

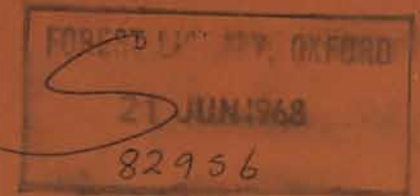
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# Land Resource Study



## 1 The Development of the Lower Mgeta River Area of the United Republic of Tanzania

**THE DEVELOPMENT OF  
THE LOWER MGETA RIVER AREA  
OF THE  
UNITED REPUBLIC OF TANZANIA**



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An aerial photograph of part of the Lower Mgeta River Area showing the Uluguru foothills, the Mgeta River and its flood plain, and Bwakira Estate. . . Scale 1:27,700

Ministry of Overseas Development

THE DEVELOPMENT OF  
THE LOWER MGETA RIVER AREA  
OF THE  
UNITED REPUBLIC OF TANZANIA

by

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and

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LAND RESOURCE STUDY NO. 1

Land Resources Division  
Directorate of Overseas Surveys  
Tolworth, Surrey, England

1966

## ABSTRACT

Three areas, totalling about 4,500 acres (1,821 hectares) were selected for development as agricultural settlement schemes, following an earlier reconnaissance survey of 190 square miles (492 square kilometres) in the Lower Mgeta River Area of Eastern Tanzania. A detailed survey of the soils, vegetation and present land use of each of these areas is described. Proposals for the settlement of 284 families, each farming 12 acres (4.9 hectares) on a rotational basis are made: cropping of one third cotton, one third sorghum, cowpeas, intercropped maize and soya beans and, in the first instance, one third fallow are described. The establishment of 360 acres (146 hectares) of *Eucalyptus* plantations to provide fuel and building poles for the settlers is also suggested.

## RÉSUMÉ

À la suite d'une première étude portant sur 492 kilomètres carrés (190 milles carrés) d'une région avoisinant le cours inférieur de la Mgeta, dans l'est du Tanzania, on a choisi trois étendues de terre d'une superficie totale de 1 821 hectares (4 500 acres) pour y établir des colonies agricoles. Le document dont il s'agit contient un compte rendu détaillé des divers sols, de la végétation qu'on y trouve, et du parti qu'on en tirait à l'époque de cette première étude. On prévoit d'y établir 284 familles cultivant chacune 4,9 hectares, en prescrivant un système d'assolement par tiers, à savoir: sur le premier tiers coton, sur le deuxième tiers sorgho, niébé, et maïs avec soja intercalaire en laissant, au moins pour commencer, le troisième tiers en friche. Il est également proposé de planter, sur 146 hectares (360 acres) des *Eucalyptus* devant servir de bois à brûler et de perches de construction.

## SUMMARY OF RECOMMENDATIONS

This land resource survey of the Lower Mgeta River Area and the evidence from crop performance suggests that the development of rainfed agriculture in the area is feasible. Increased agricultural production however, is unlikely without the provision of an all weather road into the area.

Three areas of approximately 1,160, 1,700 and 1,550 acres (469, 688 and 627 hectares) totalling about 4,500 (1,784 hectares) have been selected for development. Areas I and II lie to the west and east of Bwakira Chini respectively, and Area III to the east of Dutumi. Area III includes a privately owned kapok estate, without which this area would be too small to allow the type of development proposed.

It is suggested that 1,000 acres (405 hectares) of land can be cleared and prepared for cropping each year, and that the farmers should be settled as land is cleared of bush. If operations are able to commence in 1965, the full complement of farmers will be settled on the land by 1967, and 1968 has been set as target for completion of this preparatory work.

It is proposed that 12 acres (4.5 hectares) should be allocated to each farmer, on which he should grow 1 acre (0.4 hectares) of maize intercropped with soya bean, 0.5 acre (0.2 hectares) of sorghum, 1.5 acres (0.6 hectares) of groundnuts, 1 acre (0.4 hectares) of cowpeas and 4 acres (1.6 hectares) of cotton. Until the land is thoroughly cleared of roots and weeds 4 acres (1.6 hectares) of land should be left fallow each year.

The growing of fruit and vegetables should be confined to the homestead area. The rotation recommended is

1st year	Maize, sorghum, legumes
2nd year	Fallow
3rd year	Cotton

In order that farmers should be free to help with land clearance, road making and other work associated with starting the scheme, and to avoid overburdening the settler with farm activities in his first year, it is proposed that he should cultivate only 2 acres (0.8 hectares) of cotton during this first year, as against 4 acres (1.6 hectares) thereafter. In the first year as well as subsequently, the use of tractor drawn equipment is advocated, but only as a supplement to the farmers' endeavours at peak periods of labour demand.

It is recommended that initially the three areas should be developed by subdivision into blocks, although these may be further divided into individual holdings at a later date, if required.

The gross return and the net return (after deductions in respect of food consumed, tractor hire charges and cost of insecticides) to the farmer are estimated at Shs. 3,174/- and Shs. 2,178/- respectively from the proposed cropping system.

Each of the three areas selected should be developed under the supervision of a controller capable of day to day organisation, who in turn should be responsible to an overall manager. The latter will control the administration of machinery services and such other centralised amenities which may be considered necessary to the scheme.

An essential component of the whole scheme is a small experimental unit where innovations and changes in techniques can be examined. Amongst these, the possibility of the economic control of weeds by the mechanical application of herbicides as a substitute for hand labour, and the opportunities for introducing livestock should be examined.

When development operations start, the catchments in the foothills adjacent to the development areas must be protected and should be controlled by the development authority. Minor soil conservation measures are recommended for only limited areas in two of the three sites selected for development.

Agricultural expansion will lead to a decrease in the supplies of fuel and building poles, small plantations are required to compensate for these losses. The catchment of 360 acres (146 hectares) of fuel and pole plantations is proposed, 190 acres (77 hectares) in Area II and 170 acres (69 hectares) in Area III. These will be planted at an overall rate of 60 acres (24 hectares) per annum over a period of 6 years.

Although no difficulties are anticipated in the provision of water supplies, examination of the most economical method is recommended. In the Area III two possible sites for the homestead area have been proposed. When the cost of providing water supplies are known more accurately, a decision can then be taken whether the advantages of the centrally placed homestead area outweigh the extra cost of piping water to it. It is recommended that a valuable potential water supply, the Gombo Swamp, to the east of Dutumi be reserved.

It is recommended that an area of heavy black clay adjacent to Dutumi be reserved for detailed study and future development.

## PREFACE

This report was presented to the Government of the United Republic of Tanzania in 1965. It is now being published, with the permission of the Tanzanian Government, as the first in a new series of Land Resource Studies by the Directorate of Overseas Surveys. This series of publications will enjoy a wider circulation than did the first edition of this report.

No extra data have been incorporated in this edition, but some changes have been made in the form of presentation in order to make it more suitable for a wider distribution.

1966

R. N. Jenkin



# CONTENTS

ABSTRACT	<i>Page</i> iv
SUMMARY OF RECOMMENDATIONS	v
PREFACE	vii
LIST OF MAPS	xii
LIST OF PLATES	xiii
PART I - INTRODUCTION	1
Origin of the Project	1
Team Composition	1
Procedure	1
Acknowledgements	3
PART II - ENVIRONMENT	4
PHYSICAL ASPECTS	4
Situation	4
Climate	4
Geology	12
Topography	12
Hydrology	12
Soils	13
Vegetation	14
Game and Pests	15
Environmental Zones	16
HUMAN ASPECTS	20
Population	20
Administration	21
Communications	21
Present Land Use	21
Experimental Results	24
Production and Marketing	26

PART III - DESCRIPTION OF AREAS OF DETAILED STUDY	<i>Page</i> 29
SELECTION OF AREAS OF DETAILED STUDY	29
AREA I	29
Boundaries	29
Topography	30
Soils	30
Vegetation and Land Use	32
AREA II	34
Boundaries	34
Topography	34
Soils	35
Vegetation and Land Use	37
AREA III	39
Boundaries	39
Topography	39
Soils	39
Vegetation and Land Use	40
PART IV - DEVELOPMENT	42
GENERAL PATTERN OF DEVELOPMENT	42
Agricultural Potential	42
Catchment Protection	42
Communications	42
Water Supplies	43
Selection of Development Areas	43
Scheme Design	44
Technical Support	45
Scheme Management	45
DETAILED AGRICULTURAL DEVELOPMENT PROPOSALS	46
Selection of Crops	46
Cropping System	47
Crop Management	48
Labour and Machinery	49
Costs and Returns to the Farmer	49
Scheme Layouts	51

PART IV - DEVELOPMENT (Contd.)

DETAILED AGRICULTURAL DEVELOPMENT PROPOSALS (Contd.)

Livestock	Page 53
Ancillary Services	54
Future Agricultural Development	55
DETAILED FORESTRY DEVELOPMENT PROPOSALS	55
Fuel and Pole Plantations	55
Species	55
Plantation Areas	56
Establishment	56
Labour Requirement	57
PHASING OF DEVELOPMENT PROGRAMME	58
REFERENCES AND RELEVANT WORKS	62
APPENDIX I - SOIL PROFILE DESCRIPTION AND ANALYSES	65
APPENDIX II - AGRICULTURAL LABOUR DISTRIBUTION	102

## LIST OF MAPS

1	Areas Studied during Reconnaissance 1:2,000,000	<i>facine page 2</i>
2	Lower Mgeta Study Area 1:500,000	4
3	Lower Mgeta Area, Environmental Zones 1:125,000	(in map folder)
4	Bwakira Chini and Dutumi, Areas of Detailed Study and Major Soil Boundaries 1:50,000	40
5a-d	Lower Mgeta Area, Vegetation and Land Use 1:25,000	(in map folder)
6	Bwakira Chini and Dutumi Development Areas 1:50,000	44
7a	Lower Mgeta Area, the Soils of Development Area I 1:5,000	(in map folder)
7b	Lower Mgeta Area, the Soils of Development Area II 1:5,000	(in map folder)
7c	Lower Mgeta Area, the Soils of Development Area III 1:5,000	(in map folder)
8a	Lower Mgeta Area, Suggested Farming Layout for Development Area I 1:5,000	(in map folder)
8b	Lower Mgeta Area, Suggested Farming Layout for Development Area II 1:5,000	(in map folder)
8c	Lower Mgeta Area, Suggested Farming Layout for Development Area III 1:5,000	(in map folder)

## LIST OF PLATES

<i>Frontispiece</i>	An aerial photograph of part of the Lower Mgeta River Area	<i>Page</i> ii
1	Broken forest	17
2	Clearing broken forest	17
3	Preparation of land for cotton cultivation	18
4	Parkland	18
5	Scrub	19
6	Land prepared for rice cultivation	19



# PART I - INTRODUCTION

## ORIGIN OF THE PROJECT

This report describes a detailed investigation of selected sites within the Lower Mgeta River Area of the Upper Ruvu Basin in Eastern Tanzania, and includes recommendations for their agricultural development.

The Land Resources Division of the Directorate of Overseas Surveys was requested to investigate the possibility of developing rain-fed farming in the Ruvu Basin, following examinations of the development potential for irrigation farming by Chablani (1961) and SOGREAH (1962). The terms of reference were:

- (i) To examine and select areas suitable for agricultural development in the Lower Mgeta River Area of the Upper Ruvu Basin.
- (ii) To make proposals for the planned development of these areas.

## TEAM COMPOSITION

Two teams worked on the project. The first, consisting of Mr. R. J. Spooner (agriculture) and Dr. I. Langdale-Brown (ecology), carried out a reconnaissance survey and selected the areas for detailed study. The detailed field investigation of the selected areas and the preparation of development proposals were undertaken by Mr. R. J. Spooner and Mr. R. N. Jenkin (soils and forestry).

## PROCEDURE

The project was carried out in two stages, based on a programme which involved operations both in Tanzania and in the United Kingdom, with the submission, at suitable intervals, of brief progress reports to the Tanzanian Ministry of Agriculture. The first stage was started in January 1964 and completed in August 1964. The second stage, which immediately followed the first, was completed in March 1965.

### Stage I

Initially information from maps, reference books, territorial, departmental and specialist reports, and from personal communications was collected and reviewed.

The air photography at scales of 1:35,000 (R.A.F. 1949, 1952 and 1956; F.A.S. 1956 and 1960; A.S.D. Tang. 1953, 1954, 1955 and 1956) and 1:10,000 (A.S.D. Tang. 1962) was examined stereoscopically. During this examination, topographic, soil, drainage, vegetation and land use features were studied. Uncontrolled photomosaics were made for use as field sheets for recording data.

In February and March 1964, during the field reconnaissance, the data obtained from the air photographs were checked, and details of water

resources, local agricultural practice, game, pests and diseases as well as local administration, population and communications were recorded. Account was also taken of Tanzanian Government policy in regard to village settlement.

A broad land classification was made for the area based on soils, vegetation, rainfall, drainage and land use, which was included in the first progress report in June 1964, together with a map at a scale of 1:2,000,000, showing the location of the Lower Mgeta River Area (Spooner *et al.*, 1964a). A request for new air photography of the Lower Mgeta River Area at a scale of 1:10,000 was also made. This photography was taken in June 1964 by the Tanzanian Air Photographic Unit.

The new air photography was studied stereoscopically and differing types of vegetation and land use were delineated and mapped at 1:25,000. Zones exhibiting common features of topography, soils, vegetation and drainage were also identified and were mapped at 1:125,000.

By further stereoscopic examination of the new air photography, three localities from within these zones were selected for detailed study. These were marked on uncontrolled photomosaics at contact scale. Alternate photographic prints within these areas were enlarged to 1:5,000 scale for recording data in the field, during stage II. A second progress report embodying this information and indicating further work to be done by Directorate of Overseas Surveys was submitted to the Tanzanian Ministry of Agriculture, in August 1964 (Spooner *et al.*, 1964b).

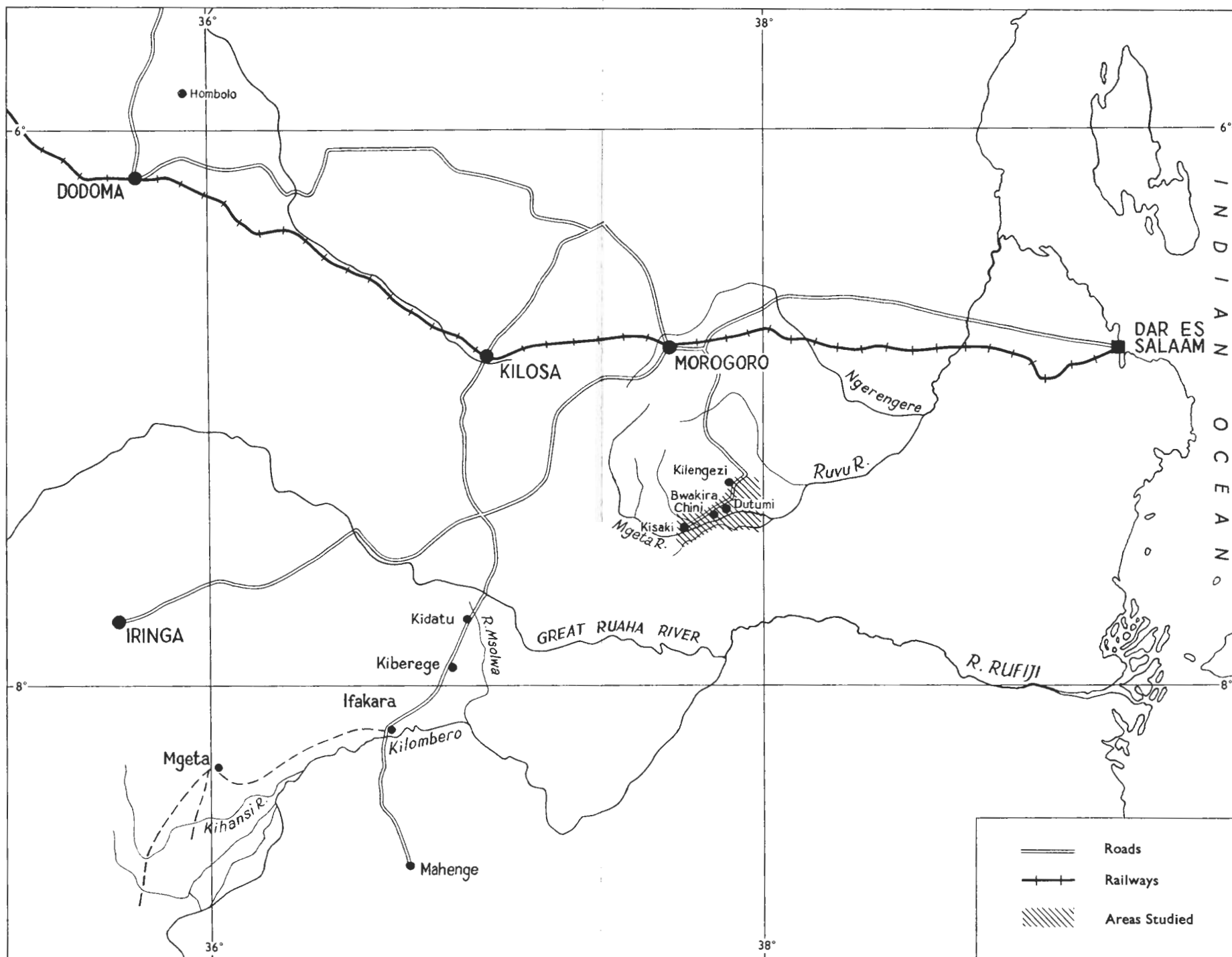
## **Stage II**

In September, October and November 1964, during the second period of field study, a detailed examination was made of topography, soils, vegetation and land use within the selected localities. Local information was widely sought on past and present agricultural practice, and before leaving Tanzania the team discussed tentative proposals for agricultural development with the authorities concerned.

A field Survey Party from the Directorate of Overseas Surveys established planimetric and height control for the 1:10,000 scale 1964 air photography. The members of this party assisted the team by providing spot heights for the calculation of gradients, and in establishing more accurately the boundaries of the study areas on the ground. These boundaries, previously marked on the air photographs, were modified where necessary.

The project was completed at the Directorate and a number of additional maps showing the areas studied in detail, the soil boundaries, and the suggested farm layouts for each development area were produced.

At the same time an assessment was made of all the data collected, and a final report was submitted to the Tanzanian Government (Spooner *et al.*, 1965).



## ACKNOWLEDGEMENTS

The members of the team are very conscious of the co-operation which they received in Tanzania during the whole of the project, and wish to thank Mr. K. Johansen, Deputy Permanent Secretary, Ministry of Agriculture, Mr. D. Mwakosya, Director of Agriculture, Mr. A. Hammersley, Assistant Director of Agriculture, Mr. R. Sangster, Chief Conservator of Forests, Mr. S. W. Fraser-Smith, O.B.E., Commissioner for Village Settlement, Mr. S. L. Paterson, Director of Water Development and Irrigation, and their staffs.

They are particularly grateful to Mr. K. Chande, Divisional Executive Officer, Bwakira Chini, who was a constant source of guidance on local matters, and Mr. M. J. Pash, Agricultural Officer (Land Planning) who was attached to the team throughout the second field investigation.

The team received valuable help from their colleagues in the Directorate of Overseas Surveys with the ground survey work and map production. They would also like to thank Dr. D. A. Osmond, Director of the Soil Survey of England and Wales for his co-operation, and in particular Mr. C. L. Bascomb and his staff for undertaking the soil analyses at short notice. Thanks are also due to Dr. R. H. Kirby of the Tropical Products Institute for his advice. Finally, the team would like to thank the staff of Kew Herbarium, and the East African Herbarium, Nairobi, for the identification of botanical specimens.

## PART II - ENVIRONMENT

### PHYSICAL ASPECTS

#### SITUATION (see Maps 1 and 2)

The Lower Mgeta River Area of the Upper Ruvu Basin is situated south of the Uluguru Mountains in Eastern Tanzania. It lies 100 miles (61 km.) west-south-west of Dar es Salaam and 40 miles (64 km.) south of Morogoro. This area occupies about 190 square miles (492 sq. km.) and is bounded on the north by the foothills of the Uluguru massif and on the south by the Mgeta River. It stretches from a few miles west of Kisaki to Kilengezi in the east. Within it lie several minor settlements of which two, Bwakira Chini and Dutumi, are the main concern of this report. They are situated four miles apart at altitudes of 485 and 450 feet (148 and 137 m.) above mean sea level respectively on a longitude of 7° 23'S and a latitude of 37° 48'E.

#### CLIMATE

##### Rainfall

The rainfall data available for the Lower Mgeta River Area, and for Bwakira Chini in particular, are insufficient to establish accurate estimates of the annual rainfall at each station. However, if the rainfall figures for Bwakira Chini and Dutumi are considered in relation to those for the neighbouring settlements of Kisaki and Mvuha a fuller picture emerges (see Table 1).

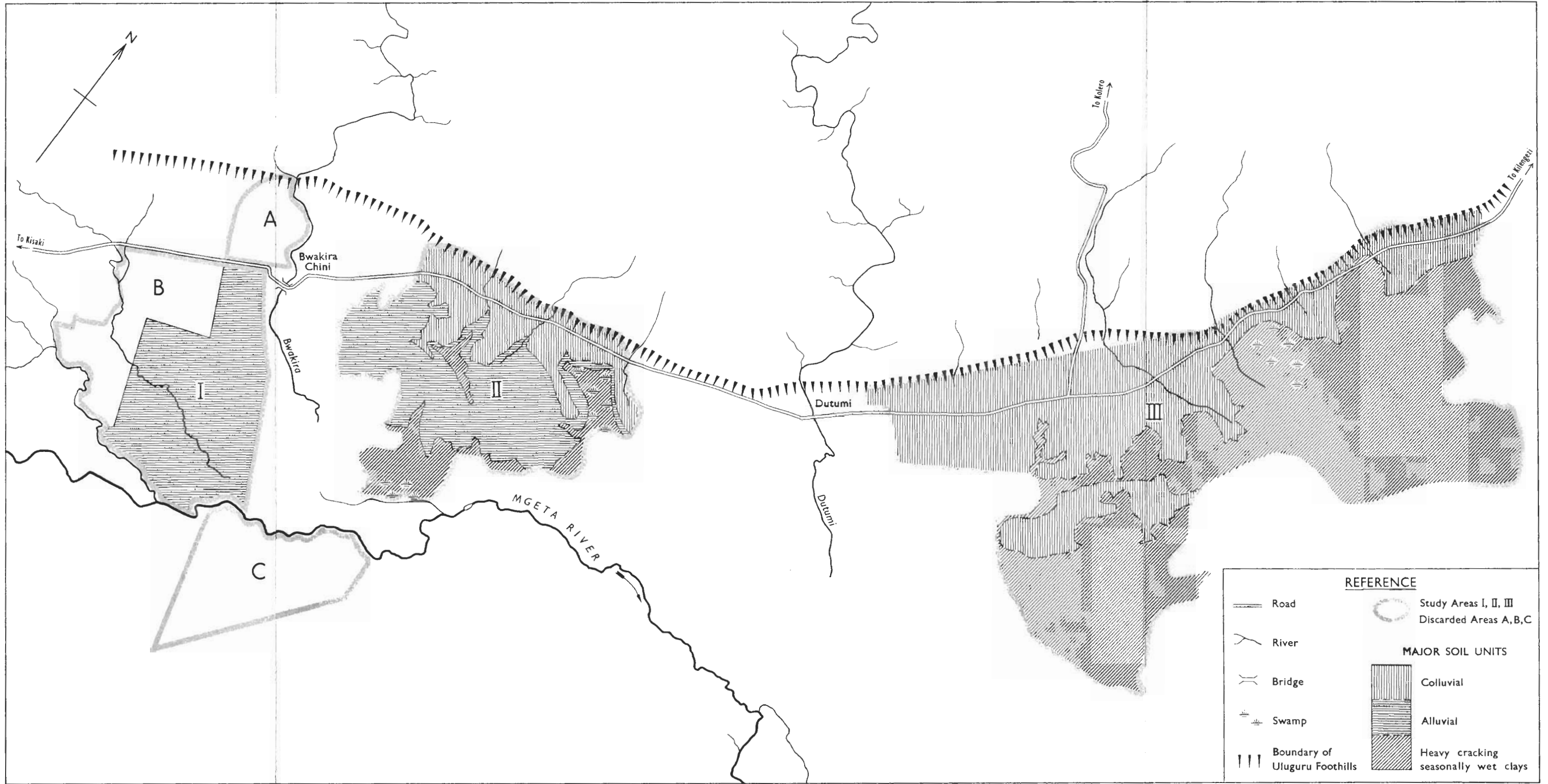
There is almost certainly an increase in rainfall from west to east due to the relative proximity of each station to the Uluguru foothills, Kisaki being the farthest away from the escarpment, and Mvuha the nearest. In this connection it is reasonable to assume that the rainfall is less on the parts of the Mgeta flood plain farthest from the escarpment. The average annual rainfall for Bwakira Chini probably lies between 960 and 1,060 mm. (38-42 in.) and for Dutumi between 1,020 and 1,120 mm. (40-44 in.). At both stations, however, considerable variations from year to year in total rainfall can be expected. Table 2 shows the extent of this variation over the past few years.

Table 3, summarising the seasonal distribution of the rainfall, shows that over three-quarters of the annual rainfall occurs between the months of December and May. Within this period there is a tendency for a small decrease in rainfall to occur at about the beginning of February and for a climax to be reached in April.

It is of particular interest to the agriculturist and forester to study the beginning and end of the wet season in selecting planting dates. A close examination of Tables 4 and 5 shows that a more or less consistent pattern of rainfall commences about the middle of December and finishes about the middle of May. Although sporadic heavy showers or periods of more prolonged rain occur before the start of the wet season, between them there are usually comparatively long periods of drought. After about the 10th - 15th May the rainfall decreases markedly both in amount and frequency.

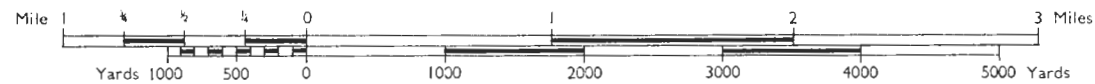
# BWAKIRA CHINI AND DUTUMI

## AREAS OF DETAILED STUDY AND MAJOR SOIL BOUNDARIES



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SCALE 1: 50,000



<b>REFERENCE</b>	
	Study Areas I, II, III
	Discarded Areas A, B, C
<b>MAJOR SOIL UNITS</b>	
	Colluvial
	Alluvial
	Heavy cracking seasonally wet clays

Printed for D.O.S. by S.P.C., R.E.  
 Topography reproduced from part D.O.S. Sheets 1:50,000 Tanganyika 201/3  
 and 201/4 with soil boundary information from 1:14,000 and 1:10,000  
 aerial photography by Tanzania Air Survey Division in 1962 and 1964.  
 Ground data obtained by the Land Resources Division of D.O.S. 1964.  
 600,3/65/1017/SPC

TABLE 1 Average monthly and annual rainfall in mm. (in.) and rain days at four stations in the Lower Mgeta River Area

STATION (Ref. No.)	MVUHA (97.3714)		DUTUMI (97.3700)		BWAKIRA CHINI (97.3727)		KISAKI (97.3708)	
YEARS	10 (1951-56, 1958-61)		15 (1949-63)		8 (1956-63)		15 (1942-55, 1959)	
MONTH	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS
JANUARY	138 (5.45)	8	109 (4.28)	6	115 (4.53)	6	99 (3.88)	6
FEBRUARY	198 (7.79)	8	139 (5.47)	7	189 (7.44)	9	86 (3.39)	6
MARCH	187 (7.35)	10	204 (8.02)	9	164 (6.44)	12	134 (5.28)	8
APRIL	255 (10.05)	16	248 (9.77)	15	201 (7.92)	17	269 (10.58)	14
MAY	93 (3.67)	9	113 (4.46)	8	82 (3.24)	6	156 (6.15)	9
JUNE	30 (1.19)	4	26 (1.04)	3	34 (1.35)	4	17 (0.65)	2
JULY	18 (0.71)	3	10 (0.40)	2	19 (0.74)	2	5 (0.21)	1
AUGUST	43 (1.70)	3	10 (0.40)	1	15 (0.60)	2	8 (0.31)	1
SEPTEMBER	31 (1.21)	3	19 (0.75)	2	22 (0.85)	2	9 (0.35)	1
OCTOBER	72 (2.85)	5	41 (1.60)	3	38 (1.49)	4	25 (0.98)	2
NOVEMBER	65 (2.56)	4	91 (3.59)	4	107 (4.20)	8	49 (1.91)	3
DECEMBER	117 (4.59)	8	76 (2.98)	5	69 (2.73)	6	65 (2.55)	4
YEAR	1,247 (49.12)	81	1,086 (42.76)	65	1,055 (41.53)	78	922 (36.24)	57

TABLE 2 Annual rainfall in mm. (in.) at Bwakira Chini and Dutumi

YEAR	BWKIRA CHINI		DUTUMI	
	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS
1949	na	na	1,013 (39.90)	56
1950	na	na	1,027 (40.45)	76
1951	na	na	1,280 (50.42)	70
1952	na	na	960 (37.79)	51
1953	na	na	604 (23.79)	48
1954	na	na	661 (26.01)	39
1955	na	na	1,195 (47.05)	67
1956	1,004 (39.52)	na	849 (32.92)	59
1957	1,491 (58.72)	na	1,308 (51.48)	71
1958	1,026 (40.40)	69	1,187 (46.72)	51
1959	869 (34.20)	59	708 (27.88)	49
1960	938 (36.94)	82	813 (32.00)	70
1961	1,359 (53.52)	120	1,520 (59.84)	111
1962	724 (28.49)	62	1,361 (53.59)	74
1963	1,028 (40.47)	79	1,861 (71.51)	80
AVERAGE	1,055 (41.53)	78	1,086 (42.76)	65

na = not available.

TABLE 3 Average rainfall in mm. (in.) and percentage of annual rainfall occurring in the wet season December to May and the dry season June to November at four stations in the Lower Mgeta River Area

STATION	YEARS		WET SEASON (Dec. -May)	DRY SEASON (June-Nov.)
MVUHA	10	RAINFALL mm. (in.)	988 (38.90)	260 (10.22)
		% of ANNUAL RAINFALL	79.2	20.8
DUTUMI	15	RAINFALL mm. (in.)	888 (34.98)	198 (7.78)
		% of ANNUAL RAINFALL	81.9	18.1
BWAKIRA CHINI	8	RAINFALL mm. (in.)	820 (32.30)	234 (9.23)
		% of ANNUAL RAINFALL	77.8	22.2
KISAKI	15	RAINFALL mm. (in.)	808 (31.83)	112 (4.41)
		% of ANNUAL RAINFALL	87.9	12.1

TABLE 4 Average rainfall in mm. (in.) and rain days for 5-day periods (and 6-day at the end of October and December) for the months of October, November and December at four stations in the Lower Mgeta River Area

STATION	MVUHA			DUTUMI			BWAKIRA CHINI			KISAKI		
YEARS	13			15			4			19		
MONTHS/ DATES	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS
	mm.	in.		mm.	in.		mm.	in.		mm.	in.	
OCTOBER												
1 - 5	3	0.12	0	0	0.01	0	1	0.03	0	3	0.10	0
6 - 10	2	0.09	1	1	0.04	0	0	0.00	0	2	0.07	0
11 - 15	6	0.24	1	4	0.17	0	4	0.14	0	6	0.25	1
16 - 20	6	0.22	0	4	0.14	0	7	0.26	1	3	0.13	0
21 - 25	10	0.40	1	9	0.35	1	18	0.72	1	5	0.18	0
26 - 31	22	0.85	1	22	0.88	1	10	0.38	1	14	0.57	1
NOVEMBER												
1 - 5	11	0.45	1	12	0.46	0	26	1.04	1	8	0.30	0
6 - 10	8	0.33	1	9	0.36	0	43	1.70	2	7	0.27	0
11 - 15	9	0.37	1	14	0.54	1	15	0.58	1	8	0.32	0
16 - 20	17	0.66	2	22	0.85	1	26	1.04	2	14	0.57	1
21 - 25	5	0.20	1	16	0.63	1	50	1.95	2	4	0.17	0
26 - 30	10	0.39	1	19	0.75	1	30	1.17	1	4	0.15	0
DECEMBER												
1 - 5	13	0.51	1	3	0.12	1	19	0.75	2	6	0.26	1
6 - 10	16	0.63	1	3	0.13	0	10	0.38	1	2	0.09	0
11 - 15	10	0.40	1	11	0.42	1	18	0.69	2	13	0.52	1
16 - 20	21	0.84	2	24	0.96	1	13	0.53	2	13	0.51	1
21 - 25	20	0.79	1	8	0.30	1	14	1.57	2	15	0.61	1
26 - 31	21	0.84	1	22	0.88	1	15	0.60	1	13	0.51	1

TABLE 5 Average rainfall in mm. (in.) and rain days for 5-day periods (and 6-day at the end of May) for the months of April and May at four stations in the Lower Mgeta River Area

STATION	MVUHA			DUTUMI			BWAHIRA CHINI			KISAKI		
YEARS	14			15			4			20		
MONTHS/ DATES	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS
	mm.	in.		mm.	in.		mm.	in.		mm.	in.	
APRIL												
1 - 5	37	1.44	2	21	0.81	1	20	0.79	2	40	1.59	2
6 - 10	34	1.33	3	41	1.61	2	19	0.75	2	35	1.38	2
11 - 15	43	1.71	3	40	1.56	3	18	0.70	2	38	1.48	3
16 - 20	53	2.08	3	43	1.68	3	30	1.20	3	56	2.22	3
21 - 25	40	1.56	3	53	2.10	3	49	1.93	4	46	1.81	3
26 - 30	44	1.74	3	45	1.78	3	36	1.41	3	50	1.95	3
MAY												
1 - 5	20	0.78	2	27	1.07	2	27	1.07	2	41	1.63	3
6 - 10	27	1.08	2	34	1.33	2	21	0.83	1	43	1.70	1
11 - 15	8	0.31	1	20	0.80	1	13	0.50	1	16	0.64	1
16 - 20	16	0.63	2	18	0.69	2	9	0.34	1	17	0.68	1
21 - 25	16	0.63	1	15	0.58	1	0	0.00	0	11	0.45	1
26 - 31	5	0.21	1	2	0.09	0	4	0.16	0	6	0.25	1

The amount of rain which falls during the wet or dry season varies considerably from year to year, but the variation between dry seasons is usually the greater. At Dutumi between July and December 1960, 56 mm. (2.20 in.) of rain fell compared with 704 mm. (27.70 in.) in the same period in 1961. Table 6 shows the variation during the growing season (January to June).

There is a similarity in rainfall pattern between the stations in the Lower Mgeta River Area, the Central Agricultural Research Station at Ilonga near Kilosa, which is about sixty miles west of Morogoro, and Mombo, which lies on the western side of the Usambara Mountains in Tanga Region (see Table 7). This similarity suggests a comparable climate for the four places and on this assumption the agricultural and silvicultural records from Ilonga and Mombo have been used in compiling this report.

TABLE 6 Rainfall in mm. (in.) during the growing season January to June at  
Bwakira Chini and Dutumi

YEAR	BWAHIRA CHINI		DUTUMI	
	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS
1949	na	na	854 (33.63)	46
1950	na	na	896 (35.28)	59
1951	na	na	950 (37.42)	52
1952	na	na	799 (31.46)	43
1953	na	na	434 (17.10)	30
1954	na	na	625 (24.61)	36
1955	na	na	978 (38.49)	55
1956	937 (36.91)	na	771 (30.37)	52
1957	1,187 (46.73)	na	977 (38.47)	53
1958	856 (33.69)	50	1,011 (39.81)	37
1959	767 (30.20)	47	611 (24.06)	35
1960	871 (34.30)	74	761 (29.98)	64
1961	718 (28.26)	64	827 (32.57)	58
1962	452 (17.83)	44	973 (38.29)	50
1963	492 (19.38)	49	1,142 (44.98)	50
AVERAGE	785 (30.91)	55	841 (33.10)	48

na = not available.

TABLE 7 Average monthly and annual rainfall in mm. (in.) at Bwakira Chini, Dutumi, Ilonga and Mombo

STATION (Ref. No.)	BWKIRA CHINI (97.3727)		DUTUMI (97.3700)		ILONGA (96.3732)		MOMBO (94.3822)	
YEARS	8 (1956-63)		15 (1949-63)		21 (1944-64)		19 (1942-57, 1959,1961-2)	
MONTHS	mm.	in.	mm.	in.	mm.	in.	mm.	in.
JANUARY	115	4.53	109	4.28	138	5.44	70	2.77
FEBRUARY	189	7.44	139	5.47	136	5.35	64	2.51
MARCH	164	6.44	204	8.02	212	8.33	87	3.42
APRIL	201	7.92	248	9.77	221	8.71	164	6.44
MAY	82	3.24	113	4.46	71	2.80	179	7.06
JUNE	34	1.35	26	1.04	9	0.36	20	0.80
JULY	19	0.74	10	0.40	9	0.35	28	1.12
AUGUST	15	0.60	10	0.40	13	0.50	13	0.53
SEPTEMBER	22	0.85	19	0.75	10	0.41	18	0.71
OCTOBER	38	1.49	41	1.60	36	1.42	37	1.44
NOVEMBER	107	4.20	91	3.59	74	2.90	67	2.62
DECEMBER	69	2.73	76	2.98	135	5.32	72	2.85
YEAR	1,055	41.53	1,086	42.76	1,064	41.89	819	32.27

### Other Climatic Factors

There are no meteorological data, other than rainfall figures, for the Lower Mgeta River Area. It is only possible therefore to record a few general observations based on the experience of people who know the area well, and upon figures available for the Central Agricultural Research Station at Ilonga near Kilosa, which has a similar topographic position and is considered by workers in Tanzania to have a similar climate to that of the Lower Mgeta River Area.

High temperatures are experienced throughout the Mgeta Plain, during the period October to February, when the sun's elevation is greatest. The highest values occur in the pre-rain period when cloud cover is small. The lowest temperatures occur on nights when the sky is clear, generally, in the period June to August. At Ilonga mean maximum temperatures of 33°C (91°F) and mean minimum temperatures of about 16°C (61°F) occur in November. Bwakira Chini and Dutumi are at a lower elevation, 450-480 feet (137-148 m.) above mean sea level, than Ilonga, at 1,850 feet (549 m.). Therefore somewhat higher maximum temperatures may be expected. During the second period of field work from late September to early November, it was noted that afternoon shade temperatures at Bwakira Chini steadily rose from 30°C (86°F) at the beginning of the period to 35°C (95°F) in early November. These temperature measurements were taken by the topographic surveyors from the Directorate of Overseas Surveys in connection with the calibration of their equipment.

With the approach of the wet season, that is during the period October to December, the humidity progressively increases to a high level which persists throughout the rains.

## GEOLOGY

The Uluguru massif is mainly composed of crystalline and metamorphic rocks. Pyroxenite granulite with garnet and some hornblende occur between Kisaki and Dutumi. Crystalline limestone and porphyroblastic gneisses are found north-east of Dutumi, but Karroo conglomerates and shales occur just north of Kilengezi.

The Mgeta plain consists of alluvial deposits and heavy, cracking, seasonally wet clays, locally termed Mbuga, overlying crystalline and metamorphic rocks; the alluvium have been derived from decomposed micaceous metamorphic rocks of the surrounding hills.

## TOPOGRAPHY (see Map 2)

The Uluguru massif, occupying about 780 square miles (2,020 square km.) and with Kimhandu rising to 8,681 feet (2,646 m.) above mean sea level at its highest point, dominates the whole of the Upper Ruvu Basin. To the south the foothills of the range fall away steeply from about 2,000 feet (610 m.) to the flood plain of the Mgeta River. The flood plain is virtually flat, there being a fall of only 55 feet (17 m.) within a distance of 2 miles (3 km.) from its northern edge to the Mgeta River. The Mgeta and other rivers, notably the Mngazi, Bwakira, Dutumi and Mvuha rise within the Uluguru Mountains.

Within the Lower Mgeta River Area there are three distinct topographic units, namely the lower slopes of the Uluguru foothills, the flood plain of the Mgeta River and the valley bottom. On the lower slopes of the foothills gradients vary between about 2 and 6 per cent, whilst on the flood plain and in the valley bottom they seldom exceed 2 and 1 per cent respectively. Minor topographic variations occur on the flood plain in the form of small ridges and shallow depressions, but the height differences are often too small for these features to be mapped from the aerial photographs. Nevertheless they are important in relation to soil profile development.

## HYDROLOGY

The water resources of the Lower Mgeta River Area are plentiful and are derived mainly from a network of permanent and seasonal rivers and streams, of which the largest and most important is the Mgeta.

The Mgeta rises in the Uluguru Mountains and flows over steep gradients for more than 70 miles (113 km.) until its course levels out on reaching the plains. Here it flows eastward for a further 50 miles (81 km.) before turning north to join the Ruvu. It forms the southern boundary of the western sector of the area under examination. Here its bed is about 100 feet (30 m.) wide and its banks form a levee about 12 feet (4 m.) above the surrounding flood plain. At the time of inspection, in November 1964, immediately before the onset of the rains, it was flowing to a depth of 1.5 to 2 feet (45-61 cm.). During the rains however, when it is in spate, the lower lying areas of the surrounding plain are flooded. Flooding in the vicinity of Bwakira Chini is however very exceptional and lasts for only a few hours. Nevertheless it is worth recording that in the 1963 rains, the Mgeta burst its banks at Kisaki, where it debouches from the mountains, and inundated a considerable area of fertile agricultural land nearby before rejoining its normal course.

The north bank tributaries of the Mgeta, that lie within the boundaries of the project area, also rise in the Uluguru Mountains, and flow southwards

towards the Mgeta. Only one however, the Mngazi, is perennial and flows directly into the Mgeta, the remainder flow into the larger depressions in the flood plain. Formerly the course of the Mngazi joined the Mgeta just south of Bwakira Chini; it now does so south of Kisanga (see Map 3). Its former course now only flows seasonally, during and immediately after the rains.

To the east of the Mngazi, the Bwakira flows during the rains into a swamp north of the Mgeta. This river is an important source of water for the local people throughout the year, as they are able to obtain water by digging in the sandy bed when the river ceases to flow.

Further east there are several minor seasonal streams including the Greater and Lesser Kikundi. Both however, flow into flood plain depressions just below the foothills, and cease to flow soon after the rains cease.

The only other river of significance is the Dutumi. Although permanent, its defined course is lost in a swamp just south of the minor settlement of the same name. No flow data are available, but at the time of inspection in November 1964 the flow was estimated to be 5 cusecs upstream of the settlement. At present the local people draw their water from this river. The rock bar noted by SOGREAH (1962) is a useful point for the control and extraction of water. Many years ago the water supply for a ginnery was obtained at this point.

About four miles east of Dutumi lies the Gombo Swamp, which is frequented throughout the year by large and small game. For part of the year it is fed by two small seasonal streams. Further recharge is provided by surface and subsurface drainage from the foothills.

Hydrological information regarding the behaviour of all these rivers and streams is incomplete, but recommendations have been made by CHABLANI (1961) and SOGREAH (1962) for their further study in relation to irrigation development. However, the existing evidence suggests that expansion of rain-fed agriculture is possible.

Apart from the rivers and streams, additional sources of water have been found by digging shallow wells. These make a useful contribution to supplies, but in years when the dry season is lengthy and severe, and heavier demands are made on them, the wells dry up. It was noted that one well on the Bwakira Estate, used during the field work, was slightly saline. It was also observed that, in the vicinity of Dutumi, several apparently permanent water holes occur at the junction of the colluvial soils of the foothills with the heavy cracking clays of the flood plain.

## SOILS

Three main soil types occur, colluvial, alluvial and heavy, grey, cracking, seasonally wet clays. Their distribution is closely correlated with the topographic units into which the study area has been divided. The colluvial soils occur mainly on the slopes of the Uluguru foothills, the alluvial soils on the flood plain and the clays, which are similar in nature to black cotton soils, are associated with valley bottom sites and depressions, in the flood plain.

## Colluvial Soils

The slopes at the foot of the escarpment are steeper than those of the other two topographic units. On these slopes the soils range in texture from coarse sandy loam to coarse sandy clay loam and contain varying amounts of stones and gravel throughout the profile. To the east of Dutumi soil colours are generally reddish brown, whilst to the west greyish brown to brown soils occur. These slightly acid, pH 6.0-6.5, colluvial soils are usually deeper than 120 cm. (47 in.) and are moderately rich to rich in the main plant nutrients, except for nitrogen.

Along the boundary between the lower slopes of the foothills and the flood plain, fine textured almost stone-free colluvial material overlies, and is to a certain extent mixed with alluvial material.

## Alluvial Soils

On the flood plain to the west of Dutumi the soils are of alluvial origin. Their profiles reveal the deposition of successive layers of alluvium varying in texture from coarse sand to clay. The texture of the upper horizons of these soils varies with minor topographic differences, and is heavier in the depressions. Pale grey, brown and yellowish brown colours predominate and the soils contain no stones or gravel. The chemical analyses indicate a neutral pH of 7.0-7.5, and a high content of assimilable phosphates and exchangeable bases.

As the name 'flood plain' implies, the soils of this topographic unit are subject to occasional inundation. This is due partly to the flooding of the main channel of the Mgeta river and its tributaries and partly to direct surface runoff from the escarpment.

## Heavy, cracking, seasonally wet clays

Heavy, dark grey calcareous clays with impeded drainage occur on the flood plain east of Dutumi and in the major depressions west of Dutumi. They also occupy the whole of the valley bottom sites except for narrow levees, consisting of fine sandy alluvium, along the banks of the Mgeta River and few of the larger drainage channels. These clays are subject to inundation during the wet season. In dry weather large cracks appear in the soil surface as the soil dries out and shrinks. The chemical analyses show these soils to be slightly alkaline, pH 7.5-8.0, and rich in the main plant nutrients. SOGREAH (1962) observed slight salinity in some profiles. Their main disabilities appear to be physical, namely the liability to flooding and the heaviness of the soil, which makes cultivation difficult.

## VEGETATION (see Maps 5a-d)

The vegetation of the lower slopes of the foothills consists of a patchwork of moist semi-deciduous forest and parkland. The characteristic trees of the forest are *Khaya nyasica*, *Sterculia appendiculata*, *Trichilia roka*, *Albizia glaberrima* and *Ficus sycamorus*, with emergents attaining a height of 100 feet (30 m.) in places. The best developed forests have an understory of shade demanding species, notably *Conopharyngia* sp. and *Chrysohyllum* sp. The predominant element of the parkland is the grass *Panicum maximum* which grows as a dense sward up to 7 feet (2 m.) high, and in which isolated forest trees, *Acacia polyacantha* subsp. *campylacantha*, *A. goetzei* subsp. *microphylla* and *Kigelia aethiopica* are scattered.

While the variation in topography is small throughout the flood plain, minor differences in elevation have a considerable effect on the vegetation. Forest and thicket are found chiefly on the higher lying ground while scrub occurs in the intervening areas. The forests contain most of the species mentioned above together with *Chlorophora excelsa*, *Erythrophleum suaveolens*, *Antiaris usambarensis* and the fan palm *Borassus aethiopum*. The scrub of the lower lying heavy textured soils consists characteristically of *Acacia goetzei* subsp. *microphylla*, *A. nigrescens*, *Combretum constrictum*, *C. chionanthoides* and *C. imberbe* with scattered *Hyphaene coriacea*. Much of the higher land along the northern boundary of the flood plain, has been cleared for cultivation, but where it has been allowed to revert to natural vegetation, scrub has developed.

Three types of vegetation occur in the valley bottom site and their occurrence is related to the elevation and drainage of the land.

- (1) Farthest from the river, bordering the flood plain, is an open scrub community dominated by *Acacia nigrescens*, *Combretum constrictum*, *C. chionanthoides*, *C. imberbe* and the grasses *Panicum maximum* and *Heteropogon contortus*.
- (2) In the main part of the area between the river and flood plain is an *Echinochloa* grassland.
- (3) Riparian forest, occurs as a narrow band along some of the drainage lines on the alluvial soils. It contains many forest species mentioned above, notably *Sterculia appendiculata*, *Khaya nyasica*, *Albizia glaberrima* and *Kigelia aethiopica*.

## GAME AND PESTS

South of the Mgeta River, but separated from it by a narrow belt of sparsely settled bush, lies the Selous Game Reserve. This reserve occupies a wide expanse of country, and its proximity to the project area increases the hazards to agricultural development which are likely to arise from game movement and damage. The extent of the inroads made by game is governed in part by the density of human settlement. The country between Kisaki and Bwakira Chini is less affected than the land to the west and south-east of Dutumi. Availability of water also influences the movement of game, and concentrations of them increase during the rains when low lying sites are inundated. Damage to isolated areas of cultivation is considerable and has been a limiting factor in agricultural expansion in the past.

Of the larger species, elephant and buffalo are the most important. Moving northwards from the Selous Game Reserve they cross the Mgeta River and feed in the woodlands and on the grasslands of the flood plain and on the lower slopes of the Uluguru foothills. During the drier weather they tend to concentrate in the neighbourhood of the Mgeta and around the open water of the Gombo Swamp. Hippopotamus are also to be found in the immediate neighbourhood of the Mgeta where their tracks become minor seasonal watercourses.

Waterbuck, warthog and bushpig also frequent the wooded areas. Baboons and other smaller monkeys cause crop losses throughout the area at harvest time.

Small flocks of *Quelea quelea* also cause considerable losses to grain crops, and much time is spent in scaring them away.

The project area lies within the extensive eastern tsetse fly belt of Tanzania. However, incidence is only significant where game are present and vegetative cover is favourable. A reconnaissance survey carried out in October and November 1964 by a Fly Control Officer showed that in the vicinity of Bwakira Chini densities were extremely low. Four flies of *Glossina brevipalpis* and one of *G. pallidipes* were found, but they were thought to have been brought in by vehicles moving through Dutumi; in the opinion of the Control Officer therefore, this area was virtually fly free. His investigations around Dutumi however, disclosed the presence of *G. pallidipes* in the broken forest, between the Dutumi - Kilengezi road and the Mgeta River. Local opinion suggests that the fly densities vary according to the movement of game in the area, concentrations being highest at the beginning and the end of the rainy season.

### ENVIRONMENTAL ZONES

As there is a close interrelationship between topographic position, soil type, drainage and vegetation it has been possible to divide the Lower Mgeta River Area into three environmental zones. These are the Scarp Foot, the Flood Plain and the Valley Bottom. Table 8 summarises the main characteristics of each environmental zone.

TABLE 8. Environmental Zones of Lower Mgeta River Area

ZONE	TOPOGRAPHIC POSITION	AREA sq. miles (sq. km.)	SLOPE %	SOIL TYPES	DRAINAGE	VEGETATION
A	Scarp Foot	31 (81)	2 - 6	Stony, sandy to sandy clay loam colluvium	free	forest and parkland
B	Flood Plain	109 (283)	0 - 2	1. Fine textured colluvium over- lying alluvium on boundary with Scarp Foot	moderately free	forest, parkland and scrub
				2. Sandy to clay alluvium	moderately free	
				3. Heavy, cracking seasonally wet clays (Mbuga) in depressions	impeded, seasonally waterlogged	parkland and scrub
C	Valley Bottom	50 (130)	1	1. Heavy, cracking seasonally wet clays (Mbuga)	impeded, seasonally waterlogged	scrub and grassland
				2. Fine sandy alluvium	moderately free	riparian forest



PLATE 1 Broken forest with *Acacia polyacantha* subsp. *campylacantha* trees and *Panicum maximum* grass on alluvial soil, Lower Mgeta River Area



PLATE 2 Clearing broken forest prior to cultivation, Bwakira Chini



PLATE 3 Preparation of land cleared from broken forest for cotton cultivation, Bwakira Chini



PLATE 4 Parkland with *Acacia goetzei* subsp. *microphylla* trees and *Heteropogon contortus* grass on alluvial soil, Lower Mgeta River Area



PLATE 5 Scrub with *Acacia goetzei* subsp. *microphylla* trees, *Salvadora persica* shrubs and *Heteropogon contortus* grass on heavy, cracking, seasonally wet clay, Lower Mgeta River Area



PLATE 6 Land prepared for rice cultivation; formerly scrub on heavy, cracking, seasonally wet clay in valley bottom site close to Mgeta River, Bwakira Chini

## HUMAN ASPECTS

### POPULATION

For many years the Lower Mgeta River Area has been occupied by the Kutu tribe. Moffett (1958) assigns this tribe to the Northern Hill Bantu Group. Primarily its members are agriculturists rather than pastoralists and even today the keeping of livestock plays little or no part in their activities.

Close by in the Uluguru Mountains live the more numerous Luguru tribe. This tribe is also a member of the Northern Hill Bantu Group and is predominantly agricultural in its activities.

During recent years there has been an infiltration by members of the Luguru tribe into the plains of the Mgeta River, on account of increasing pressure of population and deteriorating soil resources in the restricted cultivable areas of their own land. Initially this movement was seasonal and involved a stay on the plains for a period sufficient only for the planting and harvesting of small areas of annual crops. In the past few years, however, settlement has become permanent, and today there is considerable dilution of the original Kutu population. Luguru settlers are industrious, possibly because they are conditioned to hard work by the environment prevailing in the mountains. Apart from this permanent settlement, there is also a small and variable seasonal flow of labour from the foothills to the plain.

The 1957 census recorded a total population of 14,367 in the Lower Mgeta River Area distributed by age and sex as shown in Table 9.

TABLE 9. Population, by age and sex, for Lower Mgeta River Area (Territorial census No. 138), 1957

AGE	MALE	FEMALE	TOTAL
UNDER 16 YEARS	2,951	2,694	5,645
16 YEARS AND OVER	4,136	4,586	8,722
TOTAL	7,087	7,280	14,367

No data are available to show how these figures are distributed between the two tribes concerned, but evidence suggests that so far the Luguru population is but a small proportion of the total.

Current figures for the number of taxpayers show that for the administrative areas of Kisasi, Bwakira Chini and Dutumi the total is 3,884, of which 2,318 reside at or near Kisasi, 256 at Bwakira Chini and 549 at Dutumi. Assuming that 1 taxpayer represents 4.5 members of the population there would be today a total of nearly 18,000 people in the project area. To this must be added a small number, between 50 and 100, of Asians and Europeans associated with the few estates in the area, and with trading activities in the minor settlements of Kisasi, Mngazi, Dakawa, Bwakira Chini and Dutumi.

## **ADMINISTRATION**

Administrative control, in respect of both central government and local authority matters, is exercised by a Divisional Executive Officer, with offices at Bwakira Chini. He is responsible to the Area Commissioner, and in turn to the Regional Commissioner at Morogoro.

Agricultural policy and extension work are carried out by one Assistant Field Officer stationed at Dakawa and a second stationed at Dutumi.

## **COMMUNICATIONS**

There is no rail link between the Lower Mgeta River Area and other centres, neither is there an airstrip. The nearest railhead is 75 miles (121 km.) north by road at Morogoro, which lies astride the main east/west railway line linking Dar es Salaam with Lakes Victoria and Tanganyika. 80 miles (129 km.) east of the railhead, the line branches northwards to serve the Tanga, Moshi and Arusha Regions, Kenya and Uganda.

Morogoro is also situated on the east/west trunk road which connects Dar es Salaam with the developing areas of the Kilombero Valley and the Southern Highlands Region. The construction of the north/south trunk road linking Dar es Salaam with the Southern Region is proposed in the Five-year Development Plan (1964/65-1968/69). A preliminary alignment survey indicated that this road would pass close to Dutumi (see Map 2).

For the time being however, access is gained by a road of only indifferent standard, normally maintained with funds provided by the local authority. The amount of money available is small and the alignment is such as to make maintenance difficult. There are frequent crossings of streams and rivers which rise in the Uluguru Mountains, and in places the road follows rather precipitous hill-sides. As a result, in times of very heavy rainfall washaways and damage to drifts and bridges occur, and almost every year communications are completely cut.

Not only does this road provide access to Bwakira Chini and Dutumi but also to centres of population and agricultural production at Mvuha, Magogoni and Kilengezi to the east, Bwakira Juu and Kolero in the foothills to the north, and Dakawa, Mngazi, Kisasi and Kilengwe to the west.

## **PRESENT LAND USE**

### **Pattern of land use**

The area from Kisasi to Kilengezi, north of the Mgeta, is devoted predominantly to smallholder agriculture. There is a ginnery at Dutumi which was established many years ago for the processing of cotton and kapok. In the minor settlements sited along the Kisasi - Kilengezi road, traders provide for the needs of the community. Some small scale forestry activity takes place west of Kisasi where millable timber is extracted from the forests and exported from the district.

The main agricultural activity is the production of crops. Although there are extensive areas of grazing, the numbers of livestock are small. One herd of cattle is maintained on an alienated estate near Kisasi, and close to it a few work-oxen have been introduced recently. Incidence of bovine trypanosomiasis necessitates regular prophylactic drug treatment. The absence

of sheep and goats is noteworthy and contrasts with the numbers found in the eastern Uluguru foothills where the farmers keep small livestock and tether them on their holdings.

The pattern of agriculture is governed by the conditions prevailing in the three environmental zones defined in this report. At the same time the extent to which the land is used is affected by the density of settlement. This is greatest in the west and thins out to the east. Consequently the area of cultivated land is greatest in the west. This effect is associated with corresponding gradations in soil fertility, availability of water supplies and increasing liability to damage and depredation by game animals.

Within the first of these zones, the Scarp Foot, the grass cover is scanty. Because the soils are poor, shallow and stony it is little used for agriculture except at its junction with the next zone, the Flood Plain, where there is a narrow band of deeper soil on gentler slopes. Fires occur extensively and with regularity throughout the forest and parkland of the Scarp Foot during the dry season. In those areas between Dutumi and Kilegezi where there is no settlement, herds of elephants feed on the steep slopes of the Scarp Foot.

The Flood Plain comprises the greater part of the area studied and is used extensively for crop production. In the west, where this zone is at its widest, settlement and cultivation have progressively expanded as far as the Bwakira River. A comparison of the 1952 and 1964 aerial photography shows that much of this expansion has taken place during the last twelve years. A belt of woodland and a small kapok estate between Bwakira Chini and Dutumi were a barrier in the past to further expansion eastwards. Today however, local resources are being employed on clearing some of this land preparatory to bringing it into production. Little land is now left which is not allocated, occupied or cultivated.

East of Dutumi the density of settlement decreases where the belt of easily worked soils becomes narrow. Although exploited to only a limited extent in the past, this belt, like the neighbouring land, is now being cleared or is reserved for future use.

The third Environmental Zone, the Valley Bottom, contains predominantly heavy clay soils which are mainly uncultivated. This zone lacks developed water supplies and harbours a wide range of game animals. Near the Mgeta River however, a narrow fringe of workable fine sands occur, which are devoted to crop production. It was also observed that small inroads into the neighbouring heavier soils were being made. Elsewhere in this zone, and towards the eastern limits of the study area, where game are particularly abundant, there is little human activity.

### **Local agricultural practices**

Generally in the Lower Mgeta River Area vegetative growth is profuse except on the shallowest of soils and little, if any, fertiliser has been used to increase crop production. In fact, in the limited range of trials conducted in the area, few significant responses to the use of fertilisers have been obtained. While the profusion of growth is an encouraging indicator of the productivity of the land, and of high yields under good management, it also presents problems of weed control during the growing season. To overcome the competition of weeds, especially in the cotton crop, much time is given each year to hand weeding. In the last two years however,

facilities for mechanical cultivation have been improved by the introduction of a few tractors, ploughs and harrows. Except for small areas of groundnuts the practice of ridging is not adopted as a cultivation technique.

The climate and elevation of the area are favourable to a wide range of crops. Selection from within this range has largely been determined by the nature of the soils, their permeability and susceptibility to inundation. Although the range of crops grown in the area as a whole is wide, it was observed that many of them play a minor or insignificant part in the cropping pattern.

Maize is the staple food crop and is produced mainly on the lighter soils near the mountain massif where the rainfall is higher. Nearer the Mgeta River, where, rainfall is rather less sorghum is grown both as a food crop and for the brewing of local beer. Peas, beans and cassava are also grown for food, while cowpeas fulfil the dual function of subsistence and cash crop. To a lesser extent groundnuts are also cultivated. Mangoes, bananas, a small quantity of citrus and tomatoes are offered for sale in the markets of the minor settlements and consumed locally.

The most important cash crop is cotton, of which about 1,500 bales are produced annually. Kapok is also harvested in large quantities although ruling prices are low and likely to remain so. As a result it is no longer a major cash crop, but is regarded as a reliable source of money to pay annual taxes. Small areas are devoted to the production of sesame, sunflower and castor. In the past, one alienated estate grew sugar cane for jaggery manufacture, of which up to 100 tons a year were sold in Morogoro. Cane was also used for the production of beer. A few cashew nuts are also produced on the lighter soils, but are not sold outside the area as there are no marketing facilities.

Within the last year planting of sisal has been started and a small plot of kenaf, *Hibiscus cannabinus*, was successfully grown in 1962/3 on an estate near Bwakira Chini.

On the heavier soils which are predominately clay, the area cultivated is smaller and the range of cropping more restricted. Rice is the main food and cash crop and is planted when the floods of the Mgeta River and its tributaries recede. A quick growing local variety of maize is also sometimes grown as a catch crop at the beginning and the end of the rains.

Usually crops are grown in pure stand, although occasional instances of the intercropping of short term maize with rice, or sesame with maize do occur.

The size of the holding on which most of the above mentioned crops are grown varies considerably, the average size being about 4.5 acres (1.8 hectares). Approximately 1 acre (0.4 hectares) each is devoted to maize, sorghum, cowpeas, and cotton and 0.5 acre (0.2 hectares) to rice. Variations in this pattern occur however, and some of the holders of larger acreages cultivate up to 3 or 4 acres (1.2 - 1.6 hectares) of cotton as well as subsistence and other cash crops. During peak periods of work such a farmer employs hired labour, in addition to the assistance provided by his wife and older children. The family unit represents a maximum potential labour force of four or five adult equivalents per day, though the average is probably no more than two or three.

## EXPERIMENTAL RESULTS

A series of agronomic trials were carried out by the Central Research Station, Ilonga, both at Ilonga and in the Lower Mgeta River Area at Kisaki and Dutumi. The experiments at Kisaki were conducted on an alluvial soil liable to seasonal waterlogging near the village, but were discontinued in 1958 because of game damage. An alternative site was selected in 1959 on an alluvial, clay loam soil near the Dutumi River. Work ceased here at the end of the 1963/4 season when the land was required for other purposes.

Trials were conducted on these sites to select suitable varieties and establish optimum times of planting for maize, sorghum, groundnuts, sesame and soya beans. Although yields obtained were frequently lower than those at Ilonga, this fact may be accounted for by the remoteness and inaccessibility of the sites from the parent Research Station which led to difficulties of supervision. This does not however detract from the value of the results in selecting a practicable combination of crops for planting in an area where optimum times of planting are a particularly important factor in achieving an even spread of labour utilisation.

Akehurst and Sreedharan (1964) have reported on the optimum times of planting for a range of crops throughout the country. Their report demonstrates a more or less consistent effect of planting time upon yield and at the same time provides a useful guide to potential yields.

The planting time to yield relationship shows either:•

- '(a) a peak at the first planting followed by reduced yields for later plantings, or
- (b) ascending yields for the first one or two plantings, reaching a peak, followed by decreasing yields for later plantings' (*op. cit.*).

It is apparent that, in the case of maize the optimum time of planting lies within the period from late January until the end of February. Under satisfactory conditions of management yields as high as 3,000 lb. per acre (3,367 kg. per hectare) can be obtained.

The optimum time to plant sorghum is less well defined because the number of experiments was fewer. Nevertheless the figures available and current practice in the area confirm that crops planted in early February can reach a yield as high as 1,500 lb. per acre (1,684 kg. per hectare).

If groundnuts are planted between mid January and early February yields of 1,000 to 1,400 lb. per acre (1,121 - 1,569 kg. per hectare) can be obtained. Soya beans can be planted throughout February, but yields at present are no more than half the figure for **g**roundnuts. On the other hand new strains and selections have recently been tried at Ilonga and yields varying from 1,700 to 2,100 lb. per acre (1,905 - 2,354 kg. per hectare) were obtained when the crop was planted in mid February 1964.

Yields of sesame have been only moderate in trials conducted since 1959, although it has been established that the most satisfactory time for planting this crop lies within the first two weeks of February. Furthermore, in 1964 it was confirmed that a factor inhibitory to growth and previously thought to be a virus, was in fact a mite, and trials in which preventative spraying was done gave yields as high as 1,000 lb. per acre (1,121 kg. per hectare).

Agronomic data for cotton are more abundant, and its management is well understood. Yields at Kisaki and Ilonga are given in Table 10.

TABLE 10 Yields of seed cotton in lb. per acre (kg. per hectare) at Ilonga and Kisaki

YEAR	1955	1956	1957	1958	1959	1960	1961	1962
ILONGA	1,880 (2,107)	1,550 (1,737)	1,600 (1,793)	1,880 (2,107)	2,100 (2,354)	1,200 (1,345)	1,910 (2,141)	2,270 (2,544)
KISAKI	-	1,122 (1,258)	1,113 (1,247)	1,302 (1,459)	1,170 (1,311)	1,935 (2,169)	-	-

On the basis of these figures an average of 1,200 lb. (1,345 kg. per hectare) of seed cotton per acre for individual growers need not now be considered excessive.

Note should also be taken of results from the first year of experiments at Ilonga designed to facilitate mechanical spraying of cotton. It has already been established that although losses occur due to tractor damage, the benefits derived from using heavier equipment outweigh the losses. Moreover results in 1964 demonstrated that by adopting a spacing of 2 ft. x 6 in. (61 cm. x 15 cm.), that is 34,560 plants per acre (85,363 per hectare) not only was the height of the cotton reduced, but the yield from the more closely spaced crop was 89% greater than that of the 3 ft. x 1 ft. (91 cm. x 30 cm.), that is 14,520 plants per acre (35,864 per hectare) spaced controls. If these results are maintained in future experiments they will have an important bearing on the farming system adopted for cotton growing at Bwakira Chini and Dutumi.

Of the other crops already grown in the project area, cowpea is also being examined at Ilonga. Observations have been made of a large number of varieties some of which are very promising. Yields of up to 1,900 lb. per acre (2,130 kg. per hectare) have been recorded from single plant selections of local material, when as many as five pickings were made at harvest.

The cultivation of kenaf, *Hibiscus cannabinus*, is well understood. Observations made at Ilonga by Turner and Hartzook (1965) and in the Kilombero Valley show that when grown on well drained fertile land where the rainfall of 760 mm. (30 in.) is spread over at least 4 months, fibre yields of 2,000 to 2,500 lb. per acre (2,242-2,802 kg. per hectare) can be obtained. The variety 985/986 ECR has mainly been grown but improved planting material will probably be available in the future. When planted in December or early January, the stems are ready to harvest at the end of April. The recommended seed rate is 30 lb. per acre (34 kg. per hectare) sown in 9 in. (23 cm.) rows, thinning of plants being carried out where the stand is dense.

Kenaf is a host to several cotton pests, notably stainers, *Dysdercus* spp. However, cotton is already grown in the Lower Mgeta River Area, where the Baobab, *Adansonia digitata*, and *Sterculia appendiculata* and Kapok grow, which are also hosts to stainers. Under these conditions, yields of 900 lb. per acre (1,009 kg. per hectare) or more are obtained when the crop is sprayed. The Senior Research Officer at Ilonga thinks that if normal spraying precautions are taken kenaf and cotton can both be grown in the same locality.

There is little information about the labour requirements for harvesting and processing kenaf, but records are to be kept at Ilonga during the current season.

Soil fertility trials have been conducted at Ilonga for several years using crops which are suited to the Lower Mgeta River Area. In 1964, for the first time since these experiments were started, significant yield responses were obtained when fertilisers were applied to maize, sorghum and cotton. The agronomist thinks this may be the first sign of declining soil fertility after 10-15 years of continuous cultivation.

A few fertiliser trials have been conducted at Bwakira Chini and Dutumi without obtaining significant crop responses. Doubts have been expressed at Ilonga whether economic returns could be obtained from fertiliser applications to these fertile soils.

The merits of intercropping at both Ilonga and Dutumi have been tested since 1957 using several combinations of crops including maize and groundnuts, sorghum and groundnuts, castor and groundnuts, castor and soya bean, and maize and sesame. The results when expressed in overall cash returns show the intercropping system to be more economic.

Some aspects of rotational cropping have also been studied over the last five years although the programme is incomplete. Cotton, maize, and sorghum were the crops used.

## PRODUCTION AND MARKETING

The yields of the various crops grown are related to the standards of management which frequently fail to make the best use of the natural resources. The average yields and returns obtained by the local farmers as estimated by the Tanzanian Ministry of Agriculture are shown in Table 11.

TABLE 11 Present Average crop yields and gross returns in the Lower Mgeta River Area

CROP	YIELD		GROSS RETURN	
	lb./acre	kg. per hectare	sh./acre	sh./hectare
SEED COTTON (SPRAYED)	900	1,008	475*	1,173
SEED COTTON (UNSPRAYED)	300-400	336-448	158*	390
SORGHUM	600	672	80	198
MAIZE	1,000	1,120	95	235
COWPEAS	600	672	156	385
PADDY	1,000	1,120	200	494

\* 90% Grade A at -/56 cents per lb. (1/23 cents per kg.)

10% Grade C at -/24 cents per lb. (-/53 cents per kg.)

Until recently the primary consideration in the agricultural development of the area was the provision of food for the cultivator and his family. An increasing emphasis is now being laid upon the production of crops for sale. Although there is surplus production of certain crops in the area, this

fluctuates from year to year. The estimated gross value of this surplus is £40,000 - £50,000 per annum. However, the records examined were incomplete, and it was not always possible to obtain crop production figures for the Lower Mgeta River Area, because they were incorporated in returns covering a much larger area. The total value may therefore be greater than the figure suggested. The figures set out in Table 12 are the current prices paid to farmers for a number of the crops grown in the area.

TABLE 12 Crop prices paid to farmers in 1965 in the Lower Mgeta River Area

CROP	LOCAL GRADE	PRICE sh./cents/kg.
BEANS	1	-/60
BEANS	2	-/50
CASHEW	-	-/60 to -/70
CASTOR	-	-/50
COTTON	A	1/23
COTTON	C	-/53
COWPEAS	-	-/35
GRAM	-	-/50
GROUNDNUTS	-	1/-
KAPOK	1	-/40
KAPOK	2	-/35
MAIZE	1	-/22
MAIZE	2	-/19
PADDY	-	-/45
RICE	1	-/90
RICE	2	-/75
SESAME	-	1/-
SORGHUM	-	-/30
SOYA	-	-/40
SUNFLOWER	-	-/40

In the past surplus subsistence crop production was bought by traders and either resold locally or exported from the district. Cash crop production was also handled in the same way except for cotton and kapok which were sold to the ginnery at Dutumi. More recently the Ukutu West Co-operative Society, which operates at Dutumi, Mngazi, Kisanga, Bwakira Chini and Milengwelengwe, has purchased the cotton from the grower and transported it to the ginnery. The Society is now undertaking the purchase and handling of a wider range of crops.

In addition, the Co-operative Society operates a depot at Dakawa, where wheeled tractors are hired out to local farmers. Some of the nearby estate owners also provide a similar service. The cost of this service is rather high because of the time taken between operations involving only small areas of land. The farmers pay sh. 50/- per acre (sh. 124/- per hectare) for ploughing and sh. 25/- per acre (sh. 62/- per hectare) for harrowing.

There is transport by lorry and bus between the district and Morogoro. According to the Divisional Executive Officer, the current rate for the

transport of goods by lorry was sh. 1/50 per ton/mile (sh. -/80 per metric ton/km.).

The trading cycle depends on the timely despatch of produce out of the area and delivery of goods into it. The present standards of communication are far below those necessary to ensure that the cycle is uninterrupted, and there are long periods in some years when the roads are unusable. As a consequence both despatches and deliveries are delayed and perishable goods deteriorate. This situation causes financial losses to the farmer, and creates a sense of futility for a farmer planning any expansion of his agricultural production. While this may be dispelled to some extent if he sells to a co-operative or trader, the ease with which he can do so, and the prices he is likely to receive for his produce will still be affected by the problems of communications.

## PART III - DESCRIPTION OF AREAS OF DETAILED STUDY

### SELECTION OF AREAS FOR DETAILED STUDY (see Map 4)

After extensive air photograph interpretation and a preliminary field reconnaissance, three areas within the Lower Mgeta River Area, were selected for detailed field study. The more important criteria used in the selection of land were:

- (a) that the land was not already under cultivation,
- (b) that the land was readily accessible,
- (c) that the topography, soils and drainage were such that agricultural development was feasible,
- (d) that the water supplies available were adequate for development.

Two of the three areas selected lie close to Bwakira Chini, Area I to the west and Area II to the east. Area III is situated to the east of Dutumi.

### AREA I

#### BOUNDARIES

Area I, marked B on Map 4, covers about 2,075 acres (840 hectares). It consists of the whole of the property known locally as Bwakira Estate, and parts of two other alienated areas to the west of the Bwakira Estate, between the Old Mngazi River and the Kisasi - Bwakira Chini road. During the field examination two further areas were inspected. The first, marked C on Map 4, was an 800 acre (324 hectare) site south of the Mgeta River, formerly leased to the owner of the Bwakira Estate, the late Dr. Seitz. It subsequently reverted to the State. The second, marked A on Map 4, was an area of about 230 acres (93 hectares) to the north of the Kisasi - Bwakira Chini road, close to the north-west corner of Bwakira Estate and bordering the Bwakira River.

At an early stage during the field examination a decision was made to limit Area I to Bwakira Estate, an area of 1,160 acres (469 hectares) by discarding all the other areas for the following reasons:-

- (a) The land to the north of the Kisasi - Bwakira Chini road, A on Map 4, is already extensively cultivated by the local population.
- (b) The alienated land to the west of Bwakira Estate, B on Map 4, is unavailable as it is farmed by an Asian lessee.
- (c) The land south of the Mgeta River, C on Map 4, is isolated by the Mgeta River. To bridge this river, whose width is more than 80 feet (24 m.) would be very costly. The land is frequently dissected by deep drainage channels and is mainly covered by broken

forest. The proportion of usable land is therefore small and clearing would be expensive. A further disadvantage is the high concentration of game within the area, because of its proximity to the Selous Game Reserve. Finally rainfall is likely to be less here than on Bwakira Estate, because it is further from the foothills.

## TOPOGRAPHY

Bwakira Estate is situated wholly upon the flood plain of the Mgeta River, and therefore within it there are no major topographic variations. The highest point on the estate, 488 feet (149 m.) above mean sea level, is in the north-east corner. From here the land slopes very gently to the south-west, falling only 55 feet (17 m.) in a distance of 2 miles (3.2 km). An unnamed stream, believed to be a former course of the Mngazi River, flows through the estate in a south-east direction. The flow of this stream is restricted by an earth dam constructed about a quarter of a mile (0.4 km.) upstream from the eastern boundary of the estate. This dam causes periodic flooding of the surrounding land, but the flooding usually persists for only two or three weeks in any one year.

## SOILS (see Map 7a and Appendix I)

All the soils of Bwakira Estate are alluvial. Over much of the area the soil profile consists of three main horizons, namely:

- (i) dark grey to greyish brown fine sandy clay loam,
- (ii) pale brown to yellowish brown coarse sand or coarse sandy loam,
- (iii) dark greyish brown coarse sandy clay or clay.

Despite the even nature of the topography, profile differences occur which are consistent with minor topographic variations. Fine materials are washed from the higher parts of the flood plain into the drainage channels. Thus on the higher ground the surface horizon of fine sandy clay loam has been almost entirely removed, whilst in the drainage channels this horizon has not only become much thicker, but has also become somewhat heavier in texture. Where the clay content is greater infiltration into the soil and percolation through the soil is slower, and the land is less tractable. After a period of drought the surface horizon of such soils becomes very hard but no cracking occurs. Table 13 summarizes these profile differences.

The soil of profile type 2A is confined to a few small ridges orientated in a north-south direction in the centre of the estate and to the land surrounding the estate buildings. Only profile types 2B and 2C occur extensively in all parts of the estate. Profile type 2D occurs as narrow bands along the main drainage channels.

The standards of interpretation of soil chemical data developed by the Institut de Recherches d'Agronomie (I.R.A.T.) in Madagascar have been used in this report. These standards were also used by the SOGREAH mission and their use here allows comparisons between this report and the SOGREAH report (1962) to be easily made.

TABLE 13 Distribution and major soil profile characteristics of the four main soil types occurring on Bwakira Estate

PROFILE TYPE	SITUATION	AREA Acres (Hectares)	HORIZON DEPTH IN mm. (in.)			% CLAY IN TOP HORIZON
			(i)	(ii)	(iii)	
2A	ridges	53 (21)	-	0-106 (0-42)	106-170+ (42-67+)	12
2B	upper parts of intermediate slopes	491 (199)	0-33 (0-13)	33-96 (13-38)	96-150+ (38-59+)	25
2C	lower parts of intermediate slopes	518 (209)	0-61 (0-26)	61-140+ (26-55+)	-	36
2D	drainage channels	53 (21)	0-180+ (0-71+)	-	-	39

The soil analyses show that:

- (a) In profile types 2A and 2B the pH increases with depth from 6.5 to 6.0 at the surface to 7.0 to 7.5 at a depth of 90 cm. (36 in.). In profile types 2C and 2D the pH is 6.5 to 7.0 throughout the profile.
- (b) Cation exchange capacity, total exchangeable bases, exchangeable calcium, magnesium and potassium are high in the heavier textured horizons but low in the coarse sandy horizons. Profile type 2A, which is predominantly sandy in the top 90 cm. (36 in.) therefore has a low content of these exchangeable bases.
- (c) Exchangeable sodium and conductivity are low. It is therefore unlikely that there will be a salinity problem in these soils.
- (d) Total nitrogen content is low.
- (e) Assimilable phosphate content is moderately high throughout all the profiles and high to very high in the top 30 cm. (12 in.) of profile types 2A, 2B and 2C. In profile type 2D, assimilable phosphate levels are high to very high, throughout the whole profile.

From the data available the suitability for agricultural use of the four soil types described above may be assessed as:

- (a) Profile type 2A - easily worked and with good drainage, but of only poor to medium fertility because of its low cation exchange capacity and base saturation. However, assimilable phosphate content is moderate to high.

- (b) Profile types 2B and 2C - easily worked and with good drainage. Fertile to very fertile because of their high cation exchange capacity, base saturation and assimilable phosphate content.
- (c) Profile type 2D - the heavy texture of the top 90 cm. (36 in.) makes this type less tractable and more prone to drainage problems. It is however, very fertile because of the very high cation exchange capacity, base saturation and assimilable phosphate content.

A fifth soil type, 2E, covers about 45 acres (18 hectares) on a river levee site along the banks of the Mgeta River and to a lesser extent along the Old Mngazi. This soil has been formed by the deposition of successive layers of silt and fine sand, and its surface is raised a few feet above the adjacent flood plain. This soil type differs from the other alluvial types: the coarse sand fraction is absent, the pH of 7.0 to 7.6 is higher throughout the profile, and there is a very high content of assimilable phosphate in all horizons. Whilst fertility is high and permeability good there is a danger of temporary flooding when the Mgeta overflows.

#### VEGETATION AND LAND USE (see Map 5b)

All but 320 acres (130 hectares) of the 1,160 acres (469 hectares) which comprise Bwakira Estate have been cultivated during the last 50 years, and most of it within the last 5 years, so that the natural vegetation has been destroyed. The vegetation and land use classes chosen by Dr. Langdale-Brown during the air photograph interpretation and shown on Map 5a were further subdivided as a result of the field work. The areas covered by the vegetation and land use subdivisions are shown in Table 14.

TABLE 14 Approximate area in acres (hectares) of vegetation and land use types on Bwakira Estate

VEGETATION AND LAND USE TYPE	AREA	
	acres	hectares
Kapok	200	81
Cashew	70	28
Coconut	5	2
Sugar Cane	70	28
Previously cultivated - now grass fallow	390	158
Previously cultivated - now scrub	105	61
Broken forest	320	130

As a guide to land clearance costing in connection with future development planning, detailed information of tree density and size is given for each vegetation and land use class.

## **Kapok**

The average density is about 40 trees per acre (99 per hectare) though in some parts where establishment has been poor, a stocking of only 15 trees per acre (37 per hectare) has been achieved. There are about 8,500 trees of which all but 200 are more or less uniform in size, having an average g.b.h. (girth breast height) of 3-4 feet (90-120 cm.) maximum 7 feet (210 cm.) and an average height of 34-40 feet (10-12 m.), maximum 50 feet (15 m.). There is a small stand of about 200 older and larger trees whose average girth b.h. is 6-7 feet (180-210 cm.) maximum 11 feet (340 cm.) and average height is 75-85 feet (23-26 m.) maximum 100 feet (30 m.).

## **Cashew**

There are about 70 acres (28 hectares) of recently planted cashew. Establishment and early growth have been poor and the form of the trees is bad. The 2,000 surviving trees have an average g.b.h. of 3-6 inches (8-15 cm.) maximum 8-10 inches (20-25 cm.) and an average height of 5-10 feet (1.5 - 3.0 m.) maximum 15 feet (4.5 m.).

## **Coconut**

There are about 5 acres (2 hectares) of recently planted coconut palms. Establishment has been very poor and a fire in September 1964 damaged the few surviving palms.

## **Sugar cane**

There are 70 acres (28 hectares) of sugar cane, through which a fire swept in September 1964. The quality is variable and flooding near the earth dam has affected growth in the surrounding fields.

## **Grass fallow**

The same fire temporarily destroyed the grass cover making the collection and identification of species difficult. As a result the record of grasses found is incomplete. However, the following were identified: *Panicum maximum*, *P. infestum*, *Hyparrhenia rufa*, *Eragrostis ciliaris*, *Leptochloa panicea*, *Urochloa tinchopus* and *Sorghum brevicarinatum*.

## **Scrub**

In a matrix of the above grasses young secondary regrowth of the species present in the adjacent broken forest occurs. The commonest are the trees *Combretum molle*, *Acacia polyacantha* subsp. *campylacantha*, *Acacia clavigera* subsp. *usambarensis*, *Dalbergia melanoxylon*, *Securinega virosa*, *Maerua edulis*, *Cardiogyne africana*, the scrambling shrub *Tylosema fassoglensis*, and the herb *Peristrophe bicalyculata*.

The average density of woody vegetation is about 200 trees and shrubs per acre (494 per hectare). The average g.b.h. is about 12-24 inches (30-61 cm.) maximum 48 inches (120 cm.) and the average height 15-25 feet (4.5 - 7.5 m.) maximum 40 feet (12.0 m.).

## Broken Forest

The species composition, density and size of trees present in the broken forest is variable. The tree species present include *Acacia clavigera* subsp. *usambarensis* and *Kigelia aethiopica* both of which are very common, the latter particularly along the banks of the Old Mngazi. *Acacia polyacantha* subsp. *campylacantha* and *Combretum molle* are common, whilst *Combretum constrictum*, *C. imberbe*, *Securinega virosa*, *Maerua edulis*, *Sterculia appendiculata* and *Vitex doniana* occur occasionally. *Panicum maximum* is the main grass species.

The average density is about 60 trees per acre (148 per hectare) but varies from below 40 to over 100 (99 to 241 per hectare) in some places. The average g.b.h. is about 3-4 feet (90-120 cm.) and the average height 60-70 feet (18-21 m.) but trees of up to 10 feet g.b.h. (305 cm.) and over 100 feet (30 m.) in height occur throughout the area.

## AREA II

### BOUNDARIES (see Map 4)

Area II, consisting of some 2,360 acres (954 hectares) and situated to the east of Bwakira Chini, is bounded on the north by the Uluguru foothills and on the west by an area of dense cultivation. To the south and east the area is bounded by land which is either under intensive cultivation or already allocated for future development. The only part of Area II which was discarded during the detailed field examination was the permanent swamp through which the Bwakira River passes before joining the Mgeta.

### TOPOGRAPHY (see Map 7B)

Area II is situated mainly on the flood plain of the Mgeta River, although it also includes a narrow strip of the lower slopes of the Uluguru foothills along its northern boundary. The elevation on this northern boundary is about 560 feet (171 m.) above mean sea level and falls to 430 feet (131 m.) at the Mgeta, about 2 miles (3 km.) away to the south. Within this distance the slope varies from 5 per cent on the foothills to less than 1 per cent on the flood plain.

Three seasonal streams, draining a total catchment of about 1,300 acres (526 hectares) in the Uluguru foothills, flow into Area II. One of these streams crosses the Bwakira Chini - Dutumi road about 3,300 feet (1,000 m.) from the western boundary of the area and another, the Greater Kikundi, lies about 3,300 feet (1,000 m.) further east. The third stream, the Lesser Kikundi, flows along the eastern boundary. All three cease to flow along recognisable channels south of the road where they discharge their water into low-lying areas. The first two streams feed into a depression in the centre of Area II, whilst the Lesser Kikundi discharges its water into a larger depression near the eastern boundary. Periodic flooding of these depressions also results from surface runoff and subsurface drainage from the surrounding higher ground and the Uluguru foothills. This subsurface drainage water forces its way through the heavy clay soils of the depressions forming in some places small water holes, and in others small mounds of earth by the periodic discharge of wet mud.

## SOILS (see Map 4 and 7b and Appendix)

The soils of Area II may be divided into three main types:

1. Colluvial soils, occupying about 700 acres (283 hectares)
2. Alluvial soils, occupying about 1,100 acres (445 hectares)
3. Heavy, cracking, seasonally wet clay/occupying about 350 acres (142 hectares).

### Colluvial Soils

The colluvial soils occurring at the base of the foothills in the northern half of Area II were formed from deposits of material transported from the upper slopes of the foothills. They have been divided on the basis of topographic position into three categories:

- 1A. The soils nearest the foothills, occupying about 170 acres (69 hectares)
- 1B. The soils on gentle slopes further from the foothills, occupying about 230 acres (93 hectares)
- 1C. The soils furthest from the foothills and bordering the alluvial soils of the Mgeta flood plain, occupying about 300 acres (121 hectares).

The main features of the profiles of these soils are shown in Table 15.

TABLE 15 Profile characteristics of colluvial soils in Area II

PROFILE TYPE	15 cm. (6 in.)			45 cm. (18 in.)		
	COLOUR	% COARSE SAND	% CLAY	COLOUR	% COARSE SAND	% CLAY
1A	dark grey	31	28	grey	58	17
1B	dark grey brown	25	38	reddish brown	20	47
1C	grey brown	20	38	yellowish brown	15	48

Table 15 shows that with increasing distance from the foothills the coarse sand content falls and the clay content rises. The soils nearest the foothills are usually coarser and contain large amounts of stones and gravel throughout the profile. Further away from the foothills the stone and gravel content decreases markedly, to the extent that in the colluvial soil of profile type 1C no stones or gravel occur in the upper 45 cm. (18 in.) of the profile and below this depth only occasional small stones are found. Along the boundary between these soils and the alluvial soils there is a certain amount of mixing of colluvium with alluvium within the profile.

Their chemical properties can be summarised as follows:

- (a) The soils are slightly acid, pH 6.0 to 6.5. The pH is slightly higher nearer the foothills.
- (b) The soils have high cation exchange capacities and base saturations. They are rich in exchangeable potassium and very rich in exchangeable calcium and magnesium.
- (c) The exchangeable sodium and conductivity are low.
- (d) The total nitrogen content is low.
- (e) The assimilable phosphate content is high, particularly nearer the foothills.

The colluvial soils may be regarded as fertile, because of their high content of available nutrients. However the greater stone and gravel content of the soils on the steeper slopes nearest the foothills makes them a slightly less attractive proposition for agricultural development than the alluvial soils. All the colluvial soils have good drainage.

### **Alluvial Soils**

The alluvial soils occur on the flood plain in the southern half of Area II. The soils have a strongly developed structure in their upper horizons and are self mulching. They have been divided into two profile types, 2F and 2G, on the basis of differing topographic positions and occupy about 580 and 520 acres (235 and 210 hectares) respectively. Profile type 2F, occurs on the higher ground within the flood plain and Profile type 2G occurs on the lower ground, except in the larger depressions, where the third major soil type, heavy, cracking, seasonally wet clay, has developed. In profile type 2F, brownish soil colours predominate, whilst profile type 2G usually has a greyish brown colour.

Chemically these alluvial soils are similar to those of Bwakira Estate. Their chemical properties can be summarised as follows:

- (a) The soils are neutral, pH 6.5 to 7.2.
- (b) They have a high cation exchange capacity and base saturation and are rich in exchangeable calcium, magnesium and potassium.
- (c) The exchangeable sodium and conductivity are low.
- (d) The total nitrogen content is very low.
- (e) The assimilable phosphate content is very high.

These alluvial soils may be regarded as very fertile because of their high content of available nutrients. They are easily worked because of their high sand content and their internal drainage is generally good.

### **Heavy, cracking, seasonally wet clay**

Heavy, cracking, seasonally wet clay occurs in the larger depressions within the flood plain and along the southern boundary of Area II. It is dark grey in colour, similar to a black cotton soil and with moisture change

prone to extensive swelling and shrinking. During the rains waterlogging occurs, and in the dry season large cracks appear in the soil surface. These cracks penetrate to a depth of about 30-40 cm. (12-16 in.). This soil type has severely impeded drainage and is difficult to work. Frequently it contains small nodules of calcium carbonate in its lower horizons.

The following observations are based upon the analytical data for three profiles in Area II:

- (a) The soils have a neutral pH, 6.6 to 7.2, in the top horizons but the pH rises to over 8.0 below 45 cm. (18 in.).
- (b) The soils have a high cation exchange capacity and base saturation. Calcium and magnesium contents are high but the potassium content is often only moderate.
- (c) The exchangeable sodium content and conductivity below 18 inches depth indicate only slight salinity. SOGREA's analyses (1962) showed however a greater salinity, but they were of samples collected near to the centre of the flood plain.
- (d) The total nitrogen is low.
- (e) The assimilable phosphate is generally high.

In spite of possible salinity problems, it is the physical character of this soil type which is likely to be the greater obstacle to its use for agriculture, rather than its chemical character.

#### **VEGETATION AND LAND USE (see Map 5b and 5c)**

Area II, unlike the Bwakira Estate, is largely uncultivated. There are only a few farms amounting to about 70 acres (28 hectares) in all. However, bush clearance of nearly 150 acres (61 hectares) close to the Bwakira Chini - Dutumi road was being carried out during the period of detailed field study. This was being undertaken by the local farmers on the instruction of the Regional Commissioner, for the planting of cotton.

Most of Area II is covered by broken forest, though smaller areas of forest, parkland and scrub also occur. Forest covers the western end of the area close to Bwakira Chini and parkland much of the depression near to the eastern boundary, while scrub is confined almost exclusively to the land close to the southern boundary.

#### **Broken Forest**

Throughout the broken forest, which occupies about 1,500 acres (607 hectares), the species composition, density and size of the broken forest varies. The species present include *Acacia polyacantha* subsp. *campylacantha* (very common) *Acacia goetzei* subsp. *microphylla* (locally abundant) *Acacia sieberiana* subsp. *sieberiana*, *Sterculia appendiculata*, *Azelia quanzensis*, *Dalbergia melanoxylon*, *Stereospermum kunthianum*, *Vitex doniana*, *Kigelia aethiopica*, *Sclerocarya caffra*, *Annona chrysophylla*, *Harrisonia abyssinica*, *Albizia glaberrima*, *Cordia ovalis*, *Combretum molle* and *Maerua edulis* (all occasional). *Panicum maximum* is the dominant grass species with *Hyparrhenia rufa* locally abundant.

The average density of trees is about 40 per acre (99 per hectare) but varies from 25 to nearly 100 (62 to 247 per hectare) in some places. Apart from the few isolated *Sterculia appendiculata* which attain a g.b.h. of over 10 feet (305 cm.) and height of more than 100 feet, (30 m.), most of the trees are smaller than those found in the broken forest of Bwakira Estate. Average g.b.h. is about 2-3 feet (60-90 cm.) and average height about 40-50 feet (12-15 m.).

### Forest

Forest occupies about 20 acres (85 hectares). *Sterculia appendiculata*, with occasional *Acacia sieberiana* subsp. *sieberiana* along the edges of this community are the dominant species forming the upper canopy. Well below this upper canopy there is a second story of *Kigelia aethiopica*, *Azelia quanzensis*, *Antiaris usambarensis*, *Chlorophora excelsa*, *Conopharyngia* sp. and *Chrysophyllum* sp. Although the forest contains a few merchantable species they form only a very minor part of the forest flora, and the trees are usually small and of poor form.

The trees of the upper storey are well over 100 feet high (30 m.) and have a g.b.h. exceeding 12 feet (366 cm.). The lower storey trees have a height of about 50-60 feet (15-18 m.) and a g.b.h. of about 2-3 feet (60-90 cm.). The forest is very dense and contains, on average, more than 80 trees per acre (198 per hectare).

### Parkland

This community, which occupies about 200 acres (81 hectares) is largely composed of isolated trees of *Acacia polyacantha* subsp. *campylacantha*, *Acacia goetzei* subsp. *microphylla*, *Acacia nigrescens*, and *Salvadora persica* set in a matrix of *Heteropogon contortus* grassland. The woody herb *Sesbania bispinosa* is locally abundant.

The trees are usually smaller than those in the forest and broken forest and attain only about 2 feet (60 cm.) in g.b.h. and about 40 feet (12 m.) in height. Their density is less at about 30 trees per acre (74 per hectare).

### Scrub

Scrub occupies about 300 acres (121 hectares). The species occurring within this community are diverse and include most of the trees found in the communities already described, with the exception of *Sterculia appendiculata*. The trees are smaller, usually less than 2 feet (60 cm.) in g.b.h. and 40 feet (12 m.) in height, with a density of about 25-30 per acre (62-74 per hectare).

### Grassland

Grassland covers about 150 acres (61 hectares). *Heteropogon contortus* is the main grass species and scrubby growth of *Acacia nigrescens* and *Salvadora persica* occurs only very occasionally.

## AREA III

### BOUNDARIES (see Map 4)

Area III consists of about 6,400 acres (2,590 hectares) situated north-east of Dutumi and includes an alienated estate close to Dutumi. It is bounded on the north-west by the Uluguru foothills, and on the south-east by a tract of seasonally waterlogged clay. At the south-west end, dense cultivation by the local people around Dutumi, marks the boundary. The north-east boundary was chosen after taking into account the distance from Dutumi and from a reliable water supply.

At an early stage in the detailed survey, land to the east of a small stream draining into the Gombo swamp (see Map 6) was discarded, because it comprises only the steep stony slopes of the Uluguru foothills and the heavy clay soils of the flood plain. This reduced the area to about 3,400 acres (1,376 hectares).

### TOPOGRAPHY (see Map 7c)

North of the Dutumi-Kilengezi road the slope of the land is about 3 per cent and rises to more than 5 per cent nearer the Uluguru foothills. South of the road there is a shelf of gently sloping land about 1,320 to 2,640 feet (402 to 805 m.) wide which falls away sharply on its southern edge to the more or less flat flood plain. The altitude varies from just over 500 feet (152 m.) above mean sea level at the base of the foothills to about 480 feet (116 m.) on the flood plain.

There are only two seasonal streams crossing Area III, one about 1,640 feet (805 m.) west of the north-east boundary and the other along the north-east boundary. They have no recognisable channels south of the road, and their water is discharged into the Gombo Swamp and other nearby low-lying areas.

### SOILS (see Maps 4 and 7c and Appendix I)

There are two main soil types:

- (a) The colluvial soils occupying about 1,900 acres (769 hectares)
- (b) The heavy, cracking, seasonally wet clay occupying about 1,500 acres (607 hectares).

There are no alluvial soils in Area III. The major soil boundaries of this Area are shown on Map 4, while the detailed boundaries shown on Map 7c relate only to the land suitable for immediate development.

### Colluvial Soils

The colluvial soils occur on the foothills and on the broad shelf of gently sloping land immediately below them. They have been divided on the basis of topographic position into four sub-types, namely:

- 1D The soils on the fringe of the foothills, occupying about 30 acres (12 hectares)

- 1E The soils on the upper intermediate slopes, occupying about 170 acres (69 hectares)
- 1F The soils on the lower intermediate slopes, occupying about 700 acres (283 hectares)
- 1G The soils on the fringe of the flood plain, occupying about 1,000 acres (405 hectares)

These soils, unlike the colluvial soils of Area II, are predominantly reddish brown and contain a greater quantity of stones and gravel. Profile type 1D occurs on the steepest slopes, that is those over 5 per cent, profile types 1E and 1F on slopes of 3 and 2 per cent respectively and profile type 1G on slopes of up to 3 per cent at the edge of the flood plain. All four profile types have many small angular quartz stones below 45 cm. (18 in.) but only types 1D and 1E have more than a few in the top 30 cm. (12 in.).

The chemical analyses show that:

- (a) The soils farthest from the foothills are slightly acid, pH 6.3 to 6.6, and neutral, pH 6.9 - 7.1, nearer the base of the foothills.
- (b) The soils have a moderate cation exchange capacity and base saturation, and are moderately rich in exchangeable calcium, magnesium and potassium.
- (c) The level of exchangeable sodium and conductivity are low.
- (d) The total nitrogen is low.
- (e) The assimilable phosphate is generally high.

These soils are less rich in exchangeable bases, calcium and potassium than the colluvial soils of Area II, but have a much greater assimilable phosphate content, especially below a depth of 30 cm. (12 in.). Whilst being entirely adequate for agricultural development, they are likely to be less productive than the colluvial soils of Area II, because of their higher stone and gravel content and lower exchangeable base content.

### **Heavy, cracking, seasonally wet clay**

The heavy, cracking, seasonally wet clay, which occurs extensively throughout the flood plain, has similar profile characteristics to that occurring in Area II and suffers from the same disabilities.

### **VEGETATION AND LAND USE (see Map 5c)**

A kapok plantation occupies about 700 acres (283 hectares) in the south-west corner of Area III. Outside this, the majority of the area carries a parkland type of vegetation, with smaller areas of forest on the edge of the foothills and broken forest and scrub scattered throughout the lower slopes and the flood plain. The area occupied by farms is very small, less than 10 acres (4 hectares), though during the period of the detailed field study local farmers, acting upon instructions from the Regional Commissioner, were clearing a further 100 acres (40 hectares) for cotton planting.

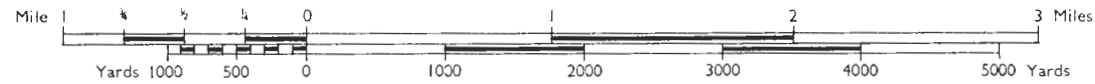
# BWAKIRA CHINI AND DUTUMI

## AREAS OF DETAILED STUDY AND MAJOR SOIL BOUNDARIES



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SCALE 1: 50,000



**REFERENCE**

- Road
- River
- Bridge
- Swamp
- Boundary of Uluguru Foothills
- Study Areas I, II, III
- Discarded Areas A, B, C

**MAJOR SOIL UNITS**

- Colluvial
- Alluvial
- Heavy cracking seasonally wet clays

Printed for D.O.S. by S.P.C., R.E.  
 Topography reproduced from part D.O.S. Sheets 1:50,000 Tanganyika 201/3  
 and 201/4 with soil boundary information from 1:14,000 and 1:10,000  
 aerial photography by Tanzania Air Survey Division in 1962 and 1964.  
 Ground data obtained by the Land Resources Division of D.O.S. 1964.  
 600,3/65/1017/SPC

## **Kapok**

Apart from a narrow strip of rather younger kapok at the western end of the plantation the majority of the trees are mature and of more or less uniform size. The average g.b.h. of the latter is 2-3 feet (30-60 cm.) maximum 5 feet (152 cm.) and the average height 20-30 feet (6-9 m.) maximum 50 feet (15 m.). The average density is about 30 trees per acre (74 per hectare) though in some parts stocking is as low as 10 and as high as 50 trees per acre (25 to 124 per hectare).

## **Parkland**

Parkland occupies about 2,100 acres (850 hectares) and is variable both in species and the size and density of stocking. The main tree species present are *Acacia polyacantha* subsp. *campylacantha*, *Acacia goetzei* subsp. *microphylla*, *Dalbergia melanoxylon*, *Stereospermum kunthianum*, *Savadora persica*, *Sclerocarya caffra*, *Tamarindus indica*, *Hoslundia opposita*, *Thylachium africanum* and *Grewia holstii*. These trees occur as isolated specimens in a grassland composed of *Panicum maximum* and *Hyparrhenia rufa* on the higher land and *Heteropogon contortus* on lower lying areas.

The size of trees varies greatly, but average g.b.h. is about 2 feet (61 cm.) maximum 4 feet (122 cm.) and average height 30 feet (9 m.) maximum 60 feet (18 m.). Average density is about 25 trees per acre (62 per hectare) but varies from about 10 to 50 trees per acre (25 to 124 per hectare).

## **Forest**

There is only a very limited area of forest, about 30 acres (12 hectares) along the edge of the foothills, where most of the species found in the forest of Area II occur, except that *Sterculia appendiculata* is not so common.

## **Broken forest**

Small patches of broken forest, amounting to about 500 acres (202 hectares) occur throughout Area III. These contain most of species found within the parkland community, but tree cover is denser, trees are usually larger and the grass cover less abundant. Average g.b.h. is about 6-7 feet (183-213 cm.) maximum 10-11 feet (305-335 cm.) and average height about 50-60 feet (15-18 m.) maximum 80-90 feet (24-27 m.). The average density is 60 trees per acre (148 per hectare).

## **Scrub**

This occupies small areas of lower lying land totalling about 80 acres (32 hectares) in which *Heteropogon contortus* is the main grass species. Most of the trees occurring in the parkland community are present, but their size is generally smaller. G.b.h. is about 1-2 feet (30-60 cm.) and height about 20 feet (6 m.) and the density of trees is usually less than 20 per acre (49 per hectare).

## PART IV - DEVELOPMENT

### GENERAL PATTERN OF DEVELOPMENT

#### AGRICULTURAL POTENTIAL

In parts II and III of this Report those resources upon which agricultural development depend have been described. There is sufficient evidence to show that the environment is generally favourable and that prospects for agricultural expansion are good. There seem to be considerable possibilities for establishing an intensive system of farming, based on current agricultural techniques. At present price levels, crop yields from experimental plots indicate that a higher income per family can be achieved.

One of the objectives of the Tanzanian Five-year Development Plan (1964/5 - 1968/9) is a much greater production of cash crops. This can be done relatively quickly within a pattern of rain-fed farming. It need not however exclude further future expansion by the introduction of irrigation farming, utilising the flood waters of the Mgeta River, or water from dams constructed in the Uluguru foothills, as envisaged by Chablani (1961) and SOGREAH (1962). These reports however, correctly stipulate that more information is required before the proposals set out in them can be implemented.

The provision of catchment protection, improved access and adequate water supplies should be studied before implementing any agricultural development in the Lower Mgeta River Area.

#### CATCHMENT PROTECTION

Within the foothills of the Ulugurus lie the catchments of several rivers and streams which flow into and through the parts of the Lower Mgeta River Area which have been studied in detail. It is essential to ensure that the amount of runoff is reduced to a minimum. Their protection therefore is important. The whole of each catchment must be protected although parts of them lie outside the boundaries laid down in the terms of reference of this Report.

At present fierce fires started in the foothills late in the dry season by destroying the vegetation cover, are the indirect cause of gully and sheet erosion. This burning must therefore be controlled and, at the same time, the cutting of trees must be prohibited. The responsibility for management of these catchments can best be assumed by the authority developing the land affected by them.

Any agricultural expansion will progressively reduce the availability of building poles and fuel on the flood plain. As a result the local people will be forced to seek supplies from the only other source close at hand in the foothills. In order to prevent the protective vegetation in the foothill catchments being further damaged, it is recommended that small plantations should be established to provide a source of fuel and poles.

#### COMMUNICATIONS

The need for an adequate all weather road to the Lower Mgeta River Area is very great. It is required at an early date to enable the development and

subsequent operation of the settlement scheme to proceed smoothly. Without this provision there is little likelihood of effective increases in agricultural production being obtained.

Proposals have been incorporated in the Five-year Development Plan for the construction of a North/South Trunk Road which will link the Southern Region with the rest of the country (see Map 2). The proposed alignment passes through the Lower Mgeta River Area. If this alignment proves feasible, the early construction of its northern section would bring considerable benefits in terms of agricultural expansion, and improved access for tourists to areas with abundant game and fine scenery. If construction is delayed however, improvement of the present road will be necessary.

## **WATER SUPPLIES**

Agricultural expansion and the implementation of government settlement policy in the Lower Mgeta River Area will result in an increase in the farming population. In this event an improved water supply will be essential.

A reconnaissance of the water resources was made in October 1964 by an engineer of the Ministry of Lands, Settlement and Water Development. His conclusion (Watts, 1964) was that the area was well watered. In the light of the authors' suggestions regarding future water demand and points at which it would be required, he prepared a tentative plan, which provided for water to be pumped from the Mgeta River to two points near Bwakira Chini. The preliminary estimated cost was about £18,000. A cheaper system could possibly be developed by tapping subsurface supplies in the Bwakira River. A third possibility involved the provision of limited supplies from the Mgeta River, augmented by water from wells closer to hand.

The plan also provided for the extraction of water from the Dutumi River at the rock bar about 1 mile (1.6 km.) upstream of Dutumi, and its distribution by gravity to the neighbourhood. No estimate of cost however, could be prepared until more observations have been made.

The water distribution as proposed in this tentative plan is shown on Map 6. An early and more detailed examination of all the possibilities is recommended in order to establish which is the most economical.

## **SELECTION OF DEVELOPMENT AREA**

It was hoped that an area sufficiently large for development as a single unit might be found. It was evident however, at an early stage of the project, that this would not be possible, mainly because extensive but scattered areas of land were already occupied and cultivated. To have incorporated them in any scheme for development would have required a major operation in boundary adjustment and land reapportionment. Nevertheless the increased economic and social benefits to be derived from carrying out this larger operation at a later date should not be overlooked.

Instead, three areas have been selected, which total about 4,500 acres (1,821 hectares) and which are close enough to each other to enable certain common services such as water, communications and welfare to be provided. One of these areas lies to the east and one to the west of Bwakira Chini, about 2 miles (3 km.) apart by road. The third is situated east of Dutumi, a further 3 miles (5 km.) away. Their boundaries are shown on Map 6 and their areas are approximately 1,160 acres, 1,700 acres and 1,550 acres (469, 688 and 627 hectares) respectively.

Area I west of Bwakira Chini was once an alienated estate and is partially developed. It is bordered by the Kisasi-Dutumi road to the north and by the Mgeta River to the south. Its western limits are bounded in part by another alienated estate and in part by a former course of the Mngazi River. In the east it adjoins smallholder cultivation along the Bwakira River.

Area II, east of Bwakira Chini contains little previous development. Its northern boundary is the Uluguru foothills, and its southern boundary the junction of the alluvial soils with the heavy, seasonally wet clay. In the west the area reaches as far as the line of smallholder cultivation flanking the left bank of the Bwakira River, and in the east it is limited by more cultivation and by a seasonal swamp.

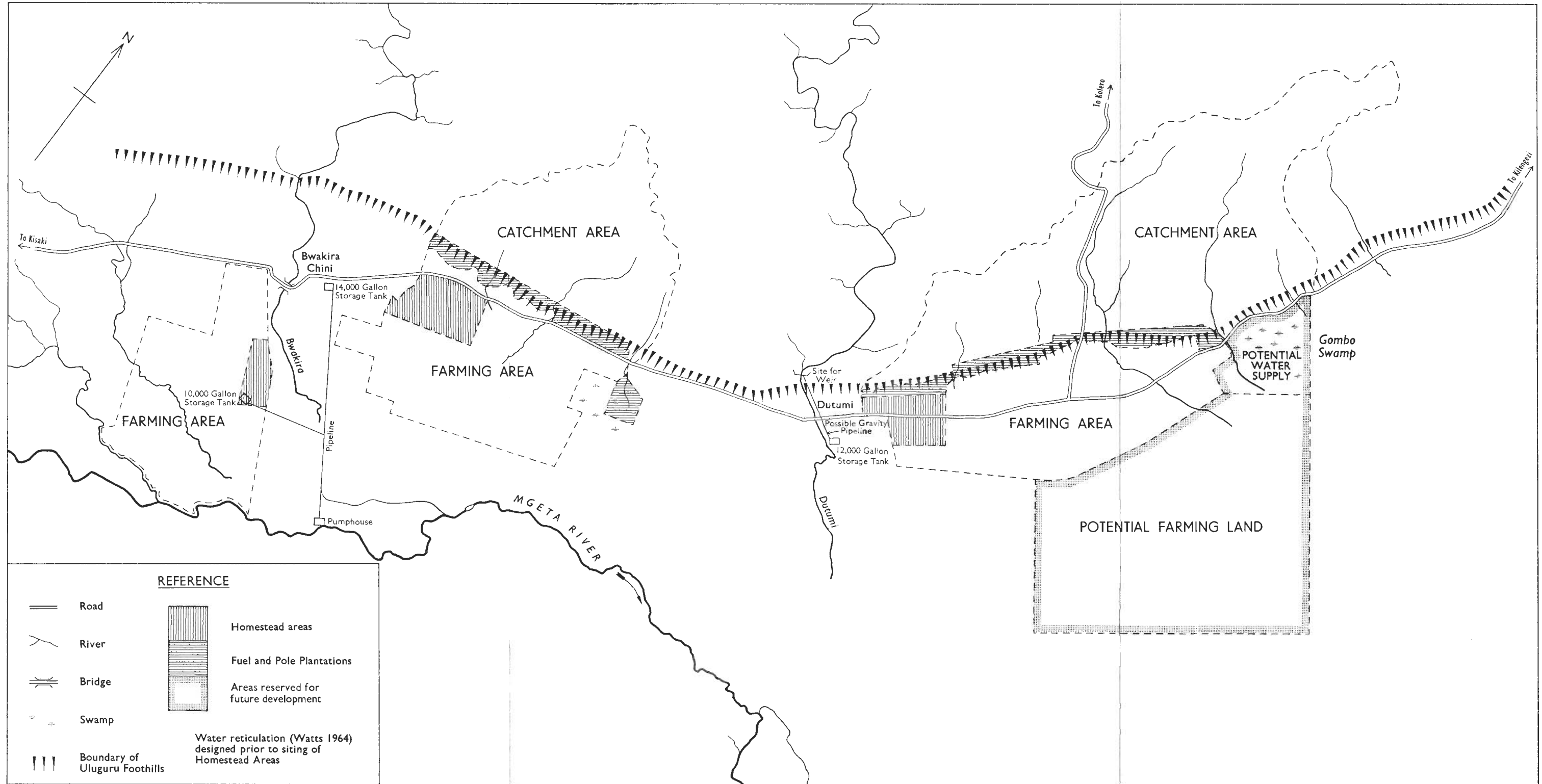
Area III contains some previous development, centred mainly around a kapok estate at its western end. Its north-western boundary is the foothills and its south-eastern boundary the junction of colluvial soils with the heavy, seasonally wet clay. To the south-west the area reaches as far as the line of smallholder cultivation along the left bank of the Dutumi River and to the north-east as far as the unnamed seasonal stream flowing into the Gombo swamp.

Attention is drawn to the fact that a considerable proportion of the land in Area III which is suited to dry land farming is at present planted to kapok and under the control of private enterprise. Unless arrangements can be made for the inclusion of this land in the third area the possibilities of formalised settlement there are very limited. For this reason the plans for the development of Area III are timed for execution at a later date than those for Areas I and II.

## SCHEME DESIGN

One system of farming can be introduced into all three selected areas, because of the uniformity of the environment. This can be done by several methods, ranging from the treatment of each area as a single large scale farming unit, to the immediate establishment of a large number of individual consolidated farms in each area. The method of operating each selected area as one large scale unit, mechanised to a high degree, lends itself in particular, to the development of plantation crops. This system is not being recommended because it is incompatible with the organised settlement of individual farmers as now practised, and because the areas involved are too small to warrant the establishment of the necessary processing plants. On the other hand, to create a large number of individual consolidated farms immediately, increases the amount of close supervision demanded of the managing authority, as well as requiring some experience on the part of the farmer himself in participating in large scale planned operations. In these circumstances, bearing in mind the many other administrative problems involved in establishing settlements, and the need for settlers to adapt themselves to a novel way of life, the application of the second method may be somewhat premature.

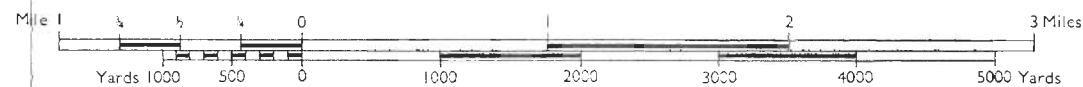
It is suggested therefore, that at the outset each selected area should be divided into blocks. Each block can then be allocated to the growing of a crop or a group of crops. Each settler will be allocated land in each block to which he will have permanent rights, subject to his conformity with any necessary requirements laid down by the managing authority. The use of this method permits the preservation of the farmer's individuality, simplicity in organising mechanical operations, and the regulation of livestock and grazing programmes should these be introduced.



REFERENCE

- Road
- River
- Bridge
- Swamp
- Boundary of Uluguru Foothills
- Homestead areas
- Fuel and Pole Plantations
- Areas reserved for future development
- Water reticulation (Watts 1964) designed prior to siting of Homestead Areas

SCALE 1:50,000



In the future it may be felt that the system of individual consolidated farms is preferable to the block system of farming. Provision has therefore been made in the design of each scheme for the blocks to be further sub-divided into individual consolidated farms, each corresponding in size to the total amounts of land previously held by the farmer in each block. Where any farmer has shown that in the block system he is capable of farming more land than his neighbours he may be allocated more than one holding. This method is perhaps more sophisticated than any other and makes the timing and execution of large scale mechanical work more difficult; it has however, the merit of giving scope to the more efficient and ambitious farmer to make many improvements on his own farm, which would otherwise have to wait upon his less capable neighbours in the block method of operation.

## **TECHNICAL SUPPORT**

Continuing agricultural expansion depends in part on being able to exploit the new opportunities and techniques resulting from experiments, possibly those carried out by the Research Station at Ilonga. It must however be remembered that this Station is situated many miles from the Lower Mgeta River Area and that during the development of the latter area some problems specific to the area will probably arise. This will be so particularly if village settlement with its relatively sophisticated characteristics is introduced, and if in the future the extensive tracts of heavy clay found on the flood plain east of Dutumi are incorporated in the scheme.

It is therefore suggested that a small unit of land, within the scheme area, should be set aside for a closely supervised programme of simple investigation. This should include improvement in techniques, the testing of new crops and the introduction of livestock. It is not envisaged that it should replace the work of the Central Research Station; it should rather be an extension of it, serving not only the areas selected in this report but others in the vicinity.

The experimental unit, under the daily supervision of a junior worker, should as far as possible be sited on the main soil types in the neighbourhood. Within it, an area similar in acreage to that selected for the holdings should be set aside and farmed in the same way, and with the same resources available to other farmers. Information obtained at the experimental level can then be field tested and assessed, before it is applied on a wider scale. The educational value of such a holding would be great. The location of a suitable site is shown on Map 8b, which offers a central position with easy accessibility.

## **SCHEME MANAGEMENT**

The proximity of the three selected areas to each other will allow their management as a single unit with centralised services.

Overall control of the scheme should be exercised by one man, whose duties should include the planning and allocation of common services and the supervision of three subordinate managers, each responsible for the day to day operations in one of the selected areas. Considerable importance must be attached to the provision of managerial staff of high calibre because success in projects of this nature depends much upon the quality of management.

Of equal importance to the scheme will be careful selection of settlers for their farming ability and physical fitness.

## DETAILED AGRICULTURAL DEVELOPMENT PROPOSALS

### SELECTION OF CROPS

The available agronomic data and the current local land management practices have been carefully considered in choosing suitable crops for inclusion in the system of cropping. The main criteria used to make this choice were

- (a) the yield capacity of the crop under local conditions,
- (b) its suitability for some degree of mechanisation,
- (c) the ability of the farmer and his workers to cultivate the crop satisfactorily,
- (d) the likelihood of there being a steady demand and stable prices for the crop.

Consideration has also been given to the advantages gained by choosing crops which may be processed or partly processed before leaving the area, but not involving a large investment in plant and buildings.

It is prudent to devote some part of the cropping programme to the production of family food requirements, for several years to come. Later possibly, as management standards improve, the pattern may change and farmers may specialise in cash crop production and purchase their food elsewhere. Meanwhile maize, groundnuts, soya beans, cowpeas and sorghum should be included in the food crop programme. It must also be accepted that periodically the rainfall may fall far short of the requirement and, to safeguard against those years of severe shortage, it is recommended that a small area of cassava should also be grown. In order to achieve a mixed and well balanced diet space should be found for both fruit and vegetables.

The range of cash crops suitable to the environment is extensive but, for the foreseeable future, cotton will be the most important of them. Groundnuts, soya beans, cowpeas and gram can also be grown and perhaps sesame, provided that yields of this crop can be substantially raised. Groundnuts, soya beans and cowpeas should be selected for inclusion in the cash crop programme because they are proven crops for the area. There is also evidence of a continuing demand at satisfactory prices for the higher grades of these crops.

Gram could be grown as an alternative to cowpeas, but has not been selected because it is less widely grown in the area and has a more limited market. Sesame has not been selected because present yields are too low, and the market is unreliable due to the ease with which sesame oil can be replaced by alternative oils.

Reference has been made to the successful growing of kenaf near Bwakira Chini and the possibilities of introducing this crop have been examined. Its advantages lie in the high yields now attainable, the earliness of planting date in relation to other crops, the length of its growing period, and its low labour requirement until harvest. The fibre is in demand in East Africa at favourable prices, and the market may be more firmly established by the construction in Tanzania of a bag factory during the Five-year Development Plan

period. A high labour input is required at harvest time and for processing, but the former may be overcome by mechanical cutting and the latter by centralised retting, for which a charge would be made to the grower per unit of fibre produced. Local trials should therefore be conducted with kenaf. If they are successful and show that economic production, harvesting and processing are possible then it should be regarded as an alternative cash crop to be established within the next few years.

The cultivation of kapok should be abandoned because of its limited demand and depressed price. Cashew, which at present occupies only a small area, cannot be regarded as suitable on account of lack of cash return until the trees mature, compared with the higher returns immediately obtained from other crops already widely grown in the area.

Although sugar cane has been growing with moderate success on small areas for several years near Bwakira Chini, the lack of available space for expansion into a large scale production unit prevents it from being considered as a suitable cash crop for the areas selected.

### **CROPPING SYSTEM**

The following factors have been considered in the preparation of a cropping system: land capability, labour, mechanisation, the farmers' skill and capability and income targets.

In making assessments of production for the future it has been assumed as a precautionary measure that, while crop yields will be above current levels they will not achieve those obtained in experiments.

Having considered all these factors a total of 12 acres (4.8 hectares) can probably be successfully farmed by a settler who is prepared to work hard. Of this total, 1 acre (0.4 hectare) is set aside for maize production which, averaging 1,600 lb. per acre, (1,793 kg. per hectare) should provide a large part of the subsistence requirement and leave a small surplus. On this same acreage, by inter-cropping with soya beans, a protein subsistence crop will be obtained amounting to 560 lb. (254 kg.) with a substantial margin for sale. There is a steady demand throughout the area for sorghum as a subsistence crop and half an acre (0.2 hectare) estimated to produce 500 lb. (227 kg.) is set aside for it. Remaining food requirements such as cassava, fruit and vegetables will find a place in the one acre (0.4 hectare) homestead area.

Cotton will be the most important cash crop and 4 acres (1.6 hectares) yielding 4,000 lb. (1,814 kg.) are allotted to it in the system. Groundnuts, occupying a further 1.5 acres (0.6 hectare) and producing 1,200 lb. (544 kg.) will be a second cash crop. Here again soya beans may be selected as an alternative. 1 acre (0.4 hectare) providing 800 lb. (363 kg.) will be devoted to cowpeas.

It will be noted that some flexibility has been introduced into the cropping pattern. This has been done to allow for price changes and climatic variation, but flexibility must not be taken to the point of interfering with large scale mechanical operations.

4 acres (1.6 hectares) remain of the total of 12 (4.8). It is proposed that these, in all one third of the total, should be set aside for a fallow season, in which the heavy weed growth and bush regeneration can be controlled. It is not however contemplated that this should be a permanent feature of the system, unless current fertility experiments prove its value in this respect. Within three or four years its replacement by further cash crops or planted grass can be considered.

The cropping system in tabulated form with anticipated yields and returns is set out in Table 16.

Table 16 Anticipated yields and returns from the rotation

CROP	AREA		YIELD		YIELD FROM HOLDING		NOVEMBER 1964 PRICE		GROSS VALUE OF CROPS PER HOLDING shillings	VALUE OF CROPS CONSUMED BY FARMERS shillings	INCOME FROM CROP SALES shillings
	acres	hectares	lb./acres	kg./hectare	lb.	kg.	cents per lb.	cents per kg.			
MAIZE	1.0	0.4	1,600	1,794	1,600	726	18	40	240	140	100
SOYA BEANS*	1.0	0.4	650	729	650	295	18	40	117	-	117
SORGHUM	0.5	0.2	1,000	1,121	500	227	13	29	65	65	-
GROUNDNUTS	1.5	0.6	800	897	1,200	544	45	99	540	-	540
COTTON	4.0	1.6	1,000	1,121	4,000	1,814	(AR) 56 (BR) 24	1/23 53	2,092	-	2,092
COWPEAS	1.0	0.4	800	897	800	363	15	33	120	56	64
TOTAL	8.0	3.2	-	-	-	-	-	-	3,174	261	2,913

\* intercropped with Maize

Experiments, which are being conducted at present, to examine the effects of rotational cropping are incomplete. Conclusive evidence will not therefore be available until these experiments have been completed. Meanwhile the profuse growth of weeds must be recognised as a major adverse factor affecting yields especially of the major cash crops. On these grounds it is proposed that the rotation should be as follows:

Maize, sorghum and legumes,  
Fallow,  
Cotton.

## CROP MANAGEMENT

Considerable attention should be paid to the improvement of techniques in crop management. Many of these techniques have already been developed and proved by experimentation and are awaiting employment in the field.

One of the most important factors is the timing of farming operations, not only the preliminary cultivation, but planting, spraying and weeding as well.

The use of good planting material is very important, and care will be required to ensure that poor quality material is discarded as rapidly as possible and replaced by improved strains and types.

The heavy weed growth in the area has already been noted, and the planting of crops in rows, thus allowing its control by cultivation between rows must not be overlooked. However these operations are expensive and alternative measures therefore merit examination, especially those employing the most recent herbicides. One, or perhaps two, applications of these may well replace the hand labour required for crop cleaning.

The value of insecticides in increasing cotton yields is well known around Bwakira Chini and Dutumi. Large scale mechanical application, without the losses due to crop damage by heavy machinery, using techniques evolved in experiments at Ilonga, is now possible.

Improvement in crop management should include crop storage after harvest. There are advantages to be derived from the preparation of crops for market

by a centralised service. This is particularly true of grains and pulses which can be offered for sale in large lots of uniform quality.

## LABOUR AND MACHINERY

The choice of crops and the acreage allotted to each farmer have been made so as to avoid large scale demands for seasonal labour. It has been assumed that in each month there will be an average of 50 man days available for use. At peak periods of demand however, it is also assumed that part time help from younger members of the family will be available.

It is recognised that during the period from December to May considerable assistance will also be needed for primary cultivation, weeding and spraying. The use of tractor drawn equipment is envisaged for these purposes as a supplement to, and not a replacement for the efforts of the farmer and his family. This is desirable in order to retain the farmer's responsibility for his own success. The machinery programme is designed to cater for all initial ploughing, after which the farmer will prepare the land for planting and will plant his crops. To meet the periods of peak demand for tractor work effectively, and to undertake the many smaller tasks which arise, the use of medium-size wheeled tractors will be more suitable than heavy crawler units. The former, however, would be unsuitable for the bush clearance operations.

It is proposed that two weedings of maize and one weeding of cowpeas should be done by hand. Groundnuts will be weeded once by hand and once by tractor. In the case of cotton it is assumed seven weedings will be undertaken in all. This falls short of the optimum number of weedings according to experimental results, but it seems unlikely that this would be achieved in practice. The first weeding will be done by hand before the weeds are strongly established. The second will be done by tractor and the third, which will include the thinning of the cotton plants will again be done by hand. The remaining four weedings will be done alternately by tractor and by hand.

The importance of insecticidal spraying of cotton is established, and of the eight sprayings involved it is proposed that three should be done by hand.

The programme showing the allocation of labour for each month of the year for the cultivation of 8 acres (3.2 hectares) of crops appears in Appendix II. It shows how operations expressed in terms of man days will be replaced by tractor work.

The programme shows a deficit of 35 man days, mainly in August and September when cotton is being picked and sorted. Part of this deficit can be met by extending the sorting season into November and December when there is a surplus of labour. The number of days allocated to these operations has been set intentionally at a high level, and a margin exists therefore, not only to meet the demand but also to cover possible increases in yield to about 1,250 lb. of seed cotton per acre (1,401 kg. per hectare). Furthermore, no account has been taken of the availability of schoolchildren on holiday for three weeks in July and four weeks in December.

## COSTS AND RETURNS TO THE FARMER

Table 16 shows that gross return from the 8 acres cropped should be sh. 3,174/-. based on conservative estimates of yield and price. This figure is equivalent to sh. 264/50 per acre (sh. 653/60 per hectare) for the 12 acre (4.8 hectares) holding or sh. 396/75 per acre (sh. 980/37 per hectare) for the cropped area. From the gross return of sh. 3,174/- a number

of deductions need to be made to arrive at the farmer's nett income. The first of these is the approximate value of food crops consumed by him and his family, assessed at sh. 261/-. No account has been taken of additional foodstuffs grown on the 1 acre (0.4 hectare) garden provided for each farmer in the homestead area.

Allowance must also be made for the costs of ploughing and other mechanical operations. The charges currently made at Dakawa for hiring co-operatively run machinery are sh. 50/- and sh. 25/- per acre (sh. 124/- and sh. 62/- per hectare) for ploughing and harrowing. At Lower Moshi where development programmes for irrigation farming have been analysed (Sir W. Halcrow & Partners, 1962) the cost of ploughing is assumed to be sh. 40/- per acre (sh. 99/- per hectare). On the Mwea-Tebere Settlement Scheme in Kenya however, a total of 11,500 acres (4,654 hectares) rotavated with medium-size tractors over a four year period has a total all in cost of sh. 26/64 per acre. (sh. 65/82 per hectare).

A comparison of costs, provided independently by two agencies importing medium-size tractors, indicate that running costs and depreciation work out at about sh. 16 per hour for similar models of tractor. It is not unreasonable to assume that where tractors are operated according to a work schedule within a planned and supervised scheme, hire charges can be significantly reduced. After allowance has been made for such items as supervision, dead time, workshop facilities and contingencies it has been assumed that a reasonable target for hire charges would be sh. 30 per acre (sh. 74 per hectare) for ploughing, sh. 10 per acre (sh. 25 per hectare) for weeding and sh. 6 per acre (sh. 15 per hectare) for spraying (excluding the cost of insecticide). The total costs for hire charges to the farmer are shown in Table 17.

TABLE 17 Cost of hire of tractors, cultivation and spraying equipment to the farmer

OPERATION	CROP	FREQUENCY per year	AREA		COST shillings
			acres	hectares	
PLOUGHING	All	1	8	3.2	240
WEEDING	Cotton Groundnuts	3	4	1.6	135
		1	1.5	0.6	
SPRAYING	Cotton	5	4	1.6	120
TOTAL HIRE CHARGES					495

No allowance has been made for the costs of controlling weed growth on the 4 acres (1.6 hectares) fallow land. The economic possibility of doing so by one or two herbicidal sprayings rather than by the more time consuming operations of ploughing and harrowing needs to be examined.

The cost of insecticide used in the control of cotton pests will amount to approximately sh. 240 for the 4 acres (1.6 hectares).

The balance remaining to the farmer after the deduction of these various amounts will be sh. 2,178/- based on the following figures:-

	Shillings	Shillings
Gross return from 12 acre (4.8 hectare) holding		3,174/-
Less subsistence	261/-	
hire charges	495/-	
insecticide	240/-	
	<hr/>	
	996/-	<hr/>
Net income from 12 acres (4.8 hectares) holding		2,178/-
Net income per acre (per hectare) for 12 acres (4.8 hectares) holding		181/50 (448/30)
Net income per acre (per hectare) for 8 acres (3.2 hectares) cropped		272/75 (673/70)

## SCHEME LAYOUTS

Tentative designs for a layout for each Development Area are provided diagrammatically in Maps 8a, 8b, and 8c. Each offers the alternative of farming the land in blocks, or in individual holdings. Six blocks are demarcated in each case. Within each, every farmer can be allocated land for cash and food crops, with two blocks set aside for fallow, two blocks for cotton and two for all other crops.

An area has been set aside in each layout to allow for homestead development, based on an acreage margin, in excess of the numbers of farmers participating in each scheme. In selecting these homestead areas note has been taken of their situation in relation to the scheme areas, existing development and proposed development. No provision has been made for land on which community service buildings may be established for the benefit of all schemes. Sufficient land for these buildings could be found within the present settlements of Bwakira Chini and Dutumi.

The very gentle slopes which predominate in Area I remove the need for measures to prevent runoff or erosion. However a belt of 50 feet (15 m.) wide along the river and stream banks has been excluded from cultivation. The greater danger will be from water tending to stand on the land in a few small and isolated places.

Small units of land which will not conveniently fit into the layout design, remain in Area I after its breakdown into 84 holdings each of about 12 acres (4.8 hectares). These could be used for growing fodder grass for future livestock needs, or for small fruit tree plantations. This would best be done by the managing authority with provision, in the longer term, for the plantations to be acquired or operated by individual farmers under a suitable form of agreement with the managing authority.

Internal roads have been designed to provide access to blocks and as far as possible to individual holdings. In constructing these roads, which need be no more than 12-15 feet (3.7 - 4.6 m.) wide, bridges will have to be provided at appropriate points along the Old Mngazi water course.

At present the outlet of the former course of the Mngazi is blocked by an earth wall which must be removed, and the outlet channel opened up to enable seasonal flow to be discharged into the Mgeta River.

To lessen the danger to maturing crops from fire, it is recommended that a simple graded road should be maintained round the perimeter.

In Area II the gradients at the base of the foothills warrant the establishment of soil conservation measures. The runoff from the catchment must be diverted through cut off drains, as shown on Map 8b, into natural drainage ways. At the same time the land farmed on these gradients will require a narrow base terracing system. Bearing in mind the control on the use of this land by the scheme manager, and the diversity of the cropping, the possibility of modifying the vertical interval and direction of terraces should be examined. It is likely that with the system of land management which will be employed the number of terraces required will be small.

The natural drainage ways in Area II lose their definition below the Kisaki-Dutumi road. It will therefore be necessary to extend them beyond the limits of the scheme by constructing shallow ditches as shown on Map 8b. While the land below the Kisaki-Dutumi road should be protected by a series of cut off drains, no internal terrace system will be needed as the land is nearly flat. These drains should run close to the road and carry water from it, discharging into the constructed drainage ways.

The present boundaries on the western side of Area II are governed by existing cultivation. Allowance has been made for a small extension of the scheme to the west. This would add a further 7 holdings, amounting to about 85 acres (34 hectares) to the present number of 103, which total about 1,250 acres (506 hectares).

Access to all blocks is indicated on Map 8b and ultimately, to all individual holdings, if such a stage is reached. The need to protect the whole area from the hazards of fire is again emphasised and a simple perimeter road should be constructed for this purpose.

The provision of a suitable layout in Area III is rather more complex on account of its length and narrowness. In order to keep the cost of water development to the lowest figure it would be best if the homestead area was sited at the western end of the area. A consequence of this approach however, would be the excessive distances to be travelled by those farmers working land at the eastern end. An alternative is to locate the homestead area beside the road to Kolero on a site which is more central. This however, will require further expenditure to pipe water from the Dutumi River. The advantages and disadvantages of each site must be weighed against each other, and therefore both have been indicated on Map 8c.

The gradients occurring on the foothills are similar to those of Area II and protection of the land by cut off drains is necessary. A possible scheme is outlined on Map 8c. Between these cut off drains and the road, additional terracing will be necessary but in Area III, as for Area II, the system of land management should be borne in mind, and examination made of the possibility of modifying the requirements for conservation, and thereby reducing the number of terraces.

Below the Kisaki to Kilengezi road the gradients are less and terracing should not be required. Provision however for water discharged from the cut off drains north of the road will be necessary and a layout for drainage ways is shown on Map 8c. It is assumed that the greater part of the discharge will be beside the Kolero road and allowance has been made to take this water through the area and away to the south-east. Use is made of a natural gully at the eastern end to carry discharge water. This gully is diverted at its

southern end to facilitate the distribution of land into blocks of more or less similar acreage.

There is sufficient land in Area III including the kapok estate, to provide for 97 farmers. If subdivision into individual holdings is ultimately acceptable, as shown on Map 8c, a few of these farmers would operate on holdings slightly in excess of 12 acres (4.8 hectares) each.

Area III will be well served basically by the two major roads. Additional roads however are indicated on Map 8c which would provide access both to blocks, and in due course to holdings if necessary. Once again reference must be made to the need for a perimeter road to reduce fire hazard.

Although no trigonometrical control points are shown on Maps 8a, 8b and 8c, their inclusion would be little or no help to those charged with laying out the schemes, because only two such points fall within the development area. It is anticipated that the schemes will be laid out with reference to such features as the points at which streams cross the Kisaki to Kilengezi road, and the boundaries of alienated estates which have been previously surveyed and mapped locally.

## LIVESTOCK

At present there is a risk of tsetse fly infestation in the whole of the area from Kisaki to Dutumi. This risk is greater in the east than the west. In the opinion of the Chief Tsetse Control Officer, control would be neither difficult nor uneconomic. Any scheme of development, therefore, would be incomplete if the potentiality of livestock keeping and the sale of livestock products were ignored.

The population is not experienced in livestock management and it would be unwise to introduce major livestock programmes for the individual farmer at an early date. Meanwhile an examination is required of the part to be played by both large and small livestock in the economic development of Bwakira Chini and Dutumi. More especially local experience should be gained of their management.

The dominant grass of the area, *Panicum maximum*, is a valuable fodder grass, but its productivity within the area is unassessed, as is the productivity of *Chloris gayana*, a small area of which, probably established by chance, was observed growing successfully near Dutumi. The presence of both these grasses suggests that good pastures could be established on which a local livestock industry could be based, but more information about their performance must be obtained.

The isolation of the area suggests that initially the policy for cattle should be based upon the rearing or fattening of steers in preference to the introduction of dairy cattle. The Livestock Breeding Centre at Mpwapwa has developed an improved Indo-African Zebu type, females of which could form the basis of beef herds if crossed with a beef Boran bull. If a substantial demand for milk products develops locally at a later stage, Dairy Sahiwal or Dairy Borans could be introduced as an alternative. The improved type of female from Mpwapwa costs about £20 at present and bulls can be made available at £8 - £10 each. Although these prices may rise in the future they should still be within reach of the smallholder farmer.

The introduction of cattle to the scheme might well start with the establishment of a small beef herd managed, initially, by the central authority.

Later, ownership and responsibility for management might be transferred to the individual farmer.

The most suitable means for housing cattle requires investigation.

There is no reason to suppose that the introduction of livestock would necessarily demand a fundamental re-organisation of the farming system, provided that the crops included produced residues suitable for cattle fodder, for example maize stover and legume haulm, and that within the system there is a resting period from crops. If cattle are introduced to the scheme this would increase the farmers' labour needs, which should not be overlooked.

The pastoralist in Tanzania places greater emphasis on the quantity of stock owned than on their quality. This need not be the case, however, in a community for whom cattle keeping would be an innovation. Education during the implementation of a cattle policy should help to avoid this tendency. The close supervision of cattle numbers to prevent disease outbreak would also help.

When cattle have been established as part of the scheme, the question of including sheep should be considered. This would depend on a suitable breed of sheep being found, and the financial returns that would be obtained. The Black Head Persian Breed has been suggested by the Veterinary Department for consideration.

Although the introduction of cattle may have to be delayed, there is good reason to encourage the early introduction of improved types of poultry. The backyard fowl is a common enough feature in the vicinity but lacks size, quality and productive capacity. An excellent opportunity exists to increase production by introducing better stock and more intensive management. This would not only help to improve the diet of the people, but if production was large enough, it would stimulate trade in poultry and eggs, thereby increasing family incomes.

## ANCILLARY SERVICES

Those direct services which will be needed for the development of the areas selected have been described. The two most important are the supervisory and machinery services. The following ancillary services might also be included in the functions of the management authority.

Firstly it is assumed that insecticides for use in the field will be purchased in bulk for application through a centralised machine spraying service or for resale to farmers where hand operations are contemplated.

Secondly crop processing and grading of groundnuts, and cowpeas could be a centralised service. There are considerable financial advantages to be gained for many crops if they are marketed according to a uniform and consistent quality, and this principle should apply to all marketable crops. The cost of providing this service to the farmer must be measured against the higher price per unit of produce sold, and the saving in time to the farmer at a busy period of the year when cash may be required quickly. This principle of centralised service may be extended to that of storage and marketing of cash crops by the managing authority. Here again the advantages of crop disposal in bulk lots out of pest free stores must be examined, in comparison with small lots despatched over a long period from farmers' stores in which little attention may have been paid to pest control.

In regard to the processing of food crops the alternatives of larger central maize mills or smaller mills operated by groups of a few farmers warrant consideration. Here again it is the cost of this service to the farmer that must be related to the better use he would make of his labour which would result from the service.

## **FUTURE AGRICULTURAL DEVELOPMENT**

This report has been concerned so far with the possibilities for development in the shorter term. The potential of the Lower Mgeta River Area is such, however, that agricultural expansion in the longer term should also be considered from the broad view. For instance, there are extensive tracts of low lying heavy black clay in the vicinity of Dutumi. These tracts show little variation in topography and are seasonally inundated. Nutrient status is for the most part high, although a deficiency in potash and slight salinity has been noted in a few soil samples (SOGREAH, 1962).

While these areas have been excluded from a programme for immediate development, it is envisaged that they could in due time be used by employing a different cropping system, possibly to include rice and cotton, based upon the control of the flood waters of the Mgeta River and its tributaries.

Before these proposals can be entertained, however, an investigation in detail of the soils, drainage and hydrology of the area should be made. For this reason a line is shown on Map 6 tentatively demarcating an area to be reserved until such an investigation is completed. If the findings are favourable this area can be used for first stage expansion, while very much larger areas of a similar nature can be incorporated progressively thereafter.

During the course of field studies the existence of a perennial water supply in the Gombo Swamp was noted. While its capacity requires measurement, it would probably be of considerable value to future expansion. Reservation of this potential water supply is therefore recommended, and the area is shown on Map 6.

## **DETAILED FORESTRY DEVELOPMENT PROPOSALS**

### **FUEL AND POLE PLANTATIONS**

The need for establishing small fuel and pole plantations has already been emphasised. These plantations should be organised on a communal basis under the control of the manager of the development scheme rather than as a series of individual woodlots. In this way planned development of the plantations on a sustained yield basis can be achieved and the dangers of sheet erosion resulting from indiscriminate felling can be mitigated.

### **SPECIES**

Trials under similar environmental conditions at Mombo have shown that *Eucalyptus C.*, a variety from Zanzibar similar to *E. camaldulensis*, offers good prospects for growth. At Mombo a yield of 970 cu. feet per acre per annum (68 cu. m. per hectare per annum) has been achieved. However, the trial plots were small and the edge effect considerable so that a figure of about 600 cu. feet per acre per annum (42 cu. m. per hectare per annum) is probably more realistic under normal plantation conditions. *Eucalyptus C.* coppices well and can be

grown on a coppice rotation. Within 6 years a height of 50 to 60 feet (15 to 18 m.) and a diameter of 6 to 8 inches (15 to 20 cm.) can be attained. A coppice rotation of 6 years should therefore be adopted.

## PLANTATION AREAS (see Maps 6, 8b and 8c)

From data available on the fuel and pole needs of the rural population in Tanzania (de Backer, Arnold and Pringle, 1962) and an estimated yield of 600 cu. feet per acre per annum (42 cu. m. per hectare per annum) 70, 85 and 85 acres (28, 34 and 34 hectares) are required for plantations in Development Areas I, II and III respectively.

In selecting the sites for the plantations the different requirements of forestry and agricultural crops have been considered. As a result, no plantations are proposed for Development Area I, because the alluvial soils, which occupy the whole of this area, represent the most valuable agricultural land available in the Lower Mgeta River Area. In Development Area II, on the other hand, sufficient land that, by virtue of its steeper slopes and lower fertility, is more suited to forestry than agricultural development, is available to support not only the fuel and pole requirements of the people in this area, but also of those of Development Area I. Similarly in Development Area III the steeper and the less fertile soils have been selected for plantation sites. Wherever possible small plantations have been sited on the upland side of the cut-off drains along the base of the Uluguru foothills with the object of protecting these drains from silting up. Provision has been made for 190 acres (77 hectares) in Development Area II and 170 acres (69 hectares) in Development Area III to be devoted to plantations. Though the total acreage allotted to plantations is considerably in excess of that required for the production of fuel and poles for the scheme participants, it should be remembered that the plantations have a protective as well as productive role to fulfil. Excess production might be disposed of to the local population who are not at present provided for by this scheme.

## ESTABLISHMENT

Plantation establishment can be achieved most readily by planting out seedlings from pots at an espacement of 8 feet by 8 feet (2.4 m. by 2.4 m.). Each year one sixth of the total plantation area, about 60 acres (24 hectares), should be planted, until in the seventh year coppicing allows the removal of fuel and poles without the necessity for replanting. In all about 42,000 plantable seedlings are required per year.

It is recommended that the current silvicultural techniques used by the Forestry Division of the Ministry of Agriculture in Tanzania be adopted. It is pertinent, however, to refer to one or two features of specific importance to the scheme areas.

During the first six years a nursery of about 1 acre (0.4 hectare) in size will be required, which could be sited most satisfactorily in the experimental farm in Area II (see Map 8b).

The seed of *Eucalyptus C.* which is available locally through the Forestry Division of the Ministry of Agriculture, should be sown in late July or early August to produce plantable stock in late December or early January. The seed can be sown either in seedboxes, the seedlings being subsequently transplanted into pots, or directly into the pots. The latter method is to be preferred where only inexperienced labour is available. Where direct sowing

into pots is used, there should be a high proportion of coarse sand in the potting mixture filling the top inch of the pot. Shade over the first 4-5 weeks will be required, and use could be made of the bamboo growing on the Bwakira Estate for this purpose. The local Forest Officer should be consulted on the use of insecticides for protection of the young seedlings against termite attack.

During the first six months after planting out in the field one or two clean weedings will be necessary. After the first year, however, the trees should have developed a closed canopy, thereby obviating the need for further clean weeding during the second wet season.

## LABOUR REQUIREMENT

In calculating the labour requirement it has been assumed that a simple system of spray lines will be used for watering in the nursery. If hand watering is used 9 men would be required each day for this task alone.

In estimating the labour required for the preparation of the planting holes it has been assumed that no mechanical help is available. However, the possibility of using a tractor driven post-hole borer should not be overlooked. From Table 18 it can be seen that where hand digging is used an extra 135 man days would be required within the period September to December.

TABLE 18 Labour requirement in Man days for implementing the establishment of fuel and pole plantations

OPERATION	J	F	M	A	M	J	J	A	S	O	N	D
<b>NURSERY</b>												
Collection of 20 cu. yards (15 cu. m.) of soil for potting compound			30									
Mixing potting compound						45						
Filling pots						135	45					
Sowing seed							30	30				
Watering	25						30	45	45	45	45	30
Culling									135			
Applying Insecticide	15										15	30
<b>PLANTING OUT</b>												
Pegging							75	105		30	30	60
Digging planting holes	35								135	105	90	
Planting	105											60
Clean weeding		180	150	180	180							
<b>TOTAL</b>	180	180	180	180	180	180	180	180	315	180	180	180

## PHASING OF DEVELOPMENT PROGRAMME

The speed with which the development programme can be achieved will depend to a large extent upon the pace at which the land can be cleared of bush. It will further depend upon whether Area III is to be included in the scheme by the purchase of the kapok estate near Dutumi.

The nature of the clearing varies from dense forest with as many as 80 large trees per acre (198 per hectare) to scrub or parkland with no more than 25 or 30 trees per acre (62 or 74 hectare). The speed of clearing these types of vegetation will be determined by the numbers and types of heavy tractor to be used. Discussions held in Dar es Salaam with such authorities as the Tanganyika Agricultural Corporation did not establish at the time whether the clearing programme could be undertaken using the heavy units at their command or whether additional similar or other units might become available. It has therefore been assumed somewhat arbitrarily, that a target of up to 1,000 acres (405 hectares) should be cleared for planting annually during a normal season of about 7 months. Regard, however, must be paid to the possibility of delays on account of long spells of bad weather when work output may be reduced.

The programme has been designed to clear the selected areas by blocks in accordance with those suggested for the layout and illustrated in Maps 8a, 8b and 8c. In some cases parts of blocks are to be cleared in one year, with the remainder being cleared in the following year, so that this work may go hand in hand with the intake of farmers and with the work that they can be expected to do initially. Table 19 sets out the annual programme of bush clearance.

TABLE 19 Area in acres (hectares) of land to be cleared by blocks in each selected area

AREA	1965			1966			1967			1968		
	BLOCK	acres	hectares	BLOCK	acres	hectares	BLOCK	acres	hectares	BLOCK	acres	hectares
I	B	20	8	E	100	41	F	180	73	-	-	-
	C	20	8	A	170	69						
	Home- stead	30	12									
II	C	120	49	C	100	41	B	110	44	A	200	81
	E	205	83	B	110	44	F	200	81			
	Home- stead	150	61	D	190	77						
III	-	-	-	E	100	41	C	100	41	B	190	77
				F	180	73	E	100	41	A	200	81
				Home- stead	65	26	D	190	77	C	100	41
							Home- stead	45	18			
-	-	545	221	-	1,015	412	-	925	375	-	690	280

It is proposed that the 83 farmers to be accommodated in Area I should be brought in during the season 1965/6. At the same time 50 of the 103 farmers for whom land is available in Area II will commence work. The remaining 53 will join the project in 1966, together with 50 of the 97 potential

participants in Area III. In 1967 the balance of 47 will be brought into that Area. The phasing of the intake of farmers will help to reduce the magnitude of the operations involved in the early stages of development.

The cropping programme has similarly been designed to expand with the increasing numbers of farmers. It is proposed that in the first year of each intake, sufficient land should be prepared to provide every farmer with his subsistence needs, 2 acres (0.8 hectare) of the target of 4 acres (1.6 hectares) of cotton and the remainder of his cash crops. It is intended that by doing this a proportion of the farmers' labour in the first year will be available for other tasks than those concerned with his cropping programme. In the second year the farmer will have become more fully aware of his responsibilities in working his land and in participating in the scheme in other ways.

Table 20 sets out, in a condensed form, how each block in each area becomes progressively incorporated in the cropping programme until the system is fully operative by 1970. It will be noted that some liberties have been taken with the basic rotation in the early years of operation in that in a few instances, land is scheduled for resting, after only a year or two of cropping. Whether this proposal is adhered to, or whether some latitude is introduced, by which larger acreages are cropped must depend upon the capabilities of the farmers and the numbers of tractors available to carry out the additional field operations.

TABLE 20 Cropping of each block in each Development in the growing season 1965/66 to 1969/70

BLOCK	AREA I				
	1965/6	1966/7	1967/8	1968/9	1969/70
A	Bush	Bush	Cereal/Legume	Fallow	Cotton
B	Cereal/Legume	Cotton	Fallow	Cotton	Cereal/Legume
C	Cotton (½ block)	Cereal/Legume	Cotton	Cereal/Legume	Fallow
D	Cereal/Legume	Cotton	Fallow	Cotton	Cereal/Legume
E	Bush	Cereal/Legume	Cotton	Cereal/Legume	Fallow
F	Bush	Bush	Cereal/Legume	Fallow	Cotton
BLOCK	AREA II				
	1965/6	1966/7	1967/8	1968/9	1969/70
A	Bush	Bush	Bush	Cotton	Cereal/Legume
B	Bush	Cotton (½ block)	Cereal/Legume	Fallow	Cotton
C	Cotton (½ block)	Cereal/Legume	Cotton	Cereal/Legume	Fallow
D	Bush	Cereal/Legume	Cotton	Cereal/Legume	Fallow
E	Cereal/Legume	Cotton	Fallow	Cotton	Cereal/Legume
F	Bush	Bush	Cereal/Legume	Fallow	Cotton
BLOCK	AREA III				
	1965/6	1966/7	1967/8	1968/9	1969/70
A	Bush	Bush	Bush	Cereal/Legume	Fallow
B	Bush	Bush	Bush	Cotton	Cereal/Legume
C	Bush	Bush	Cotton (½ block)	Cereal/Legume	Fallow
D	Bush	Bush	Cereal/Legume	Cotton	Cereal/Legume
E	Bush	Cotton (½ block)	Cereal/Legume	Fallow	Cotton
F	Bush	Cereal/Legume	Cotton	Fallow	Cotton

During the period of field study note was taken of local farmers' opinion regarding planting of crops on land previously carrying kapok. It appears that yields of such crops may well be depressed in such circumstances owing to a water deficit of the soil, unless ample opportunity is provided for 4-5 months of rain to penetrate. Attention is therefore drawn to the fact that those areas at present planted with kapok should be cleared during the early months of each season's clearing programme to provide for this need.

The approximate annual acreage of each crop in each area, until the system is fully operative, is set out in Table 21.

The establishment of the fuel and pole plantations in Areas I and II should commence in 1966/7 and be completed by 1971/2.

TABLE 21 Annual area in acres (hectares) of each crop in each Development Area

YEAR	1965/6								1966/7							
	I		II		III		TOTAL		I		II		III		TOTAL	
	acres	hectares	acres	hectares	acres	hectares	acres	hectares	acres	hectares	acres	hectares	acres	hectares	acres	hectares
Maize*	83	34	50	20	0	0	133	54	83	34	103	42	50	20	236	96
Soya*																
Sorghum	42	17	25	10	0	0	67	27	42	17	52	21	25	10	119	48
Groundnuts	125	51	75	30	0	0	200	81	125	51	155	62	75	30	355	143
Cotton	166	67	100	41	0	0	266	108	332	134	306	124	100	41	738	299
Cowpeas	83	34	50	20	0	0	133	54	83	34	103	42	50	20	236	96
TOTAL	499	203	300	121	0	0	799	324	665	270	719	291	300	121	1,684	682
YEAR	1967/8								1968/9							
	I		II		III		TOTAL		I		II		III		TOTAL	
	acres	hectares	acres	hectares	acres	hectares	acres	hectares	acres	hectares	acres	hectares	acres	hectares	acres	hectares
Maize*	83	34	103	42	97	39	283	115	83	34	103	42	97	39	283	115
Soya*																
Sorghum	42	17	52	21	49	20	143	58	42	17	52	21	49	20	143	58
Groundnuts	125	51	155	62	146	59	426	172	125	51	155	62	146	59	426	172
Cotton	332	134	412	167	294	119	1,038	420	332	134	412	167	388	157	1,132	458
Cowpeas	83	34	103	42	97	39	283	115	83	34	103	42	97	39	283	115
TOTAL	665	270	825	334	683	276	2,173	880	665	270	825	334	777	314	2,267	918

\* intercropped

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**APPENDIX I - SOIL PROFILE  
DESCRIPTIONS AND ANALYSES**

**PROFILE 1**

**COLLUVIAL, Type 1A**

**LOCATION:** Study Area II; 60 ft. (18 m.) north of Bwakira Chini - Dutumi road, 210 ft. (64 m.) from eastern boundary.

**SITE:** Lower slope of foot-hills; about 515 ft. (157 m.) elevation; gentle slope; south-east aspect; medium surface runoff.

**PARENT MATERIAL:** Colluvial material from upper slopes of Uluguru foot-hills, derived from pyroxenite granulite with garnet and some hornblende.

**VEGETATION AND LAND USE:**

- (i) Type: Low shrubby regrowth, formerly native cultivation.
- (ii) Trees: Absent
- (iii) Shrubs: *Ptilostigma thonningii*, *Vitex doniana*.
- (iv) Herbs: Absent
- (v) Grasses: *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Dark grey, 5 YR 4/1, dry (black, 5 YR 2/1, wet) coarse sandy clay; moderately well developed large coarse granular; slightly sticky, slightly plastic consistence, wet, hard consistence, dry; few small and gravelly angular quartz stones; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	8 - 23 (3 - 9)	Reddish grey, 5 YR 5/2, dry (dark reddish brown, 5 YR 3/2, wet) coarse sandy clay loam; strongly developed medium-sized angular blocky; slightly sticky, plastic consistence, wet, hard consistence, dry; few small angular quartz stones; free drainage; small woody roots common; abrupt, smooth boundary to:
3	23 - 30 (9 - 12)	Reddish grey, 5 YR 5/2, dry (dark reddish brown, 5 YR 3/2, wet) coarse sandy loam; strongly developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet, slightly hard consistence dry; many small and medium-sized angular quartz stones; free drainage; few small and medium-sized woody roots; gradual, smooth boundary to:
4	30 - 48 (12 - 19)	Reddish brown, 5 YR 4/3, dry (dark reddish brown, 5 YR 3/3, wet) coarse sandy loam; strongly developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet, hard consistence, dry; few small and medium-sized angular quartz stones; free drainage; few small and medium-sized woody roots; abrupt, smooth boundary to:
5	48 - 120 (19 - 47)+	Grey, 5 YR 5/1, dry (very dark grey, 5 YR 3/1, wet) fine sandy clay; strongly developed coarse angular blocky; sticky, plastic consistence, wet, very hard consistence, dry; no stones; poor drainage; few small woody roots.

## PROFILE 1

HORIZON	1	2	3	4	5
DEPTH cm.	0-8	8-23	23-30	30-48	48-120
Moisture 100-105°C %	2.42	1.93	1.24	1.16	2.67
200 $\mu$ - 2mm. %	19	31	46	58	11
50 $\mu$ - 200 $\mu$ %	5	21	22	20	19
20 $\mu$ - 50 $\mu$ %	14	5	5	1	11
2 $\mu$ - 20 $\mu$ %	16	10	5	2	18
<2 $\mu$ %	37	28	20	17	35
CaCO <sub>3</sub> Equivalent %	tr	-	-	-	-
Loss on Ignition %	12.7	7.7	4.3	3.5	9.5
Total Nitrogen %	0.19	0.07	0.07	0.03	0.11
pH in water (1:2.5)	6.8	6.5	6.5	6.5	6.5
pH in M/100 Ca Cl <sub>2</sub>	6.2	6.0	5.8	5.9	6.0
Exchangeable Calcium m.e. %	20.5	13.1	6.9	5.9	20.5
Exchangeable Magnesium m.e. %	7.80	4.40	6.10	2.40	7.00
Exchangeable Potassium m.e. %	2.40	0.95	0.46	0.31	0.49
Exchangeable Sodium m.e. %	0.09	0.07	0.07	0.09	0.10
Total Exchangeable Bases m.e. %	30.8	18.5	13.5	8.7	28.1
Exchangeable Hydrogen m.e. %	5.5	3.3	2.3	2.2	4.0
Cation Exchange Capacity m.e. %	36.3	21.8	15.8	10.9	32.1
Base Saturation %	85	85	85	80	88
Soluble Salts m.e. %	0.40	0.20	0.20	0.20	0.30
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	800	232	165	135	72

The analytical data presented in this appendix was obtained using the methods described on page 100.

**PROFILE 2**

**COLLUVIAL, Type 1B**

**LOCATION:** Study Area II; 60 ft. (18 m.) south of Bwakira Chini - Dutumi road, 600 ft. (183 m.) west of Lesser Kikundi stream.

**SITE:** Lower slope of foot-hills; about 520 ft. (159 m.) elevation; gentle slope; south aspect; medium surface runoff.

**PARENT MATERIAL:** Colluvial material from upper slopes of Uluguru foot-hills, derived from pyroxenite granulite with garnet and some hornblende.

**VEGETATION AND LAND USE:**

- (i) Type: Recently cleared for native cultivation.
- (ii) Trees: *Acacia polyacantha* subsp. *campylacantha*.
- (iii) Shrubs: Absent
- (iv) Herbs: Absent
- (v) Grasses: *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Dark greyish brown, 10 YR 4/2, dry (very dark brown, 10 YR 2/2, wet) coarse sandy clay loam; moderately well developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet, hard consistence, dry; no stones; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	8 - 23 (3 - 9)	Brown, 7.5 YR 5/4, dry (dark brown, 7.5 YR 3/2, wet) coarse sandy clay; moderately well developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; few small woody roots; gradual, smooth boundary to:
3	23 - 53 (9 - 21)	Reddish brown, 5 YR 5/4, dry (dark reddish brown, 5 YR 3/3, wet) coarse sandy clay, moderately well developed small angular blocky; slightly sticky, slightly plastic consistence, wet, hard consistence, dry; no stones; free drainage; few small woody roots; gradual, smooth boundary to:
4	53 - 120 (21 - 47)+	Reddish brown, 2.5 YR 4/4, dry (dark reddish brown, 2.5 YR 3/4, wet) coarse sandy clay; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, very hard consistence, dry; few small ironstone concretions, small angular quartz stones common; free drainage; few small woody roots.

**PROFILE 2**

HORIZON DEPTH cm.	1 0-8	2 8-23	3 23-53	4 53-120
Moisture 100-105°C %	2.34	3.44	3.64	3.32
200 $\mu$ - 2mm. %	30	25	20	24
50 $\mu$ - 200 $\mu$ %	29	24	23	22
20 $\mu$ - 50 $\mu$ %	7	5	4	5
2 $\mu$ - 20 $\mu$ %	6	6	4	6
<2 $\mu$ %	25	38	47	42
CaCO <sub>3</sub> Equivalent %	-	-	-	-
Loss on Ignition %	6.2	7.6	8.0	7.0
Total Nitrogen %	0.12	0.09	0.08	0.05
pH in water (1:2.5)	6.6	6.1	6.3	6.5
pH in M/100 Ca Cl <sub>2</sub>	5.4	5.0	5.6	5.6
Exchangeable Calcium m.e. %	10.2	9.0	8.1	7.2
Exchangeable Magnesium m.e. %	3.67	3.22	4.11	3.56
Exchangeable Potassium m.e. %	1.32	1.14	1.01	0.39
Exchangeable Sodium m.e. %	0.11	0.11	0.12	0.16
Total Exchangeable Bases m.e. %	15.3	13.5	13.3	11.3
Exchangeable Hydrogen m.e. %	3.7	4.6	4.3	3.7
Cation Exchange Capacity m.e. %	19.0	18.1	17.6	15.0
Base Saturation %	81	75	76	75
Soluble Salts m.e. %	0.34	0.28	0.21	0.17
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	390	105	55	32

**PROFILE 3**

**COLLUVIAL, Type 1C**

LOCATION: Study Area II; 30 ft. (9 m.) north of Bwakira Chini-Dutumi road, 90 ft. (27 m.) from western boundary.

SITE: Lower slope of foot-hills; about 505 ft. (154 m.) elevation; gentle slope; south-west aspect; slow runoff.

PARENT MATERIAL: Fine colluvial material from upper slopes of Uluguru foot-hills, derived from pyroxenite granulite with garnet and some hornblende.

- VEGETATION AND LAND USE:
- (i) Type: Broken forest.
  - (ii) Trees: *Sclerocarya caffra*, *Azelia quanzensis*.
  - (iii) Shrubs: Absent
  - (iv) Herbs: Absent
  - (v) Grasses: *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Greyish brown, 10 YR 5/2, dry (very dark grey, 10 YR 3/1, wet) coarse sandy clay loam; strongly developed medium-sized angular blocky structure; sticky, plastic consistence, wet, very hard consistence, dry; no stone; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	8 - 28 (3 - 11)	Greyish brown, 10 YR 5/2, dry (very dark brown, 10 YR 2/2, wet) coarse sandy clay; strongly developed coarse angular blocky structure; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; few small woody roots; gradual, smooth boundary to:
3	28 - 56 (11 - 22)	Dark greyish brown, 10 YR 4/2, dry (very dark brown, 10 YR 2/2, wet) fine sandy clay; moderately well developed medium-sized angular blocky structure; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; few small woody roots; gradual, smooth boundary to:
4	56 - 120 (22 - 47)+	Yellowish brown, 10 YR 5/4, dry (dark brown, 10 YR 3/3, wet) clay; strongly developed coarse angular blocky; very sticky, very plastic consistence, wet, hard consistence, dry; few small angular quartz stones; imperfect drainage; no roots.

**PROFILE 3**

HORIZON DEPTH cm.	1 0-8	2 8-28	3 28-56	4 56-120
Moisture 100-105°C %	2.77	4.79	4.23	4.08
200 $\mu$ - 2mm. %	29	20	15	12
50 $\mu$ - 200 $\mu$ %	22	22	21	20
20 $\mu$ - 50 $\mu$ %	7	7	4	2
2 $\mu$ - 20 $\mu$ %	10	10	10	10
<2 $\mu$ %	29	38	48	55
CaCO <sub>3</sub> Equivalent %	-	-	-	-
Loss on Ignition %	9.2	9.7	10.9	10.5
Total Nitrogen %	0.15	0.12	0.11	0.06
pH in water (1:2.5)	6.1	6.0	6.1	6.4
pH in M/100 Ca Cl <sub>2</sub>	5.1	4.8	4.9	5.3
Exchangeable Calcium m.e. %	10.5	10.3	10.2	9.6
Exchangeable Magnesium m.e. %	5.64	3.17	6.80	7.29
Exchangeable Potassium m.e. %	1.01	0.37	0.55	0.23
Exchangeable Sodium m.e. %	0.17	0.20	0.23	0.46
Total Exchangeable Bases m.e. %	17.3	14.0	17.8	17.6
Exchangeable Hydrogen m.e. %	7.1	7.7	6.8	4.6
Cation Exchange Capacity m.e. %	24.4	21.7	24.6	22.2
Base Saturation %	71	65	72	79
Soluble Salts m.e. %	0.25	0.15	0.17	0.20
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	150	67	67	17

**PROFILE 4**

**COLLUVIAL, Type 1D**

**LOCATION:** To the north-west of Study Area III; 2,500 ft. (762 m.) north-west of Dutumi-Kilengezi road, 30 ft. (9 m.) south-west of Kolero road.

**SITE:** Lower slope of foot-hills; about 250 ft. (159 m.) elevation; gentle slope; south-west aspect; medium surface run-off.

**PARENT MATERIAL:** Colluvial material from upper slopes of Uluguru foot-hills, derived from crystalline limestone and porphyroblastic gneisses.

**VEGETATION AND LAND USE:**

- (i) Type: Parkland.
- (ii) Trees: *Dalbergia melanoxylon*, *Lonchocarpus capassa*, *Sclerocarya caffra* and *Tamarindus indica*.
- (iii) Shrubs: Absent
- (iv) Herbs: Absent
- (v) Grasses: *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Reddish brown, 5 YR 5/3, dry (dark reddish brown, 5 YR 3/3, wet) coarse sandy loam; moderately well developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet, hard consistence, dry; few small angular quartz stones; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	8 - 15 (3 - 6)	Reddish brown, 5 YR 5/4, dry (dark reddish brown, 5 YR 3/4, wet) coarse sandy clay loam; moderately well developed small angular blocky; slightly sticky, slightly plastic consistence, wet, hard consistence, dry; small angular quartz stones common; free drainage; small woody roots common; gradual, smooth boundary to:
3	15 - 41 (6 - 16)	Reddish yellow, 5 YR 6/6, dry (yellowish red, 5 YR 4/6, wet) coarse sandy loam; moderately well developed coarse granular; slightly sticky, non plastic consistence, wet, slightly hard consistence, dry; few small angular quartz stones; free drainage; few small woody roots; abrupt, irregular boundary to:
4	41 - 76 (16 - 22)	Reddish yellow, 7.5 YR 6/6, dry (brown, 7.5 YR 5/4, wet) loamy coarse sand; weakly developed medium-sized granular; non-sticky, plastic consistence, wet, slightly hard consistence, dry; many small angular quartz stones; free drainage; few small woody roots; clear, irregular boundary to:
5	76 - 120 (26 - 47)+	Reddish yellow, 7.5 YR 7/6, dry (strong brown, 7.5 YR 5/6, wet) loamy coarse sand; weakly developed small angular blocky; non-sticky, non-plastic consistence, wet, slightly hard consistence, dry; few small angular quartz stones; free drainage; no roots.

**PROFILE 4**

HORIZON DEPTH cm.	1 0-8	2 8-15	3 15-41	4 41-76	5 76-120
Moisture 100-105°C %	1.63	2.22	2.45	2.15	1.99
200 $\mu$ - 2mm. %	44	42	38	52	54
50 $\mu$ - 200 $\mu$ %	23	16	23	19	26
20 $\mu$ - 50 $\mu$ %	6	6	9	9	6
2 $\mu$ - 20 $\mu$ %	8	10	12	8	5
<2 $\mu$ %	14	21	13	8	7
CaCO <sub>3</sub> Equivalent %	-	-	-	-	-
Loss on Ignition %	5.9	6.7	6.1	4.3	3.1
Total Nitrogen %	0.09	0.06	0.04	0.01	0.01
pH in water (1:2.5)	6.5	6.0	6.2	6.4	6.8
pH in M/100 Ca Cl <sub>2</sub>	5.6	5.2	5.4	5.7	6.0
Exchangeable Calcium m.e. %	5.4	5.3	7.4	6.9	6.3
Exchangeable Magnesium m.e. %	3.00	3.60	5.50	6.00	6.20
Exchangeable Potassium m.e. %	0.46	0.13	0.08	0.12	0.10
Exchangeable Sodium m.e. %	0.09	0.10	0.13	0.19	0.27
Total Exchangeable Bases m.e. %	9.0	9.1	13.1	13.2	12.9
Exchangeable Hydrogen m.e. %	3.3	3.1	0.4	0.0	0.0
Cation Exchange Capacity m.e. %	12.3	12.2	13.5	13.2	12.9
Base Saturation %	73	75	97	100	100
Soluble Salts m.e. %	0.20	0.10	0.10	0.10	0.10
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	37	22	15	64	142

**PROFILE 5**

**COLLUVIAL, Type 1E**

**LOCATION:** Study Area III; 650 ft. (198 m.) north-west of Dutumi-Kilengezi road, 650 ft. (198 m.) from north-east boundary.

**SITE:** Lower slope of foot-hills; about 500 ft. (152 m.) elevation; gentle slope; east aspect; medium surface runoff.

**PARENT MATERIAL:** Colluvial material from upper slopes of Uluguru foot-hills, derived from crystalline limestone and porphyroblastic gneisses.

- VEGETATION AND LAND USE:**
- (i) Type: Broken forest.
  - (ii) Trees: *Borassus aethiopum*, *Lonchocarpus carassa*, *Sclerocarya caffra*.
  - (iii) Shrubs: Absent
  - (iv) Herbs: Absent
  - (v) Grasses: *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Reddish brown, 5 YR 5/3, dry (very dark grey, 5 YR 3/1, wet) coarse sandy clay loam; moderately well developed medium-sized angular blocky; slightly sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	8 - 18 (3 - 7)	Brown, 7.5 YR 5/3, dry (dark brown, 7.5 YR 4/2, wet) coarse sandy clay loam; moderately well developed small angular blocky; slightly sticky, plastic consistence, wet, hard consistence, dry; small angular quartz stones common; free drainage; small woody roots common; gradual, smooth boundary to:
3	18 - 48 (7 - 19)	Dark grey, 5 YR 4/1, dry (very dark grey, 5 YR 3/1, wet) coarse sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; few small angular quartz stones; free drainage; few small woody roots; gradual, smooth boundary to:
4	48 - 120 (19 - 47)+	Reddish brown, 5 YR 4/3, dry (dark reddish brown, 5 YR 3/2, wet) coarse sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; many small angular quartz stones; free drainage, no roots.

**PROFILE 5**

HORIZON DEPTH cm.	1 0-8	2 8-18	3 18-48	4 48-120
Moisture 100-105°C %	2.20	2.09	2.63	1.99
200μ - 2mm. %	25	32	28	39
50μ - 200μ %	28	23	21	19
20μ - 50μ %	6	7	6	6
2μ - 20μ %	10	9	10	7
<2μ %	24	23	30	25
CaCO <sub>3</sub> Equivalent %	-	-	-	-
Loss on Ignition %	9.1	7.8	8.3	6.7
Total Nitrogen %	0.17	0.11	0.09	0.05
pH in water (1:2.5)	7.0	6.9	7.1	7.1
pH in M/100 Ca Cl <sub>2</sub>	6.3	6.2	6.4	6.4
Exchangeable Calcium m.e. %	13.0	11.4	14.1	9.2
Exchangeable Magnesium m.e. %	4.90	4.70	5.80	3.60
Exchangeable Potassium m.e. %	1.01	0.57	0.35	0.27
Exchangeable Sodium m.e. %	0.13	0.10	0.10	0.10
Total Exchangeable Bases m.e. %	19.0	16.8	20.4	13.2
Exchangeable Hydrogen m.e. %	2.9	2.7	2.7	1.4
Cation Exchange Capacity m.e. %	21.9	19.5	23.1	14.6
Base Saturation %	87	86	88	90
Soluble Salts m.e. %	0.30	0.20	0.20	0.20
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	310	161	62	43

**PROFILE 6**

**COLLUVIAL, Type 1F**

**LOCATION:** Study Area III; 45 ft. (14 m.) south-east of Dutumi-Kilengezi road, 600 ft. (183 m.) from north-east boundary.

**SITE:** Lower slope of foot-hills; about 450 ft. (137 m.) elevation; gentle slope; east aspect; medium surface runoff.

**PARENT MATERIAL:** Fine colluvial material from upper slopes of Uluguru foot-hills, derived from crystalline limestone and porphyroblastic gneisses.

**VEGETATION AND LAND USE:**

- (i) Type: Parkland.
- (ii) Trees: *Dalbergia melanoxylon*, *Acacia polyacantha* subsp. *campylacantha*, *Lonchocarpus canassa*, *Thylachium africanum*.
- (iii) Shrubs: Absent
- (iv) Herbs: Absent
- (v) Grasses: *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Reddish brown, 5 YR 5/3, dry (dark reddish brown, 5 YR 3/2, wet) coarse sandy loam; moderately well developed small angular blocky; slightly sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	8 - 25 (3 - 10)	Reddish brown, 5 YR 5/3, dry (dark reddish brown, 5 YR 3/2, wet) coarse sandy clay loam; strongly developed small angular blocky; slightly sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; few small woody roots, gradual, smooth boundary to:
3	25 - 46 (10 - 18)	Reddish brown, 5 YR 4/3, dry (dark reddish brown, 5 YR 3/3, wet) coarse sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; few small angular quartz stones; free drainage; few small woody roots; gradual smooth boundary to:
4	46 - 79 (18 - 31)	Reddish brown, 5 YR 4/3, dry (dark reddish brown, 5 YR 3/2, wet) coarse sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; small angular quartz stones common; free drainage; no roots; gradual, smooth boundary to:
5	79 - 120 (31 - 47)+	Reddish brown, 2.5 YR 4/4, dry (dark reddish brown, 2.5 YR 3/4, wet) coarse sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; many small angular quartz stones; free drainage; no roots.

**PROFILE 6**

HORIZON DEPTH cm.	1 0-8	2 8-25	3 24-46	4 46-79	5 79-120
Moisture 100-105°C %	1.60	1.59	2.46	2.30	2.17
200 $\mu$ - 2mm. %	37	37	32	34	35
50 $\mu$ - 200 $\mu$ %	35	28	27	24	27
20 $\mu$ - 50 $\mu$ %	8	8	6	6	4
2 $\mu$ - 20 $\mu$ %	5	5	4	3	3
<2 $\mu$ %	17	21	30	32	30
CaCO <sub>3</sub> Equivalent %	-	-	-	-	-
Loss on Ignition %	5.0	4.2	5.2	4.8	4.7
Total Nitrogen %	0.11	0.06	0.06	0.04	0.04
pH in water (1:2.5)	6.5	6.6	6.4	6.4	6.4
pH in M/100 Ca Cl <sub>2</sub>	5.7	5.4	5.7	5.6	5.4
Exchangeable Calcium m.e. %	6.6	6.1	6.9	4.9	4.4
Exchangeable Magnesium m.e. %	4.47	1.91	3.69	5.55	2.90
Exchangeable Potassium m.e. %	0.94	0.58	0.77	0.72	0.65
Exchangeable Sodium m.e. %	0.11	0.06	0.15	0.13	0.10
Total Exchangeable Bases m.e. %	12.1	8.7	11.5	11.3	8.1
Exchangeable Hydrogen m.e. %	3.6	3.5	3.9	3.9	3.6
Cation Exchange Capacity m.e. %	15.7	12.2	15.4	15.2	11.7
Base Saturation %	77	71	75	74	69
Soluble Salts m.e. %	0.34	0.20	0.26	0.21	0.17
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	292	225	362	227	237

**PROFILE 7**

**COLLUVIAL, Type 1G**

**LOCATION:** Study Area III; 2,400 ft. (732 m.) south-east of Dutumi-Kilengezi road, close to north-east boundary of kapok plantation.

**SITE:** Lower slope of foot-hills; about 430 ft. (131 m.) elevation; gentle slope, south aspect; slow runoff.

**PARENT MATERIAL:** Fine colluvial material from upper slopes of Uluguru foot-hills, derived from crystalline limestone and porphyroblastic gneisses.

**VEGETATION AND LAND USE:**

- (i) Type: Parkland.
- (ii) Trees: *Dalbergia melanoxylon*, *Sclerocarya caffra*, *Grewia holstii*.
- (iii) Shrubs: *Salvadora persica*.
- (iv) Herbs: Absent
- (v) Grasses: *Panicum maximum*, *Heteropogon contortus*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Greyish brown, 10 YR 5/2, dry (very dark brown, 10 YR 2/2, wet) loamy coarse sand; moderately well developed coarse granular; non-sticky, non-plastic consistence, wet, slightly hard consistence, dry; no stones; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	8 - 25 (3 - 10)	Weak red, 2.5 YR 5/2, dry (dusky red, 2.5 YR 3/2, wet) coarse sandy loam; moderately well developed small angular blocky; slightly sticky, slightly plastic consistence, wet, hard consistence, dry; no stones; free drainage; small woody roots common; gradual, smooth boundary to:
3	25 - 49 (10 - 19)	Reddish brown, 5 YR 5/4, dry (dark reddish brown, 5 YR 3/3, wet) coarse sandy clay loam; moderately well developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; few small angular quartz stones; free drainage; few small woody roots; clear, irregular boundary to:
4	49 - 81 (19 - 32)	Reddish brown, 5 YR 5/4, dry (dark reddish brown, 5 YR 3/3, wet) coarse sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; many small angular quartz stones; free drainage; few small woody roots; clear smooth horizon boundary to:
5	81 - 120 (32 - 47)+	Reddish brown, 5 YR 5/4, dry (dark reddish brown, 5 YR 3/3, wet) coarse sandy clay loam; strongly developed large angular blocky; sticky, plastic consistence, wet, hard consistence, dry; few small angular quartz stones; free drainage; no roots.

**PROFILE 7**

HORIZON DEPTH cm.	1 0-8	2 8-25	3 25-49	4 49-81	5 81-120
Moisture 100-105°C %	1.15	1.58	2.67	2.23	2.37
200 $\mu$ - 2mm. %	42	40	38	45	39
50 $\mu$ - 200 $\mu$ %	28	26	22	22	20
20 $\mu$ - 50 $\mu$ %	10	9	7	5	9
2 $\mu$ - 20 $\mu$ %	6	6	6	6	7
<2 $\mu$ %	12	18	26	21	24
CaCO <sub>3</sub> Equivalent %	-	-	-	-	-
Loss on Ignition %	3.8	3.9	4.4	4.0	4.5
Total Nitrogen %	0.07	0.06	0.06	0.03	0.04
pH in water (1:2.5)	6.4	6.3	6.6	6.6	6.6
pH in water M/100 Ca Cl <sub>2</sub>	5.5	5.2	5.9	5.7	5.8
Exchangeable Calcium m.e. %	4.9	4.3	5.1	4.4	5.1
Exchangeable Magnesium m.e. %	2.00	1.91	2.34	2.65	3.38
Exchangeable Potassium m.e. %	0.73	0.39	0.34	0.28	0.29
Exchangeable Sodium m.e. %	0.09	0.08	0.14	0.13	0.16
Total Exchangeable Bases m.e. %	7.7	6.7	7.9	7.5	8.9
Exchangeable Hydrogen m.e. %	3.4	3.6	3.3	2.5	2.6
Cation Exchange Capacity m.e. %	11.1	10.3	11.2	10.0	11.5
Base Saturation %	69	65	71	75	77
Soluble Salts m.e. %	0.24	0.13	0.21	0.15	0.15
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	272	127	80	87	75

**PROFILE 8**

**ALLUVIAL, Type 2A**

LOCATION: Study Area I; at junction of bamboo and kapok areas.

SITE: Flood plain; about 445 ft. (136 m.) elevation; nearly level; very slow runoff.

PARENT MATERIAL: Alluvial deposits.

VEGETATION AND LAND USE: Formerly cultivated, recently burnt.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Dark grey, 10 YR 4/1, dry (black; 10 YR 2/1 wet) coarse sandy loam; moderately well developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet; slightly hard consistence, dry; no stones; free drainage; few fibrous roots; abrupt, smooth boundary to:
2	8 - 20 (3 - 8)	Dark greyish brown, 10 YR 4/2, dry (very dark greyish brown, 10 YR 3/2, wet) coarse sandy loam; weakly developed medium-sized angular blocky; non-sticky, non-plastic consistence, wet, hard consistence, dry; few gravelly quartz stones; free drainage; no roots; abrupt, smooth boundary to:
3	20 - 58 (8 - 23)	Pale brown, 10 YR 6/3, dry (dark brown, 10 YR 4/3, wet) coarse sand; single grain; non-sticky, non-plastic consistence, wet, loose consistence, dry; no stones, excessive drainage; no roots; abrupt, smooth boundary to:
4	58 - 66 (23 - 26)	Dark greyish brown, 10 YR 4/2, dry (very dark greyish brown, 10 YR 3/2, wet) coarse sandy clay loam; moderately well developed medium-sized angular blocky; slightly sticky, non-plastic consistence, wet, slightly hard consistence, dry; no stones; free drainage; no roots; abrupt, smooth boundary to:
5	66 - 106 (26 - 42)	Pale brown, 10 YR 6/3, dry (dark brown, 10 YR 4/3, wet) coarse sand; single grain; non-sticky, non-plastic consistence, wet, loose consistence, dry; no roots; abrupt, smooth boundary to:
6	106 - 170 (42 - 67)+	Dark greyish brown, 10 YR 4/2, dry (very dark greyish brown, 10 YR 3/2, wet) coarse sandy clay; moderately well developed medium-sized angular blocky; sticky, slightly plastic, consistence, wet, hard consistence, dry; no stones; poor drainage, water-table at 170 cm. (67 in.) at 6/10/64; no roots.

**PROFILE 8**

HORIZON DEPTH cm.	1 0-8	2 8-20	3 20-58	4 58-66	5 66-106	6 106-170
Moisture 100-105°C %	1.65	1.70	0.53	2.26	0.68	3.07
200 $\mu$ - 2mm. %	65	64	91	43	81	24
50 $\mu$ - 200 $\mu$ %	8	11	2	19	11	22
20 $\mu$ - 50 $\mu$ %	4	4	0	4	0	6
2 $\mu$ - 20 $\mu$ %	8	7	2	11	1	10
<2 $\mu$ %	12	13	4	21	6	36
CaCO <sub>3</sub> Equivalent %	-	-	-	-	-	-
Loss on Ignition %	4.9	3.8	0.9	4.3	1.1	7.0
Total Nitrogen %	0.13	0.07	0.02	0.07	0.03	0.07
pH in water (1:2.5)	6.9	6.7	6.7	7.0	7.4	7.6
pH in M/100 Ca Cl <sub>2</sub>	6.2	5.9	6.0	6.0	6.4	6.4
Exchangeable Calcium m.e. %	9.9	8.4	1.8	10.5	2.2	13.7
Exchangeable Magnesium m.e. %	3.11	3.60	0.83	5.19	0.96	6.45
Exchangeable Potassium m.e. %	0.77	0.36	0.10	0.23	0.06	0.19
Exchangeable Sodium m.e. %	0.23	0.16	0.13	0.21	0.25	0.82
Total Exchangeable Bases m.e. %	14.0	12.5	2.9	16.1	3.5	21.2
Exchangeable Hydrogen m.e. %	2.6	2.9	0.8	2.6	0.6	2.1
Cation Exchange Capacity m.e. %	16.6	15.4	3.7	18.7	4.1	23.3
Base Saturation %	84	81	78	86	85	91
Soluble Salts m.e. %	0.37	0.24	0.15	0.30	0.17	0.35
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	125	50	30	15	30	30

**PROFILE 9****ALLUVIAL, Type 2B**

LOCATION: Area I; 1,500 ft. (457 m.) south-east of trigonometrical point 201 Y 14.

SITE: Flood plain; about 453 ft. (138 m.) elevation; nearly level; very slow runoff.

PARENT MATERIAL: Alluvial deposits.

VEGETATION AND LAND USE: Formerly cultivated, recently burnt.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Very dark grey, 10 YR 3/1, dry (black, 10 YR 2/1, wet) fine sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; few fibrous roots; gradual, smooth boundary to:
2	8 - 23 (3 - 9)	Very dark grey, 10 YR 3/1, dry (black, 10 YR 2/1, wet) fine sandy clay loam; moderately well developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; no roots; gradual, smooth boundary to:
3	23 - 33 (9 - 13)	Dark grey, 10 YR 4/1, dry (very dark grey, 10 YR 3/1, wet) clay loam; few fine faint dark yellow brown, 10 YR 4/4, dry, mottles; moderately well developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; poor drainage; no roots; abrupt, irregular boundary to:
4	33 - 96 (13 - 38)	Yellowish brown, 10 YR 5/4, dry (dark yellowish brown, 10 YR 4/4, wet) loamy coarse sand; weakly developed coarse granular; non-sticky, non-plastic consistence, wet, loose consistence, dry; no stones, free drainage; no roots; abrupt, irregular boundary to:
5	96 - 150 (38 - 59)+	Dark grey, 10 YR 4/1, dry (dark greyish brown, 10 YR 4/2, wet) gradually changing to very dark grey, 10 YR 3/1, dry (black, 10 YR 2/1, wet) clay; few prominent medium-sized olive brown, 2.5 Y 4/4, dry, mottles; moderately well developed medium-sized angular blocky; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; very poor drainage, water-table at 140 cm. (55 in.) at 6/10/64; no roots.

**PROFILE 9**

HORIZON DEPTH cm.	1 0-8	2 8-23	3 23-33	4 33-96	5 96-150
Moisture 100-105°C %	3.49	4.55	5.14	1.15	6.42
200 $\mu$ - 2mm. %	12	13	7	56	4
50 $\mu$ - 200 $\mu$ %	35	28	21	29	19
20 $\mu$ - 50 $\mu$ %	8	7	12	2	8
2 $\mu$ - 20 $\mu$ %	15	21	25	3	24
<2 $\mu$ %	25	27	32	9	43
CaCO <sub>3</sub> Equivalent %	-	-	-	-	tr
Loss on Ignition %	8.5	9.1	9.6	1.8	10.3
Total Nitrogen %	0.23	0.19	0.13	0.03	0.11
pH in water (1:2.5)	6.7	6.7	6.8	7.1	7.5
pH in M/100 Ca Cl <sub>2</sub>	5.8	5.7	5.8	6.0	6.9
Exchangeable Calcium m.e. %	22.3	24.6	28.7	5.3	39.6
Exchangeable Magnesium m.e. %	7.96	8.64	9.40	1.46	14.30
Exchangeable Potassium m.e. %	1.39	0.51	0.32	0.12	0.40
Exchangeable Sodium m.e. %	0.15	0.16	0.12	0.18	0.75
Total Exchangeable Bases m.e. %	31.8	33.9	38.5	7.1	55.1
Exchangeable Hydrogen m.e. %	5.3	4.8	2.5	1.0	1.3
Cation Exchange Capacity m.e. %	37.1	38.7	41.0	8.1	56.4
Base Saturation %	86	88	94	88	98
Soluble Salts m.e. %	0.56	0.32	0.26	0.17	0.53
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	125	100	15	30	50

**PROFILE 10**

**ALLUVIAL, Type 2C**

**LOCATION:** Area I; 1,800 ft. (549 m.) south-east of trigonometrical point 201 Y 14.

**SITE:** Flood plain; side of drainage channel; about 451 ft. (137 m.) elevation; nearly level; very slow runoff.

**PARENT MATERIAL:** Alluvial deposits.

**VEGETATION AND LAND USE:** Formerly cultivated, recently burnt.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 13 (0 - 5)	Very dark grey, 2.5 Y 3/0, dry (black, 2.5 Y 2/0, wet) clay loam; few fine faint pale yellow, 2.5 Y 7/4, dry, mottles; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, very hard consistence, dry; no stones; poor drainage; few fibrous roots; gradual, smooth boundary to:
2	13 - 38 (5 - 15)	Very dark grey, 2.5 Y 3/0, dry (black, 2.5 Y 2/0, wet) clay; strongly developed coarse angular blocky; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; poor drainage; no roots; clear, irregular boundary to:
3	38 - 46 (15 - 18)	Yellowish brown, 10 YR 5/4, dry (dark brown, 10 YR 3/3, wet) clay loam; medium-sized faint, strong brown, 7.5 YR 5/8, dry, mottles common; moderately well developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; poor drainage; no roots; gradual smooth boundary to:
4	46 - 61 (18 - 24)	Very dark grey brown, 10 YR 3/1, dry (black, 10 YR 2/1, wet) clay loam; moderately well developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stone; poor drainage; no roots; abrupt, irregular boundary to:
5	61 - 66 (24 - 26)	Dark greyish brown, 10 YR 4/2 (dark brown, 10 YR 3/3, wet) loamy coarse sand; weakly developed small granular; non-sticky, non-plastic consistence, wet, loose consistence, dry; no stones; free drainage; no roots; abrupt, smooth boundary to:
6	66 - 89 (26 - 35)	Dark grey, 10 YR 4/1, dry (very dark grey, 10 YR 3/1, wet) coarse sandy loam; moderately well developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet, slightly hard consistence, dry; no stone; free drainage; no roots; gradual, smooth boundary to:
7	89 - 140 (35 - 55)+	Brown, 7.5 YR 5/4, dry (dark brown, 7.5 YR 3/2, wet) loamy coarse sand; weakly developed coarse granular; non-sticky, non-plastic consistence, wet, loose consistence, dry; no stones; free drainage; water-table at 140 cm. (55 in.) at 6/10/64; no roots.

**PROFILE 10**

HORIZON	1	2	3	4	5	6	7
DEPTH cm.	0-13	13-38	38-46	46-61	61-66	66-89	89-140
Moisture 100-105°C %	6.69	11.01	4.92	5.33	1.13	2.65	1.15
200 $\mu$ - 2mm. %	8	5	5	9	78	42	63
50 $\mu$ - 200 $\mu$ %	12	11	17	21	6	22	21
20 $\mu$ - 50 $\mu$ %	7	6	20	13	2	6	2
2 $\mu$ - 20 $\mu$ %	30	30	28	19	4	10	4
<2 $\mu$ %	36	44	28	36	9	18	9
CaCO <sub>3</sub> Equivalent %	-	tr	tr	tr	-	-	-
Loss on Ignition %	14.6	12.9	11.0	8.6	1.9	4.2	1.6
Total Nitrogen %	0.33	0.18	0.09	0.08	0.02	0.07	0.02
pH in water (1:2.5)	6.6	7.1	7.0	6.9	6.7	6.8	6.6
pH in M/100 Ca Cl <sub>2</sub>	6.1	6.1	5.9	5.7	5.7	5.5	5.6
Exchangeable Calcium m.e. %	36.1	35.7	20.3	20.9	4.3	12.3	4.0
Exchangeable Magnesium m.e. %	12.43	15.04	10.81	13.25	3.34	6.76	3.06
Exchangeable Potassium m.e. %	0.25	0.83	0.26	0.30	0.09	0.29	0.10
Exchangeable Sodium m.e. %	0.19	0.33	0.20	0.15	0.08	0.18	0.10
Total Exchangeable Bases m.e. %	49.0	51.9	31.6	34.6	7.8	19.5	7.3
Exchangeable Hydrogen m.e. %	7.1	5.8	3.3	3.5	1.6	3.2	1.3
Cation Exchange Capacity m.e. %	56.1	57.7	34.9	38.1	9.4	22.7	8.6
Base Saturation %	87	90	91	91	83	86	85
Soluble Salts m.e. %	0.61	0.43	0.23	0.22	0.14	0.15	0.15
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	125	30	12	5	20	62	50

**PROFILE 11**

**ALLUVIAL, Type 2D**

**LOCATION:** Area I; 1,700 ft. (518 m.) south-east of trigonometrical point 201 Y 14.

**SITE:** Flood plain; bottom of drainage channel; about 450 ft. (137 m.) elevation; level; very slow runoff.

**PARENT MATERIAL:** Alluvial deposits.

**VEGETATION AND LAND USE:** Cultivation of Castor, *Ricinus communis*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 13 (0 - 5)	Dark grey, 10 YR 4/1, dry (black, 10 YR 2/1, wet) clay loam; moderately well developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; poor drainage; fibrous and small fleshy roots common; gradual, smooth boundary to:
2	13 - 28 (5 - 11)	Very dark grey, 2.5 Y 3/1, dry (black, 2.5 Y 2/0, wet) clay; strongly developed coarse angular blocky; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; poor drainage; few small fleshy roots; gradual, smooth boundary to:
3	28 - 122 (11 - 48)	Very dark grey, 2.5 Y 3/1, dry (black, 2.5 Y 2/0, wet) clay; medium-sized distinct, strong brown, 7.5 YR 5/6, dry, mottles common; strongly developed coarse angular blocky; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; poor drainage; no roots; gradual, smooth boundary to:
4	122 - 167 (48 - 66)	Brown, 10 YR 5/3, dry (yellowish brown, 10 YR 5/6, wet) fine sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage, water-table at 140 cm. (55 in.) at 6/10/64; no roots; below this horizon sampled by auger:
5	167 - 180 (66 - 71)+	Brown, 10 YR 5/3, dry (brown to dark brown, 10 YR 4/3, wet) coarse sandy clay loam; slightly sticky, slightly plastic consistence, wet, slightly hard consistence wet; no stones.

**PROFILE 11**

HORIZON DEPTH cm.	1 0-13	2 13-28	3 28-122	4 122-167	5 167-180
Moisture 100-105°C %	4.25	4.99	3.99	2.99	2.09
200 $\mu$ - 2mm. %	8	6	7	9	27
50 $\mu$ - 200 $\mu$ %	7	10	16	25	30
20 $\mu$ - 50 $\mu$ %	6	3	11	19	9
2 $\mu$ - 20 $\mu$ %	26	24	19	16	8
<2 $\mu$ %	39	46	41	26	25
CaCO <sub>3</sub> Equivalent %	-	-	tr	-	-
Loss on Ignition %	18.0	15.6	10.1	7.4	3.7
Total Nitrogen %	0.37	0.23	0.08	0.05	0.02
pH in water (1:2.5)	6.5	6.4	6.3	6.5	6.9
pH in M/100 Ca Cl <sub>2</sub>	5.9	5.7	5.6	5.8	6.4
Exchangeable Calcium m.e. %	35.5	33.7	21.9	16.5	11.2
Exchangeable Magnesium m.e. %	12.70	14.20	12.60	9.20	6.60
Exchangeable Potassium m.e. %	2.76	1.37	0.32	0.27	0.21
Exchangeable Sodium m.e. %	0.55	0.19	0.26	0.22	0.23
Total Exchangeable Bases m.e. %	51.5	49.5	35.1	26.2	18.2
Exchangeable Hydrogen m.e. %	7.7	8.0	3.1	1.2	0.9
Cation Exchange Capacity m.e. %	59.2	57.5	38.2	27.4	19.1
Base Saturation %	87	86	92	96	95
Soluble Salts m.e. %	0.70	0.30	0.20	0.20	0.30
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	633	322	68	138	157

**PROFILE 12**

**ALLUVIAL, Type 2E**

LOCATION: Area I; 20 ft. (6 m.) north of Mgeta River, 1,700 ft. (518 m.) from south-east corner of area.

SITE: Flood plain; river levee; about 444 ft. (135 m.) elevation; nearly level; slow runoff.

PARENT MATERIAL: Alluvial deposits.

VEGETATION AND LAND USE: Cultivation of sugar cane, *Saccharum officinarum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Greyish brown, 2.5 Y 5/2, dry (very dark grey, 2.5 Y 3/0, wet) fine sandy clay loam; moderately well developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet, slightly hard consistence, dry; no stones; free drainage; fibrous and small fleshy roots common; gradual, smooth boundary to:
2	8 - 51 (3 - 20)	Greyish brown, 2.5 Y 5/2, dry (very dark grey, 2.5 Y 3/1, wet) fine sandy clay loam; weakly developed medium-sized angular blocky; non-sticky, non-plastic consistence, wet, soft consistence, dry; no stones; free drainage; few small fleshy roots; abrupt, wavy boundary to:
3	51 - 58 (20 - 23)	Light yellowish grey, 2.5 Y 6/2, dry (dark greyish brown, 2.5 Y 4/2, wet) loamy fine sand; single grain; non-sticky, non-plastic consistence, wet, loose consistence, dry; no stones; free drainage; no roots; abrupt, wavy boundary to:
4	58 - 71 (23 - 28)	Greyish brown, 2.5 Y 5/2, dry (very dark grey, 2.5 Y 3/1, wet) fine sandy clay loam; weakly developed small angular blocky; non-sticky, non-plastic consistence, wet, soft consistence, dry; no stones; free drainage; no roots; abrupt wavy boundary to:
5	71 - 76 (28 - 30)	Light yellowish grey, 2.5 Y 6/2, dry (dark greyish brown, 2.5 Y 4/1, wet) loamy fine sand; single grain; non-sticky, non-plastic consistence, wet, loose consistence, dry; no stones; free drainage; no roots; abrupt, wavy boundary to:
6	76 - 94 (30 - 37)	Greyish brown, 2.5 Y 5/2, dry (very dark grey, 2.5 Y 3/1, wet) fine sandy clay loam; weakly developed medium-sized angular blocky; non-sticky, non-plastic consistence, wet, soft consistence, dry; no stones; free drainage; no roots; abrupt, wavy boundary to:
7	94 - 140 (37 - 55)+	Light yellowish grey, 2.5 Y 6/2, dry (dark greyish brown, 2.5 Y 4/2, wet) loamy fine sand; single grain; non-sticky, non-plastic consistence, wet, loose consistence, dry; no stones; free drainage; no roots.

**PROFILE 12**

HORIZON	1	2	3	4	5	6	7
DEPTH cm.	0-8	8-51	51-58	58-71	71-76	76-94	94-110
Moisture 100-105°C %	3.26	2.96	1.36	2.35	1.25	2.37	1.00
200 $\mu$ - 2mm. %	2	<1	1	1	2	3	7
50 $\mu$ - 200 $\mu$ %	20	30	57	41	67	32	70
20 $\mu$ - 50 $\mu$ %	24	29	27	27	17	32	10
2 $\mu$ - 20 $\mu$ %	23	16	2	7	2	10	2
<2 $\mu$ %	24	21	12	21	10	21	10
CaCO <sub>3</sub> Equivalent %	-	-	-	-	-	-	-
Loss on Ignition %	9.1	5.9	2.6	5.0	2.8	4.0	1.8
Total Nitrogen %	0.17	0.05	0.02	0.04	0.02	0.03	0.02
pH in water (1:2.5)	7.1	7.2	7.5	7.5	7.4	7.4	7.6
pH in M/100 Ca Cl <sub>2</sub>	6.6	6.5	6.9	6.7	6.6	6.7	6.9
Exchangeable Calcium m.e. %	18.8	14.2	6.8	11.5	5.1	11.0	4.7
Exchangeable Magnesium m.e. %	7.90	6.80	3.50	5.70	2.80	5.30	2.60
Exchangeable Potassium m.e. %	1.76	0.53	0.18	0.25	0.12	0.24	0.11
Exchangeable Sodium m.e. %	0.16	0.13	0.12	0.16	0.09	0.14	0.11
Total Exchangeable Bases m.e. %	28.6	21.7	10.6	17.6	8.1	16.7	7.6
Exchangeable Hydrogen m.e. %	3.5	2.0	0.6	0.8	0.6	1.0	0.5
Cation Exchange Capacity m.e. %	32.1	23.7	11.2	18.4	8.7	17.7	8.1
Base Saturation %	89	92	95	96	93	94	94
Soluble Salts m.e. %	0.60	0.30	0.20	0.40	0.50	0.30	0.20
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	472	283	298	230	290	264	278

**PROFILE 13**

**ALLUVIAL, Type 2F**

LOCATION: Area II; 900 ft. (274 m.) south of Bwakira Chini-Dutumi road, 2,000 ft. (610 m.) south-west of the intersection of the western boundary with the Bwakira Chini-Dutumi road.

SITE: Flood plain; about 480 ft. (146 m.) elevation; nearly level; slow runoff.

PARENT MATERIAL; Alluvial deposits.

VEGETATION AND LAND USE (i) Type: Forest, currently being cleared and recently burnt.

(ii) Trees: *Sterculia appendiculata*, *Sclerocarya caffra*.

(iii) Shrubs: *Ipomaea shirambensis* (climber on larger trees).

(iv) Herbs: Absent

(v) Grasses: *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Dark grey, 5 YR 4/1, dry (black, 5 YR 2/1, wet) fine sandy loam; strongly developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet, slightly hard consistence, dry; no stones; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	8 - 20 (3 - 8)	Reddish grey, 5 YR 5/2, dry (very dark grey, 5 YR 3/1, wet) fine sandy clay loam; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; few small woody roots; gradual, smooth boundary to:
3	20 - 41 (8 - 16)	Brown, 10 YR 5/3, dry (dark grey, 10 YR 4/1, wet) fine sandy clay loam; strongly developed coarse angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; few small woody roots; gradual, smooth boundary to:
4	41 - 61 (16 - 24)	Brown, 7.5 YR 5/4, dry (dark brown, 7.5 YR 3/2, wet) clay; few small distinct reddish yellow, 5 YR 6/6, dry, mottles; strongly developed coarse angular blocky; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; imperfect drainage; few small woody roots; abrupt, smooth boundary to:
5	61 - 120 (24 - 47)+	Light yellowish brown, 10 YR 6/4, dry (dark brown, 10 YR 3/3, wet) fine sandy clay loam; weakly developed medium-sized angular blocky; slightly sticky, slightly plastic consistence, wet, soft consistence, dry; no stones; free drainage; no roots.

**PROFILE 13**

HORIZON DEPTH cm.	1 0-8	2 8-20	3 20-41	4 41-61	5 61-120
Moisture 100-105°C %	2.99	4.46	3.76	6.80	2.93
200 $\mu$ - 2mm. %	10	8	3	2	15
50 $\mu$ - 200 $\mu$ %	41	36	39	13	40
20 $\mu$ - 50 $\mu$ %	10	12	16	9	9
2 $\mu$ - 20 $\mu$ %	19	18	10	21	8
<2 $\mu$ %	16	23	30	53	27
CaCO <sub>3</sub> Equivalent %	-	-	-	0.19	-
Loss on Ignition %	8.1	7.7	6.4	11.1	5.1
Total Nitrogen %	0.18	0.13	0.08	0.10	0.04
pH in water (1:2.5)	6.7	6.6	6.5	6.9	6.5
pH in M/100 Ca Cl <sub>2</sub>	5.9	5.6	5.5	6.1	5.3
Exchangeable Calcium m.e. %	17.3	17.3	15.0	26.6	12.9
Exchangeable Magnesium m.e. %	3.67	7.18	6.26	29.86	8.40
Exchangeable Potassium m.e. %	2.15	1.43	0.49	0.31	0.24
Exchangeable Sodium m.e. %	0.09	0.07	0.09	0.17	0.14
Total Exchangeable Bases m.e. %	23.2	26.0	21.8	56.9	21.7
Exchangeable Hydrogen m.e. %	4.7	4.9	4.6	3.5	2.8
Cation Exchange Capacity m.e. %	27.9	30.9	26.4	60.4	24.5
Base Saturation %	83	84	83	94	89
Soluble Salts m.e. %	0.06	0.29	0.22	1.01	0.19
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	180	7	81	68	81

**PROFILE 14**

**ALLUVIAL, Type 2G**

**LOCATION:** Area II; 2,500 ft. (762 m.) south of Bwakira Chini-Dutumi road, 4,200 ft. (1,280 m.) south-east of the intersection of the western boundary with the Bwakira Chini-Dutumi road.

**SITE:** Flood plain; about 460 ft. (140 m.) elevation; level; very slow runoff.

**PARENT MATERIAL:** Alluvial deposits.

- VEGETATION AND LAND USE**
- (i) Type: Broken forest.
  - (ii) Trees: *Acacia polyacantha* subsp. *comnylacantha*, *Acacia clavigera*, *Dalbergia melanoxylon*.
  - (iii) Shrubs: Absent
  - (iv) Herbs: Absent
  - (v) Grasses: *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 13 (0 - 5)	Very dark greyish brown, 10 YR 3/2, dry (black, 10 YR 2/1, wet) fine sandy clay loam; strongly developed coarse angular blocky; sticky, plastic consistence, wet, very hard consistence, dry; no stones; free drainage; fibrous and small woody roots common; gradual, smooth boundary to:
2	13 - 30 (5 - 12)	Greyish brown, 10 YR 5/2, dry (very dark brown, 10 YR 2/2, wet) coarse sandy clay loam; strongly developed coarse angular blocky; sticky, plastic consistence, wet, hard consistence, dry; few gravelly sub-angular quartz stones, free drainage; few small woody roots; gradual, smooth boundary to:
3	30 - 56 (12 - 22)	Dark greyish brown, 10 YR 4/2, dry (very dark brown, 10 YR 2/2, wet) coarse sandy clay; moderately well developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; few small woody roots; gradual, smooth boundary to:
4	56 - 120 (22 - 47)+	Dark greyish brown, 10 YR 4/2, dry (very dark brown, 10 YR 2/2, wet) coarse sandy clay; strongly developed medium-sized angular blocky; sticky, plastic consistence, wet, hard consistence, dry; no stones; free drainage; no roots.

**PROFILE 14**

HORIZON DEPTH cm.	1 0-13	2 13-30	3 30-56	4 56-120
Moisture 100-105°C %	3.81	3.59	4.34	4.16
200 $\mu$ - 2mm. %	12	30	21	24
50 $\mu$ - 200 $\mu$ %	22	22	21	21
20 $\mu$ - 50 $\mu$ %	14	10	11	7
2 $\mu$ - 20 $\mu$ %	18	6	8	10
<2 $\mu$ %	28	30	37	37
CaCO <sub>3</sub> Equivalent %	tr	tr	-	-
Loss on Ignition %	11.6	5.9	7.0	6.6
Total Nitrogen %	0.26	0.09	0.09	0.05
pH in water (1:2.5)	7.2	6.6	6.7	6.8
pH in M/100 Ca Cl <sub>2</sub>	6.2	5.5	5.6	5.6
Exchangeable Calcium m.e. %	22.7	10.2	13.8	12.7
Exchangeable Magnesium m.e. %	17.95	6.20	7.31	8.16
Exchangeable Potassium m.e. %	1.32	0.35	0.49	0.29
Exchangeable Sodium m.e. %	0.46	0.25	0.27	0.54
Total Exchangeable Bases m.e. %	42.4	17.0	21.9	21.7
Exchangeable Hydrogen m.e. %	4.7	4.3	4.3	3.8
Cation Exchange Capacity m.e. %	47.1	21.3	26.2	25.5
Base Saturation %	90	80	84	85
Soluble Salts m.e. %	0.43	0.25	0.29	0.26
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	467	165	112	100

**PROFILE 15**

**HEAVY, CRACKING, SEASONALLY WET CLAY**

**LOCATION:** Area II; 1,800 ft. (549 m.) south of Bwakira Chini-Dutumi road, midway between the Greater Kikundi stream and the Lesser Kikundi stream.

**SITE:** Flood plain; edge of large depression; about 460 ft. (140 m.) elevation; level; surface cracks during drought; no runoff.

**PARENT MATERIAL:** Alluvial deposits and colluvial deposits.

**CLASSIFICATION:** Similar in physical and chemical properties to the heavy, cracking, seasonally wet clay but lighter in texture and representing the border area of this soil type.

- VEGETATION AND LAND USE:**
- (i) Type: Parkland.
  - (ii) Trees: *Acacia nigrescens*, *Acacia goetzii*.
  - (iii) Shrubs: *Sesbania sesban*.
  - (iv) Herbs: Absent
  - (v) Grasses: *Heteropogon contortus*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 20 (0 - 8)	Very dark grey, 2.5 Y 3/0, dry (black, 2.5 Y 2/0, wet) coarse sandy clay loam; strongly developed coarse angular blocky; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; free drainage; few fibrous and small woody and fleshy roots; gradual smooth boundary to:
2	20 - 51 (8 - 20)	Very dark grey, 2.5 Y 3/0, dry (black, 2.5 Y 2/0, wet) coarse sandy clay loam; massive; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; very poor drainage; no roots; gradual, smooth boundary to:
3	51 - 90 (20 - 35)+	Grey, 2.5 Y 5/0, dry (dark grey, 2.5 Y 4/0, wet) coarse sandy clay loam; massive; very sticky, very plastic consistence; wet, very hard consistence, dry; no stones; very poor drainage; no roots.

**PROFILE 15**

HORIZON DEPTH cm.	1 0-20	2 20-51	3 51-90
Moisture 100-105°C %	2.51	3.05	3.05
200 $\mu$ - 2mm. %	32	35	33
50 $\mu$ - 200 $\mu$ %	29	23	24
20 $\mu$ - 40 $\mu$ %	6	6	6
2 $\mu$ - 20 $\mu$ %	7	7	7
<2 $\mu$ %	22	27	29
CaCO <sub>3</sub> Equivalent %	-	-	3.5
Loss on Ignition %	5.7	4.6	4.2
Total Nitrogen %	0.13	0.07	0.04
pH in water (1:2.5)	6.9	7.7	8.9
pH in M/100 Ca Cl <sub>2</sub>	6.2	6.9	8.0
Exchangeable Calcium m.e. %	13.6	13.2	24.0
Exchangeable Magnesium m.e. %	6.10	10.20	11.20
Exchangeable Potassium m.e. %	0.23	0.23	0.15
Exchangeable Sodium m.e. %	0.58	1.17	3.38
Total Exchangeable Bases m.e. %	20.5	24.8	38.7
Exchangeable Hydrogen m.e. %	3.1	1.4	0.2
Cation Exchange Capacity m.e. %	23.6	26.2	38.9
Base Saturation %	87	95	99
Soluble Salts m.e. %	0.40	0.30	1.20
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	35	9	26

**PROFILE 16**

**HEAVY, CRACKING, SEASONALLY WET CLAY**

LOCATION: Area III; 1,000 ft. (305 m.) north of north-east corner of kapok.

SITE: Flood plain; edge of large depression; about 410 ft. (125 m.) elevation; level; surface cracks during drought; no runoff.

PARENT MATERIAL: Alluvial deposits and colluvial deposits.

CLASSIFICATION: Similar in physical and chemical properties to the heavy, cracking, seasonally wet clays, but lighter in texture and representing the border area of this soil type.

- VEGETATION AND LAND USE:
- (i) Type: Parkland.
  - (ii) Trees: *Acacia goetzii*, *Acacia sieberiana*, *Grewia holstii*, *Thylachium africanum*.
  - (iii) Shrubs: *Salvadora persica*.
  - (iv) Herbs: Absent
  - (v) Grasses: *Heteropogon contortus*, *Panicum maximum*.

HORIZON	DEPTH cm. (in.)	DESCRIPTION
1	0 - 8 (0 - 3)	Reddish grey, 5 YR 5/2, dry (very dark grey, 5 YR 3/1, wet) coarse sandy clay loam; strongly developed coarse angular blocky; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; free drainage; few fibrous and small woody and fleshy roots; gradual, smooth boundary to:
2	8 - 41 (3 - 16)	Dark grey, 5 YR 4/1, dry (black, 5 YR 2/1, wet) coarse sandy clay; strongly developed coarse prismatic; very sticky, very plastic consistence, wet, very hard consistence, dry; no stones; poor drainage; few small woody roots; gradual, smooth boundary to:
3	41 - 80 (16 - 31)+	Dark greyish brown, 10 YR 4/2, dry (dark brown, 10 YR 3/3, wet) coarse sandy clay; massive; very sticky, very plastic consistence, wet, very hard consistence, dry; small sub-angular quartz stones common; poor drainage; no roots.

**PROFILE 16**

HORIZON DEPTH cm.	1 0-8	2 8-41	3 41-80
Moisture 100-105°C %	3.48	6.13	3.84
200 $\mu$ - 2mm. %	26	19	29
50 $\mu$ - 200 $\mu$ %	23	24	21
20 $\mu$ - 50 $\mu$ %	9	7	5
2 $\mu$ - 20 $\mu$ %	11	11	8
<2 $\mu$ %	28	37	36
CaCO <sub>3</sub> Equivalent %	-	-	-
Loss on Ignition %	8.4	7.5	6.2
Total Nitrogen %	0.15	0.07	0.04
pH in water (1:2.5)	6.8	7.2	8.1
pH in M/100 Ca Cl <sub>2</sub>	6.1	5.9	6.9
Exchangeable Calcium m.e. %	13.7	13.0	9.2
Exchangeable Magnesium m.e. %	6.37	7.90	8.58
Exchangeable Potassium m.e. %	1.03	0.29	0.25
Exchangeable Sodium m.e. %	0.45	1.30	2.06
Total Exchangeable Bases m.e. %	21.6	22.5	20.1
Exchangeable Hydrogen m.e. %	4.8	2.7	1.7
Cation Exchange Capacity m.e. %	26.4	25.2	21.8
Base Saturation %	82	89	92
Soluble Salts m.e. %	0.34	0.33	0.61
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	232	80	77

## AUGER POINT I

## HEAVY, CRACKING, SEASONALLY WET CLAY

LOCATION: Area II; centre of swampy area near eastern boundary.

DEPTH cm.	8	30	60	90
Moisture 100-105°C %	3.11	3.31	3.80	3.88
200 $\mu$ - 2mm. %	22	27	27	31
50 $\mu$ - 200 $\mu$ %	22	20	18	13
20 $\mu$ - 50 $\mu$ %	11	8	4	5
2 $\mu$ - 20 $\mu$ %	12	7	7	7
<2 $\mu$ %	26	34	41	42
CaCO <sub>3</sub> Equivalent %	-	-	2.9	4.9
Loss on Ignition %	9.7	7.0	6.7	6.2
Total Nitrogen %	0.18	0.08	0.05	0.04
pH in water (1:2.5)	6.6	7.0	8.3	8.5
pH in M/100 Ca Cl <sub>2</sub>	6.0	6.3	7.6	7.7
Exchangeable Calcium m.e. %	17.5	16.2	34.0	34.2
Exchangeable Magnesium m.e. %	7.20	6.10	9.30	12.20
Exchangeable Potassium m.e. %	0.69	0.25	0.24	0.24
Exchangeable Sodium m.e. %	0.22	0.23	0.34	0.62
Total Exchangeable Bases m.e. %	25.6	22.8	43.9	47.3
Exchangeable Hydrogen m.e. %	5.7	3.1	0.4	0.0
Cation Exchange Capacity m.e. %	31.3	25.9	44.3	47.3
Base Saturation %	82	88	99	100
Soluble Salts m.e. %	0.20	0.20	0.50	0.60
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	183	10	16	5

**AUGER POINT 2**

**HEAVY, CRACKING, SEASONALLY WET CLAY**

LOCATION: Area II; near southern boundary, at junction of Bwakira River with Mgeta River.

DEPTH cm.	8	30	60	90
Moisture 100-105°C %	3.25	4.61	4.84	4.28
200 $\mu$ - 2mm. %	20	13	18	7
50 $\mu$ - 200 $\mu$ %	18	15	12	16
20 $\mu$ - 50 $\mu$ %	7	6	7	8
2 $\mu$ - 20 $\mu$ %	24	20	18	21
<2 $\mu$ %	23	39	38	44
CaCO <sub>3</sub> Equivalent %	-	-	-	-
Loss on Ignition %	10.4	10.7	10.7	8.4
Total Nitrogen %	0.24	0.12	0.10	0.04
pH in water (1:2.5)	7.0	7.2	7.7	8.1
pH in M/100 Ca Cl <sub>2</sub>	6.0	6.0	6.5	7.3
Exchangeable Calcium m.e. %	20.9	21.0	23.9	21.7
Exchangeable Magnesium m.e. %	12.70	10.30	13.00	13.50
Exchangeable Potassium m.e. %	0.88	0.47	0.48	0.38
Exchangeable Sodium m.e. %	0.66	1.70	3.81	3.91
Total Exchangeable Bases m.e. %	35.1	33.5	41.2	39.5
Exchangeable Hydrogen m.e. %	7.2	5.5	3.5	1.7
Cation Exchange Capacity m.e. %	42.3	39.0	44.7	41.2
Base Saturation %	83	86	92	96
Soluble Salts m.e. %	0.30	0.30	0.40	1.40
Assimilable P <sub>2</sub> O <sub>5</sub> (Truog) ppm.	568	172	134	159

## METHODS OF ANALYSIS

**Preparation of sample:** the soil taken from the field is air dried and hand ground to pass a 2 mm screen. A sub-sample is ground in a Morrice mechanical pestle and mortar (agate) to pass a 0.5 mm sieve. The 2 mm sample is used for all determinations except carbon, nitrogen and calcium carbonate equivalent, which are made on the 0.5 mm sample.

**Mechanical analysis:** the sample is dispersed using sodium hexa-metaphosphate (*Calgon*) and sodium hypochlorite. Calcium carbonate is not dissolved. Coarse sand ( $200\mu - 2\text{ mm}$ ) is retained on a suitable sieve; the fractions  $<2\mu$ ,  $2-20\mu$  and  $20-50\mu$  are obtained by sedimentation analysis using a hydrometer (Bouyoucos, 1951). The  $50-200\mu$  fraction is calculated by difference, after making allowance for the organic matter present. The fractions separated are:

International coarse sand	$200\mu - 2\text{ mm}$	
International fine sand	$\left\{ \begin{array}{l} 50\mu - 200\mu \\ 20\mu - 50\mu \\ 2\mu - 20\mu \end{array} \right\}$	U.S. Soils Bureau silt
International silt		
International clay		

**Loss on ignition:** this value is determined using a muffle furnace maintained at  $850^{\circ}\text{C}$  and is corrected for decomposition of calcium carbonate, when this is present.

**Calcium carbonate equivalent:** a calcimeter is used to measure the volume of carbon dioxide evolved from the sample on treatment with 1:3 hydrochloric acid. This is calculated to the equivalent amount of calcium carbonate irrespective of whether other carbonates contribute.

**Organic carbon:** Tinsley's procedure of wet oxidation under reflux with a mixture of 0.4N sodium dichromate, 15N sulphuric acid and 3N phosphoric acid, at  $140^{\circ}\text{C}$  for 2 hours, is used. The excess of dichromate is titrated against ferrous ammonium sulphate using barium diphenylamine sulphonate as indicator.

**Total Nitrogen:** a Kjeldahl digestion is followed by steam distillation of an aliquot using a Hoskins apparatus, the distillate is absorbed in boric acid and titrated with 0.01N hydrochloric acid.

**pH measurements:** these are made electrometrically in a 1:2.5 suspension of soil (a) in water (b) in 0.01M calcium chloride.

**Exchangeable bases:** the soil is leached with neutral normal ammonium acetate. Sodium and potassium in the leachate are determined directly using an Eel flame photometer, while calcium is determined in the same apparatus after the addition of magnesium as release agent. Magnesium is determined spectrographically using a porous cup technique.

**Exchangeable hydrogen:** a modification of the method of Mados is used. The soil is equilibrated with 0.2N ammonium hydroxide and formaldehyde is added. After shaking, the formaldehyde is centrifuged off, 2.5N barium chloride is

added and the mixture again shaken and centrifuged. The supernatant liquid is then titrated with 0.1N sodium hydroxide.

**Soluble salts:** these are determined by conductivity measurement on a 1:5 water extract. The results are recalculated in terms of meq per 100 g soil.

**Assimilable phosphate:** Truog's method with 0.002N sulphuric acid as the extrant is used.

## APPENDIX II - AGRICULTURAL LABOUR DISTRIBUTION

CROP	OPERATION	OCT.		NOV.		DEC.		JAN.		FEB.		MAR.		APR.		MAY		JUNE		JULY		AUG.		SEPT.		
Maize 1 acre (0.4 hectares)	Cultivation Planting Weeding Picking Shelling							20	10		6		14		14		9		9							
Soya* 1 acre (0.4 hectares)	Cultivation Planting Weeding Picking Shelling										5						14									
Sorghum 0.5 acre (0.2 hectares)	Cultivation Planting Weeding Harvesting							10	5		2								5							
Cowpeas 1 acre (0.4 hectares)	Cultivation Planting Weeding Picking Shelling											15	3		6				14							
Groundnuts 1.5 acre (0.6 hectares)	Cultivation Planting Weeding Ridging Picking Shelling					30		10	8		15		15		8				8		11		11			
Cotton 4 acres (1.6 hectares)	Cultivation Planting Weeding Spraying Picking Sorting Burning		40		40	40		40	18		60	20	40	20	40	20	24	20	8		16		42		28	14
			8		8		42				20	20	40	20	40	20	24	8		16		42		30	40	
	Totals	-	48	-	48	70	42	70	51	75	53	55	52	56	48	24	51	-	52	-	53	-	69	-	54	

\*Intercropped with maize

- Notes (1) The figures on the left of each monthly column indicate the number of man-days to be replaced by tractor operations.  
 (2) Seed bed preparation is assumed to require half the number of man-days required for primary cultivation.

- (3) Hand weeding after tractor weeding is assumed to require one third of the number of man-days, 5 per acre (12 per hectare) replaced by the tractor in Feb., 15 per acre (37 per hectare) and one half thereafter, 5 man-days per acre (12 per hectare).

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|--|------|---|
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\* Out of print.





TABLE 1 Average monthly and annual rainfall in mm. (in.) and rain days at four stations in the Lower Mgeta River Area

STATION (Ref. No.)	MVUHA (97.3714)		DUTUMI (97.3700)		BWAKIRA CHINI (97.3727)		KISAKI (97.3708)	
YEARS	10 (1951-56, 1958-61)		15 (1949-63)		8 (1956-63)		15 (1942-55, 1959)	
MONTH	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS
JANUARY	138 (5.45)	8	109 (4.28)	6	115 (4.53)	6	99 (3.88)	6
FEBRUARY	198 (7.79)	8	139 (5.47)	7	189 (7.44)	9	86 (3.39)	6
MARCH	187 (7.35)	10	204 (8.02)	9	164 (6.44)	12	134 (5.28)	8
APRIL	255 (10.05)	16	248 (9.77)	15	201 (7.92)	17	269 (10.58)	14
MAY	93 (3.67)	9	113 (4.46)	8	82 (3.24)	6	156 (6.15)	9
JUNE	30 (1.19)	4	26 (1.04)	3	34 (1.35)	4	17 (0.65)	2
JULY	18 (0.71)	3	10 (0.40)	2	19 (0.74)	2	5 (0.21)	1
AUGUST	43 (1.70)	3	10 (0.40)	1	15 (0.60)	2	8 (0.31)	1
SEPTEMBER	31 (1.21)	3	19 (0.75)	2	22 (0.85)	2	9 (0.35)	1
OCTOBER	72 (2.85)	5	41 (1.60)	3	38 (1.49)	4	25 (0.98)	2
NOVEMBER	65 (2.56)	4	91 (3.59)	4	107 (4.20)	8	49 (1.91)	3
DECEMBER	117 (4.59)	8	76 (2.98)	5	69 (2.73)	6	65 (2.55)	4
YEAR	1,247 (49.12)	81	1,086 (42.76)	65	1,055 (41.53)	78	922 (36.24)	57

TABLE 2 Annual rainfall in mm. (in.) at Bwakira Chini and Dutumi

YEAR	Bwakira Chini		Dutumi	
	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS
1949	na	na	1,013 (39.90)	56
1950	na	na	1,027 (40.45)	76
1951	na	na	1,280 (50.42)	70
1952	na	na	960 (37.79)	51
1953	na	na	604 (23.79)	48
1954	na	na	661 (26.01)	39
1955	na	na	1,195 (47.05)	67
1956	1,004 (39.52)	na	849 (32.92)	59
1957	1,491 (58.72)	na	1,308 (51.48)	71
1958	1,026 (40.40)	69	1,187 (46.72)	51
1959	869 (34.20)	59	708 (27.88)	49
1960	938 (36.94)	82	813 (32.00)	70
1961	1,359 (53.52)	120	1,520 (59.84)	111
1962	724 (28.49)	62	1,361 (53.59)	74
1963	1,028 (40.47)	79	1,861 (71.51)	80
AVERAGE	1,055 (41.53)	78	1,086 (42.76)	65

na = not available.

TABLE 3 Average rainfall in mm. (in.) and percentage of annual rainfall occurring in the wet season December to May and the dry season June to November at four stations in the Lower Mgeta River Area

STATION	YEARS		WET SEASON (Dec. -May)	DRY SEASON (June-Nov.)
MVUHA	10	RAINFALL mm. (in.)	988 (38.90)	260 (10.22)
		% of ANNUAL RAINFALL	79.2	20.8
DUTUMI	15	RAINFALL mm. (in.)	888 (34.98)	198 (7.78)
		% of ANNUAL RAINFALL	81.9	18.1
BWAKIRA CHINI	8	RAINFALL mm. (in.)	820 (32.30)	234 (9.23)
		% of ANNUAL RAINFALL	77.8	22.2
KISAKI	15	RAINFALL mm. (in.)	808 (31.83)	112 (4.41)
		% of ANNUAL RAINFALL	87.9	12.1

TABLE 4 Average rainfall in mm. (in.) and rain days for 5-day periods (and 6-day at the end of October and December) for the months of October, November and December at four stations in the Lower Mgeta River Area

STATION	MVUHA			DUTUMI			BWAKIRA CHINI			KISAKI		
YEARS	13			15			4			19		
MONTHS/ DATES	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS
	mm.	in.		mm.	in.		mm.	in.		mm.	in.	
OCTOBER												
1 - 5	3	0.12	0	0	0.01	0	1	0.03	0	3	0.10	0
6 - 10	2	0.09	1	1	0.04	0	0	0.00	0	2	0.07	0
11 - 15	6	0.24	1	4	0.17	0	4	0.14	0	6	0.25	1
16 - 20	6	0.22	0	4	0.14	0	7	0.26	1	3	0.13	0
21 - 25	10	0.40	1	9	0.35	1	18	0.72	1	5	0.18	0
26 - 31	22	0.85	1	22	0.88	1	10	0.38	1	14	0.57	1
NOVEMBER												
1 - 5	11	0.45	1	12	0.46	0	26	1.04	1	8	0.30	0
6 - 10	8	0.33	1	9	0.36	0	43	1.70	2	7	0.27	0
11 - 15	9	0.37	1	14	0.54	1	15	0.58	1	8	0.32	0
16 - 20	17	0.66	2	22	0.85	1	26	1.04	2	14	0.57	1
21 - 25	5	0.20	1	16	0.63	1	50	1.95	2	4	0.17	0
26 - 30	10	0.39	1	19	0.75	1	30	1.17	1	4	0.15	0
DECEMBER												
1 - 5	13	0.51	1	3	0.12	1	19	0.75	2	6	0.26	1
6 - 10	16	0.63	1	3	0.13	0	10	0.38	1	2	0.09	0
11 - 15	10	0.40	1	11	0.42	1	18	0.69	2	13	0.52	1
16 - 20	21	0.84	2	24	0.96	1	13	0.53	2	13	0.51	1
21 - 25	20	0.79	1	8	0.30	1	14	1.57	2	15	0.61	1
26 - 31	21	0.84	1	22	0.88	1	15	0.60	1	13	0.51	1

TABLE 5 Average rainfall in mm. (in.) and rain days for 5-day periods (and 6-day at the end of May) for the months of April and May at four stations in the Lower Mgeta River Area

STATION	MVUHA			DUTUMI			BWAHIRA CHINI			KISAKI		
YEARS	14			15			4			20		
MONTHS/ DATES	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS	RAINFALL		RAIN DAYS
	mm.	in.		mm.	in.		mm.	in.		mm.	in.	
APRIL												
1 - 5	37	1.44	2	21	0.81	1	20	0.79	2	40	1.59	2
6 - 10	34	1.33	3	41	1.61	2	19	0.75	2	35	1.38	2
11 - 15	43	1.71	3	40	1.56	3	18	0.70	2	38	1.48	3
16 - 20	53	2.08	3	43	1.68	3	30	1.20	3	56	2.22	3
21 - 25	40	1.56	3	53	2.10	3	49	1.93	4	46	1.81	3
26 - 30	44	1.74	3	45	1.78	3	36	1.41	3	50	1.95	3
MAY												
1 - 5	20	0.78	2	27	1.07	2	27	1.07	2	41	1.63	3
6 - 10	27	1.08	2	34	1.33	2	21	0.83	1	43	1.70	1
11 - 15	8	0.31	1	20	0.80	1	13	0.50	1	16	0.64	1
16 - 20	16	0.63	2	18	0.69	2	9	0.34	1	17	0.68	1
21 - 25	16	0.63	1	15	0.58	1	0	0.00	0	11	0.45	1
26 - 31	5	0.21	1	2	0.09	0	4	0.16	0	6	0.25	1

The amount of rain which falls during the wet or dry season varies considerably from year to year, but the variation between dry seasons is usually the greater. At Dutumi between July and December 1960, 56 mm. (2.20 in.) of rain fell compared with 704 mm. (27.70 in.) in the same period in 1961. Table 6 shows the variation during the growing season (January to June).

There is a similarity in rainfall pattern between the stations in the Lower Mgeta River Area, the Central Agricultural Research Station at Ilonga near Kilosa, which is about sixty miles west of Morogoro, and Mombo, which lies on the western side of the Usambara Mountains in Tanga Region (see Table 7). This similarity suggests a comparable climate for the four places and on this assumption the agricultural and silvicultural records from Ilonga and Mombo have been used in compiling this report.

TABLE 6 Rainfall in mm. (in.) during the growing season January to June at  
Bwakira Chini and Dutumi

YEAR	Bwakira Chini		Dutumi	
	RAINFALL mm. (in.)	RAIN DAYS	RAINFALL mm. (in.)	RAIN DAYS
1949	na	na	854 (33.63)	46
1950	na	na	896 (35.28)	59
1951	na	na	950 (37.42)	52
1952	na	na	799 (31.46)	43
1953	na	na	434 (17.10)	30
1954	na	na	625 (24.61)	36
1955	na	na	978 (38.49)	55
1956	937 (36.91)	na	771 (30.37)	52
1957	1,187 (46.73)	na	977 (38.47)	53
1958	856 (33.69)	50	1,011 (39.81)	37
1959	767 (30.20)	47	611 (24.06)	35
1960	871 (34.30)	74	761 (29.98)	64
1961	718 (28.26)	64	827 (32.57)	58
1962	452 (17.83)	44	973 (38.29)	50
1963	492 (19.38)	49	1,142 (44.98)	50
AVERAGE	785 (30.91)	55	841 (33.10)	48

na = not available.

TABLE 7 Average monthly and annual rainfall in mm. (in.) at Bwakira Chini, Dutumi, Ilonga and Mombo

STATION (Ref. No.)	BWAHIRA CHINI (97.3727)		DUTUMI (97.3700)		ILONGA (96.3732)		MOMBO (94.3822)	
YEARS	8 (1956-63)		15 (1949-63)		21 (1944-64)		19 (1942-57, 1959,1961-2)	
MONTHS	mm.	in.	mm.	in.	mm.	in.	mm.	in.
JANUARY	115	4.53	109	4.28	138	5.44	70	2.77
FEBRUARY	189	7.44	139	5.47	136	5.35	64	2.51
MARCH	164	6.44	204	8.02	212	8.33	87	3.42
APRIL	201	7.92	248	9.77	221	8.71	164	6.44
MAY	82	3.24	113	4.46	71	2.80	179	7.06
JUNE	34	1.35	26	1.04	9	0.36	20	0.80
JULY	19	0.74	10	0.40	9	0.35	28	1.12
AUGUST	15	0.60	10	0.40	13	0.50	13	0.53
SEPTEMBER	22	0.85	19	0.75	10	0.41	18	0.71
OCTOBER	38	1.49	41	1.60	36	1.42	37	1.44
NOVEMBER	107	4.20	91	3.59	74	2.90	67	2.62
DECEMBER	69	2.73	76	2.98	135	5.32	72	2.85
YEAR	1,055	41.53	1,086	42.76	1,064	41.89	819	32.27

### Other Climatic Factors

There are no meteorological data, other than rainfall figures, for the Lower Mgeta River Area. It is only possible therefore to record a few general observations based on the experience of people who know the area well, and upon figures available for the Central Agricultural Research Station at Ilonga near Kilosa, which has a similar topographic position and is considered by workers in Tanzania to have a similar climate to that of the Lower Mgeta River Area.

High temperatures are experienced throughout the Mgeta Plain, during the period October to February, when the sun's elevation is greatest. The highest values occur in the pre-rain period when cloud cover is small. The lowest temperatures occur on nights when the sky is clear, generally, in the period June to August. At Ilonga mean maximum temperatures of 33°C (91°F) and mean minimum temperatures of about 16°C (61°F) occur in November. Bwakira Chini and Dutumi are at a lower elevation, 450-480 feet (137-148 m.) above mean sea level, than Ilonga, at 1,850 feet (549 m.). Therefore somewhat higher maximum temperatures may be expected. During the second period of field work from late September to early November, it was noted that afternoon shade temperatures at Bwakira Chini steadily rose from 30°C (86°F) at the beginning of the period to 35°C (95°F) in early November. These temperature measurements were taken by the topographic surveyors from the Directorate of Overseas Surveys in connection with the calibration of their equipment.

With the approach of the wet season, that is during the period October to December, the humidity progressively increases to a high level which persists throughout the rains.

## GEOLOGY

The Uluguru massif is mainly composed of crystalline and metamorphic rocks. Pyroxenite granulite with garnet and some hornblende occur between Kisaki and Dutumi. Crystalline limestone and porphyroblastic gneisses are found north-east of Dutumi, but Karroo conglomerates and shales occur just north of Kilengezi.

The Mgeta plain consists of alluvial deposits and heavy, cracking, seasonally wet clays, locally termed Mbuga, overlying crystalline and metamorphic rocks; the alluvium have been derived from decomposed micaceous metamorphic rocks of the surrounding hills.

## TOPOGRAPHY (see Map 2)

The Uluguru massif, occupying about 780 square miles (2,020 square km.) and with Kimhandu rising to 8,681 feet (2,646 m.) above mean sea level at its highest point, dominates the whole of the Upper Ruvu Basin. To the south the foothills of the range fall away steeply from about 2,000 feet (610 m.) to the flood plain of the Mgeta River. The flood plain is virtually flat, there being a fall of only 55 feet (17 m.) within a distance of 2 miles (3 km.) from its northern edge to the Mgeta River. The Mgeta and other rivers, notably the Mngazi, Bwakira, Dutumi and Mvuha rise within the Uluguru Mountains.

Within the Lower Mgeta River Area there are three distinct topographic units, namely the lower slopes of the Uluguru foothills, the flood plain of the Mgeta River and the valley bottom. On the lower slopes of the foothills gradients vary between about 2 and 6 per cent, whilst on the flood plain and in the valley bottom they seldom exceed 2 and 1 per cent respectively. Minor topographic variations occur on the flood plain in the form of small ridges and shallow depressions, but the height differences are often too small for these features to be mapped from the aerial photographs. Nevertheless they are important in relation to soil profile development.

## HYDROLOGY

The water resources of the Lower Mgeta River Area are plentiful and are derived mainly from a network of permanent and seasonal rivers and streams, of which the largest and most important is the Mgeta.

The Mgeta rises in the Uluguru Mountains and flows over steep gradients for more than 70 miles (113 km.) until its course levels out on reaching the plains. Here it flows eastward for a further 50 miles (81 km.) before turning north to join the Ruvu. It forms the southern boundary of the western sector of the area under examination. Here its bed is about 100 feet (30 m.) wide and its banks form a levee about 12 feet (4 m.) above the surrounding flood plain. At the time of inspection, in November 1964, immediately before the onset of the rains, it was flowing to a depth of 1.5 to 2 feet (45-61 cm.). During the rains however, when it is in spate, the lower lying areas of the surrounding plain are flooded. Flooding in the vicinity of Bwakira Chini is however very exceptional and lasts for only a few hours. Nevertheless it is worth recording that in the 1963 rains, the Mgeta burst its banks at Kisaki, where it debouches from the mountains, and inundated a considerable area of fertile agricultural land nearby before rejoining its normal course.

The north bank tributaries of the Mgeta, that lie within the boundaries of the project area, also rise in the Uluguru Mountains, and flow southwards

towards the Mgeta. Only one however, the Mngazi, is perennial and flows directly into the Mgeta, the remainder flow into the larger depressions in the flood plain. Formerly the course of the Mngazi joined the Mgeta just south of Bwakira Chini; it now does so south of Kisanga (see Map 3). Its former course now only flows seasonally, during and immediately after the rains.

To the east of the Mngazi, the Bwakira flows during the rains into a swamp north of the Mgeta. This river is an important source of water for the local people throughout the year, as they are able to obtain water by digging in the sandy bed when the river ceases to flow.

Further east there are several minor seasonal streams including the Greater and Lesser Kikundi. Both however, flow into flood plain depressions just below the foothills, and cease to flow soon after the rains cease.

The only other river of significance is the Dutumi. Although permanent, its defined course is lost in a swamp just south of the minor settlement of the same name. No flow data are available, but at the time of inspection in November 1964 the flow was estimated to be 5 cusecs upstream of the settlement. At present the local people draw their water from this river. The rock bar noted by SOGREAH (1962) is a useful point for the control and extraction of water. Many years ago the water supply for a ginnery was obtained at this point.

About four miles east of Dutumi lies the Gombo Swamp, which is frequented throughout the year by large and small game. For part of the year it is fed by two small seasonal streams. Further recharge is provided by surface and subsurface drainage from the foothills.

Hydrological information regarding the behaviour of all these rivers and streams is incomplete, but recommendations have been made by CHABLANI (1961) and SOGREAH (1962) for their further study in relation to irrigation development. However, the existing evidence suggests that expansion of rain-fed agriculture is possible.

Apart from the rivers and streams, additional sources of water have been found by digging shallow wells. These make a useful contribution to supplies, but in years when the dry season is lengthy and severe, and heavier demands are made on them, the wells dry up. It was noted that one well on the Bwakira Estate, used during the field work, was slightly saline. It was also observed that, in the vicinity of Dutumi, several apparently permanent water holes occur at the junction of the colluvial soils of the foothills with the heavy cracking clays of the flood plain.

## SOILS

Three main soil types occur, colluvial, alluvial and heavy, grey, cracking, seasonally wet clays. Their distribution is closely correlated with the topographic units into which the study area has been divided. The colluvial soils occur mainly on the slopes of the Uluguru foothills, the alluvial soils on the flood plain and the clays, which are similar in nature to black cotton soils, are associated with valley bottom sites and depressions, in the flood plain.

## Colluvial Soils

The slopes at the foot of the escarpment are steeper than those of the other two topographic units. On these slopes the soils range in texture from coarse sandy loam to coarse sandy clay loam and contain varying amounts of stones and gravel throughout the profile. To the east of Dutumi soil colours are generally reddish brown, whilst to the west greyish brown to brown soils occur. These slightly acid, pH 6.0-6.5, colluvial soils are usually deeper than 120 cm. (47 in.) and are moderately rich to rich in the main plant nutrients, except for nitrogen.

Along the boundary between the lower slopes of the foothills and the flood plain, fine textured almost stone-free colluvial material overlies, and is to a certain extent mixed with alluvial material.

## Alluvial Soils

On the flood plain to the west of Dutumi the soils are of alluvial origin. Their profiles reveal the deposition of successive layers of alluvium varying in texture from coarse sand to clay. The texture of the upper horizons of these soils varies with minor topographic differences, and is heavier in the depressions. Pale grey, brown and yellowish brown colours predominate and the soils contain no stones or gravel. The chemical analyses indicate a neutral pH of 7.0-7.5, and a high content of assimilable phosphates and exchangeable bases.

As the name 'flood plain' implies, the soils of this topographic unit are subject to occasional inundation. This is due partly to the flooding of the main channel of the Mgeta river and its tributaries and partly to direct surface runoff from the escarpment.

## Heavy, cracking, seasonally wet clays

Heavy, dark grey calcareous clays with impeded drainage occur on the flood plain east of Dutumi and in the major depressions west of Dutumi. They also occupy the whole of the valley bottom sites except for narrow levees, consisting of fine sandy alluvium, along the banks of the Mgeta River and few of the larger drainage channels. These clays are subject to inundation during the wet season. In dry weather large cracks appear in the soil surface as the soil dries out and shrinks. The chemical analyses show these soils to be slightly alkaline, pH 7.5-8.0, and rich in the main plant nutrients. SOGREAH (1962) observed slight salinity in some profiles. Their main disabilities appear to be physical, namely the liability to flooding and the heaviness of the soil, which makes cultivation difficult.

## VEGETATION (see Maps 5a-d)

The vegetation of the lower slopes of the foothills consists of a patchwork of moist semi-deciduous forest and parkland. The characteristic trees of the forest are *Khaya nyasica*, *Sterculia appendiculata*, *Trichilia roka*, *Albizia glaberrima* and *Ficus sycamorus*, with emergents attaining a height of 100 feet (30 m.) in places. The best developed forests have an understorey of shade demanding species, notably *Conopharyngia* sp. and *Chrysohyllum* sp. The predominant element of the parkland is the grass *Panicum maximum* which grows as a dense sward up to 7 feet (2 m.) high, and in which isolated forest trees, *Acacia polyacantha* subsp. *campylacantha*, *A. goetzei* subsp. *microphylla* and *Kigelia aethiopica* are scattered.

While the variation in topography is small throughout the flood plain, minor differences in elevation have a considerable effect on the vegetation. Forest and thicket are found chiefly on the higher lying ground while scrub occurs in the intervening areas. The forests contain most of the species mentioned above together with *Chlorophora excelsa*, *Erythrophleum suaveolens*, *Antiaris usambarensis* and the fan palm *Borassus aethiopum*. The scrub of the lower lying heavy textured soils consists characteristically of *Acacia goetzei* subsp. *microphylla*, *A. nigrescens*, *Combretum constrictum*, *C. chionanthoides* and *C. imberbe* with scattered *Hyphaene coriacea*. Much of the higher land along the northern boundary of the flood plain, has been cleared for cultivation, but where it has been allowed to revert to natural vegetation, scrub has developed.

Three types of vegetation occur in the valley bottom site and their occurrence is related to the elevation and drainage of the land.

- (1) Farthest from the river, bordering the flood plain, is an open scrub community dominated by *Acacia nigrescens*, *Combretum constrictum*, *C. chionanthoides*, *C. imberbe* and the grasses *Panicum maximum* and *Heteropogon contortus*.
- (2) In the main part of the area between the river and flood plain is an *Echinochloa* grassland.
- (3) Riparian forest, occurs as a narrow band along some of the drainage lines on the alluvial soils. It contains many forest species mentioned above, notably *Sterculia appendiculata*, *Khaya nyasica*, *Albizia glaberrima* and *Kigelia aethiopica*.

## GAME AND PESTS

South of the Mgeta River, but separated from it by a narrow belt of sparsely settled bush, lies the Selous Game Reserve. This reserve occupies a wide expanse of country, and its proximity to the project area increases the hazards to agricultural development which are likely to arise from game movement and damage. The extent of the inroads made by game is governed in part by the density of human settlement. The country between Kisaki and Bwakira Chini is less affected than the land to the west and south-east of Dutumi. Availability of water also influences the movement of game, and concentrations of them increase during the rains when low lying sites are inundated. Damage to isolated areas of cultivation is considerable and has been a limiting factor in agricultural expansion in the past.

Of the larger species, elephant and buffalo are the most important. Moving northwards from the Selous Game Reserve they cross the Mgeta River and feed in the woodlands and on the grasslands of the flood plain and on the lower slopes of the Uluguru foothills. During the drier weather they tend to concentrate in the neighbourhood of the Mgeta and around the open water of the Gombo Swamp. Hippopotamus are also to be found in the immediate neighbourhood of the Mgeta where their tracks become minor seasonal watercourses.

Waterbuck, warthog and bushpig also frequent the wooded areas. Baboons and other smaller monkeys cause crop losses throughout the area at harvest time.

Small flocks of *Quelea quelea* also cause considerable losses to grain crops, and much time is spent in scaring them away.

The project area lies within the extensive eastern tsetse fly belt of Tanzania. However, incidence is only significant where game are present and vegetative cover is favourable. A reconnaissance survey carried out in October and November 1964 by a Fly Control Officer showed that in the vicinity of Bwakira Chini densities were extremely low. Four flies of *Glossina brevipalpis* and one of *G. pallidipes* were found, but they were thought to have been brought in by vehicles moving through Dutumi; in the opinion of the Control Officer therefore, this area was virtually fly free. His investigations around Dutumi however, disclosed the presence of *G. pallidipes* in the broken forest, between the Dutumi - Kilengezi road and the Mgeta River. Local opinion suggests that the fly densities vary according to the movement of game in the area, concentrations being highest at the beginning and the end of the rainy season.

### ENVIRONMENTAL ZONES

As there is a close interrelationship between topographic position, soil type, drainage and vegetation it has been possible to divide the Lower Mgeta River Area into three environmental zones. These are the Scarp Foot, the Flood Plain and the Valley Bottom. Table 8 summarises the main characteristics of each environmental zone.

TABLE 8. Environmental Zones of Lower Mgeta River Area

ZONE	TOPOGRAPHIC POSITION	AREA sq. miles (sq. km.)	SLOPE %	SOIL TYPES	DRAINAGE	VEGETATION
A	Scarp Foot	31 (81)	2 - 6	Stony, sandy to sandy clay loam colluvium	free	forest and parkland
B	Flood Plain	109 (283)	0 - 2	1. Fine textured colluvium over- lying alluvium on boundary with Scarp Foot	moderately free	forest, parkland and scrub
				2. Sandy to clay alluvium	moderately free	
				3. Heavy, cracking seasonally wet clays (Mbuga) in depressions	impeded, seasonally waterlogged	parkland and scrub
C	Valley Bottom	50 (130)	1	1. Heavy, cracking seasonally wet clays (Mbuga)	impeded, seasonally waterlogged	scrub and grassland
				2. Fine sandy alluvium	moderately free	riparian forest



PLATE 1 Broken forest with *Acacia polyacantha* subsp. *campylacantha* trees and *Panicum maximum* grass on alluvial soil, Lower Mgeta River Area



PLATE 2 Clearing broken forest prior to cultivation, Bwakira Chini



PLATE 3 Preparation of land cleared from broken forest for cotton cultivation, Bwakira Chini



PLATE 4 Parkland with *Acacia goetzei* subsp. *microphylla* trees and *Heteropogon contortus* grass on alluvial soil, Lower Mgeta River Area



PLATE 5 Scrub with *Acacia goetzei* subsp. *microphylla* trees, *Salvadora persica* shrubs and *Heteropogon contortus* grass on heavy, cracking, seasonally wet clay, Lower Mgeta River Area



PLATE 6 Land prepared for rice cultivation; formerly scrub on heavy, cracking, seasonally wet clay in valley bottom site close to Mgeta River, Bwakira Chini

## HUMAN ASPECTS

### POPULATION

For many years the Lower Mgeta River Area has been occupied by the Kutu tribe. Moffett (1958) assigns this tribe to the Northern Hill Bantu Group. Primarily its members are agriculturists rather than pastoralists and even today the keeping of livestock plays little or no part in their activities.

Close by in the Uluguru Mountains live the more numerous Luguru tribe. This tribe is also a member of the Northern Hill Bantu Group and is predominantly agricultural in its activities.

During recent years there has been an infiltration by members of the Luguru tribe into the plains of the Mgeta River, on account of increasing pressure of population and deteriorating soil resources in the restricted cultivable areas of their own land. Initially this movement was seasonal and involved a stay on the plains for a period sufficient only for the planting and harvesting of small areas of annual crops. In the past few years, however, settlement has become permanent, and today there is considerable dilution of the original Kutu population. Luguru settlers are industrious, possibly because they are conditioned to hard work by the environment prevailing in the mountains. Apart from this permanent settlement, there is also a small and variable seasonal flow of labour from the foothills to the plain.

The 1957 census recorded a total population of 14,367 in the Lower Mgeta River Area distributed by age and sex as shown in Table 9.

TABLE 9. Population, by age and sex, for Lower Mgeta River Area (Territorial census No. 138), 1957

AGE	MALE	FEMALE	TOTAL
UNDER 16 YEARS	2,951	2,694	5,645
16 YEARS AND OVER	4,136	4,586	8,722
TOTAL	7,087	7,280	14,367

No data are available to show how these figures are distributed between the two tribes concerned, but evidence suggests that so far the Luguru population is but a small proportion of the total.

Current figures for the number of taxpayers show that for the administrative areas of Kisasi, Bwakira Chini and Dutumi the total is 3,884, of which 2,318 reside at or near Kisasi, 256 at Bwakira Chini and 549 at Dutumi. Assuming that 1 taxpayer represents 4.5 members of the population there would be today a total of nearly 18,000 people in the project area. To this must be added a small number, between 50 and 100, of Asians and Europeans associated with the few estates in the area, and with trading activities in the minor settlements of Kisasi, Mngazi, Dakawa, Bwakira Chini and Dutumi.

## **ADMINISTRATION**

Administrative control, in respect of both central government and local authority matters, is exercised by a Divisional Executive Officer, with offices at Bwakira Chini. He is responsible to the Area Commissioner, and in turn to the Regional Commissioner at Morogoro.

Agricultural policy and extension work are carried out by one Assistant Field Officer stationed at Dakawa and a second stationed at Dutumi.

## **COMMUNICATIONS**

There is no rail link between the Lower Mgeta River Area and other centres, neither is there an airstrip. The nearest railhead is 75 miles (121 km.) north by road at Morogoro, which lies astride the main east/west railway line linking Dar es Salaam with Lakes Victoria and Tanganyika. 80 miles (129 km.) east of the railhead, the line branches northwards to serve the Tanga, Moshi and Arusha Regions, Kenya and Uganda.

Morogoro is also situated on the east/west trunk road which connects Dar es Salaam with the developing areas of the Kilombero Valley and the Southern Highlands Region. The construction of the north/south trunk road linking Dar es Salaam with the Southern Region is proposed in the Five-year Development Plan (1964/65-1968/69). A preliminary alignment survey indicated that this road would pass close to Dutumi (see Map 2).

For the time being however, access is gained by a road of only indifferent standard, normally maintained with funds provided by the local authority. The amount of money available is small and the alignment is such as to make maintenance difficult. There are frequent crossings of streams and rivers which rise in the Uluguru Mountains, and in places the road follows rather precipitous hill-sides. As a result, in times of very heavy rainfall washaways and damage to drifts and bridges occur, and almost every year communications are completely cut.

Not only does this road provide access to Bwakira Chini and Dutumi but also to centres of population and agricultural production at Mvuha, Magogoni and Kilengezi to the east, Bwakira Juu and Kolero in the foothills to the north, and Dakawa, Mngazi, Kisasi and Kilengwe to the west.

## **PRESENT LAND USE**

### **Pattern of land use**

The area from Kisasi to Kilengezi, north of the Mgeta, is devoted predominantly to smallholder agriculture. There is a ginnery at Dutumi which was established many years ago for the processing of cotton and kapok. In the minor settlements sited along the Kisasi - Kilengezi road, traders provide for the needs of the community. Some small scale forestry activity takes place west of Kisasi where millable timber is extracted from the forests and exported from the district.

The main agricultural activity is the production of crops. Although there are extensive areas of grazing, the numbers of livestock are small. One herd of cattle is maintained on an alienated estate near Kisasi, and close to it a few work-oxen have been introduced recently. Incidence of bovine trypanosomiasis necessitates regular prophylactic drug treatment. The absence

of sheep and goats is noteworthy and contrasts with the numbers found in the eastern Uluguru foothills where the farmers keep small livestock and tether them on their holdings.

The pattern of agriculture is governed by the conditions prevailing in the three environmental zones defined in this report. At the same time the extent to which the land is used is affected by the density of settlement. This is greatest in the west and thins out to the east. Consequently the area of cultivated land is greatest in the west. This effect is associated with corresponding gradations in soil fertility, availability of water supplies and increasing liability to damage and depredation by game animals.

Within the first of these zones, the Scarp Foot, the grass cover is scanty. Because the soils are poor, shallow and stony it is little used for agriculture except at its junction with the next zone, the Flood Plain, where there is a narrow band of deeper soil on gentler slopes. Fires occur extensively and with regularity throughout the forest and parkland of the Scarp Foot during the dry season. In those areas between Dutumi and Kilegezi where there is no settlement, herds of elephants feed on the steep slopes of the Scarp Foot.

The Flood Plain comprises the greater part of the area studied and is used extensively for crop production. In the west, where this zone is at its widest, settlement and cultivation have progressively expanded as far as the Bwakira River. A comparison of the 1952 and 1964 aerial photography shows that much of this expansion has taken place during the last twelve years. A belt of woodland and a small kapok estate between Bwakira Chini and Dutumi were a barrier in the past to further expansion eastwards. Today however, local resources are being employed on clearing some of this land preparatory to bringing it into production. Little land is now left which is not allocated, occupied or cultivated.

East of Dutumi the density of settlement decreases where the belt of easily worked soils becomes narrow. Although exploited to only a limited extent in the past, this belt, like the neighbouring land, is now being cleared or is reserved for future use.

The third Environmental Zone, the Valley Bottom, contains predominantly heavy clay soils which are mainly uncultivated. This zone lacks developed water supplies and harbours a wide range of game animals. Near the Mgeta River however, a narrow fringe of workable fine sands occur, which are devoted to crop production. It was also observed that small inroads into the neighbouring heavier soils were being made. Elsewhere in this zone, and towards the eastern limits of the study area, where game are particularly abundant, there is little human activity.

### **Local agricultural practices**

Generally in the Lower Mgeta River Area vegetative growth is profuse except on the shallowest of soils and little, if any, fertiliser has been used to increase crop production. In fact, in the limited range of trials conducted in the area, few significant responses to the use of fertilisers have been obtained. While the profusion of growth is an encouraging indicator of the productivity of the land, and of high yields under good management, it also presents problems of weed control during the growing season. To overcome the competition of weeds, especially in the cotton crop, much time is given each year to hand weeding. In the last two years however,

facilities for mechanical cultivation have been improved by the introduction of a few tractors, ploughs and harrows. Except for small areas of groundnuts the practice of ridging is not adopted as a cultivation technique.

The climate and elevation of the area are favourable to a wide range of crops. Selection from within this range has largely been determined by the nature of the soils, their permeability and susceptibility to inundation. Although the range of crops grown in the area as a whole is wide, it was observed that many of them play a minor or insignificant part in the cropping pattern.

Maize is the staple food crop and is produced mainly on the lighter soils near the mountain massif where the rainfall is higher. Nearer the Mgeta River, where, rainfall is rather less sorghum is grown both as a food crop and for the brewing of local beer. Peas, beans and cassava are also grown for food, while cowpeas fulfil the dual function of subsistence and cash crop. To a lesser extent groundnuts are also cultivated. Mangoes, bananas, a small quantity of citrus and tomatoes are offered for sale in the markets of the minor settlements and consumed locally.

The most important cash crop is cotton, of which about 1,500 bales are produced annually. Kapok is also harvested in large quantities although ruling prices are low and likely to remain so. As a result it is no longer a major cash crop, but is regarded as a reliable source of money to pay annual taxes. Small areas are devoted to the production of sesame, sunflower and castor. In the past, one alienated estate grew sugar cane for jaggery manufacture, of which up to 100 tons a year were sold in Morogoro. Cane was also used for the production of beer. A few cashew nuts are also produced on the lighter soils, but are not sold outside the area as there are no marketing facilities.

Within the last year planting of sisal has been started and a small plot of kenaf, *Hibiscus cannabinus*, was successfully grown in 1962/3 on an estate near Bwakira Chini.

On the heavier soils which are predominately clay, the area cultivated is smaller and the range of cropping more restricted. Rice is the main food and cash crop and is planted when the floods of the Mgeta River and its tributaries recede. A quick growing local variety of maize is also sometimes grown as a catch crop at the beginning and the end of the rains.

Usually crops are grown in pure stand, although occasional instances of the intercropping of short term maize with rice, or sesame with maize do occur.

The size of the holding on which most of the above mentioned crops are grown varies considerably, the average size being about 4.5 acres (1.8 hectares). Approximately 1 acre (0.4 hectares) each is devoted to maize, sorghum, cowpeas, and cotton and 0.5 acre (0.2 hectares) to rice. Variations in this pattern occur however, and some of the holders of larger acreages cultivate up to 3 or 4 acres (1.2 - 1.6 hectares) of cotton as well as subsistence and other cash crops. During peak periods of work such a farmer employs hired labour, in addition to the assistance provided by his wife and older children. The family unit represents a maximum potential labour force of four or five adult equivalents per day, though the average is probably no more than two or three.

## EXPERIMENTAL RESULTS

A series of agronomic trials were carried out by the Central Research Station, Ilonga, both at Ilonga and in the Lower Mgeta River Area at Kisaki and Dutumi. The experiments at Kisaki were conducted on an alluvial soil liable to seasonal waterlogging near the village, but were discontinued in 1958 because of game damage. An alternative site was selected in 1959 on an alluvial, clay loam soil near the Dutumi River. Work ceased here at the end of the 1963/4 season when the land was required for other purposes.

Trials were conducted on these sites to select suitable varieties and establish optimum times of planting for maize, sorghum, groundnuts, sesame and soya beans. Although yields obtained were frequently lower than those at Ilonga, this fact may be accounted for by the remoteness and inaccessibility of the sites from the parent Research Station which led to difficulties of supervision. This does not however detract from the value of the results in selecting a practicable combination of crops for planting in an area where optimum times of planting are a particularly important factor in achieving an even spread of labour utilisation.

Akehurst and Sreedharan (1964) have reported on the optimum times of planting for a range of crops throughout the country. Their report demonstrates a more or less consistent effect of planting time upon yield and at the same time provides a useful guide to potential yields.

The planting time to yield relationship shows either:•

- '(a) a peak at the first planting followed by reduced yields for later plantings, or
- (b) ascending yields for the first one or two plantings, reaching a peak, followed by decreasing yields for later plantings' (*op. cit.*).

It is apparent that, in the case of maize the optimum time of planting lies within the period from late January until the end of February. Under satisfactory conditions of management yields as high as 3,000 lb. per acre (3,367 kg. per hectare) can be obtained.

The optimum time to plant sorghum is less well defined because the number of experiments was fewer. Nevertheless the figures available and current practice in the area confirm that crops planted in early February can reach a yield as high as 1,500 lb. per acre (1,684 kg. per hectare).

If groundnuts are planted between mid January and early February yields of 1,000 to 1,400 lb. per acre (1,121 - 1,569 kg. per hectare) can be obtained. Soya beans can be planted throughout February, but yields at present are no more than half the figure for **g**roundnuts. On the other hand new strains and selections have recently been tried at Ilonga and yields varying from 1,700 to 2,100 lb. per acre (1,905 - 2,354 kg. per hectare) were obtained when the crop was planted in mid February 1964.

Yields of sesame have been only moderate in trials conducted since 1959, although it has been established that the most satisfactory time for planting this crop lies within the first two weeks of February. Furthermore, in 1964 it was confirmed that a factor inhibitory to growth and previously thought to be a virus, was in fact a mite, and trials in which preventative spraying was done gave yields as high as 1,000 lb. per acre (1,121 kg. per hectare).

Agronomic data for cotton are more abundant, and its management is well understood. Yields at Kisaki and Ilonga are given in Table 10.

TABLE 10 Yields of seed cotton in lb. per acre (kg. per hectare) at Ilonga and Kisaki

YEAR	1955	1956	1957	1958	1959	1960	1961	1962
ILONGA	1,880 (2,107)	1,550 (1,737)	1,600 (1,793)	1,880 (2,107)	2,100 (2,354)	1,200 (1,345)	1,910 (2,141)	2,270 (2,544)
KISAKI	-	1,122 (1,258)	1,113 (1,247)	1,302 (1,459)	1,170 (1,311)	1,935 (2,169)	-	-

On the basis of these figures an average of 1,200 lb. (1,345 kg. per hectare) of seed cotton per acre for individual growers need not now be considered excessive.

Note should also be taken of results from the first year of experiments at Ilonga designed to facilitate mechanical spraying of cotton. It has already been established that although losses occur due to tractor damage, the benefits derived from using heavier equipment outweigh the losses. Moreover results in 1964 demonstrated that by adopting a spacing of 2 ft. x 6 in. (61 cm. x 15 cm.), that is 34,560 plants per acre (85,363 per hectare) not only was the height of the cotton reduced, but the yield from the more closely spaced crop was 89% greater than that of the 3 ft. x 1 ft. (91 cm. x 30 cm.), that is 14,520 plants per acre (35,864 per hectare) spaced controls. If these results are maintained in future experiments they will have an important bearing on the farming system adopted for cotton growing at Bwakira Chini and Dutumi.

Of the other crops already grown in the project area, cowpea is also being examined at Ilonga. Observations have been made of a large number of varieties some of which are very promising. Yields of up to 1,900 lb. per acre (2,130 kg. per hectare) have been recorded from single plant selections of local material, when as many as five pickings were made at harvest.

The cultivation of kenaf, *Hibiscus cannabinus*, is well understood. Observations made at Ilonga by Turner and Hartzook (1965) and in the Kilombero Valley show that when grown on well drained fertile land where the rainfall of 760 mm. (30 in.) is spread over at least 4 months, fibre yields of 2,000 to 2,500 lb. per acre (2,242-2,802 kg. per hectare) can be obtained. The variety 985/986 ECR has mainly been grown but improved planting material will probably be available in the future. When planted in December or early January, the stems are ready to harvest at the end of April. The recommended seed rate is 30 lb. per acre (34 kg. per hectare) sown in 9 in. (23 cm.) rows, thinning of plants being carried out where the stand is dense.

Kenaf is a host to several cotton pests, notably stainers, *Dysdercus* spp. However, cotton is already grown in the Lower Mgeta River Area, where the Baobab, *Adansonia digitata*, and *Sterculia appendiculata* and Kapok grow, which are also hosts to stainers. Under these conditions, yields of 900 lb. per acre (1,009 kg. per hectare) or more are obtained when the crop is sprayed. The Senior Research Officer at Ilonga thinks that if normal spraying precautions are taken kenaf and cotton can both be grown in the same locality.

There is little information about the labour requirements for harvesting and processing kenaf, but records are to be kept at Ilonga during the current season.

Soil fertility trials have been conducted at Ilonga for several years using crops which are suited to the Lower Mgeta River Area. In 1964, for the first time since these experiments were started, significant yield responses were obtained when fertilisers were applied to maize, sorghum and cotton. The agronomist thinks this may be the first sign of declining soil fertility after 10-15 years of continuous cultivation.

A few fertiliser trials have been conducted at Bwakira Chini and Dutumi without obtaining significant crop responses. Doubts have been expressed at Ilonga whether economic returns could be obtained from fertiliser applications to these fertile soils.

The merits of intercropping at both Ilonga and Dutumi have been tested since 1957 using several combinations of crops including maize and groundnuts, sorghum and groundnuts, castor and groundnuts, castor and soya bean, and maize and sesame. The results when expressed in overall cash returns show the intercropping system to be more economic.

Some aspects of rotational cropping have also been studied over the last five years although the programme is incomplete. Cotton, maize, and sorghum were the crops used.

## PRODUCTION AND MARKETING

The yields of the various crops grown are related to the standards of management which frequently fail to make the best use of the natural resources. The average yields and returns obtained by the local farmers as estimated by the Tanzanian Ministry of Agriculture are shown in Table 11.

TABLE 11 Present Average crop yields and gross returns in the Lower Mgeta River Area

CROP	YIELD		GROSS RETURN	
	lb./acre	kg. per hectare	sh./acre	sh./hectare
SEED COTTON (SPRAYED)	900	1,008	475*	1,173
SEED COTTON (UNSPRAYED)	300-400	336-448	158*	390
SORGHUM	600	672	80	198
MAIZE	1,000	1,120	95	235
COWPEAS	600	672	156	385
PADDY	1,000	1,120	200	494

\* 90% Grade A at -/56 cents per lb. (1/23 cents per kg.)

10% Grade C at -/24 cents per lb. (-/53 cents per kg.)

Until recently the primary consideration in the agricultural development of the area was the provision of food for the cultivator and his family. An increasing emphasis is now being laid upon the production of crops for sale. Although there is surplus production of certain crops in the area, this

fluctuates from year to year. The estimated gross value of this surplus is £40,000 - £50,000 per annum. However, the records examined were incomplete, and it was not always possible to obtain crop production figures for the Lower Mgeta River Area, because they were incorporated in returns covering a much larger area. The total value may therefore be greater than the figure suggested. The figures set out in Table 12 are the current prices paid to farmers for a number of the crops grown in the area.

TABLE 12 Crop prices paid to farmers in 1965 in the Lower Mgeta River Area

CROP	LOCAL GRADE	PRICE sh./cents/kg.
BEANS	1	-/60
BEANS	2	-/50
CASHEW	-	-/60 to -/70
CASTOR	-	-/50
COTTON	A	1/23
COTTON	C	-/53
COWPEAS	-	-/35
GRAM	-	-/50
GROUNDNUTS	-	1/-
KAPOK	1	-/40
KAPOK	2	-/35
MAIZE	1	-/22
MAIZE	2	-/19
PADDY	-	-/45
RICE	1	-/90
RICE	2	-/75
SESAME	-	1/-
SORGHUM	-	-/30
SOYA	-	-/40
SUNFLOWER	-	-/40

In the past surplus subsistence crop production was bought by traders and either resold locally or exported from the district. Cash crop production was also handled in the same way except for cotton and kapok which were sold to the ginnery at Dutumi. More recently the Ukutu West Co-operative Society, which operates at Dutumi, Mngazi, Kisanga, Bwakira Chini and Milengwelengwe, has purchased the cotton from the grower and transported it to the ginnery. The Society is now undertaking the purchase and handling of a wider range of crops.

In addition, the Co-operative Society operates a depot at Dakawa, where wheeled tractors are hired out to local farmers. Some of the nearby estate owners also provide a similar service. The cost of this service is rather high because of the time taken between operations involving only small areas of land. The farmers pay sh. 50/- per acre (sh. 124/- per hectare) for ploughing and sh. 25/- per acre (sh. 62/- per hectare) for harrowing.

There is transport by lorry and bus between the district and Morogoro. According to the Divisional Executive Officer, the current rate for the

transport of goods by lorry was sh. 1/50 per ton/mile (sh. -/80 per metric ton/km.).

The trading cycle depends on the timely despatch of produce out of the area and delivery of goods into it. The present standards of communication are far below those necessary to ensure that the cycle is uninterrupted, and there are long periods in some years when the roads are unusable. As a consequence both despatches and deliveries are delayed and perishable goods deteriorate. This situation causes financial losses to the farmer, and creates a sense of futility for a farmer planning any expansion of his agricultural production. While this may be dispelled to some extent if he sells to a co-operative or trader, the ease with which he can do so, and the prices he is likely to receive for his produce will still be affected by the problems of communications.

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## PART II - ENVIRONMENT

### PHYSICAL ASPECTS

#### SITUATION (see Maps 1 and 2)

The Lower Mgeta River Area of the Upper Ruvu Basin is situated south of the Uluguru Mountains in Eastern Tanzania. It lies 100 miles (61 km.) west-south-west of Dar es Salaam and 40 miles (64 km.) south of Morogoro. This area occupies about 190 square miles (492 sq. km.) and is bounded on the north by the foothills of the Uluguru massif and on the south by the Mgeta River. It stretches from a few miles west of Kisaki to Kilengezi in the east. Within it lie several minor settlements of which two, Bwakira Chini and Dutumi, are the main concern of this report. They are situated four miles apart at altitudes of 485 and 450 feet (148 and 137 m.) above mean sea level respectively on a longitude of 7° 23'S and a latitude of 37° 48'E.

#### CLIMATE

##### Rainfall

The rainfall data available for the Lower Mgeta River Area, and for Bwakira Chini in particular, are insufficient to establish accurate estimates of the annual rainfall at each station. However, if the rainfall figures for Bwakira Chini and Dutumi are considered in relation to those for the neighbouring settlements of Kisaki and Mvuha a fuller picture emerges (see Table 1).

There is almost certainly an increase in rainfall from west to east due to the relative proximity of each station to the Uluguru foothills, Kisaki being the farthest away from the escarpment, and Mvuha the nearest. In this connection it is reasonable to assume that the rainfall is less on the parts of the Mgeta flood plain farthest from the escarpment. The average annual rainfall for Bwakira Chini probably lies between 960 and 1,060 mm. (38-42 in.) and for Dutumi between 1,020 and 1,120 mm. (40-44 in.). At both stations, however, considerable variations from year to year in total rainfall can be expected. Table 2 shows the extent of this variation over the past few years.

Table 3, summarising the seasonal distribution of the rainfall, shows that over three-quarters of the annual rainfall occurs between the months of December and May. Within this period there is a tendency for a small decrease in rainfall to occur at about the beginning of February and for a climax to be reached in April.

It is of particular interest to the agriculturist and forester to study the beginning and end of the wet season in selecting planting dates. A close examination of Tables 4 and 5 shows that a more or less consistent pattern of rainfall commences about the middle of December and finishes about the middle of May. Although sporadic heavy showers or periods of more prolonged rain occur before the start of the wet season, between them there are usually comparatively long periods of drought. After about the 10th - 15th May the rainfall decreases markedly both in amount and frequency.