a low suitability rating for paddy rice over much of the area. Also the suitability of some of the non-tidal parts of this land system is rated very low for paddy rice because of intense acidity.

1



1 Km

FACET BREAKDOWN



Facet	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
	8	Low alluvial terraces					
		50-1000 m wide	Deep, gleyed sandy clay loams with a thin, organic surface layer. Very poorly drained. Strongly to extremely acid.	Grassland with stunted oil palm. Commonly cultivated for cassava.	d_1, a_1 or $_2$, n_3, x_1, w_3, fl_1, p_3 or $_4$	Ch: N Ca: N Ct: N Cn: S3o	Co: N G : N M : N R : N
*	4	Upper tidal flats					
		Level; 50-300 m wide; channelled	Deep, gleyed weakly developed muds. Very poorly drained to water-logged. Variable reaction.	Salt tolerant grasses and sedges. *Sesuvium sp.* common. Locally cultivated for rice.	d_1, $a_{var(av\ 4)}$, n_1, x_2, w_3, fl_3, p_4 or $_5$ *C ratings:* *Wet season 0* *Dry season 1 to 3 depending on distance from the sea.*	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2r
*	45	Lower tidal flats					
		Level; up to 5 km wide; channelled	Deep, very dark grey weakly developed muds in various stages of ripening; frequently smelling strongly of sulphate. ed. Waterlogged. Neutral.	Widespread rice cultivation. Scattered remnants of mangrove, particularly along tidal creeks.	d_1, $a_{var(av\ 4)}$, n_1, x_2 or $_3$, w_4, fl_4, p_4 *C ratings: See above*	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2r
	25	Sedge swamps					
		Level; up to 3.5 km wide	Deep, light grey gleyed silty clay loams to clays, commonly sandy at depth. Very poorly drained. Extremely to strongly acid.	Sedge grassland; rice cultivation.	d_1, a_1, n_2, c_1, x_2, w_3, fl_3, p_4 or $_5$.	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S3f
**	18	Minor floodplains					
		Level; 100-400 m wide; channelled	Deep, variably textured alluvial soils. Well drained to poorly drained. Strongly to weakly acid.	Grassland often with sedges; cultivated mostly for rice.	d_1, a_2 or $_3$, n_2, x_1 or $_2$, w_2, fl_2 or $_3$, p_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : S3o M : S3o R : S1/S2m

NB Because of the variable distribution of facets in this land system and the difficulties in precisely determining the limits of salt and fresh water flooding, no percentage ranges have been given. Areas percentages quoted represent an estimated average over the whole land system.

* Suitability classes apply to wet season cropping only.
** Not present in type area.

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

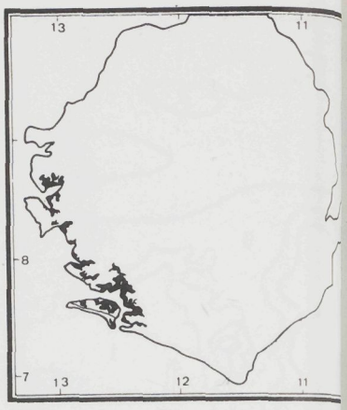
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

TASSO LAND SYSTEM 2

(1546 KM^2)



GENERAL DESCRIPTION

Tidal coastal mangrove swamps

GEOLOGY

Recent alluvial silts and clays with occasional sands and peats.

GEOMORPHOLOGY

Mud flats bordering Newton land system and associated with tidal estuaries and creeks. Sandy saline swamp margins, probably associated with groundwater seepage, fringe higher lying dissected plains along the Bunce River. Upper tidal flats, flooded only during the highest tides, commonly flank meandering creeks and gradually merge into lower, regularly flooded, tidal flats.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
0	1.5	Negligible	Level	n.a.	Estuarine	1.6 (1.5-1.9)

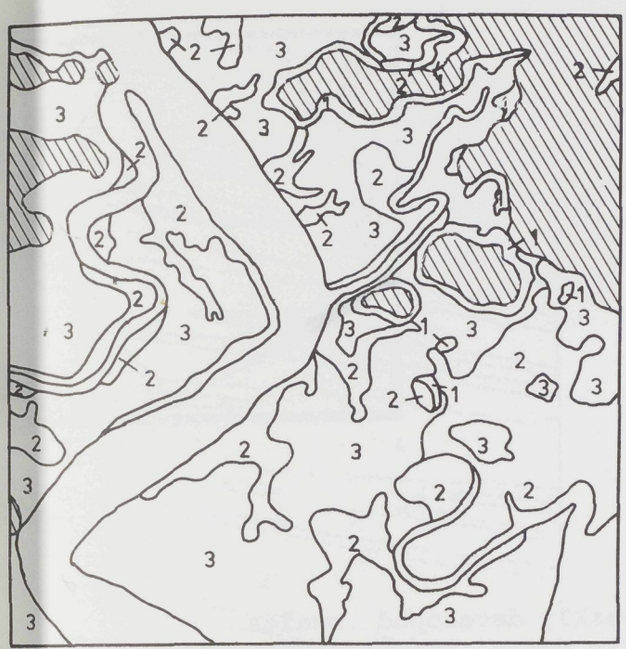
CLIMATIC TYPES C_1 and D_1

GENERAL LAND SUITABILITY

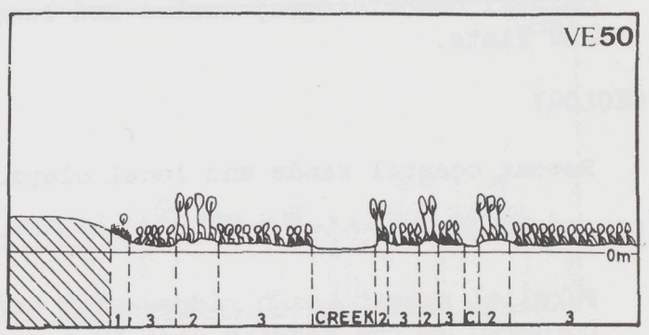
This land system has very poorly drained to waterlogged saline soils which are tidally flooded. It is suitable only for the cropping of paddy rice during the rainy season. Some areas, particularly in the north, have already been successfully utilized for wetland rice growing and yields compare favourably with those obtained in other areas of Sierra Leone. Further intensification, however, will be curbed by the shallowness of the salt free soil layer during the rainy season and the tendency of the soils to acidify when drained.

2

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	0-8	Saline swamp margins					
		Level to nearly level; 50-200 m wide; common surface salt deposits; locally stony.	Saline sands and gleyed clays with occasional buried peat layers. Laterite stones are sometimes present on the ground surface.	Salt tolerant grass and sedge species often with scattered stunted *Rhizophora spp.* Patches of bare soil common.	a_4, x_2, w_3, fl_3, d_4, *p var*, n_3, *locally* y_4, *c var: dry season 3 wet season 1*	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2r
2	26-46	Upper tidal flats					
		Level; 150-500 m wide; channelled	Deep, gleyed weakly developed muds.	Mangrove forest: *Rhizophora* and *Avicennia spp.* up to 15m high.	a_1, p_4, d_4, x_1, w_4, fl_3, n_1 *c var: dry season 3 wet season 0*	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2r
3	50-70	Lower tidal flats					
		Level; 200 to 2000 m wide; channelled.	Deep, gleyed weakly developed muds. In the Bunce River area surface sand and buried peat layers are present.	Mangrove thicket: *Rhizophora* and *Avicennia spp.* up to 5 m high.	a_1, p_4, d_4, x_1, or $_2$, w_4, fl_4, n_1, *c var: dry season 1 to 3 depending on distance from the sea. wet season 0*	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2r

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

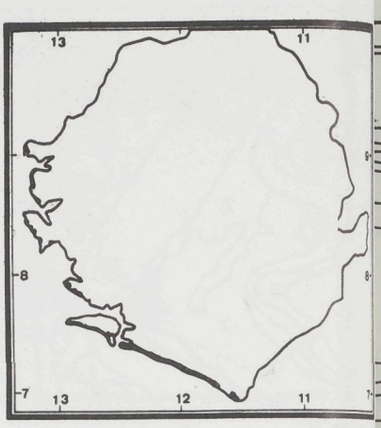
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

TURNER LAND SYSTEM 3

(382 KM^2)



GENERAL DESCRIPTION

Coastal beach ridges, swales and local mud flats.

GEOLOGY

Recent coastal sands and local clays.

GEOMORPHOLOGY

Parallel recent beach ridges with narrow, weakly developed swales bordered on the seaward side by a present day beach. Behind these lie either tidal mud flats (in the western area), or a well defined pattern of alternating older beach ridges and swales (on Turners Peninsula).

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
0	2.5	Negligible	Level to nearly level	n.a.	Colinear (estuarine on tidal flats)	1.5 (1.4-1.6)

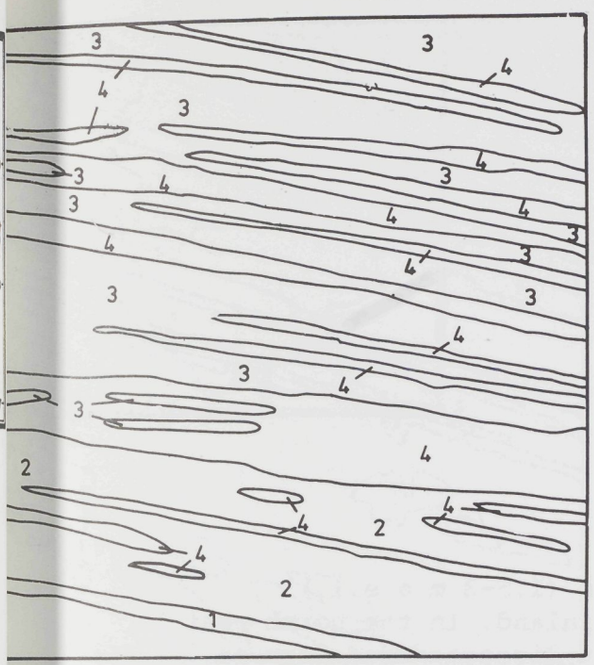
CLIMATIC TYPES C_2 and C_1

GENERAL LAND SUITABILITY

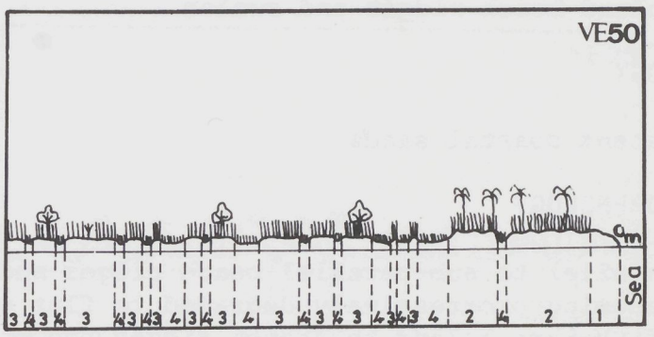
This land system has poor suitability because of rapidly permeable, infertile soils with low water holding capacity. Successful growing of arable crops cannot be expected without green manuring on these soils, which are suitable at present only for cashew and coconut. Seasonally flooded swales and locally occuring tidal flats are suitable for paddy rice. Small tracts of alluvial land in the Western Area are highly suitable for intensive cropping of vegetables and short cycle arable crops.

3

FACET BREAKDOWN



1 Km



Facet	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
	2	Present day beaches Level to nearly level; 50-100 m wide	Undeveloped sands	Bare ground	p_1, x_4, w_2, fl_4, n_4, c_2	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
	10-70	Recent beach ridges Level; 50-150 m wide; gently undulating	Undeveloped sands.	Tree savanna dominated by oil palm, coconut palm, *Parinari macrophylla* and *Anisophyllea laurina*. Scattered patches of cultivation.	p_1, x_3, n_4, a_2	Ch: S2f Ca: S3f Ct: N Cn: S2f	Co: N G : N M : N R : N
	5-55	Old beach ridges Level;60-200 m wide	Undeveloped sands and slightly leached, yellow-brown sands. Well drained. Acid.	Open savanna with *Parinari macrophylla* scrub. Scattered patches of tree savanna.	As above	Ch: S2f Ca: S3f Ct: N Cn: S2f	Co: N G : N M : N R : N
	10-36	Swales Level; 20-150 m wide	Poorly drained sands.	Sedge grassland	p_1, x_3, w_3, fl_3, n_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2f
	4	Tidal flats* Level; 100-400 m wide; channelled	Saline sands and muds.	Pioneering mangrove; *Avicennia* and *Rhizophora spp.*	a_4 or $_3$, p_1, x_3, w_4, fl_4, n_3, c_1 or $_2$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2f
	1	Alluvial flats** Level to nearly level; 200-400 m wide; channelled	Deep, friable, yellowish to reddish sandy loam to clay loam alluvial soils with silty or gravelly layers. Well drained. Weakly acid to neutral.	Intensive horticulture	p_3, x_1, fl_2, n_1, a_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1 M : S1 R : S3m

* Inclusions of Tasso land system in Western Area too small to be mapped separately.
** Scattered patches in Western Area only.

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

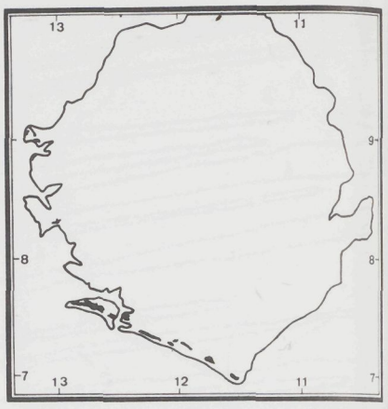
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

SHERBRO LAND SYSTEM 4

(472 KM^2)



GENERAL DESCRIPTION

Inland beach ridges and swales

GEOLOGY

Recent coastal sands.

GEOMORPHOLOGY

Parallel to sub-parallel beach ridges and swales (1.5-3 m a.s.l.) becoming progressively degraded to flat plains inland. In the north-west of Sherbro Island the beach ridges become rather dissected and form an arcuate pattern. In the northern coastal areas flats assume the indented form of drainage depressions between degraded beach ridges. Near tidal creeks, which often cut across the beach ridges, swales are affected by tidal flooding.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
0	3	Negligible	Level	Nil	Colinear	3.0 (2.8-3.1)

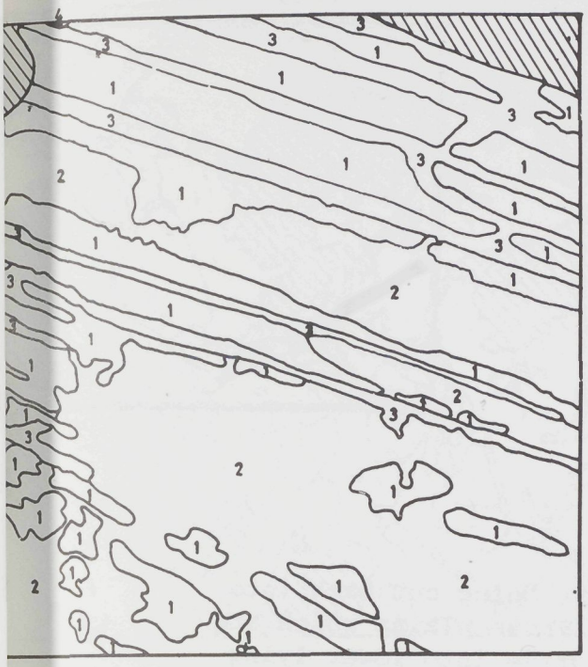
CLIMATIC TYPES C_2 and C_1

GENERAL LAND SUITABILITY

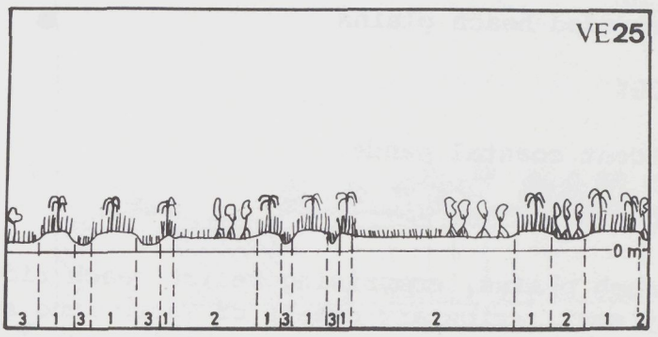
As in Turner Land System, the suitability of this land system is limited to the growing of low demanding tree crops because of very unfavourable soil conditions. Short duration flooding over a considerable part of the area further narrows the choice of crops. Seasonal or tidal flooding over the lower lying parts of this land system makes them suitable only for paddy rice.

4

FACET BREAKDOWN



1 Km



Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
30-40	Old beach ridges					
	Level; 50-400 m wide	Undeveloped sands and slightly leached, yellow-brown sands. Well drained. Acid.	Tree savanna with scattered patches of cultivation. Tree species include oil palm *(Eleas guineiensis), Anisophyllea laurina, Parinari macrophylla.*	p_1, x_3, fl_o, n_4	Ch: S2f Ca: S3f Ct: N Cn: S2f	Co: N G : N M : N R : N
35-55	Colluvial flats					
	Level; 150 m wide, Termitaria locally present.	Slightly leached acid yellow-brown sands predominate. Weakly developed acid podzols are locally present, often in areas with termite mounds.	Sedge grassland transitional to open savanna with scattered *Parinari macrophylla* shrubs commonly associated with termite mounds.	a_2, p_1, x_3, n_4, fl_1, locally w_1	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : N M : N R : N
15-25	Swales and tidal creeks					
	Level; 50-150 m wide	Poorly drained sands	Where tidal, *Rhizophora racemosa* predominates, elsewhere sedge grassland occurs.	p_1, x_3, w_3, fl_3, n_3, locally c_1 and w_4 (tidal creek areas)	Ch: N Ca: N Ct: N Cn: N	Co: N H : N M : N R : S2f

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

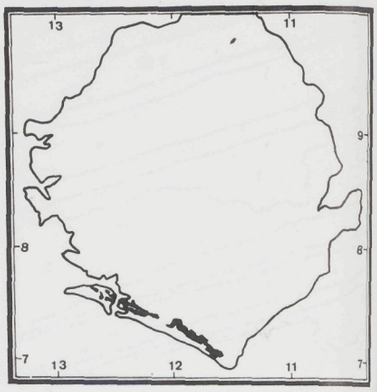
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

BONTHE LAND SYSTEM 5

(579 KM^2)



GENERAL DESCRIPTION

Degraded beach plains

GEOLOGY

Recent coastal sands.

GEOMORPHOLOGY

Beach plains, comprising relict beach ridges, are being cut back into by small tributary creeks of Tasso land system. These plains which are gently undulating, occur up to 5 m a.s.l. They grade into lower lying areas of swamp forest transitional to tidal mangrove swamps. Seasonally flooded sedge grassland flats occur locally at intermediate levels.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
0	5	Negligible	Level	Medium	Estuarine	0.9 (0.8-0.9)

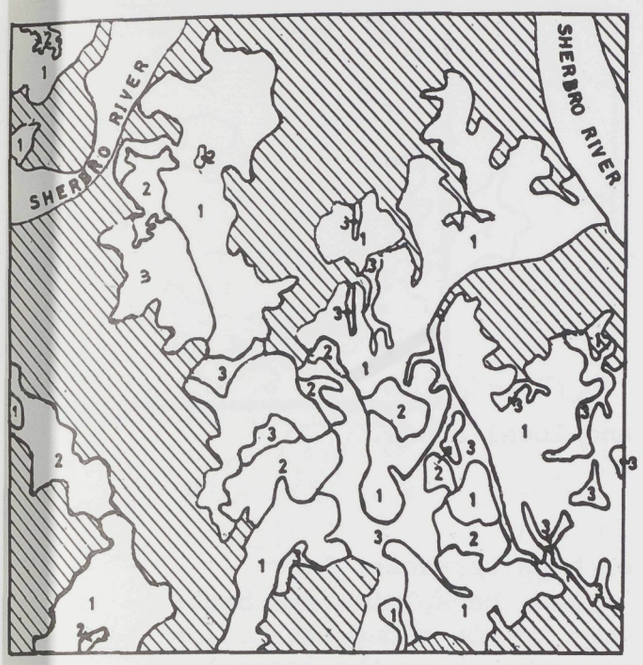
CLIMATIC TYPES C_2, locally C_1

GENERAL LAND SUITABILITY

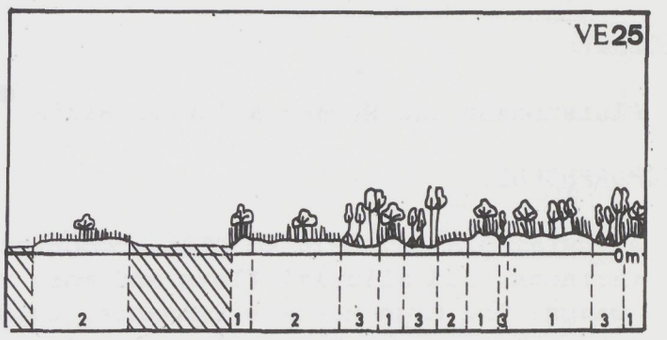
Rapidly permeable acid sandy soils with low fertility and low water holding capacity make the suitability of this land system very low and similar to that of Sherbro and Turner land systems, save for the proportion of the non-flooded area which is estimated to be greater.

5

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability
1	60-80	Remnant beach plains				
		Level; 200-2000 m wide; slightly undulating	Slightly leached acid yellow-brown sands and weakly developed podzols. Well drained.	Tree savanna dominated by *Parinari macrophylla* and *Anisophyllea laurina*. Scattered patches of cultivation, secondary forest and grassland.	a_2, p_1, x_3, fl_o, n_4	Ch: S2f Co: N Ca: S3f G : N Ct: N M : N Cn: S2f R : N
2	10-20	Colluvial flats				
		Level; 50-400 m wide	Slightly leached acid yellow-brown sands predominate with weakly developed podzols locally present.	Sedge grassland with low tree savanna.	a_2, p_1, x_3, w_1, fl_1, n_4	Ch: S3o Co: N Ca: N G : N Ct: N M : N Cn: S3o R : N
3	10-20	Brackish water swamps				
		Level; 50-500 m wide	Poorly drained sands, commonly weakly saline.	Mangrove swamp transitional to swamp forest.	p_1, x_3, w_3 or $_4$, fl_4, n_3, c_1	Ch: N Co: N Ca: N G : N Ct: N M : N Cn: N R : S2f

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

TORMA BUM LAND SYSTEM 6

(1404 KM^2)



GENERAL DESCRIPTION

Coastal alluvial plains.

GEOLOGY

Pleistocene and Recent alluvial silts clays and local sands.

GEOMORPHOLOGY

Alluvial plains, 4-16 km wide, comprising older high terraces, low terraces, old alluvial flats and more recent levees, backplains and back-swamps. The high terrace remnants, which are most common along the Scarcies and Jong River, form gently undulating areas above the general level of the plains. At slightly lower elevations low terraces, often associated with former stream channels, grade into level flats. Weakly developed levees which in places broaden into scroll complexes occur along major rivers and are backed by extensive backplains. The backplains in turn merge into back swamps subject to severe flooding. Locally these swamps were former river channels, subsequently infilled by alluvium.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
1	15	Negligible	Level	Very coarse	Anasto-matic	0.8 (0.5-0.9)

CLIMATIC TYPES

C_2, locally D_1

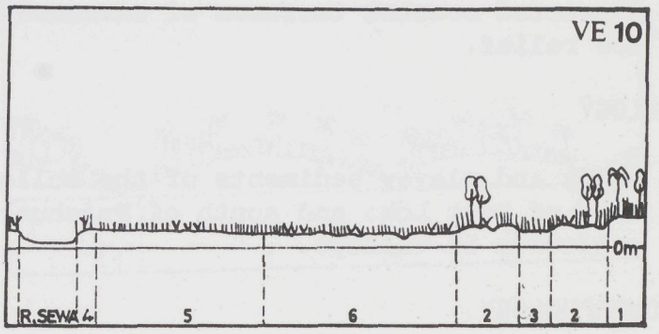
GENERAL LAND SUITABILITY

This land system was generally considered to be one of the best suited for agriculture in Sierra Leone. However, a number of feasibility studies have been carried out, revealing severe limitations in terms of flooding, drainage and soil fertility. At present a scheme is being implemented to improve the cultivation of floating rice, which along with paddy rice seems the most suitable crop for the forseable future. Locally occurring non-flooded terraces are well suited to arable and tree crops while fish farming in association with any rice development offers additional possibilities.

6

FACET BREAKDOWN





Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
	1-15	High colluvial terraces					
		Level to nearly level; locally gently sloping; 500-2000 m wide; undulating, mounds locally present	Deep loams to clays. Well drained. Strongly acid.	Tree savanna with patches of remnant woodland. Locakly cultivated with upland crops.	a_2, p_3, n_2, x_2, fl_o locally s_1	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
	6-20	Low alluvial terraces					
		Level to nearly level; 200-600 m wide; locally undulating and channelled	Deep, yellowish brown clay loams to clays with an organic topsoil. Well drained. Strongly to weakly acid.	Predominantly grassland with some scattered cultivation.	a_o or $_2$, p_3 or $_4$, d_2, x_1 or $_2$, n_2, fl_1	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S1 M : S1 R : N
	5-15	Alluvial flats					
		Level; 400-1200 m wide; mounds commonly present	Deep, gleyed, massive clays. Poorly drained. Strongly acid.	Grassland and scattered herbs. Not usually cultivated.	a_2, p_4, d_2, x_1, w_2, fl_3, n_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2f
	1-5	Recent levee and scroll complexes					
		Level to nearly level; 100-600 m wide; locally undulating and channelled (up to 2 m relief)	Deep, yellowish brown clay loams and clays high in silt and locally organic. Soils of variable texture present in old river channels. Well drained to locally imperfectly drained. Strongly to weakly acid.	Grassland predominantly *Chasmopodium sp;* with patches of remnant woodland. Scattered rice cultivation.	a_o or $_2$, p_4, d_1, x_1, fl_1, n_1 or $_2$	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S1 M : S1 R : N
	27-45	Backplains					
		Level; 800-3000 m wide; locally slightly undulating	Deep, greyish, mottled clays with an organic topsoil. Imperfectly to poorly drained. Strongly acid.	Grassland, predominantly *Chasmopodium sp.* and *Imperata cylindrica*. Common rice cultivation.	a_2, p_4, d_1, x_1, w_1 or $_2$, fl_2 or $_3$, n_1 or $_2$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1/S2m
	25-35	Backswamps					
		Level; 500-3000 m wide; locally channelled and slightly undulating	Deep, gleyed clays with an organic topsoil. Poorly drained to waterlogged. Strongly acid.	Tall floating grassland and aquatic weeds. Cultivation of floating rice varieties is common.	a_2, p_4 or $_5$, x_1, w_3, fl_3, n_1 or $_2$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

- *d* = Effective soil depth
- *a* = Soil reaction
- *n* = Nutrient status
- *c* = Soil salinity
- *x* = Soil AWC
- *w* = Soil drainage
- *fl* = Flooding
- *p* = Soil permeability
- *s* = Slope steepness
- *y* = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

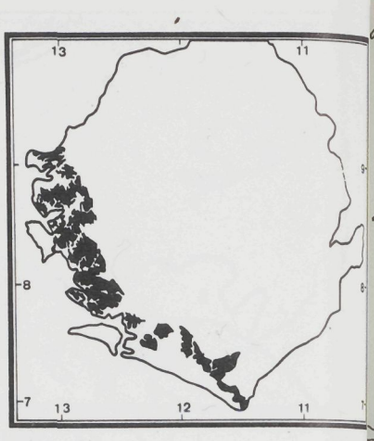
- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

NEWTON LAND SYSTEM

(5159 KM^2)



GENERAL DESCRIPTION

Dissected coastal terraces of extremely low relief.

GEOLOGY

Sandy and clayey sediments of the Bullom Group, Kasila Group granulites west of Port Loko and south of Pujehun. Recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Gently undulating plain consisting of ill-defined nearly level crests and very gently sloping side slopes. The broad interfluves, up to 1.5 km wide, are intricately dissected by generally narrow, poorly drained valleys. In their lower parts these grade into better drained floodplains attaining widths up to 200 m.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
2	40	Extremely low	Very gentle	Ultra fine to none	Dendritic	1.3 (1.0-1.6)

CLIMATIC TYPES

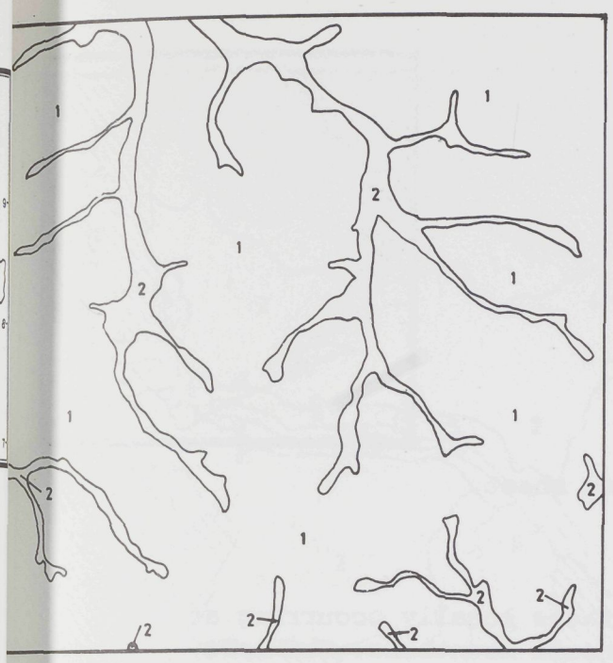
C_2 and D_1, locally C_1

GENERAL LAND SUITABILITY

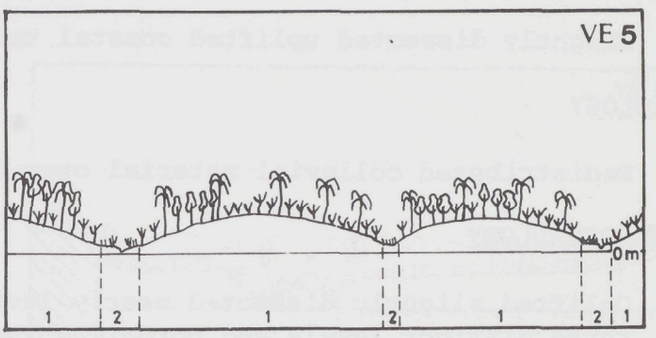
Deep, well drained, gravel free soils occur extensively over the upland parts of this land system making them highly suitable for acidity tolerant arable and tree crops. Suitability for maize and groundnuts will be only low unless soil acidity can be amended. Moreover, the dry season in most of the area is too long for successful growing of coffee and cocoa. The swampy valley floors are moderately suitable for paddy rice.

7

FACET BREAKDOWN



1 Km



cet	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability
	84-90	Interfluves				
		Ill defined crests and side slopes, nearly level to very gentle; locally gentle; 500-1500 m wide	Deep, yellowish brown to brown, sandy clay loams with sandy surface horizons. Locally gravelly especially along eastern boundary of land system and around Songo. Well drained. Strongly acid.	Mosaic of scattered cultivation, secondary forest and regrowth thicket. Oil palms are numerous. *Lophira* tree savanna prevalent in Songo area.	d_1, a_2, n_2 or $_3$, x_2, fl_o, p_3, s_1, *locally* d_2, x_3	Ch: S1 Co: S3m Ca: S1 G : S2f Ct: S3f M : S2f Cn: S1 R : N
2	10-16	Valley swamps and minor floodplains				
		Level; 50-200 m wide; channelled	Deep, variable alluvial and colluvial soils, locally silty or with peaty surface layers. Very poorly drained to waterlogged, locally imperfectly drained. Strongly to weakly acid.	Frequent rice cultivation and sedge grassland. Raphia palms common.	a_2, n_1 or $_2$, x_2, fl_3, p_3 or $_4$	Ch: N Co: N Ca: N G : N Ct: N M : N Cn: N R : S1

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

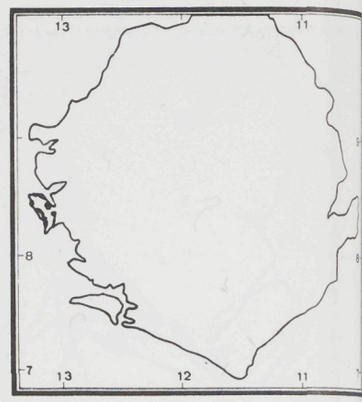
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

HASTINGS LAND SYSTEM 8

(101 KM^2)



GENERAL DESCRIPTION

Slightly dissected uplifted coastal terraces.

GEOLOGY

Redistributed colluvial material over laterite sheet.

GEOMORPHOLOGY

Uplifted, slightly dissected nearly level terraces locally occurring at three distinct levels and bordering the Peninsula mountains. The best developed terrace is a lateritic surface occurring at an intermediate level and extending up to 3 km in width. It is characterized by an extensive laterite sheet covered by predominantly shallow soils. Very locally this level grades into an upper terrace which in turn merges into the gently sloping, bouldery footslopes of Regent land system. At lower elevations the lateritic surface is bordered by a well defined steeper slope at the foot of which a gently undulating low terrace locally occurs, particularly in the northern and southern part of the land system. Deeply incised small streams flow across the terraces in steep sided rocky valleys floored with alluvium.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
2	70	Very low	Nearly level to very gentle	Medium to coarse	Weakly dendritic	0.8 (0.6-0.8)

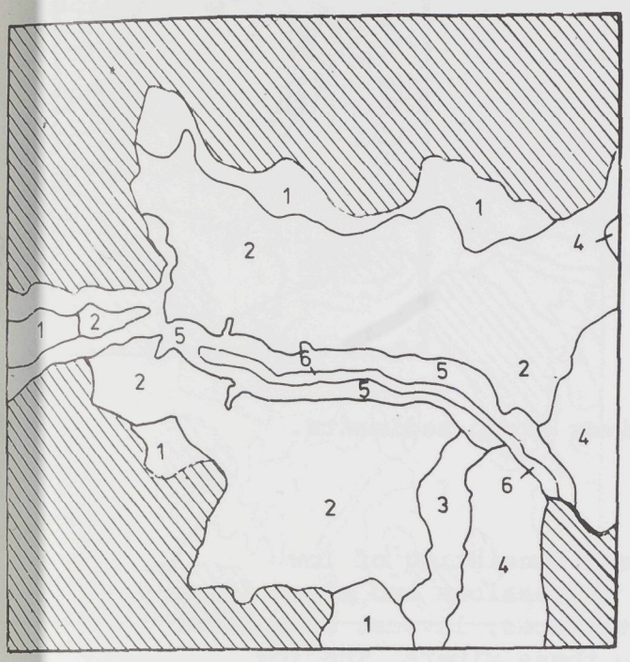
CLIMATIC TYPE C_2

GENERAL LAND SUITABILITY

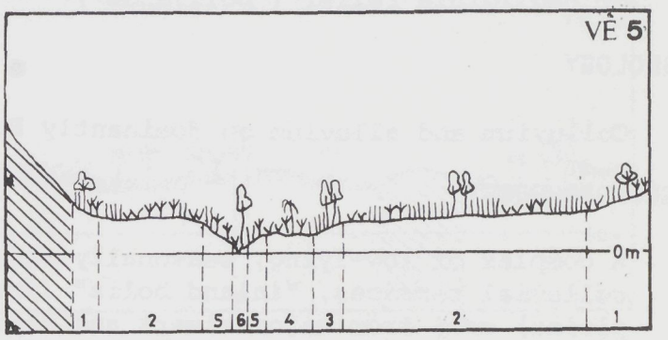
Very shallow, infertile soils with very low water holding capacity, combined with a rather long dry season, make this land system generally unsuitable, except for the deeper soils occurring on the floodplains and locally on the terraces. In some areas however, vegetables are being grown for sale in Freetown. The proximity of this land system to the capital explains the intensive growing of cash crops on the better soils.

8

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	10-15	Footslopes and high colluvial terraces					
		Very short to medium length; concave to straight; very gentle to gentle slope; locally bouldery	Shallow to locally moderately deep, reddish clay loams with variable gravel content. Well drained. Strongly to weakly acid.	Mosaic of scattered patches of cultivation, grassland, regrowth thicket and secondary forest.	d_2, a_2 or $_3$, n_3, x_3, fl_o, p_3, s_2, locally y_3	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
2	50-75	Lateritic terraces					
		Nearly level to very gentle slopes; 300-3000 m wide; locally rocky	Very shallow soils to lateritic sheet with pockets of moderately deep clay loam. Well drained. Strongly acid.	Grassland with local exposures of laterite sheet. Patches of secondary forest and thicket.	d_4 or $_5$, a_2, n_3, x_5, fl_o, p_2 or $_3$, s_o or $_1$, y_2, locally d_1, x_2, y_o	*Ch: N Ca: N Ct: N Cn N	Co: N G : N M : N R : N
3	0-5	Terrace slopes					
		Short to medium length; straight; moderate slope; gullied, often bouldery	Very shallow soils in pockets between laterite boulders. Well drained. Strongly acid.	Secondary forest	d_5, a_2, n_3, x_5, fl_o, p_2, s_3 or $_4$, y_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
4	0-15	Low colluvial terraces					
		Level to nearly level: 200-800 m wide; slightly undulating	Deep, yellowish brown sandy clay loams. Well drained. Strongly acid.	Mosaic of scattered patches of cultivation, grassland, regrowth thicket and secondary forest. Oil palm common.	d_1, a_2, n_2, x_2, fl_o, p_3, s_1	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
5	10-16	Valley side slopes					
		Ultra short to short; straight; steep slope; gullied, rocky, slump scars common	Shallow clay loams over laterite or gabbro boulders. Well drained. Strongly acid.	Patches of cultivation with regrowth thicket and secondary forest.	d_4, a_2, n_3, x_5 fl_o, p_3, s_4, y_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
6	1-3	Minor floodplains					
		Level to nearly level; 40-100 m wide; locally rocky, locally terraced. Channels 2-5 m wide, variable depth due to rocks	Deep clay loams with high silt contents. Locally sandy or shallow to bedrock. Well drained. Weakly acid.	Intensively cultivated for vegetables.	d_1, a_3, n_1, x_1, w var.(av.2) fl_2, p_3, locally y_1	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1 M : S1 R : S2m

* For locally occuring deep soils on this facet see rating of facet 4.

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

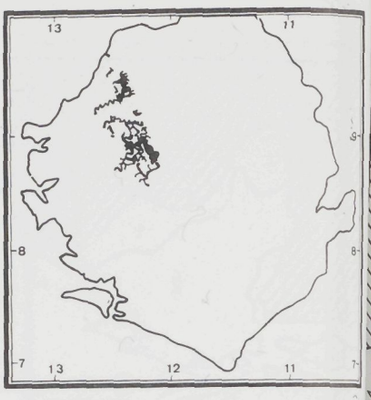
Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

MABOLE LAND SYSTEM 9



(1254 KM^2)

GENERAL DESCRIPTION

Seasonally flooded depressions and floodplains of negligible relief ("bolilands")

GEOLOGY

Colluvium and alluvium on dominantly Rokel River Group sediments.

GEOMORPHOLOGY

A complex of low-lying, seasonally flooded land consisting of low colluvial terraces, "inland bolis" (drainage depressions and minor floodplains) away from major rivers and alluvial terraces, levees, backplains and "riverine bolis" (backswamps) adjacent to these rivers. The low colluvial terraces occur in association with higher-lying remnants of Yonibana and Rokel land systems. They grade into and form a complex pattern with lower-lying (1-2 m) seasonally flooded, featureless drainage depressions varying greatly in width. Locally these are drained by small, seasonal, wooded creeks with very narrow floodplains. Near to major rivers alluvium has been deposited and subsequently dissected to form elevated terraces. These high terraces are relatively flat and are often associated with eroded termitaria. Levees and backplains occur adjacent to the rivers and are locally channelled. Dissection of the alluvium by overflow channels and tributary streams, together with subsequent infill, has led to seasonally flooded backswamps.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
20	40	Negligible	Level to nearly level	Very Coarse	Meandering to sinuous	n.a.

CLIMATIC TYPES C_2 and D_1

GENERAL LAND SUITABILITY

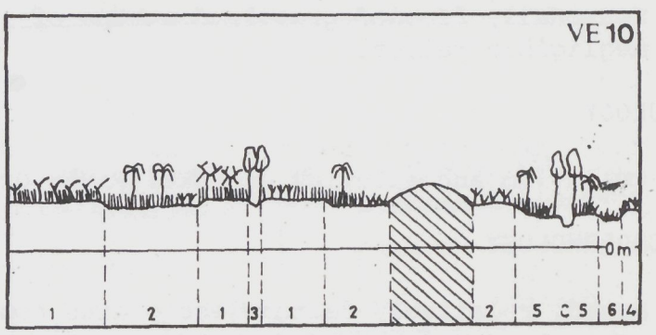
Very low soil fertility and extensive flooding of low-lying areas during the rainy season are the main limitations of this land system. The larger bolis are at present under mechanized rice cultivation for which, together with dry-season grazing, they seem to be best suited. Soils on the terraces are rather variable and often gravelly, hence their generally low suitability for arable and tree crops.

9

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
		(A) "INLAND" FACETS					
	30-50	Low colluvial terraces					
		Level to nearly level; 100-1000 m wide; slightly undulating, commonly with termite mounds	Moderately deep to deep sandy loams to sandy clay loams with variable amounts of ironstone gravel. Well to imperfectly drained. Strongly acid.	Savanna woodland and tree savanna with *Chasmopodium, Lophira* and *Parkia spp;* locally thicket regrowth and patches of cultivation.	d_1, a_2, n_3, x_2, fl_o, p_2 or 3	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
	30-50	Drainage depressions					
		Level; 100-2000 m wide; very slightly undulating, eroded termitaria common	Deep, greyish loams to clays often with high silt contents. Nodular plinthite common in subsoil. Imperfectly to very poorly drained. Strongly to extremely acid.	*Anadelphia/Rhytachne* grassland and common swamp rice cultivation, locally mechanised. Some dry season grazing.	d_1, a_1 or 2, n_3, x_2, w_2, fl_3, p_3 or 4	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2f
	1-3	Minor floodplains					
		Level to nearly level; up to 60 m wide; channels 5-10 m wide and 1-2 m deep	Deep, greyish loams to clays with high silt contents and local sands. Poorly to very poorly drained. Strongly to extremely acid.	Grassland as above with gallery forest along stream courses. Localised rice cultivation.	d_1, a_2, n_3, x_2, w_2, fl_2, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2fm
		(B) "RIVERINE" FACETS					
	3-7	High alluvial terraces					
		Level to nearly level; 100-2000 m wide; slightly undulating, commonly with termite mounds	Deep clay loams to clays, frequently silty and usually with subsoil plinthite. Well drained to imperfectly drained. Strongly acid.	Mainly grassland with *Nauclea* and *Chasmopodium sp.* Scattered cultivation of upland crops. Some dry season grazing.	d_1, a_2, n_3, x_2, w_1 fl_o, p_3 or 4	Ch: S2o Ca: S2o Ct: S3f Cn: S3o	Co: S3m G : S2f M : S2f R : N
	6-16	Levees and backplains					
		Level to nearly level; 100-500 m wide; slightly undulating, locally channelled with up to 3 m relief	Deep loams to clays with high silt contents. Well drained to imperfectly drained. Strongly acid.	*Chasmopodium* grassland. With scattered rice cultivation.	d_1, a_2, n_1, x_1, w_o or 1, fl_o or 1, p_3 or 4	Ch: S3o Ca: S2o Ct: S3f Cn: S3o	Co: S3o G : S2f M : S2f R : N
	1-3	Backswamps					
		Level; 40-600 m wide; locally channelled and slightly undulating	Deep, greyish silty loams to clays with subsoil plinthite. Poorly drained. Strongly acid.	*Anadelphia/Rhytachne* grassland with common rice cultivation, locally mechanised.	d_1, a_2, n_2, x_2 w_2, fl_3, p_4 or 5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

SENEHUN LAND SYSTEM 10



(869 KM^2)

GENERAL DESCRIPTION

Seasonally flooded grassland swamps of negligible relief.

GEOLOGY

Colluvium and alluvium on Rokel River Group sediments.

GEOMORPHOLOGY

Broad, relatively featureless plains comprising high and low colluvial terraces and drainage depressions. The greater part of the plains are formed of high colluvial terraces merging at lower elevations into seasonally flooded drainage depressions. The depressions are drained by small, tree lined creeks. Locally low colluvial terraces are present along the margins of the high terraces.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
50	70	Negligible	Level	Coarse	Dendritic	0.8 (0.6-1.0)

CLIMATIC TYPES

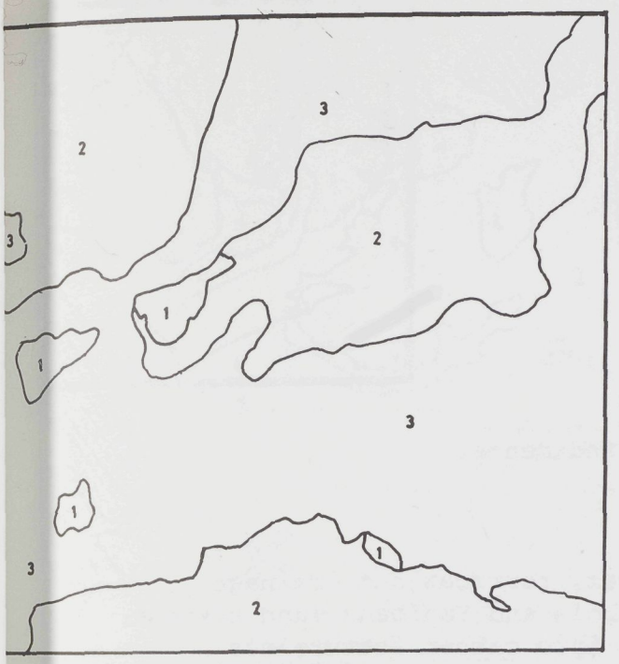
C_1 and C_2

GENERAL LAND SUITABILITY

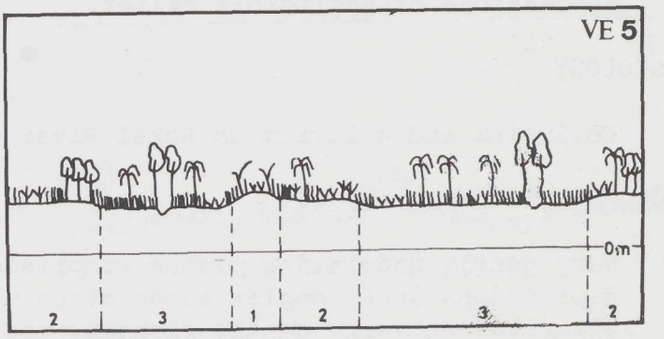
Half this land system consists of seasonally flooded depressions suitable only for paddy rice. These depressions have been rated higher than elsewhere because of rather high levels of organic matter in the topsoil. The more elevated terraces are suitable for acidity tolerant arable and tree crops, in particular for cassava, cashew and coconut.

10

FACET BREAKDOWN



1 Km



Facet no.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	0-10	**High colluvial terraces**					
		Level to nearly level; 400-2000 m wide; mounds very common	Moderately deep to deep loams to clays with varying proportions of ironstone gravel and nodular plinthite. Well drained. Strongly acid.	Mainly grassland but with scattered patches of secondary forest, thicket and oil palms. Common rice cultivation, locally mechanised.	d_1, a_2, n_2 or $_3$ x_2 or $_3$, fl_o, p_3	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S2f G : S2f M : S2f R : N
2	40-50	**Low colluvial terraces**					
		Ultra short to very short; convex; nearly level to very gentle; mounds locally present	Deep, greyish loams to clay loams, often high in fine sand and subsoil gravel or nodular plinthite. Well drained. Strongly acid.	*Lophira* tree savanna with scattered patches of upland crops.	d_1, a_2, n_2 or $_3$, x_2, fl_o, locally x_3	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S1/S2f G : S2f M : S2f R : N
3	40-60	**Drainage depressions**					
		Level; 200-3000 m wide; very slightly undulating, eroded termitaria locally present	Moderately deep to deep, greyish loams to clays, high in fine sand or silt; sandy layers common near stream channels. Imperfectly to poorly drained. Strongly to extremely acid.	Grassland with scattered oil palms and common rice cultivation, locally mechanised. Gallery forest along stream courses.	d_1, a_1 or $_2$, n_2, x_2, w_2, fl_3, p_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

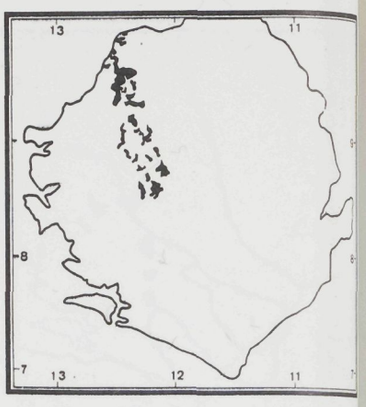
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

ROKEL LAND SYSTEM 11

(1013 KM^2)



GENERAL DESCRIPTION

Colluvial terraces and seasonally flooded depressions of negligible relief.

GEOLOGY

Colluvium and alluvium on Rokel River Group sediments.

GEOMORPHOLOGY

Very gently undulating plains comprising rises, terraces and drainage depressions in a complex association with Mabole and Yonibana land systems. The rises are very gently sloping, and merge into rather featureless terraces at lower levels. The terraces form two, rather indistinct, levels, the lowest of which is only locally present and merges into seasonally flooded drainage depressions. Locally, near major rivers, the higher terraces are formed on old alluvium and border riverine terraces of Mabole land system. The overall relief between the drainage depressions and the higher terraces is less than 3 m. Small wooded creeks are locally present.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
20	50	Negligible (locally extremely low)	Nearly level	Very coarse	Dendritic to sinuous	1.2 (1.0-1.3)

CLIMATIC TYPES

C_2 and D_2

GENERAL LAND SUITABILITY

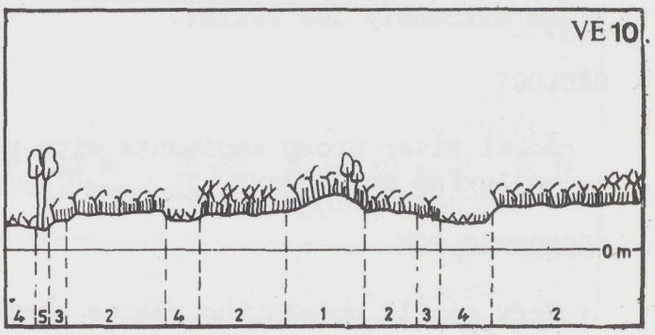
About 20% of this land system is seasonally flooded, hence suitable only for paddy rice. Furthermore, infertile and very acid soils make the suitability low. The remaining more elevated facets have moderate to very low suitability for acidity tolerant crops. However, the dry season over much of the land system is too long for coffee and cocoa growing.

11

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	6-12	Rises 100-300 m wide; slightly convex; very gentle slope	Loams to clay loams with sandy surfaces and ironstone gravel at varying depth. Laterite sheet locally present at shallow depth. Well drained. Strongly acid.	Tree savanna and savanna woodland dominated by *Chasmopodium, Lophira* and *Parkia spp.*	d_2, a_2, n_3 or $_4$, x_3 fl_o, p_2 or $_3$, s_1, locally d_3 or $_4$, x_4	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
2	55-75	High colluvial terraces Level to nearly level; 200-2000 m wide; very slightly undulating, locally slightly rocky	Moderately deep to deep loams to clays commonly sandy and often with subsoil ironstone gravel. Well drained. Strongly acid.	As above with some patches of grassland and scattered cultivation of upland crops.	d_1, a_2, n_3, x_2 or $_3$ fl_o, p_3, locally d_3, x_4	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
3	3-7	Low colluvial terraces Level to nearly level; 100-600 m wide; very slightly undulating	Deep, greyish sandy clay loams to sandy clays. Well to imperfectly drained. Strongly acid.	*Lophira* tree savanna with scattered patches of cultivation.	d_1, a_2, n_3, x_2 fl_o, p_2 or $_3$	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
4	10-30	Drainage depressions Level; 40-400 m wide; very slightly undulating, eroded termitaria common	Deep, greyish fine sands and loams, commonly strongly mottled plinthic subsoil. Imperfectly to very poorly drained. Strongly to extremely acid.	Grassland commonly cultivated for rice; mechanised. Some grazing during dry season.	d_1, a_1 or $_2$, n_3, x_2 w_2, fl_3, p_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2f
5	0-2	Minor floodplains Level; 40-200 m wide; channels 5-10 m wide and 1-2 m deep	Deep, greyish loams to clays with high silt contents and local sands. Poorly drained. Strongly to extremely acid.	Grassland with gallery forest along river channels. Localised rice cultivation.	d_1, a_2, n_3, x_2, w_2 fl_2, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2fm

Land factors

- *d* = Effective soil depth
- *a* = Soil reaction
- *n* = Nutrient status
- *c* = Soil salinity
- *x* = Soil AWC
- *w* = Soil drainage
- *fl* = Flooding
- *p* = Soil permeability
- *s* = Slope steepness
- *y* = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

NJAMA LAND SYSTEM 12



(1404 KM^2)

GENERAL DESCRIPTION

Dissected plains and terraces of negligible to extremely low relief.

GEOLOGY

Rokel River Group sediments with recent deposits of alluvium and colluvium in valleys

GEOMORPHOLOGY

Very gently undulating plains comprising interfluves and terraces, with prominent, straight hill ridges in the area south of Njala. The hill ridges have very low relief and are orientated WNW to ESE. They rise out of a rather featureless plain composed of subrounded interfluves of extremely low relief, associated with almost level footslopes and terraces of negligible relief. The terraces are most common near Senehun land system. A few narrow valley swamps, locally broadening into drainage depressions, are scattered throughout the land system. Along major rivers (e.g. R. Jong) and their tributaries, which are generally deeply incised, floodplains and alluvial terraces of variable width have developed.

TERRAIN PARAMETERS

Altitude Min.(m)	Max(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
30	75	Negligible to extremely low	Very gentle to nearly level	Medium	Dendritic	0.9 (0.8-1.0)

CLIMATIC TYPES

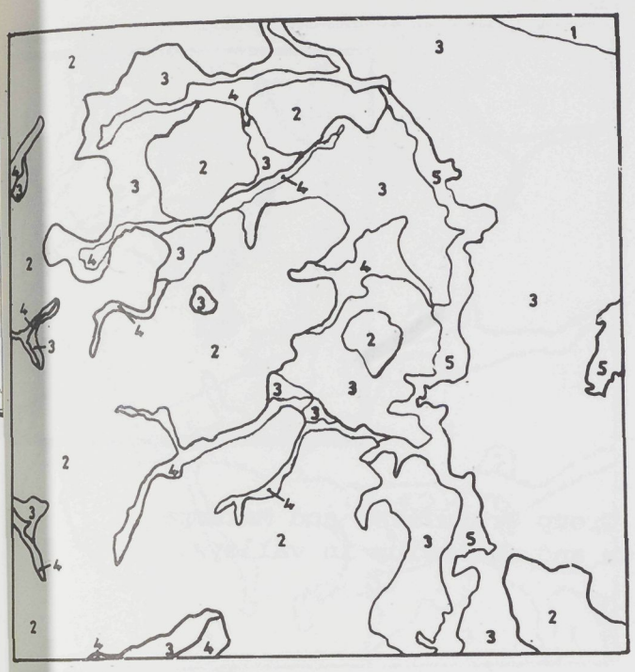
C_1 and C_2

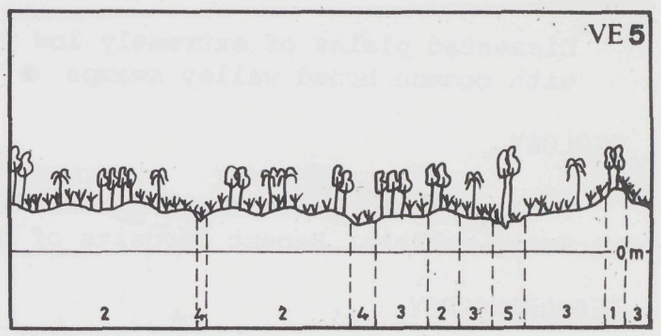
GENERAL LAND SUITABILITY

This land system is limited to less demanding tree crops such as cashew and coconut and, in the moister areas coffee, because of very gravelly, acid and infertile soils. Suitability for arable crops is generally very low but only low for less demanding crops such as cassava, sesame and sorghum. The well drained parts are well suited to ginger, and the swamps and depressions for paddy rice

12

FACET BREAKDOWN





Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	0-2	Low hill ridges					
		Very short to short; convex to straight; gentle slope	Moderately deep to deep, very gravelly, reddish clay loams. Well drained. Strongly to weakly acid.	Secondary forest with scattered patches of cultivation and thicket regrowth. Local *Gmelina* plantations.	d_3, a_2, n_3, x_3 fl_o, p_2 or $_3$, s_3	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S3m G : S3r M : S3e R : N
2	40-70	Interfluves					
		Medium to long; slightly undulating; very gentle slope; mounds locally present	Moderately shallow, brownish to reddish very gravelly clay loams to clays. Well drained.	Mosaic of secondary forest, thicket regrowth and upland crop cultivation.	d_3, a_2, n_3, x_3 fl_o, p_3, s_1	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S3m G : S3r M : S2f R : N
3	20-50	Interfluve footslopes and low colluvial terraces					
		Level to very gentle; 200-2000 m wide; termite mounds common	Deep, yellowish brown sandy clay loams with plinthite or ironstone gravel at depth. Well drained. Strongly acid.	As (2) above, oil palms more common and locally in plantations.	d_1, a_2, n_3, x_2 fl_o, p_3, s_o	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
4	3-7	Valley swamps and drainage depressions					
		Level; 40-250 m wide; locally channelled, mounds locally present	Moderately deep to deep, variable alluvial and colluvial soils. Poorly, locally imperfectly, drained. Strongly, locally extremely, acid.	Grassland with scattered oil palms. Regrowth thicket and raphia palms in valley swamps. Cultivated for swamp rice.	d_1, a_2, n_1 or $_2$, w_2, fl_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
5	0-8	Major floodplains					
		Level 50-1500 m wide; locally terraced	Moderately deep to deep alluvial loams to clays often high in silt and locally sandy or shallow to weathering shale. Well drained to imperfectly drained, locally poorly drained. Extremely acid to weakly acid.	Grassland with gallery forest along river courses. Local swamp rice cultivation.	d_1, a_2, n_1 or $_2$, w_o or $_1$, fl_1, p_3 or $_4$	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S2f M : S2f R : N

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

LUNSAR LAND SYSTEM 13

(2896 KM^2)



GENERAL DESCRIPTION

Dissected plains of extremely low relief with common broad valley swamps

GEOLOGY

Archean granite complex and local Kasila Group granulites and Marampa Group schists. Recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Very gently undulating plains dissected by broad valley swamps. The interfluves are subdued with predominantly very gentle slopes. Locally, between the interfluves and valley swamps, footslopes merging into terraces are present. The valley swamps, which are generally channelled, form a distinctive dendritic drainage pattern.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
30	60	Extremely low	Nearly level to gentle	Medium to coarse	Dendritic	1.3 (1.0-1.7)

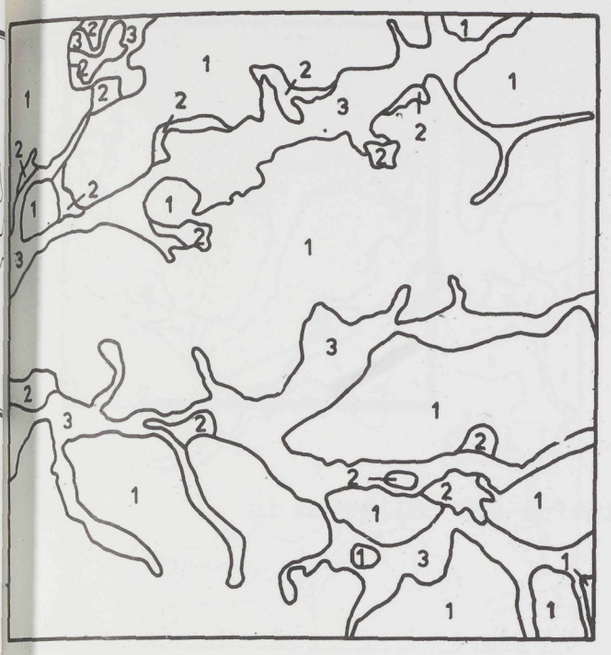
CLIMATIC TYPES C_2, locally C_1 and D_1

GENERAL LAND SUITABILITY

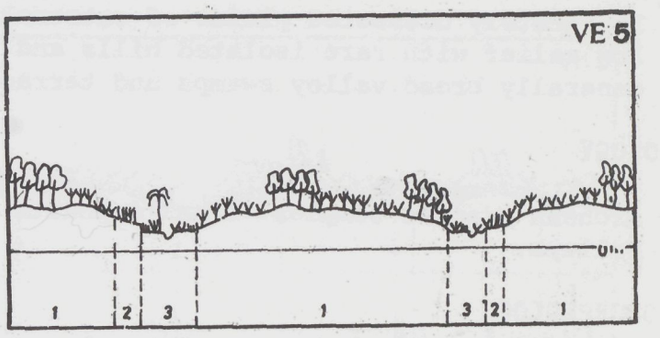
Very gravelly acid soils with low fertility and low water holding capacity are common in most of this land system. The well drained interfluves and terraces are best suited for low demanding tree crops, resistant to a rather long dry period. Suitability for arable crops is generally very low, but higher for less demanding crops such as sesame, sorghum and millet. There is relatively high proportion of broad valley swamps very suitable for paddy rice, possibly with mechanized cultivation.

13

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	70-82	Interfluves					
		Long to very long; straight to convex; very gentle to gentle slope; undulating	Moderately shallow, reddish, very gravelly, clay loams, locally shallow to laterite sheet. Deep, brownish sandy clay loams often occur on crests. Well drained. Strongly acid.	Mosaic of secondary forest, thicket and upland crops cultivation. Coffee is grown in SE. Oil palms common.	d_3, a_2, n_3, x_3, fl_o, p_3, s_1	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S3m G : S3r M : S2f R : N
2	3-5	Interfluve footslopes and low colluvial terraces					
		Nearly level to very gentle slope; 100-200 m wide; few termite mounds	Deep, yellowish brown clays and sandy clay loams with nodular plinthite or iron-stone gravel at depth. Well to locally imperfectly drained. Strongly acid.	As above with common upland crops and wild oil palm.	d_1, a_2, n_3, x_2 fl_o, p_3, locally w_1	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
3	15-25	Valley swamps					
		Level; 100-500 m wide; locally channelled	Deep, variable alluvial and colluvial soils locally peaty. Poorly drained to waterlogged. Strongly to weakly acid.	Sedge grass, raphia palms and scattered oil palms. Common swamp rice cultivation.	d_o, a_3, n_1, x_1 or $_2$, w_3, fl_3, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

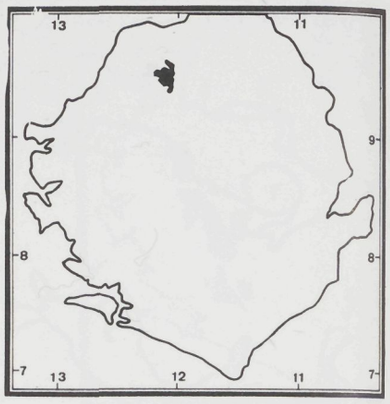
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

LAIA LAND SYSTEM 14

(262 KM^2)



GENERAL DESCRIPTION

Intricately dissected plains of extremely low relief with rare isolated hills and generally broad valley swamps and terraces.

GEOLOGY

Archean granite complex. Local deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Very gently undulating plains dissected by broad valley swamps. Scattered isolated, rocky hills of very low relief are present rising abruptly out of broad, subdued interfluves. The interfluves are very gently sloping and locally bouldery. The lower parts of the interfluves grade into the swamps through extensive footslopes and terraces. Small, tree lined creeks flowing through the swamps give rise to a distinctive dendritic drainage pattern.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
100	150	Extremely low (hills very low)	Very gentle	Coarse	Dendritic	1.7 (1.6-1.8)

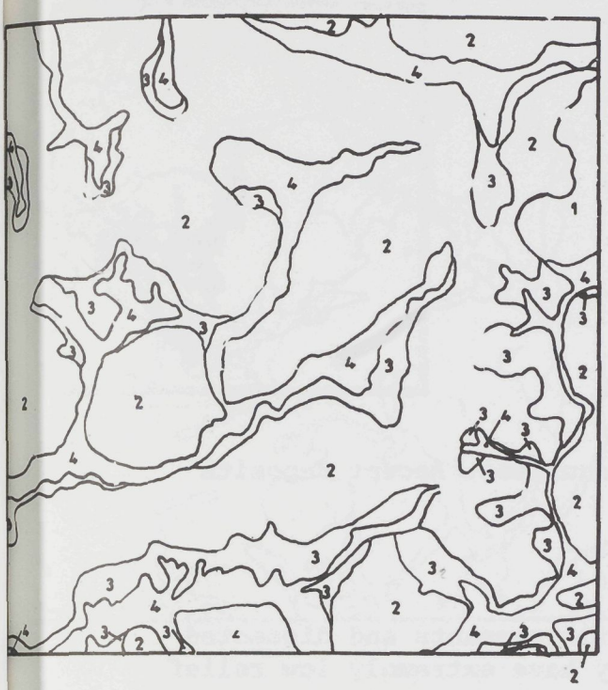
CLIMATIC TYPE D_1

GENERAL LAND SUITABILITY

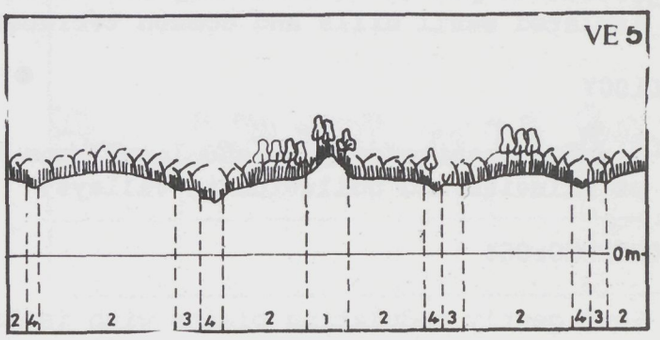
A long dry season and soils which are acid, infertile and in places very gravelly make this land system suitable for low demanding, drought resistant tree crops such as cashew, and for arable crops such as sesame, sorghum and millet. Valley swamps, being rather sandy, have a suitability for paddy rice which is lower than that of other land systems.

14

FACET BREAKDOWN



1 Km



Facet	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
	0-4	Isolated hills					
		Short to medium slopes: straight; steep; frequently rocky. Very narrow to narrow, uneven, rocky crests	Shallow to moderately deep, reddish clay loams containing varying proportions of ironstone gravel. Well drained. Weakly acid.	Thicket and secondary forest; some savanna woodland and rare patches of cultivation.	d_4, a_3, n_2 or $_3$, x_4 or $_5$, fl_o, p_3, s_4, y_1	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
	65-75	Interfluves					
		Medium length; convex; level to very gentle slope; locally uneven crests and gullied side slopes	Moderately deep to deep, very gravelly reddish loams to clay loams. Deep, brownish sandy clay loams locally present on crests. Well drained. Strongly to weakly acid.	Savanna woodland with some secondary forest. Scattered cultivation of upland crops.	d_2, a_2, n_2 or $_3$, x_3, fl_o, p_2, s_1, locally d_1, x_2, y_2	Ch: S1 Ca: S1/S2r Ct: S3f Cn: S2m	Co: N G : S2f/S3r M : S2f R : N
	10-18	Interfluve footslopes and low colluvial terraces					
		Nearly level to very gentle; 50-600 m wide; termite mounds common	Deep, brownish to reddish sandy clay loams, locally with nodules or ironstone gravel in the subsoil. Well drained. Strongly to weakly acid.	Savanna woodland dominated by *Lophira spp.* Scattered cultivation of upland crops.	d , a_2, n_3, x_2, fl_o, p_3, s_1	Ch: S1 Ca: S1 Ct: S3f Cn: S2m	Co: N G : S2f M : S2f R : N
	12-18	Valley swamps					
		Level; 50-200 m wide; locally channelled	Deep alluvial and colluvial sands. Poorly to very poorly drained. Weakly acid.	Grassland. Common rice cultivation, locally mechanised.	a_2, n_3, x_3, w_3, fl_3, p_1	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2fm

Land factors

- *d* = Effective soil depth
- *a* = Soil reaction
- *n* = Nutrient status
- *c* = Soil salinity
- *x* = Soil AWC
- *w* = Soil drainage
- *fl* = Flooding
- *p* = Soil permeability
- *s* = Slope steepness
- *y* = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

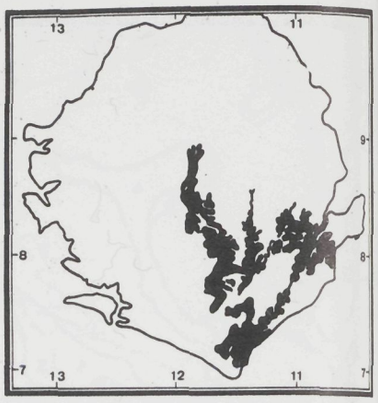
- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

BLAMA LAND SYSTEM 15

(6569 KM^2)



GENERAL DESCRIPTION

Dissected plains of extremely low relief with isolated small hills and common terraces.

GEOLOGY

Archean granite complex and local Mano-Moa granulites. Recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Very gently undulating plains with isolated hill remnants and dissected by complex valley systems. The hills generally have extremely low relief and rise sharply from broad, rounded interfluves, which are in places dissected. The valleys, which are often flanked by narrow footslopes, comprise a complex of swamps of variable width and generally narrow terraces. Narrow stream channels and associated inconspicuous terraces are locally present. Adjacent to major rivers there are discontinuous alluvial plains of variable width, the higher parts of which flood only in exceptionally wet years.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
60	120	Extremely low (locally low)	Very gentle	Medium	Dendritic	1.4 (1.4-1.5)

CLIMATIC TYPES

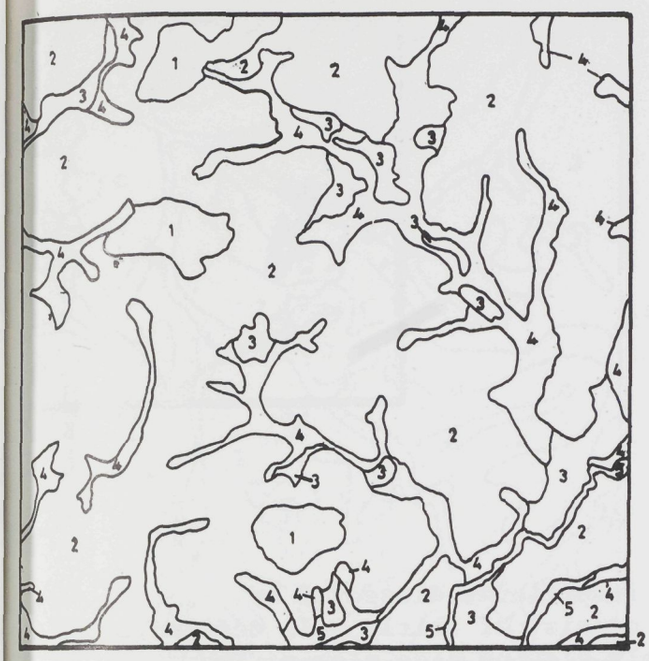
B and C_1, locally C_2

GENERAL LAND SUITABILITY

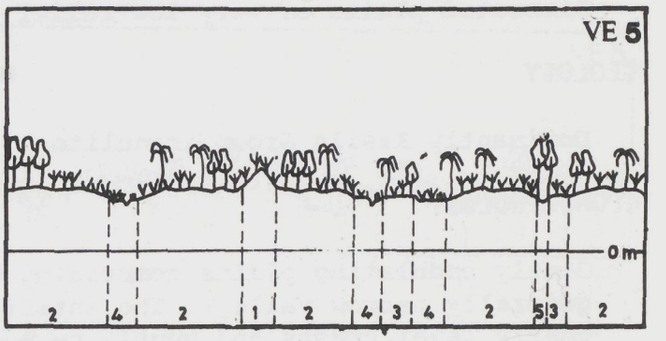
A very long rainy season characterizes most of this land system, giving it a low suitability for arable crops, unless the crop growth cycle is carefully adjusted to the end of the rains. As soils are very gravelly, acid and of low fertility, the upland areas are suited for tree crops such as coffee, oil palm and rubber. Localized occurrence of gravel free, well to imperfectly drained soils leads to suitability for cocoa. Valley swamps are well suited to paddy rice.

15

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	0-6	Isolated hills Short; straight to convex; gentle to moderate slope; slightly gullied locally rocky	Moderately deep to deep, gravelly and stony clay loams over weathering rock, interspersed with shallow soils. Well drained. Strongly acid.	Secondary forest, thicket and patches of cultivation. Coffee and cocoa locally present.	d_2, a_2, n_3, x_3, fl_o, p_3, s_3, locally d_4, x_5 and y_3	Ch: S2m Ca: S2e Ct: S3f Cn: S2e	Co: S2f G : S2fe M : S3e R : N
2	70-80	Interfluves Medium to long; undulating; very gentle to gentle slope; slightly gullied in places	Moderately deep, gravelly, reddish clay loams to clays with deep brownish sandy clay loams on some crests. Well drained. Strongly acid.	Mosaic of secondary forest, thicket and patches of cultivation. Oil palm plantations locally present. Cocoa, coffee and kola common.	d_1 or $_2$, a_2, n_2 or $_3$, x_2 or $_3$, fl_o, p_2 or $_3$, s_1 or $_2$	Ch: S2m Ca: S2m Ct: S3f Cn: S1	Co: S2f G : S2fm/S3r M : S2fm R : N
3	4-10	Interfluve footslopes and low colluvial terraces Level to very gentle; 50-200 m wide; termite mounds common	Moderately deep to deep, brownish sandy clay loams to clays, locally gravelly. Well drained. Strongly to weakly acid.	Mosaic of secondary forest, thicket and patches of cultivation. Oil palm plantations locally present. Cocoa, coffee and kola common.	d_1, a_2, n_2, x_2, fl_o, p_3, s_o or $_1$	Ch: S2m Ca: S2m Ct: S3f Cn: S1	Co: S1 G : S2fm M : S2fm R : N
4	12-16	Valley swamps Level to nearly level; 50-300 m wide, locally channelled	Deep, variable alluvial and colluvial soils. Imperfectly to very poorly drained. Strongly to weakly acid.	Sedge grassland with raphia palm and local regrowth thicket. Swamp rice cultivation common.	d_1, a_2, n_1 or $_2$, x_2 or $_3$, w_2 or $_3$, fl_3, p_1 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
5	0-1	Minor floodplains Level to nearly level; 10-40 m wide; channels 3-8 m wide, 1.5-4 m deep	Moderately deep to deep, variably textured colluvial soils, commonly gravelly in subsoil. Well drained. Strongly to weakly acid.	Gallery forest with scattered cultivation of upland crops.	d_1, a_3, n_1 or $_2$, x_2, fl_1, p_2 or $_3$	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S2m M : S2m R : N
6*	0-1	Major floodplains Level; 40-400 m wide; locally terraced	Deep alluvial loams to clays with high silt contents. Well drained to imperfectly drained. Strongly to weakly acid.	Riparian forest with understorey of coffee and cocoa.	d_1, a_2, n_1 or $_2$, x_2, fl_o, p_4, locally w_1, fl_1	Ch: S3o Ca: S2m Ct: S3f Cn: S3o	Co: S1 G : S2fm M : S2fm R : N

* Not present in type area-average over whole land system

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil ANC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

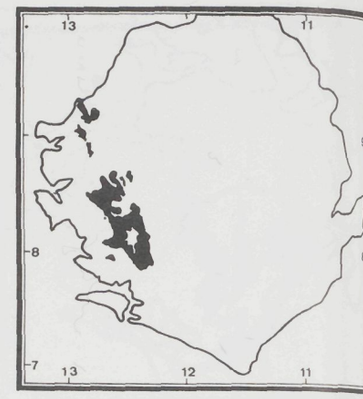
Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

MOYAMBA LAND SYSTEM 16



(2411 KM^2)

GENERAL DESCRIPTION

Dissected plains of very low relief

GEOLOGY

Dominantly Kasila Group granulites

GEOMORPHOLOGY

Gently undulating plains comprising broad interfluves dissected by generally narrow valleys. The interfluves consist of fairly well defined, nearly level crests and gently to moderately sloping side slopes. The valleys comprise poorly drained swamps in their upper reaches, which merge lower down into wider floodplains drained by small dendritic tributary streams.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
40	100	Low	Gentle	Medium	Dendritic	1.3 (1.2-1.4)

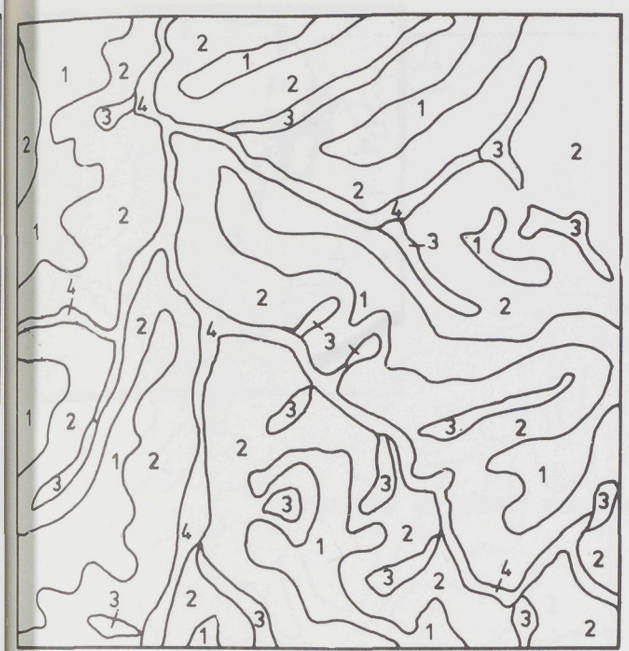
CLIMATIC TYPES C_2, locally D_1

GENERAL LAND SUITABILITY

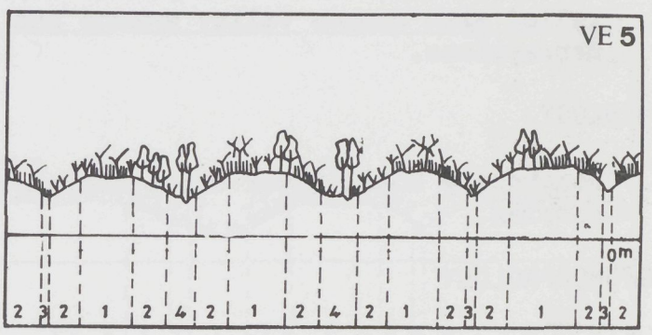
Strongly acid and predominantly very gravelly soils with low water holding capacity, combined with a high proportion of gentle to moderate slopes, rather curb the suitability of this land system. Most of the area is suitable for tree crops resistant to a moderately long dry season, and for ginger. Local swamps and floodplains are respectively suitable for paddy rice and short cycle arable crops.

16

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	20-30	Interfluve crests Nearly level to very gentle; 100 to 500 m wide; slightly undulating	Moderately shallow, very gravelly, reddish clay loams to clays. Locally gravel free and yellowish. Well drained. Strongly acid to weakly acid.	Mosaic of secondary forest, thicket regrowth and scattered cultivation. In the north, savanna woodland with *Chasmopodium*, *Lophira* and *Parkia spp.* is dominant.	d_3, a_2, n_3, x_3, fl_o, p_3, s_o or $_1$	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S3m G : S3r M : S2f R : N
2	60-70	Interfluve side slopes Medium to long; straight; gentle to locally moderate slope; slightly gullied	Moderately shallow, very gravelly, reddish loams to clays. Well drained. Strongly to weakly acid.	Mosaic of secondary forest, thicket regrowth and scattered cultivation. In the north, savanna woodland with *Chasmopodium*, *Lophira* and *Parkia spp.* becomes common.	d_3, a_2, n_3, x_3 fl_o, p_3, s_2	Ch: S1 Ca: S2re Ct: S3f Cn: S1	Co: S3m G : S3r M : S2f R : N
3	2-6	Valley swamps Level to nearly level; 40-100 m wide; locally channelled	Deep, variable alluvial and colluvial soils, commonly with sandy subsoils. Imperfectly to very poorly drained. Strongly to weakly acid.	Sedge grassland with fairly intensive swamp rice cultivation. Regrowth thicket with raphia palm locally present.	d_1, a_3, n_1, x_2, w_3, fl_3, p_2 or $_3$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
4	4-8	Minor floodplains Level to nearly level; 40-2000 m wide; channels up to 10 m wide and 3 m deep	Deep, medium to heavy textured alluvial soils; locally moderately shallow to bedrock. Well drained. Strongly to weakly acid.	Intensive vegetable and arable cultivation together with swamp rice; gallery forest along river courses.	d_1, a_3, n_2, x_1, w_o or $_1$, fl_1	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S1 M : S1 R : N

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

YONIBANA LAND SYSTEM 17



(3467 KM^2)

GENERAL DESCRIPTION

Rather variable dissected plains of very low relief with common valley swamps and drainage depressions.

GEOLOGY

Dominantly Rokel River Group sediments with some Archean granite complex.

GEOMORPHOLOGY

Gently undulating plains comprising generally broad interfluves dissected by valley swamps and broad drainage depressions. Typically the interfluves consist of fairly well defined, nearly level, broad crests, comprising approximately half of the land system, and gently sloping side slopes. However, when associated with Rokel and Mabole land systems, the interfluves occur as subdued remnants in which crests are less well defined. The valley swamps, which are generally narrow, are closely associated with broad, flat drainage depressions. Narrow terraces and valley heads are scattered throughout the land system along the swamps and depressions. Seasonally dry, tree-lined river courses and associated narrow floodplains are locally present.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
50	90	Very low	Very gentle	Coarse	Dendritic	1.2 (0.8-1.4)

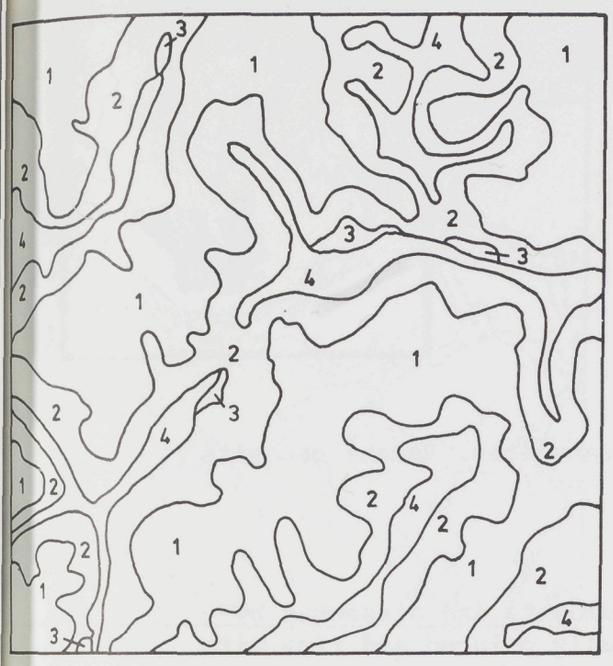
CLIMATIC TYPES D_1 locally C_1, C_2 and D_2

GENERAL LAND SUITABILITY

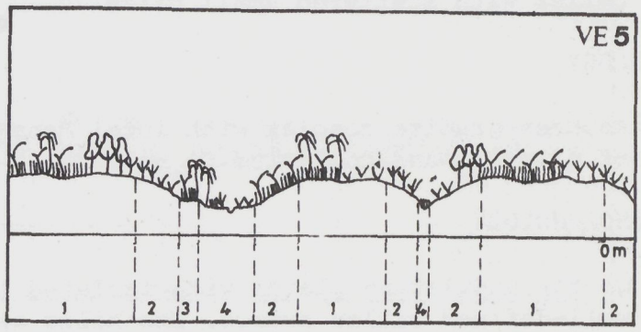
A long dry season, acid and very gravelly soils with low fertility, limit the suitability of this land system to low demanding, drought resistant tree crops, and to such arable crops as sorghum and millet. The southern part of the area is suitable for ginger and the relatively fertile floodplains suitable for more demanding short cycle crops. Valley swamps and depressions are suited to paddy rice.

17

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	38-47	Interfluve crests Nearly level to very gentle slope; 200-800 m wide; very slightly undulating	Moderately deep to moderately shallow, very gravelly loams to clays, locally shallow to laterite sheet. Well drained. Strongly acid.	Mosaic of savanna woodland, regrowth thicket and scattered cultivation; locally *Lophira* tree savanna is dominant. Towards the south patches of secondary forest are present.	d_2 or $_3$, a_2, n_3, x_2 or $_3$, fl_o, p_3, locally s_1, d_4, x_5	Ch: S1 Ca: S2r Ct: S3f Cn: S2m	Co: N G : S3r M : S2f R : N
2	38-47	Interfluve side slopes Short to medium length; straight; very gentle to gentle, locally moderate slope; slightly gullied	Moderately shallow, very gravelly loams to clays. Well drained. Strongly acid.	Mosaic of savanna woodland, regrowth thicket and scattered cultivation; locally *Lophira* tree savanna is dominant. Towards the south patches of secondary forest are present.	d_3, a_2, n_3, x_3, fl_o, p_3, s_1 or $_2$, locally y_1	Ch: S1 Ca: S2r Ct: S3f Cn: S2m	Co: N G : S3r M : S2f R : N
3	0-2	Low colluvial terraces Level to nearly level; 40-100 m wide	Moderately deep to deep sandy loams to sandy clay loams, locally very gravelly. Well drained. Strongly acid.	As above but more commonly cultivated. Oil palm plantations locally present.	d_1, a_2, n_3, x_2, fl_o, p_3	Ch: S1 Ca: S1 Ct: S3f Cn: S2m	Co: N G : S2f M : S2f R : N
4	10-16	Valley swamps and drainage depressions Level; 40-400 m wide; locally channelled	Moderately deep to deep, variable alluvial and colluvial soils. Poorly drained. Strongly acid.	Grassland or sedge grassland with raphia and stunted oil palm. Locally regrowth thicket is present.	d_1, a_2, n_1 or $_2$, w_2, fl_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
5	*0-2	Minor floodplains Level to nearly level; up to 100 m wide; channels 5-10 m wide and 1-3 m deep	Deep, medium to heavy textured alluvial and locally colluvial soils. Well drained to imperfectly drained. Strongly to weakly acid.	Grassland with few oil palms. Gallery forest along stream courses. Localised vegetable cultivation.	d_1, a_3, n_2, x_1, w_o or $_1$, fl_1	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S1 M : S1 R : N

*Not present in type area - area given is the average over the whole land system.

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

BO LAND SYSTEM 18



(5876 KM^2)

GENERAL DESCRIPTION

Intricately dissected plains of very low relief with scattered small hills.

GEOLOGY

Archean granite complex with local Mano-Moa granulites. Recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Gently undulating plains with isolated hill remnants and dissected by well-defined valley swamps. The hills are usually pointed and rise with an extremely low relief from fairly broad interfluves. The gently to moderately sloping interfluve side slopes have commonly been dissected by broad gullies giving rise to narrow,uneven crests. There is usually a well-defined break of slope between the interfluves and valley swamps, except where gentle,narrow footslopes and terraces occur. Narrow stream channels are locally present. Adjacent to major rivers there are discontinuous alluvial plains of variable width, the higher parts of which flood only in exceptionally wet years.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
60	120	Very low (locally low)	Gentle	Medium	Dendritic	1.6 (1.5-1.7)

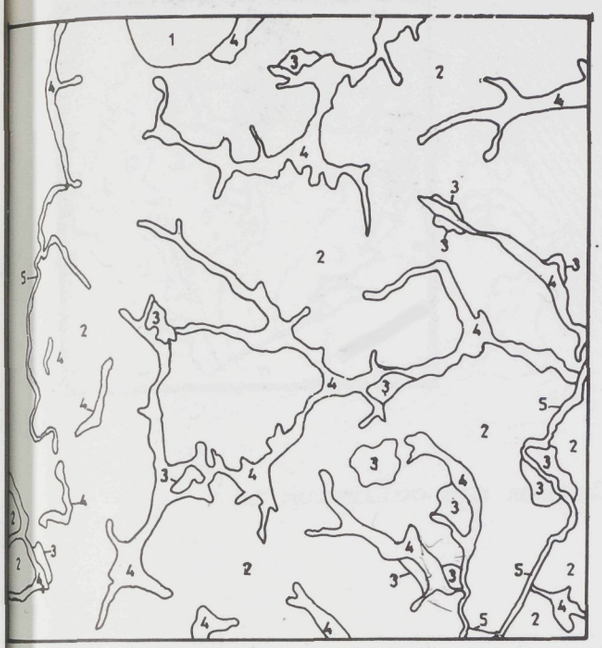
CLIMATIC TYPES B, C_1 and C_2

GENERAL LAND SUITABILITY

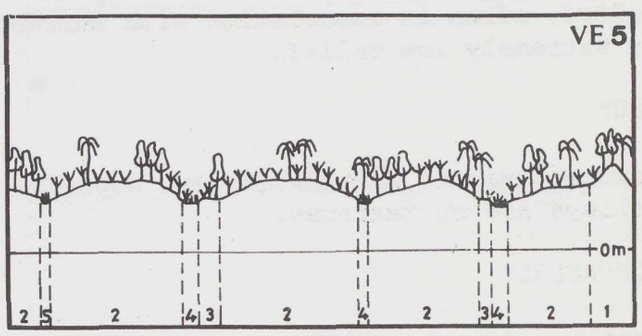
Strongly acid, infertile, mostly very gravelly soils with very low water holding capacity seriously limit the potential of this land system, making it suitable for tree crops such as coffee, oil palm, rubber and, where gravel-free soils occur, for cocoa. Valley swamps and floodplains are respectively suitable for paddy rice and short cycle arable crops.

18

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability
1	0-4	Isolated hills Short; straight to convex; gentle to moderate slope; locally rocky	Moderately deep to deep, brownish to reddish, gravelly and stony, medium textured soils over weathering bedrock, interspersed with shallow soils. Well drained. Strongly acid.	Mosaic of secondary forest, regrowth thicket and scattered cultivation; coffee and cocoa locally present.	d_2, a_2, n_3, x_3 fl_o, p_3, s_3, *locally* d_4, x_5 *and* y_3	Ch: S1 Co: S2f Ca: S2s G : S2fe Ct: S3f M : S3e Cn: S3e R : N
2	75-85	Interfluves Medium length undulating; very gentle to gentle slope; locally rocky and stony	Moderately shallow to deep, brownish to reddish, gravelly sandy clay loams to clays. Locally very shallow to bedrock. Well drained. Strongly acid.	Mosaic of secondary forest, regrowth thicket and patches of cultivation; coffee, kola and cocoa common. Oil palms common, locally as plantations.	d_1 *or* $_2$, a_2, n_2 *or* $_3$, x_2 *or* $_3$, fl_o, p_2 *or* $_3$, s_1 *or* $_2$, *locally* d_3,	Ch: S1 Co: S2f Ca: S1/S2r G : S2f/S3r Ct: S3f M : S2f Cn: S1 R : N
3	2-4	Interfluve footslopes and low colluvial terraces Level to very gentle slope; 50-100 m wide; termite mounds common	Moderately deep to deep, brownish, locally gravelly, sandy clay loams. Well to imperfectly drained. Strongly acid.	Mosaic of secondary forest, regrowth thicket and patches of cultivation; coffee, kola and cocoa common. Oil palms common, locally as plantations.	d_1, a_2, n_2, x_2 fl_o, p_3, s_o *or* $_1$	Ch: S1 Co: S1 Ca: S1 G : S2f Ct: S3f M : S2f Cn: S1 R : N
4	12-16	Valley swamps Level to nearly level; 40-100 m wide; locally channelled	Deep, generally coarse textured alluvial and colluvial soils; locally organic. Poorly drained to waterlogged. Strongly to weakly acid.	Sedge grassland with raphia palm and local regrowth thicket. Swamp rice cultivation common.	d_1, a_2, n_1 *or* $_2$, x_2 *or* $_3$, w_2 *or* $_3$, fl_3, p_1 *or* $_4$	Ch: N Co: N Ca: N G : N Ct: N M : N Cn: N R : S1
5	0-1	Minor floodplains Level to nearly level; 10-40 m wide; channels. 3-8 m wide, 1.5-4 m deep	Moderately deep to deep, variably textured colluvial soils, commonly gravelly in subsoil. Well drained; Strongly to weakly acid.	Gallery forest with scattered cultivation of upland crops.	d_1, a_3, n_1 *or* $_2$, fl_1, p_2 *or* $_3$	Ch: S3o Co: N Ca: N G : S1 Ct: N M : S1 Cn: S3o R : N
6	*0-1	Major floodplains Level; 40-400 m wide; locally terraced	Deep alluvial loams to clays, high in silt. Well to imperfectly drained. Strongly to weakly acid.	Riparian forest with understorey of coffee and cocoa.	d_1, a_2, n_1 *or* $_2$, x_2 fl_o, p_4, *locally* w_1, fl_1	Ch: S1 Co: S1 Ca: S2f G : S2f Ct: S3f M : S2f Cn: S1 R : N

*Not present in type area - average over whole land system.

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

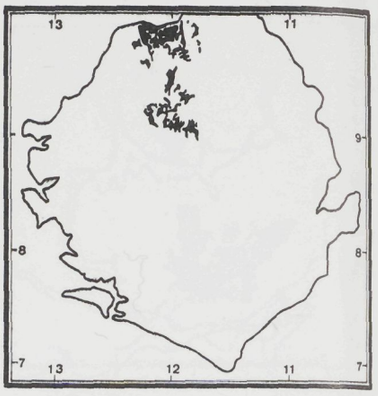
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

WARI LAND SYSTEM 19

(1381 KM^2)



GENERAL DESCRIPTION

Complex of dissected plains of very low relief, often in association with terraces of extremely low relief.

GEOLOGY

Archean granite complex. Recent deposits of alluvium and colluvium in valleys and on terraces.

GEOMORPHOLOGY

Gently undulating plains comprising, at its most typical, broad, rounded interfluves with occasional, isolated, rocky hills, dissected by ill-defined, narrow valley swamps. Generally footslopes and terraces are only locally present. However, when adjacent to hilly terrain, this land system has a much higher proportion of nearly level terraces with interfluves which are much less conspicuous. A few minor streams are present associated with narrow floodplains and terraces. Major rivers with broader floodplains occur along the edge of the plateau escarpment.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
50	80	Extremely low to low	Very gentle	Coarse	Dendritic	1.7 (1.3-2.1)

CLIMATIC TYPES

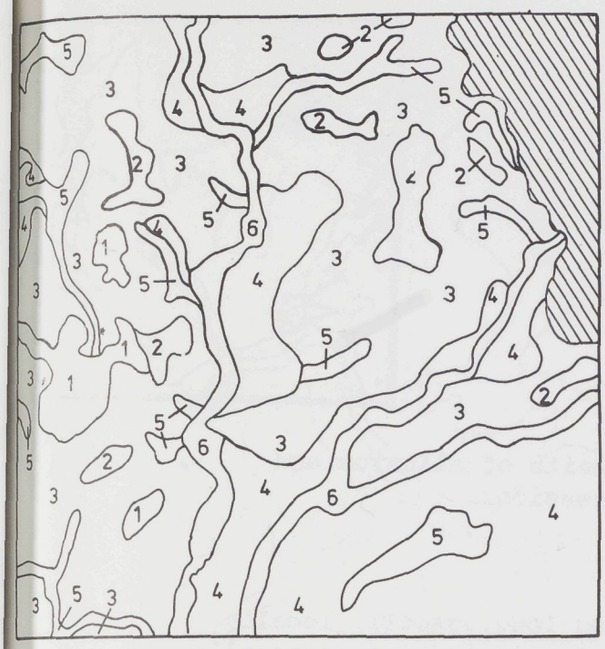
C_2, D_1 and D_2

GENERAL LAND SUITABILITY

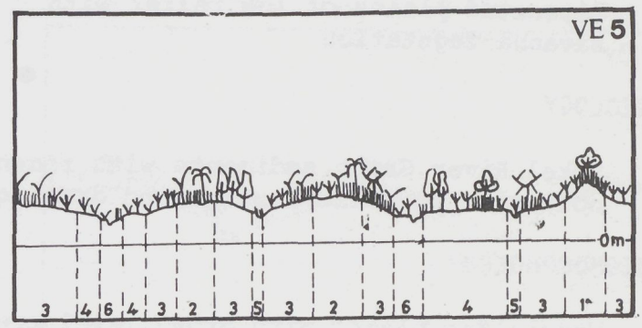
This system has a low suitability due to a long dry season and commonly gravelly and often shallow, acid, infertile soils with low water-holding capacity. Locally, deeper, gravel free soils occur on the interfluves and footslope/terraces and these are better suited for arable crops. The valley swamps and floodplains are suited to paddy rice and short cycle arable crops respectively.

19

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	0-8	Isolated hills					
		Short to medium length slopes; straight; steep; often rocky. Very narrow to narrow, uneven, rocky crests	Shallow to moderately deep, reddish clay loams containing varying amounts of gravel. Well drained. Strongly to weakly acid.	Savanna woodland and regrowth thicket with scattered patches of cultivation.	d_4, a_2, n_3, x_3, fl_o, p_2, s_4, y_2, locally d_1, x_2, y_o	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
2	4-14	Interfluve crests					
		Nearly level to very gentle slope; 50-200 m wide; slightly undulating	Moderately shallow to deep, reddish sandy clay loams with varying amounts of gravel. Well drained. Strongly to weakly acid.	Savanna woodland and regrowth thicket with some oil palm. Patches of cultivation.	d_1, a_2, n_3, x_2, fl_o, p_3, s_o or $_1$, locally d_2 or $_3$, x_3	Ch: S1 Ca: S1/S2r Ct: S3f Cn: S2m	Co: N G : S2f/S3r M : S2f R : N
3	40-80	Interfluve side slopes					
		Medium to long; straight; very gentle to gentle slope	Moderately shallow to deep, reddish loams to clay loams, frequently sandy and with varying amounts of gravel. Well drained. Strongly to weakly acid.	Savanna woodland with some thicket and locally secondary forest. Patches of cultivation.	d_1, a_2, n_3, x_2, fl_o, p_2 or $_3$, s_1 or $_2$, locally d_2 or $_3$, x_3	Ch: S1 Ca: S1/S2r Ct: S3f Cn: S2m	Co: N G : S2f/S3r M : S2f R : N
4	6-30	Interfluve footslopes and low colluvial terraces					
		Level to very gentle; 50-1000 m wide; termite mounds common	Moderately shallow to deep, brownish to reddish loams to clays, frequently sandy and with varying amounts of gravel. Well drained. Strongly to weakly acid.	Mosaic of secondary forest, thicket and savanna woodland with patches of cultivation.	d_o or $_1$, a_2, n_2 or $_3$, x_2 or $_3$, fl_o, p_3, s_1	Ch: S1 Ca: S1 Ct: S3f Cn: S2m	Co: N G : S2f M : S2f R : N
5	6-10	Valley swamps					
		Level; 50-200 m wide, locally channelled	Deep, variably textured alluvial and colluvial soils. Imperfectly to very poorly drained. Strongly to weakly acid, locally neutral.	Sedge grassland with raphia palm and stunted oil palms. Common swamp rice cultivation.	d_1, a_2, n_1 or $_2$, x var., w_3, fl_3 p var.	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
6	0-2	Minor floodplains					
		Nearly level to level; 50-200 m wide; channels 10-30 m wide, 1.5-4 m deep	Deep, medium to heavy textured alluvial soils, commonly high in silt. Well to imperfectly drained. Strongly acid to locally neutral.	Grassland with patches of thicket and cultivation, mainly swamp rice. Gallery forest along river courses.	d_1, a_3, n_1, x_o or $_1$, w_o or $_1$, fl_1, p_3 or $_4$	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S1 M : S1 R : N

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

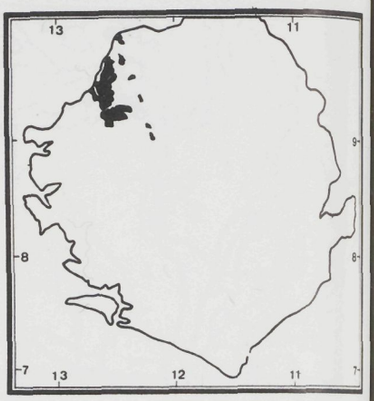
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

BOROMPO LAND SYSTEM 20

(1009 KM^2)



GENERAL DESCRIPTION

Dissected plains of low relief with savanna vegetation

GEOLOGY

Rokel River Group sediments with recent deposits of alluvium and colluvium in valley swamps and drainage depressions.

GEOMORPHOLOGY

Undulating plains with broad level crests and long, gentle, locally gullied, side slopes. Fairly broad drainage depressions and generally narrow valley swamps together comprise less than 10% of the land system.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
30	100	Very low to low	Very gentle	Coarse to very coarse	Dendritic	0.9 (0.8-1.0)

CLIMATIC TYPE D_1 and D_2

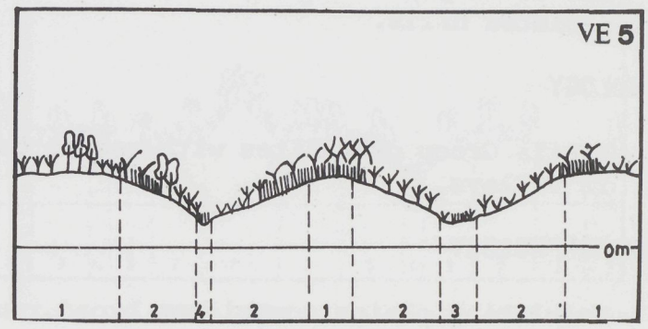
GENERAL LAND SUITABILITY

Very gravelly infertile soils with low water holding capacity, combined with a long dry season and rather pronounced slopes give this land system a suitability which is generally very low for most crops and slightly higher for cashew, cassava, sesame, sorghum and, in the swamps, for paddy rice.

20

FACET BREAKDOWN





Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	24-30	Interfluve crests Very broad; even to slightly uneven; nearly level to very gentle slope	Moderately shallow to deep, reddish, very gravelly loams to clays. Well drained. Strongly acid, locally neutral.	Savanna woodland or tree savanna with patches of secondary forest, re-growth thicket and cultivation. Some wet season grazing.	d_3, a_2, n_3, x_3, fl_o, p_2 or $_3$, y_1	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: N G : S3r M : S2f R : N
2	60-70	Interfluve side slopes Medium length to very long; straight to concave; very gentle to gentle slope; locally gullied	Moderately shallow to deep,reddish, very gravelly loams to clays. Well drained. Strongly acid.	Savanna woodland or tree savanna with patches of secondary forest, re-growth thicket and cultivation. Some wet season grazing.	d_3, a_2, n_3, x_3, fl_o, p_3, s_1 or $_2$	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: N G : S3r M : S2f R : N
3	2-6	Drainage depressions Level to nearly level; 100-400 m wide	Deep, pale, fine sand over gleyed clay. Poorly drained. Strongly acid.	Grassland with scattered raphia and oil palms. Commonly cultivated for swamp rice.	d_1, a_2, n_3, x_3, w_2, fl_3, p_1 to $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2f
4	2-6	Valley swamps Level to nearly level; 40-200 m wide; locally channelled	Deep, medium to heavy textured alluvial and colluvial soils. Very poorly drained. Strongly to weakly acid.	Sedge grassland with raphia palm and localised thicket. Common rice cultivation.	d_1 or $_2$, a_3, n_2, x_3, w_3, fl_3, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

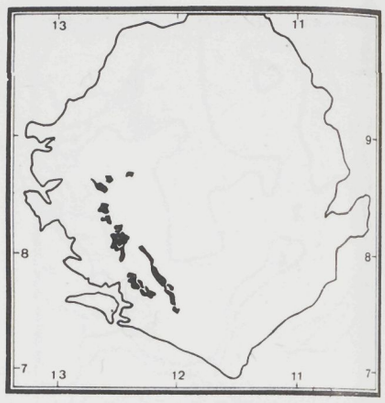
Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

MAKUNDU LAND SYSTEM 21



(779 KM^2)

GENERAL DESCRIPTION

Dissected plains of low relief and rare isolated hills.

GEOLOGY

Kasila Group granulites with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Undulating plains comprising broad,rounded interfluves dissected by valley swamps and floodplains. In some areas a few isolated,pointed hills are present. Generally, however, broad,flat interfluve crests merge into gently to moderately sloping, slightly dissected side slopes. At the foot of the side slopes well defined, generally narrow swamps are present, locally broadening into small floodplains.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
20	150	Low	Very gentle to gentle	Coarse	Dendritic	0.8 (0.6-1.0)

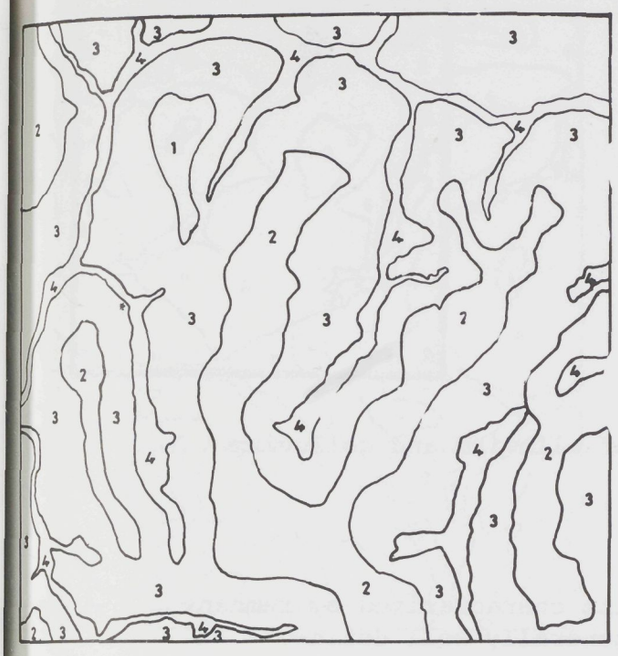
CLIMATIC TYPE C_2

GENERAL LAND SUITABILITY

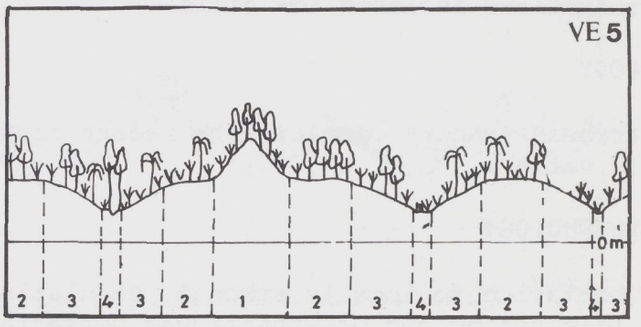
Very gravelly, rather shallow, infertile soils and sloping terrain make the suitability of this land system low. Uplands are suitable for ginger and cashew, swamps for paddy rice.

21

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	0-6	Isolated hills Short; straight; moderate to steep slope; gullied, locally rocky	Very shallow to moderately deep clay loams with variable gravel contents. Well drained. Strongly acid.	Mosaic of secondary forest, regrowth thicket and scattered cultivation.	d_2, a_2, n_3, x_3, fl_o p_1, s_4, y_1 or $_2$	Ch: S3e Ca: S3e Ct: N Cn: N	Co: S3e G : N M : N R : N
2	20-36	Interfluve crests Broad to very broad; even; very gentle to gentle slope; locally stony	Shallow to moderately deep, very gravelly clay loams to clays. Well drained. Strongly acid.	Mosaic of secondary forest, regrowth thicket and patches of cultivation. Coffee and ginger common in Moyamba area.	d_3, a_2, n_3, x_4, fl_o p_1, s_1, locally y_1	Ch: S1 Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
3	50-70	Interfluve side slopes Medium to long; straight to concave; gentle to locally moderate slope; slightly gullied	Moderately shallow to moderately deep, very gravelly loams to clays. Locally very shallow. Well drained. Strongly acid.	Mosaic of secondary forest, regrowth thicket and patches of cultivation. Coffee and ginger common in Moyamba area.	d_3, a_2, n_3, x_3, fl_o, p_1, s_2, y_1, locally d_4, x_4, y_2	Ch: S1 Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
4	8-10	Valley swamps and minor floodplains Level; 50-200 m wide; Commonly channelled	Deep, variable alluvial and colluvial soils, locally silty or gravelly. Imperfectly to very poorly drained. Strongly to weakly acid.	Swamp thicket, raphia palms and sedge grassland. Rice cultivation common. Gallery forest along stream courses.	a_3, n_2, x_2, w_2 fl_2 or $_3$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1/S2m

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Co = Coffee
- Ca = Cassava
- G = Groundnut
- Ct = Citrus
- M = Maize
- Cn = Coconut
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

KAMAKWIE LAND SYSTEM 22



(672 KM^2)

GENERAL DESCRIPTION

Rather variable dissected plains of low relief and isolated low hills.

GEOLOGY

Archean granite complex with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Undulating to locally strongly undulating plains characterized by remnant hills rising out of interfluves dissected by generally well defined valley swamps. The moderately to steeply sloping hills are commonly broad crested but locally become narrow. The interfluves have very broad crests; their slopes, although usually gently sloping, are locally steeper and gullied. Narrow footslopes and terraces are present in places, fringing valley swamps. In the Kamakwie area these swamps are particularly well defined and broad. The broader swamps are drained by small ephemeral creeks which are tributary to a few minor rivers with associated narrow floodplains.

TERRAIN PARAMETERS

Altitude		*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
Min.(m)	*Max.(m)*					
70	180	Very low to low	Gentle	Coarse	Dendritic	1.4 (1.3-1.7)

CLIMATIC TYPE

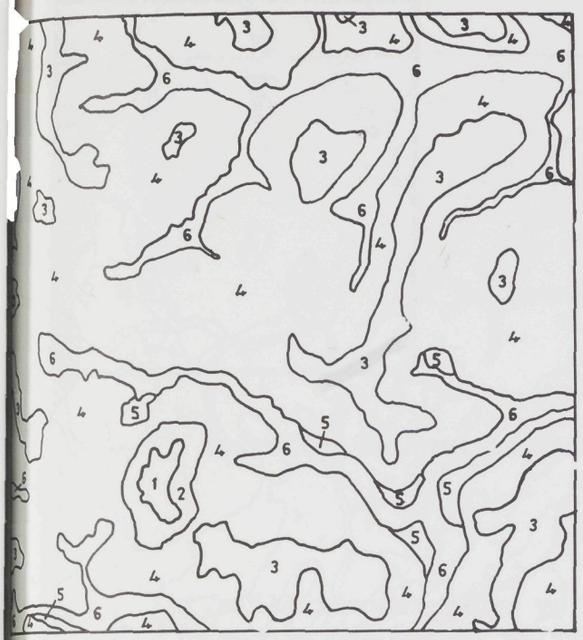
D_1 and D_2

GENERAL LAND SUITABILITY

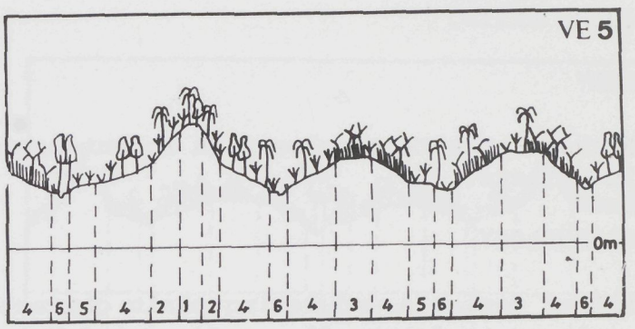
Infertile soils with low water holding capacity on gentle slopes make the suitability of this land system generally low. Uplands are suited for tree crops which can withstand a long dry season and low fertility together with low demanding arable crops. The valley swamps which are particularly well developed around Kamakwie, have high suitability for paddy rice.

22

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability
1	0-2	Hill crests Broad to very broad; even; very gentle slope	Shallow to moderately deep loams to clay loams, high in gravel content. Well drained. Weakly to strongly acid.	Mosaic of grassland, thicket and scattered cultivation.	d_3, a_2, n_3, x_4, fl_o, p_3, s_1, y_1 *locally* d_1, x_2	Ch: S2m Co: N Ca: S2r G : S3r Ct: S3f M : S2fm Cn: S3r R : N
2	1-5	Hill slopes Short to medium length; convex to straight; moderate to steep slope; broad inconspicuous to absent spurs; generally gullied	Moderately deep to deep loams to clays with varying amounts of gravel and stones. Well drained. Weakly to strongly acid.	Mosaic of savanna woodland, tree savanna and grassland, with scattered cultivation. Around Kamakwie, secondary forest and thicket regrowth with oil palms are common.	d_2, a_2, n_2 *or* $_3$, x_3, fl_o, p_3, s_4	Ch: S3e Co: N Ca: S3e G : N Ct: N M : N Cn: N R : N
3	10-24	Interfluve crests Level to very gentle slope; 100-400 m wide; gently undulating to undulating	Moderately shallow to deep loams to clay loams, high in gravel content. Locally very shallow to laterite sheet. Well drained. Strongly acid.	Mosaic of savanna woodland, tree savanna and grassland, with scattered cultivation. As above around Kamakwie.	d_2 *or* $_3$, a_2, n_3, x_3, fl_o, p_3	Ch: S1 Co: N Ca: S1/S2r G : S2f/S3r Ct: S3f M : S2f Cn: S2m R : N
4	60-70	Interfluve side slopes Short to long; slightly convex to straight; gentle to locally moderate slope; locally gullied and slightly rocky	Moderately deep, reddish loams to clay loams, high in gravel content. Well drained. Strongly acid, locally neutral.	Mosaic of savanna woodland, tree savanna and grassland, with scattered cultivation. As above around Kamakwie.	d_2 *or* $_3$, a_2, n_3, x_3, fl_o, s_2, y_1, *locally* y_2	Ch: S1 Co: N Ca: S1/S2r G : S2f/S3r Ct: S3f M : S2f Cn: S2m R : N
5	1-3	Interfluve footslopes and low colluvial terraces Nearly level to very gentle slope; 50-200 m wide; Termite mounds common	Deep, brownish sandy clay loams. Well drained. Strongly acid.	Regrowth thicket with some cultivation. Scattered *Gmelina* plantations.	d_1, a_2, n_3, x_2, fl_o, p_3, s_1	Ch: S1 Co: N Ca: S1 G : S2f Ct: S3f M : S2f Cn: S2m R : N
6	8-14	Valley swamps Level; 50-150 m wide; locally 200 m wide; locally channelled	Deep, variable alluvial and colluvial soils, locally peaty. Poorly drained to waterlogged. Strongly to weakly acid.	Sedge grassland with raphia palm. Intensive swamp rice cultivation in Kamakwie area. Discontinuous gallery forest along stream courses.	d_2 *or* $_3$, n_1 *or* $_2$, x_2 *or* $_3$, w_3, fl_3, p_2 *or* $_3$	Ch: N Co: N Ca: N G : N Ct: N M : N Cn: N R : S1
*7	0-2	Minor floodplains Level; up to 100 m wide; slightly undulating; Channels up to 10 m wide and 1 m deep	Deep clay loams to clays high in silt. Imperfectly drained. Strongly to weakly acid.	Grassland and thicket with gallery forest along river courses. Scattered cultivation.	d_1, a_2 *or* $_3$, n_1, x_2, w_1, fl_1, p_4	Ch: S3o Co: N Ca: N G : S1 Ct: N M : S1 Cn: S3o R : N

*Not present in type area.

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch* = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

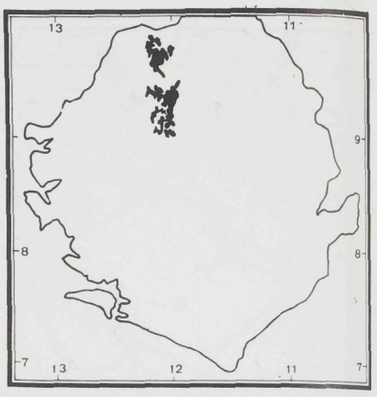
Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

KAMABAI LAND SYSTEM 23



(875 KM^2)

GENERAL DESCRIPTION

Dissected plains of low relief with common rocky hills.

GEOLOGY

Archean granite complex with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Rather variable, undulating plain characterized by rocky remnant hills, rising out of interfluves dissected by a few valley swamps and stream courses. In its lower lying parts this land system is closely associated with, and grades into, Wari land system. The hills are typically rather massive with moderate to steep slopes with narrow, often rocky crests. In places, however, the hills become distinctly peaked and gullied. The interfluves have broad crests with gentle, usually irregular, and sometimes rocky, side slopes. Footslopes grading into low terraces are rather rare and locally fringe narrow stream courses and valley swamps, which comprise less than 10% of the land system. The drainage pattern shows weak structural control.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
60	215	Low (locally moderate)	Gentle	Coarse	Dendritic	1.3 (1.2-1.6)

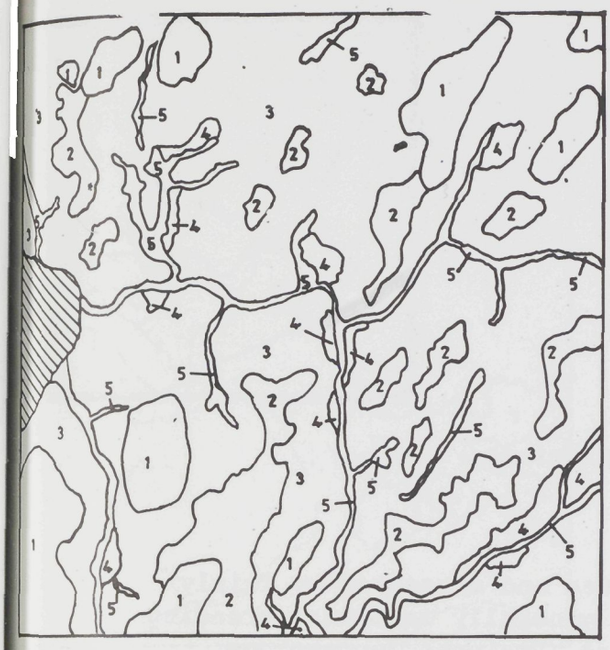
CLIMATIC TYPE D_1 and D_2, locally C_2

GENERAL LAND SUITABILITY

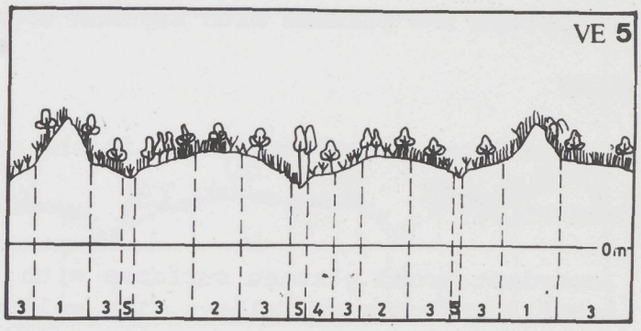
Prevalently shallow, infertile soils with very low water holding capacity and a climate with a long dry period make this land system's suitability very low. The flatter uplands are suitable for cashew and cassava, however.

23

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	10-30	Hill slopes and crests Short to medium length slopes; straight to convex; moderate to steep; irregular and rocky, locally gullied. Narrow, very uneven, often rocky, crests	Moderately shallow to deep loams to sandy clay loams with variable gravel contents. Pockets, locally common, of very shallow soils to bedrock. Well drained. Strongly to weakly acid.	Tree savanna, species include oil palm and *Lophira*. Patches of cultivation and thicket. Locally bare rock.	d_3 or $_4$, a_2, n_3, x_4, fl_o, p_3, e_4, locally d_5, x_5 and y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
2	8-16	Interfluve crests Broad to very broad; slightly uneven; nearly level to very gentle slope; locally rocky	Moderately shallow to deep, very gravelly loams to clays, locally shallow to bedrock. Well drained. Strongly to weakly acid.	Tree savanna with patches of secondary forest, thicket and cultivation.	d_3, a_2, n_3, x_3 or $_4$, fl_o, p_2 or $_3$, s_1, locally d_2, x_2 and y_1	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: N G : S3r M : S2f R : N
3	44-70	Interfluve side slopes Short to medium length; irregular; gentle slope; locally gullied and rocky	Moderately shallow to deep, reddish loams to clay loams with variable gravel contents. Locally shallow to bedrock. Well drained. Strongly acid.	Tree savanna with patches of secondary forest, thicket and cultivation.	d_3, a_2, n_3, x_3 or $_4$, fl_o, p_3, s_2 locally d_2, x_2, y_1	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: N G : S3r M : S2f R : N
4	2-4	Interfluve footslopes and low colluvial terraces Nearly level to very gentle slope; up to 150 m wide	Moderately deep to deep, reddish to brownish loams to clays, frequently sandy and locally gravelly. Well drained. Strongly acid.	Tree savanna; patches of thicket and cultivation.	d_1, a_2, n_3, x_2, fl_o, p_3, s_o or $_1$	Ch: S2m Ca: S1 Ct: S3f Cn: S2m	Co: N G : S2f M : S2f R : N
5	6-10	Valley swamps and minor floodplains Level; 50-150 m wide; locally channelled	Deep, variable colluvial and alluvial soils, locally slightly gravelly. Imperfectly to very poorly drained. Strongly to weakly acid.	Sedge grassland or thicket with raphia palm. Often cultivated for rice. Gallery forest along stream courses.	a_2 or $_3$, n_1 or $_2$, x_2, w_2, fl_3, p_2 or $_3$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

PORT LOKO LAND SYSTEM 24



(681 KM^2)

GENERAL DESCRIPTION

Dissected low plateau with savanna vegetation

GEOLOGY

Kasila Group granulites with, in the east, mylonites.

GEOMORPHOLOGY

Accordant,broad plateau surfaces with low rises and dissected by fairly broad,flat bottomed valleys. The valleys are generally east-west trending and have moderate to steep,gullied side slopes. Drainage depressions, although of rare occurrence on plateau surfaces in most of the land system, are common around Konta where infilled lake floors are also present.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
20	100	Low to moderate	Level to nearly level	Coarse	Sub parallel	0.8 (0.7-0.9)

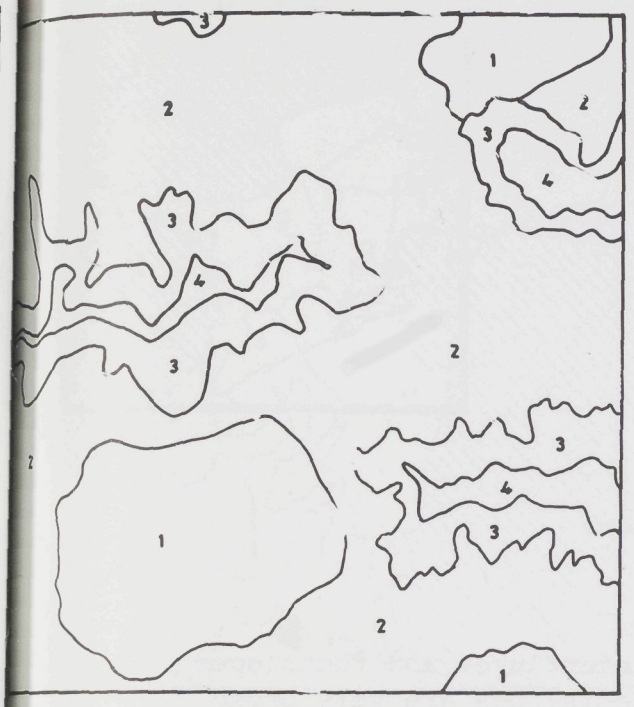
CLIMATIC TYPE D_1, locally D_2

GENERAL LAND SUITABILITY

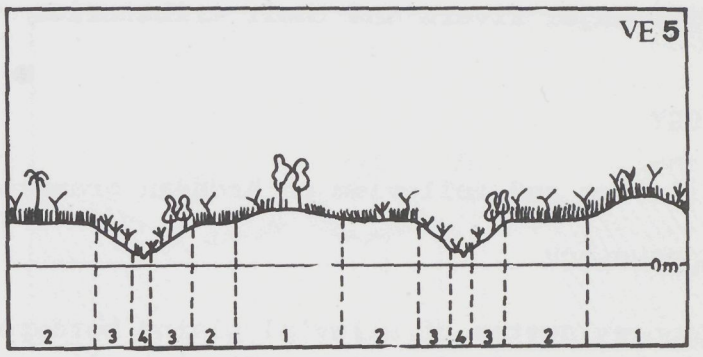
Dominantly shallow, infertile soils with very low water-holding capacity in combination with a climate having a pronounced dry season give this land system a very low suitability. The flatter upland areas appear to offer good prospects for cashew, nowever.

24

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	10-30	Rises Long; straight to slightly concave; gentle slope; locally rocky	Moderately shallow to deep, reddish, very gravelly loams to clay loams. Well drained. Weakly acid.	Secondary forest, thicket and *Lophira* tree savanna; scattered oil palms.	*d* var.(av.3), a_2, n_3, x_3, fl_o, p_2, s_2, locally y_1	Ch: S1 Ca: S2r Ct: S3f Cn: S3r	Co: N G : S3r M : S2f R : N
2	50-74	Plateau surfaces Level to very gentle slope; 500-2000 m wide; flat to gently undulating; locally stony and bouldery	Moderately shallow to locally shallow, very gravelly, reddish loams to clay loams in association with pockets of deep brownish fine sandy clay loams. Well drained. Strongly to weakly acid.	*Lophira* tree savanna with scattered oil palm. Patches of secondary cultivation especially towards Kambia.	*d* var.(av.3), a_2, n_3, *x* var., fl_o, p_3, s_o or $_1$	Ch: S1 Ca: S2r Ct: S3f Cn: S3r	Co: N G : S3r M : S2f R : N
3	8-20	Valley side slopes Medium length; straight; moderate, locally steep slope; gullied	Moderately shallow to deep, reddish loams to clays commonly very gravelly and locally silty. Well drained. Strongly to weakly acid.	Thicket and secondary forest. Patches of cultivation.	*d* var.(av.2), a_2, n_3, x_3, fl_o, p_3, s_3	Ch: S1 Ca: S2e Ct: S3f Cn: S2me	Co: N G : S3r M : S3e R : N
4	* 0-6	Valley swamps Level to nearly level; 100-400 m wide; commonly channelled	Deep, variably textured alluvial and colluvial soils, locally peaty. Poorly drained to waterlogged. Weakly acid.	Sedge grassland and raphia palm. Rice cultivation.	a_2, n_2, x_2, w_3, fl_3, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R S1
5	** 1	Drainage depressions and infilled lake floors Level; 200-1000 m wide	Deep fine sandy clay loams to clays. Poorly to very poorly drained. Weakly acid.	Sedge grassland with some rice cultivation.	d_1, a_1, n_3, x_1, w_2 or $_3$, fl_2, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S2m

* Not present in Konta area.

** Average over whole land system, comprises up to 10% in Konta area.

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

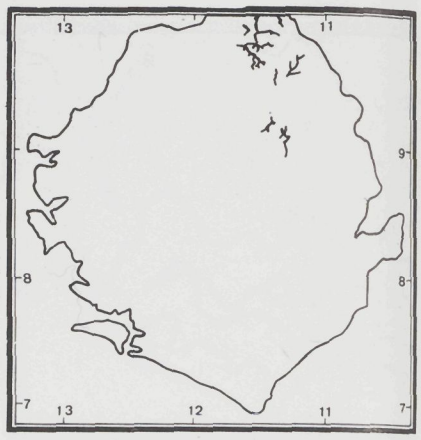
S1 = High to moderat
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

MUSAIA LAND SYSTEM 25

(292 KM^2)



GENERAL DESCRIPTION

Complex of plains and terraces associated with major rivers and their tributaries

GEOLOGY

Alluvium and colluvium on Archean granite complex.

GEOMORPHOLOGY

Complex system of alluvial plains bordered by interfluves and footslopes of adjacent land systems. The interfluves and footslopes are very broad and rise up to 20 m above the floodplains. The broad alluvial plains, associated with incised major rivers, are generally well drained. They comprise terraces strewn with old termite mounds, weakly developed, discontinuous levees and poorly drained backswamps. In-filled old river channels are locally present, Much narrower, relatively featureless floodplains are associated with tributary streams.

TERRAIN PARAMETERS

Altitude Min.(m)	*Max.(m)*	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
320	430	Extremely low	Level to very level	Medium	Meandering and sinuous	2.2 (2.0-2.5)

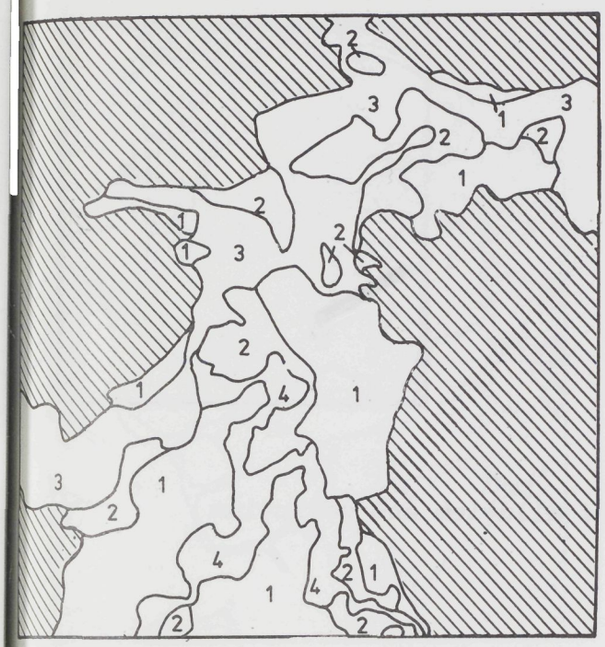
CLIMATIC TYPE D_1 and D_2, locally C_2

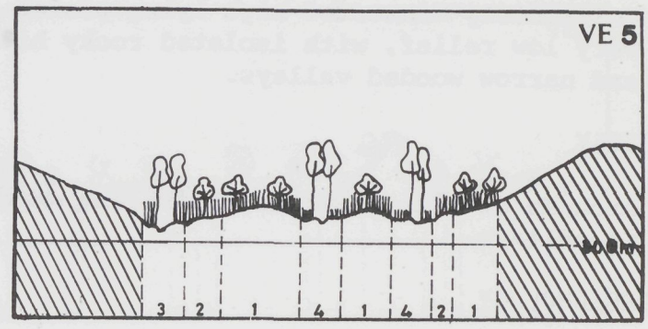
GENERAL LAND SUITABILITY

This land system has a relatively high proportion of deep alluvial soils and is considered to be one of the most suitable areas for arable cropping in the country. Possibilities also exist for simple irrigation schemes and the production of short cycle cash crops, as well as vegetables. However the suitability of the uplands is curbed by infertile soils and ong dry season and the choice of tree crops is narrowed.

25

FACET BREAKDOWN





Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	30-50	Footslopes and interfluves					
		200-1600 m wide; undulating; nearly level to very gentle slope. Dominant in Musaia area	Deep, brownish to reddish, very gravelly loams to clays. Well drained. Strongly to weakly acid.	Mosaic of open savanna woodland and grassland, fairly intensively cultivated, especially in Musaia area.	d_1 or $_2$, a_2, n_2 or $_3$, x_3, fl_o, p_2 or $_3$, s_o or $_1$	Ch: S1 Ca: S1 Ct: S3f Cn: S2m	Co: N G : S2f M : S2f R : N
2	10-30	High alluvial terraces					
		100-1200 m wide, sometimes terraced; level. Dominant in south Koinadugu and Kono Districts	Deep to moderately deep, rather variable and commonly nodular loams to clays. Well drained to locally imperfectly drained near major floodplains. Strongly to weakly acid.	Grassland with scattered patches of savanna woodland. Frequent patches of cultivation.	d_1, a_2, n_2 or $_3$, x_1 or $_2$, fl_o, p_3, locally d_2, w_1 and fl_1	Ch: S1 Ca: S1 Ct: S3f Cn: S2m	Co: N G : S2f M : S2f R : N
3	0-40	Major floodplains					
		Level; 200-600 m wide; flat to gently undulating with weakly developed levees, old river channels and backswamps. Limited to valleys of Mongo and Bagbe rivers	Deep alluvial loams and clays, frequently silty. Well drained on levees, imperfectly to locally poorly drained in lower lying areas. Strongly to weakly acid.	Tall grassland, predominantly *Chasmopodium sp.* with occasional low trees. Gallery forest occurs along some levees. Fairly intensively cultivated.	a_2, n_2, x_1, fl_1, p_3, locally n_3, w_1 and fl_3	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S2f M : S2f R : N
4	5-35	Minor floodplains					
		50-250 m wide; level; channelled	Deep alluvial loams and clays, frequently silty. Imperfectly to poorly drained. Strongly to weakly acid.	On broader floodplains grassland dominated by *Andropogan* and *Anadelphia spp.* occurs with gallery forest along channels. Poorly drained narrow floodplains are characterised by swamp thicket or sedge grassland. Fairly intensively cultivated.	d_o or $_1$, a_2 or $_3$, n_1 or $_2$, x_1, w_o or $_2$, fl_1 or $_2$, p_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1 M : S1 R : S2m

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

WADU LAND SYSTEM 26

(1054 KM^2)



GENERAL DESCRIPTION

Intricately dissected high lying plains of very low relief, with isolated rocky hills and narrow wooded valleys.

GEOLOGY

Archean granite complex with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Very gently undulating plains intricately dissected by narrow wooded valleys and stream courses. Scattered isolated rocky hills rise abruptly out of subdued interfluves throughout the land system and locally become common. The undulating interfluves are very gently sloping and locally rocky or gravelly. When present, footslopes, merging into lower-lying colluvial terraces, are best developed around the isolated hills. Locally the larger streams flow through floodplains up to 200 m wide.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
400	530	Very low (Hills-low)	Nearly level to very gentle	Medium	Dendritic	2.6 (2.5-2.9)

CLIMATIC TYPES C_1, locally C_2

GENERAL LAND SUITABILITY

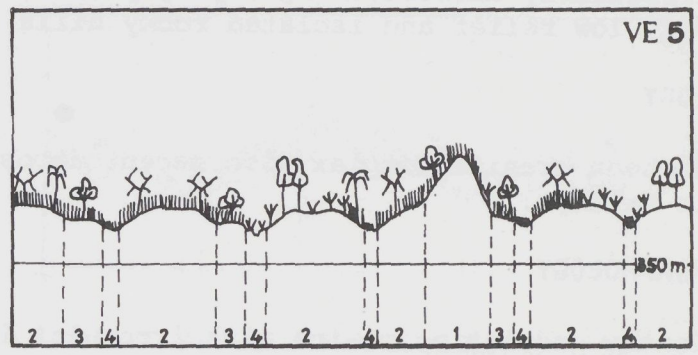
The main limitations of this land system are its scattered rocky hills and a high proportion of gravelly infertile soils on the remaining upland areas. Suitability is generally low for both arable and tree crops although scope exists for the introduction of coffee, at present little grown into this area.



1 Km

26

FACET BREAKDOWN



Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
4-20	Isolated hills					
	Short to medium length; mainly irregular; moderate to steep slope; commonly rocky	Very shallow to shallow soils, associated with pockets of deeper soils over saprolite. Well drained. Strongly acid.	Grassland and tree savanna with patches of thicket.	d_4, a_2, n_3, x_4 or $_5$, fl_o, p_3, s_4, y_1, locally d_1, x_2	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
60-80	Interfluves					
	Medium to long; undulating; nearly level to very gentle slope; termite mounds common	Moderately deep to deep, brownish sandy clay with variable gravel contents. Well drained. Strongly to weakly acid.	Tree savanna with patches of cultivation, thicket and grazing.	d_1 or $_2$, a_2, n_2 or $_3$, x_3, fl_o, p_3, s_1 locally d_4, x_5	Ch: S1 Ca: S1/S2r Ct: S3f Cn: S1	Co: S2f G : S2f/S3r M : S2f R : N
6-10	Interfluve footslopes and low colluvial terraces					
	Nearly level to very gentle slope; 50-200 m wide; termite mounds common	Deep, brownish clay loams to clays, frequently sandy and with variable gravel contents; Well drained. Strongly to weakly acid.	Tree savanna with scattered cultivation and extensive grazing.	d_1, a_2, n_2 or $_3$, x_2, fl_o, p_3, s_1	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S1 G : S2f M : S2f R : N
8-12	Valley swamps and minor floodplains					
	Level; 20-200 m wide; locally channelled and terraced	Deep, variable alluvial and colluvial soils, locally silty on floodplains. Very poorly drained to locally waterlogged in swamps, well to imperfectly drained on floodplains. Strongly to weakly acid.	Swamp thicket with raphia palms. Locally sedge grassland and rice cultivation.	a_2, n_1 or $_2$, x_2, w_3, fl_3 Minor floodplains: w_o or $_1$, fl_1	Ch: N Ca: N Ct: N Cn: N	Co: N G : S2f/N M : S2f/N R : S1

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

Ch = Cashew; Co = Coffee; Ca = Cassava; G = Groundnut; Ct = Citrus; M = Maize; Cn = Coconut; R = Paddy rice

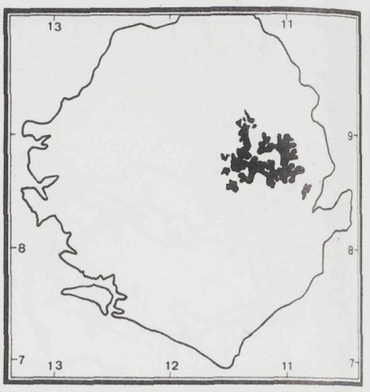
Land suitability classes

S1 = High to moderate; S2 = Low; S3 = Very low; N = Nil

Land suitability subclass limitations

r = Rooting space; f = Soil fertility; m = Moisture availability; o = Oxygen availability; e = Erosion hazard

KOIDU LAND SYSTEM 27



(1955 KM^2)

GENERAL DESCRIPTION

Irregularly dissected high lying plains of very low relief and isolated rocky hills

GEOLOGY

Archean granite complex with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Gently undulating plains with irregular interfluves and occasional small hills, dissected by narrow valley swamps and broader floodplains. The hills which are rather pointed have steep rocky slopes and very low to low relief. The interfluves are rather variable, and have very gentle to gentle, often gullied, slopes. They gradually merge into narrow valley swamps which broaden into floodplains. In the Kono area the valleys are intensively mined for alluvial diamonds.

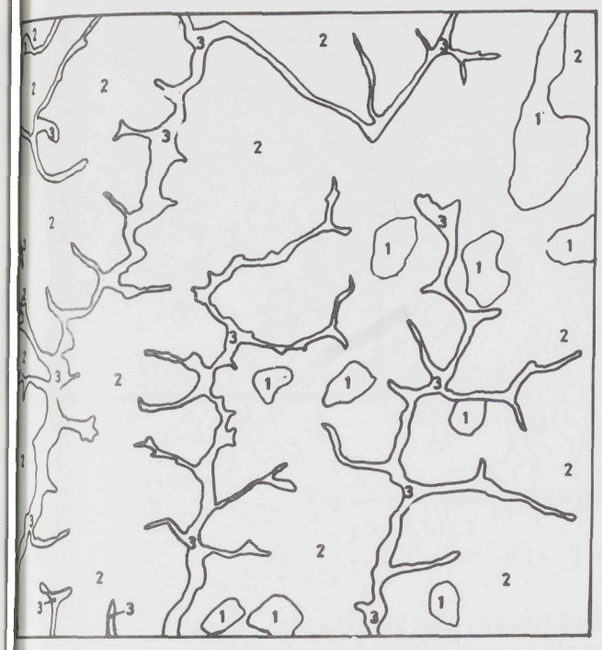
TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
300	480	Very low (locally low)	Very gentle	Medium	Dendritic	1.0 (0.8-1.2)

CLIMATIC TYPES C_1, locally C_2

GENERAL LAND SUITABILITY

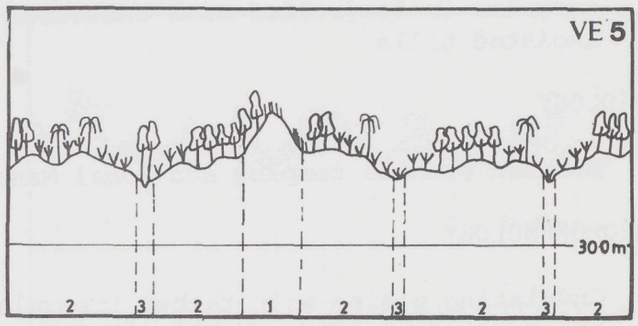
The suitability of the uplands is limited by scattered, bouldery hills and low soil fertility, while intensive mining has destroyed the natural fertility of the swamps. The more level parts of the uplands are suitable for tree crops, including coffee which is not grown at present in this area.



1 Km

27

FACET BREAKDOWN



Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
2-14	**Isolated hills**					
	Short to medium length; straight; steep slope; bouldery, locally rocky	Shallow soils to bedrock with pockets of deep soils over saprolite. Well drained. Strongly to weakly acid.	Secondary forest and grassland, some bare rock.	d_4, a_2, n_3, x_4, fl_o, p_3, s_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
74-90	**Irregular interfluves**					
	Short to long; undulating; very gentle to gentle slope; locally rocky often gullied	Moderately shallow to deep loams to clay loams commonly sandy with variable amounts of gravel. Well drained. Strongly to weakly acid.	Secondary forest, thicket and oil palm, patches of cultivation.	d_1 or $_2$, a_2 or $_3$, n_2 or $_3$, x_2 or $_3$, fl_o, p_3, s_1 locally d_3, x_4, y_2	Ch: S1 Ca: S1/S2r Ct: S3f Cn: S1	Co: S2f G : S2f/S3r M : S2f R : N
8-12	**Valley swamps and minor floodplains**					
	Level; 20-150 m wide; locally channelled, locally mined	Deep, variable alluvial and colluvial soils, commonly disturbed by mining in the Sefadu area. Poorly drained to waterlogged. Strongly to weakly acid.	Sedge grassland, raphia, oil palms and *Mitragyna sp.* Quite intensively cultivated. Discontinuous gallery forest along some river courses.	a_2, n_1 or $_2$, x_2 w_3, fl_3, p_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

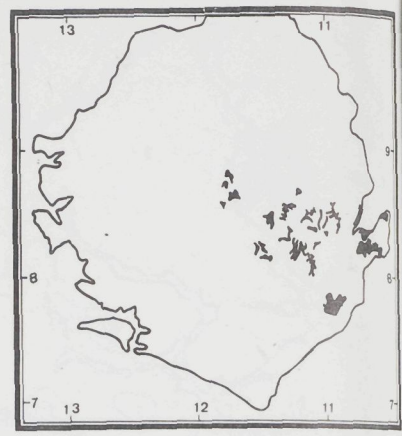
Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

KAILAHUN LAND SYSTEM 28



(1511 KM^2)

GENERAL DESCRIPTION

Strongly dissected high lving plains of very low to low relief with scattered isolated hills.

GEOLOGY

Archean granite complex and local Mano-Moa granulites.

GEOMORPHOLOGY

Undulating plains with rather irregular interfluves and isolated,small hills, dissected by narrow valley swamps and floodplains. The hills are unevenly distributed within the land system. They are commonly rocky and pointed, with low relief and moderate to steep slopes. The interfluves are variable and frequently gullied with slightly undulating crests only locally present. Typically the gently to moderately sloping interfluve side slopes abruptly border slightly incised narrow valley swamps. Locally these swamps broaden into floodplains.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
100	440	Very low to low	Very gentle	Medium	Dendritic	1.4 (1.2-1.5)

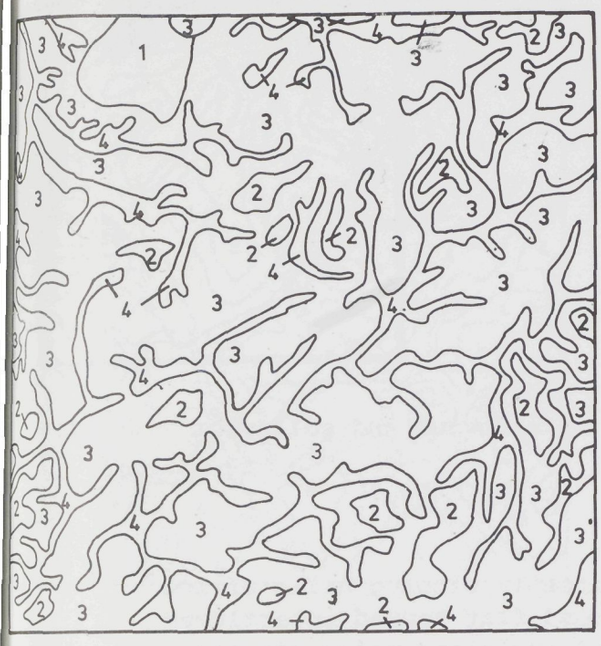
CLIMATIC TYPES B and C_1, locally C_2

GENERAL LAND SUITABILITY

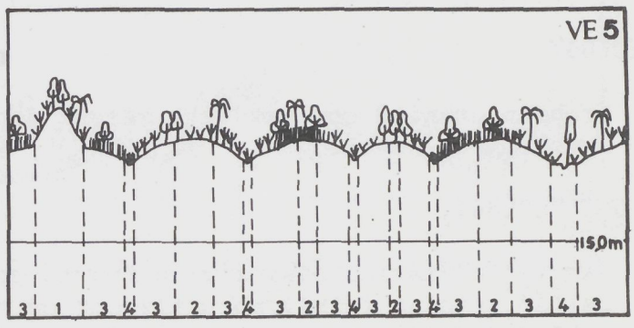
A high proportion of this land system has very gravelly, acid, infertile soils occurring on gentle to moderate slopes, giving it only a low suitability for both arable and tree crops. The long growing period makes it suited to coffee and, on locally occuring gravel free soils, cocoa. The seasonally flooded swamps and floodplains are suitable for paddy rice and short cycle arable crops.

28

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	0-6	Isolated hills Short to medium length; straight; moderate to steep slope; locally rocky and bouldery	Deep, medium to heavy textured soils with shallow soils to bedrock locally. Well drained. Strongly to weakly acid.	Mosaic of thicket, secondary forest and patches of cultivation, with bare rock locally. Oil palms fairly common.	d_2 a_2, n_3, x_2, fl_o, p_3, s_3, locally s_4, y_3, d_4, x_5	Ch: S2m Ca: S2fe Ct: S3f Cn: S2e	Co: S2f G : S2fe M : S3e R : N
2	4-10	Interfluve crests Broad; uneven; nearly level to gentle; locally stony	Moderately shallow to deep, reddish sandy clay loams to clays, commonly gravelly with localised shallow soils to bedrock. Well drained. Strongly to weakly acid.	Mosaic of tree savanna, thicket, secondary bush and patches of cultivation	d_2, a_2, n_3, x_3, fl_o, p_3, s_1, y_1, locally y_3	Ch: S2m Ca: S2m Ct: S3f Cn: S1	Co: S2f G : S2fm M : S2fm R : N
3	70-82	Interfluve side-slopes Short to medium length; undulating to irregular; very gentle to moderate slope; gullied	Moderately shallow to deep sandy clay loams to clays often very gravelly and locally over bedrock at shallow depth. Well drained. Strongly acid.	Mosaic of tree savanna, thicket, secondary bush and patches of cultivation	d_2, a_2, n_3, x_3, fl_o, p_3, s_1 or $_2$	Ch: S2m Ca: S2m Ct: S3f Cn: S1	Co: S2f G : S2fm/S3x M : S2fm R : N
4	12-16	Valley swamps and minor floodplains Level; 50-150 m wide; locally channelled	Deep, variable alluvial and colluvial soils. Poorly to very poorly drained. Locally imperfectly drained on floodplains. Strongly to weakly acid.	Sedge grass, swamp thicket and raphia palms. Fairly intensively cultivated for rice.	d_1, a_2, n_1 or $_2$, x_2, w_2 or $_3$, fl_3, *Minor floodplains* w_1, fl_2	Ch: N Ca: N Ct: N Cn: N	Co: N G : N/S2f M : N/S2f R : S1/S2m

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

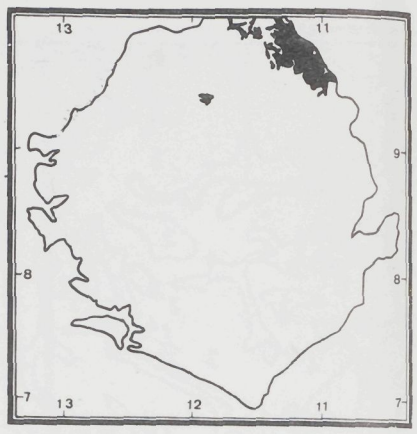
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

KOMBILE LAND SYSTEM 29

(1552 KM^2)



GENERAL DESCRIPTION

Intricately dissected high lying plains with scattered hills.

GEOLOGY

Archean granite complex with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Gently undulating plains with few to common, steeply sloping hills of low relief, rising fairly abruptly out of very broad, flat topped interfluves. Well defined drainage pattern of broad floodplains along major streams and narrow tributary valley swamps. Intermittent low terraces are present along floodplain margins.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
400	550	Low	Gentle	Medium	Dendritic to meander-ing	1.8 (1.6-2.0)

CLIMATIC TYPE

D_1 and D_2

GENERAL LAND SUITABILITY

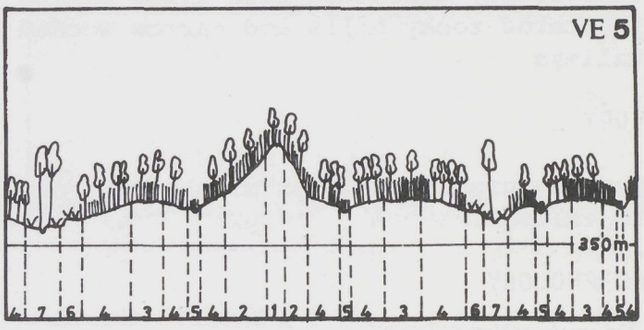
Strongly acid soils and long dry periods characterize the upland parts of this land system, which are thus suitable only for the least demanding tree crops. On the other hand, deep, moderately fertile soils make terraces, swamps and floodplains well suited for paddy rice and/or short cycle arable crops, according to duration of flooding.

29

FACET BREAKDOWN



1 Km



Facet	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability
1	0-2	Hill crests Narrow to broad; uneven; very gentle slope	Shallow to moderately deep sands to loams over weathering bedrock. Well drained. Weakly acid to strongly acid.	Tree savanna with rare cultivation.	d_3, a_2, n_3, x_4, fl_o, p_3, s_2, y_3	Ch: S2e Co: N Ca: S2re G : S3e Ct: S3re M : S3e Cn: S2me R : N
2	4-12	Hill slopes Very short to medium length; straight; generally steep; dissected by broad gullies, locally slightly rocky	Moderately shallow to deep loams to clay loams high in coarse quartz sand and commonly gravelly. Well drained. weakly acid.	Tree savanna with patches of savanna woodland. Patches of cultivation and grass regrowth.	d var, n_2 or $_3$, x var, fl_o, p_3, s_4, y_3	Ch: N Co: N Ca: N G : N Ct: N M : N Cn: N R : N
3	10-20	Interfluve crests Very gentle; 50-250 m wide; undulating; few termite mounds	Moderately shallow to deep loams to clay loams high in coarse quartz sand and commonly gravelly. Well drained. weakly acid.	Tree savanna with patches of savanna woodland. Patches of cultivation and grass regrowth.	d_1 or $_2$, a_2, n_2 or $_3$, x_3, fl_o, p_3, s_1	Ch: S1/S2r Co: N Ca: S2f G : S2f/S3r Ct: S3f M : S2f Cn: S2m R : N
4	50-66	Interfluve side slopes Medium to long; undulating; very gentle to gentle slopes; slightly dissected by broad gullies	Moderately deep to deep, variable loams to clay loams, high in coarse quartz sand. Commonly very gravelly. Well drained, weakly acid.	Tree savanna with patches of savanna woodland. Patches of cultivation and grass regrowth.	d_1 or $_2$, a_2, n_2 or $_3$, x_2 or $_3$, fl_o, p_3 or $_4$, s_1 or $_2$, locally d_3 or $_4$, x_4	Ch: S1 Co: N Ca: S1/S2r G : S2f/S3r Ct: S3f M : S2f Cn: S2m R : N
5	1-3	Low alluvial terraces Level to nearly level; 40-100 m wide	Deep, medium textured alluvial soils. Imperfectly drained. Weakly acid.	Fairly intensive cultivation of upland crops. Local citrus orchards, vegetables and rice.	d_1, a_3, n_2, x_2, fl_1, p_3	Ch: S3o Co: N Ca: N G : S1 Ct: N M : S1 Cn: S3o R : N
6	4-8	Valley swamps Level to nearly level; 20-100 m wide; locally channelled	Deep, variable alluvial and colluvial soils, locally organic. Poorly drained to waterlogged. Strongly to weakly acid.	Fairly intensive swamp rice cultivation. Patches of grass regrowth and raphia palm. Swamp thicket locally present.	d_o or $_1$, a_2, n_1 or $_2$, x_1, or $_2$, w_3. fl_3, p_4	Ch: N Co: N Ca: N G : N Ct: N M : N Cn: N R : S1
7	8-12	Minor floodplains Level to nearly level; 50-150 m wide; channelled, locally terraced	Deep, medium to heavy textured alluvial soils with local sandy layers. Imperfectly to poorly drained. Weakly acid to neutral.	Fairly intensive cultivation of citrus, vegetables and rice. Patches of grass regrowth and remnant gallery forest along stream courses.	d_o or $_1$, a_3, n_1 or $_2$, x_2, w_1 or $_2$, fl_2	Ch: N Co: N Ca: N G : S1 Ct: N M : S1 Cn: N R : S2m

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

KAMARON LAND SYSTEM 30



(1327 KM^2)

GENERAL DESCRIPTION

Intricately dissected high-lying plains with scattered rocky hills and narrow wooded valleys.

GEOLOGY

Archean granite complex with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Undulating plains with few, small, rocky hills of very low relief associated with very broad, variably sloping, irregular interfluves. Well defined, somewhat structurally controlled, drainage pattern with narrow, wooded valleys. Along major streams narrow floodplains and associated colluvial footslopes are present.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
400	500	Low	Gentle	Medium	Complex-angulate and dendritic	2.1 (1.9-2.3)

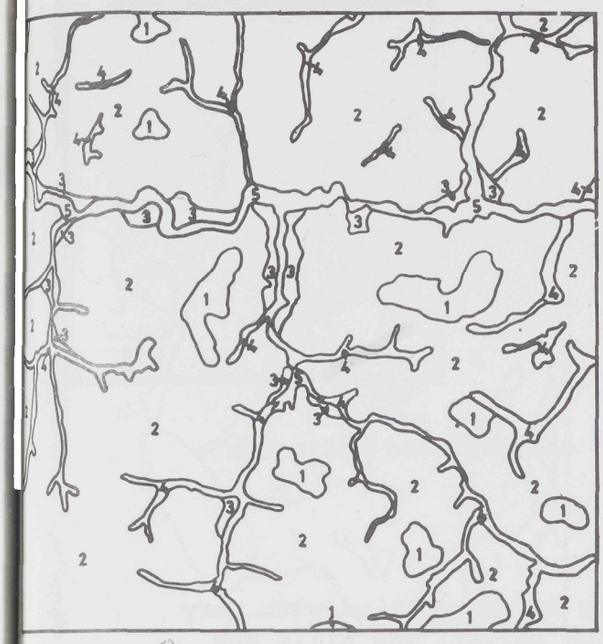
CLIMATIC TYPE D_1

GENERAL LAND SUITABILITY

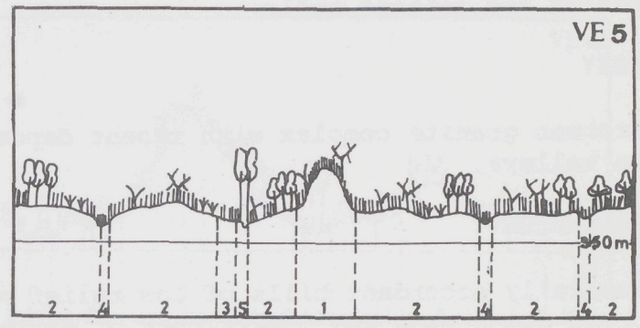
Strongly acid soils and a long dry season make most of this land system suited only for the less demanding tree crops. Floodplains are highly suitable for short cycle arable crops and swamps moderately suitable for paddy rice.

30

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	2-18	Isolated hills Compound facet of crests and slopes. Crests: narrow; uneven; crestal slope - very gentle. Side slopes: medium; straight; steep; rocky and bouldery	Loams to clays of variable depth to bedrock or weathered parent material. Locally gravelly. Well drained. Strongly acid.	Tree savanna with patches of savanna woodland and grassland. Dominant tree species are *Lophira*, *Daniellia* and *Parkia*. Grass is mainly *Chasmopodium*. Scattered cultivation.	d_3 or $_4$, a_2, n_2 or $_3$, x_4, fl_o, p_3, s_3, y_3 locally d_1, x_2, s_1, y_o	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
2	65-85	Irregular interfluves Medium to long; irregular; very gentle to moderate slope; locally rocky	Deep loams to clays, commonly sandy and locally very gravelly, in association with shallow and very shallow soils to bedrock. Well drained. Strongly to weakly acid.	As above but more commonly cultivated.	d_1, a_2, n_2 or $_3$, x_3, fl_o, p_2, or $_3$, s_1, locally d_4 or $_5$, x_5	Ch: S1 Ca: S1/S2r Ct: S3f Cn: S2m	Co: N G : S2f/S3r M : S2f R : N
3	2-4	Interfluve footslopes and low colluvial terraces Very gentle slope; 50-200 m wide	Deep medium to heavy textured soils, frequently gravelly. Well drained. Strongly acid.	Commonly cultivated	d_1, a_2, n_2 or $_3$, x_3, fl_o, p_3, s_1	Ch: S1 Ca: S1 Ct: S3f Cn: S2m	Co: N G : S2f M : S2f R : N
4	6-10	Valley swamps Nearly level to level; 20-100 m wide; commonly channelled	Deep colluvial and alluvial loams to clays, frequently silty. Poorly to very poorly drained. Weakly acid to neutral.	Swamp thicket with raphia palms. Often cultivated for rice.	d_1, a_2, n_1 or $_2$, x_3, w_3, fl_3, p_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
5	2-6	Minor floodplains Level; 50-200 m wide; channelled by streams 2-4 m wide; locally terraced	Deep alluvial loams to clays, commonly silty. Imperfectly to well drained. Weakly acid.	Grassland, often with scattered trees. Gallery forest along stream courses. Locally cultivated with vegetables and fruit trees.	d_1, a_3, n_1 or $_2$, x_2, fl_2, p_3 or $_4$, locally w_o	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1 M : S1 R : S2m

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

BENDUGU LAND SYSTEM 31



(1515 KM^2)

GENERAL DESCRIPTION

Intricately dissected association of plains and pointed hills

GEOLOGY

Archean granite complex with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Generally accordant hills of low relief occuring in association with very broad footslopes and interfluves of extremely low relief. The hills and interfluves are intricately dissected by narrow, flat bottomed colluvial valleys to give a distinctive "honeycomb" photo pattern. Along major streams narrow floodplains and associated alluvial and colluvial terraces are present.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
350	500	Low to moderate	Hills-steep to very steep; plains - very gentle to gentle	Medium	Dendritic	1.8 (1.4-2.3)

CLIMATIC TYPES C_1 and C_2

GENERAL LAND SUITABILITY

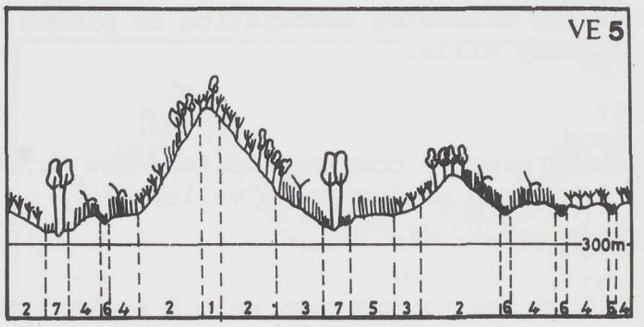
Steep slopes, infertile, very gravelly soils over much of the area combine to seriously limit the suitability of this land system to less demanding arable and tree crops. Valley swamps and floodplains. consisting of about 15% of the area, have higher suitability however, particularly for paddy rice and short cycle arable crops.

31

FACET BREAKDOWN



1 Km



% Area	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1-3	**Hill crests**					
	Broad, uneven crestal slope; very gentle	Moderately shallow, very gravelly and stony, reddish loams to clay loams. Well drained. Weakly to strongly acid.	Mosaic of secondary forest, regrowth grassland, thicket and scattered patches of cultivation.	d_3, a_2, n_3, x_4, fl_o, p_2, s_1, y_1	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
25-45	**Hill slopes**					
	Long; straight; steep to locally very steep slope; gullied	On steep slopes: shallow to moderately deep, very gravelly and stony, reddish loams to clay loams. On very steep slopes: deep, friable clay loams to clays. Well drained. Strongly acid.	As (1) above giving way to *Lophira* tree savanna in north east of the land system.	*d var.(av4)*, a_2, n_3, *x var.*fl_o, p_3, s_4, *locally on very steep slopes* d_1, x_1 s_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
40-52	**Footslopes and interfluves**					
	Medium to long; undulating; very gentle to gentle slope; mounds locally present	Moderately shallow to moderately deep, very gravelly loams to clays, gravel free topsoils locally present. Well drained. Strongly acid.	As (2) above	d_2 or $_3$, a_2, n_3, x_3, fl_o, p_3, s_1 or $_2$	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S2f G : S3r M : S2f R : N
1-5	**Low colluvial terraces**					
	Very gentle to gentle slope; 100-600 m wide; slightly undulating	Deep, variable loams to clay loams, locally with gravelly subsoils. Well to imperfectly drained. Strongly acid.	Predominantly grassland with scattered trees and localised cultivation.	d_1, a_2, n_2, x_2, fl_o, p_2 or $_3$, s_1	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S1 G : S2f M : S2f R : N
4-8	**Valley swamps**					
	Level to nearly level; 40-100 m wide; locally channelled	Deep, variable, medium to heavy textured colluvial and alluvial soils, locally peaty and frequently having sandy subsoils. Poorly drained to waterlogged. Strongly to weakly acid.	Sedge grassland/swamp thicket with raphia palms. Commonly cultivated for rice.	d_1, a_2, n_1 or $_2$, x_2, w_2, fl_3, *locally* w_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
4-12	**Minor floodplains**					
	Along drainage lines or marginal to rivers; level; 50-200 m wide; 1 m channelled relief	Alluvial loams to clays with coarser textures at variable depth. Imperfectly drained. Strongly to weakly acid.	Intensively used for rice cultivation followed by other arable crops. Gallery forest along stream courses.	d_o, a_3, n_2, x_1, w_1, fl_1 or $_2$, p_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1 M : S1 R : S2m/N

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

Ch = Cashew, Co = Coffee, Ca = Cassava, G = Groundnut, Ct = Citrus, M = Maize, Cn = Coconut, R = Paddy rice

Land suitability classes

S1 = High to moderate, S2 = Low, S3 = Very low, N = Nil

Land suitability subclass limitations

r = Rooting space, f = Soil fertility, m = Moisture availability, o = Oxygen availability, e = Erosion hazard

SANDARU LAND SYSTEM 32



(4080 KM^2)

GENERAL DESCRIPTION

Variably dissected association of plains and rocky hills.

GEOLOGY

Archean granite complex and Mano-Moa granulites. Recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Hills of low to moderate relief rising out of an undulating plain dissected by narrow valley swamps. The hills have broad crests and moderate to steep,gullied,commonly bouldery slopes. The plain comprises gently sloping,irregular footslopes and interfluves, incised into which are small,narrow, discontinuous valley swamps. Locally these swamps broaden into minor floodplains.

TERRAIN PARAMETERS

Altitude Min.(m)	*Max.(m)*	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
200	530	Low to moderate	Variable (very gentle to steep)	Medium	Dendritic	1.3 (1.2-1.4)

CLIMATIC TYPE B and C_1,locally C_2

GENERAL LAND SUITABILITY

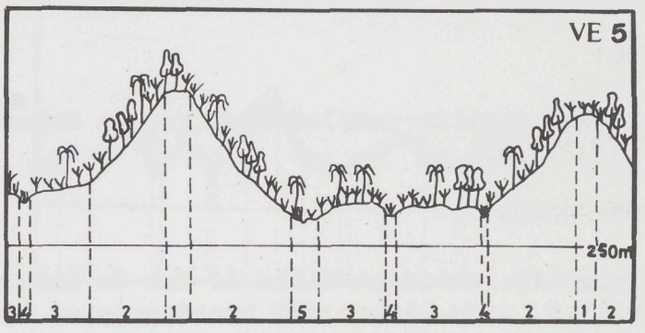
Half of this land system comprises bouldery hill slopes having little agricultural use. Of the remainder, gently undulating footslopes with predominantly very gravelly, acid and infertile soils have a very low suitability for most crops except cashew, coconuts and, in the drier north, ginger and sorghum. The floodplains and swamps are suitable for short cycle arable crops and paddy rice respectively.

32

FACET BREAKDOWN



1 Km



Facet	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
	1-3	Hill crests					
		Broad to very broad; uneven; very gentle to gentle slope	Moderately shallow to deep, gravelly sandy clay loams over saprolite. Locally very shallow soils to bedrock. Well drained. Strongly acid.	Thicket with patches of secondary forest and cultivation. Oil palms very common.	d_2, a_2, n_3, x_2 or $_3$, fl_o, p_3 or $_5$, s_2, locally y_1	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S2f G : S3r M : S2f R : N
	40-60	Hill slopes					
		Medium to long; straight to undulating; moderate to steep slope; few broad, prominent, gently to moderately sloping spurs; gullied, commonly bouldery	Moderately shallow to deep, gravelly sandy clay loams to sandy clays over saprolite. Common shallow soils to bedrock. Well drained. Strongly acid.	Thicket with patches of secondary forest and cultivation. Oil palms very common.	d_3, a_2, n_3, x_4, fl_o, p_3, s_4, y_3, locally d_5, x_5, y_4	Ch: S3e Ca: S3e Ct: N Cn: N	Co: S3e G : N M : N R : N
	28-50	Footslopes and irregular interfluves					
		Medium to long; irregular; level to gentle slope; gullied; locally bouldery, mounds locally present	Moderately deep to deep, locally shallow, very gravelly sandy clay loams to sandy clays over saprolite. Well drained. Strongly acid.	Thicket with patches of secondary forest and cultivation. Oil palms very common.	d_2, a_2, n_3, x_2 or $_3$, fl_o, p_3 or $_5$,	Ch: S1 Ca: S2r Ct: S3f Cn: S1	Co: S2f G : S3r M : S2f R : N
	3-7	Valley swamps					
		Level to nearly level; 20-100 m wide; locally channelled	Variable alluvial and colluvial soils. Very poorly drained to waterlogged. Strongly to weakly acid.	Swamp thicket with raphia palms. *Mitragyna spp.* Locally cultivated for rice.	a_2 or $_3$, n_1 or $_2$, x var., w_3, fl_3, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
	3-5	Minor floodplains					
		Level; 50-200 m wide; channelled, locally slightly bouldery	Medium to heavy textured alluvial soils, commonly silty and with sandy subsoils. Imperfectly drained. Strongly to weakly acid.	Grassland with scattered oil palms. Fairly intensively cultivated for rice.	d_1, a_3, n_1 or $_2$, x_1, w_1, fl_1 or $_2$, locally y_1	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1 M : S1 R : S2m/N

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

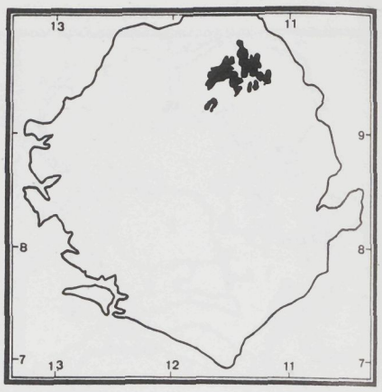
S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availabili
o = Oxygen availabilit
e = Erosion hazard

KABALA LAND SYSTEM 33

(1156 KM^2)



GENERAL DESCRIPTION

Dissected flat topped gravelly hills of low to moderate relief with common footslopes

GEOLOGY

Archean granite complex with recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Generally accordant hills of low to moderate relief with steep, often gullied, side slopes and broad crests. Gently sloping footslopes are common especially in the Kabala area. A few,narrow,flat bottomed valleys are scattered throughout the land system. Narrow floodplains locally become common along predominantly N-S structurally controlled streams.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
250	550	Low to moderate	Steep	Coarse	Dendritic	1.5 (1.3-1.7)

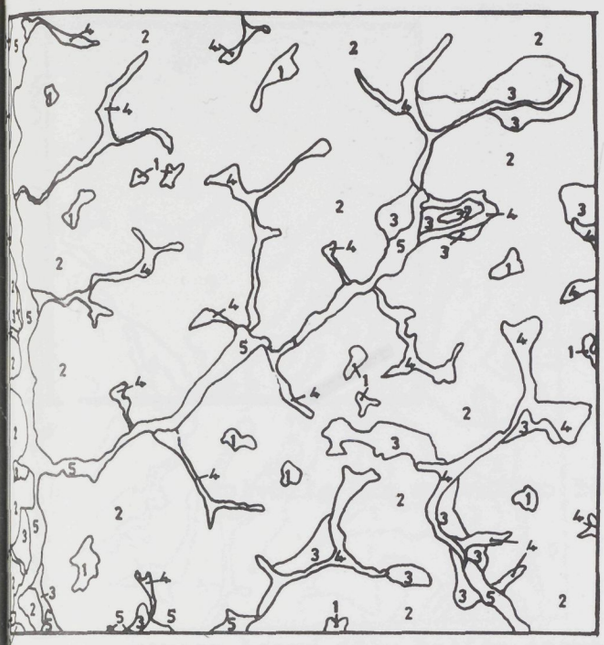
CLIMATIC TYPE D_1

GENERAL LAND SUITABILITY

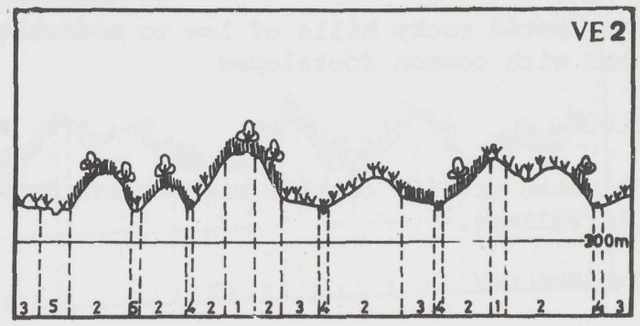
A high proportion of this land system comprises hills which, although at present cultivated by traditional methods in the Kabala area, are not suitable for more intensive forms of agriculture. The more level footslopes are suitable for drought resistant tree crops such as cashew and low demanding arable crops, e.g. sorghum and sesame. The seasonally flooded swamps and floodplains are very suitable for paddy rice and short cycle arable crops respectively.

33

FACET BREAKDOWN



1 Km



Facet No.	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	1-3	Hill crests					
		Broad; even; level to nearly level	Deep, very gravelly and stony loams and clay loams. Well drained. Strongly to weakly acid.	Grassland with tree savanna or savanna woodland.	d_3, a_2, n_3, x_3, fl_o, y_1	Ch: S1 Ca: S2r Ct: S3f Cn: S2m	Co: N G : S3r M : S2f R : N
2	50-84	Hill slopes					
		Medium to long; straight; steep; moderately dissected by gullies	Deep, very gravelly and stony loams to clays with occasional shallow loams. Well drained. Strongly to weakly acid.	Mixed savanna woodland and tree savanna with patches of secondary grassland and thicket. Scattered cultivation.	d_3, a_2, n_3, x_4, fl_o, p_3, s_4, y_2, locally s_5	Ch: S3e Ca: S3e Ct: N Cn: N	Co: N G : N M : N R : N
3	3-35	Footslopes					
		Short to medium length; straight; very gentle to gentle; rare termite mounds	Deep, reddish to yellowish loams to clays, commonly sandy or gravelly. Locally soils are shallow to weathering bedrock. Well drained. Strongly to weakly acid.	Mixed savanna woodland and tree savanna with patches of secondary grassland and thicket. Scattered cultivation.	d_2, a_2, n_3, x_3, fl_o, p_3, s_2, locally d_1 or $_4$, x_2 or $_5$	Ch: S1 Ca: S1/S2r Ct: S3f Cn: S2m	Co: N G : S2f/S3r M : S2f R : N
4	4-8	Valley swamps					
		Level to nearly level; 40-150 m wide; Commonly channelled	Deep, variable alluvial and colluvial soils. Poorly drained. Strongly acid.	Swamp thicket and also sedge grassland, commonly cultivated for swamp rice.	d_c or $_1$, a_2, n_1 or $_2$, x_2, w_2, fl_3, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
5	4-8	Minor floodplains					
		Level; 40-250 m wide; 1-2 m channelled relief	Alluvial loams to clays with silty layers. Imperfectly to poorly drained. Strongly to weakly acid.	Secondary regrowth, grassland and thicket commonly cultivated for vegetables. Gallery forest along stream courses.	d_1, a_3, n_1 or $_2$, x_1, w_1, fl_1 or $_2$, p_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G: S1 M : S1 R : S2m/N

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

Ch = Cashew; Co = Coffee; Ca = Cassava; G = Groundnut; Ct = Citrus; M = Maize; Cn = Coconut; R = Paddy rice

Land suitability classes

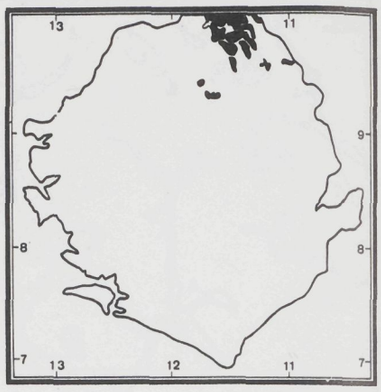
S1 = High to moderate; S2 = Low; S3 = Very low; N = Nil

Land suitability subclass limitations

r = Rooting space; f = Soil fertility; m = Moisture availability; o = Oxygen availability; e = Erosion hazard

HAFFIA LAND SYSTEM 34

(1299 KM^2)



GENERAL DESCRIPTION

Dissected rocky hills of low to moderate relief and with common footslopes

GEOLOGY

Archean granite complex with recent deposits of colluvium and alluvium in valleys.

GEOMORPHOLOGY

Generally accordant hill ridges of low to moderate relief with broad, uneven, rocky crests and steep, stony, sometimes gullied, side slopes. Occasional precipitous bare rock exposures are present. Gently sloping, short footslopes are generally frequent. A few narrow valley swamps and floodplains are present locally.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
330	760	Low to moderate	Moderate	Coarse	Dendritic	1.1 (1.0-1.2)

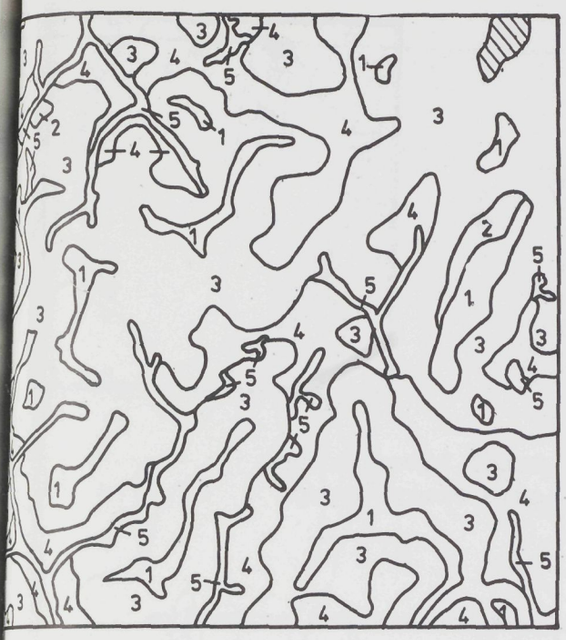
CLIMATIC TYPE D_1 and D_2

GENERAL LAND SUITABILITY

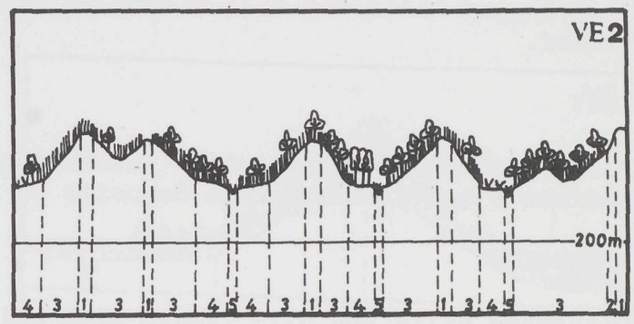
Most of this land system comprises rocky hills of no agricultural potential. The gently sloping footslopes have suitability generally low to very low for arable and tree crops due to the combination of a long dry season and infertile soils. The seasonally flooded swamps and floodplains have however, high suitability for paddy rice and, locally, short cycle arable crops.

34

FACET BREAKDOWN



1 Km



Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
5-9	**Hill crests**					
	Broad to very broad; very uneven; gentle to moderate slope	Very shallow soils to bedrock or laterite sheet.	Grassland and bare rock. Locally savanna woodland.	d_5, a_2, n_3, x_5, fl_o, p_2, s_2, y_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
1-3	**Rock outcrop**					
	Short; straight; precipitous; rocky	Pockets of very shallow soils to bedrock.	Rock outcrops with patches of grass.	d_5, x_5, fl_o, s_4 or $_5$, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
45-75	**Hill slopes**					
	Medium to long; straight; moderate to steep; in places dissected by gullies, locally rocky	Deep sandy loams and sandy clay loams over weathering parent material in association with shallow soils to bedrock. Well drained. Weakly acid to neutral.	Savanna woodland with patches of tree savanna and grassland.	d_3, a_2, n_2 or $_3$, x_4, fl_o, p_3, s_4, y_2, locally y_4	Ch: S3e Ca: S3e Ct: N Cn: N	Co: N G : N M : N R : N
20-30	**Footslopes**					
	Very short to short; straight to concave; very gentle to gentle slope very slightly gullied	Deep, reddish clay loams commonly sandy or gravelly. Commonly stones or rocks occur at shallow depths. Well drained. Strongly to weakly acid.	Mixed tree savanna and woodland with scattered patches of cultivation including a few citrus and forestry plantations.	d_2, a_2, n_2 or $_3$, x_3, fl_o, p_3, s_2, y_1 or $_2$, locally d_1 or $_4$, x_2 or $_5$	Ch: S2m Ca: S1/S2rm Ct: S3f Cn: S3m	Co: N G : S2f/S3r M : S2f R : N
4-8	**Valley swamps and minor floodplains**					
	Level to nearly level; 20-50 m wide; locally channelled	Deep, variable alluvial and colluvial soils. Poorly drained on floodplains. Strongly to weakly acid.	Swamp rice cultivation, with local vegetables; elsewhere sedge grassland or swamp thicket.	d_o or $_1$, a_2, n_1 or $_2$, x_1 or $_2$, w_1 or $_2$, fl_2 or $_3$, p var.	Ch: N Ca: N Ct: N Cn: N	Co: N G : N/S2f M : N/S2f R : S2m/S1

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

SAIONIA LAND SYSTEM 35

(628 KM^2)



GENERAL DESCRIPTION

Flat topped hills and hill ridges of variable relief.

GEOLOGY

Early Mesozoic dolerite sills interbedded with Rokel River Group sediments and glacio-marine deposits of the Saionia Scarp Group.

GEOMORPHOLOGY

Dissected hills and hill ridges with well developped crests and extensive gently sloping footslopes. The crests, which are most distinctive in the north, are somewhat concave and appear to be structurally controlled. There is a sharp break of slope between the crests and dolerite scarps with their associated scree slopes. These grade into steeply sloping dissected hill slopes which appear to be composed mainly of sediments. The more resistant dolerite sills give rise to structural benches on these slopes. Gently undulating footslopes are locally dissected by deeply incised streams, which often broaden into narrow valley swamps and drainage depressions.

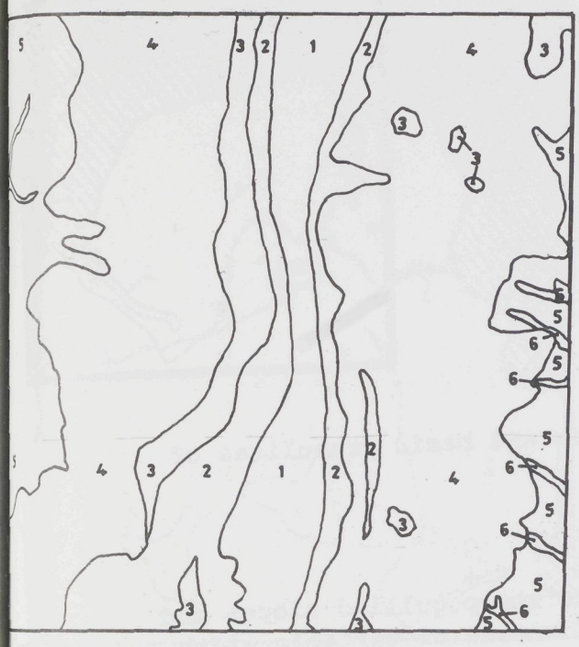
TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
80	800	moderate to very high	n.a.	Coarse to very coarse	Dendritic	0.6 (0.4-0.8)

CLIMATIC TYPE D_2, locally D_1

GENERAL LAND SUITABILITY

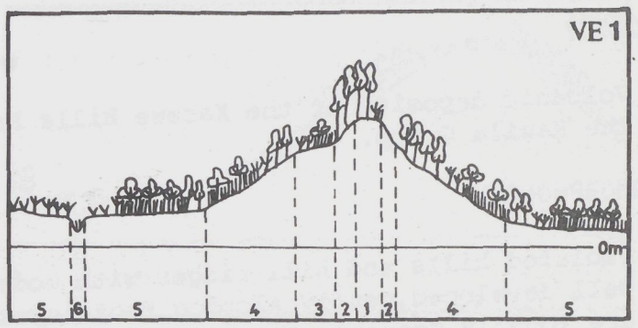
Shallow, infertile soils on steep, rocky slopes make most of this land system unsuitable. Footslopes have very low suitability for drought resistant arable and tree crops. Swamps nave high suitability for paddy rice.



1 Km

35

FACET BREAKDOWN



Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
5-15	Ridge crests					
	Narrow to very broad; uneven; very gentle crestal slope; stony and bouldery	Very shallow soils over laterite sheet.	Primary forest with thicket and grassland in places.	d_4, a_2, n_3, x_5, fl_o, s_1, y_4	Ch: N Ca: N Ct: N Cn: S3re	Co: N G : N M : N R : N
2-14	Rock outcrops and scree slopes					
	Very short to long; straight; very steep to precipitous; rocky and bouldery, gullied	Bare rock with pockets of very shallow soils.	Primary forest with areas of bare rock exposure.	d_5, x_5, fl_o, s_5, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
2-10	Benches					
	Very short to medium length; undulating; very gentle to gentle slope, bouldery	Shallow to moderately deep soils to bedrock or saprolite; locally very shallow	Thicket and tree savanna	d_4, a_2, n_2 or $_3$, x_5, fl_o, s_1, y_4, locally y_2, d_2, x_3	Ch: N Ca: N Ct: N Cn: S3re	Co: N G : N M : N R : N
34-60	Steep hill slopes					
	Medium length to very long; straight; steep to very steep; gullied	Shallow soils to bedrock or saprolite with pockets of deep loams to clays. Well drained.	Tree savanna with thicket and secondary forest on upper slopes.	d_4, a_2, n_2 or $_3$, x_5, fl_o, s_5, y var. locally d_1, x_2	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
16-40	Footslopes					
	Long to very long; concave to straight; very gentle to gentle slope	Deep, brownish sandy clay loams in association with reddish, very gravelly clay loams. Well drained. Strongly to weakly acid.	Savanna woodland with patches of cultivation, thicket and secondary forest.	d_2, a_2, n_2 or $_3$, x_2 or $_3$, fl_o, p_3, s_1	Ch: S2m Ca: S2m Ct: S3fm Cn: S3m	Co: N G : S2f/S3r M : S2f R : N
0-2	Valley swamps and drainage depressions					
	Level; 40-100 m wide; locally very slightly undulating; locally channelled	Moderately deep to deep, variable alluvial and colluvial soils. Poorly drained. Strongly acid.	Swamp thicket, sedge grassland and raphia palms. Cultivated for rice in parts.	d_1, a_2, n_2, x_2, w_2, fl_3, p_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

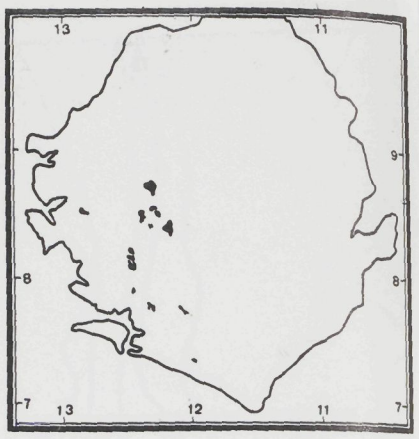
Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

KASEWE LAND SYSTEM 36



(333 KM^2)

GENERAL DESCRIPTION

Remnant hills of moderate to high relief with extensive footslopes.

GEOLOGY

Volcanic deposits of the Kasewe Hills Formation and basic granulites of the Kasila Group.

GEOMORPHOLOGY

Isolated hills and hill ridges with moderate to steep,gullied slopes and well developed,gently sloping footslopes. Hill crests of variable width are locally present. The hill ridges often exhibit a marked lineation. The footslopes are commonly formed on exposed laterite sheet and are intermittently dissected by gullies broadening into very narrow valley swamps.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
100	500	Moderate to high	Variable (gentle to steep)	Medium to coarse	Weak radial	0.2 (0.1-0.4)

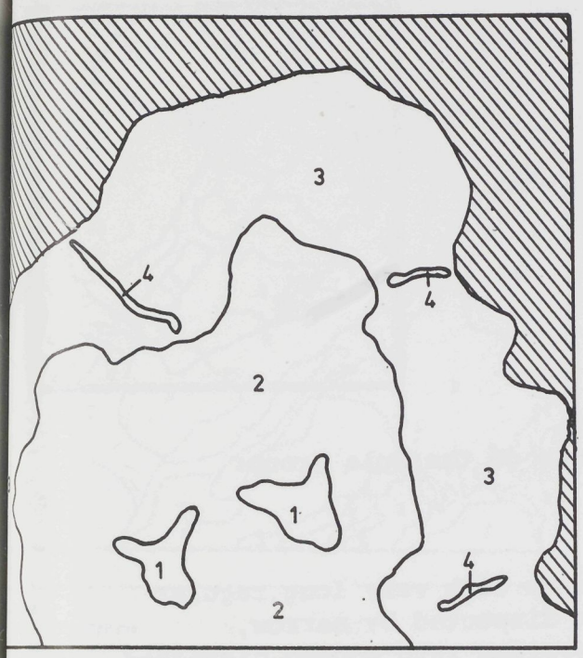
CLIMATIC TYPE C_2

GENERAL LAND SUITABILITY

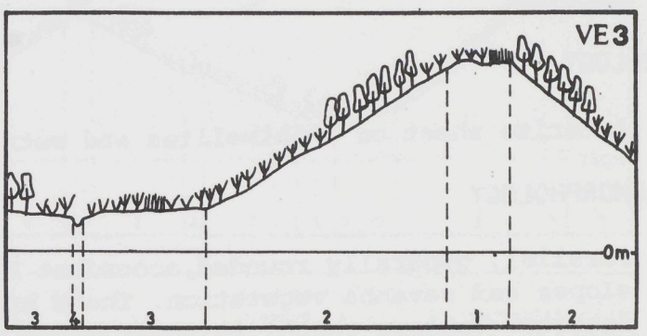
Shallow,droughty soils of very low fertility, combined with rockiness and gentle to steep slopes render this land system generally unsuitable for agriculture. Parts are at present being used for forest reserves, to which the area is most suited.

36

FACET BREAKDOWN



1 Km



Facet	Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1	0-4	**Hill crests**					
		Narrow to very broad; uneven; gentle slope	Shallow soils over bedrock or laterite sheet.	Thicket and grassland.	d_3, a_2, n_3, x_4, fl_o, p_3, s_2, y_3	Ch: S2me Ca: S2re Ct: S3fe Cn: S3r	Co: S3me G : S3e M : S3e R : N
2	40-54	**Hill slopes**					
		Long to very long; straight: moderate to steep slope; gullied; slump alcoves locally present; slightly bouldery	Moderately shallow to moderately deep, very gravelly clay loams. Very shallow soils to bedrock locally common. Well drained. Strongly to weakly acid.	Secondary forest and forest reserve	d_3, a_2, n_3, x_4, fl_o, p_3, s_4, y_3	Ch: S3e Ca: S3e Ct: N Cn: N	Co: S3me G : N M : N R : N
3	40-60	**Footslopes**					
		Long to very long; straight; very gentle to gentle slope; locally gullied, locally rocky	Very shallow to moderately shallow soils over laterite sheet. Well drained. Strongly acid.	Mosaic of secondary forest, thicket, grassland and patches of cultivation.	d_5, a_2, n_3, x_5, fl_o, p_3, y_4 *locally* d_3, x_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
4	0-2	**Valley swamps**					
		Very gentle slope; less than 50 m wide	Variable colluvial soils, commonly sandy at depth.	Sedge grassland.	a_2, n_2, x_2, w_3, fl_3, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

SULA LAND SYSTEM 37



(419 KM^2)

GENERAL DESCRIPTION

Dissected hill ridges with extensive laterite capping.

GEOLOGY

Laterite sheet on amphibolites and metasediments of the Sula Group.

GEOMORPHOLOGY

Parallel, generally rounded, accordant hill ridges with very long, regular slopes and savanna vegetation. These are often dissected by narrow, forested valleys which, in their upper reaches, widen into wooded, dissected slopes resembling amphitheatres. Broad, parallel valleys are flanked by gentle footslopes and contain rocky stream courses associated with narrow, discontinuous terraces.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
450	900	Moderate	Moderate to steep	Coarse	Sub-parallel	1.2 (1.1-1.4)

CLIMATIC TYPES C_2

GENERAL LAND SUITABILITY

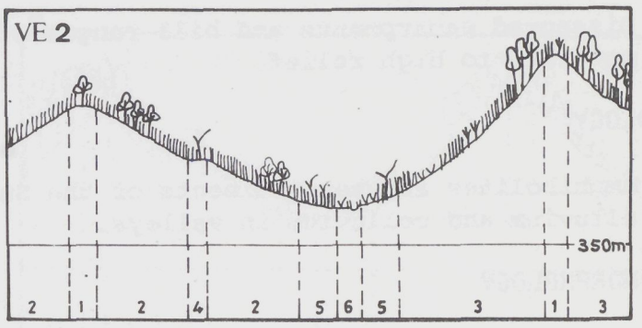
Generally unsuitable for crops because of shallow soils and stony and rocky slopes. These slopes are at present used for light cattle grazing by Foulah herdsmen and this seems to be their best use.

37

FACET BREAKDOWN



1 Km



Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
2-6	Ridge crests					
	Broad to very broad; uneven; very gentle to moderate crestal slope; stony and bouldery	Shallow soils to indurated laterite sheet predominate on facets in the central part of this land system. Locally, along the margins, deep red clay loams occur. Well drained. Weakly acid.	*Lophira* tree savanna. Localised patches of regrowth thicket.	d_4, a_2, n_3, x_5, fl_o, p_3, s_2, y_4, *locally* d_1, x_2 or $_3$, y_1	Ch: N Ca: N Ct: N Cn: S3re	Co: N G : N M : N R : N
40-50	Hill slopes					
	Very long; straight; gentle to moderate slope; very regular with laterite sheet and stones on surface	Shallow soils to indurated laterite sheet	*Lophira* tree savanna with patches of savanna woodland.	d_5, n_3, x_5, fl_o, p_2, s_4, y_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
25-35	Steep hill slopes					
	Long to very long; moderate to very steep slope; gullied, irregular, bouldery	Predominantly shallow soils to indurated laterite sheet with local occurrences of deeper, stony loams to clay loams.	Savanna grassland with regrowth thicket and patches of secondary forest. Scattered patches of cultivation on deeper soils.	d_4, n_3, x_5, fl_o, p_2, s_5, y_4, *locally* d_1, x_2, y_1	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
2-4	Benches					
	Ultra short to very short; nearly level to very gentle slope; straight; laterite sheet on surface	Shallow soils to indurated laterite sheet.	Savanna grassland dominated by *Lophira spp.*	d_5, n_3, x_5, fl_o, p_2, s_1, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
8-12	Footslopes					
	Very short to short; gentle to moderate slope; laterite sheet on surface	Shallow soils to indurated laterite sheet.	Savanna grassland with *Lophira spp.* Scattered patches of cultivation.	d_5, n_3, x_5, fl_o, s_2 or $_3$, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
6-8	Minor floodplains					
	Nearly level to level; 50-150 m wide; terraced; locally bouldery	Variable, medium to heavy textured alluvial and colluvial soils, commonly gravelly or silty. Locally very shallow to indurated laterite sheet. Imperfectly to very poorly drained. Strongly to weakly acid.	Patches of cultivation, predominantly swamp rice. Elsewhere sedge grassland or swamp thicket. Gallery forest along stream channels.	d_2, a_2, n_2, x_2, w_1 or $_3$, fl_1 or $_2$, p_4, *locally* d_5, x_5, y_2 or $_3$	Ch: N Ca: N Ct: N Cn: N	Co: N G : S2f M : S2f R : S2m
1	Drainage depressions and infilled lake floods					
	Level; up to 12 km wide	Deep, poorly drained alluvial and colluvial soils with shallow soils to indurated laterite sheet	Grassland with localised patches of gallery forest.	d_1, a_2, n_3, x_2, w_3, fl_2 or $_3$, p_3, *locally* d_5, x_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Not present in type area.

Land factors

- a = Effective soil depth
- s = Soil reaction
- n = Nutrient status
- c = Soil salinity
- z = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

KANGARI LAND SYSTEM 38



(1425 KM^2)

GENERAL DESCRIPTION

Dissected escarpments and hill ranges of moderate to high relief.

GEOLOGY

Amphibolites and metasediments of the Sula Group. Recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

General N-S trending,forested hill ranges which,in the centre of the country,form a distinctive escarpment fringing the western edge of the plateau. The ranges comprise mainly steep, dissected hill slopes with hill crests of variable width and scattered, gently sloping benches. Locally the terrain becomes more subdued with gentle, undulating foot-slopes and moderate, less dissected hill slopes with gently rounded crests. A few narrow valley swamps are present, except in the most dissected areas.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
150	830	Moderate to high	Moderate to steep	Medium to coarse	Dendritic	0.5 (0.3-0.6)

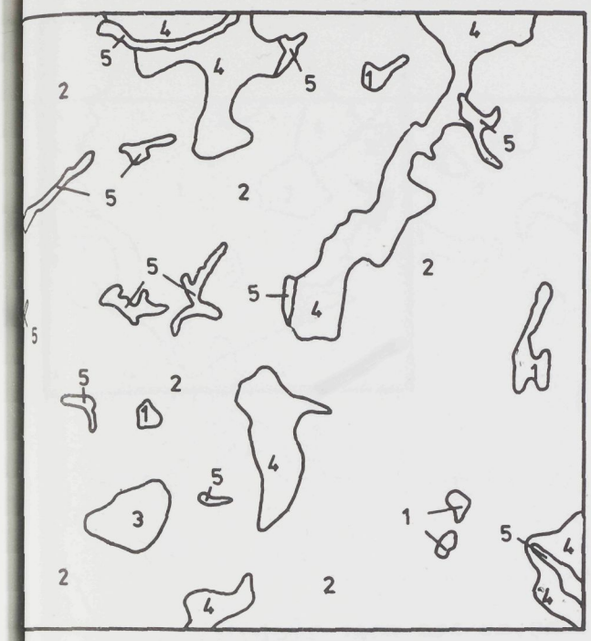
CLIMATIC TYPES B, C_1 and C_2, locally D_1

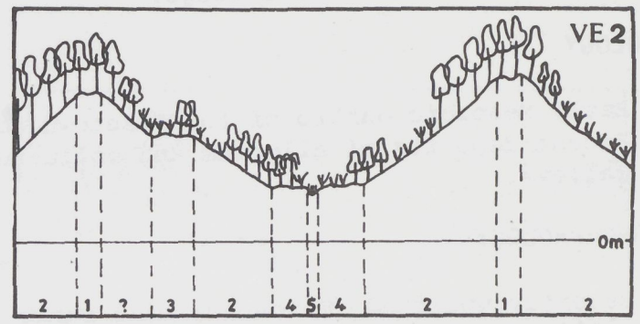
GENERAL LAND SUITABILITY

A high portion of steep slopes with shallow or very gravelly soils makes most of this land system unsuitable. The flatter footslopes and benches have limited suitability for arable and tree crops. Swamps are well suited for paddy rice. The area's highest suitability is for forest reserves under which a great part of it is at present.

38

FACET BREAKDOWN





Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
0-2	**Hill crests**					
	Narrow to broad; slightly uneven; very gentle to gentle slope	Shallow to deep, very gravelly clay loams with locally very shallow soils to laterite sheet. Well drained. Strongly acid.	Dense primary forest.	d_3, a_2, n_3, x_4, fl_0, p_3, s_2, y_2	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
80-90	**Hill slopes**					
	Medium to very long; straight; moderate to steep slope; moderately sloping prominent spurs; slump alcoves locally present, gullied, slightly bouldery	Shallow to moderately deep, very gravelly clay loams with locally very shallow soils to laterite sheet. Well drained. Strongly to weakly acid, locally neutral.	Mosaic of primary forest, secondary forest, thicket and patches of cultivation.	d_4, a_2, n_3, x_4, fl_0, p_3, s_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
0-2	**Benches**					
	Medium to long; undulating; very gentle to gentle slope	Moderately shallow to deep, very gravelly clay loams with very shallow soils to laterite sheet. Well drained. Strongly to weakly acid, locally neutral.	Mosaic of primary forest, thicket and patches of cultivation.	d_3, a_2, n_3, x_4, fl_0, p_3, s_2, *locally* d_5, x_5, s_1	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
5-17	**Footslopes**					
	Medium length; undulating; very gentle to gentle slope; locally gullied	Moderately shallow to deep, very gravelly clay loams with locally very shallow soils to laterite sheet. Well drained. Strongly to weakly acid, locally neutral.	As above with few oil palms.	d_3, a_2, n_3, x_4, fl_0, p_3, s_2, y_1	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
1-3	**Valley swamps**					
	Level to nearly level; 40-80 m wide	Variable alluvial and colluvial soils, locally organic. Poorly drained to waterlogged. Strongly to weakly acid.	Sedge grassland, rice cultivation, few oil palms.	n_2, x_2, w_3, fl_3, p_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

REGENT LAND SYSTEM 39



(326 KM^2)

GENERAL DESCRIPTION

Strongly dissected hill range.

GEOLOGY

Early Mesozoic gabbro of the Freetown complex. Recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Recently uplifted (Mesozoic) hill range comprising,at its most typical, gullied,steep,bouldery slopes with narrow crested ridges and deeply incised,V-shaped valleys. Along the northern and eastern flanks of the range slopes became less steep and are associated with broad, gently sloping ridge and spur crests. Gently sloping benches, saddles and foot-slopes are common in these areas. Very narrow, intensively cultivated, floodplains occur along major streams.

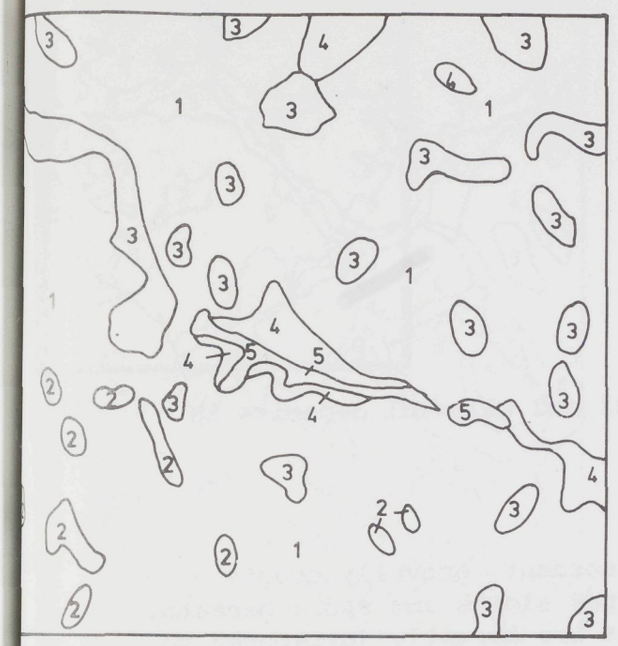
TERRAIN PARAMETERS

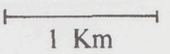
Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
50	886	High	Steep	Medium	Dendritic	0.7 (0.2-0.8)

CLIMATIC TYPE C_2

GENERAL LAND SUITABILITY

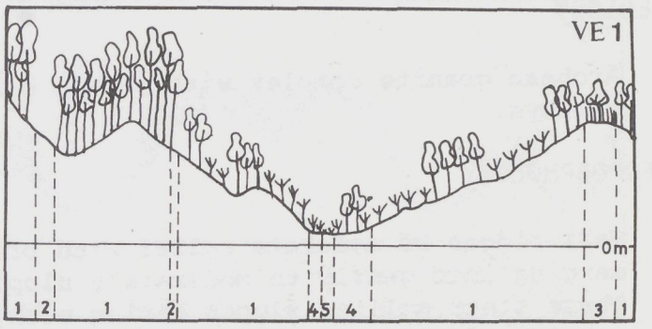
Predominantly steep,bouldery slopes with shallow,infertile soils render this area generally unsuitable. Although the central part of the range is maintained as a forest reserve, cultivation of the northern flank is increasing and erosion is becoming acute. Restriction of farming to the flatter footslope and bench areas and re-afforestation of the northern slopes will be necessary if irreversible degradation of this land is to be prevented. The narrow floodplains are at present used to grow vegetables for the Freetown market and some possibilities exist for the intensification of these activities.





39

FACET BREAKDOWN



Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
80-90	**Hill slopes and crests**					
	Long to very long; straight to undulating; moderate to steep; frequently gullied, bouldery, especially in the central part of the system. Narrow, prominent, nearly level crests	Very shallow and shallow soils to bedrock with pockets of deeper loams to clays. On the northern and eastern flanks very gravelly soils predominate. Well drained. Strongly to weakly acid.	In centre of land system closed high forest (forest reserve) predominates. On its northern and eastern flanks, a mosaic of young secondary forest, regrowth thicket and patches of cultivation occurs. Slopes are locally terraced in Freetown/Leicester area.	d_4, a_2, n_3, x_5, fl_o, p_2, s_4, y_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
1-3	**Rock outcrops**					
	Very short to short; irregular; very steep to steep; bouldery	Bare rock with pockets of very shallow soils.	Bare rock with grass patches.	d_5, n_3, x_5, fl_o, s_5, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
2-16	**Broad ridge and spur crests, benches and saddles**					
	Short to medium length; very gentle to gentle slope; undulating; stony and bouldery	Shallow to moderately deep, very gravelly loams to clays frequently with stones, boulders on the surface. Well drained. Strongly to weakly acid.	As in 1 above with patches of tree savanna north of Regent.	d_2 or $_3$, a_2, n_3, x_3 or $_4$, fl_o, p_2, s_2, y_4	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
0-6	**Footslopes**					
	Short to long; very gentle to gentle slope; undulating; locally bouldery	Moderately shallow to shallow, reddish to yellowish, gravelly clay loams to clays; frequently with gabbro or laterite boulders near the surface. Well drained. Strongly to weakly acid.	Mosaic of young secondary forest, thicket regrowth and patches of cultivation with scattered village settlements associated with gardens and fruit trees.	d_3, a_2, n_3, x_4, fl_o, s_1, y_2, locally y_3	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
0-2	**Minor floodplains**					
	Level to nearly level; up to 50 m wide; locally bouldery	Medium to heavy textured alluvial and colluvial soils, locally gravelly or shallow to bedrock. Well drained to poorly drained. Weakly acid to neutral.	Intensive horticulture.	d_o or $_1$, a_3, n_1 or $_2$, x_1 or $_2$, fl_1 or $_2$, p_3 or $_4$, locally d_4 x_4	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S1 M : S1 R : S2m

Land factors

- d = Effective soil depth
- a = Soil reaction
- n = Nutrient status
- c = Soil salinity
- x = Soil AWC
- w = Soil drainage
- fl = Flooding
- p = Soil permeability
- s = Slope steepness
- y = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

QUANTAMBA LAND SYSTEM 40



(1342 KM^2)

GENERAL DESCRIPTION

Dissected flat-topped gravelly hills

GEOLOGY

Archean granite complex with recent colluvial and alluvial deposits in valleys.

GEOMORPHOLOGY

Hill ridges of moderate relief with broad,accordant, gravelly crests merging into gently to moderately sloping upper slopes and spurs beneath. These steep,gullied slopes having stony soils are abruptly juxtaposed to gently sloping,gravelly footslopes. A few broad valley swamps and floodplains are scattered throughout the land system.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
200	600	Moderate to high	Steep	Coarse	Dendritic	1.1 (1.0-1.2)

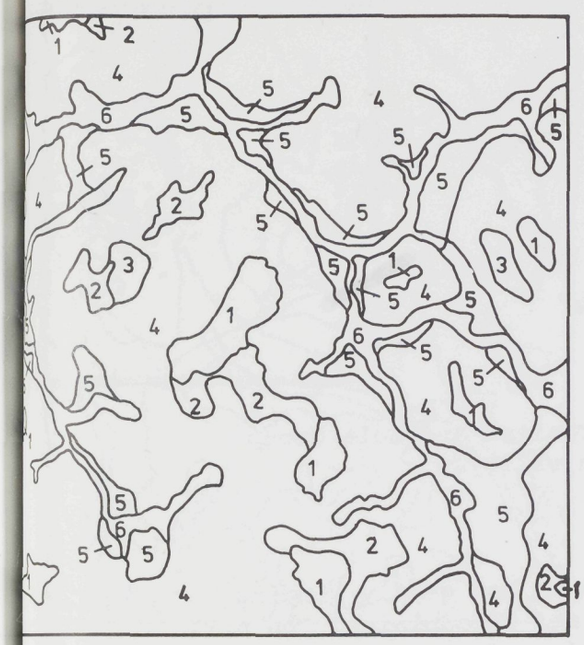
CLIMATIC TYPE D_1 and D_2

GENERAL LAND SUITABILITY

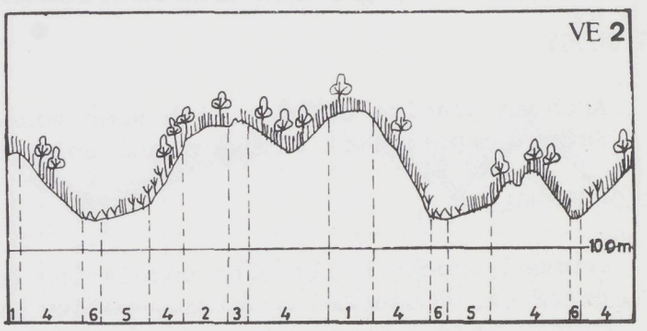
This land system is in general unsuitable because of shallow or gravelly soils with low water holding capacity on moderate to steep slopes. Footslopes have low to very low suitability for drought resistant arable and tree crops. Deep, gravel free soils make floodplains and valley swamps well suited to arable crops and paddy rice respectively.

40

FACET BREAKDOWN



1 Km



% Area	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
4-8	Hill crests					
	Very broad; even; nearly level to gentle crestal slope	Very gravelly and stony loams to clay loams. Well drained. Strongly to weakly acid.	Grassland with scattered trees.	d_3, a_2, n_3, x_4, fl_o, p_2, s_1, y_1	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: N G : S3r M : S2fm R : N
3-7	Upper hill slopes and spur crests					
	Very short to medium length; convex; gentle to moderate slope. Spur crests: even, narrow and prominent	Moderately shallow to deep, very gravelly loams to clays. Well drained. Strongly to weakly acid.	Tree savanna. Savanna woodland locally present.	d_3, a_2, n_3, x_4, fl_o, p_2, s_1	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: N G : S3r M : S2fm R : N
1-3	Rock outcrops					
	Very short to short; straight; precipitous; rocky	Very shallow soils to bedrock.	Patches of grass and occasional trees in rock fissures.	d_5, x_5, s_5, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
55-75	Steep hill slopes					
	Medium to very long; straight; steep to very steep; gullied, bouldery	Moderately shallow, gravelly and stony loams to clay loams, locally very shallow to bedrock. Well drained. Strongly to weakly acid.	Tree savanna and savanna woodland. Thicket locally present.	d_2, a_2, n_2 or $_3$, x_3, fl_o, s_5, y_1 or $_3$, locally d_4, x_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
10-18	Footslopes					
	Short to medium length; moderate slope; undulating	Deep, very gravelly to clay loams, locally stony or shallow to bedrock. Well drained. Strongly to weakly acid.	Grassland with scattered patches of cultivation and thicket.	d_3, a_2, n_3, x_3, fl_o, p_2, s_2, y_1	Ch: S1 Ca: S2r Ct: S3f Cn: S2m	Co: N G : S3r M : S2f R : N
6-10	Valley swamps and minor floodplains					
	Nearly level; 50-150 m wide; locally channelled	Deep, variable alluvial and colluvial soils. Poorly, locally imperfectly, drained. Weakly acid to neutral.	Fairly intensive cultivation and swamp grassland or thicket.	a_3, n_1 or $_2$, x_1 or $_2$, w_1, fl_2 or $_3$, p var.	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1/N M : S1/N R : S1/S2m

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

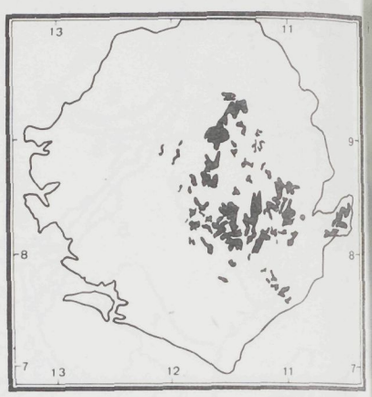
Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

KULUFAGA LAND SYSTEM 41



(4181 KM^2)

GENERAL DESCRIPTION

Rocky hill complex of moderate to high relief

GEOLOGY

Archean granite complex with some younger granites and Sula Group. Recent deposits of alluvium and colluvium in valleys.

GEOMORPHOLOGY

Commonly rocky hills with undulating footslopes and gently sloping terraces, dissected by narrow valley swamps and floodplains. The hill crests vary between very narrow and broad and grade into steep, rocky or bouldery, gullied slopes. Gently sloping, slightly dissected footslopes are often associated with inconspicuous terraces in the broader, commonly fault controlled valleys. Rare, narrow, scattered valley swamps in places form broader floodplains adjacent to minor rivers.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
350	680	Moderate to high	Steep	Coarse	Dendritic, locally sub-parallel	0.8 (0.4-1.5)

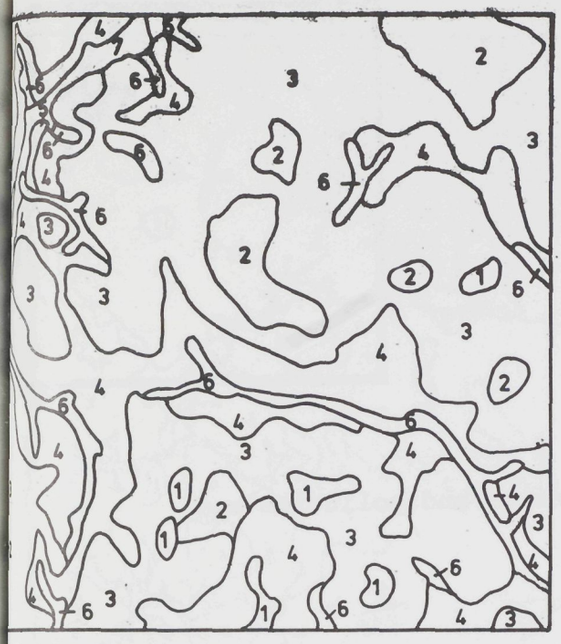
CLIMATIC TYPES C_2, C_1 and B.

GENERAL LAND SUITABILITY

Rockiness, shallow soils and moderate to steep slopes give this land system a very low suitability. However, footslopes and terraces are suitable for arable and tree crops. Swamps and floodplains are well suited to paddy rice and short cycle arable crops respectively.

41

FACET BREAKDOWN



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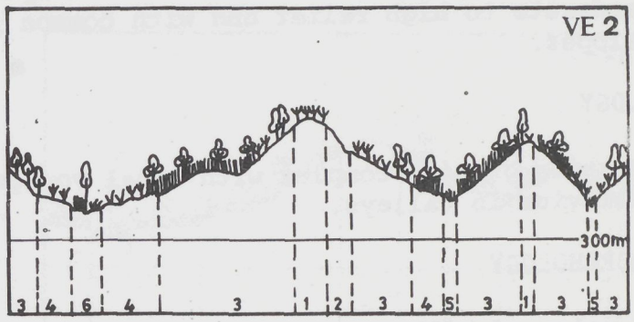


% Area	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1-3	**Hill crests**					
	Very narrow to broad; uneven; nearly level to very gentle slope	Deep, gravelly sandy clay loams over saprolite interspersed with shallow soils to bedrock. Well drained. Strongly acid.	Mosaic of thicket, patches of cultivation and secondary forest.	d_3, a_2, n_3, x_4, fl_o, p_3, s_1, y_2, locally d_1, x_3	Ch: S2m Ca: S2r Ct: S3f Cn: S3r	Co: S3m G : S3r M : S2fm R : N
2-8	**Rock outcrops**					
	Short to medium length; irregular; gentle to precipitous; rocky and bouldery	Bare rock with locally very shallow soils.	Bare rock with patches of grass.	d_5, x_5, s_4, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
60-74	**Hill slopes**					
	Medium to long; straight; steep; narrow, gently to moderately sloping, prominant spurs; bouldery, gullied	Shallow sandy clay loams to saprolite or bedrock with locally deeper, reddish clay loams. Well drained. Strongly to weakly acid.	Mosaic of tree savanna, thicket, secondary forest and patches of cultivation.	d_4, a_2, n_3, x_4, fl_o, p_3, s_4, y_2, locally d_1, x_2, y_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
15-25	**Footslopes**					
	Gentle; 50-100 m wide; locally bouldery; locally gullied	Moderately deep to deep, locally shallow, brownish clay loams, commonly sandy or gravelly. Well drained. Strongly to weakly acid.	Mosaic of tree savanna, thicket, secondary forest and patches of cultivation.	d_1, a_2, n_2 or $_3$, x_2 or $_3$, fl_o, p_3, y_1	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S1 G : S2r M : S2f R : N
0-2	**Low colluvial terraces**					
	Nearly level; 50-100 m wide	Deep loams to clay loams, frequently sandy. Well drained. Strongly acid.	As above	d_1, a_2, n_2 or $_3$, fl_o, p_3	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S1 G : S2r M : S2f R : N
2-4	**Valley swamps**					
	Level to nearly level; 40-100 m wide; locally channelled	Deep, sandy colluvial soils, commonly peaty. Poorly drained to waterlogged. Strongly to weakly acid.	Sedge grass, raphia palm and *Mitragyna sp.*	a_2, n_1 or $_2$, x_2, w_3 or $_4$, fl_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
0-4	**Minor floodplains**					
	Level; 50-200 m wide; locally terraced, channelled	Deep, variable alluvial silty clay loams to clays. Imperfectly drained. Strongly to weakly acid.	Grassland with discontinuous gallery forest along river courses. Fairly intensively cultivated with rice and vegetables.	d_1, a_3, n_1 or $_2$, x_2, w_2, fl_2, p_4	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1 M : S1 R : S2m

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

SAIAMA LAND SYSTEM 42



(2246 KM^2)

GENERAL DESCRIPTION

Intricately dissected faulted hill complex of moderate to high relief and with common footslopes.

GEOLOGY

Archean granite complex with local younger granites and colluvium and alluvium in valleys.

GEOMORPHOLOGY

Complex of hills of moderate to high relief, often fault controlled, rising out of gentler footslopes. The hills are generally pointed and have very irregular slopes, either with extensive rock outcrops or with scattered large granite boulders. They are commonly associated with gently to moderately sloping footslopes of variable width which occur at several distinct levels. Very narrow wooded valleys often grade into much wider,cultivated floodplains.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
300	1000	Moderate to high	Variable	Coarse	Dendritic	1.7 (1.6-1.7)

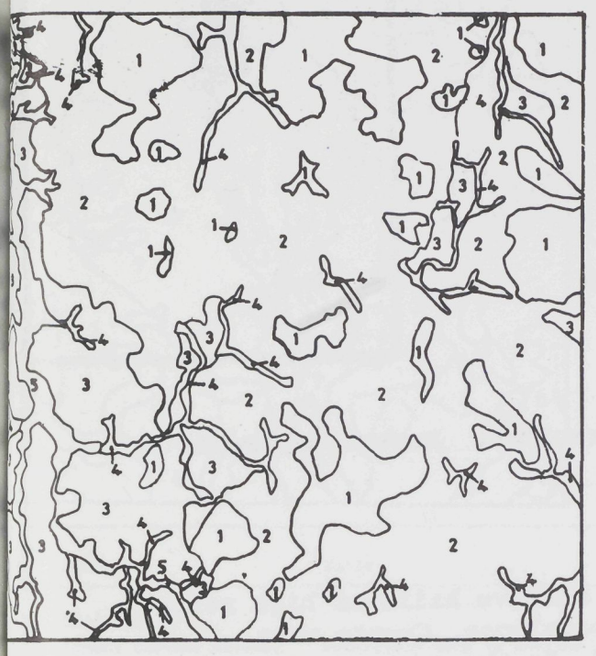
CLIMATIC TYPE C_1 and C_2

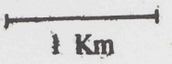
GENERAL LAND SUITABILITY

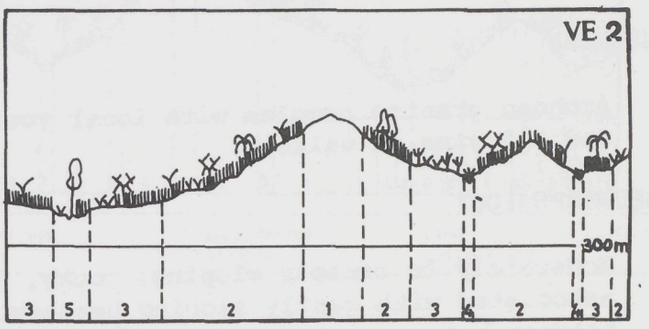
This land system is generally unsuitable due to a high proportion of steep, bouldery slopes and shallow,infertile soils. The gentler footslopes are suitable for arable and low demanding,drought resistant tree crops. The valley swamps are well suited to paddy rice and the floodplains to short cycle arable crops.

42

FACET BREAKDOWN







Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
6-10	**Rock outcrops**					
	Medium length; irregular; steep to very steep	Bare rock with localised patches of shallow soils	Bare rock with grass and shrubs in fissures	d_5, x_5, s_4 or $_5$, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
60-80	**Irregular hill slopes**					
	Short to very long; irregular; very gentle to steep; gently sloping inconspicuous spurs; bouldery	Predominantly shallow soils with pockets of moderately deep sandy clay loams. Well drained. Weakly acid.	Tree savanna. Common species are *Lophira*, *Parkia* and oil palm. Secondary forest in gulleys. Few patches of cultivation on gentler slopes.	d_4, a_2, n_2 or $_3$, x_4, fl_o, p_2 or $_3$, s var., y_3, locally d_1, x_2	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
8-20	**Footslopes**					
	Very short to long; undulating, locally irregular; very gentle to moderate slope; locally bouldery	Deep coarse sandy clay loams with patches of very shallow soils to bedrock. Well drained. Strongly to weakly acid.	Tree savanna as above. Patches of secondary forest, thicket and cultivation.	d_2, a_2, n_2 or $_3$, x_3, fl_o, p_3, locally y_3, d_5, x_5	Ch: S1 Ca: S1 Ct: S3f Cn: S1	Co: S3m G : S2f M : S2f R : N
4-6	**Valley swamps**					
	Level to nearly level; 15-50 m wide; commonly channelled	Deep, medium to coarse textured alluvial and colluvial soils, commonly organic. Poorly drained to waterlogged. Weakly acid to neutral.	Sedge grassland cultivated in places for rice. Gallery forest along stream courses.	a_2, n_1 or $_2$, x_3, w_3, fl_3, p_2 or $_3$	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
2-4	**Minor floodplains**					
	Level; 50-200 m wide; locally terraced	Deep, medium to heavy textured alluvial soils, high in silt. Imperfectly to poorly drained. Strongly to weakly acid.	Grassland with fairly intensive cultivation. Discontinuous gallery forest.	a_3, n_1 or $_2$, x_2, w_2, fl_1, p_4	Ch: S3o Ca: N Ct: N Cn: S3o	Co: N G : S1 M : S1 R : N

Land factors

- *d* = Effective soil depth
- *a* = Soil reaction
- *n* = Nutrient status
- *c* = Soil salinity
- *x* = Soil AWC
- *w* = Soil drainage
- *fl* = Flooding
- *p* = Soil permeability
- *s* = Slope steepness
- *y* = Surface stones and rocks

Crops

- Ch = Cashew
- Ca = Cassava
- Ct = Citrus
- Cn = Coconut
- Co = Coffee
- G = Groundnut
- M = Maize
- R = Paddy rice

Land suitability classes

- S1 = High to moderate
- S2 = Low
- S3 = Very low
- N = Nil

Land suitability subclass limitations

- r = Rooting space
- f = Soil fertility
- m = Moisture availability
- o = Oxygen availability
- e = Erosion hazard

TONKOLILINI LAND SYSTEM 43

(2844 KM^2)



GENERAL DESCRIPTION

Massive dissected rocky high hills and peaked hill ridges.

GEOLOGY

Archean granite complex with local younger granites. Recent colluvium and alluvium in valleys.

GEOMORPHOLOGY

Moderately to steeply sloping, rocky, rather massive hills of high relief associated with gently sloping benches and footslopes. Crests vary between being pointed and locally flat topped. In the western parts the hills of this land system occur as outliers on the interior plain and become more peaked and less massive. Very steep slopes are fairly common. Valleys are narrow, deeply incised and tend to be structurally controlled. They contain localized alluvial deposits.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
180	800	Moderate to high	Moderate to steep	Coarse	Angulate	1.4 (1.0-2.0)

CLIMATIC TYPES D_1 and D_2, locally C_2

GENERAL LAND SUITABILITY

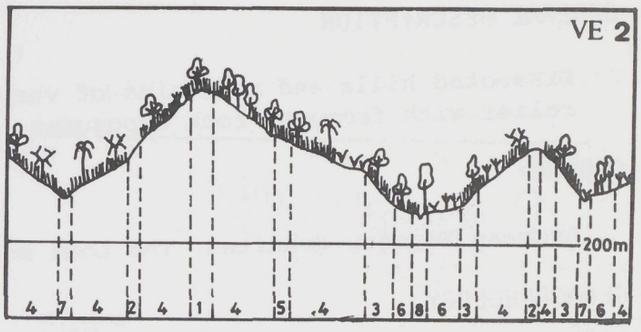
Shallow, infertile soils with low waterholding capacity, combined with a pronounced dry season and steep, rocky slopes render this land system generally unsuitable. The flatter upland areas have low suitability for tree crops while the swamps and floodplains are suitable for paddy rice and short cycle arable crops respectively.



1 Km

43

FACET BREAKDOWN



Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1-3	Hill crests					
	Broad; uneven; crestal slope: gentle to very gentle; locally bouldery	Moderately deep to shallow loamy sands to sandy clay loams over weathering bedrock, locally very shallow soils. Well drained. Strongly acid to neutral.	Tree savanna with patches of secondary forest and thicket.	d_3, a_2, n_2, x_4, fl_o, s_2, y_2	Ch: S2m Ca: S2r Ct: S3fm Cn: S3rm	Co: N G : S2fe M : S2fe R : N
4-6	Rock outcrops					
	Very short to short; irregular; very steep to precipitous; bouldery	Patches of very shallow soils to bedrock.	Bare rock, some grass and shrubs in fissures.	d_5, x_5, fl_o, s_5, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
5-15	Steep hill slopes					
	Short to medium; straight; steep to very steep; sometimes gullied; bouldery	Predominantly shallow soils to bedrock with pockets of deep clay loams to clays. Well drained. Strongly to weakly acid.	Tree savanna with patches of secondary forest and thicket. Rare cultivation.	d_4, a_2, n_2 or $_3$, x_5, fl_o, p_3, s_4 or $_5$, y_3, locally d_1, x_2	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
54-70	Irregular hill slopes					
	Long;undulating, irregular; moderate to steep; generally conspicious spurs of variable width; gullied, bouldery	Predominantly shallow soils to bedrock with pockets of moderately deep sandy clay loams. Well drained. Strongly to weakly acid.	Tree savanna with patches of secondary forest and thicket. Scattered cultivation.	d_4, a_2, n_2 or $_3$, x_5, fl_o, p_2 or $_3$, s_3 or $_4$, y_3, locally d_1, x_2	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
1-5	Benches					
	Short;very gentle to gentle slopes; undulating; bouldery	Moderately deep to shallow sandy loams to clays with pockets of very shallow soils. Well drained. Strongly acid.	As in 4 above	d_3, a_2, n_2 or $_3$, x_4, fl_o, p_2 or $_3$, s_1, y_3, locally d_5, x_5,	Ch: S2me Ca: S2re Ct: S3fm Cn: S3rm	Co: N G : S3r M : S3r R : N
8-16	Footslopes					
	Very short to short; gentle slopes; undulating; stony, locally bouldery.	Moderately deep to shallow sandy loams to clay loams,in places gravelly. Well drained. Strongly acid.	Tree savanna ; patches of thicket, secondary forest and cultivation.	d_3 or $_4$, a_2, n_2 or $_3$, x_4, fl_o, p_2, s_2, y_1, locally y_3, d_2, x_3	Ch: S2me Ca: S2re Ct: S3fm Cn: S3rm	Co: N G : S3r M : S3r R : N
3-5	Valley swamps					
	Level to nearly level; 50-100 m; locally channelled	Deep,variable alluvial and colluvial soils generally medium to heavy textured. High in silt and organic matter. Imperfectly to very poorly drained.	Sedge grassland and swamp thicket. Common swamp rice cultivation.	d_1, a_2, n_1 or $_2$, x_2, w_1 to $_3$, fl_3, p_3 or $_4$,	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : S1
0-4	Minor floodplains					
	Level to nearly level; 50-200 m wide; channelled, sometimes terraced	As in 7 above but lower in organic matter	Grassland with discontinuous gallery forest. Scattered patches of thicket and cultivation.	d_1, a_3, n_1 or $_2$, x_2 w_1, fl_1, p_3 or $_4$	Ch: N Ca: N Ct: N Cn: N	Co: N G : S1 M : S1 R : N

Land factors

d = Effective soil depth
t = Soil reaction
n = Nutrient status
c = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
Ct = Citrus
Cn = Coconut
Co = Coffee
G = Groundnut
M = Maize
R = Paddy rice

Land suitability classes

S1 = High to moderate
S2 = Low
S3 = Very low
N = Nil

Land suitability subclass limitations

r = Rooting space
f = Soil fertility
m = Moisture availability
o = Oxygen availability
e = Erosion hazard

LOMA LAND SYSTEM 44

(979 KM^2)



GENERAL DESCRIPTION

Dissected hills and mountains of very high relief with frequent rock exposures.

GEOLOGY

Archean Younger granites. The Loma mountains are capped by dolerite.

GEOMORPHOLOGY

Sharp crested, rocky ridges and pointed peaks forming generally massive, wedge-shaped blocks, bounded by deeply incised, structurally controlled valleys. The rocky side slopes are very steep to precipitous and in the Loma Mountains and Tingi hills abruptly pass, at lower altitudes, into dissected, steep, forested slopes. In the Gbengbe hills forested slopes are absent: here incised narrow gullies divide the blocks into numerous sub-parallel ridges. Throughout the land system a relatively small proportion of gentle slopes are present, comprising high lying benches and lower lying footslopes adjacent to valley bottoms. While most of the valleys have narrow irregular, bouldery streambeds some of the larger valleys at lower altitude have floors which are commonly flat and contain small floodplains.

TERRAIN PARAMETERS

Altitude Min.(m)	Max.(m)	*Relief*	*Dominant slope*	*Grain*	*Drainage pattern*	*Drainage density*
200	1945	High to very high	Very steep to precipitous	Coarse	Sub-parallel to dendritic	1.2 (0.8-1.6)

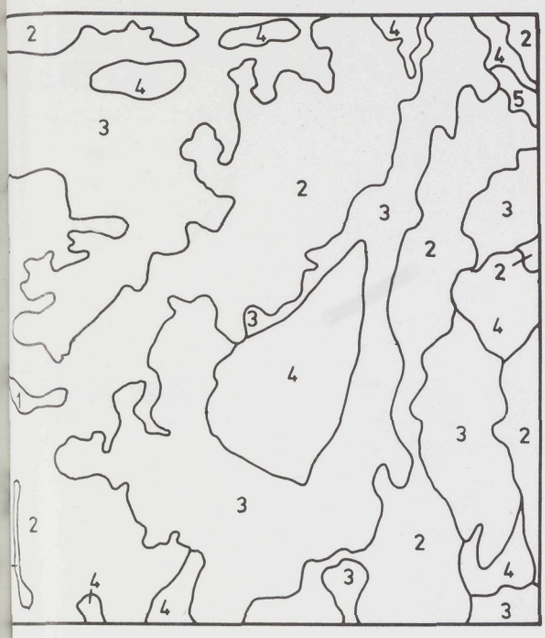
CLIMATIC TYPE C_2

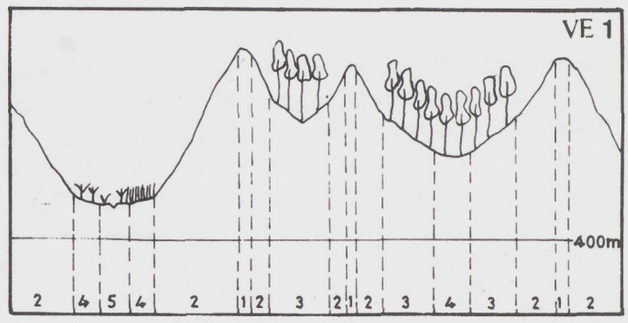
GENERAL LAND SUITABILITY

Because of its rugged topography this land system is unsuitable, with the exception of very small floodplains at present under paddy rice. Under careful management it might be suitable for forestry, but probably it should be maintained as a wild life refuge and tourist attraction.

44

FACET BREAKDOWN





Area (%)	Landform	Soils	Vegetation and land use	Land factor classes	Land suitability	
1-3	Ridge crests					
	Very narrow to very broad; uneven; gentle to moderate crestal slope; rocky	Bare rock with scattered pockets of shallow soils.	Scattered patches of moss. Grass and shrubs in joint fissures.	d_5, n_3, x_5, fl_o, s_2, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
3-75	Steep rocky hill slopes					
	Long to very long; straight; very steep to precipitous; very steep prominent spurs; very rocky and bouldery	Bare rock with scattered pockets of shallow soils.	Scattered patches of moss. Grass and shrubs in joint fissures.	d_5, n_2 or $_3$, x_5, fl_o, s_5, y_5	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
0-60	Steep forested hill slopes					
	Long to very long; straight to concave; steep to very steep; inconspicuous spurs; bouldery, gullied	Pockets of sandy clay with a deep organic surface layer. Depth to bedrock and weathering granite boulders is very variable.	Gallery forest dominated by *Parinari excelsa*.	d_4, n_2 or $_3$, x_4, fl_o, p_2, s_4 or $_5$, y_3	Ch: N Ca: N Ct: N Cn: N	Co: N G : N M : N R : N
8-16	Benches and footslopes					
	Short to long; very gentle to gentle slopes; undulating, bouldery	Moderately deep to shallow loams to clays with pockets of very shallow soils. Well drained.	Variable: generally grass and scattered shrubs in Loma Mountains; in Tingi Hills primary forest predominates.	d_4, a_2, n_2 or $_3$, x_4, fl_o, s_2, y_2, *locally* d_2, x_3	Ch: N Ca: N Ct: N Cn: S3r	Co: N G : S3r M : S3r R : N
1-2	Minor floodplains					
	Level to nearly level; 50-150 m wide; channelled	Variably textured alluvial and colluvial soils. Generally poorly drained.	Generally cultivated; patches of regrowth thicket and grassland.	d_1, a_2, n_1 or $_2$, x_2, w_2, fl_2, *p var.*	Ch: N Ca: N Ct: N Cn: N	Co: N G : S2f M : S2f R : S2m

* Absent in Gbengbe Hills and Wara-Wara area.

Land factors

d = Effective soil depth
a = Soil reaction
n = Nutrient status
o = Soil salinity
x = Soil AWC
w = Soil drainage
fl = Flooding
p = Soil permeability
s = Slope steepness
y = Surface stones and rocks

Crops

Ch = Cashew
Ca = Cassava
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G = Groundnut
M = Maize
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Land suitability classes

S1 = High to moderate
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S3 = Very low
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Land suitability subclass limitations

r = Rooting space
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m = Moisture availability
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e = Erosion hazard

art 7
GRICULTURAL
OTENTIAL

NTRODUCTION

The following sections elaborate on the survey findings. Firstly the land available for improved farming under conditions of sustained crop yield is discussed, in terms of the area of arable upland and swampland. The suitability of the land systems for the eight crops selected for mapping is then outlined crop by crop. Brief mention is made of suitability for other crops which are currently grown in Sierra Leone or which might be introduced in the future, including prospects for irrigated crops. Finally prospects for modification of the traditional farming system, necessary to increase food production for a rapidly expanding population, are briefly discussed.

In presenting the findings of this study, its scope and purpose need to be emphasised. The work was carried out country-wide at reconnaissance level by specialists in pedology and agronomy. The survey data are of a generalised nature and incorporate physical land and climate factors only. Land has been evaluated for specific crops rather than groups of crops because of the variation in crop tolerances and requirements within the same group, eg land suitable for coffee is not necessarily suitable for cocoa or oil palm. It is realised that in any given area a number of different crops will be grown in rotation, although it was beyond the scope of this study to give more than a general indication of possible future farming systems. However, the suitability for other crops that might be grown in rotation in any land system can be inferred either directly from the 8 land suitability maps, or from Table 12 in conjunction with the physical data contained in Part 6).

No consideration of socio-economic factors which might have an important influence on the future cropping pattern was possible at this stage. Consequently the maps show suitability for the cultivation of crops on a sustained basis in terms of climate, slope, soil and flooding regime only; the possible effects of land use changes[1] or the economics of production have not been systematically evaluated.

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[1] *Information on present land use can be obtained from the complementary map and report produced simultaneously with this study FAO/LRSP TR 2 (1979).*

To give an example, the flatter areas of the Gola forest in the southeast of the country have been rated high for cashew since, in terms of the physical parameters considered, they have few limitations for that crop. When considering the overall economy of the country, however, it is highly unlikely that clearance of the primary forest in the area, even for a high value cash crop, could be justified, particularly as there are many other areas in which cashew might profitably be grown. A second example is the rating given to the beach ridges of Turner's Peninsula with respect to coconut. Although these areas, because of poor soils, are considered less suitable for this crop than much of the interior of the country, the fact that few other crops will grow there may be a sufficient justification to promote its expansion.

ARABLE LAND AREA

Table 13 summarises the area of the various land types in Sierra Leone and the proportion of arable and non arable land. A distinction has been made between upland and swampland because of their differing present and potential land use intensities. Non arable land includes those hill areas with only very low or nil suitability for the sustained cultivation of crops (over 94% of the total hill area).

As already discussed in Part 3 the uplands of Sierra Leone are characterised by a bush fallow cultivation system with an average fallow period of 9 years. In 1970/71 the area of upland under cultivation was approximately 4 500 km^2 (CSO, 1970/71) out of a total arable upland area of about 43 000 km^2 (Table 13). The apparent shorter fallow period suggested by these figures is due to the fact that the land area available to the traditional farmer includes hills which cannot be considered arable under improved, more permanent, forms of farming.

The area of arable swampland is about 10 600 km^2, or 15 per cent of the country. Of this only 838 km^2 were cultivated in 1970/71 (CSO,1970/71), although this figure is undoubtedly higher now due to the emphasis placed by Government on increased swamp cultivation. At the present time a high proportion of the swampland is suited only to paddy rice due to difficulties of flood control and drainage, and, along the coast, to potential acid sulphate soils. Good prospects exist however for crop diversification on some of the better drained floodplain soils.

LAND SUITABILITY FOR SELECTED CROPS

Plates 7 and 8 attached to this report indicate the suitability of the 44 land systems for 8 selected crops in terms of 4 suitability classes, while Table 14 gives a summary of land suitability. The variation in land suitability is discussed below.

Cashew

Table 13 - Summary of land areas

Land types		Km^2	%
Uplands:	Hills	17 350	24.0
	Undulating plains	40 000	55.3
	Beach plains	1 000	1.4
	Terraces	2 300	3.2
Swamplands:	Major floodplains	1 300	1.8
	Minor floodplains and valley swamps	6 900	9.5
	Drainage depressions (Bolis)	1 450	2.0
	Tidal swamps	2 000	2.8
	Total land area	72 300	100.0
Arable land[1]			
Arable upland		43 020	59.5
Non-arable upland:	Hills and rock land	16 330	22.6
	Roads and towns[2]	900	1.2
	Forest reserves not on hills[3]	400	0.6
	Total	17 630	24.4
Total upland area		60 650	83.9
Arable swampland		10 600	14.7
Non-arable swampland:	Rivers & creeks[2]	1 050	1.4
Total swampland area		11 650	16.1
TOTAL ARABLE		53 620	74.2
TOTAL NON-ARABLE		18 680	25.8

(1) Land suitable for the cultivation of crops on a sustained basis
(2) Derived from measurements on 1:50 000 topo maps
(3) Estimated at 15% of total forest reserves

Cashew

Cashew appears to be one of the most promising cash crops which could be introduced into Sierra Leone. Nearly half the country has been rated high to moderate for this crop since it is well adapted to the free draining, acid, infertile soils of the gently sloping uplands. The drier, northern plains and the moister areas of the south in climate types D_2 and *B* respectively are rated low.

Table 14 Suitability class areas of selected crops

Crop	*Cashew*				*Cassava*				*Citrus*				*Coffee*			
Suitability class	S1	S2	S3	N	S1	S2	S3	N	S1	S2	S3	N	S1	S2	S3	N
Approx. area (km^2)	32605	10305	5056	24360	15043	27895	4669	24719	-	-	43100	29226	-	16073	15613	40640
% of Sierra Leone	45	14	7	34	21	38	7	34	-	-	60	40	-	23	22	55

Crop	*Groundnut*				*Maize*				*Coconut*				*Paddy rice*			
Suitability class	S1	S2	S3	N	S1	S2	S3	N	S1	S2	S3	N	S1	S2	S3	N
Approx. area (km^2)	1468	20610	22180	28068	1468	41704	1086	28068	26990	11000	6415	27923	6900	3990	203	61233
% of Sierra Leone	2	28	31	39	2	58	2	38	37	15	9	39	10	5	-	85

NB These figures include land under towns, roads and forest reserves and the area of swampland occupied by rivers and creeks.

Coconut

Citrus

Cassa

Although cashew grows well on well drained soils, the beach sands are considered too infertile for optimum yields and have generally been rated fair. Hills with predominantly moderate to steep slopes and relatively deep soils are rated very low, while very steeply sloping hills and hills with a high proportion of shallow soils are regarded as unsuitable for this crop under improved forms of management. Minor floodplains and parts of the beach plains which are flooded only for short periods are rated poor, while most of the swamplands, flooded for more than one month a year, are unsuitable for cashew.

Cassava

Cassava is grown throughout Sierra Leone on the well drained, poorest soils. It is a popular crop since, once planted, it requires little attention and can be harvested over 1 or 2 years during periods of food shortage. Although yields under the traditional system of cultivation are very low, the use of fertilizer and improved varieties in a more intensive farming system justifies a high to moderate suitability rating for cassava on the well drained, gravel free, upland soils. Well drained soils with appreciable amounts of topsoil gravel have been given a low suitability rating for cassava while all seasonally flooded land is rated unsuitable. Hills with moderate to steep slopes and a relatively low proportion of shallow soils have been rated very low; those with very steep slopes or a high proportion of shallow soils are considered unsuitable for this crop.

Citrus

Citrus is grown throughout Sierra Leone for consumption as fresh fruit on the local market. It is particularly common in the drier, northern areas of Bombali and Koinadugu districts. Citrus yields best on weakly acid to slightly alkaline, well drained soils in areas with moderate humidity and a distinct, but not too prolonged, dry season. The strong acidity of the upland soils of Sierra Leone is a major limitation for the successful cultivation of this crop at improved levels of management and the reason why the gently sloping, non flooded areas of the country have only been given a very low suitability rating. However, this rating is based on the assumption that, for most farmers, the addition of lime in the quantity necessary to raise the soil pH to neutral would not be economic at the present time. For those farmers within marketing distance of the fruit canning factory recently constructed near Makeni this situation might not apply, in which case a high suitability rating can be envisaged, particularly for areas with a C_1 or C_2 climate.

Coconut

Like citrus, coconut is grown for local consumption throughout the country. It is particularly common on the infertile soils of the beach plains, where few other crops will grow. At the present time it is eaten fresh or processed for oil. No copra is being produced for export. The gently sloping plains in the moister parts of the country have high to moderate suitability for coconut since it is tolerant of acid, infertile soils. The sandy soils of the beach plains, however, are considered too infertile for optimum yields and have been rated low. Undulating plains with a growing period of 270 to less than 250 days have

been rated low to very low. Coconut has little tolerance to flooding so most of the swamps are unsuitable for its cultivation. The minor floodplains and parts of the beach plains, with only short duration flooding, are rated very low. The hill areas have either slopes too steep or soils generally too shallow for the successful cultivation of coconut.

Coffee *(robusta)*

Although coffee is grown extensively in the south and east of Sierra Leone on well drained gravelly upland soils, low soil fertility makes these areas less than optimum for this crop. Consequently, the undulating plains with C_1 and B climate have been given a low suitability rating, while those plains with a drier C_2 climate are rated very low. Areas with a growing period of less than 270 days are unsuitable for coffee and so too are the valley bottom lands with prolonged flooding. Hills have been rated unsuitable because of steep slopes and shallow soils, while the soils of the beach plains are considered too infertile for the successful cultivation of this crop. Floodplains which are only occasionally flooded have been rated very low.

Groundnuts

This, after rice and cassava, is the most important food crop in Sierra Leone both in terms of area cultivated and total production. It grows best on gravel free soils in the less humid northern districts. Optimum yields on the uplands cannot be attained because of low soil fertility, while very low yields can be expected on soils which are gravelly up to the surface. Consequently the gravel free coastal terraces have been rated fair and the Interior Plains have been rated low to very low depending on the prevalence or otherwise of gravel free topsoils. The low lying coastal areas have soils which are either too infertile or too poorly drained for the successful cultivation of this crop, while the hills have been rated unsuitable because of the erosion hazard on steep slopes, which will prevent sustained cultivation. Most of the interior swamplands, with prolonged flooding during the rains, have also been rated unsuitable. However, those swamps and floodplains which have short to medium duration flooding and relatively fertile, medium textured soils, have a high to moderate suitability for groundnuts, provided cropping is adjusted so as not to take place during the height of the rains.

Maize

After rice this is the most important of the grain crops, and is particularly common as a minor constituent of mixed crop stands in the central and western part of the country. It has been rated similarly to groundnuts, except that soils with gravelly surface layers are not considered to be so limiting.

Paddy rice

Without the introduction of large scale, capital intensive, irrigation schemes only those areas flooded for 3 months or more each year (about 15 per cent of the country) are suitable for paddy rice cultivation. Although the valley swamps and coastal floodplains have been given a high to moderate suitability rating for paddy rice, low soil pH and a lack of sunshine during the rains are likely to preclude the attainment of optimum paddy yields except under the most favourable management conditions. An estimated 20% of valley swamps have a low suitability because highly permeable sandy soils predominate, while the Boliland and mangrove swamps have been rated low because of other unfavourable soil conditions. In the Bolilands the soils are extremely acid and have a very low nutrient status and in mangrove areas the soils suffer from seasonally high salinity and a tendency to acidify if drained.

Considerable scope exists for the intensification of paddy rice cultivation, particularly in those areas with the highest suitability rating.

LAND SUITABILITY FOR OTHER CROPS

Grain crops

Upland rice is grown throughout the country and is particularly common in the moister areas of the south and east. The main limitation to increased production of this crop is the low fertility of the upland soils. The most suitable areas for its cultivation are the undulating plains with a C_1 or C_2 climate. Areas with a B climate are considered too humid for optimum yields of this crop.

Sorghum and *millet* are grown mainly in the northern parts of the country. They are less demanding in terms of soil nutrients than maize or rice and are therefore better adapted to the upland soils than those crops. The most suitable areas for their cultivation are the undulating interior and plateaux plains with a D_1 or D_2 climate.

Oil seeds and pulses

Sesame (benniseed) is a minor constituent of mixed crop stands and is grown mainly in the southern part of the country. It is relatively tolerant of low soil fertility but does not grow well on shallow or gravelly soils. The most suitable areas are the undulating interior and plateaux plains with a C_1 or C_2 climate and gravel free or slightly gravelly soils.

The most common pulses are *broad bean* and *pigeon pea*, grown mainly as minor crops in the northern areas. *Pigeon pea* is a useful cover crop normally left in the field after the main crops have been harvested.

Pulses, apart from providing an additional source of protein in the local diet, help in maintaining soil fertility by fixing nitrogen in the rooting zone. Although the yield of pulses will be inhibited by the low fertility of the upland soils there appear to be good prospects for their diversification and increased production in all but the most humid southern areas. Additional pulse crops which should be considered include *soybean, kidney bean* and *cowpea*.

Tree crops

Although *oil palm* has been declining in relative importance as a cash crop in Sierra Leone it is nevertheless a crop for which there is considerable scope for increased production. The well drained undulating plains with a C_1 or B climate and less gravelly soils are the most suitable areas for oil palm. In this respect it should be noted that the estate at Gambia-Mattru is located in an area with a dry season too long for optimum yield of oil palm.

Rubber is tolerant of soil acidity but requires moderately fertile soils for optimum yields. Only areas with C_1 or B climate are suitable for this crop, the latter being the best.

Avocado, *banana* and *plantain* are grown mainly in the south of Sierra Leone around villages and homesteads. The upland soils are too acid and infertile for optimum yields under improved forms of cultivation, while the drier northern areas are climatically unsuitable. The better drained floodplain soils in areas with a C_1 or B climate would appear to have the highest suitability for these crops.

Cocoa has very specific requirements for optimum yields, preferring deep, gravel free soils with a high moisture holding capacity and a climate with a very short dry season. Only the more fertile floodplain soils in areas with a B climate have a high suitability for this crop.

Other cash crops

Ginger is a crop which is well adapted to the upland soils. The undulating interior and plateaux plains with a C_1 or C_2 climate and with soils which are gravel free in the topsoil are the most suitable areas.

The prospects for rain-fed *sugar cane* are currently being evaluated in the southeast of Sierra Leone (see Part 4). The most suitable areas are the better drained river floodplains with a C_1 or C_2 climate and moderately fertile, gravel free soils. The relatively infertile, gravel free, upland soils in these areas have only a low suitability for sugar cane, whereas the very gravelly soils have a very low suitability. Areas with a B climate have too little sunshine for optimum yields.

The most suitable areas for *tobacco* are the interior and plateaux plains with a C_1 or C_2 climate, followed by the drier northern plains. Although the upland soils of these areas are reasonably well suited to this crop, optimum yields can be expected only on the minor floodplains, when flood control measures are undertaken.

Possibilities exist for the introduction of *tea* into the moist southern areas of Sierra Leone (United Consultants Ltd. 1978).

Irrigated crops

It was beyond the scope of this survey to evaluate land for large scale irrigation. Such an exercise involves careful consideration of the availability of irrigation water and the costs of water reticulation and drainage,

as against the value of the crop produced. A number of feasibility studies have been carried out in the past, notably for sugar cane at Torma Bum (Gibb and Partners, 1967), and for sugar cane and rice in the Rhombe swamp on the Little Scarcies estuary (MRT, 1972). Serious soil and drainage limitations were identified in these areas and to date no schemes have been implemented. Very little information is available on the irrigated sugar scheme currently being implemented by the Chinese in Tonkolili district. It would seem however, that the Boliland area on which the scheme is situated is marginal for sugar cane and very low yields can be anticipated. Preliminary investigations along the lower Mano (Birchall, 1977) indicate that the area of irrigable land on the Sierra Leone side of the border is very limited.

Although prospects for irrigation on a large scale do not appear very favourable at the present time, ample scope exists for the development of small scale irrigation and drainage schemes in the valley swamps and on the minor floodplains. Much has already been achieved through the activities of the IDA Projects and the World Food Programme and it is estimated that as much as 25% of the cultivated inland swamps are now under improved farming.

Proposals exist for the development of a further 11 000 ha of inland swamps by the end of the decade. While emphasis is being placed o paddy cultivation in the swamps, the better drained areas with medium to heavy textured soils are highly suitable for the production of other grain crops and vegetables. In general, benefits from dry season irrigation will be greatest in the northern parts of the country, since they receive higher amounts of solar radiation.

Livestock

Preliminary findings of the 1979 livestock sectoral study indicate that the widespread annual burning of the northern savanna areas is a major constraint to increased cattle production on the rangelands. Some form of rangeland protection, incorporating controlled late dry season burning in restricted areas will be necessary to restore the productive capacity of the savannas. Considering the semi-nomadic way of life of the Foulahs, formal settlement schemes are unlikely to succeed, but clearly more control is needed over their grazing activities if further environmental damage is to be avoided.

Good prospects appear to exist for the increased production of cattle and other livestock in the moister southern parts of the country. With adequate tsetse control, livestock could play an important role in the future intensification of upland farming in these areas. A mixed farming system involving perennial cash crops, annual food crops and livestock production on planted grass/legume leys is a promising alternative to the present traditional system (see below). Possibilities also exist for dry season livestock grazing and fodder production in some of the better drained swamps, together with paddy rice cultivation during the rainy season. A major limitation in these areas, however, is

lack of traditional skill in the rearing of cattle.

Forestry

A National forest development study(Atlanta 1979) has recently been carried out in Sierra Leone. The draft report on this survey concludes that prospects for the establishment of large-scale plantations for export of pulpwood and chips are unfavourable at present. Alternative recommendations centre around the establishment of 5000 ha of fuelwood and poles plantation in order to meet the long term demand of the Freetown market, stabilise prices and reduce the harmful ecological effects of the current practice of indiscriminate felling of young trees. Recommendations for subsidiary projects include strengthening the protection of existing high forest areas, establishment of high-value species plantations, initially on a pilot basis, and the setting up of rural nuseries and extension service with a view to encouraging farmers to grow their own fuelwood on a woodlot basis.

The report goes on to emphasise the role that forestry activities could play in the future agricultural development of Sierra Leone, particularly with respect to the attainment of more stable and permanent forms of cultivation. On the one hand, several years of arable cropping could be followed by a 10 to 15 year fallow rotation of suitable forest trees and shrubs, thus providing for soil regeneration while at the same time producing a valuable timber resource. Alternatively the present system of continuous tree crop cultivation under an upper storey of forest trees could be further developed by the introduction of high-value forest species.

LAND MANAGEMENT PROBLEMS

Fertility

Most of the soils in Sierra Leone are strongly acid and deficient in exchangeable calcium and magnesium, while they frequently contain toxic levels of exchangeable aluminium *(Odell et al, 1974)*. The addition of limestone and magnesium sulphate would serve to correct the calcium and magnesium deficiencies and decrease the likelihood of aluminium toxicity. Dolomitic limestone could be used to correct both the low soil pH and calcium and magnesium deficiencies. However, since there is no domestic source of limestone, raising the soil pH to optimum neutral levels is likely to be uneconomic unless market conditions are particularly favourable.

Potash and phosphate are unlikely to be deficient during the first year's cultivation following bush clearance, because of high concentrations of these nutrients in the ash residue after burning but more permanent forms of cultivation would require the addition of both P and K. Nitrogen deficiencies occur, particularly in rice, during the first year's cultivation because burning gives only a short-lived flush of this nutrient and regular applications of N are necessary to provide adequate yields even under existing forms of cultivation. The current practice of applying nitrogen in the form of ammonium sulphate is not to be recommended since this serves to increase soil acidity and urea is a preferable nitrogen source. Phosphate fertilizers with a high calcium content such as regular

superphosphate or basic slag are generally superior to triple superphosphate *(Odell et al, 1974)*.

Drainage

An estimated fifteen percent of Sierra Leone soils suffer some form of drainage impedence. Conditions range from the tidally flooded mangrove areas through the riverain grassland, boliland and inland valley swamps with prolonged freshwater flooding to the periodically flooded minor floodplains, as described in Part 3.

The mangrove swamps are difficult to reclaim because the soils acidify when drained due to high sulphur contents. A more intensive use of this land would require major water control structures and a carefully regulated drainage system to maintain soil water at a level sufficient to prevent excess drainage and oxidation.

The freshwater swamps vary in flooding pattern and drainage requirements. The broad floodplains of the riverain grassland and boliland swamps have a complex pattern of flooding resulting from major rivers overflowing their banks. In these areas large-scale flood protection and drainage works will be necessary to enable land use intensification. On the other hand the inland valley swamps can fairly easily be reclaimed by the construction of peripheral bunds and a central drainage-way, provided the soils are not sandy. For those swamps fed by a perennial stream the construction of head works would permit the use of supplementary irrigation in the dry season. Prospects for irrigation are particularly favourable on the minor floodplains, with their medium to heavy textured soils of higher than average fertility and rather favourable drainage characteristics.

Moisture

The minimum length of the growing season in Sierra Leone is about 250 days, thus guaranteeing the success of at least one upland crop per year. However, during the height of the rains in July, August and September, high humidity, lack of sunshine and a high pest and disease incidence, particularly in the south, are not favourable for optimum crop yields. The use of short duration improved upland crop varieties, grown towards the end of the rains and on residual soil moisture during the early part of the dry season, would help to maximise yields particularly on the gravel free footslope and terrace soils. The use of mulches would further help to conserve soil moisture on these soils. Improved swamp drainage would offer good prospects for the cultivation of high value crops, such as vegetables, during the dry season, either on residual soil moisture or with supplementary irrigation.

Tree crops experience moisture stress during the dry season, especially in the north where there is a soil moisture deficit of 3 to 4 months. The effects of drought could be minimised by planting crops adapted to seasonal moisture stress, eg cashew and citrus, on the non-gravelly, well drained footslope and terrace soils.

Erosion

The amount and intensity of rainfall in Sierra Leone is such that there is a considerable erosion hazard on cultivated slopes. The present system of bush fallow cultivation minimises this hazard but nevertheless there is evidence of widespread sheet erosion, especially on the steeper slopes. The erosion serves to remove the topsoil organic layer and expose the relatively infertile, frequently gravelly subsoil. In the northern areas, overgrazing by cattle has exacerbated the erosion hazard and has led to serious land degradation in places. Clearly, overgrazing and the cultivation of steep slopes should be discouraged, while any intensification of arable cultivation on the more suitable land areas should be accompanied by appropriate erosion control measures.

PROSPECTS FOR IMPROVED FARMING

At present growth rates, the population of Sierra Leone will reach 5.5 million by the end of the century. Based on existing rice yields and per capita consumption, approximately one quarter of the arable uplands would have to be cultivated annually for rice if the staple food demand were to be met solely from upland production. With yields already declining through a shortening of the fallow period, an alternative to the traditional farming system clearly has to be found if the country is to achieve long term self sufficiency in staple foods. In addition, the aspirations of the rural population for higher living standards will have to be satisfied through the increased production of high value crops for export.

Attempts to increase the output of the traditional farm in Sierra Leone have often in the past proved unsatisfactory (Muckle, 1971). This can be attributed to a preoccupation of the farmer with the provision of food for himself and his family which results in a natural avoidance of risk taking and a loyalty to local low yielding but dependable varieties. It is compounded by a general lack of appropriate input packages designed to minimise such risks. The traditional farmer is thus naturally reluctant to change from what used to be a relatively sound and successful system of farming to one which involves a high element of uncertainty, even though the latter may bring considerable long term benefits. In addition it is possible that the cost of improvements necessary to adapt the traditional system into one capable of supporting sustained cultivation, in terms of improved seed, fertiliser and erosion control measures, will outweigh the value of the crops produced (Greenland, 1975). Despite these difficulties, however, a number of promising alternatives to the traditional system exist in Sierra Leone.

In recent years considerable progress has been achieved, through the IDA projects and the World Food Programme, in improving rice yields from the inland valley swamps. Up to 4-fold yield increases have been achieved in some

areas, although a tendency has been observed for farmers to quickly revert to upland rice cultivation if not given continuous encouragement and support.

Provided that farmers can be induced to continue inland swamp cultivation on a permanent basis, and that no marked decrease in the fertility of the swamp soils occurs, it seems likely that future rice requirements can readily be met from the cultivation of these areas. Increased paddy rice production will be further facilitated through the implementation of projects designed to increase paddy yields from mangrove and riverain swamps in the Scarcies and Torma Bum areas respectively Flood control on the minor floodplains, together with supplementary irrigation of the better drained soils in these areas, offers good possibilities for the more intensive production of crops such as vegetables, maize, sorghum, sesame (benniseed), groundnuts and beans. For Prospects for increasing yields in the Bolilands appear less favourable, since the value of production is unlikely to justify the cost of improving the existing, very low, soil fertility.

The most satisfactory use of the uplands is for perennial tree crops. Apart from providing a cash income for farmers, tree crops minimise soil leaching and erosion losses and help preserve the humus content of the topsoil. Although tree crops are at present concentrated in the south and east of the country the introduction of a drought resistant, low demanding crop such as cashew would provide a useful alternative for the northern districts.

Although tree crops are the most promising alternative for the uplands it cannot be envisaged that they will ever become the sole crop in such areas. The uplands will continue to be the main producing areas for rice for many years to come because the change to swamp rice cultivation will be necessarily slow, while some other food crops, notably cassava, can only be cultivated in upland areas. Efforts should therefore be made to intensify food crop production on the more favourable gravel-free or only slightly gravelly upland soils, whilst cultivation of those soils with very high gravel contents should be limited either to the more tolerant species or tree or, preferably, forest crops. The widespread practice of bush fallow cultivation of steep slopes should be controlled to allow for the regeneration of the natural vegetation in these areas.

Although the inherent low fertility of the upland soils is likely to preclude the attainment of continuous field cropping without heavy and possibly uneconomic applications of mineral fertilizers, a number of improved management techniques exist which could help to increase existing upland crop yields, whilst providing for a more permanent system of farming. The undercropping of tree crops with food crops such as yams and cassava is a system of farming common in Eastern Nigeria which has received little

attention in Sierra Leone. Such a system provides for a more intensive use of the land whilst minimising fertility and erosion losses. Similarly the *Taungya* system of raising forest trees and agricultural crops on the same area of land, developed in East Asia but hitherto untried in West Africa, provides an opportunity for the maximum utilization of land resources, whilst at the same time effecting the desired control over traditional shifting cultivation (USAID, 1977). Other techniques so far untested in Sierra Leone include strip cropping, stubble mulching, minimum and zero tillage, incorporation of grass or legume leys into existing crop rotations and the introduction of cattle to provide for a mixed farming system.

Clearly, the means by which the production of upland annual food crops can be increased, whilst at the same time maintaining soil fertility and minimising soil erosion, is one of the crucial problems facing agriculture in Sierra Leone. Consequently the proposal for a research and extension programme geared specifically to the uplands (USAID, 1978) can be seen as a welcome first step towards finding solutions to some of the problems associated with upland crop production.

Part 8
CONCLUSIONS AND RECOMMENDATIONS

CONCLUSIONS

The following conclusions have been drawn from the results of the study:

a) The use of high flight aerial photography, flown specifically for the project, enabled the rapid mapping of broad physiographic units (land systems). Subsequent investigations, not reported here, revealed that the accuracy of the mapping was considerably greater than would have been achieved using satellite imagery. In the absence of enlargements from the 1975/76 series, due to financial constraints, older larger scale photography was used to subdivide land systems into their constituent land facets.

b) Reconnaissance field checks of soil and terrain parameters, based on the mapping of land systems and their breakdown into facets, together with other relevant data particularly on climate, subsequently led to a qualitative crop-wise land suitability classification. The recurrence of similar facets with similar soils throughout several land systems enabled reasonably reliable deductions to be made from comparatively few data. However, integration of socio-economic factors into the suitability classification was not considered possible within the scope of the present study.

c) Although the soils were correlated with the main international soil classification systems for comparative purposes, those systems are not satisfactory for routine use in Sierra Leone. This was due to difficulties in the recognition of some of the diagnostic horizons used in these systems, coupled with the tendency for soils with similar agricultural potential to be grouped into different categories at the highest levels of classification. Instead the soil map legend was characterised in terms of broad soil groups, defined on the basis of criteria having a direct influence on land suitability for crops.

d) The total area variously suitable for improved forms of traditional farming is about 53 600 km^2 nearly 74% of the country. About a quarter of this is swampland, the remainder upland.

e) The low fertility of the uplands and severe flooding over much of the swamplands restrict suitability for crops. The gently sloping uplands are suitable for low demanding arable and tree crops and the swamplands are

suitable for paddy rice. The more fertile and better drained floodplain areas are very suitable for short-cycle catch crops. Most of the hill land is considered unsuitable for sustained cultivation, mainly because of severe erosion hazards.

f) A rapid rate of population growth is leading to an increasing pressure on land in rural areas and to a fast growing market dependent population in urban and mining centres.

g) While the demand for staple foodstuffs, particularly rice, is increasing, crop yields are falling due to a shortening of the fallow period on the uplands as a result of increasing demographic pressure. In order to raise staple food production to a level of national self sufficiency, while at the same time improving the living standards of the rural population, a gradual intensification of agricultural production will be necessary. Improved agricultural practices will have to replace the now unsatisfactory traditional system, particularly as virgin upland areas suitable for sustained cultivation are no longer available.

h) With the increased cultivation of inland swamps in recent years, the first stages of intensification have already taken place. Considerable scope exists for extending and intensifying swamp cultivation further, provided that social barriers can be overcome.

i) Attempts to improve agricultural production on the uplands have been less successful. However, it is imperative that suitable means be found to intensify upland farming to achieve a balanced national economy in the long term. Tree crops will continue to play an important role in the upland farming system and the introduction of a low demanding, drought resistant tree crop such as cashew would help diversify production in the drier northern areas. Possibilities exist for increased production of coffee, cocoa, oil palm, coconut and rubber; prospects for citrus do not appear so promising.

j) Other possible upland crops include cassava, sorghum, millet, maize, groundnuts, sesame, pigeon pea, tobacco and ginger. The use of leguminous cover crops to maintain soil fertility and reduce erosion would be particularly advantageous.

k) Forestry and livestock have an important role to play in any improved system of farming. Prospects also appear good for the introduction of inland fisheries in association with swamp rice cultivation. However a prerequisite for the successful involvement of traditional farmers in these activities is a fully integrated programme of research and extension.

l) Since the commencement of this study a number of development projects have been implemented, while

others have been planned or are under consideration. The study team was actively involved in the formation of some of these projects, while for others it merely supplied technical information. The large number of requests for technical advice since the survey started is confirmation of the essential need for the kind of expertise currently being developed by the Land Resources Survey Project.

RECOMMENDATIONS

In view of the large number of development projects either underway, planned or under consideration, for which recommendations have already been made elsewhere, specific proposals for future land development are omitted here. Instead, the following paragraphs are concerned with suggestions for further studies and co-ordination of research and planning activities which, it is believed, will help to underpin existing and future agricultural projects. No specific recommendations are given for livestock or forestry in view of the recent release of the findings of country-wide surveys for these sectors.

a) *Detailed integrated studies*

Detailed integrated studies should be carried out with the aim of developing an appropriate methodology for quantitative crop-wise land suitability classification in Sierra Leone. The studies should follow a multi-disciplinary approach in the fields of soils, water, climate, vegetation, crops and socio-economics. In view of the level of detail necessary to quantify the inter-relationships between the various factors governing land suitability such studies should be based on small catchment areas[1] The stream catchments should be carefully selected to be representative of the main agricultural environments, using the findings of the reconnaissance survey, so that the results of the studies can be extended to future routine surveys.

In order to get good results from these studies it will be necessary to conduct them on a trial basis initially, so that work objectives can be clearly defined and coordination problems minimised at the outset.

b) *Detailed surveys of development areas*

Once an appropriate quantitative land suitability methodology has been developed, the reconnaissance survey should be followed up by routine, more detailed, surveys in development priority areas. Such surveys are one of the prerequisites for successful agricultural development and therefore should be aimed at

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[1] *Detailed integrated studies of stream catchments at Newton, Makoni and Moyamba were started in February, 1979.*

fulfilling the practical land use planning needs of the country, both at feasibility and implementation levels. B & W infra-red enlargements of the 1975/76 aerial photography series will provide a satisfactory mapping base for the surveys which should be carried out at scales between 1:10 000 and 1:50 000, depending on the land use alternatives envisaged. Land suitability classification should, wherever possible, be expressed in economic terms and should relate to specific crops within clearly defined farming systems and a known socio-economic framework.

c) *Soil classification and correlation*

A comprehensive framework for soil classification and correlation in Sierra Leone should be developed at an early date to contribute to the consistency and accuracy of future surveys as well as to research activities. The framework should be devised in such a way that its taxonomic units have relevance within the contexts of crop response to soil conditions and practical land evaluation. The broad categories used to define the soil map units in this report provide a useful framework within which to classify and correlate national soil series. Attempts should be made to establish and study in detail 'bench mark' soil series and to correlate these with the main international classification systems. The work of the recently established international committees on soil taxonomy for improving the classification of tropical soils, particularly with respect to low activity clay soils and oxisols, should be closely followed and their recommendations adopted.

d) *Agricultural statistical survey*

The agricultural statistical survey carried out in 1970/71 by the Central Statistic Office is out of date. It is recommended that a similar survey be undertaken as soon as possible to provide essential base line data for use in planning, research and extension work. Attempts should be made to relate the survey data to agro-ecological zones, which should be defined using the results of this present study.

e) *Upland crop research*

Although a considerable amount of research has been carried out into the agronomic aspects of rice cultivation, particularly in the mangrove areas, research inpúts with respect to rainfed upland crops have been relatively few. If a more intensive system of upland cultivation is to be achieved appropriate agronomic practices will have to be identified which can guarantee sustained cropping without the harmful effects of irreversible environmental degradation. It is recommended that the FAO funded national agronomic rice trials programme of 1978 be extended to include other upland crops, in conjunction with the ACRE project shortly to be

implemented. Trial sites should be carefully selected, using the findings of this present study as a basis, to represent the various agro-ecological conditions in the country.

f) *Inland swamp fertility*

The effects of continuous cultivation on soil fertility in the inland valley swamps is not known. The relatively high rice yields obtained from these areas are due mainly to the high levels of topsoil organic matter. In view of the low subsoil fertility in the swamps it is likely that yields will fall rapidly if organic matter levels are not maintained during cultivation. In addition such swamp soils often have iron toxicity and trace element deficiency problems which require further investigation. It is recommended that selected representative swamps be carefully monitored to establish a data base on which to identify suitable measures to conserve and improve inland swamp fertility.

g) *Inland swamp reclamation*

Attempts at developing inland swamps have sometimes failed due to unfavourable soil conditions. Some swamps are not easily reclaimed because of sandy, very permeable soils or excessive flooding. It is imperative that preliminary investigations be carried out in the swamps to determine the nature of the subsoil and the pattern of flooding before reclamation is attempted.

h) *Agricultural research coordination*

The failure of previous attempts to set up a central agricultural research centre has meant that there has been little co-ordination of activities between the institutions involved in this field. There has also been a lack of dissemination of research findings through the extension service to the farmer. The ACRE project proposals, fully endorsed here, recommend a comprehensive ten year national plan for food crop adaptive research and extension out of which will ultimately evolve an institution or institutions capable of adequately fulfilling the essential roles of co-ordination and practical application. The ACRE project should liaise closely with the Land Resources Survey Project in the selection of representative sites for research and extension activities.

i) *Planning co-ordination*

In view of the accelerated rate at which development projects are being formulated and implemented, the planning services of MAF need to be further strengthened. During the course of this study, limited but useful co-operation was possible between the project, the planning units of the Ministry and the National

Authorising Office as well as with numerous foreign technical missions invited to Sierra Leone by Government. A useful first step would be to strengthen the links between the national bodies to improve the planning and monitoring of future agricultural development projects.

j) *Land conservation*

On numerous occasions warnings have been given against indiscriminate deforestation, overgrazing, cultivation of slopes without appropriate erosion control measures and an excessive shortening of bush fallow periods. These malpractices lead to a degradation of the land which, once started, cannot be stopped or amended. It is recommended that plans for future agricultural development should take into account the necessity for a fully integrated approach to land use intensification to provide for sustained cropping without environmental deterioration. A crucial element in this approach should be the introduction of improved soil conservation practices. To prepare for this it is recommended that the soil conservation element of the Land Resources Survey Project be strengthened and that consideration be given to the eventual establishment of a soil conservation service within MAF.

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APPENDIX 1

TERRAIN PARAMETERS

The parameters used for describing land systems and facets in Part 6 of this report are outlined below:

Altitude

The maximum and minimum altitude were measured from 1:50 000 topo maps and are expressed in metres.

Relief

Relief is defined as the largest difference commonly occurring within a land system, between the altitude of a major ridge crest (or summit) and that of the nearest adjacent valley floor. The relief classes used are as follows:

Relief class	*Relief (m)*
negligible	<10
extremely low	10 - 20
very low	20 - 50
low	50 - 100
moderate	100- 200
high	200- 400
very high	>400

Slope

The slope data was based on field observation (using an Abney level), supplemented by estimations from 1:40 000 scale photographs. The following classes are used:

Slope class	*Degrees*	*Percentage*
Cliffed slope	72 - 90°	>300
Precipitous slope	45 - 72°	100 - 300
Very steep slope	30 - 45°	56 - 100
Steep slope	15 - 30°	27 - 56
Moderate slope	7 - 15°	12 - 27
Gentle slope	3 - 7°	5 - 12
Very gentle slope	1 - 3°	2 - 5
Nearly level	0°30' - 1°	0.9 - 2
Level	<0°30'	<0.9

Grain and drainage density

Grain is defined as the modal value of half the distance between major stream beds and was estimated from 1:50 000 topo maps. The grain classes used are as follows:

Grain class	*Grain*
Ultra fine	<75 m
Very fine	75 -150 m
Fine	150 - 300 m
Medium	300 - 600 m
Coarse	600 - 1200 m
Very coarse	>1200 m

The drainage density is defined as the total length of the streams in a drainage basin, expressed in terms of length per unit area.

Drainage density was measured in sample squares each of 36 km^2. Where possible, three sample areas per land system were selected. Streams were interpreted on the 1:120 000 scale photographs used for land system mapping. Where valley swamps are prevalent, it was assumed that a stream flows through the centre of the swamp. The length of streams was measured by using a pisometer and the average drainage density was calculated for each land system, with the exception of those with a drainage pattern too ill defined to permit such measurements.

Drainage pattern

This is described by a visual assessment of the 1:120 000 scale photographs and 1:50 000 scale topo maps, using standard geomorphological terms.

Facet morphology

The morphology of the land facets was described using the parameters detailed in Table A1.1 overleaf.

Table A 1.1 - Land facet terminology

Land Facet	*Parameter*	*How Measured*	*Descriptive Classes*
Crest (eg. hill crest)	Width	Horizontal distance between limits of summit convexity	Narrow 0 - 50m Broad 50 - 150m Very broad 150 - 500m
	Profile	Visual estimate	Even: small variation in crestal slope. Uneven: moderate variation in crestal slope. Very uneven: great variation in crestal slope.
	Crestal slope	Along ridge crest	As listed under slope classes
High-angle planes (eg. rock outcrop, hill slope, interfluve)	Length	Down line of greatest slope	Ultra short <50m Very short 50 - 100m Short 100 - 200m Medium 200 - 400m Long 400 - 800m Very long >800m
	Curvature	Visual estimate	Straight Concave Convex Undulating (alternating concave and convex) Irregular
	Slope	Down line of greatest slope, supplemented by topographic maps	As listed under slope classes
	Spur characteristics	Visual estimate	Crestal slope: as listed under slope classes Prominence: Prominent Inconspicuous Absent
	Micro relief	Visual estimate	Boulders and rocks Gullies Debris slide tracks Termite mounds Slump alcoves Slump scars
Low-angle planes (eg. terrace, floodplain, valley swamp)	Gradient or slope	Parallel to the major drainage lines	As listed under slope classes
	Width	Perpendicular to the major drainage lines across uninterrupted areas of the land unit	Not classified: expressed in m or km
	Micro relief	Visual estimate	Height: expressed in m Type: undulating hummocky, channelled, terraced, termite mounds
Water courses	Gradient	Along the channel	As listed under slope classes
	Width	Between bank tops or between the bases of conforming hill slopes	Not classified: expressed in m, unless the stream is incised, when no width is stated
		From bank top level to mean thalweg level	Not classified: expressed in m, unless the stream is incised, when no depth is stated.

APPENDIX 2

LAND FACTOR CLASSES AND LAND QUALITIES

This appendix gives details of how the field and laboratory data collected during the survey were classed according to 11 land factors. For the purpose of land suitability evaluation the land factors were grouped into 5 land qualities as follows:

Land quality	*Land factors*
Rooting space (r)	Effective soil depth *(d)*
Soil fertility (f)	Nutrient status *(n)* Salinity *(c)* Soil reaction *(a)*
Availability of moisture (m)	Available water capacity Climate type *(z)*
Availability of oxygen (o)	[1]Drainage *(w)* [1]Flooding *(fl)* [1]Permeability *(p)*
Resistance to erosion (e)	Slope steepness *(s)* Surface stones and rocks *(y)*

The rating of specific crops with respect to each of the land factor classes is given in Table 12.

Rooting space (r)

Effective soil depth is used to assess rooting space and the depth classes retained are shown in Table A2.1 below.

Table A 2.1 - Effective soil depth classes

d	*0*	*1*	*2*	*3*	*4*	*5*
Effective soil depth class	very deep	deep	moderately deep	moderately shallow	shallow	very shallow
Depth in cm	>150	110-150	80-110	50-80	25-50	<25

Notes

a) Effective soil depth is calculated as the sum of the products of the depth coefficients and the thicknesses in cm of the soil layers to which these coefficients apply.

b) Depth coefficients were derived from the consistency rating of the soil at field moisture state as elaborated in Bleeker (1976). In general the more

[1]*Also used in the assessment of moisture availability for paddy rice.*

compact the soil the less the depth coefficient on a scale from 1 (friable or loose soils) to 0 (massive inpenetrable rock), such that the effective depth decreases with increasing compactness.

c) The assessment of soil depth plays an important role in the suitability evaluation of deep rooting crops (eg tree crops) or crops which develop underground (eg cassava and groundnuts).

Soil fertility (f)

The land factor classes used to assess soil fertility are shown in Table A2.2 below.

Table A 2.2 - Soil nutrient, salinity and reaction classes

n *Nutrient status class*	*0* High	*1* Mode-rate	*2* Low	*3* Very low	*4* Extremely low
CEC (meq %)	>20	12-20	6-12	3-6	< 3
Base saturation (%)	>50	<50	<50	<50	< 20
Topsoil organic carbon (%)	>3	>3	2-3	1-2	<1

c *Salinity class*	*0* Non saline	*1* Weakly saline	*2* Saline	*3* Strongly saline
Electrical conductivity (mmhos/cm at 25°C)	<4	4-10	10-16	>16

a *Soil reaction class*	*1* Extre-mely acid	*2* Strongly acid	*3* Weakly acid	*4* Neutral	*5* Alkaline
pH (1:1 H_2O)	< 4.5	4.5-5.5	5.6-6.5	6.6-7.5	>7.5

Notes

a) The soil nutrient class was derived from average laboratory analyses for the main soil types, based on data from 657 horizon samples.

b) In calculating the cation exchange capacity and the percent base saturation, topsoil (0-50 cm) data were averaged separately. When the subsoil class was one lower than that of the topsoil, the topsoil class only was used in the assessment. However, when the classes differed by a greater margin than this the average was taken.

c) The nutrient status class was downgraded by one unit for soils with over 50% gravel and stones throughout two thirds or more of the top 100 cm.

d) Salinity was inferred from the results of weekly measurements of soil electrical conductivity at ten points between Rokupr and the sea along the Little Scarcies River (WARDA, 1977).

e) Soil reaction was initially determined by field measurements of topsoil and subsoil pH, on approximately 900 soils, using a Truog colorimetric kit. The majority of these soils were rated strongly to weakly acid (pH 4.5 to 6.5). Laboratory tests carried out later on a 1:1 soil: water paste indicated that most Sierra Leone soils appear to be strongly acid (pH 4.5 to 5.5) and generally the lower pH class was retained for the suitability evaluation.

f) Although the assessment of fertility was generally based on the nutrient class of the soil, both salinity and reaction served to seriously downgrade or even nullify the suitability of certain soils for one or a number of the crops considered.

g) Soil depth was not taken into consideration when assessing fertility, even though it is realised that many crops are able to compensate for a lack of nutrients in the upper layers of the soil by extending their roots deeper into the subsoil. It is considered, however, that sufficient emphasis has been given already to effective soil depth in the assessment of rooting space as a separate land quality, to justify its omission while rating soil fertility.

h) In general, soil fertility has been considered to be a more important quality in the assessment of land suitability for annual arable crops than for perennial tree crops.

Availability of moisture (m)

The land factor classes used to assess crop water availability are shown in Table A2.3 below.

Table A 2.3 - Available water capacity and climate type classes

x *Available Water Capacity class*	*0* very high	*1* high	*2* moderate	*3* low	*4* very low	*5* extremely low
cm available water in 150 cm of soil	> 25	20-25	15-20	10-15	5-10	< 5

z *Climate Type*	*B*	C_1	C_2	D_1	D_2
Length of dry season	very short	short	moderately long	long	very long
Ratio of dry and wet months x 100	14-33	33-44	44-60	60-80	80-100
Length of growing period (days)	> 315	315-300	300-270	270-250	<250

Notes

a) AWC was calculated from estimations of the percent moisture storage of each soil horizon above 150 cm. The moisture storage estimates were inferred from the textural class of the soil as determined in the field by hand, using the methods outlined in Bleeker (1976).

b) Climate type classes were determined by an analysis of monthly rainfall figures from 30 stations with ten and more years of records, based on the methods of Schmidt and Ferguson, (1951). The number of dry (<60 mm rainfall) and wet (≥ 100 mm rainfall) months was computed year by year for each of the stations. The average number of dry and wet months was then calculated and expressed as a ratio. Three of the classes of Schmidt and Ferguson, namely B,C, and D, were found to be present in Sierra Leone. In order to add precision to the assessment the C and D classes were subdivided into C_1, C_2, D_1 and D_2 classes. The resulting 5 climate types were later correlated with the length of the growing period as determined by Kowal (1977).

c) Assessment of crop water availability was made first by rating the specific crops against the climate type within which any given land system occurred. This rating was then modified by taking into account the AWC of the soil. However, since a soil AWC of 10% has been assumed in the calculation of the length of the growing period, only soils with low, very low or extremely low water storage capacity were downgraded.

d) Soil permeability and drainage, although used principally for rating oxygen availability, have a minor affect on the moisture availability for paddy rice. As regards upland tree crops, the well drained and permeable nature of most of the upland soils in Sierra Leone serve to exacerbate dry season moisture stress. Although the permeability and drainage factors were not included in the tree crop moisture availability rating, recognition of their indirect affect on soil moisture resulted in considerable weight being given to the climate type and AWC ratings for such crops.

e) Flooding is the dominant factor affecting the moisture availability for paddy rice. It has also been taken into account in the rating of short cycle arable crops which can be grown on residual floodwaters in the dry season.

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Availability of oxygen (o)

Tha land factor classes used to assess oxygen availability are shown in Table A2.4 below.

Table A 2.4 - Drainage, flooding and permeability classes

w *Drainage class*	*0* Well drained	*1* Imperfectly drained	*2* Poorly drained	*3* Very poorly drained	*5* Waterlogged (swampy)
fl *Flooding class*	*0* None	*1* Short duration	*2* Medium duration	*3* Long duration	*4* Permanent or semi permanent
No. of months	Nil	<1	1-3	3-6	> 6
p *Permeability class*	*1* very rapid	*2* rapid	*3* moderate	*4* slow	*5* very slow
Permeability (cm/h)	> 20	6-20	1-6	0.25-1	< 0.25

Notes

a) Drainage was inferred from the degree and depth of gleying of the soil profile as observed in the field, using the method in Bleeker (1976). Vegetation and site characteristics were used to assess the drainage class of sandy soils with very rapid permeability which did not exhibit gley colours, even when saturated with water for long periods.

b) As the field survey was carried out mainly during the dry season, flooding had to be assessed from geomorphological setting, vegetation type and information obtained from local inhabitants. Three patterns of flooding have been recognised in Sierra Leone:

   1) inundation of low lying inland areas resulting from prolonged and heavy rainfall and a gradual rising of the water table.

   2) overflow of moving water from overladen streams and rivers.

   3) tidal flooding along river estuaries.

All three patterns of flooding are complex and could not be thoroughly evaluated at the reconnaissance level. In particular there was no distinction made between 1 and 2 above, although for practical agriculture purposes variations in the pattern of flooding are important.

c) Permeability was assessed from soil texture, porosity, structure and cracking and the classes were based on the soil horizon with the lowest permeability (Bleeker, 1976). In Sierra Leone soil oxygen becomes limiting mainly in low lying, poorly drained sites which are seasonally or tidally flooded. Soil permeability is of secondary importance and has therefore been given less weight in the assessment of oxygen availability.

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rosion (e)

The land factor classes used to assess resistance to erosion are shown in Table A2.5

Table A 2.5 - Resistance to erosion classes

s *Slope steepness class*	*0* nearly level or level	*1* very gentle	*2* gentle	*3* moderate	*4* steep	*5* very steep.
o Slope	< 1	1-3	3-7	7-15	15-30	>30
% Slope	< 2	2-5	6-12	12-27	27-58	> 58

y *Surface stone and rock class*	*0* absent	*1* slight	*2* moderate	3 pronounced	*4* very pronounced	5 extreme
% Stones or rocks on ground surface	<0.1	0.1-4	5-14	15-39	40-90	>90

Appendix 2

Notes

a) Degrees of slope were measured in the field using an Abney level and the classes approximately correspond to the percent slope classes of FAO and USDA.

b) Stones are defined as having a diameter between 3 and 30 cm, while rocks refer to boulders larger than 30 cm diameter and outcrops or bedrock. Originally surface stoniness and rockiness were rated separately according to the classes of FAO (1961) and USDA (1951). It was later considered justified, in view of the broad scale of the survey and the fact that the intensive management level is not being considered, to amalgamate surface stoniness and rockiness into one class.

c) In assessing resistance to erosion the slope was considered first, as being of foremost importance. The rating for slope was then adjusted to take into account the surface stone and rock class.

d) Other factors such as surface soil structure, vegetal cover or surface texture have not been considered in the assessment at this stage, although it is recognised that they have an important bearing on the erodibility of slope soils. Erosion by floodwaters also has not been considered.

e) The assessment of resistance to erosion assumes a greater importance in the case of short cycled crops than it does for perennial tree crops.

APPENDIX 3

CROP REQUIREMENTS

This appendix contains the requirements of crops grown or likely to be grown in Sierra Leone. The reasons for the selection of crops for systematic suitability rating and mapping purposes are also given. Table A 3.1 summarises the tolerance of selected crops to some soil, climate and site characteristics.

Table A 3.1 - Tolerance of crops to various environmental conditions

Flooding/waterlogging

Nil	*Low (15 days)*	*Moderate (1-2 months)*	*High (2-4 months)*
avocado; beans; breadfruit; cassava; chillies; citrus; cotton; cucumber; eggplant; ginger; groundnut; kapok; kola; maize; millet; papaya; passion fruit; pepper; pigeon pea; sesame; sunflower; sweet potato; tobacco; yam	banana; cashew; cocoa; coconut; coffee; guava; mango; oil palm; rubber; sorghum; soybean; sugarcane	upland rice	cocoyam; swamp rice

Drought

Very low (14 days)	*Low (1 month)*	*Moderate (2-3 months)*
beans; cocoa; pineapple; swamp rice; rubber; soybean	banana; citrus; cocoa; coconut; coffee;[1] cotton;[1] groundnut;[1] kapok; maize;[1] millets; oil palm; pepper; pigeon pea ; upland rice; rubber; sesame; sorghum;[1] sweet potato; tobacco	cashew

Appendix 2

[1] *Essential before harvesting or at flowering.*

Soil reaction

Acidity			*Alkalinity*		
Low	*Moderate*	*High*	*Low*	*Moderate*	*High*
beans; cotton; some forage legumes; spinach	avocado; banana; citrus; groundnut; maize; tobacco; most vegetables	cashew; cocoa; coconut; coffee; most grasses; some forage legumes; rice; rubber; yam	cocoa; coffee; rubber	cashew; groundnut; maize; sorghum; sugarcane; tobacco	cassava; citrus; cotton; swamp rice; sesame; sorghum

Soil salinity

Nil	*Low*	*Moderate*	*High*
avocado; beans (field and green); cashew; citrus; clovers; cocoa; coffee; ginger; rubber; sweet potato	beans; coconut; groundnut; millets; oil palm; upland rice; soybean; tobacco	alfalfa; banana; cabbage; carrot; cassava; lettuce; maize; mango; onion; pepper; swamp rice sorghum; sudan grass; sugarcane; tomato	bermuda grass; cotton; date palm; rape; sesame; spinach; sugarbeet

Avocado
(Persea spp)

Soil/Land

Texture	sandy loams - clays
Depth	greater than 100 cm
Permeability	rapid
Drainage	well to imperfectly drained
Flooding/waterlogging	nil
Fertility requirement	moderate to high
Reaction	weakly acid pH 5.5 - 6.5
Salinity tolerance	nil

Climate

Temperature	21 - 32°C
Water requirement	120 - 250 mm per month
Drought resistance	moderate
Humidity	moderate to high
Wind	liable to damage
Topography	level to gentle slope
Elevation	less than 1500 m

Growth cycle — perennial evergreen

Bananas, Plantain
(Musa spp)

Soil/Land	
Texture	loams to clays
Depth	greater than 100 cm, but as low as 30 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	short periods are tolerated
Fertility requirement	moderate to high
Reaction	pH 5.0 to 8.0
Salinity tolerance	moderate
Climate	
Temperature	20 to 40°C, optimum 25 to 28°C
Water requirement	more than 140 mm per month
Drought resistance	nil or only short dry periods
Humidity	moderate to high
Wind	low wind velocities are desirable
Topography	requires practices to prevent erosion on steeper slopes
Elevation	less than 1500 m, optimum 0 - 300 m
Growth cycle	can be continuous crop, time to mature first fruit is about 8 months
Yield	World: average 1000 bunches per ha, 20MT/ha good 2500 bunches per ha, 50MT/ha
	Sierra Leone: undetermined

Beans
(Phaseolus spp)

Soil/Land

Texture	medium
Depth	80 - 100 cm
Permeability	rapid
Drainage	well drained
Flooding/waterlogging	nil
Fertility requirement	moderate
Reaction	neutral pH 6.5 - 7.5
Salinity tolerance	low

Climate

Temperature	above 20°C
Water requirement	moderate
Drought resistance	nil
Humidity	moderate
Wind	unimportant
Topography	level to gentle slope
Elevation	less than 1500 m

Growth cycle	60 - 120 days

Cashew
(Anacardium occidentale)

Soil/Land	
Texture	sands to loams
Depth	unimportant
Permeability	must be rapid
Drainage	must be well drained
Flooding/waterlogging	short periods
Fertility requirement	grows well on infertile sands, high soil fertility results in vegetative growth and low yields
Reaction	resists very acid soils, pH 4.00 to 7.5
Salinity tolerance	nil
Climate	
Temperature	grows poorly at low temperatures
Water requirement	as low as 900 mm per year
Drought resistance	needs dry period at flowering and maturing harvesting stages
Humidity	low
Wind	unimportant
Topography	grows well on slopes
Elevation	less than 750 m, poorly at higher altitudes
Growth cycle	evergreen perennial, canopies up to 12 m in diameter, roots twice as much, planted at stake (directly in the field), starts producing after 3 years, full production around 8 - 10 years
Yield	World: average 600 kg/ha good 1000 kg/ha very good 2200 kg/ha Sierra Leone: undetermined

* This crop has been selected for mapping because of the interest shown by Government in increasing its production, particularly in the northwest of the country. It has low demands in terms of climate, fertility and management and it could be introduced into the drier, poorer areas as a cash crop. The world market demand is high and increasing, resulting in fair prices. Moreover, additional employment could be created in small factories for first processing.

Cassava
(Manihot esculenta)

Soil/Land

Texture	loamy sands to clay loams
Depth	greater than 50 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	nil
Fertility requirement	moderate but will produce on poor soils
Reaction	pH 4.0 to 7.0 - optimum 5.0 to 6.0
Salinity tolerance	very low

Climate

Temperature	20 - 35°C, optimum 20 to 25°C
Water requirement	more than 100 mm per month
Drought resistance	will tolerate dry periods of medium length
Humidity	low to high
Wind	unimportant
Topography	nearly level to moderately steep, if grown on steep slopes practices to prevent erosion are required
Elevation	less than 1500 m

Growth cycle — up to 2 years, harvesting can begin at 6 months and last up to 18 according to variety and growing conditions.

Yield — World: average 7 - 10 MT/ha
good 25 MT/ha

Sierra Leone: 4 - 10 MT/ha

*This crop has been selected for mapping because of Government interest in increasing its production as a staple food crop. If, as is planned, swamp rice cultivation is increased sufficiently to supply the needs of the country, then this would leave the uplands free for cultivation of such crops as cassava. Moreover its roots and leaves are an important component of the local diet and by introducing improved varieties and better management practices, particularly erosion control, yields could be dramatically increased. Cassava has a longish growth cycle and does not withstand flooding. Therefore it gives clear indication of unflooded land, not suitable for paddy. This indication is not obtainable with other short cycle arable crops.

Citrus
(Citrus spp)

Soil/Land

Texture	does not grow well on sands
Depth	greater than 100 cm
Permeability	rapid
Drainage	well drained
Flooding/waterlogging	nil
Fertility requirement	moderate to high
Reaction	pH 5.5 - 7.0
Salinity tolerance	low

Climate

Temperature	20 to 35°C
Water requirement	200 mm per month
Drought resistance	suffers from long drought (> 3 months), requires some dry period for flowering and maturing
Humidity	moderate
Wind	unimportant
Topography	gentle to moderate slopes
Elevation	in the tropics up to 2000 m, change in colour above this, otherwise fruits remain green.

Growth cycle — evergreen perennial

*This crop has been selected for mapping because of the interest shown by Government in increasing its production. This is to meet the demand now being generated by a new canning factory which was recently opened at Panlap, near Makeni. Citruses require less humidity, less soil acidity, a longer drier period and better drainage than coffee. By comparing the two respective maps, different land qualities become evident.

Cocoa
(Theobroma cacao)

Soil/Land

Texture	loams to clay loams
Depth	greater than 100 cm
Permeability	moderate
Drainage	well to moderately well drained
Flooding/waterlogging	short periods are tolerated
Fertility requirement	moderate to high
Reaction	pH 4.5 to 7.5, optimum 5.5 to 7.0
Salinity tolerance	nil

Climate

Temperature	20 to 40°C, optimum 25°C
Water requirement	200 mm or more per month
Drought resistance	will tolerate short periods
Humidity	moderate to high, needs shade
Wind	nil
Topography	nearly level to gentle sloping, steeper areas need practices to prevent erosion
Elevation	50 to 1000 m, optimum 50 - 500 m
Growth cycle	continuous, first pods harvested after about five years
Yield	World: 500 - 1500 kg/ha Sierra Leone: 100 - 300 kg/ha

*Although of great interest to government this crop has not been selected for mapping because its highly specific soil requirements preclude its representation in map form at reconnaissance scale. By selectively applying the ratings given in Table 12, suitability for cocoa can be derived from that of coffee.

Coconut
(Cocos nucifera)

Soil/Land	
Texture	sandy loam to sandy clay loam
Depth	greater than 80 cm
Permeability	moderate to rapid
Drainage	well to moderately well drained, can tolerate poor drainage if water table can fluctuate to allow air entry into soil as long as water table not higher than 50 cm from surface.
Flooding/waterlogging	short periods are tolerated but not continuous for more < 3 days
Fertility requirement	low to moderate
Reaction	pH 4.0 to 8.0
Salinity tolerance	low
Climate	
Temperature	24 to 40°C, optimum 27°C
Water requirement	more than 150 mm per month
Drought resistance	will tolerate dry periods of one to three months depending on AWC and water table
Humidity	moderate to high, optimum 85%
Wind	can be felled by strong gusts
Topography	nearly level to sloping (<10% for nucleus plantation)
Elevation	less than 900 m, optimum less than 300 m
Growth cycle	continuous, with first harvest after 4-5 years for hybrid and 7-10 years for local varieties.
Yield	World: 20 nuts per palm/year average 60 nuts per palm/year good 140 nuts per palm/year very good Sierra Leone: undetermined

* This crop was selected for mapping because of Government interest in increasing coconut production from coastal areas.

Coffee
(Coffea liberica, robusta)

Soil/Land

Texture	loams to clays
Depth	greater than 60 cm
Permeability	moderate to rapid
Drainage	well to poorly drained
Flooding/waterlogging	short periods are tolerated
Fertility requirement	moderate to high
Reaction	acid to strongly acid, pH 4.5 - 6.5
Salinity tolerance	nil

Climate

Temperature	20 to 35°C, optimum 24 to 26°C
Water requirement	180 to 300 mm or more per month
Drought resistance	will tolerate only short dry period before flowering
Humidity	moderate to high, needs shade
Wind	unimportant
Topography	nearly level to moderately steep, needs practices to prevent erosion on steeper slopes
Elevation	50 to 1500 m, optimum 50 - 500 m
Growth cycle	continuous crop, with first harvest after about five years
Yield	World: average 500 kg/ha good 2000 kg/ha Sierra Leone: reported 400 kg/ha, but actually lower than 250 kg/ha

* This crop has been selected for mapping because of strong Government interest in its expansion and improvement in view of the recent, very favourable, world market situation. Together with cocoa, coffee is the traditional cash tree crop in the south-eastern area of the country. As cocoa has more specific soil requirements, mainly in terms of effective depth, a map for it can be more easily extracted from the map for coffee than vice versa.

Cotton
(Gossypium hirsutum)

Soil/Land	
Texture	loams to clays, best on medium textured soils
Depth	greater than 80 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	nil
Fertility requirement	moderate
Reaction	pH 5.6 to 8.0, does not do well in S.L. where soils are mostly very acid.
Salinity tolerance	high
Climate	
Temperature	20 to 40°C, optimum 25 to 35°C
Water requirement	100 to 250 mm per month
Drought resistance	needs relatively dry period before flowering and for harvest
Humidity	low to moderate
Wind	unimportant
Topography	nearly level to gently sloping, steeper areas need practices to prevent erosion
Elevation	less than 500 m
Growth cycle	150 to 190 days

Ginger
(Zingiber officinale)

Soil/Land

Texture	loams
Depth	30 - 100 cm
Permeability	moderate to rapid
Drainage	well drained
Flooding/waterlogging	nil
Fertility requirement	moderate to high
Reaction	neutral to acid pH 5.0 - 7.5
Salinity tolerance	nil

Climate

Temperature	21°C
Water requirement	about 150 mm per month
Drought resistance	prefers drier areas
Humidity	low
Wind	unimportant
Topography	gentle to steep slopes
Elevation	200 to 300 m

Growth cycle	9 to 10 months but harvest can be delayed

Groundnut
(Arachis hypogaea)

Soil/Land

Texture	sands to clays, best on sandy loams to clay loams, heavy textured and stony soils are not suitable
Depth	80 - 100 cm
Permeability	moderate to rapid
Drainage	well drained
Flooding/waterlogging	will not tolerate waterlogging
Fertility requirement	moderate
Reaction	pH 5.0 to 7.0
Salinity tolerance	low

Climate

Temperature	20 to 40°C, optimum 25 to 35°C
Water requirement	150 mm per month
Drought resistance	will tolerate short periods of drought, dry periods necessary at time of lifting
Humidity	low to high
Wind	unimportant
Topography	nearly level to moderately steep, steeper areas require practices to prevent erosion
Elevation	less than 1500 m

Growth cycle 90 to 150 days

Yield World: average 600 kg/ha
good 1300 kg/ha
very good 2500 kg/ha

Sierra Leone: 200 - 300 kg/ha

* This crop has been selected for mapping because of its unique behaviour. Its mode of fruit formation and harvesting procedures make the soil requirements (in terms of texture, surface stones and gravel, tillage and resistance to erosion) quite specific and very important under the conditions prevailing in Sierra Leone. It is also an important, nutritious component of the local diet.

Maize
(Zea mays)

Soil/Land

Texture	loams to clay loams
Depth	greater than 80 cm
Permeability	moderate
Drainage	well to moderately well drained
Flooding/waterlogging	nil, no waterlogging tolerated
Fertility requirement	moderate to high
Reaction	pH 5.0 to 7.0
Salinity tolerance	moderate

Climate

Temperature	18 to 40°C, optimum 25 to 35°C
Water requirement	100 to 200 mm per month, needs ample water supply during flowering and relatively dry period at harvest
Drought resistance	short period tolerated
Humidity	low to moderate
Wind	can cause lodging
Topography	nearly level to gently sloping, steeper areas need practices to prevent erosion
Elevation	less than 1500 m

Growth cycle — 100 to 130 days - new varieties less than 100 days

Yield

World: average 1300 kg/ha
good 2000 - 4000 kg/ha
very good 4000 - 8000 kg/ha

Sierra Leone: 600 - 1000 kg/ha

* This crop has been selected for mapping because of the Government interest in promoting grain crops other than rice. Ample scope exists for improving the present low yields for both human and animal consumption. Also, from the maize map, those for sorghum and millets can be easily obtained.

Millet, bullrush
(Pennisetum andiploides)

Soil/Land	
Texture	sandy loams
Depth	30 to 75 cm
Permeability	rapid
Drainage	well drained
Flooding/waterlogging	nil
Fertility requirement	low to moderate
Reaction	pH 5.5 to 8.5
Salinity tolerance	low to moderate
Climate	
Temperature	25°C
Water requirement	as low as 500/600 mm year (40 - 50 mm per month)
Drought resistance	drought resistant and drought avoiding
Humidity	low
Wind	unimportant
Topography	level to gentle slope
Elevation	less than 1200 m
Growth cycle	60 to 100 days
Yield	World: average 500 kg/ha good 2000 kg/ha Sierra Leone: 500 kg/ha

* By selectively applying the ratings given in Table 12 a land suitability map for bullrush millet could easily be derived from the map presented for maize.

Millet, finger
(Eleusina coracana)

Soil/Land

Texture	loams to clays
Depth	30 to 70 cm
Permeability	rapid
Drainage	well drained
Flooding/waterlogging	nil
Fertility requirement	low to moderate
Reaction	5.5 to 8.0
Salinity tolerance	low to moderate

Climate

Temperature	20 - 30°C
Water requirement	900 mm year is sufficient (75 mm per month)
Drought resistance	good
Humidity	low
Wind	unimportant
Topography	level to gentle slope
Elevation	less than 2400 m, less than 1000 m is preferred

Growth cycle: 60 to 120 days

Yield:
World: average 600 kg/ha
good 1200 kg/ha
very good 2000 kg/ha

Sierra Leone: not available

* By selectively applying the ratings given in Table 12 a land suitability map for finger millet could easily be derived from the map presented for maize.

Oil Palm
(Elaeis guineensis)

Soil/Land	
Texture	loams to clays
Depth	greater than 100 cm
Permeability	moderate
Drainage	well to moderately well drained
Flooding/waterlogging	short periods are tolerated
Fertility requirement	moderate to high
Reaction	pH 4.5 to 7.5, optimum 5.5 to 6.5
Salinity tolerance	low

Climate	
Temperature	22 to 40°C with low fluctuation, optimum 25 to 35°C
Water requirement	more than 200 mm per month
Drought resistance	good
Humidity	moderate to high
Wind	unimportant; high sunshine requirement for optimum production
Topography	nearly level to moderately steep, steeper areas need practices to prevent erosion
Elevation	less than 500 m

Growth cycle	continuous, with first harvest after four years

* This crop is growing wild over more than 60% of the country wherever conditions permit. Several plantations are in production, notably in the south-east of Sierra Leone and several oil palm projects are currently being implemented.

Rice, Swamp
(Oryza spp)

Soil/Land

Texture	loams to clays
Depth	greater than 40 cm
Permeability	moderate to slow, permeable areas must have a high water table or be puddled to maintain surface water
Drainage	well to very poorly drained
Flooding/waterlogging	short periods of deep flooding are tolerated
Fertility requirement	low to high
Reaction	pH 4.0 to 7.0, optimum 5.0 to 6.0
Salinity tolerance	moderate

Climate

Temperature	15 to 40°C, optimum 20 to 30°C
Water requirement	more than 250 mm per month, fields must be saturated or flooded
Drought resistance	tolerates only very short periods with dry surface soil
Humidity	moderate to very high
Wind	unimportant
Topography	flat or terraced slopes
Elevation	less than 2000 m

Growth cycle — 120 to 180 days depending on variety and altitude

Yield — World: average 5000 kg/ha
good 8-9000 kg/ha

Sierra Leone: 1500 - 3000 kg/ha

* This crop has been selected for mapping because of the interest shown by the Government in increasing its production, so as to achieve self sufficiency in rice which is the staple food in Sierra Leone. It has been found that by improved methods of management in terms of improved varieties, water control and pest control, the yields of swamp rice could be substantially increased. This would release the uplands from rice cultivation and free them for growing other grain, food, cash and tree crops.

Rice, upland
(Oryza spp)

Soil/Land

Texture	sandy loams to clay loams
Depth	greater than 80 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	medium period tolerated
Fertility requirement	moderate to high
Reaction	pH 5.0 to 7.0
Salinity tolerance	low

Climate

Temperature	18 to 35°C
Water requirement	150 to 200 mm per month
Drought resistance	only very short periods
Humidity	moderate to high
Wind	unimportant
Topography	nearly level to moderately sloping, steeper slopes need practices to prevent erosion
Elevation	less than 2000 m

Growth cycle	90 to 120 days
Yield	World: average 1000 kg/ha good 1500 kg/ha Sierra Leone: 600 kg/ha

Rubber
(Hevea brasiliensis)

Soil/Land

Texture	sandy loams to clays
Depth	greater than 100 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	short periods are tolerated
Fertility requirement	moderate
Reaction	pH 4.0 to 8.0, optimum 5.0 to 6.0
Salinity tolerance	nil

Climate

Temperature	15 to 40°C, optimum 20 to 30°C
Water requirement	200 mm or more per month
Drought resistance	not for periods longer than 30 days
Humidity	moderate to high
Wind	unimportant
Topography	nearly level to moderately steep, can be grown on steep slopes if erosion control is practiced.
Elevation	less than 600 m

Growth cycle	continuous, first harvest about five years after planting under good management practices.

Sesame
(Sesamum indicum)

Soil/Land	
Texture	loams to clay loams
Depth	greater than 80 cm
Permeability	moderate
Drainage	well drained
Flooding/waterlogging	nil
Fertility requirement	moderate to high
Reaction	pH 5.0 to 8.0
Salinity tolerance	high
Climate	
Temperature	20 to 35°C
Water requirement	150 to 250 mm per month
Drought resistance	tolerates short periods
Humidity	low to moderate
Wind	unimportant
Topography	nearly level to gently sloping
Elevation	less than 1000 m
Growth cycle	90 to 120 days
Yield	World: average 300 kg/ha good 500 - 1000 kg/ha Sierra Leone: undetermined

Sorghum
(Sorghum vulgare)

Soil/Land

Texture	sandy loams to clays
Depth	greater than 50 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	nil
Fertility requirement	low to moderate
Reaction	pH 4.0 to 8.0
Salinity tolerance	moderate

Climate

Temperature	18 to 35°C, optimum 25 to 35°C
Water requirement	100 to 200 mm per month or more
Drought resistance	will tolerate dry periods of up to three weeks
Humidity	low to moderate
Wind	unimportant
Topography	nearly level to moderately sloping, steeper areas need practices to prevent erosion
Elevation	less than 1500 m

Growth cycle	90 to 140 days
Yield	World: average 500 - 1500 kg/ha good 3000 - 4000 kg/ha very good 6500 kg/ha Sierra Leone: 500 kg/ha

* This crop has not been selected for mapping because a map can be easily obtained from that prepared for maize by taking into account the ratings in Table 12.

Soybean
(Glycin maxima)

Soil/Land

Texture	sandy loams to clay loams
Depth	greater than 60 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	short periods are tolerated
Fertility requirement	low to high
Reaction	pH 5.5 to 7.5
Salinity	low

Climate

Temperature	20 to 40°C, optimum 25 to 35°C
Water requirement	100 to 200 mm per month
Drought resistance	will tolerate dry periods of two to three weeks
Humidity	low to moderate
Wind	unimportant
Topography	nearly level to moderately sloping, steeper areas need practices to prevent erosion
Elevation	less than 2000 m

Growth cycle

90 to 120 days

Yield

World: average 2000 kg/ha
good 3500 kg/ha

Sierra Leone: undetermined

Sugarcane
(Saccharum spp)

Soil/Land

Texture	loams to clays
Depth	greater than 80 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	short period of flooding is tolerated
Fertility requirement	high
Reaction	pH 4.5 to 7.0, optimum 5.0 to 6.0
Salinity tolerance	moderate

Climate

Temperature	20 to 40°C, optimum 25 to 28°C
Water requirement	150 to 250 mm per month
Drought resistance	will tolerate short dry periods, dry period for 2-3 months beneficial before harvest
Humidity	moderate to high
Wind	can cause lodging
Topography	nearly level to moderately steep, practices are necessary to prevent erosion on steeper slopes
Elevation	less than 1000 m

Growth cycle — 18 months if no ratoon crop is taken.

Yield — World: average 150MT/ha cane without ratoon crop
good 300 MT/ha cane without ratoon crop

Sierra Leone: unknown as yet

* This crop has not been selected for mapping because possibilities for its increased production are currently being investigated by other agencies and involve only a small area in the country.

Sweet Potato
(Impomoea batata)

Soil/Land	
Texture	loams to clay loams
Depth	greater than 50 cm
Permeability	moderate
Drainage	well to imperfectly drained
Flooding/waterlogging	nil
Fertility requirement	moderate to high
Reaction	pH 4.0 to 7.0, optimum 5.0 to 6.0
Salinity tolerance	nil
Climate	
Temperature	15 to 35°C, optimum 16 to 25°C
Water requirement	more than 150 mm per month
Drought resistance	will tolerate short dry periods
Humidity	moderate to high
Wind	unimportant
Topography	nearly level to moderately steep, steeper slopes need practices to prevent erosion
Elevation	less than 2000 m
Growth cycle	120 to 180 days
Yield	World: average 5-15 MT/ha good 50 MT/ha
	Sierra Leone: undetermined

Tobacco
(Nicotiana tabacum)

Soil/Land

Texture	sandy loams to clay loams
Depth	greater than 60 cm
Permeability	moderate
Drainage	well to moderately well drained
Flooding/waterlogging	nil
Fertility requirement	moderate to high, particularly in K
Reaction	pH 4.0 to 7.0, optimum 5.0 to 6.5
Salinity tolerance	low

Climate

Temperature	20 to 40°C
Water requirement	150 to 250 mm per month
Drought resistance	will tolerate short dry periods, dry period beneficial at harvest
Humidity	moderate
Wind	unimportant
Topography	nearly level to moderately steep, practices to prevent erosion are needed on steeper slopes
Elevation	50 to 1500 m depending on variety
Growth cycle	90 to 110 days
Yield	World: average 600 kg/ha good 1000 kg/ha very good 2500 kg/ha Sierra Leone: 150 - 300 kg/ha

* This crop has not been selected for mapping because the problems related to its expansion and improvement are already being dealt with by another project.

Improved pasture	They can be produced on a wide variety of soils by choosing adapted species or varieties. Yields vary with climate, soil fertility and management.
	This agricultural activity was not selected for mapping because it seems that the type of management of cattle should be considered rather than botanic species. In either case, it would be too wide a subject, exceeding the present capability of the LRSP.
Forest	This agricultural activity was not selected for mapping inspite of keen Government interest because it was found too broad a subject, exceeding the present capabilities of the LRSP. Moreover, other institutions have studies already in progress.

APPENDIX 4

LABORATORY ANALYTICAL METHODS

Soil samples received were air dried and sieved on a 2.0 mm sieve to separate the gravel (>2.0 mm) from the soil (<2.0 mm) fraction. The soil fraction was then presented for analysis.

Particle size analysis

Organic matter was oxidized by hydrogen peroxide (30%) treatment and the sample was dispersed in calgon solution(sodium hexametaphosphate, 50 g/l). The dispersed sample was filtered through a 0.05 mm screen to separate the sand from the silt and clay fractions. The silt and clay fractions were separated through differential sedimentation by the Pipette Method.

pH

The pH was measured in a 1:1 soil/water suspension on a Pye Unican PW 9418 pH meter.

Cation exchange capacity (CEC)

The soil was saturated with 1.0 N ammonium acetate buffered at pH 7.0 and the replaced ammonium was distilled into a 4% boric acid mixed indicator solution on the macro Kjeldahl distillation apparatus. The ammonia distilled was determined by titration with 0.1 N hydrochloric acid.

Exchangeable cations

The ammonium acetate extract was ignited in a muffle furnace for 20 minutes. The ignited residue was taken up in 0.1 N hydrochloric acid and aliquots were used for determination of exchangeable sodium and potassium on a flame photometer. Exchangeable calcium and magnesium were determined by EDTA titration.

Total exchangeable bases

An aliquot was prepared as described in the procedure for determining exchangeable sodium and potassium and the excess hydrocloric acid was titrated with 0.1 N sodium hydroxide.

Exchangeable aluminium

Exchangeable aluminium was obtained by leaching the sample with 1.0 N potassium chloride and the aluminium in solution was determined by colorimetric methods after development of a "red lake" with aliminon reagent (NH_4 aurine tricarboxylate) in buffered ammonium acetate solution of pH 4.2. Interfering Fe was complexed with thioglycolic acid (5%).

Available phosphorus

Available phosphorus was extracted by shaking the soil with the extracting solution (1.0 N ammonium flouride +

	0.5 N hydrofluoric acid) for 30 minutes. The extracted phosphorus was determined colorimetrically by the molybdenum blue method using stannous chloride as the reducing reagent.
Organic carbon	The organic matter was oxidized by treating the sample with excess potassium dichromate in 2 volumes of concentrated sulphuric acid for 30 minutes. The excess dichromate was determined by titration with standard ferrous sulphate.
Total nitrogen	Organic nitrogen was converted to ammonium by digestion with concentrated sulphuric acid on the macro Kejdahl digestion apparatus and the ammonium was determined by distillation as described in the procedure for determination of cation exchange capacity.

LIST OF LRSP REPORTS (SIL/73/002)

TECHNICAL REPORTS (TR)

T R No 1	Land in Sierra Leone: a reconnaissance survey and evaluation for agriculture, based on the work of C J Birchall and P Bleeker, in collaboration with C Cusani-Visconti. FAO Freetown, 1979. AG:DP/SIL/73/002 T R 1.
T R No 2	Vegetation and Land Use in Sierra Leone: a reconnaissance survey, based on the work of O G A Gordon, G Kater and D C Schwaar. FAO Freetown, 1979. AG:DP/SIL/73/002 T R 2.
T R No 3	Proceedings of the first national remote sensing seminar on land resources (Freetown, 24 - 29 April 1978), based on the work of management and staff of LRSPProject in collaboration with the Remote Sensing Unit of FAO/Hqs. FAO Freetown, 1979. AG:DP/SIL/73/002 T R 3.
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T R No 5	Agro-ecological atlas of Sierra Leone: a survey and appraisal of climate and crop resources, based on the work of J Kowal in collaboration with the Agro-climatological section and staff of the LRSP. FAO Freetown, 1980.AG:DP/SIL/73/002 T R 5.
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T D No 2	Broad Guidelines for Soil Survey Procedures on Land Resources Project, by C J Birchall 1976.
T D No 3	A Framework for Land Suitability Classification with particular reference to Sierra Leone, by P Bleeker 1976.
T D No 4	Guidelines for the Transfer of Details from HFAP onto small scale Topo Base Map by means of optical pantograph, by D C Schwaar 1976.
T D No 5	A Preliminary Framework for Soil Classification and Correlation in Sierra Leone, by C J Birchall 1976 (draft).
T D No 6	Explanatory Notes for Use of the LRSP Field Data Sheets, by C J Birchall and P Bleeker 1976.
T D No 7	Summary of Sierra Leone Agriculture Trade Statistics 1963/1976, by W K Alkire & P Bleeker 1977.
T D No 8	Peace Corps Volunteers Rice and Crops Information Summary 1974/76, by W K Alkire and P Bleeker 1977.
T D No 9	Notes for Participants in Senior Staff Seminar in Photo-Interpretation for Land Resources Survey (10 to 21/10/77), by C J Birchall and G Kater 1977.
T D No 10	Notes for the In-Service Training of Soil Survey Officers and Field Assistants, by C J Birchall and T N J Lamboi 1977.
T D No 11	Review and Selection of Remote Sensing Imagery for Integrated Land Resources Surveys, by D C Schwaar 1978.
T D No 12	Photo-Interpretation Techniques, by D C Schwaar 1978.
T D No 13	Photo-Interpretation Procedures, by D C Schwaar 1978.
T D No 14	High Flight Aerial Photography for Reconnaissance Land Evaluation, by C J Birchall 1978.
T D No 15	High Flight Aerial Photography for Reconnaissance Vegetation and Land Use Surveys, by O L A Gordon 1978.
T D No 16	Transfer of Thematic Details from High Flight Aerial Photographs onto Base Maps, by M E A Pratt 1978.
T D No 17	Basic Principles of Photo-Interpretation and Orientation of Aerial Photographs, by O L A Gordon 1978.
T D No 18	Syllabus for the In-service Training of Observers in Agricultural Meteorology and Hydrology (3/7 to 12/8/78), by Met. Dept. and LRSP Staff 1978.

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T D No 19	Agroclimatological Observer's Field Manual, by A S Lamin and J O Benjamin 1978.
T D No 20	Bush Fallow in Sierra Leone: An Agricultural Survey, by LRSP Agronomy Staff 1979.
T D No 21	Glossary of terms used on multi-disciplinary land evaluation, by Project Staff, 1980.
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T D No 23	Land Evaluation, The Land Resources Survey Project Approach (Seminar paper) by M S Kargbo.1979.
T D No 24	The Role of Soil Survey in the Agricultural Development of Sierra Leone (Seminar paper) by M Kandeh 1979.
T D No 25	Soil Survey Data and Land Evaluation (Seminar paper) by L Touber 1979.
T D No 26	The Vegetation and Land Use of Sierra Leone (Seminar paper) by O L A Gordon 1979.
T D No 27	Bush Fallow in Sierra Leone - An Agricultural Survey (Seminar paper) by Agronomy Section 1979.
T D No 28	Proposals for Future Development and Improvement of Management Level and Farming System (Seminar paper) by C Cusani-Visconti 1979.
T D No 29	Land Suitability Evaluation in Sierra Leone: Methodology and Results (Seminar paper) by D C Schwaar 1979.
T D No 30	Cation Exchange Capacity of some Sierra Leone Soils (Seminar paper) by M A R Conteh 1979.
T D No 31	Harnessing Climate for the Agricultural Development of Sierra Leone: I. Sunshine-based Cropping System (Seminar paper) by M W Baradas 1979.
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T D No 34	Instructions to Field Assistants on the procedures for the conduction of production plots in catchment areas, by C Cusani-Visconti and J M Kallon 1980.
T D No 35	Report and Aide Memoire on a fellowship to India on Library/Documentation, by O L D Griffin 1980.

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M R No 1	Remote Sensing. Preliminary Investigation of Mapping Land Use and Vegetation by Computer Processing of Landsat Data, by R Baltaxe 1975.
M R No 2	Cartography and Printing I, by H Engeler 1975.
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M R No 4	Cartography and Printing II, by H Engeler 1977.
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M R No 19	Detailed Quantitative Land Suitability Evaluation: an appraisal for Sierra Leone with preliminary findings from a case study of the Makoni Catchment Area, by D Diltz, 1980.

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Misc No 2	Reconnaissance Soil and Land Suitability Appraisal for the proposed Torma Bum Rice Project, by C J Birchall 1976.
Misc No 3	Notes on the Reconnaissance Survey of the proposed IAD Project Area between Mile 36 and 99 - Magbosi, P Bleeker, C J Birchall and G Kater 1976.
Misc No 4	Reconnaissance Visit to Kipulun Creek Valley Swamps, by T N J Lamboi and G Kater 1977.
Misc No 5	Preliminary Land Evaluation of Part of the Koinadugu District for Integrated Agricultural Development, by C J Birchall and H Parker 1977.
Misc No 6	Reconnaissance Visit to the Robis Swamps, by T N J Lamboi 1977.
Misc No 7	Report on G Kamara's Oil Palm Estate, Newton, by T N J Lamboi and C J Birchall 1977.
Misc No 8	LRSP Progress Report and Programme of work, by M S Kargbo 1978.
Misc No 9	Preliminary Land Evaluation of the Kambia and part of Port Loko IADP Project Area, by C J Birchall *et al*, 1978.
Misc No 10	Crops interrelation, rotation, bush fallow, shifting cultivation (Inter-section Notes), by Agronomy Staff 1978.
Misc No 11	Reconnaissance Visit to the Catholic Mission Farm at Newton, by J van Wambeke *et al*, 1978.
Misc No 12	Reconnaissance Visit to Sembu Fornah's plantation, by C Cusani-Visconti, H Parker and J van Wambeke 1978.
Misc No 13	Report on Duty Tour of the LRSP Co-Manager to Europe (28/10/78 to 5/12/78), by M S Kargbo 1978.
Misc No 14	LRSP Annual Report - State and Progress, by M S Kargbo 1978.
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Misc No 17	LRSP Information Brochure, by LRSP Management and Staff 1979.

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Misc No 23	Proposals for the irrigation and drainage units within the Water Resources Section of the LRSP/UNDP-MAF, by J C Hamelberg, 1980.
Misc No 24	Land Suitability evaluation data for selected crops in parts of the Ribbi, Dasse and Lower Bambara Chiefdoms, by H Renes, 1980.
Misc No 25	Semi-detailed Land evaluation study of proposed Tigbema coffee plantation scheme, by J A Eschweiler and M F Sesay 1980.

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