TCP/URT/6759/8961
Field Document 1

TECHNICAL COOPERATION PROGRAMME

EVALUATION OF LAND RESOURCES IN ZANZIBAR
PHASE 1 & 11

TANZANIA

PART 1 : MAIN VOLUME
LAND EVALUATION AND LAND SUITABILITY
CLASSIFICATION - UNGUJA & PEMBA ISLANDS

FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Zanzibar, May 1990

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Part 1: Main Volume
LAND EVALUATION AND LAND SUITABILITY CLASSIFICATION - UNGUJA & PEMBA ISLANDS

by

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS
Zanzibar, May 1990

This Technical Cooperation Programme - Evaluation of Land Resources in Zanzibar consisting of phase 1 - Unguja island and phase 11 - Pemba island was prepared and executed by the Food and Agriculture Organization with the Government of Zanzibar as the technical cooperating agency. It was intiated in December 1988 with duty station located in Zanzibar city, Unguja island. The duty station was moved to Wete in Pemba island in January 1990 to carry out work in Pemba.

The field document is one of a series of reports prepared during the course of the project identified on the title page. The conclusions and recommendations given are those considered appropriate at the time of its preparation, and they may be modified in the light of further knowledge gained at subsequent stages of the follow-up project.

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FAO Evaluation of Land Resources in Zanzibar, Phase 1 and 11
Land Evaluation and Land Suitability Classification - Unguja and Pemba Islands, based on the work of Piyasiri M.L.Hettige Zanzibar May 1990. 144 Pages, 27 Tables, 6 Figures, 9 Maps. TCP/URT/6759/8961, Field Document 1

ABSTRACT

The government of Zanzibar with the Technical assistance of the Food and Agricultural Organization began the evaluation of the land resources in December 1988. In the first phase TCP/URT/6759 which lasted from December 1988 to November 1989, the evaluation of land resources in Unguja island was carried out and during the second phase TCP/URT/8961, from December 1989 - May 1990, the evaluation of land resources in Pemba island was carried out.

Part 1: Main volume of this publication deals with the primary objective of the study: Land evaluation and land suitability classification of the two islands.

In the first chapter, information on project background, objectives of study and level of intensity of land evaluation is outlined.

In chapter 2, detail description of the physical environment, climatic factors effecting crop growth, geology, hydrology, vegetation and present land use are in-corporated.

The human environment, the major contributing factor to land utilization is dealt with in detail in chapter 3 which covers the economic situation, Agricultural and land policies, land tenure systems prevalent, etc. The need for conservation based, planned land utilization is stressed.

In chapter 4 soil resources of the two islands are described and the correlation of soils with the FAO system discussed.

The inventory of land resources, the methodology used in the development of physiographic legend for the land evaluation exercise and the description of the land mapping units, are outlined in chapter 5.

In chapter 6 the existing land utilization types are presented in tabulated format and goes to outline unorthodox system of agricultural usage of the same peice of land by two farmers under the Shamba and Konde farming systems, and how it effects the subsequent land suitability classification for major crops grown in mixed tree intercrop farming systems.

The land suitability classification system and the approach used to adapt the system to the unique land utilization systems prevelant in Zanzibar is presented in chapter 7.

Part 11 of the Field Document consists of two Annexes:

Annex 1 outlines proposals for follow-up project and is presented in the UNDP Project document format.

Annex 11 incooporates all Technical Data Specifications, Soil Profile descriptions, available laboratory analysis results, climatic analysis, land requirements of major crops, and specimens of data collecting formats used, etc.

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1. INTRODUCTION

This report presents the results of a reconnaissance Land Resources study of Unguja and Pemba Islands, Zanzibar, undertaken between November 1988 and May 1990 as part of the Programme of activity of FAO Technical Co-operation Programme TCP/URT/6759/8961.
The study was restricted to a qualitative Evaluation of the Physical features affecting the agricultural potential of the Island. No attempt was being made at this stage to appraise the Socio-Economic aspects of land development.

It is intended however, that quantitative land evaluation based on both physical and socio-economic factors will form the main emphasis of the follow up project at more detailed levels of investigation.

1.1. Justification

Agriculture dominates the economy, with cloves and coconut plantations accounting for more than nine tenth of demestic exports. Most of the clove plantations are in Pemba, while coconuts are dominant in Unguja. Both clove and coconut plantations are currently undergoing rehabilitation since poor husbandry has greatly reduced their productivity. Principal subsistence crops are cassava, rice, bananas, sweet potatoes, citrus, maize, millet, groundnuts, pidgeon peas, chillies, sorghum and pepper.

Sugarcane and rice growing areas have been increased recently. Tobacco and rubber growing has been started. Agriculture will continue to be the mainstay of the economy; 70% of the population live in rural areas and 90% of the rural population is engaged directly in agriculture.

Most of the good agricultural land is occupied, most of it under tree crops while the poor soils of the Wandas and Maweni zones are used for extensive grazing, forestry projects and shifting cultivation.

Owing to the growth of the population which has nearly doubled since 1963 and the resulting expansion of the towns, pressure is increasing on the land. Most towns are located in the westward side of the islands, where the best soil is found and their expansion is taking up good farmland.

Organisational Chart of the Ministry of Agriculture, Livestock and Natural Resources

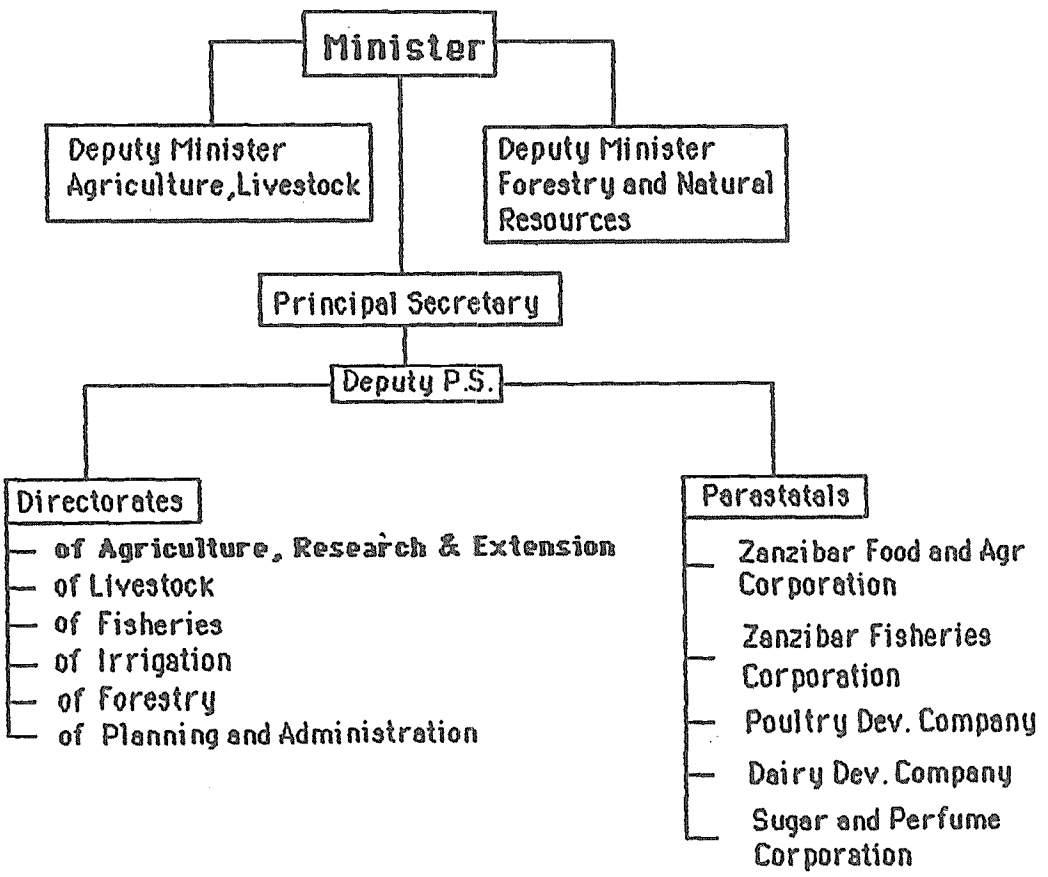


FIGURE: 1 ORGANISATIONAL CHART OF THE MINISTRY OF AGRICULTURE, LIVESTOCK AND NATURAL RESOURCES

Organisational Chart of the Department of Agriculture, Research & Extension

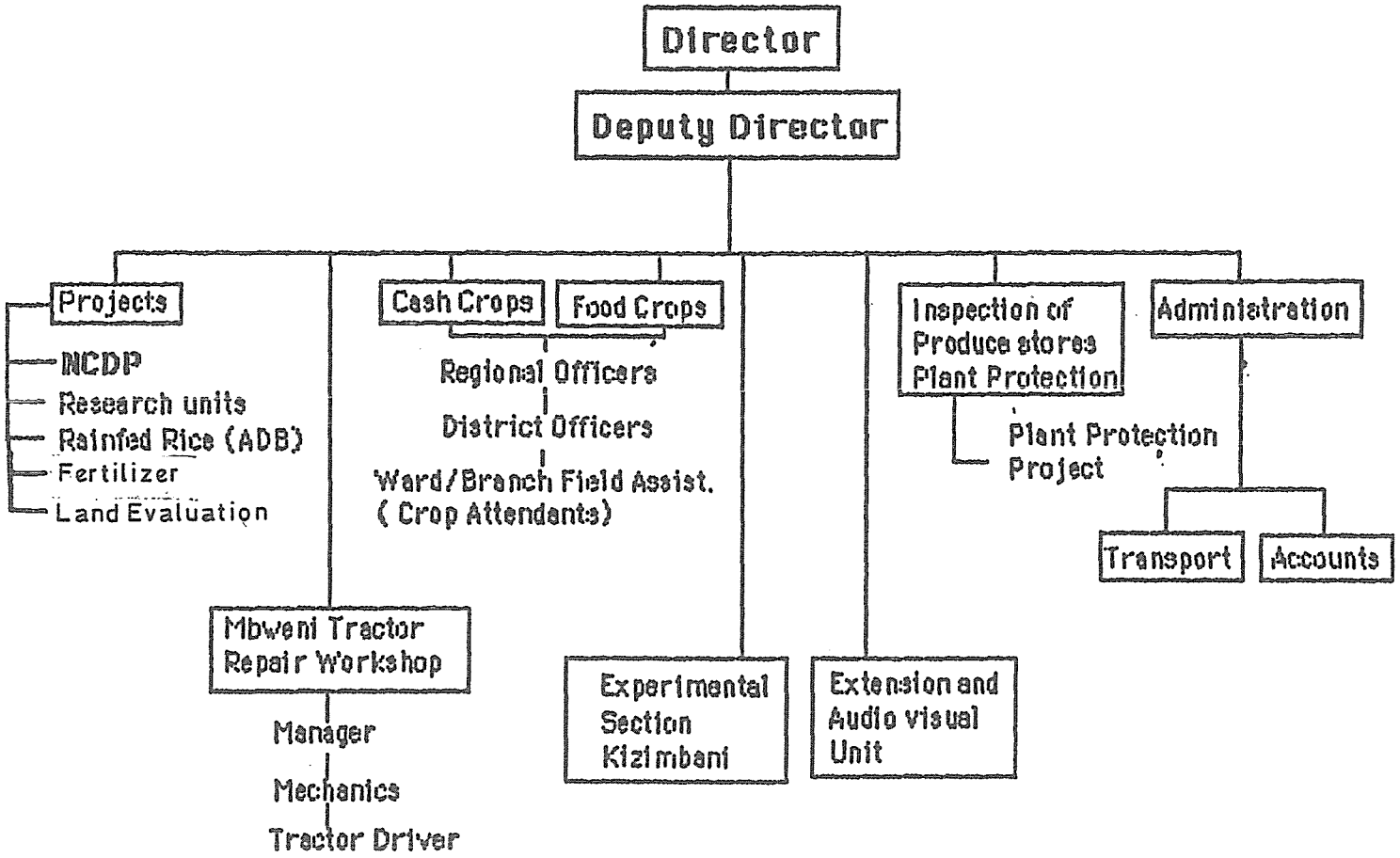


FIGURE: 2 ORGANISATIONAL CHART OF THE DEPARTMENT OF AGRICULTURE RESEARCH & EXTENSION

Therefore, there is an urgent need to diversify agriculture and to increase productivity from the various kinds of land, and at the same time prevent the fertility status of the soils from deterioration or degradation resulting from improper usage.

At present there is no good map showing the detailed distribution and suitability of land for agriculture. The existing soil maps of Calton were prepared over 35 years ago, as such an evaluation of the land resources would be essential for the effective functioning of a national land use plan.

1.2 Objective of the Study

Aims of the project are to provide an evaluation of the extent and suitability of land for various agricultural and other uses, to produce maps showing basic data required for planning purposes, and to establish an effective organisation, with a cadre of national officers, within the Department of Agriculture, who will be trained to carry out the following:-

Analysis of the landforms of Zanzibar by airphoto interpretation. Morpho-pedologic mapping for reconnaissance level soil survey and correlation studies.

Detailed surveys of sample areas to identify the soil and their distribution in relation to landform.

Evaluation of the potential of the soil for existing and possible future uses within each agro-climate zone.

Review existing land uses and identify areas that are under-used or inappropriately used.

Preparation of related maps and reports.

1.3. Level of Intensity of Land Evaluation Carried Out

This study is to provide a qualitative land evaluation based on reconnaissance surveys with a broad inventory of resources and development possibilities at national level. The evaluation will contribute to national plans, permitting the selection of development areas and priorities whilst forming the basis for an ongoing line of investigation for national soil survey and land use planning.

The study was carried out using a two stage approach in which the first step is mainly concerned with qualitative level evaluation. The economic and social analysis at the first stage was limited to ascertaining the relevance of the kinds of major land use selected for the suitability classification.

After the first stage has been completed and its results presented in map and report form, these results may then be subject to the second stage, that of economic and social analysis in a more detailed study.

1.4 Previous Soil Studies

No recent soil mapping has been carried out at National Level, in Zanzibar since the original 1: 250,000 reconnaissance level soil survey work of Messrs. W.E. Calton, G.E.Tidbury and G.P.Walker during the period 1948 to 1955. See attached map Nos. 6 and 7.

Altered versions of the original Calton soil maps covering both Unguja and Pemba were found in the Drawing office of the Department of Agriculture. These maps contain modified boundaries and additional soil phases demarcated on them. On field checking this map, it was found that the new boundaries and their subdivision did not correspond with the actual soils occuring within them, also these maps do not have any report attached explaining on what basis the demarcations were made. Mr. Uledi the only trained soil scientist within the Department of Agriculture was not aware of any soil investigation leading to the preparation of such maps. Hence it was decided it is best to ignore this map and the Director of Agriculture was informed accordingly.

Subsequently after 1975 several project levels soil studies of specific areas were carried out and these are briefly summarised in the following pages.

1.4.1 'Soil Studies for Agricultural Development in Zanzibar' - November 1975 - January 1976 by Dr. V.S.Subramanian FAO Consultant Soil Scientist

This study was carried out tc assess the Agricultural potential of tho soils of Zanzibar and was mainly confined to the morphological and chemical studies (incomplete) of the Mwera and Kipange valleys and some depressional areas such as Upenja and Cheju.

Further studies of the physical and chemical properties of soils were recommended for the production of crop suitability maps and the revision of the existing 'Calton' soil map was considered vital before agricultural development planning.

1.4.2. Detailed Soil Survey of the Cheju Plain

A detailed soil survey was conducted by Pedology Consultants in 1978 to determine the extent and suitability of the lands for irrigated rice production in Cheju rice irrigation project area.

The survey area covered approximately 1200 ha. and soil mapping was confined mainly to areas with deep imperfect to poorly drained clay soils used for growing rice.

1.4.3 Detailed Soil Survey for Irrigated Rice

During the period 1979 to 1981 detailed soil survey of four rice growing areas of Unguja and twenty nine valleys of Pemba wore carried out by B.P. Sharma, Soil Scientist, URT/73/024 - Extension in Vegetable Production in Zanzibar.

In Unguja Island the survey sites were:

1.	Bumbwi Sudi	- 586 Ha.
2.	Chechele	- 716 Ha.
3.	Mchangani - Mgonjoni	- 1539 Ha.
4.	Kisima mchanga	- 404 Ha.
	Total	- 3245 Ha.

The soil were classified according to their suitability for irrigated rice production based on the Canadian Soil Survey methods as adopted for the Cheju area by Pedology Consultants in 1978. Using 4 suitability classes and two sub-classes.

1.4.4 National Cocomut Development Project Surveys

Land suitability studies for cocomut cultivation in the costal areas of Tanzania were carried out by Agrar-Und - Hydrotechnique in 1980. This included some studies carried out in Selem and Bambi areas of Unguja Island for the location of 50 ha. of suitable land for the establishment of a cocomut seed garden and an additional 50 hectares for extension. This is the only work done since 1955 on the upland soils.

1.5. Project Staff

The following project personnel took part in the field work, map and report compilation.

From		To	FAO
1st December 1988	-	Duration of Project	Piyasiri M.L.Hettige Land Evaluation Specialist;
			GOVERNMENT OF ZANZIBAR
10th December 1988	-	- do -	Uledi M. Uledi Counterpart Soil Scientist.
10th December 1988	-	- do -	Humudi Omar Chande Field Asst. for Land Use Planning.
20th January 1989	-	- do -	Suleiman Zahor Field Officer Land Use Planning.
24th January 1989	-	- do -	Muhammed Habib Mohammed Field Assistant.
10th January 1989	-	30 June 1989	Duchi Abdalla Duchi Survey Asst./Cartographer.
9th January 1989	-	19th Jan. 1990	Mwanahuri Mohammed Trainee Typist .
1st Feb. 1990	-	7th May 1990	Masha Khamis Typist.

2. PHYSICAL ENVIRONMENT

2.1 General Information on Unguja and Pemba

Zanzibar is essentially a group of Islands consisting of two main Islands and several small Islands off the Eastern coast of Tanzania mainland.

The main Island, Unguja (sometimes called Zanzibar Island) and Pemba are about 50 km apart and separated from the mainland by approximately 40 km and 60 km respectively. The two islands lie between 40° 50' and 6° 30' south latitudes and 39° and 40° east longitudes.

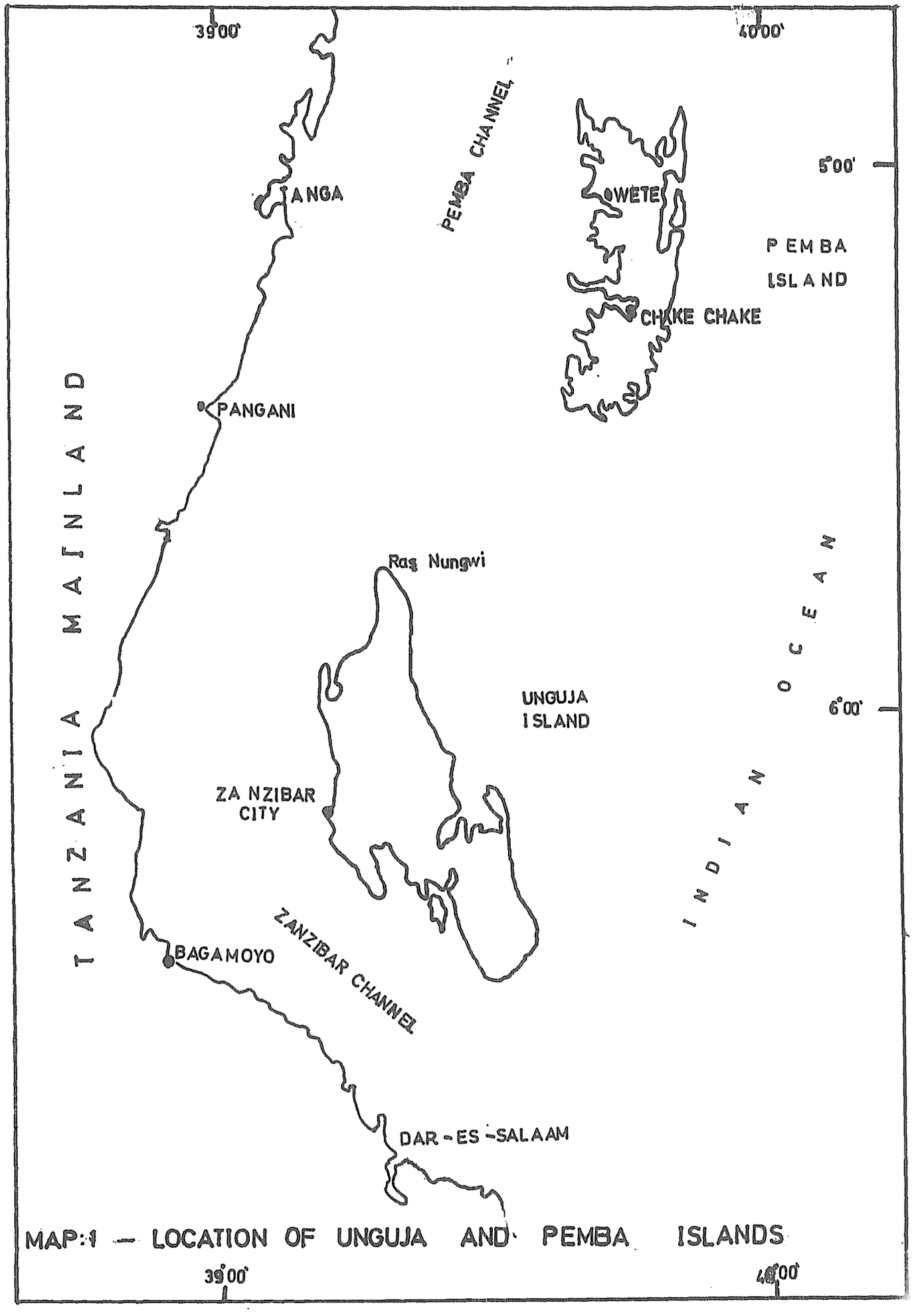
The area of Unguja is some 1600 sq. km and that of Pemba is 1014 sq. km, inclusive of the swamp zones and small islands. Unguja has a total length of 85 km, north - south, the width in east - west direction varies from 37 km (North of Ras Chukwani to East) to 9 kilometers (South of Ras Nungwi).

Pemba has a total length of 65 km north south, the width varies from 16 km in north, to 13 km in the middle and 18 km in the south (along the east - west direction).

The population (1988 census) of the Islands total to about 640,578, Unguja 375,539 and Pemba 265,039.

The main city is Zanzibar, situated in Unguja and has an area of 25 sq. km and about 170,000 inhabitants.

The main language spoken is Kiswahili, the location of the Islands are shown in map 1.



MAP:1 — LOCATION OF UNGUJA AND PEMBA ISLANDS

TABLE 1

CLIMATOLOGICAL DATA SUMMARY FOR ZANZIBAR AND PEMBA

Station: Zanzibar, Kisauni (Zanzibar Airport), Latitude 6 13' South, Altitude 18m

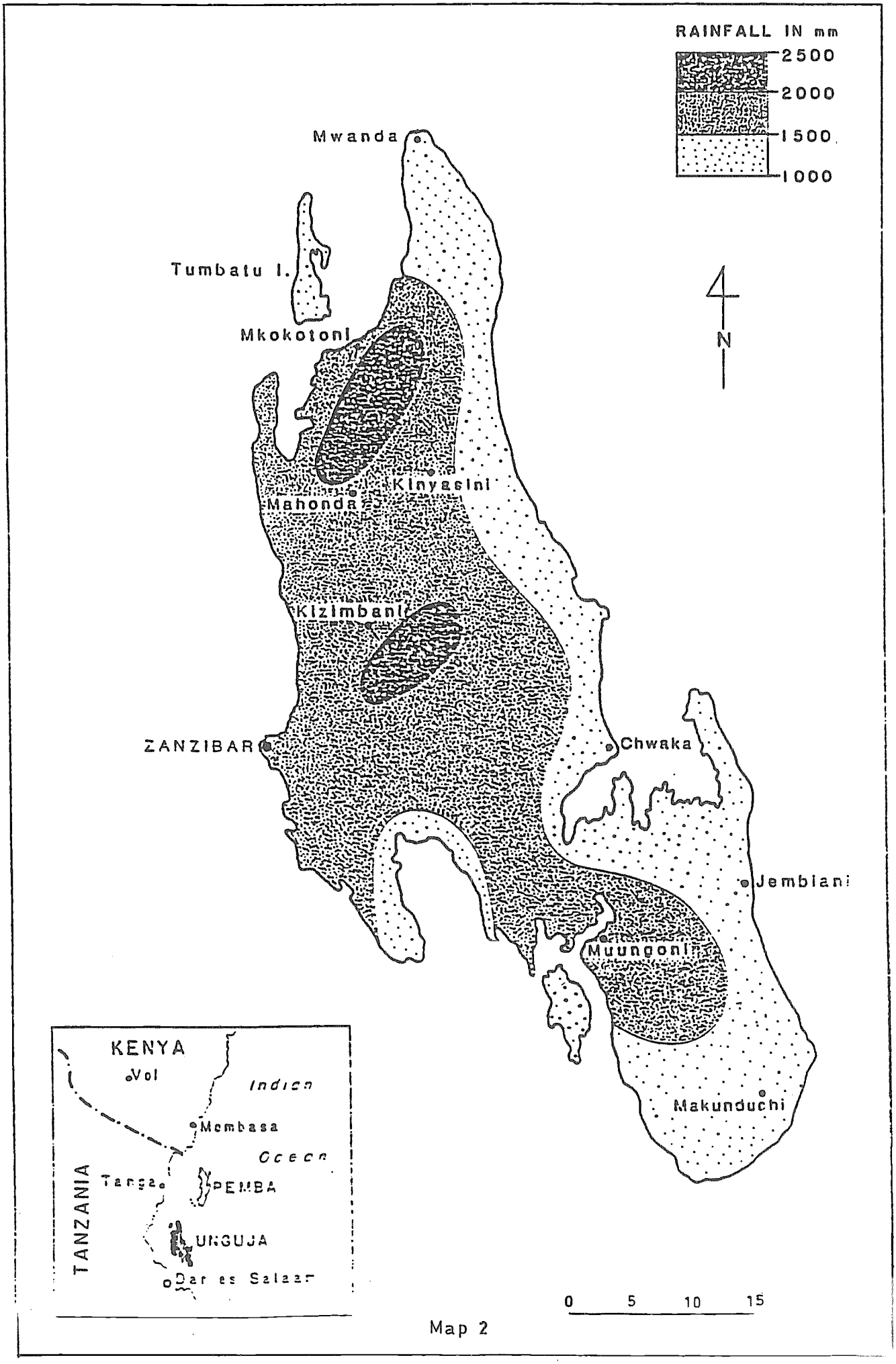
MONTH	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Max Temp (C)	31.40	31.90	31.90	30.30	29.40	28.30	28.30	28.90	29.80	30.40	30.40	31.20	
Min Temp (C)	23.00	23.70	23.10	23.50	22.80	21.70	20.60	19.70	19.20	20.10	21.30	22.50	
Mean Temp (C)	27.20	27.80	27.50	26.90	26.10	25.00	24.40	24.30	24.50	25.20	25.80	26.80	
Act Vapor (mb)	28.40	28.60	29.80	29.50	27.40	24.60	23.10	22.80	23.50	25.00	27.80	28.80	
Humidity (%)	78	76	81	83	81	76	75	75	76	77	83	81	
Wind (m/s)	1.90	1.80	1.80	1.60	2.20	2.30	2.30	2.20	2.20	2.00	1.60	2.00	
Sunshine (%)	60	65	60	48	59	63	61	71	70	67	60	64	
Daylength (h)	12.40	12.30	12.10	12.00	11.80	11.70	11.80	11.90	12.10	12.20	12.40	12.50	
PET Daily (mm)	5.50	5.80	5.30	4.40	4.60	4.60	4.60	5.10	5.50	5.50	5.00	5.40	
PET Month (mm)	189	162	163	130	141	139	143	159	164	171	149	167	1862
Rain (mm)	87	86	127	403	249	54	48	37	33	105	187	145	1561
Eff Rain (mm)	44	43	76	297	174	22	18	12	9	59	124	91	974

Station: Pemba, Wete, Latitude 5 04'S, Altitude 20m

MONTH	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Max Temp (C)	30.90	31.60	31.90	30.30	29.10	28.70	27.90	28.20	29.00	29.80	30.30	30.90	
Min Temp (C)	22.90	22.70	23.00	22.70	21.90	20.70	19.80	19.40	19.70	20.40	21.70	22.60	
Mean Temp (C)	26.90	27.10	27.40	26.50	25.50	24.70	23.80	23.80	24.30	25.10	26.00	26.70	
Act Vapor (mb)	28.60	28.80	30.00	30.20	28.60	26.10	24.90	24.30	24.90	26.80	29.10	29.70	
Humidity (%)	81	80	81	87	87	83	84	82	81	84	86	84	
Wind (m/s)	1.70	1.40	1.00	1.00	1.10	1.60	1.20	1.30	1.40	1.50	1.30	1.20	
Sunshine (%)	45	55	50	40	35	35	33	35	40	45	40	40	
Daylength (h)	12.40	12.30	12.10	12.00	11.90	11.80	11.80	11.90	12.10	12.20	12.30	12.40	
PET Daily (mm)	4.70	5.00	4.60	3.80	3.30	3.30	3.10	3.50	4.00	4.30	4.10	4.10	
PET Month (mm)	145	141	143	113	101	100	97	109	120	133	122	128	1455
Rain (mm)	65	47	157	433	456	136	77	47	34	100	223	151	1926
Eff Rain (mm)	29	18	100	321	339	83	36	18	10	55	153	95	1250

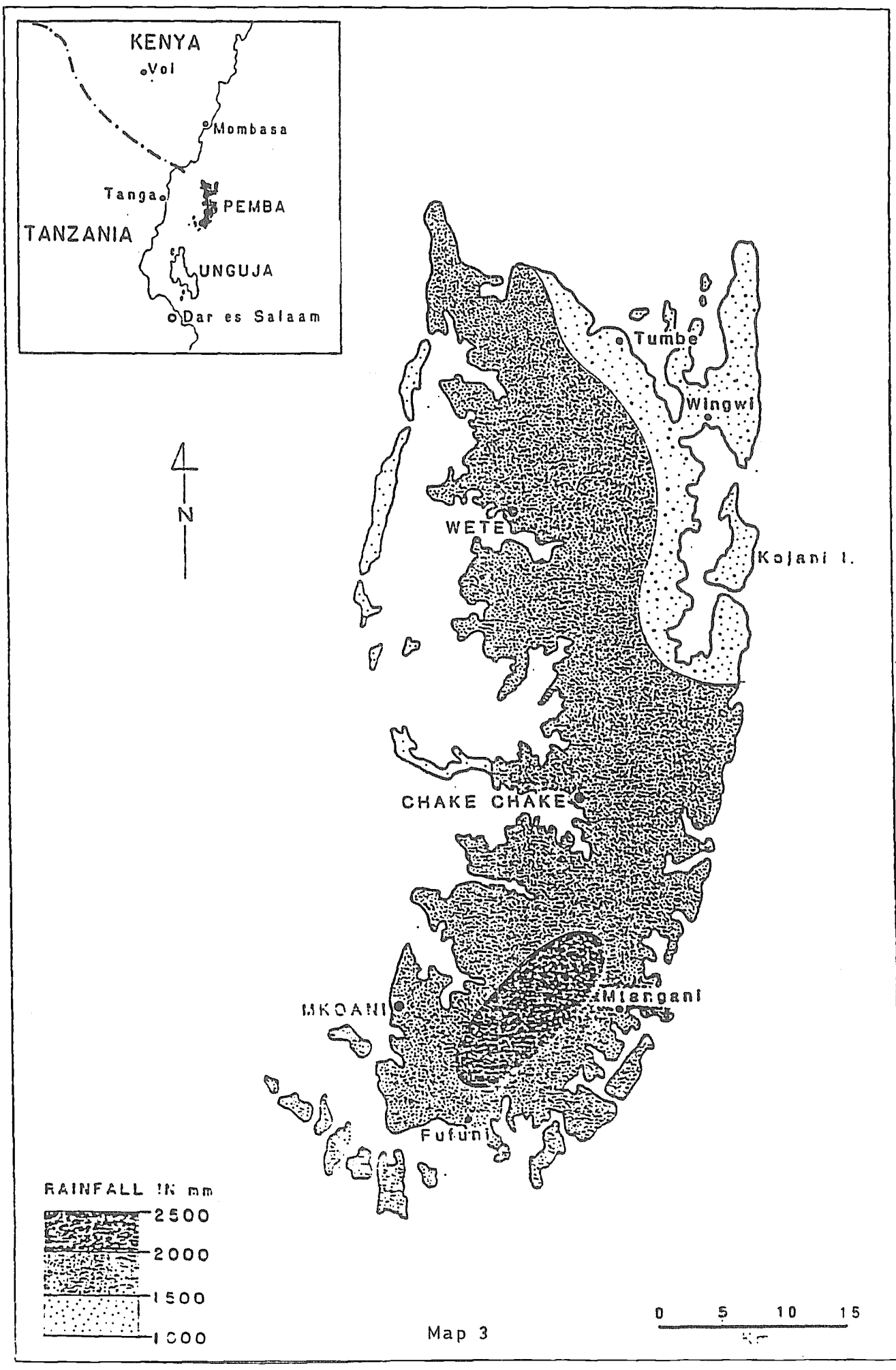
Source: FAO.

UNGUJA - ANNUAL RAINFALL DISTRIBUTION



Map 2

PEMBA - ANNUAL RAINFALL DISTRIBUTION



Map 3

RAINFALL DISTRIBUTION

UNGUJA

PEMBA

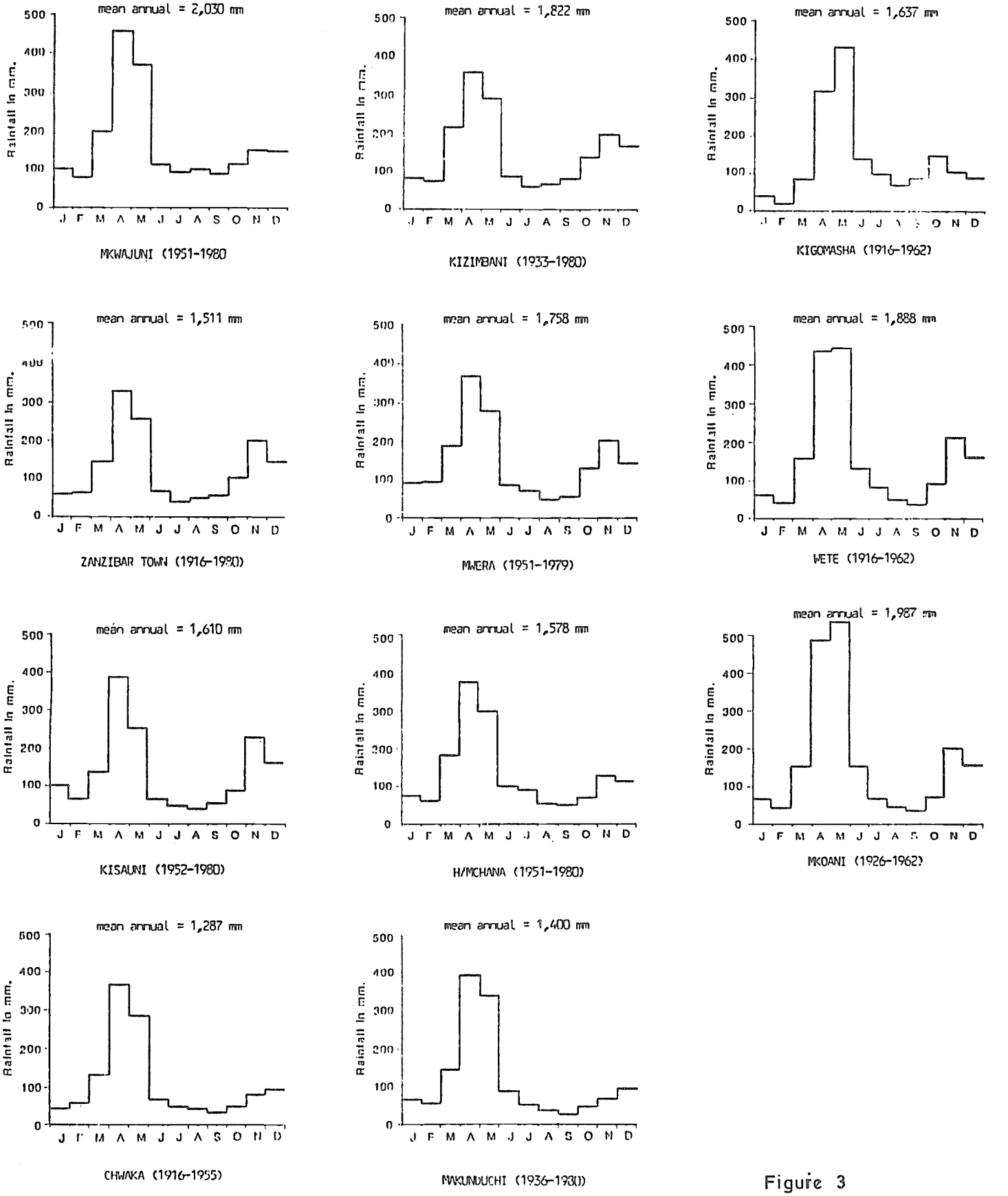


Figure 3

Table: 2

UNGUJA - RAINFALL PROBABILITY ANALYSIS FOR DETERMINATION OF DEPENDEBLE GROWING SEASON AND THEIR LENGHTS -MASIKA SEASON

Rainfall Distribution System	Rainfall Stations in Unguja Island Zanzibar						
	Kisauni	Kizimbani	Mwera	Mkwajuni	H/mchana	Chwaka	Makunduchi
A Possibility of occurance of three consecutive Humid months(H) Pattern of occurance= Month / Rainfall category	2 out of 10 M A M J J H H H I D	6 out of 10 M A M J J H H H D D	5 out of 10 M A M J J H H H D D	5 out of 10 M A M J J H H H I I	5 out of 10 M A M J J H H H I D	3 out of 10 M A M J J H H H I D	3 out of 10 M A M J J H H H I D
B Possibility of occurance of two consecutive Humid months and two intermidiate months within 4 consecutive months. Pattern of occurance= Month / Rainfall category	3 out of 10 M A M J J I H H I D	6 out of 10 As above	5 out of 10 As above	6 out of 10 M A M J J I H H I I	5 out of 10 As above	3 out of 10 As above	5 out of 10 M A M J J I H H I D
C Possibility of occurance of two consecutive Humid months with one intermediate month immediately proceeding or after the Humid period. Pattern of occurance= Month / Rainfall category	7 out of 10 M A M J J I H H D D	8 out of 10 M A M J J I H H D D	8 out of 10 M A M J J I H H D D	8 out of 10 M A M J J I H H D D	8 out of 10 M A M J J I H H D D	6 out of 10 M A M J J I H H D D	7 out of 10 M A M J J I H H D D
D Possibility of occurance of two consecutive Humid month Pattern occurance= Month / Rainfall category	8 out of 10 M A M J J D H H D D	8 out of 10 As above	8 out of 10 As above	8 out of10 As above	8 out of 10 As above	7 out of 10 M A M J J D H H D D	8 out of 10 M A M J J D H H D D

Note: The above Rainfall categories were calculated using the Potential Evapotranspiration figures for Kisauni as shown in Table: 1

Table: 3

UNGUJA RAINFALL PROBABILITY ANALYSIS FOR DETERMINATION OF DEPENDEBLE GROWING PERIOD LENGTH - VULI SEASON

Rainfall Distribution System	Rainfall Station in Unguja Island Zanzibar						
	Kisauni	Kizimbani	Mwera	Mkwajuni	H/mchana	Chwaka	Makunduchi
1 Possibility of occurance of two Humid months(H) and two intermidiate months in a 4 month period. Pattern of occurance=Month Rainfall category	4 out of 10 S O N D J D I H H I	4 out of 10 S O N D J I I H H D	3out of 10 S O N D J D I H H I	3 out of 10 S O N D J I I H H I	1 out of 10 S O N D J I I H H H	-	-
2. Possibility of occurance of two consecutive Humid months Pattern of occurance= Month Rainfall category	4 out of 10 -	4 out of 10 -	3 out of 10 -	3 out of 10 -	2out of 10 -	- -	- -
3 Possibility of occurance of one Humid month and one intermidiate month. Pattern of occurance= Month Rainfall category	5 out of 10 S O N D J D D H I D	5 out of 10 S O N D J D I H I D	5 out of 10 S O N D J D I H I D	3 out of 10 -	3 out of 10 -	- -	- -
4 Possibility of occurance of three consecutive intermediate months. Pattern of occurance= Month Rainfall category	- -	7 out of 10 S O N D J D I I I D	5 out of 10 S O N D J D I I I D	4 out of 10 S O N D J I I I I I	-	-	3out of 10 N D J I I I
5 Possibility of occurance of two consecutive intermidiate months Pattern occurance= Month Rainfall category	8 out of 10 S O N D J D D I I D	7 out of 10 As above	6 out of 10 S O N D J D D I I D	6 out of 10 S O N D J D D I I D	5 out of 10 S O N D J D D I I D	4 out of 10 S O N D J D D I I D	3 out of 10 N D J I I I

Table: 4

PEMBA - RAINFALL PROBABILITY ANALYSIS FOR DETERMINATION OF DEPENDABLE GROWING SEASON AND THEIR LENGTHS - MASIKA SEASON.

Rainfall Distribution System	Rainfall Stations in Pemba Island Zanzibar		
	Wete	Mkoani	Kigomasha
A Possibility of occurance of three consecutive Humid months (H).	5 out of 10	5 out of 10	6 out of 10
Pattern of occurance = Month / Rainfall category	M A M J J I H H H I	M A M J J I H H H I	M A M J J D H H H I
B Possibility of occurance of two consecutive Humid months and two intermediate months within 4 consecutive months.	7 out of 10	6 out of 10	7 out of 10
Pattern of occurance = Month / Rainfall category	M A M J J I H H I D	M A M J J I H H I D	M A M J J D H H I I
C Possibility of occurance of two consecutive Humid month with one intermediate month immediately proceeding or after the Humid period	8 out of 10	7 out of 10	8 out of 10
Pattern of occurance = Month / Rainfall category	M A M J J D H H I D	M A M J J D H H I D	M A M J J D H H I D
D Possibility of occurance of two consecutive Humid month	9 out of 10	9 out of 10	9 out of 10
Pattern occurance = Month / Rainfall category	M A M J J D H H D D	M A M J J D H H D D	M A M J J D H H D D

Note: The above Rainfall categories were calculated using the Potential evapotranspiration figures for Wete as shown in Table: 1

Table: 5

PEMBA RAINFALL PROBABILITY ANALYSIS FOR DETERMINATION OF DEPENDEBLE GROWING PERIOD LENGTH - VULI SEASON

Rainfall Distribution System	Rainfall Station in Pemba Island Zanzibar		
	Wete	Mkoani	Kigomasha
1 Possibility of occurance of two Humid months(H) and two intermidiate months in a 4 month period. Pattern of occurance= Month / Rainfall category	3 out of 10 S O N D J D I H H I	3 out of 10 S O N D J D I H H I	3 out of 10 S O N D J I H H I D
2 Possibility of occurance of two consecutive Humid months. Pattern of occurance = Month / Rainfall category	6 out of 10 S O N D J D I H H D	5 out of 10 S O N D J D D H H D	3 out of 10 S O N D J I H H I D
3 Possibility of occurance of one Humid month and one intermidiate month. Pattern of occurance= Month / Rainfall category	7 out of 10 S O N D J D D H I D	7 out of 10 S O N D J D D H I D	5 out of 10 S O N D J I H I I D
4 Possibility of occurance of three consecutive intermidiate months. Pattern of occurance = Month / Rainfall category	-	-	6 out of 10 S O N D J I I I D D
5 Possibility of occurance of two consecutive intermidiate month. Pattern of occurance = Month / Rainfall category	8 out of 10 S O N D J D D I I D	8 out of 10 S O N D J D D I I D	6 out of 10 As above

2.2. Climate

Analysis of climatic factors based on data obtained from Directorate of Meteorology, have been carried out by Gunesinghe et al 1983 and subsequently summarised in FAO/IFAD Report 1989, these findings are detailed in table 1, and maps 2 and 3 attached.

2.2.1 Rainfall

Unguja and Pemba experience a bimodal rainfall pattern. Rainfall throughout the island vary within the range of 1000 - 2500 mm/yr. The mean annual rainfall for Unguja is 1600 mm. (Average rainfall for North Unguja is 1800 mm/yr and for south Unguja is 1500 mm/yr). Whilst that for Pemba is 1900 mm/yr wherethe highest rainfall is experienced in the areas around Mtambile and Wete. The wettest areas of Pemba are in the south and north central regions.

The main rainy season "Masika" (March - May) accounts for almost half the total annual rainfall and the second rainy season "Vuli" (October - December) contribute a further 450 mm.

Seasonal rainfall distribution for a range of sites on Unguja and Pemba are shown in Figure 3.

Analysis of rainfall variability for each of above sites is shown in the Tables 1 -10 in Annex 11 of part 11 of this report.

The major crop producing areas namely Ridge zones and Corridor zones receive between 1500 - 2000 mm/yr with isolated areas around Mkwajuni and Kizimbani receiving 2000 - 2500 mm/yr, the Wanda zones, Maweni zones and associated coastal zones receive lower rainfall within the range of 1000 - 1500 mm/yr.

Rainfall analysis carried out by FAO/IFAD, shows that:

a) Masika rains are reliable throughout the islands.
b) Vuli rains are reliable in certain areas and not reliable in some.
c) Rainfall during the off season months are highly variable from year to year in all areas.

Further rainfall analysis was carried out to determine the reliability of the Masika rains providing 3 consecutive Humid months required for producing S1 yields of Rainfed Rice (Assuming the requirements of ideal soil conditions and optimum management are met).

The criteria used for this analysis was based on the Agro-Ecological Zones Project Categorisation of Humid, intermediate and dry months as outlined below:-

Criteria		Classification of month
$P(m) \triangleright PET(m)$	-	Humid month (H)
$PET(m) \triangleright P(m) \triangleright \frac{1}{2}PET(m)$	-	Intermediate month (I)
$\frac{1}{2}PET(m) \triangleright P(m)$	-	Dry month (D)

Where P(m) = Total precipitation of the month (m)

PET(m) = Potential Evapotranspiration during month (m)

Using these formulae on analysis of Rainfall variability in table 1 - 10 of Annex 11. The desired probabilities for each Rainfall station, are derived and listed in table Nos. 2, 3, 4 and 5.

From table 3 and 5 the possibility of obtaining 3 consecutive Humid month during the Vuli season was around one in 10 years and the possibility of occurance of two Humid months and two intermidiate months were 4 and 3 out of 10 for Kisauni, Kizimbani and Mwera. As for Pemba the same results were obtained with the possibility of occurance of two Humid months and a intermidiate being 6 out of 10 in Wete, 5 out of 10 in Mkoani and 3 out of 10 in Kigomasha area.

Due to the above low probabilities the Vuli rains are not reliable enough for rainfed rice and is therefore not evaluated seperately in the suitability classification for a second crop of rice under the rainfed project systems (LUT 2) However in the traditional system of rice cultivation (LUT 1) the Vuli and Masika rains are both utilised for a single crop of long duration, local variety of rice, and is considered as such.

2.2.2 Temperature

Unguja and Pemba have tropical sub-humid climate with average temperatures around 26°C. This varies from about 20°C to 32°C between the cooler periods (June - September) and warm period (December - February). The difference between the individual monthly mean maximum and minimum temperatures range from about 6.8°C in April and May to 10.5°C in September as illustrated in figures 4 and 5.

2.2.3 Windspeed and Direction

Both islands are similarly influenced by trade winds from June to September when the prevailing wind is South Easterly, winds blow from the South East and from November to February these blow from the North East. Average wind speeds are highest during the dry periods and range between 1.8 - 2.3 m/s (Kisauni, Unguja) and 1.4 - 1.7 m/s(Wete Pemba)

2.2.4 Solar Radiation

Solar radiation in Zanzibar averages around 400 cal/cm^2/day. In general radiation values during the Vuli season are higher than those in the Masika. The level of radiation greatly affect crop yields according to the linear relationship between daily incident radiation and yield depending on the photosynthetic effeciency of the crop(Energy captured x Energy received -1).

2.2.5 Evapotranspiration

The everage daily evaporation for Unguja is around 5mm and varies from 4.4 mm in April to 5.8 mm in February. The average for Pemba is around 4mm per day and range from 3.1 mm in July to 5 mm in February.

The monthly potential evapotranspiration approches a maximum of 169mm in January and falls tc a minimum of 130 mm in April for Unguja. For Pemba the maximum is 145 mm in January and minimun of 97 mm in July.

2.2.6 Major Climatic Factors Determining Crop Adaptability

According to the characterisation of major climates by Higgins and Kassam 1981 Zanzibar islands come within the warm tropics with 24 hours mean temperatures regime around 26°C and is therefore suitable for crop adaptability group 11 with photosynthetic pathway C3 as illustrated in Table 6

TABLE 6 CROP ADAPTABILITY GROUPS, BASED ON PHOTOSYNTHETIC PATHWAY AND RESPONSE TO RADIATION AND TEMPERATURE.

Crop adaptability group	I	II	III	IV	V
Photosynthetic pathway	C_3	C_3	C_4	C_4	CAM
Optimum temperature for photosynthesis (°C)	15-20	25-30	30-35	20-30	25-35
	Sugarbeet Phaseolus Wheat Barley Oats Potato Bean (TE) Chickpea	Soybean (TR) Phaseolus Rice Cassava Sweet Potato Yams Bean (TR) Groundnut Cotton Tobacco Banana Coconut Rubber Oil palm	Sorghum (TR) Maize (TR) Pearl millet Panicum Millet (TR) Finger millet Setaria Millet (TR) Sugarcane	Panicum Millet (TE,TH) Sorghum(TE,TH) Maize (TE,TH) Setaria Millet (TE,TH)	Sisal Pineapple

TE = Temperate cultivars, TR = Tropical (lowland) cultivars, TH = Tropical (highland) cultivars.

Source: FAO, 1978

Table: 7

LENGHT OF GROWING PERIODS AND RESULTING SUITBALITY LIMITATIONS ACCORDING TO WATER AVAILABILITY AND MANAGEMENT -MASIKA SEASON

Rainfall Station and Area represented	Probability out of 10 years.	Growing period / Rainfall categories month	Length of growing period days	Suitability limitations imposed by water availability for rainfed rice		
				LUT 1 1/	LUT 2 2/	
				Without bunds	With bunds	Without bunds
Unguja Island Kisauni Western costal and low ridge areas. North of Zanzibar City.	2	0 H 30 H 60 H 90 Sm March April May June	92 + Sm	S_3	S_1	S_2
	7	0 I 30 H 60 H 90 D(sm) March April May June	92 + Sm	S_3	S_2	S_2
Kizimbani Western and central low and medium ridge zones	6	H H H D (Sm) March April May June	92 + Sm	S_3	S_1	S_2
	8	I H H D (Sm) March April May June	92 + Sm	S_3	S_2	S_2
Mwera Central corridor zones	5	H H H D (Sm) March April May June	92 + Sm	S_3	S_1	S_2
	8	I H H D (Sm) March April May June	92 + Sm	S_3	S_2	S_2
Mkwajuni Central and northern medium ridge and corridor zones.	5	H H H D (Sm) March April May June	92 + Sm	S_3	S_1	S_2
	8	I H H D (Sm) March April May June	92 + Sm	S_3	S_2	S_2

1/ Long duration traditional varieties

2/ Short duration improved varieties

Sm Time taken for soil moisture reserves to be exhausted.

Table: 7 Cont. LENGTH OF GROWING PERIODS AND RESULTING SUITABILITY LIMITATION ACCORDING TO WATER AVAILABILITY AND MANAGEMENT MASIKA SEASON

Rainfall station and Area represented.	Probability out of 10 years.	Growing period Rainfall categories month	Length of growing period days	Suitability limitations imposed by water availability for rainfed rice		
				LUT 1 1/	LUT 2 - 2/	
				Without bunds	With Bunds	Without bunds
M/mchana	5	H H H I I(Sm) March April May June	122 + Sm	S_3	S_1	S_2
Cheju, Bambi central area	8	I H H D(Sm) March April May June	92 + Sm	S_3	S_2	S_2
Chwaka	3	H H H I Sm March April May June	122 + Sm	S_3	S_1	S_2
Eastern Coastal area	6	I H H D (Sm) March April May June	92 + Sm	S_3	S_2	S_2
Mahunduchi'	3	H H H I (Sm) March April May June	122 + Sm	S_3	S_1	S_2
Southern area	7	I H H D(Sm) March April May June	92 + Sm	S_3	S_2	S_2
Pemba island						
Wete	5	I H H H I March April May June	153 + Sm	S_2	S_1	S_2
	8	D H H I Sm March April May June	91 + Sm	S_3	S_2	S_2
Mkoani	5	I H H H I(Sm) March April May June	153 + Sm	S_3	S_1	S_2
	7	D H H I (Sm) March April May June	91 + Sm	S_3	S_2	S_2
Kigomasha	6	D H H I (Sm) March April May June	121 + Sm	S_3	S_1	S_2
	8	D H H I (Sm) March April May June	91 + Sm	S_3	S_2	S_2

1/ Long duration traditional varieties.

2/ Short duration improved varieties.

Sm Time taken for soil moisture reserves to be exhausted.

GRAPHS SHOWING MEAN VALUES OF MAXIMUM AND MINIMUM TEMPERATURES AND THE MEAN AVERAGE TEMPERATURES

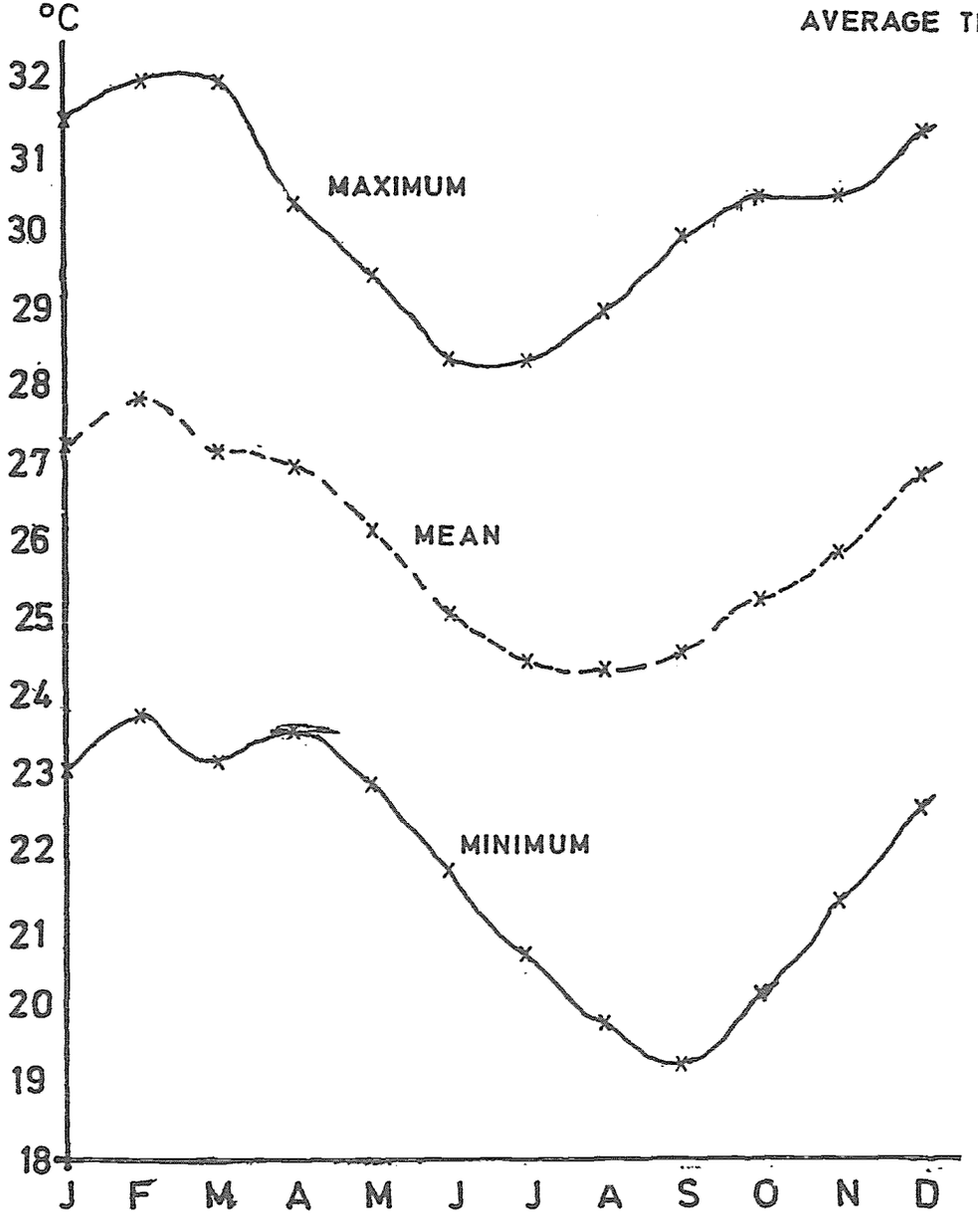


FIG. 4 ZANZIBAR AIRPORT - UNGUJA

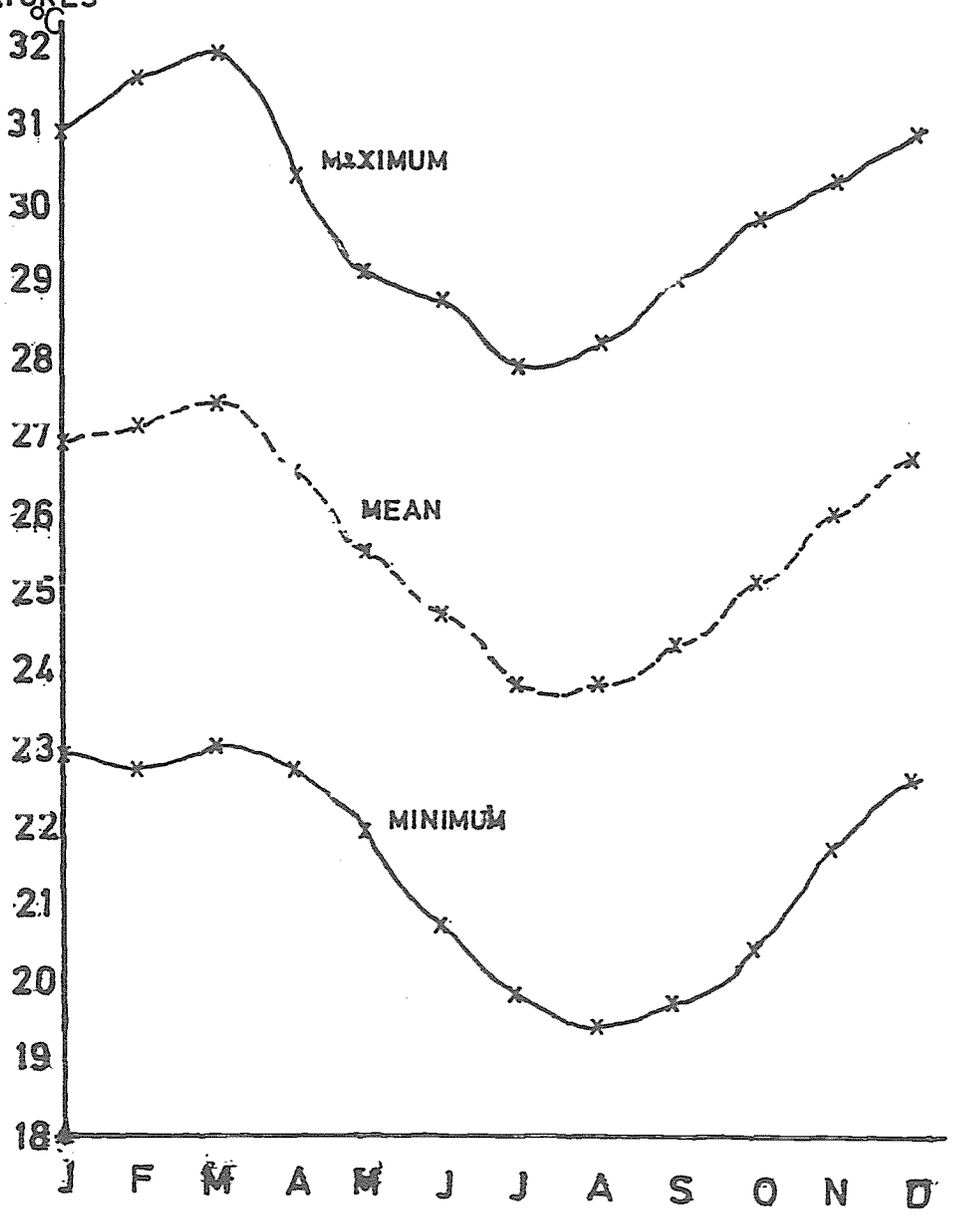


FIG. 5 WETE-PEMBA

2.2.7 Dependable growing periods

The dependable growing periods and their length during the two seasons for Unguja and Pemba are in-corporated in tables 2 - 5 and could be used to determine most suitable crops to be grown during the seasons.

The dependable growing period lengths and resulting suitability limitations according to water availability and management for major crop category 'Rice' under the two Land Utilization Systems prevalent in Zanzibar are tabulated in table 7.

2.3. Geology and Hydrology

2.3.1 Geology and Stratigraphy

The ridges of Unguja and Pemba were mainly deposited as sediments during the middle and lower Miocene time (12 to 26 million years ago). When Unguja and Pemba were parts of the prehistoric Delta formed at the confluence of the two great rivers Rufiji and Ruvu.

During this period deposition, sedimentation and subsequent lithification of the limestone layer were affected while the land forms were shaped by the many deltaic streams that flowed from South to North producing several corridors and the predominantly North South oriented ridges. These corridors still form conspicuous landform patterns as are apparent in Unguja e.g. Southern Kiwani Bay - Mwera - Bumbwi - Mahonda - Northern Kiwani Bay and Bambi - Upenja - Kibokwa - Chaani corridors.

Although the original corridor zones were nearly level to gently sloping, stratified clay and sand deposited deltaic corridors. The present remnants of these are seen as differently elevated broken corridors due to differential uplift and block faulting etc. experienced in the early Pleistocene period (1 - 2 million years ago) which also caused the separation and emergence of the Islands from the original delta. Subsequently, higher sea levels than at present caused considerable marine erosion during the Quaternary period, and gradual stepwise fall in sea levels resulted in the formation of the terraced corralline limestone reef at the out-lying fringes of the Islands.

The surface geological features of both Islands are characterised by the following sequence as described in Stockley 1928,

Kent, et al 1971 and later summarised by Johnson 1983 and 1987.

Q1 - Recent deposits: Consisting of Colluvial Scree, Alluvial and the soils developing on them. These are mainly located within the corridor zones. Soils on these deposits are classified as Sandy Mchanga in Unguja and unclassified in Pemba.

Q2 - Quartenary formations: (Less than 1 million years ago) consisting of Terraced Coralline Reef formations which took place due to rise in sea levels and subsequent stepwise lowering of sea. The Q2 is also found underlying the Q1 within the corridor zones. The soils formed on these are classified as Uwanda and Maweni Kinongo in Unguja and Makani in Pemba.

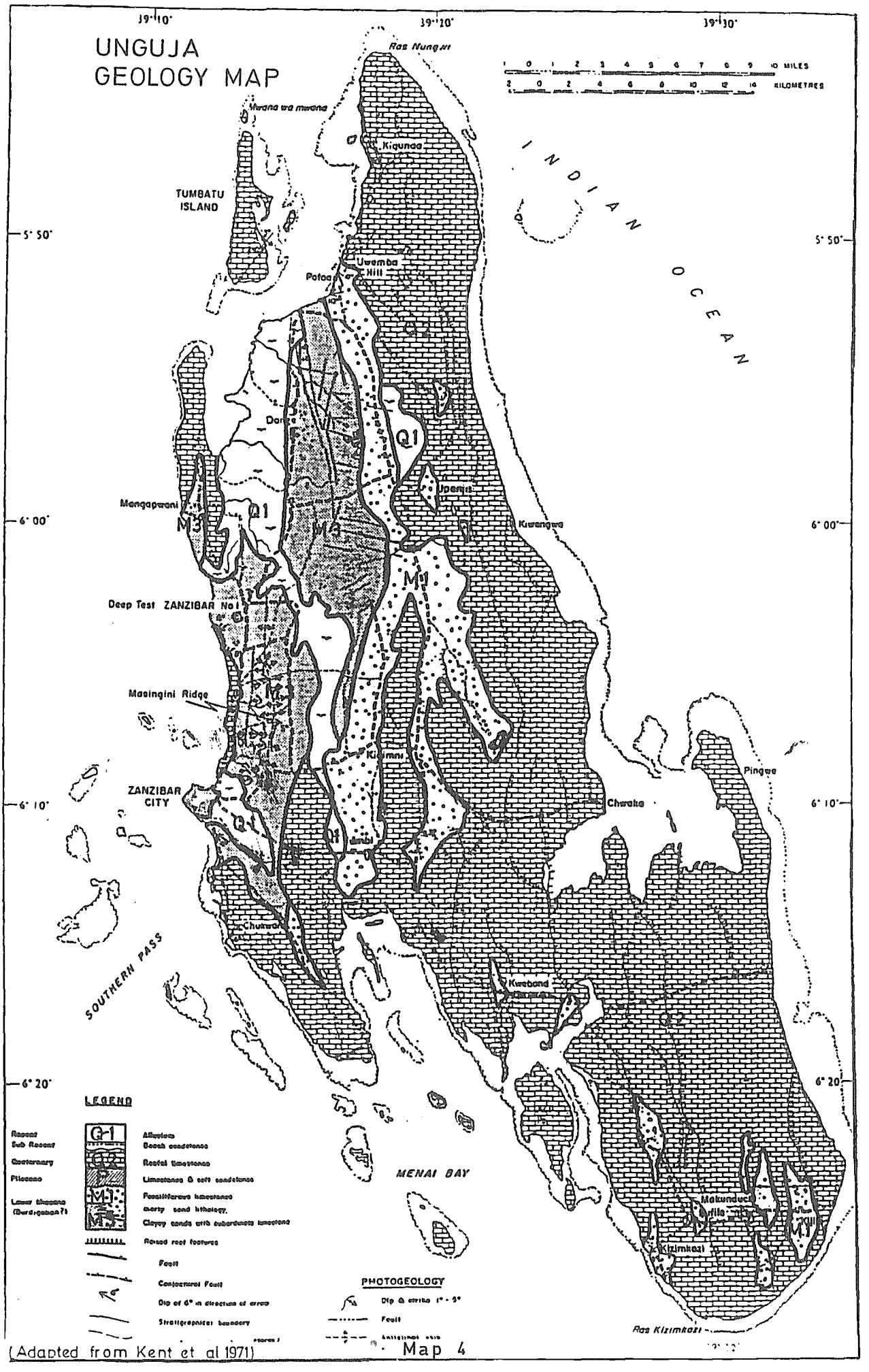
Q3 - Early Quartemary deposits, which refilled the reactivated corridors and channels. These consist mainly of marine sands and are found below the Q2 layer. At times this layer is not found as it has been eroded off prior to Q2 formation.

M - Miocene Limestones

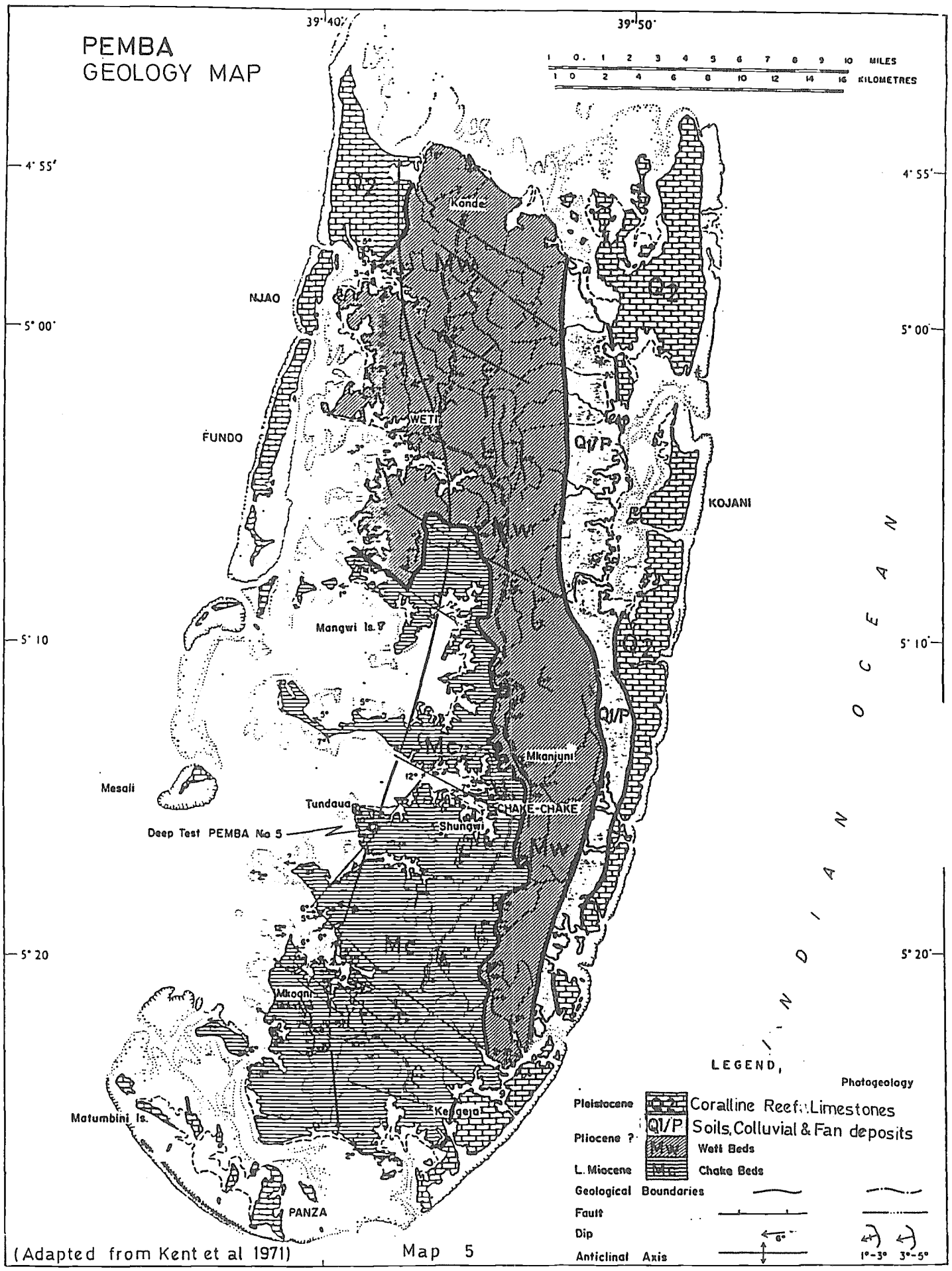
The Miocene limestones of Unguja are differentiated according to age and stratigraphy as M1, M2 and M3 limestone. The M1 being the most recent of the three deposits and therefore located on a higher stratigraphic plane with M2 and M3 being located in lower stratigraphy planes.

M1 - Consists mainly of crystalline, reef and detrital limestones of the original Delta sediments, they weather to form the Kinongo soils.

M2 - Consists of grey to white sandy limestones with hard siliceous bands, which easily weather into sand and sandstones most of the exposed layer of this limestone group have been weathered and as such no consolidated outcrops are mapped but their weathered products are all too apparent within the corridor zones, coastal ridge areas and dissected ridges. They give rise to the Sandy Mchanga soils.


UNGUJA
GEOLOGY MAP
39°10'
39°20'
39°30'
5° 50'
6° 00'
6° 10'
6° 20'
Ras Nungwi
Kiqunda
TUMBATU ISLAND
Uwemba Hill
Potoa
Mangapwani
Deep Test ZANZIBAR No 1
Masingini Ridge
ZANZIBAR CITY
Kiwengwa
Pingwe
Chwaka
Kizimkazi
Ras Kizimkazi
SOUTHERN PASS
MENAI BAY
INDIAN OCEAN
10 MILES
16 KILOMETRES
LEGEND
PHOTOGEOLOGY
(Adapted from Kent et al 1971)

Map 4



(Adapted from Kent et al 1971) Map 5

FAULT BLOCKS OF UNGUJA SLAND

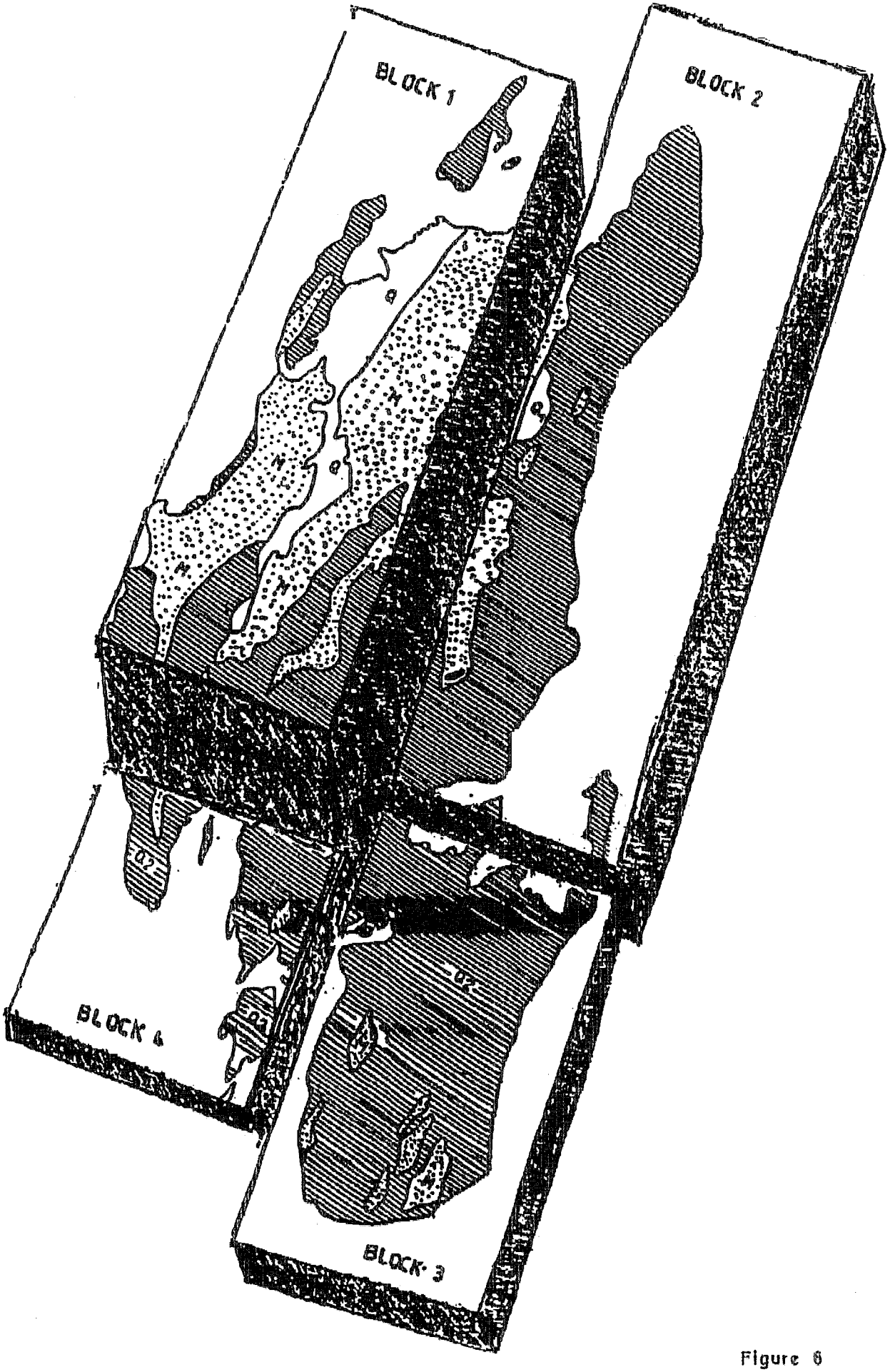


Figure 6

M3 - These are Greyish to Bluish green limestones, consisting of marls clay and sandy clays and weather into heavy clay materials which are found underlying the weathered M2 products - coarse sands. This combination of deep sandy surface material overlying heavy sandy clays subsurface material have given rise to the dissected ridge topography seen in the C2 mapping unit (Dissected low ridges). The soils occuring on these limestones have been classified as Kinamo and Sandy Mchanga.

In Pemba, only the lower stratigraphic and therefore the older M3 Miocene formations have been identified. The M3 Miocene formation recognised here are much finer in grain size and less permeable due to the higher shale content evident. They consist of shales, marls and sandy clays. They have been sub-divided into two groups according to local differences. MC for Chake Chake limestone beds and MW for Wete limestone beds.

In both Islands localised outcrops of Pliocene material have been identified but are not of perticular significance in the mapping sequence. Both the Q2 coralline reef limestone and M1 miocene limestone are Karstic and there are many sinkholes and caverns located within these regions. Most of the rivers and streams that flow into them go underground into some subterranian channel. The predominantly North-South orientation of the Geophysical features on Unguja and Pemba are considered as natural continuation of the landforms around Dar es Salaam shaped by the deltaic stream flow patterns.

The Geological maps of Unguja and Pemba together with a map showing the differently elevated fault blocks of Unguja are presented in pages 27,28 and 29 resopectively.

2.3.2 Hydrology & Drainage Systems

The main sources of water for town, villages and rural use are from spring zones, limestone caves hand dug wells and boreholes. There are no surface water development or storage mainly due to the poor water holding characteristics of the surface layer.

Generally all the Zanzibar strata have aquifer potential to a greater or lesser extent.

The shoestring limestone of the corridor zones of Unguja acts as the most important Aquifer. The larger of these aquifers are about 2 - 4 km wide.

These hydrologically productive corridor zones on Unguja are a complex of Q1, Q2 and Q3 strata, where Q2 and Q 3 are transmissive strata. The main permeable zone is the top weathered 10 m of the Q2. Besides these the M1 and M3 limestone are also discrete aquifers, although their productive capacity is very much less.

Most water encountered on the Island is suitable for domestic, industrial and irrigation usage. Averege TDS values can be as low as 50 rarely as high as 600 mg/l.

In coastal areas some village wells exhibits a shallow perched aquifer overlying a saline aquifer. During dry spells the fresh water lens is subject to exhaustion.

Deeper aquifers such as those found within the Karroo deposits which are continuous to the mainland are recharged on the mainland.

2.3.3 Drainage

The drainage of Unguja are chiefly westerly but predominatly subsurface, except in areas with the heavy clay soil. Major streams disappear into the peripheral coralline and Miocene limestone areas where many sinkholes and caverns characteristic of Karstic limestone formations are common.

Infiltration is very rapid and there is also a rapid rise in the water table after heavy rainfall due to the underlying clayey sequence in certain areas. In the dissected ridge area the underlying slowly permeable heavy clay soils give rise to lateral subsurface drainage flows causing the silding and slumping of the top sandly layers resulting in dissected landscape and a dendritic drainage pattern.

Pemba consists mainly of a single ridge from which sharply incised valleys are seen penetrating the partly drowned and often precipitious west coast. The valleys of the eastern watershed are flat bottom and filled with eroded silts, clays and sands. The eastern coastal valley flocrs are generally flat and often water logged.

2.3.4. Topographic Features

The main topographic features of Unguja are series of corridors bounded by a number of parallel ridges (highest point 117 metres) running in the North South direction. These corridors were originally the streams on the Miocene Rufiji/ Ruvu river delta system before Unguja was raised due to block faulting. "In the Quaternary times reefs and coralline limestone growth commenced in the channel zones, and continued in a falling sea with coral reef growth (which must grow in the shallow sunlit portions of the sea) retreating down and along the corridors and across the wide coastal coral rag platform". (Johnson 1983). Subsequent erosion and colluvial movement deposited the soil materials over the coralline limestone. These corridors are up to 5 kms. wide and 30 to 45 meters deep. Chief among these corridors are the Bumbwi corridor and the Bambi - Upenja corridor (Report on the Hydrogeology of Zanzibar Island, 1982). The Bumbwi corridor is bounded by the Masingini ridge on the west and the Donge ridge on the east. It slices through the whole island from north to south forming wide bays on the north and south coasts. Mahonda, Bumbwi, and Mwera valleys lie in this corridor. The width of the corridor varies from 4 kms, at Bumbwi, 4.5. kms. at Mahonda/ Chechele, to 5 kms, at Mwera. The valley floors are 30 to 45 metres below the ridge tops in general.

The Bambi - Upenja corridor includes the Chaani, Kibokwa, Upenja and Kilombero rice growing areas. This corridor lies bordering the east side of Kinyasini, Chaani and Mkwajuni ridges.

The topography of Pemba is dominated by a central ridge (Maximum elevation 97 m above sea level) running in the north - south direction which permits the major streams to drain to the east and the west. Steep sandy cliffs occur on the west coast and low cliffs of the reef limestone on the east coast. There are numerous long and narrow valleys surrounded by steep slopes. The valley floors are flat. Most of the valleys have river systems originating from springs and winding sluggishly along the sides or the middle of the valley floors.

TABLE 8

EXTENTS OF LANDS UNDER DIFFERENT MORPHO-ECOLOGICAL ZONES IN UNGUJA ISLANDS

ZONE	EXTENT (HA)	FRACTION OF TOTAL LAND EXTENT (%)
Ridge Zones	51,630	32.26
Reworked Corridor Zones	11,890	7.43
Wanda Zones	16,720	10.45
Maweni Zones	75,610	47.24
Swamp Zones	4,210	2.63

TABLE 9

EXTENTS OF LAND UNDER DIFFERENT TERRAIN CLASSES IN UNGUJA

TERRAIN OR TAPOGRAPHY CLASS	SLOPE RANGE (%)	LAND EXTENT (ha)	FRACTION OF TOTAL LAND EXTENT (%)
Generally flat	0 - 2	12,420	7.76
Flat to undulating	0 - 6	132,350	82.69
Rolling	6 - 33	12,040	7.52
Hilly	33 and above	3,250	2.03

Table: 10

EXTENT OF LANDS UNDER DIFFERENT MORPHO-ECOLOGICAL ZONES IN PEMBA ISLAND

ZONE	EXTENT (HA)	FRACTION OF TOTAL LAND EXTENT (%)
Ridge Zones	75,180	74.1%
Makaani Zones	15,010	14.8%
Swamp Zones	11,220	11.1%

Table: 11

EXTENT OF LAND UNDER DIFFERENT TERRAIN CLASSES IN PEMBA ISLAND

TERRAIN OR TOPOGRAPHY CLASS	SLOPE RANGE (%)	LAND EXTENT (HA)	FRACTION OF TOTAL LAND EXTENT (%)
Flat to gently slope	0 - 6%	34,080	33.6%
Gently undulating to rolling	2 - 20%	34,080	33.6%
Rolling to hilly	20+%	33,250	32.8%

2.4. Vegetation and Present Land Use

2.4.1 Natural Vegetation

The original vegetation of Unguja would have been tropical high forest except in the corralline areas such as Maweni where less humid conditions would have given rise to decidous woodland. Due to activities of man this pattern has been greatly modified to the extent, such that mosaics of forest regrowth, secondary forest and derived Wanda vegetation types, resulting from bush fallow cultivation practices, now cover the Maweni and Wanda zones within the coastal and coralline areas, which were the locations of the earliest known settlements on Unguja.

In the coastal and inland swamp areas; Swamp specific vegetation patterns have developed due to the influence of tidal and fresh water inundations respectively. The most extensive swamp forests are located around Chwaka bay. Some of the taller species of trees attain heights up to 20 m and produce valuable timber. Some are suitable for canoe building and all species are suitable for poles and fuelwood.

2.4.2 Present Land Use

Within the ridge zones and corridors zones the original high tropical forest prevailed till the occupation of the Omani Arabs who started the clove and coconut plantations and within a short interval of time nothing much was left of the original vegetation and forest, except for what is left in the Masingini, Jozani and Ngezi forest reserves.

In 1980 - 82 a Land Use atlas of Zanzibar was produced by the National Coconut Development Programme based on aerial photos taken in 1977. This is the only land use study covering both islands, Unguja and Pemba, available at present. The atlas is made up of 101, 1:25,000 scale coloured maps, 58 covering Unguja and 43 covering Pemba.

The various categories of Land uses recognised and their extents as extracted from the land Use atlas are tabled overleaf.

Table 12

LAND USE PATTERN, 1977 1/

Land use category	Unguja ha	Unguja % of total	Pemba ha	Pemba % of total	Total Zanzibar ha	Total Zanzibar % of total
1. Cultivated land, of which						
(a) Sugar cane	1 850	1	-	..	1 850	1
(b) Rainfed rice	5 395	4	8 385	9	13 780	6
(c) Irrigated rice 2/	405	..	-	..	405	..
(d) Other continual/ rotational crop land	8 815	6	11 980	13	20 795	8
(e) Purestand tree crops	2 375	2	31 145	34	33 520	14
(f) Complex associations						
(i) associations of tree crops	31 655	21	10 180	11	41 835	17
(ii) associations of tree crops and food crops	12 685	8	6 030	7	18 715	8
(iii) other associations 3/	590	..	80	..	670	..
(g) Total cultivated area	(63 770)	(42)	(67 800)	(74)	(131 570)	(54)
2. Grazing land, of which						
(a) Ranches and dairy farms	2 140	1	-	..	2 140	1
(b) Unimproved grazing	60 645	40	16 915	18	77 560	32
3. Forest and woodland	24 890	16	5 705	6	30 595	12
4. Other land use						
(a) Settlements	1 695	1	1 300	2	2 995	1
(b) Other	200		110		310	
Totals	153 340	100	91 830	100	245 170	100

Source: Land Use Atlas, Zanzibar and Pemba Islands, 1:25 000, prepared by the Airphoto Interpretation Section, National Coconut Development Programme (NCDP); Ministry of Agriculture, Tanzania, and German Agency for Technical Cooperation (GTZ), 1982.

1/ Excluding mangroves and tidal swamps.

2/ Does not take into account the results of the rice development programme.

3/ Crops in settlements and pasture or swamp/tree associations.

3. HUMAN ENVIORENMENT

3.1. Basis of The Present Economy

Agriculture, including fisheries and livestock production, is the mainstay of the Zanzibar economy with cloves and coconut plantations accounting for more than nine tenths of the exports.

About 70% of the population live in rural areas and 90% of the rural population are engaged directly in Agricultural pursuits.

Agriculture accounts for nearly 55% of the GDP and over 90 percent of the foreign exchange earnings, followed by trade and public administration which together contribute around 30% of the national production. Most of the clove plantations are in Pemba while coconuts are dominant in Unguja, however, both clove and coconut plantations are currently undergoing rehabilitation since poor husbandry has greatly reduced their productivity.

Agriculture is also the main employer of work force. Fishing in particular provides lucretive employment for the people living in the coastal areas, particularly in the Maweni zones, where shifting cultivation is extensively practiced.

Zanzibar's agriculture has generally suffered from inadequate price incentives, devaluation of Tanzania Shilling and associated high cost of productivity.

The rural households in Zanzibar show remarkable similarity in terms of available and disposable resource. There is no incentive for surplus production of any forms. The rural shops too, have only the very basic requirements for sale. Since almost all the rural population produced the staples they needed.

Very few strive to produce more than immediate needs due to uncertain marketing facilities and high cost of transportation of produce. Where the land resource was insufficient for sustenance or in corraline areas, off farm income generating activities such as charcoal making, fuelwood and pole extraction and fisheries etc. provided the essential means of existence.

3.2. Population & Education

3.2.1 Population Distribution

According to the preliminary report of the 1988 population census, the total population of Zanzibar is 640,578. The detailed distribution according to regions, districts and sex, for each Island is tabled below:-

Table - 13

ZANZIBAR POPULATION DISTRIBUTION*

ISLAND	REGION	DISTRICT	TOTAL POPULATION	MALE	FEMALE	AVERAGE HOUSE-HOLD SIZE	POPULA-TION GROWTH % (1978 -89)
UNGUJA	NORTH	NORTH A	59,992	28,228	31,764	4.1	2.3
"	"	NORTH B	37,036	18,082	18,954	4.1	2.3
"	SOUTH CENTRAL	GENERAL	45,037	23,025	22,012	4.5	3.1
"	"	SOUTH	25,147	12,012	13,135	4.5	3.8
"	TOWN & WEST	WEST	50,693	26,396	24,297	4.5	3.8
	"	TOWN	157,634	77,787	79,847	5.0	3.8
FOR UNGUJA (Total)			375,539	185,530	190,009	4.5	3.0
PEMBA	NORTH	WETE	76,258	36,988	39,270	4.8	2.6
"	"	MICHEWENI	61,141	29,862	31,279	4.5	2.6
"	SOUTH	CHAKE CHAKE	60,131	29,408	30,723	4.9	2.6
"	"	MKOANI	67,509	33,076	34,433	4.7	2.6
FOR PEMBA (Total)			265,039	129,334	135,705	4.7	2.6

* Figures from 1988 population cencus Preliminary Report Bureau of Statistics Ministry of Finance, Economic Affairs and Planning, Dar es Salaam.

3.2.2 Education

The Department of Education, Zanzibar celebrated 25 years of free education in September 1989.

Compulsory schooling starts at age 7 in co-educational institutions and goes on for 11 years. Most of the schools have two sessions per day in order to cope with the student population. Even with these measures reportedly only approximately 60% of the age-eligible children were enrolled in primary schools (Standard 1 to Std. V111) and approximately 40% in lower secondary schools (Form 1 - Form 111). *

A department for Adult Education established in 1978 has contributed much to the present estimated figures that over the adult population is literate, which is higher then in most countries in Africa.

3.3. Agricultural and Land Policies

The Government of Zanzibar has summed up its agricultural policies in its Publication: 'Sera ya Kilimo', Agriculture and livestock Policy for Zanzibar Published in 1984 which made a number of proposals on land tenure. The most important outcome of this is the setting up of a land Commission within the office of the Chief Minister responsible for deciding and arbitrating on all matters concerning land use and land allocation.

Objectives of the Zanzibar Agriculture and Livestock policies is briefly summarised below:-

Improve agriculture sector to become self-sufficient in most requirements; Diversify economy with new better managed cash crops and produce necessary raw materials for agro-based industries. Encourage people and youth in rural areas to participate more in agricultural and livestock production through various incentives such as export facilities, loans, essential services and encourage them to form farmer cooperatives. Increase the use of livestock in agriculture related activities such as transportation, ploughing, production of bio-gas etc.

*FAO/IFAD Report 1989.

3.3.1 Agricultural Policy and Subsidies

All lands in Unguja and Pemba to remain as national property.

Re-registration of land with the ultimate goal of producing a general land use plan.

Establishment of a land commission with representatives at regional, district and ward level.

New laws to be legislated to deal with utilisation, conservation and reclamation of lands. Consider the validity of past and present land laws and the consequences of the land allocation practice after 1964.

The following table summerises the subsidies offered by the Government as incentives to farmer.

Table - 14

GOVERNMENT : SUBSIDIES

ITEM	SUBSIDY	COST TO FARMER(T.SHS)
Fertilizers	92%	150/100 Kg.
Ploughing and Harrowing by Tractors	89%	1940/ Ha.
Irrigation water	87%	2000/ Ha.
Land Development costs for Irrigated Rice Production	100%	-
Herbicides	41%	500/ Liter

Source: Departments of, Planning and Administration and Plant protection.

3.3.2 Ownership of lands

Revision of the Government 3 acre plot land allocation policy as the population is increasing at a high rate while the land area remains constant. Reallocation of lands not properly maintained or abandoned amongst those who can make it productive to the required level.

In rice valley, according to availability of lands, farmers to be allocated 0.2 ha. in irrigation fields and 0.4 ha in rainfed areas with right of ownership up to 33 years. Owned lands, be it on upland or Valley, three acre plots or with permanent crops will have the right of ownership up to 200 years.

3.3.3 Usage of Lands

Every region, district and ward will have the social and economic values of the land identified and its own land use programme. Land use plan will be prepared indicating lands for different purposes and Ministry of Agriculture is to conduct Soil Analysis and monitor yields through surveys.

Due to existing scarcity of land every citizen with arable land is required to use it for growing either food or cash crops.

Where possible farmers will be encouragedto practice mixed farming to increase production from the small amount of land.

Extension services will be improved and great emphasis placed on proper land management as specified under the land laws.

3.3.4 Mtakula Programme

Subsequently the national Programme for food Self Sufficiency (Mtakula) was launched in 1987. Its main goals are to achieve food self sufficiency by year 2000 through increased production of rice and also other staples such as roots, tubers and grain crops:

1. Reduce the dependency on rice imports.
2. Diversify exports.
3. Reduce subsidies on fertilizer from present 92% to the actual cost.
4. Remove consumer subsidies on rice;
5. Stabilize producer prices.

Techniques and methods to be adopted to achieve the 'Mtakula' objectives are:-

1. Improve extension;
2. Mobilize farmers, motivate and unite them in cooperative societies of their own choice through proper management.

'Mtakula programmes will be mainly involved in the production of rice, cassava, sweet potatoes, bananas, maize, millet, pidgeon peas, sugar cane, cowpeas, citrus, meat, milk and eggs.

3.4. Land Tenure Systems *

The present land tenure system is dominated by (i) Presidential Decree PD 13/1965 which vested all land in the government. (ii) PD 5/1966 land distribution Decree to effect the distribution of agricultural land to landless families. (iii) PD 1/1969 - Distribution of plots for construction/ building purposes.

Therefore lands within the present tenure system comprises of:
- Private property with titles granted under the above decrees;
- State land - Land which government held before 1964;
  - Land and premises confiscated under confiscation Decree PD 8/1964;
  - Land in the form of forest reserve and unoccupied lands.
- Land under Wakf and Trust Commission.

According to the present legislation, only transactions of property are registered, hence, there is no register showing the holdings of more than 70,000 families who undertake small -holder farming in the Islands. Not even the 27,825 ha of plantation land, which was distributed during 1964 - 1975 to more than 26,000 families, recorded, surveyed or the rights of occupancy for the recipients of the 'three acre plots' clearly addressed in records.

* Based on information received from the on-going Regional Land Use Plan Project.

The newly established Commission for lands and Environment (Bill of establishment passed in the House of Representatives in early October 1989), divided in Department of Lands, Surveys and Detail Planning and Environment, is to be the first co-ordinative body ever in Zanzibar, to be responsible for all land issues. The new legislation (Land tenure Act, land Adjudication Act, Land Registration Act) will, after being accepted (Late 1989 - early 1990), lead to registration of rights of occupancy of all holdings, whether private or incorporate/ government. Surveys of the holdings and titles will provide the security of rights now largely missed.

3.4.1. Categories of Land Rights Within the Tenure System

Although all land in Zanzibar is vested in the Government land rights and habits which originated in the islamic law and traditional rights are still respected. In the rural areas of Zanzibar the following kinds of land Tenure is prevalent:

Plantation Region

(a) Shamba Farming System

1. Three acre plots distributed by the Government out of the land that was confiscated after the Revolution. These were allocated to the former plantation workers and landless people who had large families. These lands could be confiscated if the allottees do not adhere to conditions as laid down in the decree PD 5/1966.

2. Inherited Land

Despite the fact that all land belong to the Government the habits of inheritance of property follows the Islamic and existing laws and it is possible to inherit land.

3. Family Plots

Family plots are inherited land belonging to several family members, usually one family member looks after the land on behalf of the rest of who are living elsewhere.

4. Bought Land

These are inherited land (except Wakf land) which have been sold by the owners. The payment extracted is usually for the crops and infrastructure on the land. No value is put on the land as all land is Government owned.

(b) Konde Farming System

1. Borrowed Land

These lands can be used for growing non permanent crops. No rent is paid, usually the borrower can use the land during his life time.

2. Land seasonally allocated by the Government

These lands are usually in the developed valleys of the corridor zones they are conditionally allocated in small plots for specified land uses e.g. rice.

Coralline Region

Shifting Cultivation System

These are usually Maweni lands used for shifting cultivation. Permission for their use is obtained from the local CCM branch. The usual mode of safeguarding the right to use after a short ley period is by erecting a fence of coral around the perimeter of the plot.

3.4.2 Land Tenure and Farming Systems

There are three district farming systems practised within the two major Agroclimatic Regions in Zanzibar. The plantation region has two farming systems and the coralline region has one farming system as detailed below:

Plantation Region

Restricted to the Plantation regions with good soil there are two traditional Farming systems which characterise Land Tenure.- They are:-

(a) Shamba Farming System

A shamba farmer is one who owns or has assurance by law for long term utilisation of the land he farms. His land will come under one of the following categories of land rights within the tenure system:

(a) 3 acre plot (b) Inherited (c) Family plot

(d) Bought land.

He is free to cultivate permonant tree crops, field perinnials or annuals on the land. If he is unable to farm

all the land on his own he has the right to allow a Konde farmer to farm in the under-utilised portions of his land, if one or more Konde farmers are farming within certain portion of a shamba these portions are termed shamba cum Konde farming areas.

(b) Konde Farming System

A konde Farmer is primarily farming on someone else's land, his land will come under the following categories of land rights within the tenure system (a) Borrowed land (b) Land seasonally allocated by Government. Konde farmers are not allowed to grow permanent tree crops on the land they farm. However they are allowed to grow annual crops and field perennials like Cassava, Banana, Papaya, Pidgeon peas, Sugar cane etc. The permanent tree crops within the land he farms belong to the shamba owner. A Konde farmer does not pay for the land he farms but is duty bound to safeguard the tree crops in the Shamba.

Coralline Region

Within these regions a traditional shifting cultivation system is practised. Permission from the local CCM Branch has to obtained before the land can be cleared for farming.

It is common that one year of cultivation alternate with a short term fallow period of 3 - 5 years or three years of cropping succeeded by 7 - 10 years of fallow depending on the productive capacity of the land being farmed. Some farmers build walls by stacking coral around the perimeter of these plots for protection from animals and as a means of reserving it for future use after the fallow period.

3.4.3 Distribution of crop areas (%) by owned/borrowed land tenure terms within plantation regions:-

Crop	Owned Shamba %	Borrowed Konde
Clove	100	0
Citrus	96	4
Mango	100	0
Breadfruit	88	12
Papaya	50	50
Banana	50	50
Pigeon pea	30	70
Cassava	40	60
Rice	40	60
Cowpea	45	55
Sweet potato	35	65

Source: Adapted from Farming Systems in Zanzibar -NCDP 1988 (Provisional results)

3.4.4. Existing Land Tenure and its Impact on Socio Economic Factors*

Many people have abandoned their allocated three acre plots under PD 5/1966 and moved to towns or even to the mainland. Some had no experience in farming the types of crops that were grown in the plots. This is mainly the case in clove and coconut plantation areas. Some live far from their allocated lands.

There has been uprooting of families from their traditional residential areas moving to various other parts of the islands. This has contributed to neglect of their farms and decline in production.

The life interest on land allocated freely as guided by the decree is new to "Zanzibar Culture of ownership."

People do not trust in the offer as it does not provide adequate security for major investments and improvement to the land. Some perceive it in the light "What was given free can be taken free."

Squatting on land has increased and it has been difficult to practice "Land Use Planning."

Land administration has been unsatisfactory, having different government and party institutions involved in a allocating land and advocating land use planning. Activities that are never co-ordinated. No enforcement of the regulations for those who breach the covenants.

3.4.5 Physical Planning of Land Resources in the Context of Existing Land Tenure*

Since land use activities are guided and controlled by the public sector as well as the farmers, land use policies should be binding to all.

Attempts have been made by some of the institutions that practice land administration with regard to planning of the use of the land resources. Ministry of Agriculture plans for agricultural developments and Commission of lands and Environment plans for settlement development. These activities have been going on separetely and with less co-ordination resulting in a number of problems on the planning and implementing process itself and to the management of land resources. It has not been easy to implement the good physical plans prepared by these institutions and realise their impact on land resource management due to limitation of resources, such as trained manpower, facilities for regular field travel and non availability of provisions for reimbursement of travel expenses incurred while on duty within the country. Other drawbacks are the loop holes, within the land decrees that make every one free to deal with land usage the way he thinks is profitable regardless of the directions of plans. Ad-hoc decision by politicians on land use i.e. what should be developed where, is also a contributing factor.

* Based on information provided by the regional land Use Plan project.

Hence, it is appropriate that a competent organisation responsible for land resources inventory and land use planning should serve as a tochnical body to suggest and formulate land Use policies on behalf of the Commissions.

3.4.6. Land Tenure and Degradation of Land Resources

Majority of land users in Zanzibar who directly engage in small holder farming practices mainly under the Konde farming system on borrowed lands and the 26,000 families which have been allocated 3 acre plots under the land allocation decree,do not hold legal title to the lands they cultivate.

The first category (Konde farmer) is cultivating lands which already have tree crops belonging to a third person whose entitlement to the permanent crops on the land is assured. He is allowed to farm the land with semi-permanent and annual crops without damaging the existing crops.

The second category farms their 3 acre plots and are free to choose whatever crops they prefer to cultivate according to the traditional Shamba system or engage a Konde farmer to look after their interests while they reside elsewhere however, both these categories have no real committment to invest in land improvement as they consider the land as belonging to a third party.

In the case of these two catagories of farmers there is no interest in conservation of the land resource as it does not belong to them. Therefore either intentionally (for ease of cultivation), or unintentionally (due to lack of knowledge and sound extension advise) they carry out damaging land use practices such as ridging down the slope for cassava or clearing the protective grass cover on slopes exposing the bare soil. Thus causing accelerated erosion of good soil layers and simultaneously subjecting the permanent tree crops on upper and mid slopes to severe moisture stress. This in turn has adverse effects on the yields of the tree crops planted on the higher aspects of the land-form,finally resulting in these tree crops succumbing easily to disease and pests, from which they seldom recover, as their nutrient supply as well as their soil moisture is depleted.

This is amply reflected in the gradual decline of yields during the last decade and the high incidence of die back, sudden death, and other diseases. Hence, it is absolutely essential in the interests of the future generations to enact legislation on soil and water conservation and lay down proper guidelines regarding the cultivation of sloping and hilly lands, whereby both the Konde farmer and the Shamba owner are responsible to effect prescribed conservation measures.

3.4.7 Legislation on Land Use

Present Legislation relating to land use is very weak and fragmented new laws are required to ensure that proper soil and water conservation measures are adopted together with the appropriate land use as planned. It is proposed that a land utilization ordinance be enacted, designed to review existing land use, plan new land use activities and conduct research on land use and land management practices on all lands in Zanzibar, the ordinance should provide for compulsory land use planning and environmental impact assessment before any organisation or individuals embarks on new land Use activities present land use too should be reviewed with an intention of examining the suitability and adoption of more suitable enterprises and improved land management practices.

3.5. Transportation and Road Network

Inadequate transportation and deteriorating physical infrastructure such as roads are the weakest links in the economic chain of predominantly agricultural Zanzibar.

The present situation is the culmination of neglect and or insufficiency of resources being provided over the past few years for adequate maintenance of the essential road network which serves as the only link between the farm and the market.

Some major roads are currently being upgraded under assisted projects. However, these programmes are expected to take several years to be able to contribute much in terms of cheaper and better transportation facilities, especially for the farming population. Most of the existing secondary roads and feeder roads connecting with the major roads are also in very bad condition even during the dry season and become impassable in the rainy season, thus cutting off the timely supply of inputs to farms and the transportation of perishable produce to markets.

This situation has to be urgently rectified to realise the actual effects of increased food production through the "Mtakula" Programme that is to be effected within the next 10 years.

3.6 Allocation of land among enterprises and land uses

The question of land allocation for enterprises rests on several factors all of which are dependent on land tenure laws that are currently being revised.

A consultant on land tenure will be needed to interpret the new laws and look into the possibility for the allottees obtaining such facilities as agricultural credit, etc. before any decisions could be taken as to weather it will be a viable proposition.

The Regional Land Use Plan Project will deal with this subject after the laws are passed and fully interpreted.

4. SOIL RESOURCES

4.1. Introduction

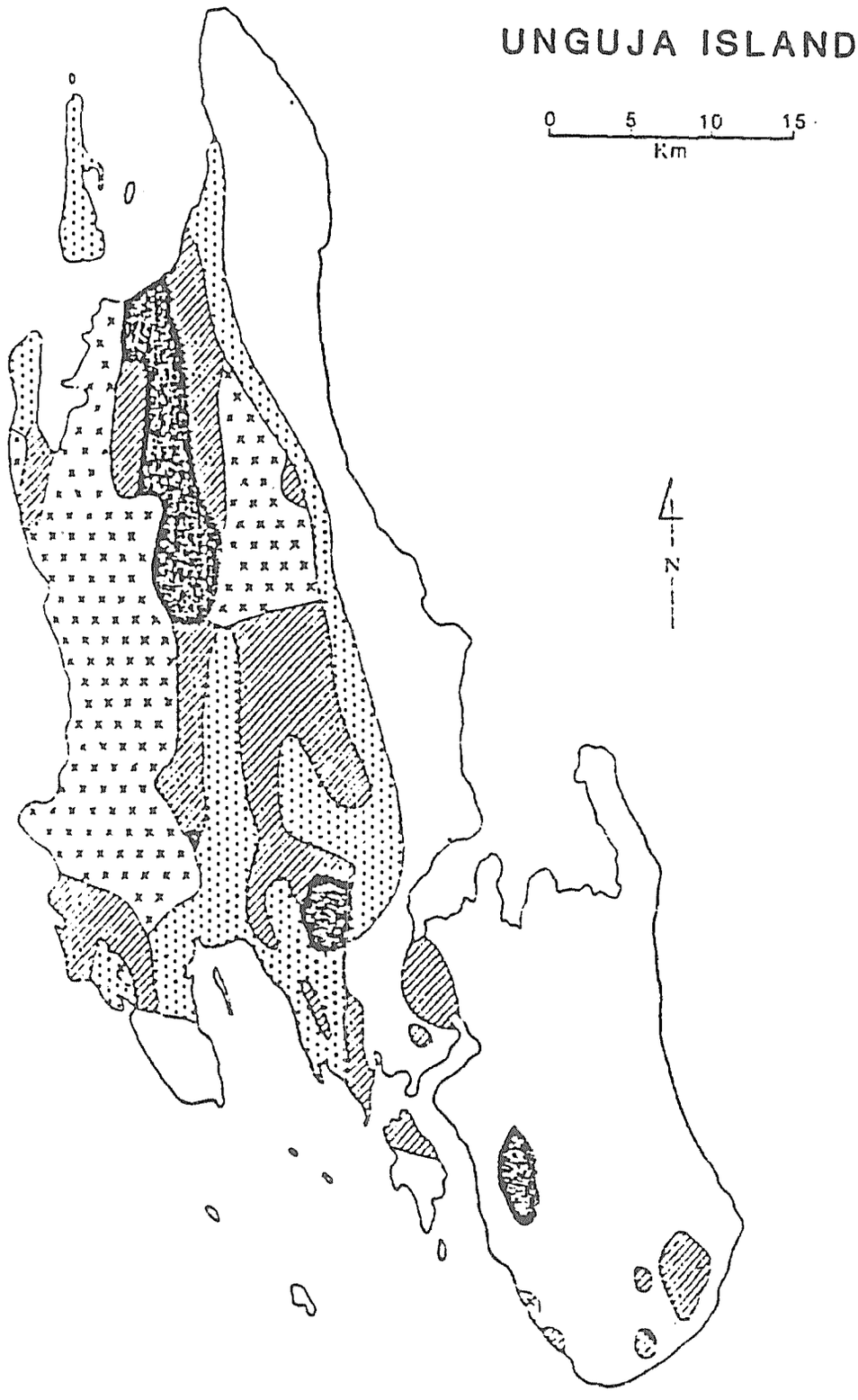
Calton et al characterised the soils of Unguja and Pemba during the period 1949 - 1955. No recent soil classification has been carried out at national level since this work. Unfortunately not a single soil profile description or other detail records of the field activities in Unguja or Pemba were available to understand the criteria used in this classification, except the very brief descriptions of the soils outlined in an article published in the East African Journal Vol. XX1 - No. 1 of July 1955, titled. 'A study of more important soils of Zanzibar protectorate' by W.E.Calton, G.E Tidbury and G.F. Walker, respectively of chemical laboratories Dar es Salaam, Department of Agriculture, Zanzibar and Macaulay Institute for Soil Research Aberdeen.

During the project field work, profile description were made of 'Typical Pedons' in each of the soil units described by Calton. These were subsequently used together with the available laboratory data for correlation of the soils with the FAO System. The project profile descriptionsare included for reference in Part 11 Annex 11 of this field document.

Thirty representative soil profile pits from Unguja and thirty four pits from Pemba were sampled and the soil samples despatched to the National Soil Service Laboratories at Mlingano, Tanga in August 1989 and April 1990 respectively. No analytical data on any of the samples were available for use in the soil correlation exercise or for inclusion in this report.

FAO guidelines for soil profile descriptions were used in the description of the Pedons and soil correlation was carried out using the FAO/UNESCO/ISRIC, soil map of the world, revised legend (1988 edition).

Table 16 and 17 show the correlation of the soils of Unguja and Pemba and the corresponding profile numbers relevant to each soil profile description included in annex 11.


UNGUJA ISLAND
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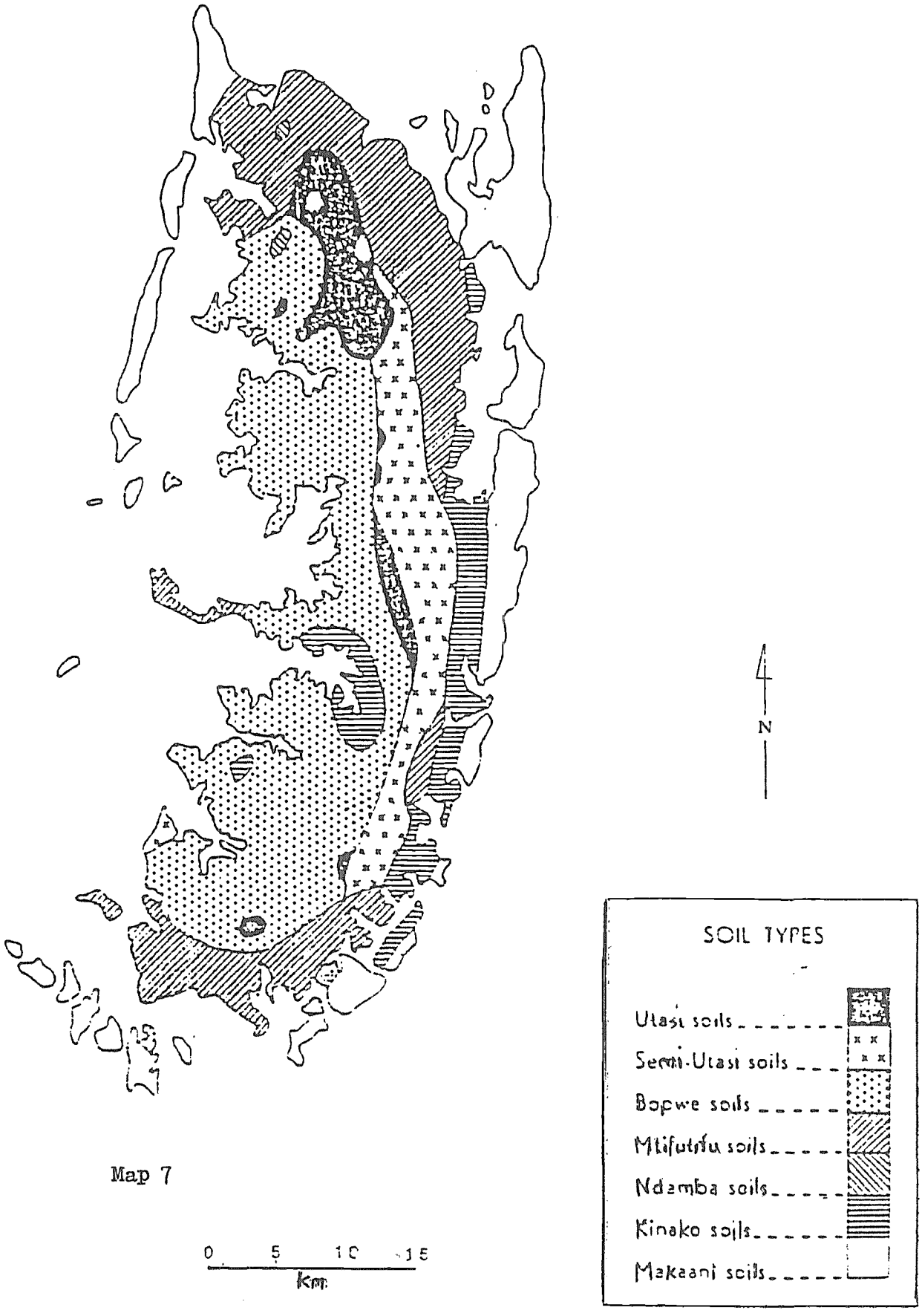
N
SOIL TYPES
Kinongo soils
Uwanda soils
Maweni soils
Mchanga soil

Map 6

PEMBA ISLAND



Map 7

Table: 15

AREA UNDER DIFFERENT CATEGORIES OF SOILS BASED ON CAMPON'S CLASSIFICATION

Soil groups	UNGUJA area (ha)	%	Soil groups	PEMBA area (ha)	%
Kinongo soils (loamy type)			Upland soils		
Deeper kinongo	8,912	5.81	Bopwe	24,123	26.2
Shallower kinongo	12,231	7.98	Utasi	8,998	9.8
Uwanda	25,337	16.52	Semi-utasi	7,329	7.9
Maweni	65,045	42.42	Ndamba	765	0.8
Swampy Wanda	1,269	0.83			
Shell soils	704	0.46			
Mchanga soils (sandy type)			Lowland soils		
Reddish and brownish	10,725	6.99	Mtifutifu	26,564	28.9
Yellowish and greyish	13,277	8.66	Kinako	8,215	8.9
Sandy	7,596	4.95	Makaani	15,836	17.2
Kinamo soils (clayey type)					
Kinamo	8,244	5.38		91,830*	100.0
	153,340*	100.00			

*Area under marshes and swamps not included.

Source: FAO/IFAD, 1987

4.2. Soil Classification - Unguja Island

The soils of Unguja have been subdivided into the following three groups by Calton:

1. Mchanga (Kichanga) group
2. Kinango group
3. Kinamo group

Each of these group have been further subdivided into sub groups based on colour depth and Texture as outlined below: .

4.2.1 Mchanga group

This group is described as soils of variable drainage derived from non calcarious sediments. They are regarded as the normal soils of the island developing on mixed materials, particularly the M2 and M3 limestone associated with the coastal areas, and are similar to the dominant soil of the adjacent mainland. The Mchanga soils, are described and mapped under the following sub groups.

4.2.1.1 Reddish and Brownish Mchanga

They are deep, reddish in upper slopes of the terrain, becoming brownish on midslopes and lower slopes and are described as well leached soils lacking in soluble salts and Carbonates. In terms of soil drainage they are well to moderately well drained deep soils.

They have a pH of about 5.5 which usually remains the same or decreases to around 5.0 at depth. Exchangeable Calcium is uniform in profile at 2 - 3 m.e per 100 g of soil, organic carbon is usually about 1% in the top 25cm and falls to about half this amount within the next 25cms.

The Truog Phosphate is around 5 parts per million P throughout the profile. Kaolinite is the predominant clay mineral with traces of Goethite.

The main crops grown in these soils are clove, coconut, citrus, bananas, cassava, sweet potato, pineapples, together with variety of homegarden, tree crops such as jak break fruit, durian, rambuttan, etc.

FAO equivalent:- Rhodi-Haplic Acrisols and Haplic Acrisols respectivoly.

4.2.1.2 Greyish/Yellowish Mchanga

This sub group is not clearly defined. In the soil map both imperfectly drained Mchanga soil occuring adjacent to the corridors and the actual corridor zones with the associated hydromorphic soils of variable texture and or origin are grouped together and Mapped as one unit.

During the field investigation it was apparent that this grouping was not satisfactory as the corridor zones soils which were classified as Gleysols and Fluvisols do not conform to the general description and morphological characteristics of the Mchanga group.

The yellowish Mchanga is described as deep but sluggishly draining loamy to heavy soil with blue grey mottles at depth, this appears to be imperfectly drained member of the Mchanga group and the corresponding terminology according to FAO classification, as determined during field observations conducted, points to these being Ferric and Gleyic Acrisols.

The Greyish Mchanga is separately described as sandy to silty soils with a permanent high water table, together with a peaty topsoil with black concretionary materials which are found just above the water table. These are clearly the Hydromorphic soils of the corridor zones which need to be separated from the Mchanga group due to the above mentioned reason. According to the FAO system of classification these soils are best described as Gleysols and Fluvisols, depending on their respective origins and locations. The pH values of these soils range from 4.5 to 5.0.

Land Use in the Yellowish Mchanga is similar to the Reddish Mchanga except with no clove trees at the lower aspects of the slopes.

While in the depressions and corridor zones where the Greyish Mchanga soils occur rice is predominantly grown during the Masika rains, and beans vegetables, maize and sweet potatoes during the Vuli rains. If the farmers got assistance of the Irrigated rice project, two crops of rice are grown.

4.2.1.3 Sandy Mohanga

These are described as more or less pure sands akin to the reddish and brownish Mchanga soils but dominated by their sandy parent material which are non calcarious sands and sandy clays. No other description of this sub-group, beside the above is given. In the soil map this group is demarcated along the western coastal area Northwards from Zanzibar city.

The predominant Land Use in these soils are coconut with mango, cassava, banana, Homegarden tree crops and arable crops such as pulses, groundnuts. Rice is grown in the Alluvio - Colluvial depressions and basins within this unit.

During the course of field work two [illegible]ere identified within this sub-group. They consist of Areni-Dystric Acrisols and Cambic Arenosols.

The Acrisols are composed of about 50cm of Loamy Sands overlying an almost Brownish Mohanga soil consisting of deep Sandy Clay Loams of uniform textural gradation to great depths, while the Arenosol consists of over 100 cm of Loamy sand overlying sandy clay loam described above.

4.2.2. Kinongo Group

The Kinongo soils are described as free draining soils, developing on weathered limestone materials and forming a maturity sequence. The deeper Kinongo soils are located on ridges, in almost parallel formation, mostly around the centre of the island; and in contact with the Mohanga group, while the shallower types cover the flat country to the East and South East. They do not exhibit catenary differentiation although the topography is generally irregular, probably due to the entirely vertical leaching regime and highly permeable substrata, as evidenced by a low water table within the parent rock below the soil material and the absence of a river system.

The degree of maturity of the Kinongo Soils are determined by the length of time during which the parent material has been exposed to weathering, the four clearly defined groups reflect a stepwise exposure of the parent material to weathering during the staggered period of emergence of the Island.

The following sub-groups of Kinongo Soils have been mapped:

4.2.2.1 Deep Kinongo

This is described as the most mature soil group with well drained profiles of above 1½ meter or more directly overlying limestone. The soils are rather heavy loams of full red colour (10R 3/6) with a remarkable uniform textural gradation in the profile with a slight increase of clay content which is possibly attributed to the diminishing organic matter content with depth. There are no illuvial horizons and the change from soil to parent material is sharp.

The pH of the deep Kinongo is around 6.4 with about 2.0% organic carbon. The exchangeable calcium content is less than 12 me per 100 gm of soil and the Truog phosphate is 43 parts per million. The pH rarely fall below 6.0 at depth, nor the exchangeable calcium below 6 me.

The main clay mineral is Kaolinite with some Goethite. The Cation Exchange Capacity is medium. The deep Kinongo soils are rather intensively cultivated with cloves, coconuts, citrus, banana, cassava, sweet potatoes, mango, pulses, pineapples and all types of homegarden tree crops and arable crops.

The Deep Kinongo Soils are correlated as Rhodic Ferral.sols.

4.2.2.2 Shallower & Shallow Kinongo

These soils exhibit most of the properties of the deep Kinongo except that the colour is a shade less red (10R 4/6) and the base saturation higher. The shallower Kinongo has a soil profile of about 1 meter over-lying decomposing limestone while the shallow Kinongo had decomposing limestones within 50 cms of the surface.

During the course of field work, it was established that the shallower and shallow Kinongo soils occured almost side by side in the low elevated portions of the ridges and were a result of differential weathering in situ of the underlying limestone rocks, which exhibited a rather wavy weathering surface in contact with the soil. The Land Use was similar to the deep Kinongo with the shallow areas not supporting cloves.

The top soil pH recorded was 6.8 with higher organic Carbon content of around 2.8%. Exchangeable Calcium at 25.5 me per 100 gr soils and Truog phosphate around 148 parts per million. The clay mineralogy is largely kaolinite with traces of vermiculite and Goethite. Calcite being the main constituent of the parent material with traces of kaolinite and hydrous mica.

The shallow Kinongo soil was correlated as a Calcaric Cambisol while the shallower Kinongo was classified as a Chromic Cambisol.

4.2.2.3. Uwanda Kinongo

The Uwanda is a dark reddish coloured high humic shallow soil of around 30cm depth overlying very porous shelly Coralline limestone materials, unlike in other Kinongo soils, Boehimite accounts for more than half the clay fraction of the Uwanda. The remainder being Vermiculite and Kaolinite. Increased amounts of Kaolinite, perhaps derived from the breakdown of Vermiculite are found in the more mature soil clay fractions. The presence of Vermiculite enhances the base holding capacity of the soils and the highly sesquioxidic nature is probably due to the porosity of the parent material (Q2 limestone) which permit very rapid leaching. The parent material is said to be like a sieve below the soil.

The soils are neutral to slightly alkaline with pH around 7.0. Organic Carbon content at around 6.8 and the Exchangeable Calcium content is 45.5 me per 100 gr soil, with Truog phosphate at 184 parts per million.

The Uwanda Land Use is generally open grasslands used as unimproved grazing land with scattered clumps of short scrub- like growth mainly composed of the Mtopetope (Anona Senegalensis), Guava and several other species.

The predominant grass species is 'Kichomanguo' (Heteropogon Contortus) which in its young stage provides excellent grazing for cattle but as the season progresses it becomes tough and lignified. These are subject to frequent bush fires during the drier periods. With the increasing population pressures a lot of the Uwanda land surrounding the thickly populated areas are now taken up as homestead garden and crops are planted in holes dug in the coral parent material. The FAO equivalent of this soil group is Mollic Leptosols.

4.2.2.4 Maweni Kinongo

This soil consists of pockets of black humic material which are located in the crevices of tho almost flat terraces of tho coralline reef limestones (Q2) which form tho extensive Eastern and Southern portions of the Islands.

The pH of tho soil material is around 8.0 with a high organic carbon content of around 20.3. Tho Exchangeable Calcium content is high and Truog Phosphate is around 107 parts per million. The area is mainly forested with low deciduous forest types with some tall trees in patchy areas with M1 limestone parent material. Traditional shifting cultivation is carried out in patches of fertile lands after cutting and burning the existing vegetation. Once yields start to decline, the lands are allowed to revert back to bush for soil regeneration.

There is a variety of crops grown under the shifting cultivation system, the most popular crops are cassava, banana, papaya, pigeonpeas, tobacco, tomatoes and chillies.

Those soils are classified as Rendzic and Lithic Leptosols

4.2.3. Kinamo Group

These are described by Calton as sluggish draining soils and located in several isolated areas. The largest area located in the North of the Island consists of gray clays to sandy clays, derived from clayey parent materials. Tho remaining patches are said to occur in Cheju and Muyuni. Tho Kinamos are described as heavy cracking soils without perceptible, catenary differentiation.

The major proportion of the Cheju clay fraction occuring at depths around 1½ meter is described as consisting, mainly of, Montmorilonite with some Kaolinite and a trace of Boehemite. Higher up the profile at depths around 1 meter the Kaolinite content is greater than the Montmorilonite and Hallosite clays.

During the course of present field investigation it was found necessary to differentiate between the Northern Kinamo, the Kinamos of Cheju Plain and Muyuni areas. Due to differences in climatic, soil and topographic features.

4.2.3.1 Northern Kinamo

The Northern area Kinamos exhibit, quite different landform characteristic from the others. They are located at a much higher, topographic position in the landscape and resulting from this and the higher rainfall experienced. The land here is highly dissected. The surface soil is very sandy probably due to the removal of the finner clay particles by water.

These sandy soils overly a heavily gleyed, coarse sandy clay subsoil which is almost impervious. As a result the subsurface drainage is very restricted with water flowing laterally over the compact sandy clay underlying this sandy top soil at around 60cm depth. It is this lateral drainage that induces the sliding and slumping of the saturated, weakly structured, sandy top soil giving rise to the dissected landscape within this Kinamo area.

The soils here do not exhibit any surface cracks due to the sandy nature of the topsoil but the sub-soil is very compact and hard sandy clay which greatly restrict root penetration.
These areas were grouped as C2 within the mapping units and the soils occuring within them are classified as Areni - Gleyic Cambisols and Cambic Arenosols.

The Areni - Gleyic Cambisols are those with coarse, loamy sands and sandy loam layers not exceeding 60 cm overlying the compact and Gleyed sandy clay. The Cambic Arenosols which occupy about 20% of this map unit consists of mainly thick sandy deposits in excess of 100 cm overlying the clay. These are located on the lower aspects of the slope. Land Use is restricted to coconut, mango, cassava and upland rice.

4.2.3.2. Choju Kinamo

The Kinamo's of Cheju are mapped separately under the A2 mapping unit. The Choju plain is a part of a broken corridor with underlying coralline limestones (Q2) material below the clay layer. It is probable that this clay layer originated from decomposed Shales, Marls and Clays of the M3 limestone rather than the M1 due to the nature of the clays.

The Cheju soils are heavy cracking clays and therefore fall into the Vertisol group, their Vertic properties are quite apparent on the dryer parts of the surface and in the leaning of fence posts, cracks in the water ways and channels and even inside the Paddies. Slickensides are observed on most profiles and vertical cracks more than 1 - 3 cm wide are observed up to depths of 1 meter or more, in some places on the periphery of the area away from the paddies.

The soils here have been previously classified as Mollic Gleysols but it is quite obvious that, they are Vertisols.

They are therefore mapped as Eutric and Calcic Vertisols. The Calcic Vertisols overly the Q2 roef coralline materials at depths less than 125 cms and covers approximately about 20% of the mapping unit.

The land use here is predominantly rice cultivation. Land preparation is carried out using government tractors, under the Rainfed Rice Project. A small area comes under irrigated rice. Good quality local variety of mangoes called Dodo are grown in small mounds within the plain possibly to provide shade for the rice farmers, these mangoes seem to thrive on the heavy clay soils.

4.2.3.3 The Muyuni and Kizimkazi Kinamo

These Kinamos' are mapped as low Elevated rounded ridges -C13 as they occur as outcrops in the Southern areas entirely surrounded by the Maweni (reef Coralline Q2).

These are probably the remnants of the sunken M3 limestone Ridges which have weathered into Shales, Marls and Clays giving rise to the present soils which are mapped as Eutric Vertisols and Calcic Vertisols.

Land Use is restricted to Home garden crops chief of which is the famous Muyuni mangoes. The lowlands surrounding the Ridge is used for rice and annuals.

4.2.3.4 Complex Slope Kinamo's

These occur adjacent to the Northern Kinamo's and are located around Pangeni Hills area, with complex slopes, bordering the medium elevated ridges. They are heavy clay soils from surface downwards but do not exhibit the surface cracks and slickenslides which are characteristic of the Vertisols. Some profiles examined had deep clays with shiny ped faces down to about 2 meters, while some others had clay throughout with Calcic Nodules and Calcic material occuring at about 100 cm depth.

The land use on these soils were mainly rubber plantations and grasslands, with mango trees, used for cattle ranching.

These soils were classified as Haplic and Gleyi-Haplic Nitisols.

4.3. Soil Classification - Pemba

The soils of Pemba have been classified as markedly different from those of Zanzibar. They have been subdivided as upland soil types and low land soils types.

The upland soils are:-

Utasi

Semi Utasi

Bopwe

And the lowland types are:-

Mtifutifu

Kinako

Makaani

The upland and lowland categorisation of these soils, do not correspond with project findings based on Systematic Analysis of landforms by Airphoto Interpretation and field investigations. The Bopwe and Semi Utasi soils are found even in the lowlands near swamp levels on the Western side as seen in the cross section on the Land Evaluation & Suitability Classification Map of Pemba.

It became obvious during the field studies of the pedons of the upland soils that they are interelated and the degree of differentiation of the Utasi, Semi Utasi & Bopwe profiles depended on the steepness of the slopes on which they occur. The Utasi & Semi Utasi soils were encountered regularly occuring within the Bopwe soil areas on more gently sloping locations, while the Bopwe soils were found occuring on the more steep aspects of slopes in the Semi Utasi and Utasi area. Therefore it was apparent that the Bopwe was a truncated Utasi.

The Bopwe and Semi Utasi soils have truncated sub soil layers which exhibit prominant reddish yellow varigated staining and psuedo Gley colours which can be mistaken for mottling resulting from impeded drainage. These varigated colours are in fact a natural phenomena of this type of soils which are commonly refered to as Podzolic soils in the tropics.

The mtifutifu is composed of a moderately thick Alluvio-Colluvial cover of sandy textured material overlying the insitu partly eroded subsoils of the utasi and semi utasi, and resembles the sandy mchanga of Unguja, with the exception that the soils below the sandy layers are markedly different in colour and physical properties, also the inherent fertility of the mtifutifu is superior to that of the sandy mchanga.

Based on observation of representative soil profiles and using the scanty laboratory data of the original description of these soils in the East African Journal, tentative soil correlation was carried out on the modal profiles, described and attached to the Annex 11 of Part 11 of the report.

4.3.1 Utasi

Utasi soils are associated with the plateau remnants of North - Eastern Pemba and described by Calton as follows:

"The utasi, though most extensive in the north of the island, can be traced a long a central line of plateau remnants. It is a deep grey to brownish grey (2.5Y 6/2) firm sandy soil with cementing material is possibly silica. pH is fairly constant at about 5.5 but may be a little higher in the topsoil. Organic matter is low and exchange capacity amounts to 4 - 6 m.e per 100 g. Calcium carbonate accounts for about 66 per cent of the exchangeable bases and potassium may be as high as 8 percent. The clay composition is uniform down to 7ft. and consists very largely of kaolinite with some goethite and perhaps gibbsite. Qualitative mineralogical examinantion of the sand fractions of utasi soils show mainly quartz with some feldspars and minor accessory minerals, most grains showing a fair degree of rounding".

Except for minor colour differences the above description of utasi soils is similar to the profiles encountered in the field. The dark surface horizon are due to the high organic matter content and faunal activities in the unusually deep A horizon observed in these soils with 10YR 3/2 and 3/4 colours. Which is underlain by strong brown 7.5YR 6/8 Cambic B horizon of sandy clay loams.

The soil was correllated as being a Humic Cambisol according to the FAO legend.

Detail soil profile descriptions are available for reference in part 11 Annex 11 of this report.

4.3.2. Semi Utasi

The semi utasi soils are best described as an eroded version of the utasi with a secondary deposition of a thick A or AB horizon over the underlying 2B horizons. Caltons original description of the semi utasi is out lined below:-

' The semi utasi soils occur as a strip to the east of the utasi plateau remnants and are probably related to them. It may also be of significance that in places the semi - utasi overly the less pervious kinako. The semi utasi closely resembles the utasi at the surface but have some gray and brown mottling at depth. There is the further difference that the semi-utasi country is undulating. Reaction in this type is about the same as in the utasi but exchange capacity is a little higher and the clay fraction which is uniform in composition down to 6 ft. is largely kaolinite but with a small amount of montmorillonite.

This type appears to be the most like Milne's mottled clays (Milne, 1936) but none of the profiles examined showed within 6ft. of the surface the disjointed character - red earth type over heavy clay which he mentions. It may be argued that this type is more dissected than the utasi because it is less water absorbtive. Whether it is a more silicius variant of the utasi due to the lack of leaching solutions by underlying impervious material or whether it is derived from originally more clayey sediments is not clear'.

The grey brown mottling discussed above are mainly the Reddish varigated stains found in the sub soils, and the clay sub soils are attributed to the Chake limestone which tend to be more clayey. As such it would be necessary to subdivide the semi utasi into two soil groups based on difference in chemical properties of the soils related to sub soil variations in a more detail study. The semi utasi soils were classified as Dystric Cambisols.

4.3.3. Bopwe

The Bopwe soil exhibits a remarkably high fertility status considering its truncated profile characteristics. A moderatly thick, Dark A horizon is observed abruptly underlain by Reddish yellow 2B & 2C horizons. Caltons descrption of the Bopwe soils are as follows:

' The bopwe occupy the remaining high lovel country to the west of the utasi and semi-utasi. Contrasting with all the other soil zones the topography is sharply dissected. Those soils have developed in the basal miocene sediments which, except for some buckling, are horizontally bedded. Narrow bands of coarse sand, fine sands, silts and clays are common though the upper soil layers (0.4ft.) are generally fairly homogeneous probably due to the soil creep.
The topography in fact is too sharp for normal catenary development and leads to run-off of water, and the maintenance of relatively shallow soil profile. The bopwe are generally reddish brown (7.5YR 5/6) loams from ridge top to stream edge, though there are some dark coloured wet alluvial-Colluvial bottom lands of minor extent.

The bopwe have a pH between 5.5 and 6.0 whilo exchangeable calcium varies from 1 to 7 m.e per 100g of the clay fraction, which is uniform to 5ft., consists of kaolinite with traces of goethite. Perhaps the most significant fact about these soils is their perpetually maintained shallowness'.

The bopwe soils are remarkably similar to the Red yellow Podzolic Soils, without the irreversible hardening effects of the tropics. Detail profile description are available for reference in Annex 11 of part 11 of this report.

The bopwe soil was correlated tentatively as a Ferralic Cambisol. These soils require further study and evaluation of their chemical properties in order to properly classify them.

4.3.4. Ndamba

The origin of the Ndamba soils clearly pose problems unless they can be seen as series of marine platform deposits on depressions in old landforms formed by the step like lowering of the sea levels, or emergence of the land surface from the sea. Calton's orginal description of the ndamba soils are reproduced below:-

' The ndamba is usually associated with the utasi though there are two outlying patches, one in the bopwe and one in the mtifutifu. Probably the patch of ndamba in the bopwe area was once connected with the utasi, the intervening bopwe having formed by the cutting back of the utasi plateau. The ndamba patch in the mtifutifu indicates that this type can occur whenever, perhaps by water sorting, the parent material is highly quartzic. The ndamba has a practically level surface and is characterised by a heath vegetation - "giant heather" (Phillipia mafiensis) being the dominant species. So far as can be seen there is no difference in height between the ndamba and the utasi. The upper layer of the ndamba consist of a pale grey, coarse sand while at about 3ft. there is black organic cemented layer. This layer may induce water-logging in the wet season. pH is about 4.0 and there is an almost complete absence of exchangeable bases. In the A and B horizons the clay fraction consist of quartz with traces of boehmite and perhaps anatase. The ndamba is considered an organic podzol.'

During field work most of the ndamba areas visited were waterlogged as a result clear profiles could not be studied. However based on existing information and field observations, the soils were tentatively classified as Stagni-Dystric Planasols.

4.3.5. Mtifutifu

The mtifutifu soils occupy intermediate to low topographic positions bordering the utasi and semi utasi soils which occupy the upper aspects. The mtifutifu soils are seen as soils developing on old Alluvio-Colluvial sediments overlying the lower plateau surfaces. The original descriptions of these soils by Calton are as follows:-

'The mtifutifu, the first of the low level soils, abound on all the high level types. It is extensive in the north-east and the south but tends to encircle the whole high level block. It is deep brownish grey (10YR 6/2) sandy soil without marked profile differentiation. It resembles to some extent the utasi, but is without the tendency to cementation at depth, and the surface is more irregular, and occasionally dark coloured bottom land types may be found. Organic matter levels are very low in this type, probably due to the drier conditions and sparser vegetation cover. pH may be as low as 4.5 at the surface increasing to 6.0 at depth. Exchange capacity is of the order of 8m.e per 100g and in one profile a considerable content of exchangeable Magnesium was found. Clay minerals which are uniform down to 7ft. are similar to those of the utasi and the bopwe and consist of kaolinite with a trace of goethite.

It seems likely that the mtifutifu has been derived as an offshore deposit from erosion products of the more elevated soils.'

Another possibility about the origin of the mtifutifu would be that they are the reworked sediments of the corridors formed by the rivers that were a part of the ancient Rufiji/Ruvu Delta.

Based on profile characteristics observed the mtifutifu was classified as a Aroni-Dystric Cambisol.

4.3.6. Kinako

The kinako soils are located on the lowest position or step of the plateau surfaces occuring in Pemba, they appear to be soils deposited as erosion products of the adjacent Chake Chake Miocene clays deposited over that old corridor zones created by the deltaic rivers of the ancient Rufiji/Ruvu delta. Caltons description of the kinako is reproduced below:

'The kinako, derived from the calcareous Chake Chake beds, occupy a well defined narrow strip along the east coast and two isolated areas within the bopwe. The eastern strip is probably the result of the exposure of marly beds by faulting. While the larger western area probably owes its origin to the removal by erosion of the overlying non calcareous beds.

The kinako are usually dark grey brown (10YR 4/2) cracking clays with Calcium Carbonate at depth. pH ranges from about 6.8 in the topsoils to 8.3 at depth with over 20m.e per 100g. exchangeable Calcium at the surface increasing with depth. One profile showed the clay fraction to be largely montmorillonite with kaolinite increasing and montmorillonite decreasing towards the surface. Traces of goethite were also found at all levels. The underlying rock consisted mainly of calcite with some montmorillonite and goethite'.

In the above description two levels of kinako are described, the western kinako clearly does not confirm to the lowland type of kinako soil in its original classification.
The high level kinako soil occuring in & round Chake Chake are attributed the exposure of the marly beds due to faulting and would therefore be a sub grouping of the Bopwe soil unit which has to be separated at a detailed study. The low level kinako soil were classified as an association of Vertic & Gleyic Cambisols.

4.3.7. Makaani

The Makaani soil of Pemba are an intergrade between the shallow Kinongo and the shallow Uwandas of Unguja. The orginal description of Caltons is reproduced below:

'The Makaani festoon the island and are the main soils of the outlying islands and peninsulas. They are shallow dark brown (7.5YR 3/2) humid soils, ranging from vestigial crevice soils to continuous soils a foot or so deep on recent compact limestones. Reaction is neutral and exchangeable calcium content is high. They may contain 10 per cent or more of organic carbon. They differ fundamentally from the uwanda in the mineralogy of their clay fractions, one profile (6in deep) being found to have clay fraction consisting of anhydrite partly altered to gypsum with traces of micaceous material. This suggests that they are very young soil indeed'.

The soils found occuring here were similar in characteristic to thoso in Unguja and were classified as Mollic & Rendzic Leptosols.

Table: 16

SOIL CORRELATION - UNGUJA

SOIL UNIT		Reference Nos. of representative Profile discriptions in Part 11 Annex 11
Local classification (Calton's)	FAO/UNESCO/ISRIC Classification	
Mchanga Group		
Reddish Mchanga	Rhodi-Haplic Acrisol	LEP 5, LEP 7, LEP 11
Brownish Mchanga	Haplic Acrisol	LEP 1, LEP 16, LEP 32
Yellowish Mchanga	Ferric/Gleyic Acrisol	LEP 3, LEP 21.
Greyish Mchanga	Gleysols/Fluvisols	LEP 33.
Sandy Mchanga	Areni-Haplic Acrisols	LEP 15, LEP 34
	Cambic Arenosols	LEP 19
Kinongo Group		
Deep Kinongo	Rhodic Ferralsols	LEP 12, LEP 14, LEP 17, LEP 20, LEP 26.
Shallower Kinongo	Chromic Cambisols	LEP 8, LEP 9, LEP 10, LEP 25.
Shallow Kinongo	Calcaric Cambisols	LEP 4, LEP 28.
Uwanda Kinongo	Mollic Leptosols	LEP 35.
Maweni Kinongo	Rendzic Leptosols	LEP 6
	Lithic Leptosols	
Kinamo Group		
Kinamo (undifferentiated) (Dissected Ridge Kinamo)	Areni-Gleyic and Gleyic Cambisols	LEP 2, LEP 13, LEP 18
Complex slopes Kinamo	Haplic and Gleyi-Humic Nitisol.	LEP 22, LEP 23
Southern Kinamos (Cheju and Muyuni, etc)	Eutric and Calcic Vertisols	LEP 24, LEP 27, LEP 29 LEP 30, LEP 31, LEP 36

Table: 17

SOIL CORRELATION - PEMBA

SOIL UNIT		Reference Nos. of representative Profile descriptions in Part 11 Annex 11.
Local classification (Calton's)	FAO/UNESCO/ISRIC Classification	
Bopwe	Ferralic Cambisol	LEP 52, LEP 60, LEP 63, LEP 67, LEP 72, LEP 81.
Semi utasi	Dystric Cambisol	LEP 61, LEP 75.
Utasi	Humic Cambisol	LEP 53, LEP 54, LEP 55, LEP 66, LEP 70, LEP 73, LEP 74, LEP 79.
Ndamba	Stagni-Dystric Planasol	LEP. 82
Mtifutifu	Areni-Dystric Cambisol	LEP 50, LEP 59, LEP 62.
Kinako	Vertic and Gleyic Cambisols	LEP 56, LEP 64, LEP 71
Makaani	Mollic and Rendzic Leptosols	LEP 78

5. LAND RESOURCES INVENTORY

5.1 Methodology

5.1.1. Introduction

Relief and Tectonic upheavels coupled with mass movements are responsible for the complexity of the land uses in Zanzibar.

In Unguja Island two main Agro-Ecological Regions are plainly evident. They are:-

(A) The Plantation Region consisting of the Western and Central portions of the Island where the good soils are located.

(B) The Coralline Regions consisting predominantly of the Maweni soil types on which shifting cultivation is the main agricultural activity.

This subdivision will be too general and not useful from the point of view of Land Evaluation and subsequent suitability classification. As such it was considered that Systematic Analysis of Land Forms would, logically, be the best approach and the Physiographic method which is universally recommended was adopted.

A map demarcating Morpho- Ecological Zones of Zanzibar, (Broad natural regions which have a significant bearing on the agricultural potential) were plotted at scale 1:50,000, based on background information on Geology, Geomorphology, soils, rainfall etc. obtained through airphoto interpretation and use of the following base maps:

1. Topographic maps of the Department of Land & Survey Scales 1:50,000 and 1:10,000.
2. Mean annual distribution of rainfall- Directorate of Meteorology.
3. Hydrogeological maps - UNDP scale 1:125,000.
4. Generalised Geological maps by Kent et al (Based on ivestigation of Shell - BP).
5. Land Use Maps scale 1:25,000 of the National Coconut Development Programme.
6. Soil Map of Calton et al 1:250,000 enlarged to scale 1:50,000.

The Morpho-Ecological zones map thus prepared together with other practical considerations such as proximity to agricultural research stations, locations of on-going projects, future development interests etc. were utilised to determine suitable sample areas for land evaluation studies.

Five Morpho-Ecological Zones were identified and demarcated. They are:-

1) RIDGE ZONES
2) REWORKED OLD ALLUVIAL DEPOSITS OF THE CORRIDOR ZONES
3) WANDA ZONES
4) MAWENI ZONES
5) SWAMP ZONES

Owing to the complex block faulting and subsequent rise and fall of ocean levels, these zones are disjointed and non continuous.

The integration of the above zones together with the rest of the on - going Natural Phenomena such as, marine and alluvio-colluvial deposition, past and present erosion, human and animal activity connected with agricultural and livestock production, human settlements etc. within the framework of the proposed physiographic Legend will enable the systematic mapping and subsequent evaluation of the natural resources of Zanzibar.

The Ridge Zone

Most of the good agricultural soils occur within these zones and therefore all the land area is extensively used under various agricultural practices.

The Ridge Zones consist of one Central Zone and several isolated zones occuring within the coralline portions of the Island.

The Central ridge Zone consists of low to medium elevated (0 -117 meter), predominantly North South oriented complex of ridges and associated valleys.

Differences in Soils, Climate, Geomorphology, susceptibility to erosion, and land use make it relevant that the Central Ridge Zone be divided into several sub-divisions as outlined in the final Legend for Land Evaluation.

Reworked Old Alluvial Deposits of the Corridor Zones:

The original zones were nearly level to gently sloping to stratified miocene clay and sand deposited deltaic areas of the ancient Rufiji Delta, of which Zanzibar was an integral part. The present remnants of these Corridor Zones are seen as differently elevated broken corridors with reworked old alluvial deposits charactorised by mud-flow patterns and colluvial infill from adjacent ridges. In certain areas mud-flows from these elevated zones have influenced the adjacent coralline zones, contributing to their 'Wandafication'.

There are several such zones identified, they are:-

The Bambi - Uponja - Kibokwa - Chaani Corridor which is broken up due to block faulting into several corridors, Pagali - Bambi, Mchangani - Uponja, Uponja - Chaani.

The second major corridor zone is the Northern Kiwani Bay, Bumbwi, Jumbi, Southern Kiwani bay which is broken up into three parts and below Jumbi is now a Wanda zone with coral formation on submerged floor of corridor. Another Wanda corridor is the Mgenihaji - Kibondeni - Southern Kiwani bay which is the continuation of the Kisima Mchanga - Kilombero corridor.

Wanda Zones

Are those which have a very thin soil cover, (about 1/3 meter) over the porous coralline reef formations. They are located adjacent to the ridge zones, corridor zones, and sometimes within the corridor zones. Due to their relatively lower position in the landscape they are continuously receiving colluvial influx of soil material from adjacent good soil zones. Periodic bush fires sweep through the open grassland type of unimproved grazing lands within this zone making it rather unsafe for cultivation permanent crops.

The Maweni Zones

Are those terraced coralline reef zones which do not receive any influx of Alluvio-Colluvial soil materials due to:

(1) Their surface being almost flat and porous as well as their being separated from the higher elevated Ridge Zones by the Wanda Zones.

(2) Their higher topographic location with respect to the adjacent or surrounding Wanda areas.

Shifting cultivation is the predominant Agricultural practice within this zone of secondary bush and forests.

Swamp Zones

Are those low lying areas having regular swampy vegetation which are highly tolerant to fluctuating tidal influences. They consist of Tidal Marshes, Swamps and Temporary Marshes. The swamp vegetation provides useful material for chorcoal making, poles and fibres. They act as buffer zone between the sea and the cropping areas such as rice fields and also protect crop- lands from excessive sea spray effects.

The above Morpho-Ecological Zones are integral parts of the rural landscape. It is therefore necessary to understand them and how they affect and influence the lifestyle, environment and climate. Any long term planning of the natural resources of the country will have to be undertaken only after a thorough evaluation of the development potentials, limitations and adverse side effects that might occur as a result of the proposed long term usage of each separate zone. To achieve this purpose, further anlaysis of these Morpho-Ecological Zones was carried out using the physiographic Legend developed as outlined.

5.1.2 Physiographic Legend Development:-

Panchromatic aerial photographs, scale 1:20,000, flown during the period, August - October 1977 were stereoscopically analysed together with ground correlation to develop a comprehensive physiographic legend based on landforms, Geomorphology etc. The interpretation of the complex landform was made more complicated due to the North -South orientation of the flight lines, which made it difficult to differentiate terrain and landform pattern, since the ridges are also North -South oriented. Block faulting and subsequent changes in elevation of different blocks further complicated the issue due to resulting elevation differences in similar formations and soil units.

After taking into careful consideration the above and in conjunction with the topographic details and slope ranges calculated on 1:10,000 maps a pragmatic classification of land units into three major systems which permit the delineation of tracts of land according to their major characteristics and in a way which is significant for land suitability assessment were made as follows:

B. MARINE SYSTEM

- B1 - Beaches and Dunes
- B2 - Marshes and swamps

C. RIDGE SYSTEM

- C1 - Low elevation ridges (0 - 45 metres)
- C2 - Low-medium elevated dissected ridges (30 - 70 metres)
- C3 - Medium elevated ridges (45 - 117 metres)

D. CORALLINE REEF SYSTEM

- D1 - Wanda sub system, (Coralline formations) influenced by influx of soil materials from adjacent C and A systems).
- D2 - Maweni subsystem. (Terraced Coralline Reef formations which do not receive any influx of alluvio colluvial soil materials).

A - Alluvial System (Recent and Old)

Groups all deposits and formations which are not characteristic of the previous systems. In practice a river starts in the ridges and flows from the catchment area into the adjacent and then to sea or into some subterranean channels (sinkholes associated with the Karstic and Coralline limestones of the island). It is difficult to systematically attribute a portion of the valley to a given system.

A0 - Alluvio-Colluvial subsystem, consisting of very gently sloping valley bottoms and associated colluviated deposits.

A1 - Reworked old Alluvial Subsystem, with flat to gently sloping broad plains consisting of old alluvials, recent colluvial and mud flow deposits occuring in disjointed corridors.

A2 - Old clay plains

A3 - Depression and basins

M - A miscellenoous system is used to indicate units such as bluffs, sea cliffs, rock outcrop, sinkhole, quarries settlements etc.

The legend stays open to admit eventual new units as more information becomes available from field checks and correlation of field data, until finally a comprehensive physiographic legend is obtained.

Dominant slopes and slope ranges occuring within the various sub-divisions of tho ridge and platoau zones of Unguja and Pemba were calculated using the 1: 10,000 topographic maps with 5 meter contour intervals, these calculations together with variations in soils and climate were utilised to demarcate the boundaries of the various sub-divisions within the Ridge Zones of the physiographic legend. Generalised Land Use maps were prepared for Unguja island using the existing detailed land use maps, scale 1: 25,000, prepared by the Coconut Development in 1982. These were subsequently used as a controlled base for transfering the boundaries of stereoschpically generated mapping units from airphotos (scale 1: 20,000) via the enlarging/reducing photocopior after making appropriate adjustments to offset the effects of tilt and resulting scale differences. The map unit boundaries thus obtained were tranferred on to 1: 50,000 topographic maps and used as base maps for field work after making appropriate corrections, they were reduced to 1: 100,000 scale of final map.

The physiographic legends developed for Unguja & Pemba are presented in paragraphs 5.1.4 and 5.1.6 respectively.

5.1.3 Topographic Maps and Air Photos Used as Base Materials

The following maps and air photographs produced during the period 1977 - 1985 were available and used as base materials.

1: 10,000 Scale Topographic Maps

This is the largest scale at which complete coverage is available for both Islands.

There are 57 sheets covering Unguja and 43 sheets covering Pemba Island. Each sheet covers an area of 6 x 8 km (4800 ha) and is printed in four colours on 90 grams chart paper. The specification includes contouring at 5 meter interval and classification of Vegetation into 10 categories. These were used together with the generalised Land Use map for Land Evaluation studies in sample areas.

1: 50,000 Scale Topographic Maps

These are also four colour, printedsheets and derived from the 1: 10,000 series using East African specifications and a contour interval of 10 meter. There are five sheets covering Unguja and two sheets covering Pemba.

These were used as field maps and controlled intermediate mapping base before reducing into final map scale of 1: 100,000.

1: 100,000 Scale Planning Map

These are available to special order from the Department of Land and Surveys as monochrome dyelineprints on either paper or plastic and have the advantage that each Island is depicted on its entirety on a single sheet. These maps are also available with an overprinted index showing the position of individual sheets in the 1: 10,000 series. These were used as controlled base for the final map.

Aerial Photography

Good quality panchromatic air photography flown during the period August - October 1977 at scale of approximately 1:20,000 are available for both islands.

The aerial photography was commissioned by the Ministry of Overseas Development on behalf of the Government of Zanzibar and carried out by M/S Fairey Survey.

5.1.4 Survey methods

1: 25,000 scale generalised land Use maps together with the 1: 10,000 scale Topographic maps with slope classes delineated were used as base maps for the land evaluation and soil studies.

Preliminary Air photo interpretation of the 1977 Aerial photos were carried out for the purpose of arriving at a tentative physiographic legend.

This legend was improved on as field work progressed and more complete information on the requirements for the Land Evaluation study become apparent. Photo Interpretation and field derived boundaries thus obtained were then incorporated on to the base maps and reduced onto 1: 50,000 topographic maps for final field checking and updating. Subsequently these physiographic units were further subdivided according to land use, soils, topography, climatic conditions or combination of them, to obtain the final land mapping units which appear in the finalised legend.

Soil pits and soil, bores were described using standard methods and procedures as laid out in the FAO Guidelines for soil profile descriptions on project description sheets. Land Evaluation Questionaire were filled where appropriate on standard formats prepared for project use, specimens in annex ii.

One Suzuki pick -up was the means of transportation for the survey team.

Field Work - Unguja

Approximately four months were spent in Unguja on field investigation to identify the soils and evaluate the land.

225 soil bore descriptions were made and 189 evaluation questionarise were filled while 36 soil pits were cut in representative areas and 30 of these were described and 24 sampled for laboratory analysis.

Field Work - Pemba

Total time available for completion of Pemba field studies and preparation of maps and reports was restricted to 6 weeks as such field work was limited to the profile description and samples of 30 representative profile pits.

However due to the uniform evoluation of the landform and homogeneous development of soil profiles on the island, time constraints did not disrupt the systematic mapping of landform and soils or the correlation of the soils with the FAO classification system.

5.1.5 Physiographic Legend for Land Evaluation Unguja Island, Zanzibar

Scale of Mapping 1: 100,000

A - Alluvial system (Recent and Old)

AO* Alluvio-Colluvial Subsystem (Common to A&C systems only) consisting of Flats, Valley Bottoms and Fan Deposits.

* Not possible to map present scale of mapping

A1 Reworked old Corridor Subsystem

A1.1 Open corridors

A1.2 Closed Corridors

A2 Plains.

A3 Depressions and Basins

B - Marine System

B1 Beaches and Dunes

B2 Marshes and Swamps

C - Ridge System (0 - 117 Metros)

C 1 Low Elevatod Ridge Subsystom (0 -45 motros)
0 - 6% slopes

C1.1 Coastal

C1.2 Central

C1.3 Rounded

C1.4 Isolated

C1.5 Transitional

C1.6 Raised Corridors

C2 Low medium Elovatod Subsystom of dissected ridges with associated V shapes valleys and gullies (30 - 70 metres) 0 - 55% slopes.

C3 Medium Elevated Ridge subsystem (45 - 117 metres)
0 - 20% slopes.

C3.1 Elongated single slopes

C3.2 Rolling with complex slopes

C4 Erosional Remnants.
Wedge shaped elevated limostono ridgos with noar vertical sides occuring within tho coralline zone.

D - Shallow corallino and raisod reef system (Elevation range 0 - 45 meter) (Generally flat very broad marine terraco formation. Elevation differonces botwoon terraces 2 - 10 meters)

D1 Wanda Subsystem
Coralline reef formation influoncod by influx of alluvio - colluvial soil material from adjacent C and A system.
Consisting of wanda corridors unimproved grazing lands, rotational croplands and mixed homestead gardens.

D2 Mawoni Subsystem
Terraced coralline reef formations which do not receive any influx of alluvio -colluvial soil materials due to:

(1) their surface being almost flat and porous as well as their being separated from the higher elevated C system by the Wanda subsystem.

(2) Their higher topographic location with respect to the adjacent or surrounding Wanda areas.

D2.1 Reserved shifting cultivation areas.
D2.2 Unimproved grazing and shifting cultivation.
D2.3 Thickets.
D2.4 Open Forests.
D2.5 Mixed forests.

*M Miscelleneous System (Common to all systems)
M1 Escarpments.
M2 Bluffs/sea cliffs - (slope more than 100%, rockiness more than 60%)
M3 Settlements urban (more than 50% surface area occupied by buildings)
M4 Settlements rural (more than 20% of surface area occupied by buildings)
M5 Water bodies (inland)
M5.1. Lagoons (brackish water)
M5.2 Lakes and reservoirs (fresh water)
M6 Miscellaneous land.
M6.1 Badlands and quarries.
M6.2 Gullies and earth slide scars.
M7 Sinkholes.
M8 Springs.
M9 Caverns and caves.

* Not possible to map individual units at present scale of mapping.

5.1.6 DESCRIPTION OF LAND MAPPING UNITS - UNGUJA.

The Alluvial System - A

The mapping units identified within this system consists of recent and old Alluvial, Alluvio-Colluvial deposits and formations, which are not characteristic of the B,C or D systems. The alluvial system in Unguja is found occurring mainly within the C and B system, they rarely occur in the D system due to the Karstic nature of the Q2 coralline limestone, the only exception being the old Corridor deposit at Cheju.

Alluvio-Colluvial Subsystem - AO

This subsystem is designated by the AO as it is not physically mappable at the present (1:100,000) scale of Mapping, but it is an integral part of the existing physiography and therefore needs to be evaluated. These areas consist of the typical broad and narrow, sometimes steep sided Alluvio-Colluvial valleys that form a part of the dissected lanform of the ridge areas. The AO unit consists primarily of valley bottoms which carry concentrated water flows from adjacent upland areas, the associated depositional flats and fan deposits (Alluvio-Colluvial deposits on slopes). The soils associated with these land units are Dystric and Eutric Fluvisols. In the local classification they are not mapped. Detailed description of those soils are given in the appendix containing the soil profile descriptions.

Reworked Old Alluvials - A1

The unit consists of the deposits mapped within the corridor zones. According to differences in soils and drainage, this unit is subdivided into:

A11 - Open corridors

A12 - Closed corridors

Open Corridors - A11

The all mapping unit consists of those areas which have unrestricted surface drainage. The open corridors of this unit are located within the southern Kiwani Bay- Northern Kiwani Bay Corridor and the Southern Kiwani bay - Kisima mchanga corridor. The Mwera - Bumbwi, Mahonda - Chochole and Kisima mchanga valleys are located within this mapping unit. Within these valleys rivers and water ways are active and few flow to the adjacent Wanda areas of the sea. Those valleys are mainly used for the cultivation of rice in the Masika and vegetables, yams and subsidiary food crops etc., during the Vuli.

About 3000 ha of this land unit has been allocated to the Government sugar plantation project; of this area, about 2500 ha have been developed with adequate land drainage and planted in sugar while 500 acres of sandy area have been put under forest plantations.

The slope ranges encountered here vary from about 1 - 3%. The top soils range from black to dark brownish grey sandy loam and sandy clay loams overlying dark grey to greyish sandy clay loam with rusty red mottles, becoming prominent around 30 cm depth and becoming yellower with depth. The pH of the top soil is usually around 5.0 and that of the subsoils around 5.5 or 5 according to differences in locations. Where the subsurface horizons merge with the Q2 the pH tends to be around 6.0 to 7.0

In the local classification these soils fall under the greyish mchanga subgroup according to the FAO system, they have been classified as association of Dystric Gleysols and Dystric Fluvisols.

Closed Corridors - A 12

The A12 mapping unit consits of nearly level to gently sloping wide depressional areas located within the Kilombero, Upenja, Chaani corridors, the differentiating characteristics of this corridor from A 11 unit is that most of the drainage is subsurface and into the underlying Q2 material which is mainly coralline limestone.

The thick clay layers encountored in betwoen results in them being poorly drained. This land is extensively used for rice cultivation, while about 1100 ha are earmarked for cultivation of rainfed sugarcane with appropriate soil drainage and land development.

The slope rangos encountered hore are 0 -2%, most of the areas are however less than 1% slopes, the topsoil is black to very dark grey sandy loam or sandy clay loam with medium subangular blocky to massive structures. The pH of the surface ranges between 5.0 and 6.0 while that of the subsurface soils vary from 4.5 in some sites to around 7.0 in others.

In the local classification these soils are not separated from the upland soils and are mapped as Greyish Michanga. The soils associated with this mapping unit consists of Mollic and Eutric Gleysols.

Cheju plain - A 2

This mapping unit covers the Cheju rice growing plains. The topography is generally flat with slope ranges, less than 2%. This area is mapped as Kinamo in the local classification. The soils found here are predominantly deep, poor to imperfectly drained cracking clays,(Vertisols) from surface down wards. They overly Coralline limestone indicating that this area has been part of an old corridors. The soils mapped are Eutric Vertisols with about 20% Calcic Vertisol.

The area is extensively used for rice growing under the rainfed rice Project, with some areas, under irrigated rice Project. Land preparation is done usually with Government tractors. Due to heavy textures and cracking nature of the soils manual land preparation is almost impossible, till the ground is saturated with water. The Dodo mango which seems to thrive on heavy clay soils, are found growing very well within this unit and producing between 1000 - 2000 mangoes per tree.

Depressions and Basins - A 3

These are mainly located within the coastal low Ridges system and Comprises of flat to depresional areas with their drainage to the sea blocked by coastal deposits.The drainage therefore is predominantly subsurface these areas are extensively used for Rice and Vegetable cultivation during the wet seasons. The soils encountered here are mixture of Arenosols and Gleysols.

B - MARINE SYSTEM

Beaches Dunes - B 1

These consits of predominantly marine deposits and formations such as the sandy and crushed coral Beach deposits overlying the recent coral terraces and old sand dune formations etc. The Land Use here is mainly Coconut and home gardens. The slope is around 2% and the landform generally flat except in areas where the Dunes are gently undulating. Some of the Beach deposits specially in the North Eastern sides have a high proportion of crushed coral sands which are excessively well drained.
The soils identified here are Calcaric Regosols on the coastal beach formations and Cambic Arenosols on the dune formations.

Marshes and Swamps - B 2

These constitute the characteristic swamp forest that thrive on the low lying and partly submerged coral reefs. They are parts of the coralline reefs that form the basement of the Corridors which continue on to the sea, such as the Northern and Southern Kiwani Bay areas, Chwaka Bay areas, etc. Predominantly swamp specific, medium to high forest are found within this land unit.

The soils occuring here are Thionic Histosols and Fluvisols they are constantly inundated during high tide by the sea, as such the salinity is very high, the Histosols contain weekly docomposed peaty and mucky materials to about 40cm depth overlying the Coralline reef soils while the Fluvisols are mainly Humic clay and sand mixed stratified soils overlying the coral formations.

C - Ridge System

Low Elevated Ridges - C 1

The range of elevation of this subsystem varies from 0 -45 meters with slopes varying from 0 - 6%. Based on differences in soil, landform, land use, climatic factors and socio-economic criteria, etc., they have been subdivided into six mapping units as outlined below.

Low Elevated Coastal Ridges - C11

This land mapping unit is mainly restricted to the western coastal areas of the island and has been subdivided due to the nature of its surface soil which are predominantly coarse textured. Texture vary from coarse loamy sand to fine loamy sands, which go down in certain areas up to 50cm, while in other areas to the depth of over 150 cm. Usually underlain by medium sandy clay loams, with textures gradually becoming heavier with depth, with lower profile features resembling those of the brownish mchanga soils.

Surface drainage ways and small streams are a common occurrence within this unit and are observed in near parallel pattern draining to the sea. The minor valleys thus formed contain deep colluvial sands and are used mainly for rice cultivation. The predominant land use within the unit is coconut, mango, citrus, followed by the usual home garden crops, cassava, sweet potatoes, etc. Cloves are restricted to the areas where the sand cover is thin. The soils found here are predominantly Areni - Haplic Acrisols in the local classification they are mapped as sandy machanga.

Low Elevated Central Ridges - C 12

This unit covers the central potion of the low elevated ridge subsystems and is located between the two medium elevated ridge areas. The subdivision of this unit is mainly based on the soils, which are fine clay loams and fine sandy clay materials. Drainage variation from well to moderately well drained through to imperfectly drained were observed with poorly drained location being very rare due to the good subsurface drainage associated with the deeply weathered soft sandstones and limestones which form the parent materials. Streams run only intermittently. Infiltration and transmission to the large ground water aquifer appears to be rapid with little surface run off. Slope gradient rarely exceed 6% with lower slopes tending to be steeper than the upper convex forms.

The predominant land use is mixed tree crops. Cloves, coconut are the main crops while others such as citrus, mango, jackfruit, durian, kapok, breadfruit are grown as shamba home garden produce and cassava, banana, papaya are included in the intercrops under the Konde system, minor ground crops include sweet potatoes, cowpeas, sugarcane, pineapples and pigeon peas.

Both Konde and Shamba farming systems are practised extensively within this land unit. Usually on the same piece of land as described in land utilisation types 4 and 5. The main soils are reddish, deep, well to moderately drained and highly leached. The texture vary from fine to medium. Soil reaction varies between 5 and 6 and the clay fraction appears to consist of predominatly kaolinite and oxide minerals. Cation exchange capacities are all below 10 milli-equivalent per 100g of fine earth. The moderately developed clay skins and increase in clay content with depth are sufficient to qualify subsurface horizon as "Agric horizon" as subsoils base saturation are less than 50% the reddish and greyish mchanga soils occurring within this unit are classified as Haplic and Ferric Acrisols while the Kinongo soils are classified as Rhodic Ferralsols.

Low Elevated Clay Ridges - C13

This unit covers the Muyuni and Kizimkazi ridges located in the down thrown southern blocks of the island and is entirely surrounded by coralline reef limestone Q2. It is possible that the parent limestone here consists of the lower statigraphic M3 category, which on weathering produce heavy clays, as the soils found are very heavy cracking clays from surface downwards.

The predominant land use are homesteads consisting of mango and coconut while the lower almost flat foot slopes are used for rice cultivation as well as mango growing. Muyuni is famous for the very special and delicious mangoes, which produce about 1500 mangoes per tree.

These are classified as kinamo soils in the local system. In the FAO system they are recognised as Eutric Vertisols and Calcic Vertisols.

Low Elevated Isolated Ridges - C 14

These are sunken limestone ridges of the down thrown blocks around Makunduchi area only the ridge tops seem to be exposed above the surrounding maweni soils of the Q 2 coralline reef, these ridges are separated from the other subunits due to climatic as well as socio-economic differences such as being located far from the markets, etc. The soils have moderately deep to shallow, well drained red clay loams, and sandy clay loams overlying fine calcic clay and sandy clays.

Land use is mainly coconut and citrus with all other home garden trees, the main crops in the areas is a special variety of small pungent chillies which are propagated at the local agricultural station.

In the local system the soils within the unit are classified as shallow Kinongo and the FAO system they can be classified as Rhodic Ferralsols and Calcaric Cambisols.

Low Elevated Transitional Ridges - C 15

This unit occurs bordering the C 12 unit as isolated limestone ridges within the central and southern parts of the ridge zone. The soils occurring here are well and moderately well drained moderately deep to shallow clay loams and sandy clay loams, overlying fine calcic clay materials developing on the M1 limestone. There is a gradual merging of this land unit with the Wanda land mapping unit due to expansion of home garden plots into the surrounding Wanda areas and it is not possible to clearly demarcate the boundary of this unit based on air-photo interpretation, as the photos are nearly 12 years old, neither do they help much in the field checking process. Land use is mainly home garden plots with coconuts, citrus and mango. Cloves are grown only where the soil is deep.

The soils here are classified as Calcaric Cambisols and Mollic Leptosols and in the local classification as Kinongo soils.

Low Elevated Raised Corridor Ridges - C 16

This unit consists of the raised Bambi corridors which have been drained of its original deposits and is now developing its own residual soil material. The area is a gentle undulating plain with slope gradient rarely exceeding 2%. Permeable soils and porous underlying Calcitic limestone allow very rapid infiltration, so that there is very little run off and no coherent surface drainage pattern as in the other kinongo land forms, a special feature of this unit are the common isolated knolls or mondnocks which are up to 3m high and vary in diameter from 10 -40 meters. Some of the smaller mondnocks are quite steep sided with shallow and stony soils suggesting that, they result from differential weathering, others have very deep soils (2 meters) which illustrates that they are remnants of older and higher land surfaces which were in existence while the corridor forming streams eroded the surroundings.

The natural vegetation within the plain has been completely removed. The southern part is under arable cultivation of maize and vegetables. Previously the area has been used for tobacco cultivation. There are some scattered mango citrus trees.

The coconut nursery and plantation occupy most of the remaining area. The northern area gradually merges with the intervening Wanda formations. The soils are classified as kinongo (local) and as Chromic and Calcaric Cambisols.

Low to Medium Elevated Dissected Ridges - C 2

This unit occurs in the central and North central portion of the island, bordering the Masingini and Donge ridges. Based on the findings obtained after investigation of soils within this unit, it is most probable that this area is a raised plateau like quartenary deposit of mixed sands, clays rounded gravel and sand clay which are now eroding. The present landform of the area is highly dissected with many Alluvio-Colluvial valleys.

The rolling to hilly topography associated with this unit has slope ranging from 0 - 55%. Within an elevation range of 30 - 70 meters, the surface soils encountered on the ridge tops are loamy sands and coarse sandy loams to depths of about 50cm underlain by dark grey heavily mottled and gleyed, impervious layer of sand clays, which hinder root penetration to a great extent. On the lower slopes and foot slopes deep loamy sands are found to depth over 100 cm overlying the impervious sandy clay layer descried above.

The land use here consists mainly of coconut and mango with intercropping of cassava and upland rice. Cassava is planted on ridges which are usually aligned down the slope causing very severe erosion of the soil layers and equally unchecked draining of the soil moisture from the upper slopes. The coconut trees on the upper slopes are barely managing to survive. However the mango trees whose roots are able to penetrate the subsoil are seen to thrive on this land. The soils encountered within this mapping unit consist predominantly of Areni-Gleyic Cambisols according to the FAO classification system. In the local system they are classified as undifferentiated kinamo soils.

Medium Elevated Ridges - C 3

These are the almost north south oriented parallel ridges that are located in the upthrown western and central portions of the island. The range of elevation is 45 - 117 meters and slopes vary from 0 - 20%. On the basis of soils and slope this landform unit is subdivided into two mapping units and described below.

Medium Elevated Elongated Ridges with single slopes - C 31

This mapping unit consists of the gently sloping crest and upper slopes of the Masingini, Dongo and Mkwajuni ridges with elevations ranging from 45 - 117 meters and associated single slopes where most of the deep clove growing soils are located. The slopes are generally in the region of 0 - 6% and rarely exceed 13%. The soils according to the local classification are mostly deep mchanga with about 30% deep to moderately deep kinongo. However, the deep mchanga and deep kinongo encountered here are almost alike in morphological characteristics and difficult to separate on purely field observation. Furthermore they differ very much from the original description of them given by Calton in his reports, is that both exhibit Nitisolic characteristics such as clay contents in excess of 30% with marked increase of clays with depth.

The surface soils are dark reddish brown with fine subangular blocky structures, friable consistence and fine sandy clay loam textures, grading down to fine sandy clay, with moderate medium angular and subangular blocky structures and friable to firm consistence.

The land use here consists mainly of cloves with coconut, citrus, mango and home garden crops like jackfruit, breadfruit, durian, rambutan, banana, cassava, papaya, etc. Both shamba and Konde types of farming is practised on these land. The soils here are classified as Rhodi-Haplic Acrisols and Rhodic Ferralsols.

Medium Elevated Ridges with complex slopes - C 32

This mapping unit consits of complex slopes within the medium elevated ridge areas and bordering on the Kinyasini, Mahonda and Kitope areas. The Pangeni cattle ranch, the areas under rubber and the forest plantations are included within this mapping unit.

The soils here are described in the local classification as kinamo. The landform is complex with slopes ranging from 0 - 20%. The soils are dark brown 2.5YR 3/2 clay loams and sandy clay loams overlying mottled and gleyed clays. In some locations decomposing limestones are found underlying the heavy clay layer. The soils encountered here are best classified as Haplic Nitisols and Gleyi-Humic Nitisols.

Erosional remnants - C 4

These occur in the eastern portions of the island and are seen as wedge shaped flat topped isolated limestone out-crops above the maweni areas with almost vertical sides. Several sinkholes and depressions are seen on the nearly level surface of this unit. Tall tree species together with occasional patches of coconut indicates that small areas of deeper soils found in some locations. These limestone out-crops are classified as belonging to the M1 group by Johnson 1987.

Land use here consists of short medium and tall tree species together with occasional patches used for shifting cultivation and homesteads.

The soilsare best classified as Lithic and Mollic leptosols, although there are isolated deeper patches with shallow to moderate deep kinongo soils.

Shallow Coralline and Raised reef system - D

This system occupies the major portion of the Eastern, Northern and Southern parts of the Island with some scattered portion on the Western coastal areas. The range in elevation of the system varies from 0 - 45 meters while the topography consists of generally flat to gently sloping reef formations on old corridors and broad step like marine terrace formations which gradually grade down to the coast. Elevation difference between successive terraces vary from 2 - 10 meters. According to soils, Land use and landforms this system is subdivided in to the following subsystems.

Wanda Subsystem - D 1

This subsystem consists of the coralline reef formations found within the corridors and areas adjacent to the good soil zones of A and C system, from which they can receive Alluvio- Colluvial soil materials. The Wanda subsystem comprises of the Wanda corridor zones, which are generally used as unimproved grazing lands, rotational shifting cultivation and mixed home garden plots. It is not possible to separate the different land uses on these mapping unit at the present scale of mapping, hence it is mapped as one complex unit.

The soils are shallow (1/3 meter) consisting of high humic dark brown fine clay loam overlying decomposing reef limestone parent material. In the foot slope adjacent to A and C mapping units the soils are deeper and generally more permanent crops like citrus, banana, papaya, cassava and homestead garden crops are grown. The predominant land use is unimproved grazing. The natural grass growing here is subjected to periodic burning before the main rains. These soils are classified as a complex of Mollic and Rendzic Leptosols. In the local classification they appear as Uwanda Kinongo.

Maweni Subsystem - D 2

This subsystem consists of Terraced Coralline reefs which formed due to the step wise emergence of the Island from the sea. The subsystem do not receive any influx of Alluvio- Colluvial soils material from the surrounding good soil or Wanda areas due to the fact that the intervening Wanda system is without any surface drainage system.

Based mainly on different land use patterns observed on the Air photography (1977). The Maweni was separated into five sub categories as outlined below in order to assist in the Land Use Planning process.

In the local soil classification all maweni subsystem soil are classified as Maweni Kinongo.

Reserved shifting areas - D 21

This map unit consists mainly of areas located within the Northern and Southern parts of the island where traditional shifting cultivation has been practised since the earliest settlements. These lands have permanent fences made out of limestone which safeguard the right of the original cultivator to cultivate on the same land after the fallow period. No other person has right to cultivate on these reserved plots without the consent of the original cultivator. It was thought that this land should be separated from the rest of the maweni due to its exclusive nature, however the demarcation is based on the 1977 Air photography as such considerable increase of the acreage is expected at present due to the pressure on farm lands. The usage of those lands is carried out according to the traditional shifting cultivation system as outlined in land utilisation types 7. Soils occuring on the unit consists of high Humic Black coloured loam developing in the Coralline limestone of the Maweni and occurs in the crevices and cracks in the limestone. The limestone cover usually exceed 50% and varies in place up to a maximum of about 80%.

Cultivation is usually done by splitting or moving the coral to reach the soil within the crevices and planting after burning the vegetation before the onset of the rains. The soils occuring in this map unit consists of Rendzic and Lithic leptosols.

Unimproved grazing and shifting cultivation - D 22

This mapping unit consists of areas that are being used extensively for shifting cultivation, areas that have become transformed into Wanda and now only support grass and short scrub type vegetation or areas devoid of normal forest vegetation with grasses, trees and scrub forming the major portion of land cover. These areas are extensively used for grazing of cattle, goats and for obtaining firewood, etc.

The soils are same as above, with dark high humus loamy soil material in cracks and crevices of the reef limestone and are classified as a complex of Randzic and Lithic leptosols.

Thickets - D 23

The mapping unit consists of dense stands of thorny or spiky scrubs and also areas of secondary forest regrowth after being abandoned to bush on completion of the shifting cultivation cycle, some of these areas are too infertile to support normal forest species and can produce only stunted tree types with occasional taller trees in between, producing an open appearance when viewed from inside although the crowns are interlaced to form close canopy. Under growth here can support grazing mainly by goats. These areas supply fuelwood and small poles and sticks, the soil rock ratio here is much less than in D 22 unit with around 80% of the surface covered with coral. These soils are classified as Lithic and Rendzic Leptosols.

Open forests - D 24

These are the predominating type of forest prevalent in Unguja. Normally, they consist of trees with heights varying between 3 - 6 meters and crown coverage between 20 - 80%. The intervening open areas are occupied by grasses or other ground vegetation which also serve as potential grazing land. These forest areas provide most of the country's timber, pole and fuelwood requirements. It is very essential to safeguard these areas under a properly managed forest conservation and development plan so as to preserve the productive capacity of these forests. Some of these areas are currently classified as closed forest and cutting of fuelwood and clearing for farming prohibited but not rigidly observed due to lack of effective organisational control and manpower.

Replanting with improved plantation species with good rooting system and heavy leaf fall that promote and activate rapid soil forming process within the coral formations should be the consideration when selecting planting materials.

It is prudent to give priority to this factor of rapid soils rejuvenation rather than concentrating solely on quality of timber or output potential.

Local soil classification - Maweni Kinongo

Project classification - Rendzic and Lithic Leptosols.

Mixed forest - D 25

This mapping unit consists mainly of a mixture of tall and medium (5 - 15 meters) high forest species. Some of the species are seen intermixed with the typical forest species of the D 24 mapping unit.

The undergrowth here is not heavy but consists mainly of fern type of vegetation with a thick mat of roots which add to the high humic content of the soil and also cover the coral thus preserving the soil moisture. About 80% of the canopies touch each other. These consist of mainly existing forest reserves and closed areas. The Jozani natural forest reserve is included in this unit. The soils here mainly consist of black humic material developing on cracks and crevices of the reef limestone, the percentage of rock exposed varies from 50 - 80%. These soils are mapped as Rendzic Leptosols and Lithic Leptosols.

5.1.7. Physiographic Legend for Land Evaluation - Pemba Island, Zanzibar

Scale of Mapping 1:100,000

A ALLUVIAL SYSTEM

AO Alluvio - Colluvial Valleys 1/

B MARINE SYSTEM

BO Beaches and Dunes 1/

B2 Marshes and Swamps

C RIDGE/PLATEAU SYSTEM

RANGE IN ELEVATION 0-97m

C1 Steep sided dissected ridges
Slope range 13 - 55%.

C2 Moderately dissected ridges
Sloping to rolling, slope range 6-33%

C3 Elevated plateau with incised valleys, undulating to rolling. Slope range 2 - 20%

C4 Elevated flats on ridges and plateaus with drainage impedance
Slope range 0 - 2%
Elevation range 20 - 70m

C5 Moderately elevated plateau, undulating to rolling, slope range 2 - 13%. Elevation range 10 -25m

C6 Low plateau, generally flat to gently undulating, slope range 0 - 6%. Elevation range 0 - 15m.

D CALCARIOUS/CORALLINE SYSTEM

RANGE IN ELEVATION 0 - 15m

D1 Makaani plains.

1/ not mapped due to scale limitations

5.1.8 DESCRIPTION OF LAND MAPPING UNITS - PEMBA.

The Alluvial System - A

The Alluvial System in Pemba is located occuring within the Ridge/Plateau System and consists mainly of recent deposits within the many Alluvio - Colluvial Valleys with minor stream and water ways flowing across the B System into the sea. This system does not occur within the Coralline System due to its Karstic nature.

Alluvio - Colluvial Subsystem - AO

Is the only subsystem recoganised within the Alluvial System in Pemba. It can be further sub divided in-to narrow V shaped valleys and wide U shaped valleys in a detail study. Due to limitation in scale of the present study the unit AO is not demarcated on the map. But is an important constituent of the existing physiography and therefore needs to be evaluated for its potential for agriculture. The AO unit consists of the many valleys which carry concentrated water and sediment flows from adjacent upland areas.

They are highly fertile and are mainly cultivated with rice the poripheral areas sourrounding the valleys are cultivated with a wide variety of food crops, vegetable and banana. The slope ranges vary from about 1 - 4%.

The soils associated are Eutric and Dystric Fluvisols. In the local classification they are not mapped but the word Bonde is used to describe the land-form as well as soils.

DETERMINATION OF LAND SUITABILITY RATINGS OF MAPPING UNITS FOR RAINFED PRODUCTION OF MAJOR CROPS - PEMBA.

B. Marine System

Beaches and Dunes - B0

These areas are much less extensive than in Unguja and are difficult to map at the present scale of mapping but they form a significant potion of the physiography and have to evaluated for agricultural and other uses.

The land use is mainly coconut and home gardens, the slopes vary from about 2 - 3% and the landform is generally flat to gently sloping. The soils occuring here are simmilar to those of Unguja and consists mainly of Calcaric Regosols.

Marshes and Swamps - B2

These formation are simmilar in characteristic to those on Unguja and consists of wide extents of low lying lands underlain by partly submerged coral reefs and off shore muck and peat materials, through these marshes and Swamps the many minor rivers and water ways are seen to meandor their way to the sea.

Predomminatly swamp specific low to medium forests speecies are found within this landform unit. The soil occuring here are simmilar to those found in the swamps in Unguja. Except that the Histosols seem to be the predominant soil. These are constantly inundated during high tide by sea or by the inland lagoon type of tidal water ways which have high concentration of sea water. Histosols containing over 100cm of partly decomposed peat and muck material and Fluvisols consisting of Humic clay and sand mixed materials are the main soils that occur within the unit. They are called Jangwa by the indegenous population.

The Ridge/Plateau System - C

The Ridge/Plateau formation in Pemba constitutes the main topographic feature of the island. It divides the island in to two water-sheds, Western and Eastern.

The Western watershed areas consists of highly dissected Ridge landform, with associated narrow V shaped valleys which wind their way in to the mangrove swamps and then to the sea.

The eastern side of the divide consists of a sloping to rolling plateau which is uniformaly dissected by wide valleys with almost flat bottoms.

The plateau formation is pronounced in the north eastern potions of the island, while plateau remmnants give way to steep to rolling & dissected slopes in the south eastern potion.

Based on differences in soil, landform and land use the Ridge/Plateau System is subdivided into six subsystems as outlined.

Steep Sided, Dissected Ridges-C1

This mapping unit occuring mainly within the Western watershed, consists of steep sided and dissected ridges with the associated, complex of V shaped valleys. Predominat slopes ranges between 13% - 55%, with elevation ranging from coral reef or swamp level up to 97 meter are typical of this unit. The ground rises steeply from the West coast up to a height of about 30 meters and then by a series of steps.

Surface drainage ways and minor rivers and streams with rather steep sides are quite extensive within this unit. Slight subsidence of the Western coast line has led to aggradation of the larger river valleys near the coast and the formation of mangrove swamps.

The predominant land use within this mapping unit is cloves, which are grown from hill top almost to valley edge in a Agroforestry type of land utilisation. The valley edges are cultivated extensively with banana while the narrow valleys are used exclusively for rice cultivation.

The Agroforestry type of land utilisation preserves the steep slopes from accelerated erosion which would occur if a less effective ground cover was present.

The Bopwe soils that occur predominantly in this landform unit were classified tentatively as Ferralic Cambisol based on the brief description of chemical properties outlined in Calton's original reports and project studies of soil profiles in the field.

Moderately Dissected Ridges - C2

This mapping unit resembles the C1 unit with the exception that the slope are less steep, landscape less dissected and the soils less truncated. It occurs on the South - Eastern potion of the central divide. Within this unit are found plateau remnants, as such it would probably be a more dissected version of the 'Utasi' plateau of the North - East. The advanced state of dissection in the Southern areas may be attributed to the presence of the higher clay content of the underlying parent material which consists of the Chako limestone deposits.

Surface drainage ways consisting of wider valleys, than found in the C1 maps unit, with almost flat valley bottoms are a regular feature of this mapping unit. These valleys are ideal for rice growing if proper bunding and drainage control is effected in the form of peripheral canals and central floodways, which would serve the dual purpose of irrigation as well as flood control.

The agroforestry system of land use practised by the Shamba owners within this unit tend to conserve the soil and soil moisture very well so as to maintain the essentially moist micro-climate required for good yields, in cloves.

The soils found are predominantly Semi - Utasi with some inclusions of Bopwe and Utasi in steeper and gentle land surfaces, respectively.

According to available laboratory data (Calton's) on soil chemical properties the semi utasi was correlated with the FAO soil group Dystric Cambisol.

Elovated plateau - C3

This unit consists of tho North Eastern Plateau areas which wore tormod by Calton as the 'Utasi plateau.

Tho landform is undulating to rolling with slope rangos varing from 2 - 20%. The plateau surface is quite apparent on the Airphotos and appear mostly as flat topped ridges because of the : rather sharp incisions made on the plateau surface by the many flat bedded rivers and streams.

The fertile plateau surface is used exclusively for clove production with coconut now gaining popularity. A higher proportion of Konde farmers than in C1 & C2 landform units, carry out their activities of cassava, banana, mango and citrus growing, within the clove shambas, of this unit.

The principal soil associated with this unit is the Utasi and this was correlated as a Humic Cambisol.

Elevated Flats on Ridgos & Plateaus - C4

This unit is found occuring as isolated patches at differont elevation within the C1, C2, C3 & C5 mapping units indicating that its origin is not confined to any particular topographic level. However the study of soil morphology and properties points to it boing formod due to marine sorting & deposition in depressions on earlier land surfaces. Tho possibility of several differont levels of marine influonce & sedimention is evodent even in the step like gradation of the land surface in land units such as C1 and C5. Also tho limiting material below tho 'Carbic' layer portray several properties attributed to those of sandy clays with marine influonce.

The land surface is nearly level resulting in surface water stagnation duo to the impervious layor present below 100cms.

Tho land surface is gonorally bare except for short grasses and a particular type of heath vegetation - 'giant heather' - (phillipia mafiensis). Calton 1950 designated this soil as Ndamba. In tho absonce of any chomical analysis data. This soil was tontatively classified as Stagni - Dystric Planasol, according to the observed physical characteristics.

Moderately Elevated Plateau - C5

This mapping unit girdles the C3 and C2 units on the Eastern watershed and goes to illustrate further the stepwise formation of the plateau surfaces at different sea levels. A subsequent deposition of a mantle of Alluvio Colluvial soil material from the adjacent high lands have produced the undulating to rolling topography presently observed. The slope ranges within this unit vary from 2 - 13% while the elevation ranges vary from 10 - 25meters.

The land use here is a rich mix of all variaties of food crops and home garden crops. Coconut, mango and citrus are the predominant tree crop followed by home garden crops such as jack, breadfruit, banana, cassava, maize, etc. The soils which were disgnated by Calton as mtifutifu was correlated as Areni - Dystric Cambisol of the FAO classifioation.

Low plateau - C6

This map unit forms the lowest step in the plateau surfaces and could possibly be the continuation of the corridor zones formed by the deltaic streams of the prehistoric Rufiji/Ruvu rivers which greatly influenced Unguja and occupies a boxed in position with respect to the C5 and D1 mapping units of the Eastern coast. The B2 mapping unit is found encroaching into this mapping unit at sites where the many rivers and streams empty their sediment loads from the upland areas, into the tidal lagoons which are fringed with the mangrove swamps.

The land use here is predominently rice in the poorly drained low areas with cassava, sweet potatoes & maize grown on better drained areas, and coconut & home garden crops in the undulating crests.

The soils here are called Kinako and were correlated as Vertic and Gleyic Cambisols.

Makaani Plains - D1

This mapping unit groups all the Calcarious and Coralline formations that are found occuring around the perimeter of tho island. The land surface is nearly level and elevations rarely exceed 10 meters. This unit could be further subdivided into two subunits based on soil depth and extent of limestone exposures, but it was not practical to do so at the present scale of mapping.

The land use here is predominantly shifting cultivation and rearing of livestock. Cassava, cowpea, maize, banana & papaw are cultivated in cleared 'Cultivation areas' with short fallow periods. Some areas are seen to support occasional mango & baubaab trees. Low to medium type of natural forest vegetation is found in some uncleared areas with high proportion of corallino out-crop.

Tho Makaani soils were correlated as Mollic and Rendzic Leptosols.

6 AGRICULTURE AND LAND UTILISATION.

Evolutionary Phases in Agricultural land utilisation in society can be illustrated as follows:-

Activity	Land tenure	Land utilisation	
		Agriculture	Livestock
Hunters and gatherers	None	None	None
Nomadism	Tribal	None	Low
Shifting cultivation and semi -nomadism	Tribal	Low	Low
Present day Agriculture	Private, collective, Government	Medium to high	Medium to high

All over the world, with the increase in Agricultural activity, gradual disappearance of the natural vegetation and forest cover is an ongoing and almost irrevocable process. The resulting maleffects leading to enviromental degradation such as irregular and lower rainfall with resulting increase in temperature, drought effects, wind erosion, accelerated soil erosion due to inadequate ground cover, salinisation, dissected landforms, etc., are becoming the primary concern of all agriculturally dependent countries and especially so in developing countries like Zanzibar where the land resources are limited.

6.1. Agricultural Production

Smallholder mixed farming dominates land use in Zanzibar. Two major Agroecological regions can be distinguished, the plantation region within the more fertile upland areas of both islands with good soils and the more marginal coral limestone areas in eastern potions. The total cultivable area of the plantation regions of both islands amounts to about 130,000 ha. of which about 90% are under crops. In the coral-line areas with relatively poor Uwanda, Maweni and Makaani soils less than 20% is cultivated. It is largely as a result of fishing and to a lesser extent, on livestock production, lime burning and charcoal making that most families in these areas are able to sustain themselves.

About 60 percent of the total cultivated area is planted to food crops. Cassava, banana, sweet potatoes, legumes, are grown in almost every rural household plot. Rice is grown whenever there is suitable land. With the exception of rice, all crops are grown as intercrops, mixed intercrops and complex crop associations often under tree crops. Cassava, rice, sweet potatoes, yams and banana constitute the staple food of all rural households.

6.2. Agricultural Practices

In Zanzibar the presence of rather unique shamba and konde farming systems where intensive agricultural practices are carried out on the same piece of land by two different farmers, results in very high levels of land utilisation within the plantation regions with good soils. However, this dual land management coupled with the fact that all lands are the property of the state has resulted in detrimental land use practices to obtain short term benefits, without due regard to the serious and irreparable damage caused to the land itself. This is plainly evident the highly dissected landform observed on the airphotos, and in the constant filling up of minor valleys and paddy areas with deep sandy deposits from the adjacent high-lands. More difficult to notice but equally evident is the gradual decline in yields of the upland tree crops with every passing year.

6.3. The need for a well organised extension service

Increase in food crop yields through improved production practices are constrained by poor and short sighted agricultural practices still followed by the traditional farmer, which are detrimental to the future productivity of the land. As a result the agricultural productivity of lands are steadily decreasing even with the availability of heavily subsidised fertilisers, pesticides, etc.

Indiscriminate and unchecked use of fertilisers could also result in pollution of the underground water source which is located in the interconnected aquifers of the karstic limestones. This can cause even more severe problems than that caused by lower yields. The main cause for the persistence of above problem could be attributed to the virtually ineffective extension service which need to be properly trained and reorganised into an efficient working system.

The limited research and extension which are available for coconut, rice and fertiliser programs under various donor funded projects should be intergrated with the national extension service which should cover all crops, land preparation, farmer education on appropriate soil and soil moisture conservation etc.

It is essential that the agricultural extension workers should be properly trained in the most up to date agricultural practices, sufficiently motivated and mobilised within an effective and forceful organisational structure, which has full authority to recommend and effect appropriate soil and soil moisture conservation measures so as to safeguard the countries land and water resources - " the life blood of the nation".

6.4. Cash crops

Zanzibar has an estimated 2.8 million clove trees of which around 82 percent are in Pemba, while of the 5.8 million coconut trees about 80 percent are grown in Unguja.

The main cash crops are:-

1. Cloves and coconuts, which are also the main export crops.
11. Fruits and spices consisting mainly of mangoes, citrus and cillies, which have high export potential.
111. Rice, sugarcane, etc, which are import substitutes.

6.5. Livestock

Livestock production in Zanzibar is steadily increasing with about 29 percent of rural household in Unguja with poultry and 11 percent having cattle and about 5 percent raising goats. In Pemba the corresponding figures are; poultry 65 percent, cattle 37 percent, and goats 10 percent. With the availability of more Uwanda and Maweni lands in Unguja these could be more facilities for developing the livestock industry further.

6.6. Fuelwood and timber

The most common sources of cooking is through use of fuelwood and charcoal. These resources have been steadily decreasing during the last decade. Fuelwood as well as timber, poles, etc., are obtained from coral thickets, forests, swamp and mangrove, village plantations, old coconut and clove trees, etc. Recently the Department of Forestry, through FINNIDA funded project, has established several forest nurseries and new plantations. Woodlots have been also started with individual, community and farmer group participation. Maintenance of adequate forest cover and proper ecological balance is essential to ensure that advorse climatic variations do not occur.

6.7. Land preparation

Timely land preparation and planting is essential for suocessful rainfed farming. Soils, especially the Kinamo and Gleysols are usually very hard and difficult to cultivate immediately before each rainy season, especially with the native hoe and the available tractors are insufficient to cover all the farm lands. Unfortunately animal draught to prepare land for cultivation is not practised in Zanzibar, consequently farmers tend to delay land preparation until one or two showers have softened the soil. Their crop thus loose the benefit of the early rains and delayed land preparation normally allows prolific weed growth and therefore a loss of soil moisture. Whether a Vuli crop is taken or not, farmers should prepare the land for the next crop immediately after harvesting the Masika crop when soil conditions are still suitable. Naturally weed growth must be suppressed between land preparation and planting, care must be taken in land preparation to plough a-long the contour and not down the slope to minimise erosion hazard.

6.8. Selection of ecologically feasible crops

Choosing or breeding crops whose water demand fit as closely as possible to the available soil moisture and selection of the best time plant is essential to fully use the limited rainfall within the two seasons.

The modal length of the season need to be increased by the extra time that a crop can keep growing on residual soil moisture. This extra time depends upon the crop, effective moisture extraction days, available soil moisture to that depth and permissible soil moisture depletion. It is assumed that the soil is at field capacity at the end of the last wet pentade included in the rainy season. The length of time this soil moisture will last depends upon the rate at which evapo-transpiration is occuring.

Restricted length of growing season is one of the main reasons for low yields. Short seasons may not allow crops to develop their full potential yields. In dry areas, the best chance of success lies with short - term crop that can mature before available soil moisture is depleted, particularly if they have deep roots to extract moisture from deep in the soil. Within nearly all crops thero are cultivars with different maturity ratings. Consequently, for any given area or season, cultivars should be chosen to fit the expected growing season length. Furthermore, agronomic practices can be adjusted to the season length needed. High nitrogen levels tend to increase it, high plant populations to reduce it. Use of the latter effect has been made in cotton. It is already a commercial practice in USA and Australia to use close-cluster cultivars at abnormally high populations. Individual plants are stunted and produce less bolls but the same total yield per hectare is obtained about three weeks earlier.

Besides making every effort to use the full length of the available growing seasons in marginal seasons length areas, it is also important to use rainfall within the growing seasons as effeciently as possible. This means either minimising or conserving run-off, increasing moisture storage and retention, etc., as every drop of moisture stored in the soil is an insurance against low yields.

Major crops considered in the land suitability classification are all crops whose cultivars have been tested under the present ecological condition and found suitable within the accepted profitability range for local production.

Additional major crops are not proposed or incorporated in the suitability classification due to the complexity of the land Utilization Systems prevalent, and the need for more careful study of the Socio-Economic factors involved.

The on going Regional Land Use Planning Project is expected to study the feasibility of promoting new major crops.

6.9 Major crops considered for suitability assesment

The following major crops were considered for the suitability classification within the context of the relevant land utilization types:-

Crops	Farming System	Relevant Land Utilization Type
Rice	Rainfed Traditional System	LUT - 1
	Rainfed Project system	LUT - 2
Sugarcane	Project system	LUT - 3
Cassava	Konde farming system	LUT - 4 & LUT - 7
Banana	Konde farming system	LUT - 4
Cloves	Shamba farming system	LUT - 5
Cocomut	Shamba farming system	LUT - 5
Citrus	Shamba farming system	LUT - 5

6.10. Land utilisation types

Land utilisation types existing in Zanzibar have been recognised as:-

1. Traditional smallholder rainfed rice farming system.
2. Smallholder rainfed rice project system
3. Government rainfed sugar plantation system.(not appliable to Pemba).
4. Smallholder rainfed mixed farming according to Konde farming system.
5. Smallholder rainfed mixed farming as practised according to Shamba farming system.
6. Smallholder mixed farming involving both above systems (Shamba cum Konde farming).
7. Shifting cultivation system, mainly restricted to the Maweni zones.

The detailed description of these are presented in table 18

Table: 18

DESCRIPTION OF LAND UTILISATION TYPES - EXISTING AND IMPROVEMENTS

(Improvements Vital for Higher Production levels and Prevention of Further Land Degradation)

Kind of Farming	Inputs	Tools	Land Preparation	Varieties	Produce	Labour Intensity	Farm Power	Level of Technology	Farm size	Farm Income	Price Structure	Land Tenure
1. Traditional Smallholder rainfed rice.	Low	Hoe (Jembe) matchette (panga) Hand hoe knife	By hand hoe or Government tractor (no bunds)	Local which take 180 - 200 days	Rice Yields very low 0.2-1.2 t/ha	High	None	Low	¼-1 ha	Low mainly subsistence	Gov't rates and market rates	Gov't land leased or borrowed
Recommended Improvements For LUT 1	Introduction of the sickle for harvesting of rice. Timing of land preparation and planting to get best effects of Masika rainfall: Bunding of the plots into small managable paddies with a minimum bund height of 10" will upgrade the system to water and nutrient conserved. Use of short duration varieties which allow a second crop of beans, vegetables or grass during the short Vuli rains. (In smaller valleys with concentrated water movement during rains minor floodways and peripheral canals may have to be established. Once these are laid out minimal maintenance required could be done by farmer).											
2. Smallholder rainfed rice project system	High. Seeds Fertilizer, Herbicide and Insectiside	Hoe (jembe) matchette (panga) Hand hoe Knife	By tractors no bunds are made	Improved pinlot 330 Colombia 5179 BKN/IRAT 3036A 120-140 days	Yields from 2-3 t/ha	Moderate not so high as under traditional	Tractor thresher	Medium	0.1/ 0.5 ha	Low-Med.	Gov't rates and market rates	Gov't land leased or borrowed.
Recommended Improvements For LUT 2	Water and nutrient conservation in rice plots by providing with scientific layout and bunding of the rice plots to a minimum height of 10". This will in no way obstruct the use of tractors in land preparation.											
3. Government Parastatal rainfed sugar plantations	High Fertilizer drainage herbicide	Hoe (Jembe Matchette (Panga) Knife	Planted in furrows made by tractor lay-out in large bunded plots and drained as required.	Improved varieties	Sugar alcohol perfume molasses	Mod. to high	Mechanized traction & transportation factory based in Mahonda	Medium to high	large over 500 ha	Medium	Not applicable (Govt. controlled)	Govt. land
Recommended Improvements For LUT 3	Appropriate management levels for different soil types to bring about the rooting condition necessary for good yields.											

Table: 18 Cont.

DESCRIPTION OF LAND UTILISATION TYPES - EXISTING AND IMPROVEMENTS

(Improvements Vital for Higher Production Levels and Prevention of Further Land Degradation)

Kind of Farming	Inputs	Tools	Land preparation	Varieties	Product	Labour Intensity	Farm power	level of technology	Farm size	Farm Income	Price structure	Land tenure
4. Smallholder rainfed mixed farming (Konde system) Not entitled to grow permanent tree crops.	low	Hoe (jembe) matchette (Panga) hand hoe knife	By hand	local	Cassava S/Potatoes Maize, Pidgeon peas, bananas, pineapple, pawpaw, sorghum sugarcane etc.	High	None	Low no conservation	½ ha or less	Mainly subsistence	Depending on local market prices	Leased or borrowed. Crops usually grown in tree crop shamba as an intercrop.
Recommended Improvements For LUT 4	Use of Bio-fertilizer (compost, farmyard manure etc). Upgrade level of technology with extension advise. No ridging for cassava except on flats, minimum tillage cultivation. Establishment of Vertiver grass conservation hedges on all lands above 6% slopes. Note: Ridging for cassava down the slope, as is commonly practiced, causes accelerated soil erosion as well as depletion of the soil moisture availability, resulting in severe moisture stress on the upper slopes.											
5. Rainfed mixed Field Crops annuals and tree crops production (shamba system) No restrictions cropwise.	low to medium	Hoe (jembe) matchette (Panga) hand hoe knife, axe.	By hand Tractor (only for ploughing and harrowing	Local and improved	Cloves, coconuts, mango, citrus, jackfruit etc. Annuals, bananas, pineapple, Cassava etc.	High	Hired tractor	Low No conservation with some fertilizer	½-5 ha.	Relatively high supplemented by poultry and livestock rearing	Depending on Govt. rates for cloves, coconuts and copra for other depending on local market.	Govt. Plantation or private owned or leased.
Recommended Improvements For LUT 5	All recommendations for LUT 4 applicable, such as adequate use of Bio-fertilizer supplementary to normal fertilizer applications. In addition ring weeding, mulching, minimum mechanical tillage, adequate soil and soil moisture conservation measures as above, and close canopy planting (i.e. closing the gaps between trees with appropriate tree crops).											

Table: 18 Cont.

DESCRIPTION OF LAND UTILISATION TYPES - EXISTING AND IMPROVEMENTS

(Improvements Vital for Higher Production Levels and Prevention of Further Land Degradation)

Kind of Farming	Inputs	Tools	Land preparation	Varieties	Produce	Labour Intensity	Farm power	Level of Technology	Farm size	Farm Income	Price structure	Land Tenure
6. Smallholder rainfed Agroforestry system combing systems described under 4 & 5 (shamba cum konde system)	Low to medium	hoe (jembe) matchette (panga) Hand hoe Knife, etc.	to plant yams and cassava by hand and/ or tractor.	Local and improved	Mixture of those described in 4 & 5 systems.	High	Hired tractors	Low no conservation sometimes fertilizer or organic manure.	½- 5 ha.	Low to to medium	Depending on market and market rates.	Owned leased or bought
Recommended Improvements For LUT 6	Same recommendations as valid for LUT 4 and LUT 5 above.											
7. Shifting cultivation rotational cropping, followed by fallow period when yield decline. Mainly restricted to the Maweni & Makaani Zones	Low	Hoe (Jembe) matchette (panga) hand hoe, knife, axe. crowbar	Clearing followed by burning after drying, plant- in pockets where soil is present or breaking Surface rock	Local	Cassava maize millet sorghum pidgeon peas chillies pawpaws tomatoes vegetables. Tobacco.	High	None	Low sometimes organic manure.	½-1 Ha.	Below subsistence level supplemented by other other activities such as fishing, charcoal making or selling firewood etc.	Depending on market prices.	Traditional village Government land
Observation:	More appropriate and acceptable alternative to above system has to be worked out in subsequent studies.											

7. LAND SUITABILITY CLASSIFICATION

7.1. Introduction

Land, as defined by Christian and Stewart (1964), is a specific area of the surface of the Earth, its characteristics embracing all reasonably stable or predictably cyclic attributes of the biosphere vertically above and below this area, including those of the atmosphere, the soil and the underlying geology, the topography, the hydrology, the plant and animal population as well as the result of past and present human activity, to the extent that these attributes exert a significant influence on present and future uses of the land by man.

Land is the most important natural resource in any country which is dependent on agriculture. It is a reusable resource which can be utilised on a sustained basis. However, this resources is vulnerable to poor management and is virtually irreplaceable if destroyed or degraded. Therefore, utilisation of land has to be done on a scientifically planned basis.

7.2. System of classification

The land suitability classification as outlined in the framework for land evaluation FAO Soils Bulletin No. 52 of 1976 and the FAO Soils Bulletin No. 52. Guidelines for land evaluation for rainfed agriculture, were used in this study, together with appropriate modification required to match the diverse, land tenure, social, cultural and economic systems prevalent in Zanzibar.

7.3. Suitability Analysis

Criteria laid out in the National Food Strategy as well as Ecological adaptability and environmental requirements were taken into consideretion in the definitions of major crops to be considered for rainfed agriculture. These were evaluated at reconnaissance level using the available land resources information to determine the criteria for land suitability classification. Combining parameters thus obtained together with agronomic and crop performance data applicable, soil requirement for each of the major crops were defined, and presented in table 19. The land characteristics of each mapping unit (table 20,22) were then matched against the land requirements, of the different crops with due considerations to the applicable land utilisation types, to arrive at the final suitability ratings of the qualitative classification. Quantification of the suitability classification through the incorporation of crop yield and economic data will require further studies.

7.4. Definition of Land Suitability Classes

	Definitions
Suitability Orders	
Order S, Suitable	Land on which sustained use of the kind under consideration is ecpected to yield benefits which justify the inputs, without unacceptable risk of damage to land resources.
Order N, not suitable	Land which has qualities that preclude sustained use of the kind under consideration.
Suitability Classes	
Class S1, highly suitable	Land having no significant limitation to sustained application of a given use, or only minor limitations that will not significantly reduce productivity or benefits and will not raise inputs above an acceptable level.
Class S2, moderately suitable	Land having limitations which in aggregate are moderately severe for sustained application of a given use: the limitations will reduce productivity or benefits and increase required inputs to the extent that the overall advantage to be gained from the use, although still attractive, will be appreciably inferior to that expected on class S1 land.
Class S3, marginally suitable	Land having limitations which in aggregate are severe for sustained application of a given use and will so reduce productivity or benefits, or increase required inputs, that this expenditure will be only marginally justified.
Class N1, currently not suitable	Land having limitations which may be surmountable in time but which cannot be corrected with existing knowledge at current acceptable cost; the limitations are so severe as to preclude successful sustained use of the land in the given manner.
Class N2, permanently not suitable.	Land having limitations which appear so severe as to preclude any possibilities of successful sustained use of the land in the given manner.
NR, not relevant	Land which has not been assessed for a given use, because the application of the use to that area is precluded by the initial assumptions of the evaluation.

Source: FAO Soils Bulletin 52 (1983).

7.5. Criteria for Land Suitability Classification

The presence of unique Shamba and Konde farming systems where intensive agricultural practices are carried out on the same piece of land by two different farmers, necessitated that the land Suitability Classification for the major crops should be carried out within the context of the specified land utilisation types, as appearing in the previous chapter, inorder to reflect the various limitations and socio-economic factors affecting the overall level of production and management. The following criteria were used in the Suitability Evaluation within the restrictions of the specified land utilisation types.

7.5.1. Drainage

This is an important soil characteristic which define the land quality availability of oxygen to the root zone. Drainage classes recognised are, well, Moderately well, Imperfect and Poor. Poor and imperfect drainage is limiting to most crops, an exception is in paddy where the higher suitabilities are in poorly drained situations.

7.5.2 Slope Gradient

Slope is not a critical factor for the sole growth of tree crops where over 90% of the ground surface is covered but where a mixed cropping system such as Shamba cum Konde farming is practised, it is necessary to adhere to appropriate conservation practices recommended on slopes exceeding 6%.

7.5.3 Presence of Rock Out-crops

The degree of surface rockiness was not very relevant in the A and C systems. However, it was relevant criteria for suitability assessment in the Wanda and Maweni zones.

7.5.4 Rootable Depth of Soil

For most crops the deeper the soil, the higher the suitability rating, to a limit of about 1.5m with the exception of paddy which is shallow rooted and can grow satisfactorily on shalower soils. The depth classes defined are deep, greater than 1m, moderately deep (75 - 100 cm), moderately shallow (50 - 75cm) and shallow (less than 50 cm).

7.5.5. Salinity and Alkalinity

Level of salinity of more than 4mhos/cm on saturation extracts, ESP of more than 15% are likely to be severely limiting for crop growth. However, there are no apparent alkalinity or salinity hazards yet recorded in the rice growing areas, but there is a tendency of it developing in the irrigated rice areas due to the high salt and Calcium content of the irrigation water, which is pumped from the underground aquifers. On the Wanda and Maweni areas the high alkaline status is considered.

7.5.6. Retention of water and nutrients

Availability of nutrients and nutrient retention is an important criteria for land suitability classification in Zanzibar. The Mchanga soils are of fairly low chemical fertility but make up for this in the structure and water holding capacity which aids in the uptake of nutrients, the Kinongo soils are of moderate chemical fertility however their depth are subject to variation at short distances. Inspite of the clayey nature of the subsoil, they are free draining soils with a lower holding capacity. The kinamo soils are moderately fertile soils with limited agricultural potential due to their vertic properties.

7.5.7 Climatic adaptability of crops

Climatic criteria is generally uniform in the good soil zones. There is no restriction, except in the case of rainfed rice, imposed by climate on the growth of other major crops which are considered in the suitability classification, if the proper timing of planting is carried out. Hence it was used only in determining the relevance of the suitability of the particular crop outside the plantation zone, when considering isolated area within the Maweni zones. Furthermore climatic differences were also taken into account when the mapping units were subdivided.

7.5.8 Other criteria

The following were considered where applicable:

1. Limitations of the traditional farming system in terms of realisation of yield levels to match the suitability ratings.

2. Input and management limitations in the "Dual Farmer - One piece of Land" mixed farming system as described in the land utilisation.

3. Limitation in the availability of large contiguous block of land for land utilisation type 3 and need for extensive drainage layout.

4. Limitation of soil moisture during the Vuli season.

The suitability ratings were down graded by one class where these considerations imposed limitations.

7.6 Land suitability ratings for major crops.

Tables 20 and 21 outlines the land qualities of the land mapping units encountered and Tables 22 and 23 illustrates how the land suitability ratings were derived, using the matching process, for major crops.

7.7 Conclusions and Recommendations

In order to be of positive assistance in the future planning activities and at the same time prevent the alarming rate of land degradation taking place, whilst ensuring the proper utilization of the natural resources, the proposed land suitability classification embodies certain improvements to the existing farming systems (land utilization types) which are easy to effect and considered well within the capabilities of the Government's ongoing development programme. These are incorporated in the detailed description of the updated land utilization types with recommended improvements.

The land suitability legend together with the land utilization units will form the descriptive legend of the land suitability maps produced for each Island. As can be seen from the simplified legend it will be easy for the planners, as well as the agricultural and extension officers to understand and follow the systems applicable to each region or locality without having to go through the reports to interpret the map.

It is recommended that technically qualified personnel from relevant organisations responsible for land resource inventory, soil survey, and land use planning should serve in an advisory capacity within the Land Commission to suggest and formulate land use polices.

In order to arrest the alarming rate of land degradation taking place at present, and safeguard the natural resources for the future generations legislation on resources conservation should be enacted.

Present legislation relating to land utilisation is very weak and fragmented, new laws are required to ensure that proper land utilisation and conservation measures are adopted. It is proposed that a more comprehesive land utilisation ordinance be enacted, which will be designed to review existing land use, plan new land use activities and conduct research on land use and management practices. The ordinance should provide for compulsory land use planning and environment impact assessmant before any organisation or individual embarks on new land use activities.

Produce transportation facilities, marketing and storage facilities, rural credit facilities and physical infrastructure such as roads needs revitalization.

In forest replanting or establishment it is prudent to give priority to improved plantation species with good rooting system and heavy leaffall that promote and active rapid soil forming processes within the coral formations.

Agricultural extension workers should be properly trained, sufficiently motivated and mobilised within an effective and forceful organisation which has the full anthority to reccomend and effect, appropriate soil and moisture conservation measures in addition to their other duties.

Table: 19

SOIL REQUIREMENTS OF MAJOR CROPS

Crop	Texture: Moderately heavy preferred	Texture: Moderately sandy preferred	Texture: Moderately sandy well tolerated	Texture: Very sandy tolerated	Drainage: Free essential or very desirable	Drainage: Imperfect well tolerated	Drainage: Poor tolerated or needed	Depth: Deep soil very desirable	Depth: Moderately shallow well tolerated	Moisture: Drought resistance	Moisture: High AWC important	Moisture: Low AWC well tolerated	Erosion hazard	Reaction: Optimum pH	Reaction: Range of pH tolerance	Nutrient content: General level of requirements	Nutrient content: Specific requirements	Salinity tolerance class
Cereals																		
Rice	+		+				+			L	+		L	5.0-6.5	4.0-8.0	M	High N	M
Root crops																		
Cassava		+	+	+	+			+		M		+	M			M	Low tolerated	
Field perennials																		
Sugarcane	+		+			+		+		L	+		H	6.0-7.5		H	High N	
Tree and shrub perennials																		
Clove	+		+		+			+		L	+		L	5.5-6.5		H	Balanced	L
Mango	+		+			+			+	L			L	4.0-6.5	3.5-8.0	L		
Coconut		+	+	+		+		+		L		+	L	6.0-7.5	5.0-8.0	L		H
Banana	+		+		+			+		L	+		H	6.0-7.5	4.0-8.0	M	High N, K	
Citrus		+	+		+			+		M			L	5.5-6.5	5.0-8.0	M	High N, K	L

L.M.H.= Low, Medium, High. For soil textures. Moderately heavy= Sandy clays, heavy loams and well structured clays. Moderately sandy= Sandy clay loams and other light loams, with sandy loams only slightly suboptimal. Compiled from various sources.

Table: 20

LAND QUALITIES OF MAPPING UNITS – UNGUJA

Map Unit	Texture: Coarse Textured <15% clay	Texture: Medium Textured <35% clay <70% sand	Texture: Fine Textured >35% clay	Drainage: Excessive	Drainage: Well – Mod	Drainage: Mod – Imp.	Drainage: Imp – Poor	Drainage: Poor	Depth: Less than 50cm	Depth: 50 – 150cm	Depth: 150+ cm	Moisture: High	Moisture: Medium	Moisture: Low	Slope %: 0 – 2	Slope %: 2 – 6	Slope %: 6 – 13	Slope %: 13 – 20	Slope %: 20 – 33	Slope %: 33+	Stones & Gravel	Nutrient content: High	Nutrient content: Med	Nutrient content: Low	Erosion Hazzard: High	Erosion Hazzard: Med	Erosion Hazzard: Low	Climate (Rainfall): 1000–1500mm	Climate (Rainfall): 1500–2000mm	Climate (Rainfall): 1500–2500mm	Climate (Rainfall): 2000–2500mm	Alkalinity Salinity: High	Alkalinity Salinity: Medium	Alkalinity Salinity: Low	Alkalinity Salinity: Very Low
A0	+	+					+	+			+		+		+						NIL		+				+			+					+
A11		+						+		+			+		+						NIL		+				+			+					+
A12			+					+			+	+			+						NIL	+					+			+				+	
A2			+				+	+		+		+			+	+					NIL	+					+		+					+	
A3		+	+				+	+			+		+		+						NIL		+				+		+				+		
B1	+			+							+			+		+					NIL			+		+		+				+			
B2		+						+		+	+	+			+						NIL		+				+	+				+			
C11	+	+		+	+						+			+			+	+			NIL			+			+		+				+		
C12		+			+						+		+					+			NIL		+			+				+					+
C13			+			+					+		+					+			NIL		+			+			+						
C14		+	+		+					+			+	+		+					NIL		+				+	+				+			
C15		+			+					+				+		+	+				NIL		+			+			+				+	+	
C16		+	+		+					+			+		+	+					NIL		+				+		+				+	+	
C2	+			+	Surface Subsurface			+			+			+			+	+	+	++	NIL			+	+					+				+		
C31		+	+		+						+		+			+	+				NIL		+			+					+				+	
C32			+				+	+		+	+	+	+				+	+			NIL		+		+						+				+	
C4		+		+					+					+		+					HIGH			+	+		+	+					+			
D1		+		+					+					+		+					HIGH		+				+		+				+			
D2		+		+					+					+		+					HIGH			+			+	+					+			

Table: 21

LAND QUALITIES OF MAPPING UNITS - PEMBA

Map Unit	Texture: Coarse Textured <15% clay	Texture: Medium Textured <35% clay <70% sand	Texture: Fine Textured >35% clay	Drainage: Excessive	Drainage: Well - Mod	Drainage: Mod - Imp.	Drainage: Imp - Poor	Drainage: Poor	Depth: Less than 50cm	Depth: 50 - 150cm	Depth: 150+ cm	Moisture: High	Moisture: Medium	Moisture: Low	Slope %: 0 - 2	Slope %: 2 - 6	Slope %: 6 - 13	Slope %: 13 - 20	Slope %: 20 - 33	Slope %: 33+	Stones & Gravel: High	Stones & Gravel: Mod	Stones & Gravel: Low	Nutrient content: High	Nutrient content: Med	Nutrient content: Low	Erosion Hazzard: High	Erosion Hazzard: Med	Erosion Hazzard: Low	Climate (Rainfall): 1000-1500mm	Climate (Rainfall): 1500-2000mm	Climate (Rainfall): 1500-2500mm	Climate (Rainfall): 2000-2500mm	Alkalinity Salinity: High	Alkalinity Salinity: Medium	Alkalinity Salinity: Low	Alkalinity Salinity: Very Low
A0		+	+					+			+	+			+	+					NIL			+					+			+					+
B0	+			+					+					+		+					NIL					+		+		+	+			+			
B2		+						+			+	+			+						NIL				+				+	+	+			+			
C1		+			+	+					+		+					+	+	+	NIL				+		+				+					+	
C2		+			+	+					+		+				+	+	+		NIL				+		+				+					+	
C3		+			+	+					+		+			+	+	+			NIL				+			+			+					+	
C4	+							+	+					+	+						HARD PAN					+			+			+			+			
C5		+			+	+					+		+			+	+				NIL				+			+			+				+	+	
C6			+				+	+			+	+	+		+	+					NIL			+	+				+		+			+	+		
D1		+		+		+			+					+	+	+					ND.				+				+		+			+	+		

Table: 22

Major Crop: Rice Cultivated under Land Utilisation Type 1

Map Unit	Drainage	% Slope	% Stoniness	Soil Depth	Salinity & Alka-linity	Nutrient Retention	Climate Limita-tion.	Management Limitation	Suitability Ratings
A0	1	1	1	1	1	1	1/2	3	3
B0	N	1	1	1	3	2	1/2	3	N
B2	1	1	1	2	N	3	1/2	3	N
C1	3	N	1	2	1	2	1/2	3	N
C2	3	N	1	2	1	2	1/2	3	N
C3	2	3	1	1	1	1	1/2	3	3
C4	1	1	hard pan 3	1	3	3	1/2	3	N
C5	1	2	1	1	1	1	1/2	3	3
C6	1	1	1	1	1	1	1/2	3	3
D1	NR	NR	NR	NR.	NR	NR	NR	NR	NR

Table: 23

DETERMINATION OF LAND SUITABILITY RATINGS OF MAPPING UNITS FOR RAINFED PRODUCTION OF MAJOR CROPS - PEMBA

Major Crop: - Rice Cultivated under Land Utilisation Type 2

Map Unit	Drainage	% Slope	% Stoniness	Soil Depth	Salinity & Alka-linity	Nutrient Retention	Climate Limita-tion.	Management Limitation	Suitability Ratings
AO	1	1	1	1	1	1	1/2	2	2/2
BO	N	1	1	1	3	2	1/2	N	N
B2	1	1	1	2	N	3	1/2	N	N
C1	3	N	1	2	1	2	1/2	N	N
C2	3	N	1	2	1	2	1/2	N	N
C3	2	3	1	1	1	1	1/2	2	3/N
C4	1	1	Hard pan 3	1	3	3	1/2	Drainage 3	N
C5	1	2	1	1	1	1	1/2	2	2/3
C6	1	1	1	1	1	1	1/2	2	2/3
D1	NR	NR	NR	NR	NR	NR		NR	NR

Table: 24

LAND SUITABILITY CLASSIFICATION & RATINGS FOR MAJOR CROPS OCCURING WITHIN RESPECTIVE LAND UTILISATION TYPES - UNGUJA

LAND MAPPING UNITS	AREA	ASSOCIATED SOILS	RAINFALL	LUT-1	LUT-2	LUT-3	LUT-4		LUT-5				MISCELLANEOUS USES			
SYSTEMS & MAIN UNITS	Ha.	L-LOCAL CLASSIFICATION F-FAO CLASSIFICATION	MEAN ANNUAL Range in mm.	Traditional smallholder Rice	Rainfed Project Rice	Sugarcane plantations	Mixed inter cropping Konde farming system Cassava	Banana	Mixed tree inter cropping Shamba farming system Cloves	Coconut	Mango	Citrus	Rangeland for Animal Production	Conserv Forestry	Brackish water Fisheries	Tourism Recreation
A-ALLUVIAL SYSTEM																
A0 Alluvio-Colluvial Valleys		L-Unclassified F-Dystric Regosols & Dystric Fluvisols	1500-2500	S3	S2/S3*	S3	N	N	N	N	N	N	NR	NR	N	NR
A1 Reworked Old Corridors																
A11 Open Corridors	7610	L-Greyish Mchanga F-Umbric Gleysols, Dystric Fluvisols	1500-2500	S3	S2/S3*	S2	N	N	N	N	S3	N	NR	NR	NR	NR
A12 Closed Corridors	2980	L-Greyish Mchanga F-Mollic & Eutric Gleysols	1500-2500	S3	S2/S2*	S2	N	N	N	N	S3	N	NR	NR	NR	NR
A2 Plains	1300	L-Kinamo F-Eutric & Calcic Vertisols	1500-2000	S3	S2/S2*	N	N	N	N	N	S2	N	NR	NR	NR	NR
A3 Depressions & Basins	530	L-Sandy Mchanga F-Cambic Arenosols, Umbric Gleysols	1500-2000	S3	S2/S3*	S3	N	N	N	N	N	N	NR	NR	NR	NR
B-MARINE SYSTEM																
B1 Beaches & Dunes	1190	L-Sandy Mchanga F-Calcaric Regosols, Cambic Arenosols	1000-2000	N	N	N	N	N	N	S3	N	N	NR	NR	NR	S1
B2 Marshes & Swamps	4210	L-Swampy Wanda F-Thionic Histosols, Thionic Fluvisols	1000-2000	N	N	N	N	N	N	N	N	N	NR	S2	S2	NR

NOTE:-
The D2 Maweni coralline deposits have been subdivided according to the Land Use existing at the time of photography (1977). Although these subdivisions do not confirm to normal format in a physiographic legend they are nevertheless useful in demarcating boundaries within the Maweni for planning purposes.

* denotes:-
Suitability ranges considering the rainfall variability factor when the required 3 consecutive humid months do not occur during Masika season.

S1-Highly suitable. S2-Moderately suitable. S3-Marginally suitable.

N -Conditionally not suitable & Permanently not suitable. NR Not Relevant

LUT-Land Utilization Types

e Soil Profile
(S) Sugar Plantation

Table: 24 Cont.

LAND SUITABILITY CLASSIFICATION & RATINGS FOR MAJOR CROPS OCCURING WITHIN RESPECTIVE LAND UTILISATION TYPES-UNGUJA

LAND MAPPING UNITS	AREA	ASSOCIATED SOILS	RAINFALL	LUT-1	LUT-2	LUT-3	LUT-4		LUT-5				MISCELLANEOUS USES			
SYSTEMS & MAIN UNITS	Ha.	L-LOCAL CLASSIFICATION F-FAO CLASSIFICATION	MEAN ANNUAL Range in mm.	Traditional smallholder Rice	Rainfed Project Rice	Sugarcane plantations	Mixed inter cropping Konde farming system Cassava	Banana	Mixed tree inter cropping Shamba farming system Cloves	Coconut	Mango	Citrus	Rangeland for Animal Production	Conserv Forestry	Brackish water Fisheries	Tourism Recreation
C-RIDGE SYSTEM																
C1 Low Elevated Ridges																
C11 Coastal	8620	L- Sandy Mchanga														
		F- Areni-Haplic Acrisols	1500- 2000	N	N	S3	S2	S2	S3	S1	S1	S2	NR	NR	NR	NR
C12 Central	12130	L- Reddish/Greyish Mchanga & Deep Kinongo														
		F- Haplic & Ferric Acrisols, Rhodic Ferralsols	1500 - 2000	N	N	S3	S1	S1	S2	S1	S1	S2	NR	NR	NR	NR
C13 Rounded	800	L- Kinamo														
		F- Eutric Vertisol, Calcic Vertisol	1500 - 2000	S3	S3/S3*	N	S2	S2	N	S3	S1	S3	NR	NR	NR	NR
C14 Isolated	2340	L- Deep & Shallow Kinongo														
		F- Rhodic Ferralsols & Calcaric Cambisols	1000 - 1500	N	N	N	S1	S1	S3	S2	S1	S2	NR	NR	NR	NR
C15 Transitional	8550	L- Shallow Kinongo, Uwanda Kinongo														
		F- Calcaric Cambisols, Mollic Leptosols	1500 - 2000	N	N	N	S1	S1	S3	S2	S1	S1	NR	NR	NR	NR
C16 Terraced	840	L- Shallower & Shallow Kinongo														
		F- Chromic & Calcaric Cambisols	1500 - 2000	S3	S3/N	S2	S1	S1	S3	S1	S1	S1	NR	NR	NR	NR
C2 Dissected Ridges	3250	L- Kinamo														
		F- Areni-Gleyic Cambisols	1500 - 2500	N	N	N	S3	N	N	S3	S2	N	S1	S1	NR	S2
C3 Medium Elevated Ridges																
C31 Elongated Single Slope	550	L- Reddish Mchanga, Deep Kinongo														
		F- Rhodi-Haplic Acrisol, Rhodic Ferralsols	1500 - 2500	S3	S3/N	S3	S1	S1	S1	S1	S1	S1	NR	NR	NR	NR
C32 Complex Slope	1490	L- Kinamo														
		F- Haplic Nitisol, Gleyic-Humic Nitisols	1500 - 2500	N	N	S3	S2	S1	S2	S2	S1	S2	S1	NR	NR	NR
C4 Eroded Plants	1340	L- Unclassified														
		F- Lithic Leptosols, Mollic Leptosols	1000 - 2000	N	N*	NR	NR	NR	N	N	NR	NR	S2	S1	NR	S2

C02 Maweni coralline deposits have been subdivided according to the Land Use existing at the time of photography (1977). Although these subdivisions do not conform to normal format in a physiographic legend they are nevertheless useful in demarcating boundaries within the Maweni for planning purposes.

* denotes Suitability ranges considering the rainfall variability factor when the required 3 consecutive humid months do not occur during Masika season

S1-Highly suitable S2-Moderately suitable. S3-Marginally suitable.

N -Conditionally not suitable & Permanently not suitable. NR Not Relevant

LUT-Land Utilization Types

e Soil Profile

(S) Sugar Plantation

Table: 24 Cont.

LAND SUITABILITY CLASSIFICATION & RATINGS FOR MAJOR CROPS OCCURING WITHIN RESPECTIVE LAND UTILISATION TYPES-UNGUJA

LAND MAPPING UNITS	AREA	ASSOCIATED SOILS	RAINFALL	LUT-1	LUT-2	LUT-3	LUT-4		LUT-5				MISCELLANEOUS USES			
SYSTEMS & MAIN UNITS	Ha.	L-LOCAL CLASSIFICATION F-FAO CLASSIFICATION	MEAN ANNUAL Range in mm	Traditional smallholder Rice	Rainfed Project Rice	Sugarcane plantations	Mixed inter cropping Konde farming system Cassava	Banana	Mixed tree inter cropping Shamba farming system Cloves	Coconut	Mango	Citrus	Rangeland for Animal Production	Conserv Forestry	Brackish water Fisheries	Tourism Recreation
D CORALLINE SYSTEM																
D1 Wanda	16720	L-Uwanda Kinongo F-Moilic Leptosols.	1000-2000	NR	NR	NR	Applicable LUT-7 S3	S3	NR	NR	NR	NR	S2	NR	NR	S2
D2 Maweni (Coral cover 50-80%)	530	L-Maweni Kinongo F-Rendzic Leptosols, Lithic Leptosols														
D21 Reserved Shifting cultivation	4530	-do-	1000 1500	NR	NR	NR	S3	S3	NR	NR	NR	NR	NR	NR	NR	NR
D22 Unimproved grazing & Shifting Cultivation	45.590	-do-	1000-1500	NR	NR	NR	S3	S3	NR	NR	NR	NR	S2	S2	NR	S2
D23 Thickets	4900	-do-	1000-1500	NR	NR	NR	N	N	NR	NR	NR	NR	S3	S2	NR	S2
D24 Open Forest	18970	-do-	1000-1500	NR	NR	NR	N	N	NR	NR	NR	NR	S3	S2	NR	S2
D25 Dense Forest	1090	-do-	1000-1500	NR	NR	NR	N	N	NR	NR	NR	NR	N	S1	NR	S2

NOTE:-
The D2 Maweni Coralline deposits have been subdivided according to the Land Use existing at the time of photography (1977). Although those subdivisions do not confirm to normal format in a physiographic legend they are nevertheless useful in demarcating boundaries within the Maweni for planning purposes.

* denotes:-
Suitability ranges considering the rainfall variability factor when the required 3 consecutive humid months do not occur during Masika season.

S1-Highly suitable, S2-Moderately suitable, S3-Marginally suitable,
N -Conditionally not suitable & Permanently not suitable, NR Not Relevant
LUT-Land Utilization Types

• Soil Profile
(S) Sugar Plantation

Table: 25

LAND SUITABILITY CLASSIFICATION AND RATINGS FOR MAJOR CROP- OCCURING WITHIN RESPECTIVE LAND UTILISATION TYPES - PEMBA

LAND MAPPING UNITS	AREA	ASSOCIATED SOILS	RAINFALL	LUT 1	LUT 2	LUT 4		LUT 5				MISCELLANEOUS USES			
Systems & Main units	Ha.	L-Local Classification F-F.A.O Classification	Mean annual Range in mm.	Traditional smallholder Rice	Rainfed project Rice	Mixed intercropping Konde farming system Cassava	Banana	Mixed-tree intercropping Shamba farming system Cloves	Coconut	Mango	Citrus	Rangeland for animal production	Conserv Forestry	Brackish water Fisheries	Tourism Recreation
A-ALLUVIAL SYSTEM															
A0 Alluvio-Colluvial Valleys		L-Bonde F-Umbric & Dystric Fluvisols	1500-2500	S3	S2/S2*	N	N	N	N	N	N	NR	NR	NR	NR
B-MARINE SYSTEM															
B0 Beaches & Dunes		L-Ufukwe F-Calcaric Regosols	1000-2000	N	N	N	N	N	S2	N	N	NR	NR	NR	S2
B2 Marshes & swamps		L-Jangwa F-Thionic Histosols & Fluvisols	1000-2000	N	N	N	N	N	N	N	N	NR	S2	S2	NR
C-RIDGE/PLATEAU SYSTEM **RANGE IN ELEVATION** **0-97m**															
C1 Steep sided dissected ridges Slope range 13-55%		L-Bopwe F-Ferralic Cambisols	1500-2500	N	N	S3	S3	S1	S3	S1	S3	NR	NR	NR	NR
C2 Moderately dissected ridges Sloping to rolling, slope range 6-33%		L-Semi Utasi F-Dystric Cambisols	1500-2500	N	N	S3	S3	S1	S2	S1	S2	NR	NR	NR	NR
C3 Elevated plateau with incised valleys, undulating to rolling Slope range 2-20% Elevation range 20-70m		L-Utasi F-Humic Cambisols	1500-2000	S3	S3/N*	S1	S1	S1	S1	S1	S1	NR	NR	NR	NR
C4 Elevated flats on ridges and plateaus with drainage impedance Slope range 0-2% Elevation range 20-70m		L-Ndamba F-Stagni-Dystric Planasols	1000-2000	N	N	N	N	N	N	N	N	S2	S3	NR	S3
C5 Moderately elevated plateau, undulating to rolling, Slope range 2-13%, Elevation range 10-25m		L-Mtifutifu F-Areni-Dystric Cambisols	1000-2000	S3	S2/S3*	S1	S1	S3	S1	S1	S1	NR	NR	NR	NR
C6 Low plateaus, generally flat to gently undulating, slope range 0-6%, Elevation range 0-15m		L-Kiaako F-Vertic & Gleyic Cambisols	1000-2000	S3	S1/S3*	S3	S2	N	S2	S1	N	NR	NR	NR	NR
D-CALCARIOUS/CORALLINE SYSTEM **RANGE IN ELEVATION** **0-15m**															
D1 Makaani plains		L-Makaani F-Eutric & Rendzic Leptosols	1000-2000	NR	NR	S3	S3	NR	NR	NR	NR	S1	S2	NR	S2

* denotes:-
Suitability ranges considering the rainfall variability factor when the required three consecutive humid months do not occur during Masika season.

S1-Highly suitable: S2 Moderately suitable;
S3-Marginally suitable: N - Conditionally and permanently not suitable;
NR-Not relevant: LUT-Land utilization types.
o - Soil profile

Table: 26

LAND EXTENTS IN RELATION TO SUITABILITY CATEGORIES FOR MAJOR CROPS – UNGUJA

MAJOR CROPS	SUITABILITY CATEGORY	RELEVANT LAND UTILIZATION TYPE	EXTENT IN HA
Rice (Masika)	S1	LUT 1	–
	S2		–
	S3		24,610
Rice (Masika) (With three humid months)	S1	LUT 2	–
	S2		12,420
	S3		12,190
Rice (Without three humid months)	S1	LUT 2	–
	S2		4,280
	S3		8,940
Sugarcane	S1	LUT 2	–
	S2		11,430
	S3		33,320
Cassava	S1	LUT 4	34,410
	S2		10,910
	S3		3,250
Banana	S1	LUT 4	35,900
	S2		9,420
	S3		–
Cloves	S1	LUT 5	10,550
	S2		13,620
	S3		20,350
Coconut	S1	LUT 5	32,140
	S2		12,380
	S3		5,240

Table 26 Cont.

LAND EXTENTS IN RELATION TO SUITABILITY CATEGORIES FOR MAJOR CROPS

MAJOR CROPS	SUITABILITY CATEGORY	RELEVANT LAND UTILIZATION TYPE	EXTENT IN HA
Mango	S1	LUT 5	45,320
	S2		4,550
	S3		10,590
Citrus	S1	LUT 5	19,940
	S2		24,580
	S3		800
	SHIFTING CULTIVATION		
Banana	S1	LUT 7	-
	S2		-
	S3		66,840
Cassava	S1	LUT 7	-
	S2		-
	S3		66,840

Table: 27

LAND EXTENTS IN RELATION TO SUITABILITY CATEGORIES FOR MAJOR CROPS - PEMBA

MAJOR CROPS	SUITABILITY CATEGORY	RELEVANT LAND UTILIZATION TYPE	EXTENT IN HA
Rice (Masika)	S1	LUT 1	-
	S2		-
	S3		36,980
Rice (Masika) (With three humid months)	S1	LUT 2	6,830
	S2		19,150
	S3		11,000
Rice (Without three humid months)	S1	LUT 2	-
	S2		-
	S3		25,980
Cassava	S1	LUT 4	30,150
	S2		-
	S3		44,010
Banana	S1	LUT 4	30,150
	S2		6,830
	S3		37,180
Cloves	S1	LUT 5	48,180
	S2		-
	S3		19,150
Coconut	S1	LUT 5	30,150
	S2		21,980
	S3		33,250

Table: 27 Cont.

LAND EXTENTS IN RELATION TO SUITABILITY CATEGORIES FOR MAJOR CROPS - PEMBA

MAJOR CROPS	SUITABILITY CATEGORY	RELEVANT LAND UTILIZATION TYPE	EXTENT IN HA
Mango	S1	LUT 5	74,160
	S2		-
	S3		-
Citrus	S1		30,150
	S2		3,930
	S3		33,250
	SHIFTING CULTIVATION		
Banana	S1	LUT 7	-
	S2		-
	S3		15,010
Cassava	S1	LUT 7	-
	S2		-
	S3		15,010

GLOSSARY

This is included to define terms commonly used in the report; it is not a comprehensive glossary.

Alluvial deposit : sediments deposited by moving water.

Cation : an ion carrying a positive charge of electricity. The common cations are calcium, magnesium, sodium, potassium, and hydrogen.

Cation-exchange capacity (C.E.C.) : a measure of the total amount of exchangeable cations that can be held by the soil. It is expressed in terms of milliequivalents per 100 grams of soil.

Concretion : a local concentration of a chemical compound, such as calcium carbonate or iron oxide, in the form of a grain or nodule of varying size, shape, hardness and colour.

Consistence : (a) the resistance of a material to deformation or rupture; (b) the degree of cohesion or adhesion of the soil mass.

Drainage classes : Very poorly drained.--Water is removed from the soil so slowly that the water table remains at or on the surface the greater part of the time. Soils of this drainage class usually occupy level or depressed sites and are frequently ponded. These soils are wet enough to prevent the growth of important crops (except rice) without artificial drainage.

Poorly drained--Water is removed so slowly that the soil remains wet for a large part of the time. The water table is commonly at or near the surface during a considerable part of the year. Poorly drained conditions are due to a high water table, to a slowly permeable layer within the profile, to seepage or to some combination of these conditions. The large quantities of water that remain in and on the poorly drained soils prohibit the growing of field crops under natural conditions in most years. Artificial drainage is generally necessary for crop production, provided other soil characteristics are favourable.

Imperfectly or somewhat poorly drained.--Water is removed from the soil slowly enough to keep it wet for significant periods but not all of the time. Imperfectly drained soils commonly have a slowly permeable layer within the profile, a high water table, additions through seepage or a combination of these conditions.

Moderately well drained.--Water is removed from the soil somewhat slowly, so that the profile is wet for a small but significant part of the time. Moderately well drained soils

commonly have a slowly permeable layer within or immediately beneath the solum, a relatively high water table, additions of water through seepage, or some combination of these conditions.

Well drained.--Water is removed from the soil readily but not rapidly. Well drained soils are commonly intermediate in texture although soils of other textural classes may also be well drained. Well drained soils commonly retain optimum amounts of moisture for plant growth after rains or additions of irrigation water.

Somewhat excessively drained.--Water is removed from the soil rapidly. Some of the soils are lithosolic. Many of them have little horizon differentiation and are sandy and very porous. Only a narrow range of crops can be grown on these soil, and the yields are usually low without irrigation.

Excessively drained.--Water is removed from the soil very rapidly. Excessively drained soil are commonly Lithosols or lithosolic and may be steep, very porous, or both. Shallow soils on slopes may be excessively drained. Enough precipitation is commonly lost from these soils to make them unsuitable for ordinary crop production.

Erosion: the wearing away of the land surface by running water, wind or other erosive agents. It includes both normal and accelerated soil erosion. The latter is brought about by changes in natural cover or ground conditions and includes those due to human activity.

Fertility: the status of a soil in relation to the amount and availability to plants of elements necessary for plant growth.

Horizon: a layer in the soil profile approximately parallel to the land surface with more or less well-defined characteristics that has been produced through the operation of soil forming processes soil horizons may be organic or mineral.

Land Characteristic: an attribute of land that can be measured or estimated, and which can be employed as a means of describing land qualities or distinguishing between land units of differing suitabilities for use.

Land Evaluation: the process of assessment of land performance when used for specified purposes, involving the executions and interpretation of surveys and studies of landforms, soils, vegetation, climate and other aspects of land in order to identify and make a comparison of promising kinds of land use in terms applicable to the objectives of the evaluation.

Land Quality: a complex attribute of land which acts in a manner distinct from the actions of other land qualities in its influence on the suitability of land for a specified kind of use.

Land Suitability: the fitness of a given type of land for a specified kind of land use.

Land Suitability Classification: an appraisal and grouping, or the process of appraisal and grouping, of specific types of land in terms of their absolute or relative suitability for a specified kind of use.

Land suitability rating: the partial suitability of a land unit for a land utilisation type, based on one land quality or a partial set of land qualities. Land suitability ratings are combined to give a land suitability class (cf. note on suitability rating).

Land mapping unit: an area of land possessing specified land qualities and land characteristics, which can be demarcated on a map.

Land use requirement: the conditions of land necessary or desirable for the successful and sustained practice of a given land utilisation type (cf. crop requirements, management requirements, conservation requirements).

Land utilisation type: a kind of land use described or defined in a degree of detail greater than that of a major kind of land use. In the context of rainfed agriculture, a land utilisation type refers to a crop, crop combination or cropping system with a specified technical and socio-economic setting.

Major climate: a broad climatic division, defined in terms of monthly temperature, seasonality of rainfall, and temperature regime.

Major kind of land use: a major subdivision of rural land use, such as rainfed agriculture, annual crops, perennial crops, swamp rice cultivation, irrigated agriculture, grassland, forestry, recreation.

Management requirements: the land-use requirements (q.v.) largely or entirely related to management of a land utilisation type.

Matching: this term is employed in two senses, broader (i) and restricted (ii).

(i) The process of mutual adaptation and adjustment of the descriptions of land utilisation types and the increasingly known land qualities.

(ii) The (specific) process of comparing land-use requirements with land qualities of land units.

Mollic epipedon: A surface horizon of mineral soil that is dark coloured and

relatively thick, contains at least 0.58% organic carbon, is not massive and hard or very hard when dry, has a base saturation of more than 50% when measured at pH7, has less than 250ppm of P_2O_5 soluble in 1% citric acid, and is dominately saturated with bivalent cations.

Morphology, soil: the make-up of the soil including the texture, structure, consistence, colour, and other physical, mineralogical and biological properties of the various horizons of the soil profile.

Mottles: spots or blotches of different colour or shades or colour interspersed with the dominant colour. Mottling in soils usually indicates poor aeration and drainage.

Minor land improvement: a land improvement which has relatively small effects on the suitability of land, or is non-permanent, or which normally lies within the capacity of an individual farmer or other land user.

Multiple land utilisation type: a land utilisation type consisting of more than one kind of use or purpose simultaneously undertaken on the same land, each with its own inputs, requirements and produce or other benefits.

Organic matter: the decomposed residues of plant material derived from:

i) plant materials deposited on the surface of the soil, and
ii) roots that decay beneath the surface of the soil.

Parent material: unconsolidated mineral material or peat from which the soil profile develops.

Percolation, soil water: the downward movement of water through soil. Especially the downward flow of water in saturated or nearly saturated soil at hydraulic gradients of the order of 1.0 or less.

Permeability: the ease with which gases, liquids, or plant roots penetrate or pass through a bulk mass of soil or a layer of soil. Since different horizons of soil vary in permeability, the particular horizon under question should be designated.

Profile: a vertical section of the soil throughout all its horizons and extending into the parent material.

Qualitative land suitability classification: a land suitability classification in which the results are expressed in qualitative terms only, without specific estimates of outputs (crop yields), inputs, or costs and returns (cf. quantitative land suitability classification). Note that the description 'qualitative'

refers to the results of the suitability classification, not to the conduct of the land evaluation.

Quantitative land suitability classification: a land suitability classification in which the results are expressed in numerical terms which permit comparison between suitabilities for different kinds of use (cf. quantitative physical land suitability classification and economic land suitability classification).

Relief: the elevations or inequalities of the land surface when considered collectively. Minor configurations are referred to as "micro-relief".

Saline soil: a non-alkali soil with enough soluble salts to interfere with plant growth. The pH and exchangeable sodium percentage are less than 8.5 and 15, respectively.

Slickensides: polished and grooved surfaces that are produced by one mass sliding past another. Slickensides are very common in swelling clays in which there are marked changed in moisture content.

Soil reaction (pH): the degree of acidity or alkalinity of a soil, usually expressed as a pH value. Descriptive terms commonly associated with certain ranges in pH are:
extremely acid, <4.5;
very strongly acid, 4.5-5.0;
strongly acid, 5.1-5.5;
moderately acid, 5.6-6.0;
slightly acid, 6.1-6.5;
neutral, 6.6-7.3;
slightly alkaline, 7.4-7.8;
moderately alkaline, 7.9-8.4;
strongly alkaline, 8.5-9.0; and
very strongly alkaline, >9.0.

Soil structure: the combination or arrangement of primary soil particles into secondary particles, units, or peds. The secondary units are characterised and classified on the basis of size, shape, and degree of distinctness into classes, types and grades.

Stratified: composed of, or arranged in strata or layers as applied to parent material.

Subsoil: technically, the B horizon; broadly, the part of the profile below plow depth.

Texture (soil): the relative proportions of the various-sized soil separates in a soil as described by the textural class names.

Soil textural classes are based on the following particle size separations:

Separates	Diameter in millimetres
Very Coarse Sand (V.C.S)	2.0-1.0
Coarse Sand (C.S)	1.0-0.5
Medium Sand (M.S) Sand (S.)	0.5-0.25
Fine Sand (F.S)	0.25-0.1
Very Fine Sand (V.F.S)	0.10-0.05
Silt (Si.)	0.05-0.002
Clay (C.)	less than 0.002
Fine Clay (F.C)	less than 0.0002

Topsoil:
i) the layer of soil moved in cultivation.
ii) the A-horizon.
iii) the Ah-horizon.
iv) presumably fertile soil material.

Umbric epipedon: a surface layer of mineral soil that has the same requirements as the mollic epipedon with respect to color, thickness, organic carbon content, consistence, structure, and P_2O_5 content, but that has a base saturation of less than 50% when measured at pH7.

Water-holding capacity: the ability of soil to hold water. The water-holding capacity of sandy soils is usually considered to be low while that of clayey soils is high. Often expressed is mm of water per cm depth of soil.

Water table: the upper limit of the part of soil or underlying rock material that is wholly saturated with water.

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