LAND RESOURCES ASSESSMENT OF A PART OF SERENJE DISTRICT

by

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A dissertation submitted to the University of Zambia in partial fulfilment of the requirements of the degree of Master of Science in Land Resources Survey.

THE UNIVERSITY OF ZAMBIA

LUSAKA

1980

DECLARATION

I declare that I have undertaken the work recorded (except for soil analyses and plant identification) and I have composed this dissertation. All quotations have been distinguished by quotation marks and sources of all material referred to are specifically acknowledged. I also declare that this dissertation has not been accepted in any previous application for an academic award at this or another university.

1st September 1980.

Thomson M. M'sango.

'This dissertation of Thomson Musonda M'sango is approved as fulfilling part of the requirements for the award of the Master of Science in Land Resources Survey by the University of Zambia'.

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ABSTRACT

This dissertation describes the natural resources of a part of Serenje district known as Kamena. It is based on a reconnaissance survey carried out between August and October 1979 and January 1980.

The method of study was the landscape approach to land classification. The basis of such a study is on the interpretation of aerial photographs to identify land facets followed by field work.

Each individual facet was studied with its vegetation, soils and present land use. These were studied in an integrated manner so that relationships and interactions between them could easily be seen.

Altogether, eight land facets were identified and they were seen to recur within the Kamena area, which belongs to one land system. Hence the basic feature of the landscape method was tested and found to be practicable.

The land facets identified were plateau and valley interfluves, piedmonts, dambos, escarpments, river valleys, quartzite ridges and inselbergs.

Kamena consists of igneous, meta - igneous and metasedimentary rocks of pre-Katangan age. Its topography is characterised by north-east trending ridges and is dissected by the main rivers the Lukusashi and Chipendezi flowing in an east to south-east and south to south-east direction respectively.

The rainfall is high (1160 mm per annum) though confined to one season. The soils are heavily leached, have a low Cation Exchange Capacity and variable base saturation percentage. The soils are known as sandveldt soils and associated with them are the Brachystegia, Isoberlinia and Julbernardia woodland, alternatively known as Miombo woodland.

From the study correlations between land form (facet), soils, vegetation and land use were observed. For example, certain soils types like shallow or rocky soils were associated with a particular vegetation and land use.

The main occupation is the chitemene or shifting cultivation. It is an erosional hazard but the study indicated that farmers take some measures of conservation.

Rapid mobility, the development of communications and the government's discouragement of the chitemene system has led to a change in farming methods and crop types. Permanent fields are common and maize and tobacco have exceeded the production of finger millet. Nevertheless, numerous problems still exist in the development of agriculture.

This dissertation begins by explaining the need for a land resources assessment using the landscape method in Kamena. This is followed by describing the background to the study, location of the area and the objectives of the study. It then describes the methods of land classification which can be used for such studies and explains why the landscape method is the best one for this area, taking into consideration its purpose - reconnaissance survey.

The physical environment is described with seven Soil Series being identified based generally on the land facets. A land capability classification is given for each facet as well as the soil suitability to grow certain crops. All this plus the necessary management are taken into consideration with the present socio-economic conditions.

A summary of the typical characteristics of each facet and its present and potential land use is attempted.

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CHAPTER 1

INTRODUCTION

1.1 BACKGROUND

Zambia today is faced with a problem of trying to adjust from its more or less total dependance on copper as the major source of its income, to agriculture.

The success of any method of improving agriculture and the exploitation of her renewable resources depends to a large extent on the information available on the quality of natural resources. Such information is a prerequisite before any meaningful steps in agricultural land use planning can be taken.

Reconnaissance surveys have been done for certain parts of the country like for example, the Northern and Luapula Provinces (Mansfield et al., 1976), and the Ecological Survey of the Western Province (Verboom and Brunt 1970). The Land Use Branch (LUB) of the Ministry of Agriculture usually does surveys for specific projects.

Earlier work of a similar nature, was conducted by Trapnell et. al. (1953 and 1957) who produced reports on the soils, vegetation and agricultural systems of then Northern Rhodesia (Zambia).

1.2 THE STUDY AREA

This study centres on a part of Serenje district. The area covers the whole of the topographical map 1330A4 at a scale of 1:50,000 and it was published by the Surveyor General in 1969. It lies south of Serenje town, and its geographical coordinates are 13°15'S, 13°30'S and 30°15'E, 30°30'E (see map 1). The area covers mostly what is known as Ward 17 Chibale East popularly known as Kamena, and has an area of 1052 square kilometres.

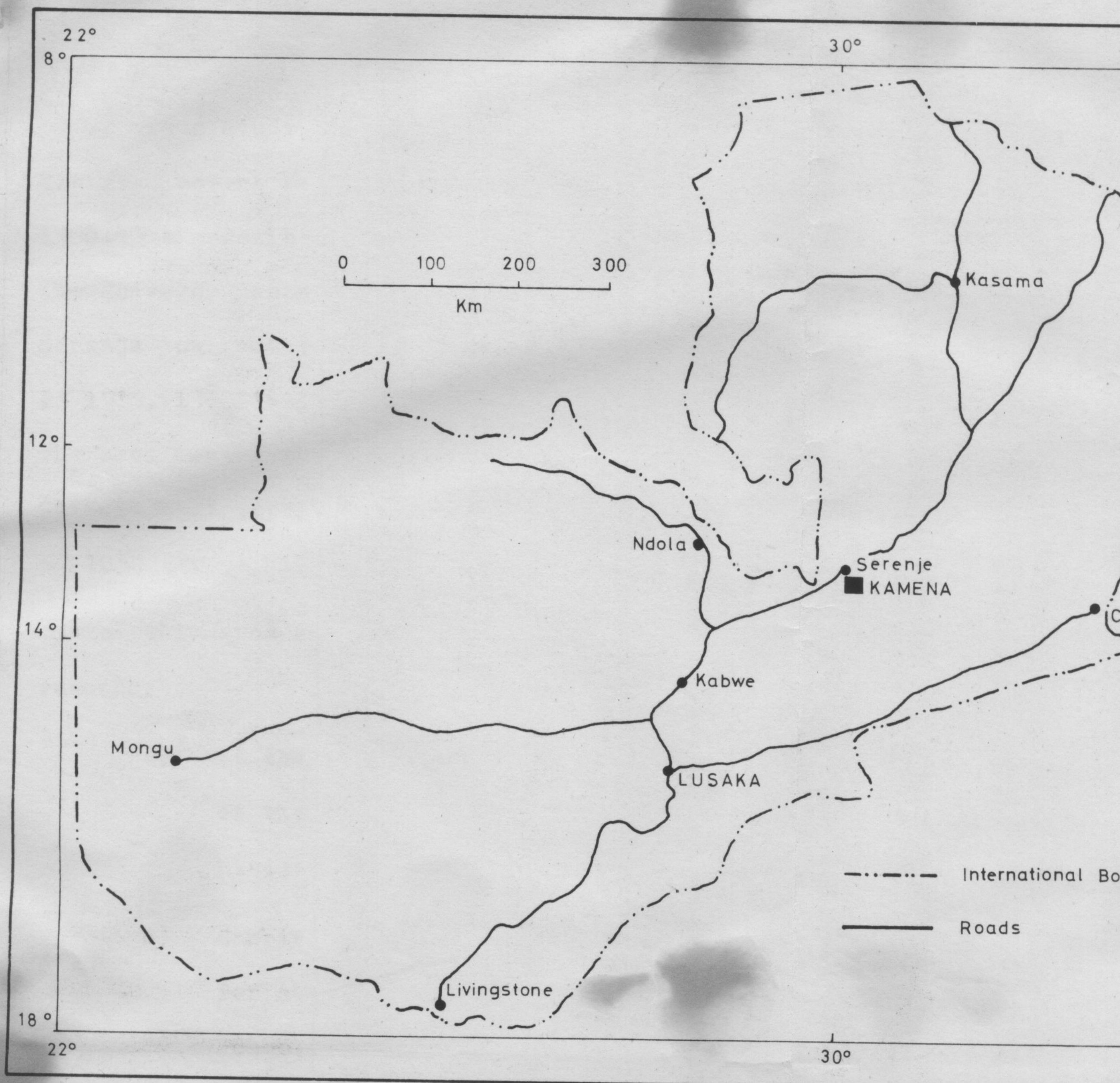
This area was chosen for the following reasons:

a) At the proposed time of study, it was one of the few areas declared safe by the Ministry of Defence.

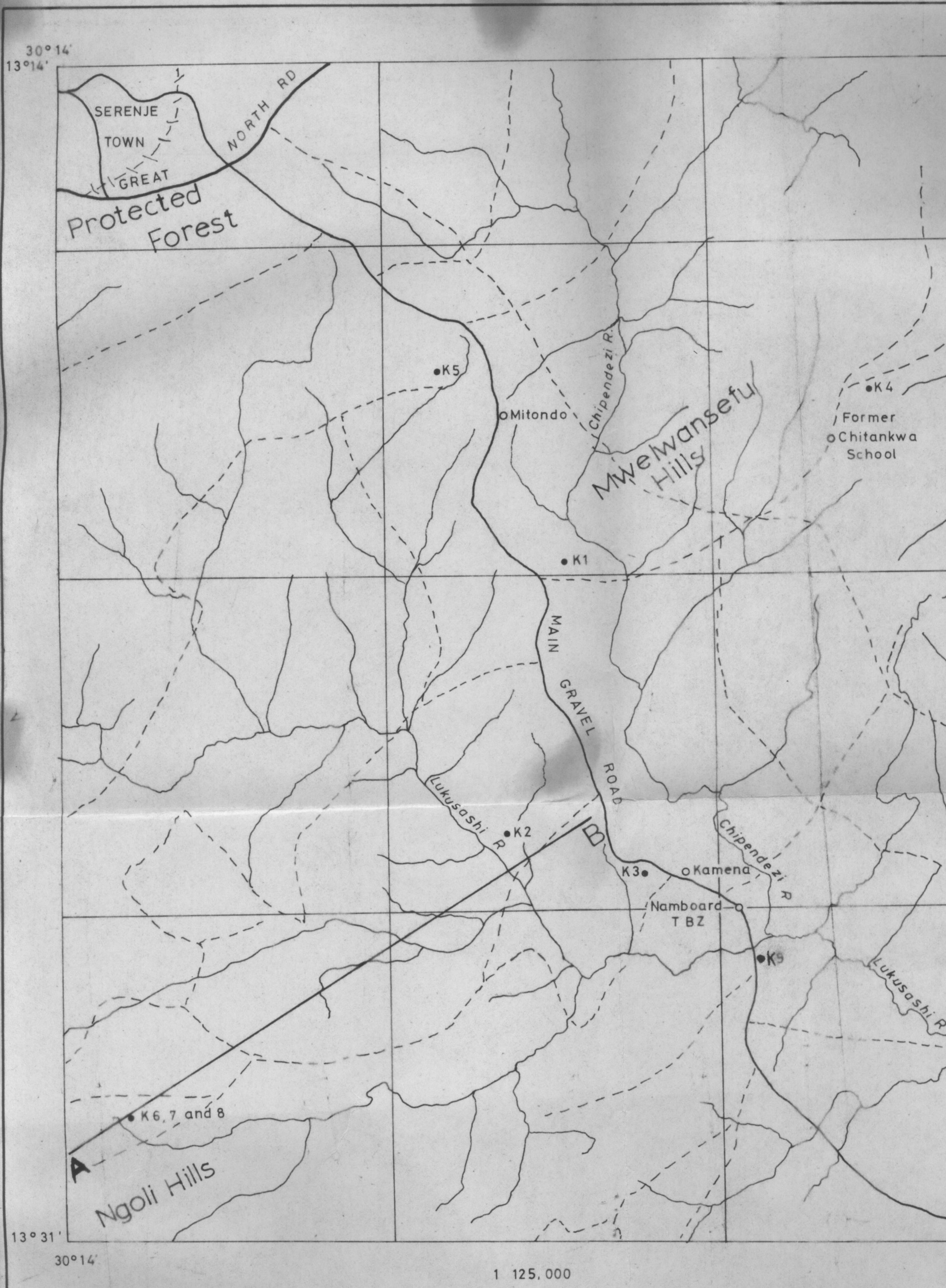
b) Camping facilities were going to be provided for some time by the Department of Geology, School of Mines of the University of Zambia. Their fourth year students were going for an exercise in independent

MAP 1-A

LOCATIONAL MAP IN ZAMBIA



MAP 1-B. LOCATION OF STUDY AREA



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geological mapping and it was felt to the advantage of the author, to take up the opportunity by going with them.

c) The local language is understood by the author and hence problems in communication were minimal.

1.3 THE OBJECTIVES OF THE STUDY

a) To map and describe the land characteristics in terms of land forms, soils, vegetation, hydrology and present land use.

b) To identify and delineate the area into land facets integrating the resources offered in (a) and evaluate them.

c) To suggest a plan for the utilization of the resources delimited, in the context of the prevailing socio-economic conditions.

1.4 PREVIOUS WORK

Integrated resources surveys have been conducted in the Northern, Luapula and Western Provinces by the UK Ministry of Overseas Development. A similar survey has also been carried out in the Luangwa valley (Astle et al. 1969).

In the Serenje district, previous maps on natural resources have been on a small scale usually covering the whole country. The only exception is the base map of the study area, topographical sheet number 1330A4 on a scale of 1:50,000. Peters (1951) carried out a land usage study of the whole Serenje district while Smyth (1958) published a report on the agriculture. Fanshawe (undated) also published an internal report on the vegetation of the district.

Other than these individual studies, an integrated resource survey has not yet been done in Serenje district and neither has a land capability study been done in Kamena, in particular. Thus this study will be the first of its kind.

CHAPTER 2

A REVIEW OF THE METHODOLOGY OF LAND CLASSIFICATION

2.1 INTRODUCTION

Land, to many people, has different meanings. Christian and Stewart (1968), described land as consisting of a wide array of natural resources characteristics in a profile from the atmosphere above the surface down to some metres below it. To them, the most important characteristics, and of significance in land classification are climate, landform, soil, vegetation, fauna and water. Zonneveld (1979), uses the Food and Agricultural Organisation of the United Nations' (F.A.O.) definition of land. This like Christian and Stewart's definition (1968), describes land as that part of the earth's surface which includes characteristics of the atmosphere, soil, hydrology, plants, geology and the animal population (FAO, 1976). However, a recent addition has been the emphasis of the results of past and present human activity, to such an extent that these land attributes exert a significant influence on present and future uses of the land by man. Therefore it is seen that parameters alone. Such a division of the land obviously would not be equivalent to a more tangible feature, as climate is based purely on statistical analysis. Tangible features like landform, soil and vegetation are easily recognised in the field and on aerial photographs and, depending on the scale of mapping, fairly accurate boundaries of these features can be drawn.

Ultimately, the aim of a classification of land, is one which would help in its use and management. As pointed out by Nelson et al. (1978), 'objects to be classified should be land units when classification involves land management'. According to them, these land units reflect the combined influence of basic features on a wide array of potential uses. They cite a study by Lacate (1965), in British Columbia, who adopted units that were '.......relatively homogeneous with respect to more stable features of land form, as reflected in the slope, surficial geology, soil and vegetation'. It is thus seen that units used to classify land must be based on several characteristics of it. The implication here is that land classification is an integrated process.

Even though attempts have been made for standardization, the basis of land classification is still the subject of much controversy. At this stage it is considered appropriate and apposite to go over the attempts at land classification using different parameters, and trace their development over the years.

2.3 CRITERIA OF LAND CLASSIFICATION

Attempts to classify land may be grouped on a historical sequence into three broad categories namely:

(a) The Genetic Method;

(b) The Landscape Method;

(c) The Parametric Method.

2.4 THE GENETIC METHOD

The earliest form of classification of land was the genetic approach. Genetic here means pertaining to origin, and different types of land were identified based on environmental factors such as relief, climate, vegetation and so on.

Herbertson (1905) used factors of climate to define climatic regions. He reasoned that climate affects surface phenomena such as vegetation, hence it thus indirectly affects other physical processes on the earth and therefore is a suitable criterion for delimiting natural regions. Later on, he also incorporated relief with climate, in his classification of natural regions.

One of the earliest to use relief was Fenneman in 1916. He divided the U.S.A. into physiographic regions and proposed a hierarchy of landforms ranging from 'section' (micro) on a lower order, to 'divisions' (macro) on a higher order. The 'divisions' delimited were based on areas attributed to major geological epochs, for example mountain building eras, while broad erosional histories were used to define 'sections'. Though Fenneman deserves credit for his attempt to use a causative factor to delimit relief regions, the fact that each region thus delimited was large in extent and necessarily incorporated a number of relief features, was its chief weakness and drawback. Fenneman's idea of a hierarchy of landforms was more or less remodelled by Unstead (1933) who tried to subdivide Fenneman's 'section'. Unstead thus used the terms 'feature', 'stow' and 'tract' for lower order geographic subdivisions of landforms. This was followed by Linton (1951), who redefined these terms of Unstead, replacing 'feature' with 'site' in a hierarchy of morphological regions.

One of the earliest researchers to use aerial photography as a tool in land classification was Bourne (1931), who worked on forestry stock-taking assessment studies in the British Empire. It is probable that he based his classification on topography as this is generally a distinct and clear cut feature on aerial photographs. Bourne's aim was to identify a physiographic unit which would be correlated with vegetation. These two attributes were also supposed to conform as far as possible with similar areas of geology, soils and climate. He showed that such a physiographic unit which he termed the 'site', could be grouped into associations to constitute a distinct region, similar to Herbertson's (1905) natural region. This could mean that he (Bourne) was a fore-runner in the application of the concept of integrated land system in scientific thought. On the other hand, Wooldridge (1932) refined the method of delimiting 'sites' as used by

Bourne. This was done by clearly redefining two distinct landform features namely, 'flats' and 'slopes'. These he said were 'the ultimate units of relief of which regions were composed'.

Veatch (1933) also adopted the same principle as Bourne when he identified a topographical feature called 'natural land type'. This he said, 'was a natural division based on the nature of the soil, topography, native vegetation and the drainage'.

Nevertheless as Mabbutt (1968) points out, the techniques of systematization of land, using relief features as mentioned above, are all just as significant in land classification, no matter which criteria are used. This is because each technique defines, describes and classifies its subdivisions in a hierarchy, by systematically naming the objects being classified and showing the relations among them.

The advantages of the genetic method as mentioned above, are that it is a basis for classifying large though nevertheless basically uniform areas of land in a hierarchic system. It fits in well, linking one category of the hierarchy to the other. It is thus a model depicting bonds with other areas having similar features. For example, when large areas of land are being surveyed at a reconnaissance scale, the genetic method of classification enables a surveyor to get an overall view of relationships; not only of the categories of relief, but also correlations with the other tangible environmental features such as vegetation and soil. Recognition of such relationships minimizes and economizes efforts in field sampling and surveying.

However, the genetic method has several weak points too. For example, delimitation of land is based on an intuitive (qualitative) method. Consequently, land types classified using such a method may extend over thousands of square kilometres. Thus boundaries delimited separating different landforms tend to be necessarily vague and obscure, especially on small scale maps. However, as it is for reconnaissance survey, these boundaries are found to be suitable, because they provide a base as it were, for subsequent detailed work to be formulated. In this sense, it appears that the genetic approach using the relief criterion, is suitable for classifying land into broad categories. Nevertheless, many workers as mentioned above, who have attempted the genetic method to classify land have had to modify it, using other procedures to suit their particular needs.

As stated earlier, the genetic method has certain inherent problems when used for detailed study, one such being the delimitation of accurate and clear-cut boundaries on large scale maps. Land components, according to the work in mind, need to be delimited either broadly or in detail. Detailed studies have led to a refinement of the genetic approach. This refined method was greatly aided by the easy availability of aerial photographs from the 1940s. Thus the use of aerial photographs, to first obtain an overall picture of the large unmapped areas, led to the formulation of the landscape method. The landscape method is basically a genetic method using the factor of relief. It is more precise and accurate in the identification of landscape features and their boundaries, than the genetic method, provided that the limitations of aerial photographs are given due cognisance.

2.5 THE LANDSCAPE METHOD

The landscape on an aerial photograph is depicted as a composite feature at a particular time. As in nature, it depicts an integrated form of all its components such as relief, vegetation, soil and so on. That was probably the reason as to why an analysis and classification of land on this basis was termed the landscape or integrated approach.

Probably the earliest workers to use the landscape method in the form it is now applied, were Christian and Stewart in 1946, of the Commonwealth Scientific and Industrial Research Organisation (C.S.I.R.O.) in Australia. Their work however, was only published in 1953. Basing their studies on the integrated or landscape method, but still using the prominent attribute of relief, Christian and Stewart (1953) divided land in a hierarchic system into 'land system' and 'land units'. They defined 'land systems' which are a composite of related 'land units' as, 'an area or a group of areas, throughout which there is a recurring pattern of topography, soils and vegetation', in an area of uniform climate. A change in this pattern determines the boundary of a 'land system'. 'Land systems' are composed of 'land units', each with its own distinctive combination of topography, vegetation and soil.' Later, Christian (1958) clarified the criterion of 'land units' to include land forms ranging from a complex feature such as a whole mountain structure, with all varieties of slope together with its other physical attributes of soil and vegetation, down to the simplest 'topographical unit'. In this sense 'simplest topographical unit', would be identical to Bourne's site. Hence it appears Christian suggested two types of 'land units', one being complex, the other being simple, as the lowest land subdivision.

One problem with the landscape method of land classification, is that many scientists have adopted their own terms to practically mean the same thing. This of a plethora of terms has led to a certain degree of confusion regarding their explicit and implicit significance. Hence it is useful to examine the terms in some detail to ascertain their true meanings and contradictions. For example Taylor (1959) working in Nicaragua on an F.A.O. mission, uses the term 'land unit' in a similar sense as the 'land unit' of Christian and Stewart (1953), and Christian (1958). On the other hand, he uses the term 'land type' for 'land system' of Christian and Stewart (1953). Downes and Rowe (1960) also of the same organisation as Christian and Stewart, substituted 'land form' for 'land unit' in their work in Glennmaggie resevoir area in Australia.

There is need therefore, to settle the differences in terminologies used for land classification adopted between the various workers. In the first place, there seems to be not much of a confusion over the meaning and definition of a 'land system'. Most workers have generally agreed and accepted Christian and Stewart's (1953) definition where the 'land system' is based on one genetic factor, namely the topography as the basis of land division. On the other hand, it is the subdivisions of the land system, that have caused controversy both in nomenclature and criteria used in delimiting it.

Beckett and Webster (1962), classified land into 'land facets' and 'recurrent landscape patterns'. 'Land facets' were identified as the largest portion of terrain that can be conveniently treated as one block, for the purposes of moderately extensive land use or construction. 'Recurrent landscape patterns' were 'regularly occurring groupings of facets'.

In 1964, Christian and Stewart modified their earlier meaning of 'land unit' (1953, Christian 1958), to make it a broader concept more similar to the 'facet' of Beckett and Webster (1962). However, Christian and Stewart's work of 1964 was only published in 1968, and hence some confusion has arisen about their not being the first to introduce a new middle land subdivision. They also in 1968, introduced a new term the 'site' to denote the lowest subdivision of land. In this they linked 'site' with their new meaning of 'land unit'. 'Site' was defined as 'a part of the land surface which was, for all practical purposes, uniform throughout its extent in land form, soil and vegetation', and 'a group of related sites associated with a particular landform within a land system, constitutes the land unit, and whenever the unit occurred it was the same association of sites'. The land system and land unit, of Christian and Stewart (1968) were to an extent in practice, similar to the 'recurrent landscape pattern' and 'land facet' respectively of Beckett and Webster (1962). Christian and Stewart (1968) had now established three lower subdivisions of land in the hierarchy that of 'land system', 'land unit' and 'land site'.

Brink et al. (1966) agreed with Christian and Stewart's (1953) definition of 'land system'. For the term 'land site,' they used 'land element' which in their own words meant 'the simplest part of the landscape for practical purposes uniform in lithology, form, soil and vegetation'. Thus land element was considered the lowest category in the hierarchy of land subdivision. In this sense the 'land element' is equivalent to the 'land unit' of Christian and Stewart (1953), the 'simpler land unit' of Christian (1958) and the 'land site' of Christian and Stewart (1968). On the other hand, the 'land element' is not equivalent to the 'land unit' of Christian and Stewart (1968).

Brink et al. (1966) also suggested an intermediate category between 'land system' and 'land element'. For this they adopted Milne's (1937) concept of the catenary sequence of soil which, though having differences of origin and morphology, were linked in occurrance by topography. On this analogy, Brink et al. suggested the term 'facet' as the intermediate land subdivision between the 'land system' and 'land element' as they were in a catenary sequence. They defined 'facet', as 'the smallest unit of description and consists of one or more elements grouped for practical purposes.... It is a part of the landscape which is reasonably homogeneous and fairly distinct from the surrounding terrain'. Brink et al. (1966) had therefore adopted a classification based on a hierarchy of 'land system', 'land facet' and 'land element' as their three lower subdivisions of land.

Beckett and Webster (1970) redefined and classified the concept of the facet of Brink et al. (1966) (of which they were a team), noting that it is 'usually with a simple form, on a particular rock or superficial deposit, and with soil and water regimes that are either uniform over the whole of the facet; or vary in a simple and a consistent way'. In this manner the 'land facet' of Brink et al. (1966) is similar to that of Beckett and Webster (1962). However, it should be noted that these workers use the term 'facet' in a different sense from that used by Savigear (1965) who refers to 'facets' as 'planes which are horizontal, inclined or have vertical surface areas'.

Gunn and Nix (1977) of the C.S.I.R.O., adopted 'land unit' to be similar to 'land facet' of Brink et al. (1966), in their study of the Fitzroy Region, Australia. It is also noted that the 'land unit', as used by Gunn and Nix is similar to the 'land component' of Gibbons and Downes (1964), the 'land type' of Davis (1969) and the 'terrain unit' of Grant (1968). This again illustrates the diversity of terms despite increased attempts at standardization.

Thus it is now observed that on the whole, the conceptualization of a 'facet' as consisting of a number of 'elements' in a catenary sequence has been accepted by many workers in this field. Of great help today is that despite the numerous terminologies for various land subdivisions, overall agreement has been generally reached, on the most commonly used terms in land subdivision and classification. In decreasing order, it is as follows: Land system, land facet/unit and land element/ site.

At this stage it is useful to summarize the conflicting use of terminology discussed above pertaining to land classification as this would help clarify the position.

TABLE I: A summary of the different terminologies of the landscape method of land classification.

	Higher Division	Middle Division	Lower Division
Christian & Stewart (1953)	Land system		Land unit
Christian (1958)	Land system	Land unit	Land unit
		decreasing complexity →	
Taylor (1959)	Land type		Land unit
Downes & Rowe (1960)	Land system		Land form
Beckett & Webster (1962)	Recurrent landscape pattern	Land facet	
Gibbons & Downes (1964)		Land component	
Brink et al. (1966)	Land system	Land facet	Land element
		in a catenary sequence →	
Christian & Stewart (1968)	Land system	Land unit	Land site
Grant (1968)	Terrain pattern	Terrain unit	Terrain component
Davis (1969)		Land type	
Beckett & Webster (1970)	Land system	Land facet	Land element
Gunn & Nix (1977)	Land system	Land unit	Land site

Mitchell et al. (1979), have recently brought in a new concept to land classification as have Nelson et al. (1978), where they attempt to make a quantitative assessment of facets and other land units for long range prediction of site conditions for practical purposes, quoting examples to show its relevance for land management. In a sense this is indeed a refinement of his earlier work (Mitchell 1973) as is also the criteria used by workers noted above. Mansfield et al. (1976) in their Zambian study adopted Christian and Stewart's (1968) and Brink et al.'s (1966) basis of land classification. Their work (Mansfield et al.) implies incorporating management practices too. Facets were recognised in terms of management practices by naming them as agricultural land facets, engineering land facets and so on. This is acceptable because after all, the value of any classification depends on the ultimate application to which it can be used.

In their earlier work, Christian and Stewart (1953) have described 'complex' and 'compound land systems'. 'Complex land systems' consist of intermixed and related 'simple land systems'. On the other hand, a 'compound land system' is a group of 'land systems' enclosed within the boundary for convenience in mapping. Such systems have many topographic, soil or vegetation features in common. The criteria for identifying the type of land system also depends on climatic differences, geomorphic cycles, geological differences or on the survey's mapping scale. Bawden et al. (1972) used mostly 'simple land systems' in their Nigerian studies. At times where two or more contiguous land systems could not be distinguished at the survey's mapping scale, 'compound land systems' were used. Mansfield et al. (1976) in Zambia, classified land into 'simple land systems' only.

Another major problem arises in adapting the landscape method to land classification. This problem is concerned with the land subdivisions, that is, whether in practical application their divisions begin from the smallest and then to the complex or vice versa. In other words, does the division or dissection of the landscape begin by first recognizing a 'facet' or a 'land system'. Generally as aerial photographs are the basis of beginning these studies, it is observed, that the 'facets' are usually more recognisable than are 'land systems' on the common aerial photograph scales. 'Facets' are generally mapped at scales from 1:10,000 to 1:80,000 (Mitchell et al. 1979), and are recognized on aerial photographs easily at these scales (Beckett and Webster, 1970). On the other hand, at these scales a 'land system' will cover a number of photographs. Therefore only when a mosaic of an area under study is constructed, will 'land systems' tend to be more easily recognised.

As earlier stated, topography forms the basis of the landscape method. However, in Papua New Guinea, Haantjens (1965), used the basic criteria of vegetation rather than relief, because as he says 'the jungle does not permit relief sighting'. However, this practice of vegetation first, has not received much favour amongst many of the scientists at the C.S.I.R.O., nor those in other countries. This is because even in areas of thick forest, methods based on topography have been employed and suitable results obtained. For example, Speight (1974) based his 'preliminary mapping units' in Chimbu, Papua New Guinea on landform rather than vegetation. He argued that forest vegetation was not relatively uniform and was disturbed by bush fallow agriculture and hence, vegetation could not form the basis of a meaningful delineation of land. Refining the genetic method based on topography for recognizing relief subdivisions was his next step. Thus he attempted to delineate and describe a landform by using about sixty attributes, specifying landform patterns such as altitude, accordance relations, toposequences present and so on. According to him, one reason for using such criteria was as he found out, that no two map boundaries or a regional description produced by his own team in Papua New Guinea would be identical with those produced by another team studying the same area, as boundaries drawn solely on the interpretation of aerial photographs were generally too vague. He also showed that this would equally apply to his own team if it worked in the same area at two different times. This refined method of Speight (1974) is described later on.

The use of the property of 'recurring patterns' is one useful advantage of the landscape method. At a national level of planning, categorization of similar properties of alike land subdivisions is felt adequate because the 'facet' for example can be mapped from scales ranging from 1:25,000 to 1:50,000. Selected elements can then be mapped at 1:10,000. Nevertheless, at regional and project levels this method or procedure is inadequate. Methods have to be devised to obtain more detail (of the land) concerning the surface geometry and its relationship to hydrology and soil to be useful in detailed planning. For this a more quantitative method has to be used as adopted by Speight (1968). Hence to obtain a precise boundary of the divisions of landscape and also of their features, applications of the parametric method to such surveys is considered appropriate.

2.6 THE PARAMETRIC METHOD

Primarily this is concerned with the quantification of certain land attributes used in the division of land. Speight (1968, 1974) suggested a two level step for parametric classification of land. The first group he termed 'the landform elements' (which consisted of 'elements' or 'sites'). These he said possessed, like all surfaces, geometrical shapes which could be described in terms of altitude, slope, unit catchment area, rate of change of slope, concavity and convexity and so on. Description of these characteristics would be in a quantitative form.

The next level of description were the 'landform patterns' which consisted of 'land systems'. This means the 'elements' are repeated in a cyclic manner in a 'land system' so as to form a three dimensional geometrical pattern. 'Land systems' are then described in terms such as; ridgeness (the total length of crest per unit area); reticulation (the total length of the largest connected network of crests that project into a sample area); orientation (directional properties of crests within a sample area); and so on. The scale of mapping 'land systems' will be smaller than of the 'elements'.

Maps can then be drawn with lines or figures representing certain values of the attributes being measured. Combinations of the maps can also be produced. For the 'land elements' map, a grid system can be devised such that measured attributes can be registered on computer cards and the information thus stored.

The main point about the parametric method is the choosing of the attributes to be measured. This will depend on the purpose in mind. Attributes chosen must be recognised and measured in the field. For each factor considered, an array of numerical values or quantitative statements related to a group of sample points are needed and measured, to give a characteristic feature of the land.

The parametric method of land classification is not associated with 'land systems' and 'elements' only. The scale of measurement can even be on a smaller basis than of 'elements' and 'systems', that is, it can be on a world wide scale (Mitchell, 1973). Therefore, depending on the scales, what is measured and its accuracy will differ from area to area or within the same area. For example if work is on a scale of an element (large scale), it would be more detailed and accurate than work on a system which would be on a smaller scale. Many other parameters other than those mentioned by Speight may be used, for example climatic (isotherm maps and so on), morphological maps such as derived by Savigear (1965) and Waters (1958).

A merit of the parametric approach is that it is a more quantitatively reliable means of measuring degrees of change. As such, it is good for detailed studies of small areas and for large scale mapping. Properties of the facets, elements and systems identified by the landscape method, are probed into in more detail using the parametric method. Boundaries are numerical values of attributes in this method, and when for example measuring slopes, they will coinside with slope changes. As Speight (1968) has shown, it has the facility to be used by modern electronic data handling plants.

It has disadvantages too, because it is quite a problem to choose the most suitable parameter for the work in mind. Although it is predictive, it requires a lot of detailed measurements, and maps produced will be only on small areas which entails greater costs. This shows that the parametric method is more useful and required for planning at project level and not at reconnaissance or at national level of planning.

This study needed to devise a form of land classification for the work to be carried out at reconnaissance scale. Having discussed three methods of classifying land, the land resources of a part of Serenje district have largely been assessed using the landscape method. Reasons for choosing this method are discussed in chapter 4.

CHAPTER 3

METHODS OF LAND EVALUATION AND THEIR APPLICABILITY TO THE STUDY AREA

3.1 INTRODUCTION

Land evaluation has been described by Young (1976) as the assigning of value to land for one or more purposes or uses. It is evident from this statement that any piece of land has one or more uses to the occupier or user. Zonneveld (1979) more or less agrees with Young's (1973) earlier reference to land evaluation as 'describing processes and investigations in an area to find its usefulness (value) of the natural environment to man'. This definition is based on observations of biophysical and man made features and the socio-economic conditions. Of interest in the above is the considerable weight given to the socio-economic conditions. After all, the way man in a particular region is able to use and manage the land is governed to some extent by the prevailing socio-economic conditions. In Tropical Africa in particular at the village level, this is of great importance.

Unlike land evaluation, the foundation of land classification is based only on certain criteria which are the biophysical factors namely topography, vegetation and soils in an area of uniform climate. Most workers have tended to classify these factors into scalar hierarchies of land units, grouping those at each level on the basis of geographical proximity and similarity of properties. The groups thus categorized will have similar characteristics and may also require the same type of land use. The landscape or land system method of resource surveys is an example of land classification as has been discussed earlier. The connection between land evaluation and land classification is that before any land can be evaluated, it has to be classified.

On the other hand, soil classification is based on two main principles. The first being the classification of soil on its presumed genesis mainly rock type, climate and native vegetation. Secondly, it may be a classification based on observable and measurable properties of the soil. Soil is thus also grouped in a hierarchy of classes, the highest one being named the 'order' and the lowest the 'series'. Evaluation of soil is concerned with categorizing soil into its potential uses and limitations with other aspects of the physical environment being dealt with in less detail, while land evaluation is also taking into consideration the other features namely the physical attributes of the earth's crust of which the soil is one (Young 1976). However before soil or land evaluation can be done, the two have to be broken down into groups. The process is more difficult when dealing with land because of numerous land attributes which may be chosen for evaluation and the various combinations possible. Perhaps this difficulty in grouping land evaluation has led to the choice by many countries to use soils as the most important attribute for such work. Zonneveld (1979) goes on to stress that even when one attribute of the land is being studied, the term land evaluation should still hold. Here again, as Zonneveld's statement shows, it is found that in land evaluation, the commonly used land attribute is based on the soil, thereby making land and soil evaluation more or less synonymous.

Land capability has been said to have a meaning sometimes similar to that of land suitability which is the fitness of a given tract of land for a defined land use (Young 1976). However, this term is strongly aligned to one system of evaluation namely that of the Soil Conservation Service of the U.S. Department of Agriculture (U.S.D.A.), which centres on soil, and not so much the other land attributes since the soils here is taken to include the slope angle, climate and frequency of flooding too (Young 1973).

Soil capability on the other hand, is the division of soil only into its abilities to support various types of land use. The classes may be based on such aspects as slope and erodability.

3.2 TYPES OF LAND EVALUATION

Data for land evaluation comes from three sources namely natural resources surveys, technology of resource use and economics (Young, 1976).

The types of land evaluation systems may be single, multiple or general purpose. Single refers to one purpose, multiple to a combination of one or more single purposes while general refers to various uses with no particular purpose in mind (Young 1976).

The above purposes may be based and attributed to one or more of the following:-

a) Current land suitability which means 'classification based on the suitability of land for a specified use in its present condition, without major land improvements' (F.A.O. 1976).

b) Potential land suitability which is 'the future use of the land after major land improvements have been carried out' (Young 1976) ...... 'using a large non-recurrent input in land-improvement which causes a substantial and reasonably permanent change in the suitability of the land, and which cannot normally be financed or executed by the individual farmer or other land user' (F.A.O. 1976).

c) Minor land improvements which can be done by the individual farmer and causes little effect on the suitability of land (F.A.O. 1976, Young 1976).

The above land suitability classifications may be quantitative when the distinction between classes is in numerical terms usually economic, or qualitative when the classes are in general physical terms, as usually used in reconnaissaince surveys (F.A.O. 1976, Young 1976).

3.3 PURPOSES OF LAND EVALUATION

Young (1973) identifies nine purposes for which land is generally evaluated. Taking into consideration the biophysical and human resources of the study area, these fall into the following major groups:-

(a) Agriculture

(i) Cultivation of specified crops, annual or perennial

(ii) Grazing on improved or unimproved pastures.

(b) Forestry

(i) Logging of natural forest.

(ii) Forest plantations.

(c) Conservation.

(i) Groundwater and surface storage.

(ii) Flora and Fauna.

(d) Engineering purposes.

(i) Transportation purposes in general.

However, as the goal of the study is to prepare a reconnaissance survey it may well be that multi-purpose evaluation is more appropriate (to be used). Each land facet is thus evaluated for a single or multi-purpose use. As the work of Robertson et al. (1968), has shown, multiple purpose has been found to be of great use at the national or larger regional level.

3.4 SYSTEMS OF LAND EVALUATION

1. The USDA system of land evaluation is to a great extent based on soil capability. The term land capability classification has been coined by them to be similar to land suitability (Young 1976). They used their broad criteria for evaluating land on its usefulness for such purposes as suitability for agriculture, forestry, recreation and so on (Klingebiel and Montgomery 1961).

The system of classification has as its main criterion — 'limitations', in other words, land characteristics which adversely affect land use.

On the basis of the USDA system, land is subdivided into capability classes of different categories of soil. Capability classification is based on the risk of soil erosion and other hazards harmful to soil and land such as slope angle and flooding. It is therefore necessary that all factors associated with erosion are also studied. Factors of the soil such as its depth, texture, permeability, slope, and erosion are all necessary to be known for such a classification.

The USDA system is probably the most well known system of land evaluation and is used mostly by land use planners and conservationalists. As Hudson (1971) points out, the aim of the USDA classification is to devise a method which combines agricultural land use and conservation without the risk of soil erosion. However as the USA is more or less a non-tropical country, modifications are required for the application of this method to other parts of the world, to reflect in accordance, obvious needs of the land users in these respective countries.

In the USDA system, eight classes of soil numbered I to VIII in Roman numerals are the basis of grouping. Classes I to IV are suitable for cultivation, while the remaining are not.

Soils within a given class may further be subdivided into subclasses according to hazards involved in their management for example water erosion, low moisture capacity and so on. Subclasses may also be subdivided into land capability units.

2. Soil evaluation is the foundation for most of the work on land evaluation by the F.A.O. (Steele, 1967, F.A.O., 1976). Here again as they explain, it is the soil, which determines the use of the land. The F.A.O. system is similar to the USDA (1961) land capability classification system, based on the soil and factors affecting its status quo, plus the socio-economic conditions. The F.A.O. recognizes the importance of soil evaluation and of interest is the great emphasis placed on the soil as the determining factor of land evaluation. Land is evaluated mostly on the soil characteristics and how it is suited for various crops, forestry, recreation and so on.

3. The Canadian Land Inventory Survey (Rees, 1977), evaluates land on a soil capability classification for agriculture. The land is classified according to the inherent productive capability for use in the separate fields of forestry, recreation and wildlife. The basis of the classification is on arranging into seven classes all soils according to their abilities for agricultural

potential, or growing commercial timber in the case of forestry and their limitations and so on. The socio-economic structure, present and past land uses are also primarily looked into.

4. The Australian scientists at the CSIRO first analyse and classify aspects of the biophysical environment before attempting land evaluation. This is probably because they are mostly working in large and sparsely populated areas. Evaluations they recognize, are largely subjective and may change with economic conditions or as new technologies and plant breeds become available. They add on saying that 'the objectives of capability classifications (form of land evaluation) is to facilitate the grouping of land having the same degree but not necessarily the same kind of limitations' (Galloway, et al. 1974). Land evaluation is seen as a system for classifying land in terms of its capability for possible types of use. Management and the socio-economic conditions also play a vital role in this scheme of classification at the evaluation stage. In this sense it is similar to the USDA system, though the emphasis is in dividing the classes into land types but still the overriding aspect being the soil. The Australian system has eight classes, four arable and the other four non-arable.

Canada and Australia have large parts of their area unoccupied. Young (1978) groups these barely occupied areas as 'sparsely settled lands situated in countries with a high standard of living'. Hence development in these areas will be based on high capital investments with small amounts of labour. In other words, profitability of potential land uses will determine the use of the evaluated piece of land.

5. Most of Western Europe according to Young (1973), would fall under the 'densely settled developed lands'. Land in these countries is in short supply and in most cases has already been evaluated for over many years. Land evaluation here will look at every possible use (and the benefits to be derived), some of which cannot be easily converted in economic terms. He concludes that in many cases in Europe it is actually a case of 're-evaluation for re-development'.

Scientists from Western Europe working in less developed countries have used other land evaluation methods. Young (1976) as stated earlier, believes in natural resources surveys with special emphasis on soils and geomorphology, followed by resource use technology and economic surveys, as the three fundamental steps to land evaluation in any area. Others advocating a more or less similar approach are the scientists at the British Directorate of Overseas Surveys (D.O.S.) and Hunting

Technical Services. The D.O.S. work in Zambia is based primarily on the initial recognition of land facets and systems or vice versa, followed by an analysis of the biophysical environment, current land use and the socio-economic factors prevailing at that time. This leads to land capability classification and identification of development potential to base recommendations (Mansfield et al. 1976).

6. In the USSR it is suggested that land classification be based on those land factors that separate vegetation sites namely soil moisture and soil nutrient availability. Other factors such as relief and climate may also be considered. It is thus seen that land evaluation is based mainly on factors affecting biological productivity (Ignatyev, 1968).

7. The Zambian Department of Agriculture. Land Use Services Division (L.U.S.D. 1973) had adopted and modified the USDA system for land capability classification. Here the arable classes were numbered I to IV, while the non arable ones were V (wet land), VI (grazing) and VII (forestry). Class VII was regarded as non agricultural. There were little differences between the Zambian and USDA systems. However of late a new land capability classification has been devised by the Department of Agriculture L.U.S.D. and L.U.B. (1974, 1977).

3.5 LAND CAPABILITY CLASSIFICATION IN ZAMBIA (1977)

Land capability classification in Zambia has been described as 'the system used or designed to indicate the relative suitability of land for rainfed, medium and large scale ox or tractor cultivation under a high level of management'. (Woode, 1980).

For arable land, maize, tobacco and to a lesser extent groundnuts, soyabeans and sunflower are the main crops considered. Also given emphasis is the use of fertilizers, pesticides and a high managemental level. For non arable land, grazing whether intensive or minimum is considered, again with the emphasis on high management levels, so that land does not deteriorate.

In this evaluation system, the most important phenomena considered are the physical and economic factors on a broad scale.

a) Types of land: there is a division into four categories (Woode, 1980).

(i) Arable land:- land suitable for use on a long term economic basis for annual or semi - perennial cultivated crops.

(ii) Marginal arable: land that will not support long term intensive use for arable crops without great risk of poor yields, limited freedom of choice of crops, or much environmental control.

(iii) Grazing land: land unsuitable for the long-term production of arable crops, but suitable for grazing cattle.

(iv) Unsuitable land:- land with too severe limitations for either arable cropping or grazing.

b) Land classes:- below the 'types of land' level, only arable and marginal arable land are divided into land classes. The L.U.B. describes 3 clayey 'C' and 4 sandy 'S' land classes, based on certain site or soil limitations . (See appendix 1 for details of the L.U.B. land capability classification.

'C' land classes have a topsoil texture of sandy clay loam or heavier. Subsoil colours are usually red or reddish brown where soil drainage is good, but dark brown to olive-brown or dark grey where drainage is less satisfactory. (Department of Agriculture L.U.B. 1977). Parent material is generally basic rock like limestone, calc-silicate schist, gabbro, diorite and calcareous shales. Vegetation associated with this includes woodland dominated by species of Acacia, Combretum, Albizia, Terminalia, Afrormosia or Philiostigma. The grass types include Hyparrhenias and Andropogons.

'S' land classes have a topsoil texture of sandy loam or lighter, for example sandy loam, sand, loamy sand, silt loam. Loam subsoils of 'S' soils are usually yellowish brown to yellowish red, and range in texture from sand to clay. The soils are developed over granites, acidic gneisses, mica-schists, phyllites, quartzites and sandstones, and in colluvium/alluvium derived from such rocks. The main vegetation types on these soils include Brachystegia - Julbernardia woodland. Grass cover though generally poor under the trees can be dominated by Hyparrhenia when woodland is cleared, (L.U.B. 1977).

Land capability sub-classes are also an important feature in the L.U.B. classification. They divide the classes according to limiting factors such as salinity/ alkalinity, slope, texture and so on. Subclasses are indicated by small letters.

To make the work easier of classifying the land into a land capability class, a land capability code has been devised. It consists, of a series of letters and numbers representing four soil and land characteristics. (See appendix 1) as shown below:-

$$\frac{2 \quad AXB \qquad C \quad GLZ}{A \quad E1 \quad W1 \quad (10YR4/4) \quad Gr}$$

These represent:

Effective Depth	Texture	Hindrance to Cultivation	Limiting Material	
Slope	Erosion	Wetness	Colour	Parent material

Using both the Zambian land capability classification code and the land capability classification method (L.U.B. 1977, Woode 1980), the land in the study area has been evaluated based on the characteristics of the land facets recognized and delimited. There may be modifications of the method to suit the study area, for example if as augering does not exceed 50cm then the code for this will be left out. The wetness class may at times be left out because the work was carried out during the dry season and it was not possible to determine the degree of wetness within the rooting range. Even in January, the level of water for example in the dambo wells had gone down than when initial studies were conducted.

CHAPTER 4

TECHNIQUES

4.1 PREPARATIONS FOR FIELDWORK

For this study, the aerial photographs used were at a scale of 1:40,000 and were printed by the Survey Department in 1965. As stated in Chapter 2, the land facet is most easily recognized on the basis of its form at this scale. This therefore indicated the adaptability of using the landscape approach as will be illustrated later. After such recognition, the land system was identified after examining adjoining aerial photographs and maps. It was found that the Kamena area fell under one land system.

As this research was conducted by one person and the number of land parameters and attributes needed to be measured or noted were numerous, a method that would integrate them was required. This is another facility afforded by adopting the landscape method.

The parametric method was useful at stages where more details of the facet were required. For example a part of a facet or the whole facet was chosen and changes and breaks of slope measured and noted in detail.

For other similar facets, such measurements were generalised or studied in less detail except where considerable differences occurred. In such a case, that facet would be studied in detail to explore it fully. A soil survey is also an example of the parametric approach, as was done in Kamena because the soils were analysed physically and chemically, giving quantitative results which would be used for mapping.

Aerial photographs formed the basis on which to begin the study. Firstly, land facets were identified and demarcated on the photographs. This was followed by identification of the roads and other paths so as to determine routes for traversing. As this was a reconnaissaince survey, a grid pattern base method for survey operation was planned with distances between traverses being about 2.5 to 3 kilometres.

4.2 FIELDWORK

Basically the aim of the fieldwork was to distinguish and check first and foremost the boundaries of the facets in the field and then that of the land system. This was in order to determine the characteristics of the landform, vegetation and soils within them. The boundaries once delimited made it possible to describe each facet in terms of its associated topography, vegetation, soil and land use characteristics.

It was found that once in the field, the grid method was not always possible. This was largely due to the nature of the area in particular:- the dambos, rivers and ridges. Therefore for most of the time the traverses followed roads and this was a practical solution, and did not cause problems on gathering information on each facet in question.

The work was done mostly by foot and bicycle traverses. The start of the traverse was always from known points following existing roads and foot-paths or cutting through the forest using compass bearings. The latter type of traversing was infact more used, towards the end of the fieldwork as this coincided with the burning of the bush and thus the forest was cleared of grass and undergrowth.

Problems during traverse were numerous. The aerial photographs were taken in 1965 and the base map (1:50,000) used during traversing was also based on the photographs. The map was produced in 1969. It was found that certain villages marked on the photographs and map either did not exist any longer, had moved or new ones had come into being. The same applied for the footpaths.

Most paths followed natural features such as interfluves or <u>dambo</u> edges and to get at facets outside these areas, diversions had to be made. The distances travelled per day varied from 6 to 20 kilometres. It followed too that the more easily accessible facets were studied in detail at first and once the different types of facets were identified representative examples of each were examined further.

Depending on the size of the facet, three points (usually going downslope) within it were chosen for studies and collection of materials. These points were chosen in a straight line and usually at equal distances apart, unless any major change occured before such a distance. If necessary offset traverses or lines could be made, again if major differences occured.

A number of variables were measured, noted and soil samples taken at selected sites. These included the following:

a) The type of the facet and the position of the selected point within it.

b) Slope reading.

c) The drainage type, whether it was poor or well drained.

d) Special features such as the erosional state or extent of gullying.

e) The vegetation and land use if any.

f) Soil auger cores were taken and the depth, colour (dry and moist, using the Revised Standard Soil Colour Chart, Japan), texture, structure, root size and boundaries of the soil stated or measured. At selective augering sites, soil pits were dug to gather information on horizons, and it was from these that samples were usually gathered for mechanical and chemical analysis.

g) Dominant characteristic plant species found in each facet were recorded in the local Lala language, and herbarium samples taken to Lusaka for identification in the University's Biology laboratory. Lala names were also checked using Fanshawe (1965) as a guide.

h) As regards cultivation, if any signs existed, it was noted and the maximum slope angle where it occured measured. Crop types were also noted.

CHAPTER 5

ENVIRONMENTAL FACTORS

5.1 CLIMATE

Generally rainfall has been recognized as the most important climatic characteristic feature affecting Zambia. This is due to the fact that Zambia has two main seasons, one wet the other dry.

Records of rainfall in Kamena come from Serenje town (13° 14'S, 30°13'E) which has an elevation of 1384 metres. The distance of the town of Kamena area varies from about as little as six kilometres to well over thirty kilometres. Therefore there will not be much difference in the macro-climatic conditions.

As stated earlier, rainfall is seasonal, falling between November and March. The wettest months are from December to February, receiving 70 percent of the rainfall. The mean annual rainfall is about 1159mm. The heaviest rainfall lately was in the 1977-78 season which recorded 2322mm. The climatic data for Serenje is given in table 2. (page 53).

From this table the mean minimum temperature of the coldest month - (July) is 14.8°C. The mean maximum temperature in the hottest month - (October) is 21°C.

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The absolute maximum monthly temperatures vary from 20.9°C in July to 35°C in November. The absolute minimum temperature is - 0.5°C in June and July and during this period frost may occur (Department of Meteorology 1970).

The relative humidity is highest during the rainy season, from 67 to 85 percent, and lowest during the dry season when it ranges from 43 to 66 percent. As for rain days, (where 0.4 to 10mm rainfall is expected to occur), it is observed that these rainy days are likely to occur in the wettest period and average 42 for the year.

A dry spell has been defined as a series of days with no rain or rainfall less than approximately 6mm in any day during the period. This is because rainfall less than 6mm in a day adds to evaporation and contributes little to soil moisture (Department of Meteorology 1970). Table 3 shows the average number of dry spells per 10 years for Serenje. It is observed that the chances of dry spells are higher at the beginning and end of the rainy season, and lowest during the period of highest rainfall (December to February).

Figs. 1 and 2 show the distribution of average monthly rainfall and temperature throughout the year.

Like most parts of Zambia, the temperature in Serenje, is generally favourable for crops that will produce their yields at a high temperature range.

FIG. 1 AVERAGE MONTHLY RAINFALL

KAMENA.

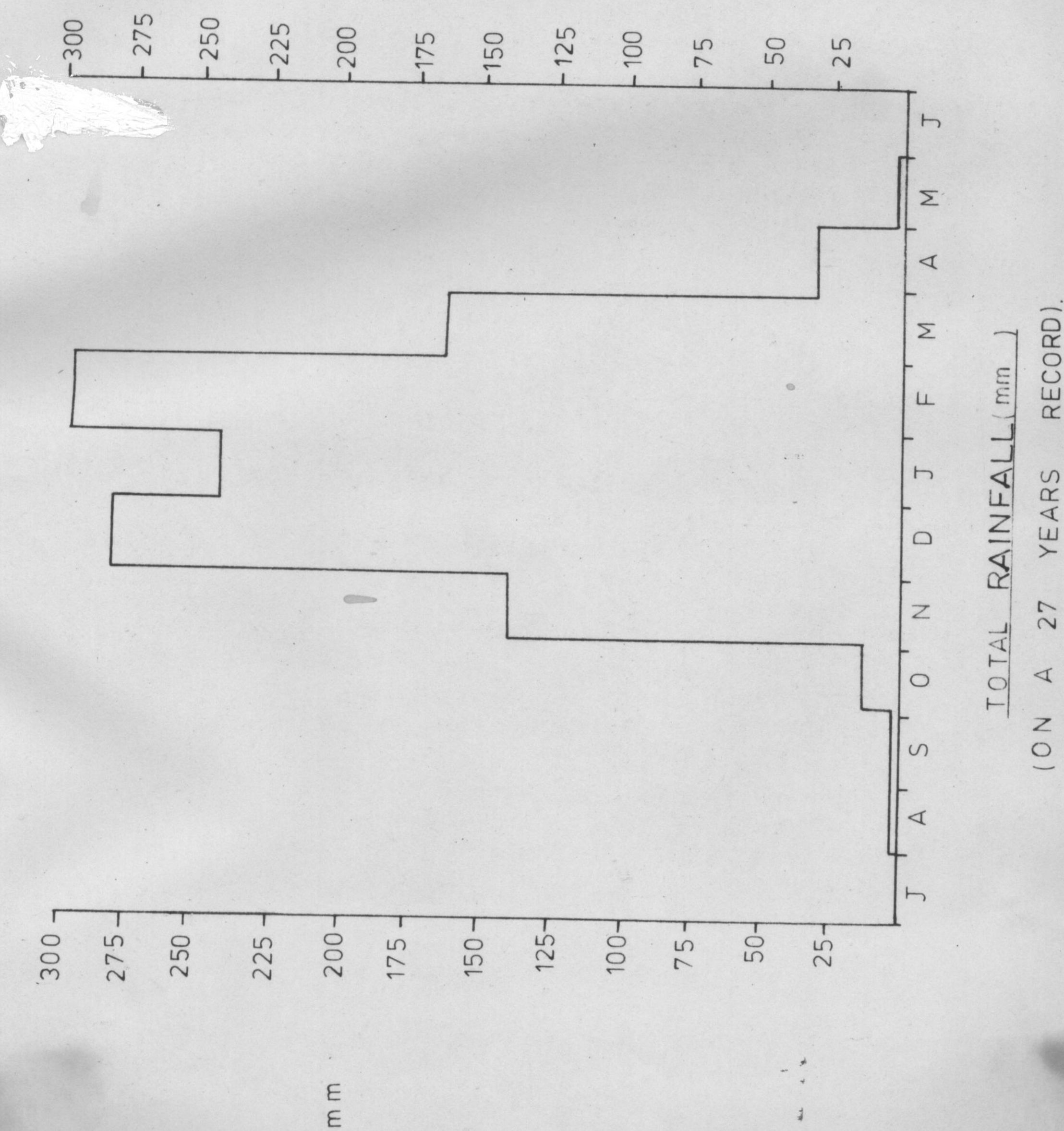


Fig: 2 AVERAGE MONTHLY TEMPERATURE

KAMENA

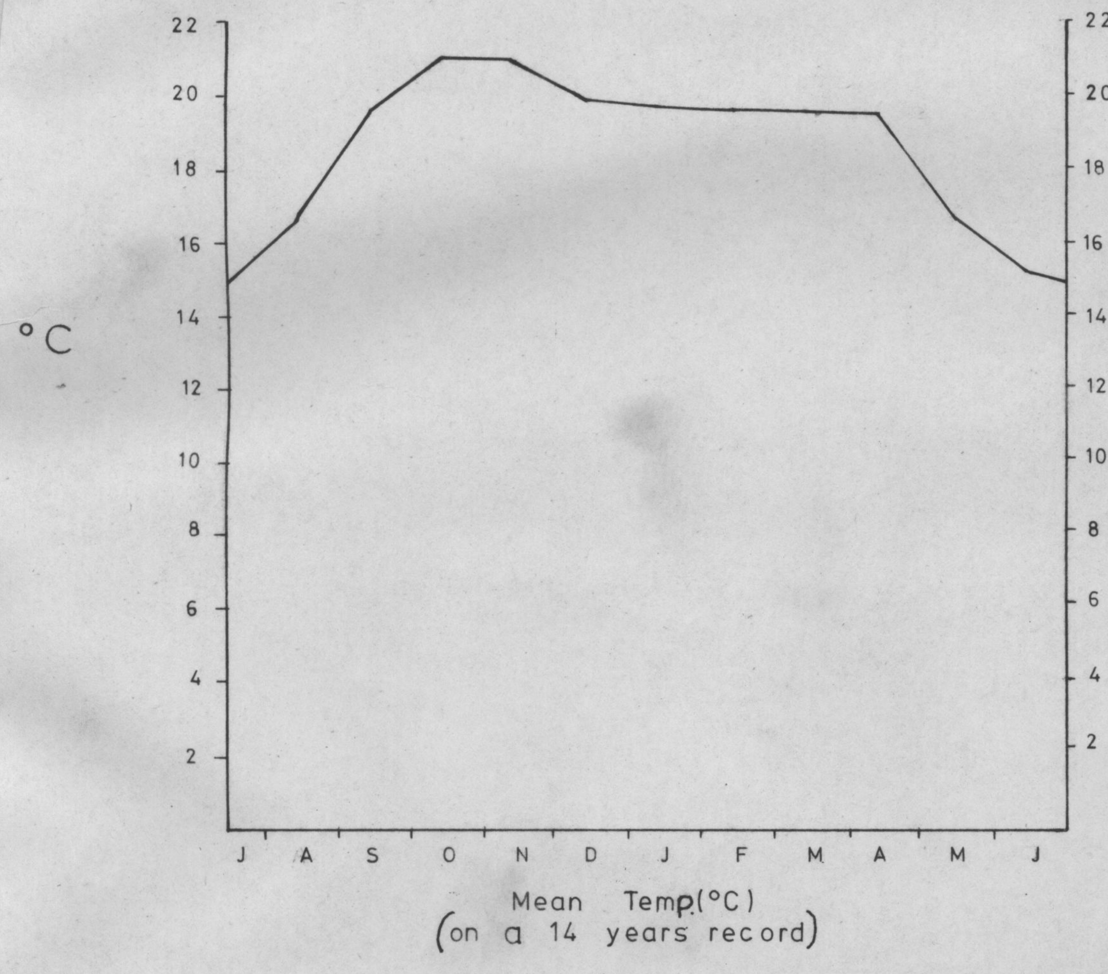


TABLE 2. Climate of Serenje

Months	Mean temp. °C.	Abs. max. temp. °C.	Abs. min. temp. °C.	Frost days	Relative humidity %	Rainfall total mm	Rain days 0.4-10mm	Rainfall Variability %
July	14.8	20.9	-0.5	4	60	0	0	-
Aug.	16.7	31.7	1.7	0	55	1	0	-
Sept.	19.6	33.9	3.9	0	49	1	0	-
Oct.	21.0	33.9	9.1	0	43	12	0	-
Nov.	21.0	35.0	10.6	0	67	139	5	66
Dec.	19.9	32.0	11.1	0	81	280	15	40
Jan.	19.7	30.6	10.0	0	84	241	9	34
Feb.	19.5	20.9	10.0	0	85	291	7	40
Mar.	19.4	30.0	8.3	0	81	161	8	55
Apr.	19.1	30.6	5.0	0	75	32	1	89
May	16.6	30.0	1.7	1	66	1	0	-
June	15.0	28.3	-0.5	2	63	0	0	-
Year	18.6	35.0	-0.5	7	68	1159	42	19

Temperature data ; 14 years period.

Total rainfall ; 27 years period.

Frost days ; 3 years period.

Rain days ; 10 years period.

SOURCE: DEPARTMENT OF METEOROLOGY (1970).

TABLE 3. Average number of dry spells per 10 years in Serenje

	Nov.	Dec.	Jan.	Feb.	Mar.	Season
5 days or more	10.0	9.5	9.5	9.5	22.5	70.0
10 days or more	7.4	3.7	3.2	2.1	7.4	23.8
15 days or more	[illegible]	0.5	0.5	0	3.7	8.4
20 days or more	1.0	0.5	0.5	0	1.6	3.6

SOURCE: DEPARTMENT OF METEOROLOGY (1970).

5.2 GEOLOGY

Map 2 inserted in the pocket gives a simplified outline of the geology of a part of Kamena area ([illegible]). The geology of most of the Serenje area was studied at a scale of 1:50,000 by Moore (1964) though both map and report were never published. Later in 1973, Cvetkovic investigated the Kamena area locating mica bearing pegmatites. The pegmatite belt is centered on the confluence of the Lukusashi and Chipendezi rivers. The reserves of mica and feldspar were estimated to be about 5,000 tonnes.

Recently a part of Kamena was studied geologically in more detail between July and August 1979, by the fourth year geology students (1978-79 group) from the University of Zambia. They mapped at a scale of 1:25,000 and their reports and maps were consulted in writing this summary.

Kamena is underlain by metasedimentary rocks all of which are of pre-Katanga age. Generally the rocks strike north-east. South-east of Kamena School the rocks dip steeply to the north-west whereas the rocks in the north-east dip steeply to the south-east.

'Most of the area is underlain by porphyroblastic and granitic gneisses which apparently form the upper part of a thick sequence of metasediments which may prove to belong to the Kalonga or Musufu formations of the neighbouring Ndabala and Mkushi areas to the west and south-east respectively' (Moore 1964).

These rocks are of overall granitic composition, consisting of entirely quartz, pink or white feldspar and biotite. The gneiss has been foliated and this is usually shown by parallel alignment of platy minerals such as biotite. Granitic gneisses have intruded the extensive outcropping gneiss east of the Namboard depot. Another area, where the paragneiss has been intruded by granitic gneiss, is north-east of Chintankwa School. The granitic gneiss north-east of this school forms an isoclinal fold.

The minerals in the gneiss consist of feldspar, quartz, biotite, sillimanite and minor garnet. In the banded gneiss, feldspar and quartz form the leucocratic bands measuring up to 10mm alternating with relatively thin biotite-rich bands. In places the banded gneiss has sporadic patches of porhyroblastic gneiss consisting of feldspar. (UNZA, 1980).

The schists of the Kamena area characterised by pinching and swelling occupy the central part of the map trenching north-east. The schists are interbedded with persistent quartzite horizons. Minerallogically the schists consist of biotite, quartz, garnet and sometimes sillimanite. Schists occur as lenses within the coarse grained quartz.

Several large ridges of massive quartzite caught up in the gneisses and porphyritic granites in Kamena are believed to be 'undigested remnants' of the Kalonga quartzite. The quartzites are very coarse grained probably as a result of metamorphism and recrystallization are variable in nature being sometimes quite micaceous even flaggy and sometimes glassy and massive (Moore 1964). This quartzite interbedded within schists forms most of the prominent hills and ridges such as Ngoli Hills near Kaseba School, Mwelwansefu Hill and several others in the area.

East of Kamena and Kaseba Schools, the area of porphyritic granite intrude into the metasedimentary rocks extensively. The porphyritic granite is very coarse grained and the intrusions are in a form of large domes (inselbergs).

Rocks in Kamena area have a general axial plane striking north-east (Moore 1964). The structure consists of a synform on regional scale. The synform runs through Kaseba and Kamena schools through the source of Kankoso river. Folding as of the Irumide event is characterised by intense folding and deformation along the north-east trending zones in Kamena. Isoclinal folding has been recognized in and around Chintankwa school in the north.

Repeated parallel outcrop patterns of persistent quartzite horizons may be attributed to isoclinal folding north-east of the Tsetse control village.

Three fault planes in Kamena area have the same north-west orientation. As seen in map 2, one fault is 2km east of Chintankwa school, another north of Kamena school and the third one 1km west of Mamba river. All three faults have a relative displacement of quartzite bands. Another fault located 3km east of Kaseba school has a considerable shear component. Faulting in the quartzites could be attributed to the brittle behaviour (UNZA 1980).

TABLE 4. Local stratigraphic succession of Kamena area

Lithology		
Mafic intrusives (i.e. gabbro granodiorites etc)	Probably post isumide	
Porphyritic granite	Mkushi Group	Pre Katanga Basement Complex
Schists interbedded with massive quartzites		
Granite gneiss		
Paragneissess occasionally interbedded with quartzite		

The largely granitic metasedimentary rocks of Kamena area may be lateral equivalents of the Mkushi Group.

Moore (1964) in his brief summary also talks of metamorphism. He observes that 'the metamorphic grade increases south-eastwards to the sillimanite zone, although the regional grade is in the garnet zone'. Regional metamorphism which accompanied deformation in the area has reached the high almandine - amphibolite facies. The schists have the mineral assemblage of biotite-quartz - garnet - sillimanite, while the quartz - feldspathic rocks and the granitic rocks have the mineral assemblage andesine - microcline - garnet - sillimanite.

5.3 GEOMORPHOLOGY.

Serenje district, lies along the divide of the Congo-Zambezi watershed. Moore (1964) says 'a belt of sugary, sericitic quartzites trending north-east forms the Congo-Zambezi watershed'.

According to Dixey (1941, 1945) the fashioning of the present day landscape began at the close of the Karroo period (in the Triassic times), when warping occurred and this is said to have produced the Congo-Zambezi watershed along a south-west north-east axis. Since the close of the Karroo period, the geomorphology of Zambia was dominated by the processes associated with peneplanation or pediplanation.

The Jurassic era saw the erosion of the Karroo sandstones and smoothing therefore of the land surface (Gondwana land-surface). The Gondwana land surface was dissected by the beginning of the Cretaceous era. However the early Cretaceous period was disrupted by upwarping along the north-west south-east axis. The late Cretaceous era was also an erosional one, reducing the surface to smoothness (African surface). The period was followed by more uplifting and continental flexing.

Finally there was another erosional period which by the mid-Tertiary produced the Miocene peneplain the present surface of the Central African plateau. Therefore according to Dixey (1941, 1945) the Congo-Zambezi watershed at an average of 1402m is one of erosion in the mid Tertiary (peneplain) era. Its origin is attributed to warping of the Miocene peneplain in the course of uplifting. The flatness of certain parts of the watershed is associated with waterlogging. Warping during uplifting increased the general altitude of the plateau to 1524 and even 1830m. The erosional surface of the area is a late Cretaceous remnant however.

In actual position to Kamena, the Congo-Zambezi watershed lies north across the Great North Road. Kamena lies to the south of this. The area has rugged topography and is characterised by generally north-east trending quartzite - schist ridges and hills ranging from 1220 to 1676m in height. It is interspersed by plateau surfaces.

Generally it is a homogeneous region because there is a general accordance of summit levels giving an indication of rock type and the way it has been denudated.

The general landform types of Kamena are illustrated by a block diagram (Fig. 3); which shows the main land facets of the area. Map 3 shows a typical distribution of the facet types, of a part of Kamena. The land facets identified are namely plateau and valley interfluves, dambos, piedmonts, river valleys, inselbergs, ridges and escarpments. (See figure 4 for positions of facets). The facets are defined below based partly on Mansfield et al. (1976).

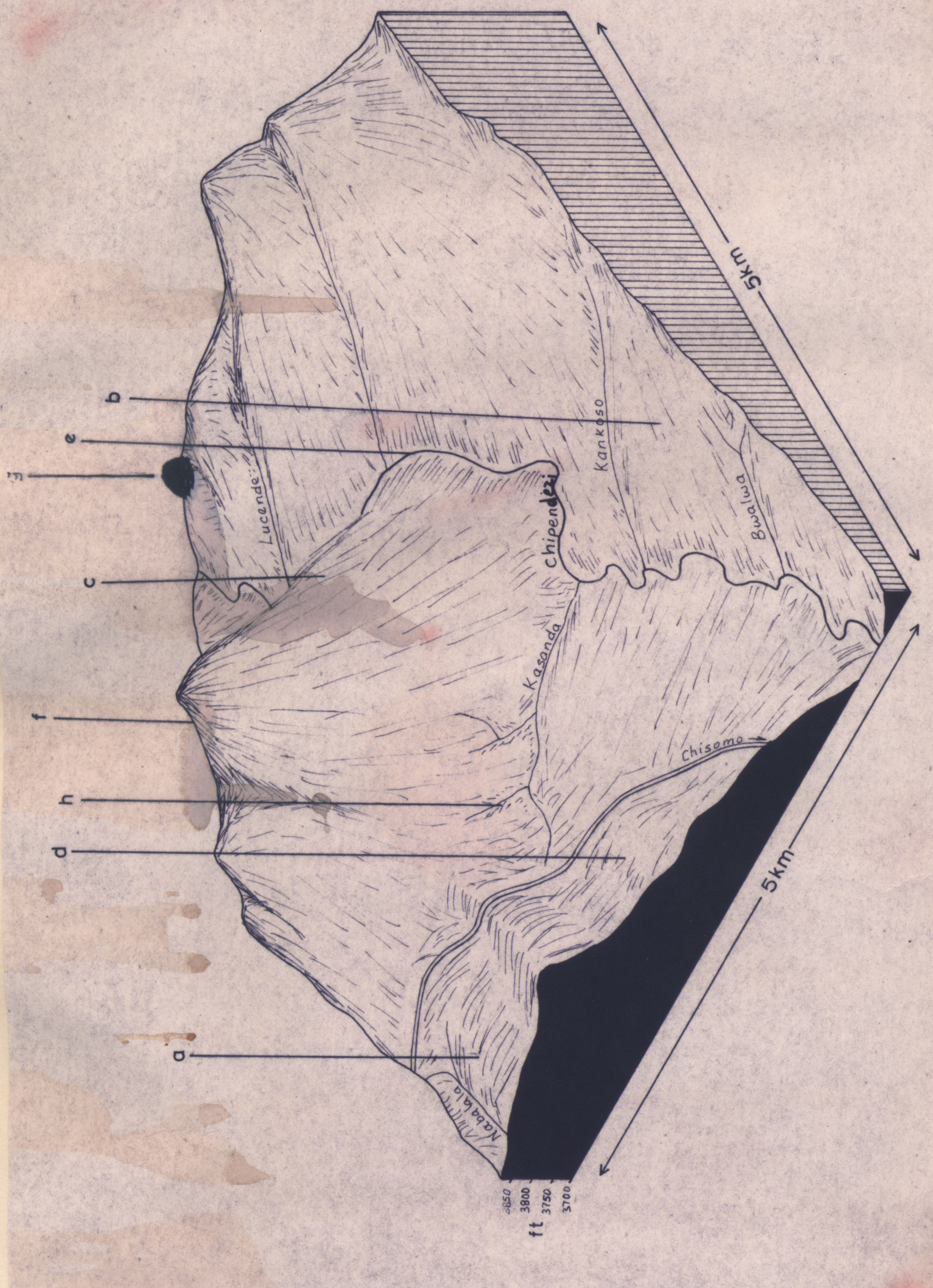
a) Plateau interfluve. The gently sloping usually convex land which is freely drained.

b) Valley interfluve. The gently sloping usually convex land which is freely drained but lying on a lower altitude than the plateau interfluve.

c) Escarpment. The steep area just below a plateau interfluve or ridge usually. It is too steep for most human activities. It refers or corresponds to some steep sides of many large ridges in the area.

d) Piedmont. The concave moderate slope found below an escarpment. It may possess a convex profile parallel to the escarpment or be separated and isolated from it.

Fig: 3 BLOCK DIAGRAM



c) River Valley. The valley is the area associated with lateral river erosion of the main rivers.

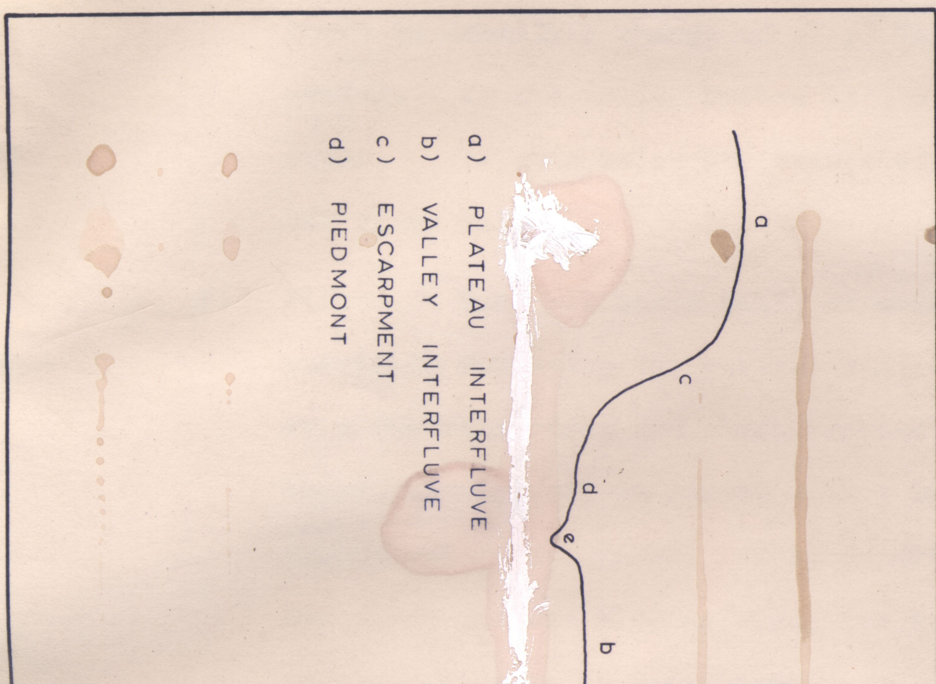


Fig: 4 GENERALIZED FACET POSITION
(AFTER KING, 1976)
(FROM MANSFIELD ET AL. 1976)

rainfall. (Refer to figure 5).

e) River Valley. The valley is the area associated with lateral river erosion of the main rivers. There is usually a change of slope in the profile from the valley bottom to the interfluve crest. The area below the change of slope is the river valley.

f) Ridges. Long and large hills of massive quartzite spreading for several hundred metres or a few kilometres and characterized by their gravely soil or quartz rubble on the crests and upper slopes. They usually have one steep and one sloping side, the former corresponding to an escarpment in Kamena.

g) Inselbergs. These are isolated large to small granitic rocky domes characterized by barreness or carry little vegetation mostly xerophytic in nature.

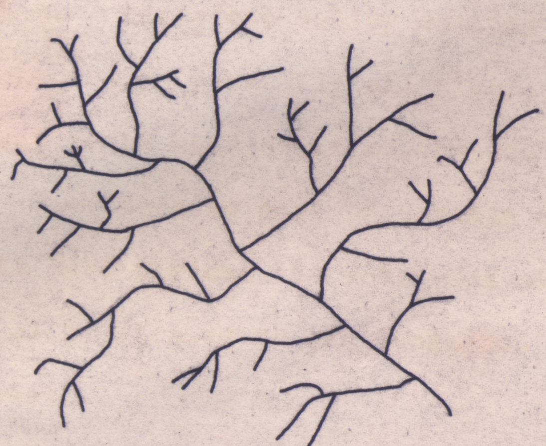
h) Dambo. Usually a low lying, gently sloping treeless but seasonally waterlogged grassland area. It receives water by seepage from surrounding higher grounds and rainfall. (Refer to figure 5).

Kamena has two main rivers the Lukusashi and its major tributary the Chipendezi. The Lukusashi drains from the north-west to the south-east and ends up in Chisomo's valley in the south before joining the Luangwa river. The beds of the major rivers have steep slopes suggesting that the rivers cut downwards eroding their beds and that local rejuvenation is in process, because if this did not happen, then the levels of steep banks cannot exist. Therefore valley cutting by rivers is a common process. Generally all rivers to the south of the Great North Road drain southwards towards the Zambezi. Therefore in most of Serenje district the Great North Road divides the watershed with rivers to the north of it flowing to the Congo and those south to the Zambezi.

In Kamena the drainage pattern is typically dendritic (see Fig. 6) with the smaller rivers running subparallel to the strike of the country rocks.

The stream frequency (which is the total number of effective stream segments in an effective land system divided by the area of the effective land system) is high being over 0.6 per square kilometre. This gives an indication of interfluves not being wide. The drainage density too is quite high (length of stream channel per

FIG. 6. DENDRITIC DRAINAGE PATTERN



(FROM MANSFIELD ET AL. 1976)

unit area) being as much as 1.1 per km^2. These factors also give therefore an indication of the general ruggedness of topography.

Generally the local relief from one valley bottom to the other is low (a few metres) if the valley bottom refers to adjacent dambo. The case is not so when it comes to the rivers like the Chipendezi and Lukusashi. These and their major tributaries incise to great depths into the terrain at various places. Within the river channels are many rock outcrops mainly gneisses.

Land evolution process are slow but on the other hand geomorphic processes have affected land functions. For example, shifting cultivation areas if close to settlements, tend to be on the steeper slopes and, with the onset of the heavy rains, a lot of material tends to be washed down. River transportation of materials is not much of a problem because rivers follow defined courses.

Gulley erosion is common near steep slopes especially following footpaths, roads or cleared fields. For example, the road to former Chintankwa School was probably ruined by gullying, (gulleys are not necessarily post settlement, but clearing certain areas seems to have encouraged their acceleration).

CHAPTER 6

NATURAL VEGETATION

6.1 VEGETATION TYPES

In his work in 1953, Trapnell divided the Serenje District according to the vegetation classification P. 4, which was the Northern Brachystegia - Isoberlinia paniculata woodland on plateau soils. He therefore noted that vegetation varied with topography and soil. Cole (1963) also recognized this when she said that, 'within the climatic limits, the composition and character of the vegetation is largely governed by soil and drainage conditions, which are in turn related to geomorphology'. Generally this type of woodland is found on the extensive Zambian plateau representing the ancient pediplains recognized by Dixey (1941, 1945). 'The pediplains carry infertile and generally sandy to sandy-clay soils with a laterite layer at a variable depth below the surface' (Cole, 1963). The soils have a pH of 5.0-5.5 and are low in exchangeable bases and organic matter.

Fanshawe (1971) divided the Brachystegia-Isoberlinia - Julbernardia woodlands into open forest with grass known as Miombo which consisted of a two storey woodland. Again, he recognized the importance of topography and soils and thus identified Plateau Miombo which would gradually change into Hill Miombo on inselbergs, rock outcrops and escarpments. The Miombo woodlands are a biotically controlled vegetation and Fanshawe said they ended up as grassland dambo in the lower reaches or valleys, and this was an edaphically controlled vegetation.

According to Fanshawe, the Serenje district consists of regrowth Miombo. This is because the area has for a long time been subjected to shifting cultivation and has resulted in a forest of secondary characteristics.

Plateau Miombo (the interfluves) is characterised by species of *Brachystegia* namely *B. boehmii*, *B. spiciformis* and *B. longifolia*. Also associated with tree type of vegetation are *Julbernardia paniculata* and *Isoberlinia angolensis* as the main tree canopies. The commoner canopy associates of the *Brachystegias*, *Isoberlinias* and *Julbernardias* in Kamena on the interfluves are, *Parinari curatellifolia* and *Monotes katangensis*.

Small tree canopies on the interfluves are dominated by the *Uapacas* namely *U. kirkiana*, *U. nitida* and *U. sansibarica*. These according to Fanshawe (1971) are secondary invasive species and persist in the woodlands for a long time. Others in this second and shorter storey include Diplorhynchus condylocarpon, Monotes sp., Protea sp., Pseudolachnostylis maprouneifolia, Diospyros sp. and Syzygium guineense sp.

Shrubs on interfluves include Diospyros virgata and Aerocephalus rupestris.

Hill Miombo as stated earlier, is associated with rock-outcrops and so on. Unlike the interfluves, the soil will be shallow and stony. The dominant canopy is dominated by tall trees such as Brachystegia spiciformis and B. utilis. To a less extent in being dominant are other Brachystegia species. Julbernardia paniculata and Uapaca sp. are also quite common. Other associated species include Parinari curatellifolia, and Faurea intermedia. Smaller trees include Protea sp. The shrubs where they exist on Hill Miombo include Vallozia equisetoides, V. bellinghamii and Erugrostis racemose.

On rock outcrops with no obvious soil as on parts of the gneiss outcrops, vegetation is of succulent and xerophytic form such as Euphorbia sp, Aeolanthus sp, and Aloe sp.

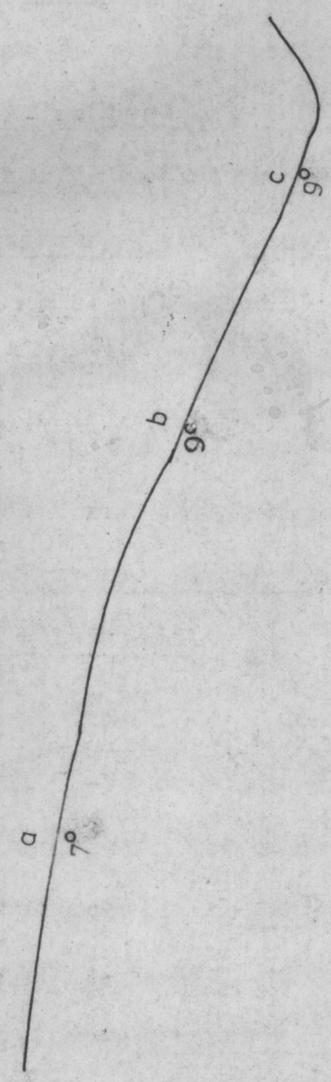
Miombo like other woodland types, shows a catenary sequence, that is from woodland, scrub, suffrutex savanna to biotic grassland. 'Scrub and savanna are nearly always associated with an impediment in the drainage, usually in the form of a laterite pan'. (Fanshawe 1971).

There is in the Kamena area an abrupt change on lower slopes between the woodland and grasslands of the dambo. The dambo vegetation is basically suffruticose, sedge, grass and herb type interspersed with a few trees. The Seepage zone of the dambo (See figure 7 for zones of the dambo) has just above it trees such as Brachystegia spiciformis, B. boehmii, Isoberlinia angolensis, Protea sp. and Uapaca kirkiana. The seepage zone is dominated by Syzygium guineense sp, Aeschynomene sp, and Dissotis canescens as common shrubs and subshrubs. These may also be found around stream heads.

On the wash zones and the middle and lower reaches of the stream are found the following shrubs; Eriosema psoraleioides, Syzyguim guineense sp, Parinari capensis and Truimfetta welwitshii.

The dambo grassland itself is a dense mat of grasses, sedges and herbs 50-75 cm high with flowering culms 1-1.6 m high. The grasses are perennial bunch grasses, cushionlike (tussocky) with Loudetia simplex as the characteristic species. Seepage heads of streams have grasses 3-4m high such as Hyparrhenia bracteata and H. cymbaria (3-9m) high as the dominant species.

FIG. 7. POSITIONS WITHIN A DAMBO.



a) SEEPAGE ZONE
b) UPPER WASH ZONE
c) LOWER WASH ZONE

(DRAWN NOT TO SCALE)

Sedges such as Cyperus sp. and Kyllinga sp. are common in the dambo zones. Other common grasses include Eragrostis capensis and Microchloa caffra. The reed Phragmites mauritianus is also common.

Savory (1963) experimented on the rooting habits of important Miombo species (trees) on the Copperbelt. Some of the results he found were briefly as follows:

a) Brachystegia longifolia could grow well (root) in about 3m plus of sandy soil but could not penetrate rubble or murram.

b) B. spiciformis grew well in 3m plus deep of sandy or loamy soil texture. It could penetrate loose rubble or murram for approximately 0.6m. It occurred with B. longifolia on moist sites but could not stand permanent waterlogging.

c) B. floribunda was common on rather heavy textured soils derived from shale or seracite schists. It was rarely on sands or light loams but was frequently on fairly shallow soils. It could penetrate murram.

d) B. boehmii had condition preferences for growth as for B. floribunda and grew well too around laterite and pans on shallow soils. It could tolerate seasonal waterlogging and grew best on medium depth clay loam soils.

e) *B. utilis*. Its rooting depth was between 0.6 to 2m. It did not occur on shallow moist sites or soils subject to permanent waterlogging. It was best developed on deep loamy soils and could tolerate seasonal waterlogging.

f) *Julbernardia paniculata* was a rival to *Brachystegia longifolia*. It grew well on deep sandy soils (rooting up to 5 metres). Soil texture was found apparently to be unimportant for its growth. It was not found on permanently moist soil zones.

g) *Isoberlinia angolensis*. It had a wide soil range with texture and depth being unimportant. It could survive in a permanent (moving) water table. Tap roots fork out and rarely go beyond a metre in depth. Rooting depth was about 3m.

h) *Syzygium* sp. Trees in this species could perform well on clay loam soils of medium depth and imperfect drainage. They also survived in sands with a permanent water-table within 3m of the surface. They were healthy in gley zones and within a permanent water table.

i) *Uapaca kirkiana* could survive well over rubble, rock murram and gley horizons. This may also help to explain as to why it is such a dominant species being found from a ridge crest right up to the *dambo* zones in Kamena.

With the <u>Brachystegia</u> group discussed above, <u>B. floribunda</u> and <u>B. utilis</u> are said to be in a group which is associated with remnants of the <u>Marquesia macroura</u> dry evergreen forest (Mansfield et al. 1976). This group indicates deep, freely drained soils that retain moisture on deep upper slope soils. <u>B. utilis</u> on the other hand is common on shallow rocky soils and where concretions occur, but still may be associated with the dry evergreen forests. (Mansfield et al. 1976).

<u>B. boehmii</u> is an indicator of shallow soils occurring on lower interfluve slopes (waterlogged soils) and on upper slope shallow soils. <u>B. boehmii</u> belongs to a group that indicates compact soils often underlying a layer of laterite or parent rock. Soils may dry out in the dry season or be waterlogged in the wet season. The group includes shallow soils on escarpments and rocky ridges. <u>B. spiciformis may</u> be a component of both groups (Mansfield et al. 1976).

Therefore as (Mansfield et al. 1976) concluded, some species of <u>Brachystegia</u> occupy two different habitats, one on steep escarpments or rocky crests and the other on lower slopes near watercourses. The soils on the rocky crests and escarpments are physically shallow, while those on the lower slopes may be waterlogged or wet in the rainy and part of the post rainy season, thereby making them physiologically shallow.

6.2 PLANT INDICATORS OF SOIL FERTILITY

For a long time vegetation has been used by the local people as an indicator of fertility. Trapnell (1953) recognized that various tall grasses of the genus *Hyparrhenia* are used as indicators of good land (tall green grass on black soil usually) by the local people. This may indicate the opening up of new areas for cultivation that is only in *dambo* margins because this shows the ability of that land to retain water and thus extend the growing season. Land with grass such as *Trichopteryx superba* and *T. simplex* would be avoided. Tree species such as *Uapaca* denote poor soil and not infrequently one with an impermeable ironstone pan (Trapnell 1953).

Trapnell (1953) stresses that in the shifting agriculture areas the above mentioned ways of indicating soil fertility are not clearly defined since the burning of chopped trees make up for the insufficient nutrients in the soil. However, there is a tendancy by the local people to choose old woodland which is well grown so as to gain more nutrients.

In Kamena a generalized way, people would use vegetation as an indicator of fertility or to chop trees for a chitemene field would be using some of the following as indicators.

a) Old woodland especially that which is dominated by Brachystegia spiciformis.

b) Tall and luxuriant grass on dambo fringes dominated by Hyparrhenia bracteata.

c) Tall luxuriant grass with open forest canopy.

d) Absence in the primary vegetation growth of Isoberlinia paniculata, Uapaca and Protea sp.

6.3 LAND FACETS AND VEGETATION

The following gives a list of the plant species found in each facet. The list is incomplete as quite a number of species were unidentified. (Refer to fig. 8)

a) Ridge.

Trees	Shrubs
Afrormosia angolensis	
Azanza garekeana	
Brachystegia spiciformis	Vellozia equisetoides
B. boehmii	V. bellinghamii
B. bussei	

B. utilis

Craterosiphon quarrei

Cryptosepalum maraviense

Faurea intermedia

Julbernardia paniculata

Lonchocarpus sp.

Monotes sp.

Parinari curatellifolia

P. excelsa

Protea sp.

Pterocarpus angolensis

Strychnos sp.

Uapaca sp.

Grasses

Andropogon sp.

Hyparrhenia sp.

Eragrostis sp.

b) Escarpment (vegetation quite similar to ridge)

Trees

Afrormosia angolensis

Brachystegia boehmii

B. spiciformis

B. bussei

Diospyros sp.

Diplorhynchus condylocarpon

Isoberlinia paniculata

Isoberlinia angolensis

Shrubs

Uapaca nitida

Grasses

Ochna schweinfurthiana sp.

Uapaca kirkiana

Andropogon sp.

Hyparrhenia sp.

c) **Plateau and Valley interfluves**

Trees

Afrormosia angolensis

Anysophyllea pomifera

Albizia versicolor

Brachystegia boehmii

B. longifolia

B. spiciformis

B. utilis

Craterosiphon quarrei

Diplorhynchus condylocarpon

Diospyros sp.

Faurea saligna

Isoberlinia angolenis

Julbernardia paniculata

Monotes sp.

Ochna schwenfurthiana

Parinari curatellifolia

Piliostigma thonningi

Pseudolashnostylis maprouneifolia

Pterocarpus angolensis

Strychnos sp.

Syzygium guineense sp.

Shrubs

Acrocephalus rupestris

Byrsocarpus orientalis

Diaspyros virgata

Dichrostachys cinerea

Ozoroa reticulata

Protea sp.

Securidava longipedunculata

Grasses

Hyparrhenia sp.

Andropogon sp.

Swartzia madagascariensis

Uapaca kirkiana

U. nitida

d) Piedmont

Trees

Acacia sp. (rare)

Albizia versicolor

Brachystegia boehmii

B. bussei

B. spiciformis

B. utilis

Craterosiphon quarrei

Isoberlinia angolensis

Julbernardia paniculata

Monotes sp.

Parinari curatellifolia

Pterocarpus angolensis

Piliostigma thonningi (rare)

Swartzia madagascariensis

Syzygium guineense sp.

Uapaca kirkiana

Shrubs

Bridelia sp.

Byrsocarpus orientalis

Dichrostachys cinerea.

Grasses

Andropogon sp.

Hyparrhenia sp.

e) <u>Valley</u> (river)

The valley has no agricultural significance. However tree species are those associated with rivers e.g. <u>Syzygium guineense</u> sp. Most of the species were said to be of Riparian forest type with <u>Chrysophyllum magalismontanum</u> as a common species

f) <u>Inselbergs</u>

<u>Trees</u>	<u>Shrubs</u>
	<u>Shrubs</u>
Brachystegia boehmii	Vellozia equisitoides
B. utilis	V. bellinghamii
B. spiciformis	Euphorbia sp.
Isoberlinia angolensis	Aloe sp.
Uapaca kirkiana	Aeolanthus sp.
	<u>Grass</u>
	Andropogon sp.
	Aristida sp.
	Hyparrhenia sp.

g) <u>Dambo</u>

i) <u>Seepage zone and edge of woodland</u>

<u>Trees</u>	<u>Shrubs</u>
Afrormosia angolensis	Aeschynomene sp.
Albizia anthumesiana	Dissotis sp.
Anysophyllea pomifera	

Brachystegia boehmii

B. floribunda

B. spiciformis

Ficus sp.

Isoberlinia angolensis

Julbernardia globiflora

Parinari curatellifolia

Protea sp.

Syzygium guineense sp.

Uapaca kirkiana

ii) Upper wash zone

Trees	Shrubs
Syzygium guineense sp.	Aeschynomene sp.
Ficus sp.	
Ziziphus mucronata	Coleus esculentus
iii) Lower wash zone	Dissotis sp.
	Indigofera sp.

Tree

Syzygium guineense sp.

Herb and grass species of the dambo

Aristida sp.	Loudetia simplex
Brachiaria sp.	

Brachystegia wangermeeana

Cyperus sp.

Elephantopus sp.

Eragrostis capensis

Hyparrhenia

Kyllinga sp. (Cyperaceae)

Microchloa caffra

Phragmites mauritianus

Phyllanthus sp.

Polygonum sp.

Schizachyrium sp.

Sporobolus sp.

Vigna sp.

In the Serenje District, two kilometres on either side of the Great North Road is protected forest. The forest to the north of Kamena lies on extremely sandy soil. Though Kamena generally has soils unfavourable for agriculture, its trees have great value for many purposes. On the other hand, Fanshawe says even exotic trees can be introduced for forestry purposes. He expands his point saying experiments have shown that 'pines grow well on the mica schists soils, and eucalyptus on deep granite sands and mica schists'.

6.4 USES OF SOME OF THE MIOMBO TREES

a) Brachystegia boehmii. Moderately heavy, cross-grained, fairly tough and hard but it is liable to decay and is very susceptible to borers. It is difficult to work with and blunts tools quickly. It can be used for making pick handles, rough constructional timber, shuttering and cheap batten doors. It is reasonable firewood and charcoal (Hart and Fanshawe, undated).

b) B. spiciformis. Its timber warps if left in the sun. It is cross grained, heavy and tough. The sapwood is susceptible to borers but it absorbs preservatives well. Its uses are in copper mines, wagon and lorry bodies and roof trusses. Good firewood and charcoal.

c) Isoberlinia paniculata. It is good for making handles for picks and axes. Good for copper mine timber. It contains lots of tannin in the bark (leather can be tanned) 13-22 percent.

d) Swartzia madagascariensis can be used where timber of small size is required, turnery work, carvings, walking sticks and charcoal.

e) Diplorhynchus condylocarpon. Light timber with a creamy sapwood and heartwood. It can be used for making small furniture, roofing poles and firewood. Its dried latex contains 75 percent resin and 24 percent of a rubbery substance.

f) Monotes sp. Good for timber and charcoal.

g) Pseudolachnostylis maprouneifolia. It is moderately heavy timber for rough carpentry and joining. It is good firewood and charcoal. A dark dye may be obtained from the fruits.

h) Parinari curatellifolia. The immediate use is its fruit for wine making and other food processings, now becoming seemingly important in the cities.

i) Uapaca kirkiana - Its fruit is more preferred than the Parinari's, and it may well serve to be the most used in wine and other food processing activities.

j) Isoberlinia angolensis. It is the favourite tree of the most treasured of all food caterpillars which fetch a lot of money in the cities.

Generally all the above trees and others not mentioned have also medicinal properties which could also prove helpful in modern medicine.

The forest is a resource potential for grazing and forestry.

CHAPTER 7

THE SOILS

7.1 METHODS

A hand auger with a core diameter of eight centimetres was used throughout the survey. As it was during the height of the dry season the ground was very hard and therefore in many cases the augering and pit depths rarely went more than 60 cm. This is a point worth noting, especially in connection with the LUS code on the part dealing with the limiting material; because this may well occur below augered depth and may not be recorded. For the texture of different soil layers this depth is quite sufficient because it is included in the code.

Soil samples as soon as they were collected, were tied tightly in plastic bags and brought to Lusaka (Mt. Makulu Research Station) for physical and chemical analysis, numerous problems were encountered however and it was decided that soils would be analysed according to those collected in each individual facet. In other words, it was assumed that for the whole area each alike facet had similar soil characteristics. Of course it was also taken into consideration that soils within a facet will differ depending on their position. This therefore reduced the soils to be analysed for the whole area considerably. Boundaries, for soil mapping units were therefore drawn more or less on facet identification, aerial photography interpretation and field data. As Areola (1977) points out, the land facet is an important unit in land use planning, because soil attributes which are found to be common to the various types within a facet, generate similar ecological responses in all the soils.

7.2 GENERAL CHARACTERISTICS OF THE SOILS

Generally the Serenje district has what is known as the sandveldt soils (Brammer 1973). Clayton (1975) is of the opinion that it is only in the wet (4-5) months period that rainfall will exceed potential evapo-transpiration. During this period all except impervious soils will tend to be leached. Consequently clay will be leached from the topsoil to the lower layers, if the surface layer is not highly organic, ferruginous or calcium saturated. The soils then tend to be light textured and sandy, and thus the use of the term sandveldt to describe them.

Trapnell (1953) called them 'plateau' soils saying that they consisted of 'coarse to fine grained sandy to sandy clay soils, having an eluviated top horizon as a common characteristic, formed through long periods of seasonal leaching on a maturely eroded topography'.

Mansfield et al. (1976) noted that the principal determining factor in soil formation in Northern Zambia is the age of the land surface. It has been recognized that during certain phases in the last Ice Age (Pleistocene) the deeply weathered mantle of Africa was preserved and later weathered under wetter climatic conditions (Clayton 1975). Thus the theory that these soils are relatively old.

Kamena lies over acidic rocks which have low mineral reserves and are less resistant to leaching. Soils developed on such rocks will be generally strongly weathered, leached and have a low Cation Exchange gapacity (CEC). They are usually generally considered poor for agriculture.

The fact that plants maintain soil fertility by nutrient cycling is a factor that has been recognized by the indigenous people. As a consequence this is why they have practised shifting cultivation and have adapted their techniques to meet the needs of exploitation and conservation. For example in a chitemene field they do not cut down the trees completely but the trunks are left standing at breast height so that regeneration is faster. (Clayton, 1975).

The general upland except the escarpments have texture ranging from sandy loam to sandy clay. Soil will tend to become clayey down the profile. Ferruginised gravel (laterite) layers can be expected down a profile at depth separating the subsoils from the weathered rock. This will be sometimes exposed as sheet laterite in the dambo. (Clayton 1975).

7.3 SOIL MAPPING UNITS

Soil mapping units were recognized in Kamena and these were based mostly on the facet. However within a recognized facet a number of soil types may occur. For example a dambo would have different soil types within its zones, therefore these associations of soil would be grouped as one series. Thus the soils in the facets were given Soil Series status. Seven Soil Series were identified and names adopted from the type of garden/field likely to be found on the facet, or the nature of the soil as described by the local people (Lala).

The major Soil Series recognized are as follows:-

a) The well drained soils on the interfluves which were mapping unit 1 called Ibala Soil Series.

b) The well to somewhat excessively drained soils on the piedmont slopes which were mapping unit 2, the Chibela Soil Series.

c) The moderately drained soils on lower slopes near the fringes of the dambos which were mapping unit 3, the Fisebe Soil Series.

d) The imperfectly drained to poorly drained dambo edge soils which were mapping unit 4, the Nika Soil Series. This included the dambo centre too.

e) The excessively drained soils on the escarpments or steep ridge sides which were mapping unit 5 the Nkutu Soil Series.

f) The alluvial soils along banks of the major rivers which were mapping unit 6 the Muchenga Soil Series.

g) The shallow rocky soils on and including the ridges and inselbergs which were mapping unit 7 the Mabwe Soil Series. (See fig. 9).

7.4 DESCRIPTIONS OF THE SOIL SERIES

Appendix 2 gives the detailed soil profile descriptions of each series. However generally they are as follows:-

a) The Ibala Soil Series. As stated earlier these are soils on the interfluves (plateau and valley). These in places may have shallow gravelly soils, particularly if rock outcrops occur within the facets. Two general such units were recognized in this series.

1a) The Ibala sandy clay loam. This is a deep to moderately deep and well drained soil. Its colour ranges from dull reddish brown (5YR 3/4) to dark reddish brown (2.5 YR 3/6). It becomes more clayey in the deeper horizons. The top soil may be sandy loam but changes in the upper sub - soil to sandy clay loam or sandy clay. This soil is usually developed over a rock with a high concentration of dark minerals for example biotite. The pH values range from 4.70 to 5.1 which is strongly acidic and would indicate a progressive risk of fertility being adversely affected, and thus the need for liming becoming urgent. The CEC is low. (CEC is a measure of the capacity of the soil to hold nutrients against leaching). It is defined as a measure of the exchange capacity of the clay and humus expressed as milligram equivalents per 100 grams of soil i.e. me/100g. In Kamena the low C.E.C., indicates increasing intensity of weathering associated with the high rainfall.

The base saturation, also an indicator of present day leaching, is relatively low to medium. The available phosphorus is deficient to marginal on the whole. Organic carbon and total nitrogen are also low.

Typical profile description.

0-10cm	Dark reddish brown sandy clay loam
10-21cm	Reddish brown sandy clay loam
21-100cm	Dark reddish brown sandy clay loam
100-125cm	Dark reddish sandy clay

Typical LUB code $\frac{\text{1 BBB ---}}{\text{A-- (2.5YR 3/6)Gr/Gu}}$

Land Capability Unit S1

Profile K1 is typical of this soil.

1b) The Ibala sandy loams. The soils are moderately shallow to deep and may have gravelley topsoils and rock outcrops occuring frequently. In places a layer of loamy sand overlies the sandy loam. Textural change is from sandy loam to sandy clay in the upper subsoils (25 cm onwards). Slopes are usually higher thus more of an erosional risk than for sub-map unit 1a.

This soil is usually developed over a rock with less content of dark minerals. This soil is also strong to medium acid (pH 4.6-5.2). The CEC will probably also show a trend as that of the CEC of the Ibala Soil Series sub-map unit 1a.

It must be specified that local variations occur in analytical data and this naturally reflects local differences in degree of leaching of soils developed over rocks with variable mineralogy as with the soils in Kamena.

Typical profile description of such map unit 1b.

0-15 cm Dark brown sandy loam

15-23 cm Dark reddish brown sandy loam

23-60 cm Dark reddish brown sandy clay loam

Typical LUB code $\frac{\text{3 B C---Z}}{\text{A -- (5YR 3/6)GM}}$

Land Capability Unit S2d

Profile K2 is typical of this soil.

The limiting materials for both 1a and 1b would probably be laterite, gravel or clay matrix.

b) The <u>Chibela</u> Soil Series will normally coincide with the piedmont position. These soils are drained to excessively drained. They are deep to moderately deep.

Subsoils colour is red to dark red. Any limiting material, will probably be weathered rock especially quartzite from the upper ridges. This may pose an erosional problem. Generally soil texture is from sandy loam to sandy clay loam.

The soils are medium acid. They are satisfactory for most crops, but to maintain the pH in this range under regular cultivation, liming would be necessary at a suitable stage in the rotation. The values for the CEC are low to medium. Base saturation percent is variable while available phosphorus is high.

These piedmont soils are favoured by the local people for their so called permanent fields, but however because of slopes, these can be an erosional hazard. Once again variations will occur within the local area.

Typical profile description

0-8 cm	Very dark reddish brown sandy loam
8-26 cm	Dark reddish brown sandy clay loam
26-50 cm	Dark red sandy clay loam

Typical LUB code $\frac{3\ B/C\ C\ C\ -\ -\ -\ Z}{A/B\ El\ -\ (10R\ 3/6)\ Qu-}$

Land Capability Unit S2e

Profile K3 is typical of this soil.

c) The Fisibe Soil Series. These are the soils in the woodland above the dambo fringe. Generally the soils are moderately deep to deep. They may perhaps in the wet season be influenced by a high water table. Texture wise they vary from sandy loam to sandy clay loam in the subsoil. Limitations would be laterite layer, weathered rock or a clay layer.

They have a medium to slightly acid pH 5.0-6.5, making them quite satisfactory for almost all crops. In a true sense these soils could be included within the piedmont or Chibela Soil Series as usually in Kamena the piedmont preceeds a dambo. The CEC is low to medium.

Typical profile description

0-10 cm	Dark brown sandy loam
10-30 cm	Brown sandy loam
30-60 cm	Yellowish brown sandy clay loam
60-85 cm	Dull yellowish brown sandy clay loam
85-100 cm	Dull yellowish brown sandy clay loam

Typical LUB code $\frac{\text{2 BBB - - -}}{\text{C El - (10YR5/6) Gr}}$

Land Capability Unit S2w

Profile K4 is typical of this soil.

d) The Nika Soils Series. This is mainly associated with the dambo soils. The soils are moderately shallow to moderately deep. The dambo type of Kamena is the acidic one ranging from strongly acid to slightly acid pH 4,8-5.5. Therefore the dambos are considered as 'sour'. Available phosphorus is marginal and the CEC would be medium to low.

Dambos are important for vegetable gardens and locally consumed early maize. They have the greatest potential for producing food throughout the year because their lower and upper wash zones are capable of 'storing' (retaining) water during the rainy season which is released during the dry season.

Four sub units were recognized:-

i) The soils on the seepage zone boundary (where there is a break of slope into the actual seepage zone from the adjoining woodland). This soil may be affected by the high water table during the rain season. Laterite will probably be the limiting factor.

	Typical profile description
0-7 cm	Brownish black sandy loam
7-13 cm	Brownish black sandy clay loam
13-45 cm	Dark brown sandy clay loam

Typical LUB code $\frac{4\ C-----}{D-W1\ (7.5YR\ 3/4)\ \ Gr/Gn}$

Land Capability Unit S3 w

Profile K5 is typical of this soil.

ii) The seepage zone. It has deep to moderately shallow soils. The topsoils are brownish black 10YR 4/2. Root channels may be rusty and mottles are present in upper subsoil. Limiting materials may be laterite and quartz gravels.

Typical profile description

0-19 cm	Brownish black sandy loam
10-30 cm	Brownish black sandy loam
30-50 cm	Greyish yellow brown sandy loam

Typical LUB code $\frac{1/3\ B\ B\ B\ -\ -\ -}{C\ W1/W2\ (10YR\ 4/2\ \ Gr/Gn}$

Land Capability Units S3 w, Gw

Profile K6 is typical of this soil.

iii) The upper wash zone. Here the soils are moderately shallow, imperfectly to poor drained. The top soil is brownish grey and the subsoils grey. Rust root channels and mottles are evident.

Typical profile description

0-12 cm	Brownish black sandy loam
12-25 cm	Black sandy loam
31-49 cm	Grey sandy loam.

Typical LUB code $\frac{1/4\ B\ B\ -\ -\ -\ -}{e\ -\ W2(7.5Y\ 5/1)\ Gr/Gn}$

Land Capability Units Gw, S3w, Uw

Profile K7 is typical of this.

IV) This is the lower wash zone. The top soil is brownish black. The sub soil is grey. Rusty root channels occur in the top soil while yellowish red to blackish mottles occur in the upper sub soil. Limiting material will be laterite, quartz gravel, wetness and so on.

Typical profile description

0-11 cm	Brownish black sandy loam
11-25 cm	Black sandy loam
25-35 cm	Brownish black clay loam
35-51 cm	Brownish black clay loam
51+ cm	Dark grey clay

Typical LUB code $\frac{2/3\ B\ B/D\ F\ -\ -\ -}{B\ -\ W3\ (N3/3)\ Gr/Gn}$

Land Capability Units. Gw, Uw

Profile K8 is typical of this.

e) The Nkutu Soil Series. These are the soils found on the escarpment and steep banks of river valleys. They have a lot of quartz gravel exposed to the surface. Generally these areas are untouched for agricultural purposes. However in Kamena, where there is a concentration of people in the villages, some people cut down the trees in these facets for shifting cultivation, despite the steep slopes and gravely ground.

However a typical profile description is as follows;

0-5 cm Dark red loam sand to sandy loam

5-20 cm Red sandy loam - sandy clay loam

20-40 cm Red sandy clay loam

Typical LUS code $\frac{\text{L X/B B/C - - g R/Z}}{\text{E E3 - (2.5 YR 4/8)}}$

Land Capability Units S3e, S3g, Us, Uz

f) The Muchenga Soil Series are found near river banks. The profile information has advertently been omitted for the Nkutu Soil Series because of their low productivity and because of the precarious positions within the land systems on which they occur; the steep slopes of the escarpments. They are basically sandy loams and at times may be over-lained by loam sand. They may be to a certain extent be flooded in the rain season. Most of the time the subsoil will be moist. They have been investigated down only to 0.3m because some vegetable gardens are found alongside the rivers.

They have a pH of between 4.6-5.3, strongly to medium acid. What makes them of importance is their nearness to rivers and thus the suitability for vegetable gardens.

Typical profile description

0-5	cm	Yellowish grey loam sand
5-12	cm	Brownish grey sandy loam
12-20	cm	Brownish black sandy loam
20-30	cm	Greyish yellow brown sandy loam

Typical LUB code $\frac{\text{4 X/B B - - -}}{\text{C/D E2/E3 -/W1(10YR5/2)Gm Gp}}$

Land Capability Units S3e, S3s, S3w, Uw,

Profile K9 is typical of this.

g) The Mabwe Soil Series. These are shallow soils though well drained. They are sandy and stoney (gravelly) and are found around the inselbergs, rock outcrops and in the north on the Forest Reserve alongside the Great North Road (where they can be quite deep).

This land is unsuitable for agricultural (crops) purposes and is best left for forestry and grazing. The soils have not been investigated.

Land Capability Units. Uz, Ur.

Figure 10 shows the land capability classification of a part of Kamema.

CHAPTER 8

CROP SUITABILITY

8.1 INTRODUCTION

The LUB has devised a system of dividing soils into suitability classes based on their suitability to grow certain crops. The soils are classified according to their present conditions and at prevailing management levels. A point worth noting is that what is expected after clearing a woodland and when field preparation is done, :e must also be considered. Major and minor improvements in land such as draining the dambos, levelling, irrigation and so on, can cause re-classification of certain soils.

Most crops tolerate a wide range of soil conditions. The assumption being made here is that crops will be grown at an average level of management, and that this will determine the yield, assuming other factors such as the climatic ones are stable. The soils are grouped into four suitability classes taking the above factors into consideration:-

8.2 SUITABILITY CLASSES

Suitability class 1, well suited.

Under good management, the crop grows well and can produce high yields. For the crop under consideration, the soil has favourable physical properties, has a moderate or high fertility level, and is responsive to good management. Provided economic and other conditions are satisfactory, the crop can be recommended for the soil.

Suitability class 2, moderately suited

Under good management the crop grows moderately well, or is subject to occasional hazards or failure, or requirés extra effort (expenditure) to produce high yields. The soil may have somewhat unfavourable physical properties, like being subjected to wetness or having a low fertility level. The response to management may be low.

Suitability class 3, poorly suited.

The crop will either not grow, it will produce poor yields or it will be subject to severe hazards or failure. The soil has unfavourable physical or chemical characteristics that can not easily be amended, or occurs in an unfavourable climatic environment for the crop.

Response to management is low.

Suitability class 4, not suited

The crop will not grow or will grow only after expensive land improvements have been carried out, such as drainage. The crop cannot be recommended for cultivation.

Table 5 shows the relative soil suitability for the major crops grown in Kamena and for grazing.

The table refers to rainfed crops. Due to the nature of the topography and the existing socio-economic conditions, irrigation has been left out, because it will imply high cost management, Fig. 10 shows the land capability of Kamena in relation to facets.

8.3 CROPS AND GROWTH REQUIREMENTS

Maize (*Zea mays*). It has been said that in the Central, Southern and Copperbelt Provinces, most maize comes from the 'small farmers' (Mbewe 1979). Maize grows well on virgin land in Kamena, but it depletes nutrients fast. Crop rotations help maintain good yields better than monoculture, especially with leguminous plants. Soils below p^{H5} may require lime. Maize is grown on the interfluves mostly for commercial purposes.

'Early maize' for home consumption is grown in the *dambo* margins.

TABLE 5. SOIL SUITABILITY FOR CROPS AND GRAZING UNDER RAINFED CONDITIONS

SOIL SERIES	LUB CAPABILITY CLASS	MAIZE	TOBACCO	FINGER MILLET	SUNFLOWER	SORGHUM	SUMMER GRAZING	WINTER GRAZING
Ibala (1a)	S1	1	1	1	1	1	2-3	2-3
Ibala (1b)	S2d	1	1	1	2	1	2-3	2-3
Chibela	S2e	2-3	2-3	1-2	2-3	2	2-3	2-3
Fisebe	S2w	2-3	3-4	3-4	2-3	2	2-3	2-3
Nika (4a)	S3w	3-4	4	3-4	3-4	3-4	2-3	2-3
Nika (4b)	Gw	4	4	4	4	4	3-4	1
Nika (4c)	Gw	4	4	4	4	4	3-4	1
Nika (4d)	Gw	4	4	4	4	4	4	11
Muchenga	S3w	3-4	4	3-4	4	3-4	3-4	2-3
Nkutu	S3e	3-4	3-4	2-3	3-4	3-4	2-3	3-4
Mabwe	Uzr	4	4	4	4	4	3-4	3-4

NOTES: 2-3 or 3-4 and so on are border line cases.

KEY 1 well suited 2 moderately suited

3 poorly suited 4 not suited

Tobacco (Nicotiana tabaccum). This crop grows well on the Kamena interfluves and piedmonts. It can tolerate acidic soils (pH 4.5-5.8) and prefers light, deep and well drained soils. The best crop yield is on virgin land. Unlike other crops, it is not the yield per hectare that matters, but the tobacco quality!
Sorghum (Sorghum sp). It is very well adapted to semi arid regions because it is resistant to moisture stress. It tolerates high heat and drought conditions. It has less leaf area compared to maize, and thus its resistance to dry spells. Its root system is extensive and covers a wide area (more roots per unit volume compared to maize, and therefore it absorbs more moisture). It does well in soils with a pH 5-5.8. It removes a lot of nutrients and thus fertilizers (nitrogen) have to be applied).

Finger millet (Eleusine coracana). It tolerates some dry periods in early growth. Generally, a lot of input of fertilizer is required. It can grow on shallow soils in steep slopes of even 10°, but this should be avoided in Kamena, for it creates soil erosion.

Cotton (Gossypicum hirsutum). Though not grown in Kamena, it can perform well on the Ibala Soil Series (interfluves). Rotation is a must. pH values more than 5.0 are suitable for its growth.

Sunflower (Helianthus annuus). Any soil that provides or produces a good maize crop is suitable for sunflower. It is deep rooting and therefore drought resistant. pH values of 4.5 and above are suitable for it.

Groundnuts. (Arachis hypogaea). They prefer light, sandy and well drained soil for easy shell penetration and ease of harvest. Suitable pH values are 5.5-6.4.

Cassava. (Manihot esculenta). It possesses a wide adaptability for different soils. It is a perennial crop and so can survive, in case of a year with little rainfall.

Banana. (Musa sapientum). Can tolerate quite a wide range of soil conditions. However it requires a lot of fertilizer and a soil with a high water holding capacity such as edges of dambos and streams.

Citrus. Rare in Kamena, but can perform well on Dambo fringes where simple irrigation can be practised.

Sugar Cane. (Sacharum officinarum). It does well in the dambo area or where simple irrigation is practised.

Vegetables. The dambo (margins) are the key to vegetable growing throughout the year.

8.4 ANIMAL FEED

Generally as there are few domesticated animals in Kamena, pasture and fodder crops will not be discussed. The discussion is on the natural vegetation as a source of food for the few ruminants in Kamena.

With numerous problems faced by the people to acquire tractors for ploughing, animal draught could be an answer to their problems; despite the dangers from the tsetse fly zone to the south.

Cattle if kept, may at times when the nutrition content of the grass is low (dry season) feed on the leaves of the Miombo tree species. Trees may be lopped to a height cattle can reach.

This browse is of high protein content but lacks suffient energy when taken alone. For example trees such as Brachystegia spiciformis, B. boehmii and Isoberlinia splobifora make good browse.

Crude protein from B. spiciformis is 24 percent in September when that of grass is about 1 percent, and 17 percent for I. splobifora when grass is 2 percent (Chimwano 1978).

Crop byproducts for example, maize stalks, groundnut straws and finger millet stubble can also be used as supplementary feed. In fact many crop residues can make good animal feed.

Finally though the dambo grasses can be used for grazing purposes in the dry season, the annual bush burning usually destroys them. Therefore it is important to collect and store crop residues for animal feed.

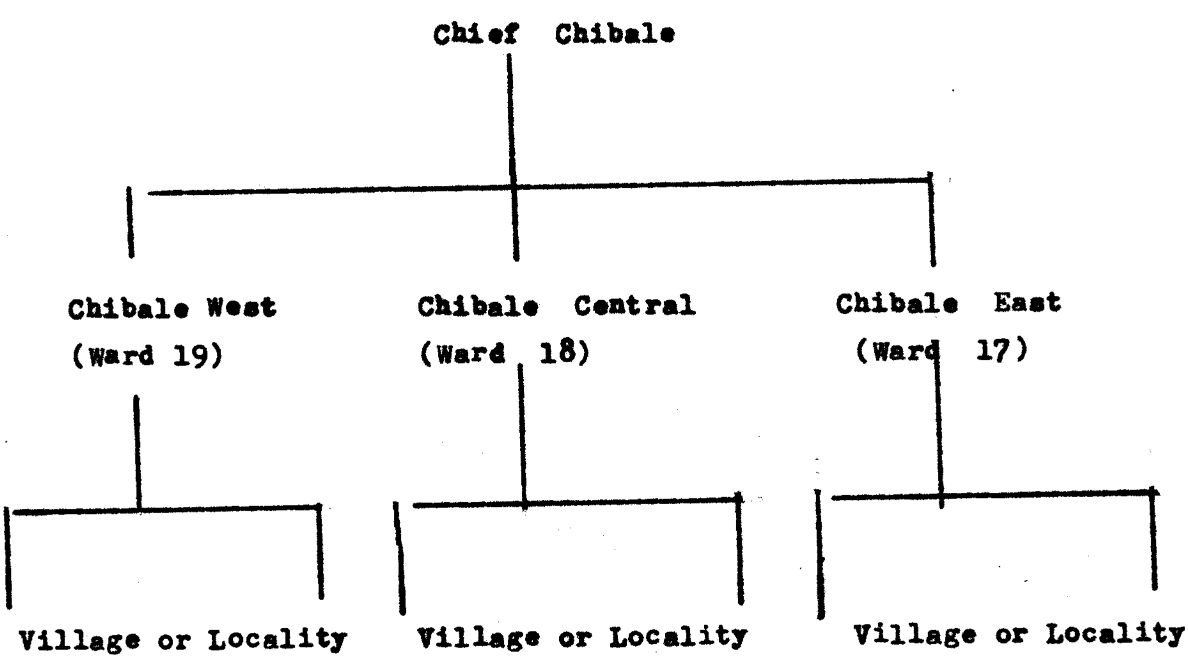
CHAPTER 9

SOCIO-ECONOMIC CONDITIONS AND THE PRESENT LAND USE.

9.1 POPULATION

According to the 1969 census, Serenje District as a whole had a population of 52,981 people. The estimated mid 1979 population for the district only, was put at 62,000. The study area covers mostly what is broken down into the Chibale East Polling District Number 17 (Central Statistical Office 1974). Alternatively it is also known as Kamena, Ward Number 17 (District Agricultural Office 1977). Serenje has altogether 19 wards of which numbers 17, 18 and 19, are in Chief Chibale's area.

The land as the first name suggests is trust land belonging to Chief Chibale. It is administered in the following manner as illustrated in the diagram below:-



Each ward is headed by a councillor, and on village level he/she is the headman. On top of the village hierarchy is the chief. On a district level a step further on top is the district secretary and finally the district governor as the topmost official in the whole district.

Kamena has a total population of 1,752 people of whom 841 are male and 921 female (Central Statistical Office 1974). Its total area is 1,052 km^2. This then gives it a population density of 1.67 people per square kilometre. The table below, (Table 6) shows the distribution of population by age group in Kamena.

TABLE 6 The Distribution of Population by Age Groups (in years) 1969.

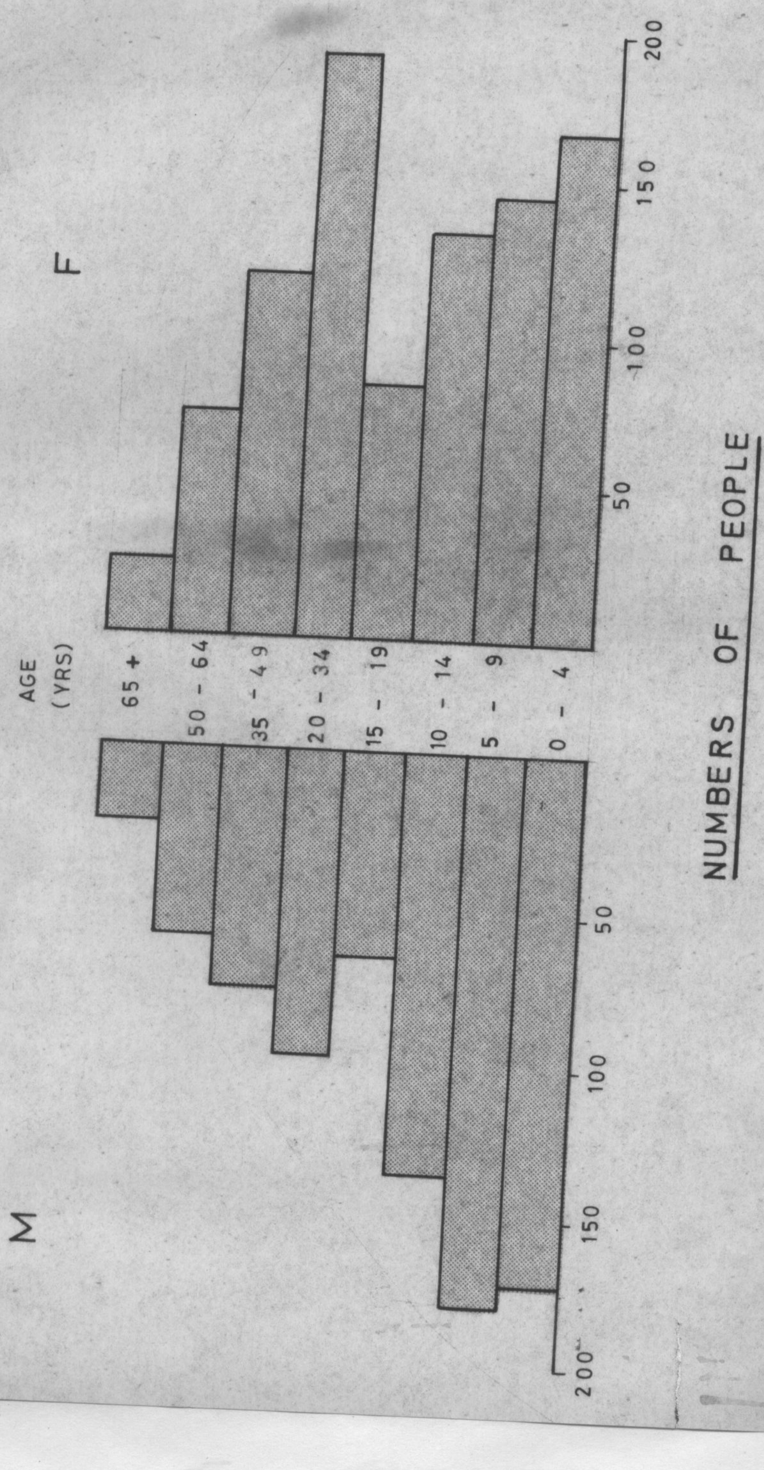
SEX	TOTAL	AGE GROUP	0-4	5-9	10-14	15-19	20-34	35-49	50-64	65+
M	841		173	179	141	67	102	83	66	30
F	921		167	144	132	84	188	118	77	17

SOURCE: (Central Statistical Office, 1974)

Figure 11 gives the population pyramid for age groups in Kamena.

From this pyramid, the majority of the population is under 15 years of age. Of interest too is the low population for both sexes of those aged between 15 and 19, showing perhaps a migratory

Fig:11. POPULATION PYRAMID OF KAMENA (1969)



trend towards the towns. The 'normal' working age is between 20 and 49, and it shows that 29 percent of the males have migrated or are absent, while it is the largest group for the women. A fact worth noting is that on the whole, people aged above 35 (21 percent) are few, indicating a trend that would perhaps be found in towns. The general working age has been assessed by the author to be 20 to 49 years old.

The village concept, as defined in the Central Statistical Office, Polling District Census (1974), is rather vague. It simply uses village/locality in its population counts perhaps to make the work easier. What it has done it seems, is to take names (and add on some more) as they appear on the 1:50,000 scale topographical maps of 1969, as a base for defining a village/locality. A particular spot having houses concentrated together is counted as one village, while a lone house or houses 200 metres away or less is also counted separately. This is perhaps why the census does not differentiate between a village and locality. Another example is that the population in a village/locality varies from as low as 2 to as high as 59 (Central Statistical Office 1974). It seems therefore, that at times, the enumerators took families or households to represent villages.

Bearing this in mind, all villages/localities were counted but at this level, there was no differentiation of age groups, but only between sexes. Altogether the number of villages/localities was put at 106, making the average population per village/locality as 16.6 persons.

The Serenje District is occupied by the Lala people who are matrilineal. Polygamy is common and this also means the man spreads out his time among his wives, usually about two to three, in other words he must live in the wife's village, and thus if he has more than one wife, he has to move from one village to the other. Being a rural population, it means their main occupation is agriculture. The Lala practise what is known as the 'Small Circle Chitemene System'. (Trapnell, 1953). Trees are felled at breast-height level or less. The branches are then stacked in circles, or even rectangular shapes of varying dimensions, and are burnt to make a seed bed for mostly finger millet (*Eleusine coracana*).

The education level in the area of study was found to be of quite a low standard. The average standard was found to be up to grade four. Two reasons were given for this, firstly parents want to farm and hunt with their boys at an early age, and secondly, that the parents cannot afford to clothe their children nor buy stationery, and so the children lose interest in school.

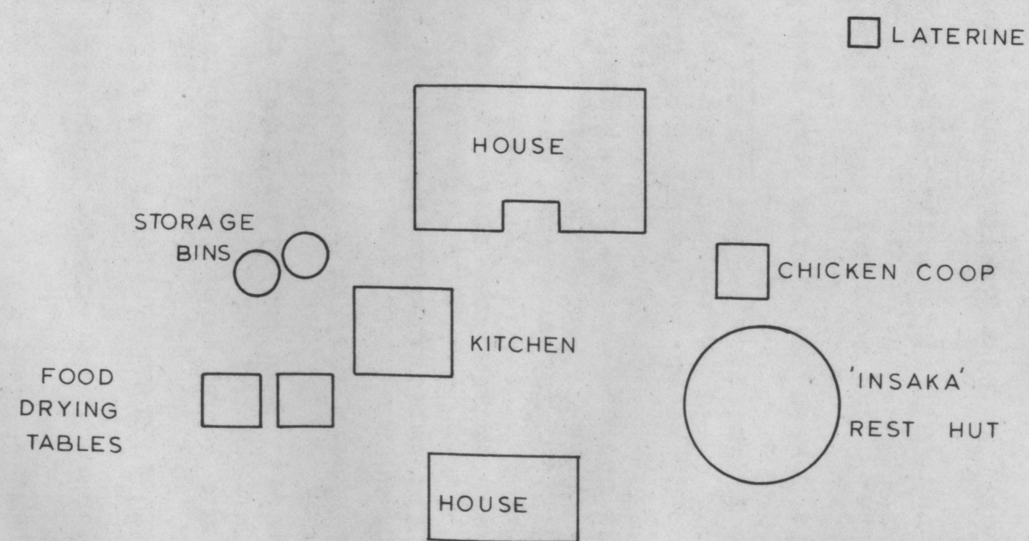
Births are not registered except those at the hospitals and local churches. There are a number of churches with the Jehovah Witness Church dominating. Local churches will only register their members. Deaths too are not registered. However for marriages this can be done at the District Office or Boma in town if the couple so desires. Sometimes the

Rural Council registers come to villages but do not force the people to sign up. However people who are members of churches are forced to register. There was a ruling from the chief that those of marriageable age who were not registered would be sent to rural reconstruction camps to learn farming skills. However no evidence of this was observed.

There is no clinic in this area of study and the nearest health centre is in Serenje town with the distance to hospital varying from 20 to as much as 40 kilometres away. Diseases amongst the young which are prevelant are scabies, coughs, colds and malaria. For the elder folk, eye diseases and malaria are common. There is thus a dependence on local medicines.

The typical village/locality may consist of as little as 6 buildings or less and up to as many as forty or more (see diagram 12). The buildings consist of sleeping quarters, kitchens, tobacco curing barns, grain storage huts, opean eating shelters and so on. Two types of houses are found to be common. There is an increase in the mikanda or brick type of houses. These are houses built from home made bricks using the local sandy clay soils. The roof may consist of tree poles with reeds or even corrugated iron sheets. The other type is the common tree pole house, with clay coating on the outside and inside. This is now seemingly out of date. Houses are generally being built in a rectangular fashion as opposed to round structures.

Fig:12 TYPICAL VILLAGE LAYOUT



9.2 LAND TENURE

Eight main landscape (terrain) facets were identified in the study area namely dambos, piedmonts, plateau and valley interfluves, valleys, inselbergs, ridges and escarpments. Of importance in this section will be the first four mentioned above. Village sites and fields will be related to land facets.

The choosing of a site for a village does not necessarily depend on how close to the road a suitable place is situated. Water is the most important determinant so as to shorten the distance from supply to house. Therefore interfluves, areas above the dambos and piedmonts were the most usually settled in facets. A common practice to ascertain if water was available was as follows; planting cassava in the dambo margins or within the drier seepage zone in the height of the dry season. (October for example), and if the crop grows well, it is an indicator of the suitability of an area of providing water even in the dry season. This indicates that water supplies which are usually obtained from digging wells within the seepage and upper wash zones in the dambo will be consistant throughout the year.

Within the typical villages, three types of cultivation are observed. These are firstly permanent fields (measured fields by the agricultural assistants and party officials), secondly semi-permanent or chitemene fields (prepared by the individual villager), and thirdly the subsidiary gardens (fields usually near the homes, of varying sizes for crops grown in small quantities). Subsidiary gardens again are owned and demarcated by individual farmers and have associated with them different land sites for various crops.

Permanent fields are if possible selected such that they are as near to a village as possible, with the main aim being to select a sufficient area for permanent cultivation, as allowed by the authorities. Factors such as stoniness and slope of land must be considered. Facets favoured for such fields are plateaux/valley interfluves and piedmonts. Three years is usually the maximum term which each plot of land is continuously used.

It was found that with the chitemene fields, ground conditions were sometimes not taken into consideration and on several occasions trees on quite stony and steep ground were felled and the area cultivated. A point to note is that near settlements or villages, chitemene fields tend to occur above the piedmonts, that is in escarpments; and slopes were found to be as high as twelve degrees. However, in the remote areas where such fields were common, plateau/valley interfluves and piedmonts were the favoured facets and have low to moderate slopes. Trees are cut and piled up in the chitemene fields ready for burning in October, so as to avoid the wind in August-September, which might otherwise blow the ash if burning takes place earlier.

As a general rule, subsidiary gardens are found to be near the villages. The favourite land facets are the dambos and areas just above them, and areas near the river banks.

Fig 13 illustrates the position of typical villages and field sites (land use) within a given area by means of a profile diagram.

Distances from villages to chitemene fields varied from as near as two kilometres, to as far off as twelve kilometres or more. The permanent fields are either next to villages with additional or other ones being as far off as five kilometres.

The site for a chitemene field is assessed by two or more members of a family or relatives. As stated earlier, if it is to be near settlements, the steep uplands or stony areas are chosen for such purposes. However, since it is against the law; the people travel far to clear such forests. So the determining factor as to which facet will be cleared if the chosen site is far from settlement, will be the extent of regenerated tree growth, in other words if the trees are considered mature enough to be cut. (The period of regeneration is 20-30 years; on the average 15 years). The actual area of cultivated millet per head requires as much as 11 times the area of woodland to be cut (Peters 1951). Once a site has been chosen, a semi permanent hut is built there (distance to water is not a prominent factor here). People go to their chitemene fields (nkutua) in May (because it is cooler then), and build their huts of poles and grass during this month. From June to August they cut the trees. At the end of August and beginning of September, they begin to return to the villages. They go back to the nkutus to burn the felled and dried branches towards the end of October to avoid winds and early rains and also to make sure that the big branches are also dry as to thoroughly burn and prepare ground for finger millet.

How does a villager manage a far away nkutu and a nearby home permanent field? Either:-

a) he spends two weeks at the nkutu, then two or less than two weeks harvesting maize in the home fields,

b) he goes alone to the nkutu, leaving the wife and children harvesting in the permanent field,

c) both wife and husband and other relatives go to the nkutu, to speed up the work.

As mentioned earlier, the chitemene system has been discouraged and actually may be a punishable act. However, people have disregarded the law, and taken advantage of it because it contradicts with a traditional custom. Every year chiefs set up dates when the forest should be burnt, so that new young leaves may flush and make food for the caterpillars, which are a cherished food among the people. The burning time coincides with the period the chitemene branches are dry, and ready for burning, and so people take advantage of it.

As for the permanent fields, most industrious farmers have about (three acres)* 1.2 hectares. The whole family participates in cultivating these fields. A case study of a farmer with three acres of land is discussed. This farmer is aided by his wife and in-laws in the work. They spend an average of one month during the pre-cultivation season to prepare the fields.

The growing period differs as far as work to be done is concerned. Two days per acre* is spent for putting fertilizer as top dressing to the fields. On the other hand, weeding time per acre is four days. One acre of maize takes an average of one week to harvest.

The general working schedule on a working day is from 06.00 hours to 12.00 hours, then from about 15.00 hours to 18.00 hours; from Monday to Saturday. However it was observed that beer was brewed irregularly, and this disrupted working schedules, because all work stopped on such days.

One acre in a very good season gives the farmer 11 to 20 bags of maize (one bag is 90 kg in weight). It was also found that out of an acre of maize, approximately 25% of the crop was kept for home consumption.

*NOTE. In Kamena land is still measured in acres.

A comparison between a chitemene field and a permanent one was studied. Permanent fields involved "too much sweat" because of ploughing, weeding, pesticides and so on. The chitemene field was less tiring because it only involved cutting of trees as the tiring part. After piling and burning, *seeds were just broadcast into the ashes, and the* only time needed to go to the chitemene was to see if growth had occurred or at harvest time.

9.3 LAND PROBLEM

A man wishing to cultivate a permanent field, goes in search of unoccupied and 'non-booked' land and plants his crops. For those without permanent fields demarcated by party officials and agricultural assistants, they may request the latter to assign them fields for farming. To begin with, the officials give these villages 2 acres (or 0.8 hectares) one for maize, the other for finger millet. If a person has been allocated a field and does not wish to use it at once, he may put stumps into the fields boundaries or mark the tree barks so that no one uses the field. This is another reason why people mark out their proposed fields and also it ensures them against using an authorised field for chitemene farming.

The land traditionally belongs to the Chief. His words to the Ward Councillors before each growing season, are that they start preparing demarcating stumps in the forests to assign people fields. Then once this is done, farmers whose areas are defined or marked by stumps, have their names sent to the Chief and the Boma. If the cultivation and harvesting results are for no genuine reason, not good enough in the assigned fields, the farmer is reprimanded by having the fields taken away from him.

A farmer wishing to have a larger piece of land than normally allowed, may ask the agricultural assistant to inspect such sites. Once the assistant is satisfied with the farmer's past and present records in farming, he may recommend the farmer for a loan. Good farmers are allowed to choose as large an area as they can manage, so long the land does not extend into someone else's.

Normally in recent years, ploughing and clearing of fields was done by the mechanization unit (mobile) of the agricultural department. They used to camp in villages, and the extension officers would give them lists of those farmers prepared to pay to have their fields ploughed at K4 per acre. During the period of study, the unit had no working vehicles. Nevertheless, the Agricultural Finance Company (A.F.C.) had eight tractors which were ploughing at K11 per hour for unused land. (1 acre takes approximately 2½ hours to plough, therefore a total of K25). The farmers were complaining that K11 was just too much. The charge for used land is K10 per hour.

Sometimes certain villagers sold their once cultivated fields at about K8 or more per acre. This is an offence. However reasons given for such actions were as follows:-

a) because land nearby the villages is in great demand, the owner will charge the potential buyer for labour which he (owner) had put in to clear and farm it.

b) they (villagers) are generally poor and need money badly.

Kamena has one main badly maintained gravel road which passes from the Great North Road, down south to Chief Chisomo's area. *Infact at the Lukusashi river the bridge is nearly* worn out. It is found that villages are mostly concentrated along the road. This was not the case, some years ago. Most people used to live some fifteen kilometres from present sites near the main road. Since then, there has been a lot of movements to the present sites. Reasons for such present day occupation stems from a governmental order for village regrouping so as to speed up village productivity and provide social amenities, because before this they were quite scattered. Thus each person had a farm allocated to him, and together the community formed a village productivity committee or grouping.

It seems not to have worked satisfactorily however. Regrouping they were told, would mean schools, good water, clinics and transport. This has not been all been done, and there is no clinic nor transport service in the area. There are three schools, two going up to grade four, one up to grade seven.

Evidence of population increase is seen. Land near concentrated villages is in short supply, and people have to travel far in search of places to cultivate. Infact, a 'scramble' for land exists, such that people have to put stumps in the ground, or make marks on tree barks to 'book' that land for the next farming season. This land scramble in such a manner without authority backing, is usually for chitemene cultivation although, it can also be for the permanent cultivation fields. Of interest here was that once a person demarcated a field in such a manner, even the agricultural assistant and party officials could not repossess it.

In most villages which were not densely populated, the wells in the dambo, during the height of dry season, when the water table level was low, never run out of it (water) during the day. In one village which was heavily populated, during months of September and October, people had to rush to the streams and wells early in the morning to collect water, a clear indication of the population being too large for the particular spot and the water amount available. There were even stories of people considering moving to other areas (splitting up and returning to their old system of scattered and mobile villages).

9.4 CROPS GROWN

The crops in the study area have been split into two groups, namely commercial level crops such as maize, tobacco, sunflower and the subsistance level crops, such as beans, finger millet, sorghum, groundnuts and so on.

a) Commercial level crops.

1. Maize. This crop is grown in piedmonts and interfluves. The 'early' maize is grown in dambo margins for home consumption. Since maize is considered as a commercial level crop, it is grown mainly in permanent fields.

With the establishment of National Agricultural Marketing Board depots (NAMBOARD), the growing of maize has been accelerated. NAMBOARD has also provided fertilizer, pesticides and agricultural tools. Farmers are encouraged to grow maize and taught how to apply pesticides and fertilizers by agricultural assistants. NAMBOARD provides sacks to farmers at a small fee. The general trend for maize is that most of it is planted for selling as a cash crop.

Maize in the permanent fields may be rotated with finger millet for the second year, and finally maize in the third year. Subsidiary gardens are also popular for maize cultivation, especially dambo margin in September-October, and this maize is for home consumption.

Though the total acreage under maize was not given, sales of maize in Kamena have been as follows:-

1975/76 season	3,062 bags.
1976/77 "	2,149 "
1977/78 "	2,521 ".

SOURCE: DISTRICT AGRICULTURAL OFFICER (1980).

Reasons for drop in production are the poor rainy seasons after the 1975/76 one, and the high price in fertilizers.

2. **Tobacco.**

Tobacco favours the piedmonts and interfluves where soils are lighter. The tobacco depot in Kamena belongs to the Serenje Family Farming Schemes. It was established in 1974. Production rates in 1977/78 season were 6,000 kg (42 farmers). This according to farmers was a poor harvest and the blame was put on the Tobacco Board of Zambia (T.B.Z.) who provided facilities for ploughing late. Again in the 1978/79 season only 42 farmers grew it and reaped 14,000 kg.

It was also found that given the average 3 acres of permanent fields, those who decided to grow tobacco used one acre for it. The deal here was that Tobacco Board of Zambia would plough all his fields, if a farmer decided on tobacco growing. If a farmer's tobacco crop did not do well, and therefore could not pay back the credit facilities having been offered to him by Tobacco Board of Zambia, then the balance was obtained by the Board from part of the farmer's maize fields.

Tobacco Board of Zambia also provides the required seedlings per acre at K25. Ploughing is done on T.B.Z. credit at K9 per acre (1978/79 price). (This year 1979/80) a strike by farmers was predicted because the charge was expected to be done using clock metres per hour, (coming up to approximately K25 per acre). Another complaint from farmers was the high price of fertilizers.

Many problems have faced the tobacco farmers in Serenje. Machinery and ploughs keep breaking down, and there are shortages of spare parts and so on. A lot of time elapses before the machines can be repaired, such that by the time they are put in working order, planting time has actually passed. In the 1978/79 season, tractors were in bad shape, and a lot of time was spent in the workshop repairing them, such that they could not be used to transport firewood for curing tobacco to the farmers, resulting in the crop rotting.

Another problem is late payment for the bought tobacco to the scheme, from the provincial headquarters in Kabwe. This results in farmers accusing T.B.Z. that they (farmers) are unable to hire workers to stump new fields for the next season.

Farmers selected to grow tobacco are chosen by the section manager of the scheme or his commodity demonstrators. They go with the councillors to meetings and explain how the T.B.Z. functions and so on. Those interested come to register and are given a trial plot with seedlings with those proving to be successful at tobacco growing being chosen.

The tobacco type grown in Serenje is virginia. An excellent crop is obtained if raised on virgin land, because it reduces pest attack and the land is fertile. The old land is then used for maize or another crop.

3. <u>Sunflower</u>. Very few farmers grow it. It is grown in parts of the permanent fields (plateaux, interfluves and piedmonts). Sales in Kamena area have been as follows:

1975/76	-	16 bags
1976/77	-	15 "
1977/78	-	1 bag.

SOURCE: DISTRICT AGRICULTURAL OFFICER (1980).

Infact at the time of study, only two farmers grew it. Although it is simpler to grow than maize, it is the seeds that are expensive, being sold in bags of 50 kg at K32 each which the people can't afford.

b) <u>Subsistance level crops</u>.

1. <u>Beans</u>. This is a common subsidiary garden crop grown mostly on mounds in the seepage sites of <u>dambos</u>

4. Groundnuts. They are commonly grown in subsidiary gardens (the upland soils above the dambo), piedmonts and interfluves. Farmers just sell a little of their crop usually to neighbours. The reason for low productivity is the non-availability of seeds. The soil (sandy soil and especially after chitemene burning), is good for groundnuts but the seeds are sold in 50 kg bags at K28 each bag.

Cassava. It is a common subsidiary garden crop grown in the mounds in the dambo margins mostly. It can also grow well in other land facets such as piedmonts, interfluves, and areas above the piedmont. It is a staple food, and is mostly used to mix with maize flour.

Livingstone potatoes. These are grown on very large mounds, within the seepage and upper wash flanks of the dambos. Once again, they are grown for home consumption.

c. Fruits.

Bananas are the most common fruits, and are grown mostly where soil for brick making is dug from (mikanda as these ditches are called). Such places may well be on upland soils above dambos, piedmonts and interfluves, the aim being to cut drainage channels to transport water to the plants. The mikanda is first buried with grass, manure and so on. With the onset of the rains, the seedlings are put into mikanda which has now soil covering it. This is why most banana plants are found near homesteads and supply shade for villagers in hot seasons too.

Mangoes are not as common as bananas, but a few are grown around the homes. As for citrus fruits they are sold at 50 ngwee per seedling in Serenje, but the farmers are not just interested, and hence very few grow them even around houses.

d) Forest produce, livestock and game.

1. Forest produce. Three common wild fruits are mupundu (Parinari curatellifolia), masuku (Uapaca kirkiana), and mufinsa (Syzygium guineense sp.). The mupundu favours mostly highland, except in the dambo and inselbergs. Mufinsa is a dambo tree. Mupundu and masuku could be of great commercial value, especially to town dwellers and wine manufacturers.

When such trees are near villages they are usually left standing. This can also be so even in the midst of a proposed chitemene field, if concentration of these fruit trees is high enough.

2. Livestock. The northern area of Kamena, (north of the Fukwe river) borders, a tsetse fly infested area,

to the south (across the river) towards Chief Chisomo's territory. Chisomo's area lies in a valley with plenty of game. At the time of study only four people in Kamena had cattle which were used for ploughing. It was felt that cattle could be kept, but at a safe enough distance, and could do well feeding on succulent dambo grass, which is flushed just after burning. Besides with the type of topography in the area, mechanised agriculture has a disadvantage over ox ploughs.

Goats are not favoured by the Lala people, and only two people kept them at the time of study. Reasons for this unpopularity, were that since there were no herdsmen to look after them, the goats destroyed maize, bananas and so on.

Chickens were kept but are rarely consumed, except on very special occasions.

3. Game. The animal population is considered to be low where there is a concentration of people. Common game animals include duiker, wild pigs and antelopes. There is a lot of game meat however, which finds its way into Kamena and Serenje town from Chief Chisomo's area. Common small animals such as bush mice and moles are a favourite amongst the Lala.

9.5 VILLAGE FARMERS AND THEIR PROBLEMS

Serenje has a farmers college, where villagers are sent on courses to learn improved farming methods. However due to the present economic crisis, it is not functioning up to the required standards. Many of the successful farmers interviewed had attended the college. It was found that these farmers did not have any chitemene fields. One successful farmer runs a market garden by the Lukusashi river, where he has harnessed one of its tributaries and dammed it for irrigation purposes. He grows vegetables, fruits especially bananas and sugar cane.

Another group of successful farmers were termed 'dambo farmers'. This group made use of the various zones within the dambo, and the immediate upland for successful farming throughout the year. Within the dambo zones, they grew sugar cane, maize and vegetables.

These farmers prefer to work, eat and earn also throughout the year as they put it, unlike those who keep chitemene fields.

Problems faced by this group of farmers again are lack of transport for their produce to markets, and no immediate market (fellow villagers), because the people have no money and the high price of fertilizer and farming implements.

Locally there are a few agricultural commodity demonstrators. They go to teach farmers individually. Kamena altogether had about two demonstrators. This meant that too few farmers are seen. The farmers who go to attend the college are usually the inexperienced ones, and are chosen by the demonstrators.

9.6 CONCLUSIONS

Fig. 14 is a cross section of a part of Kamena showing facet/vegetation/soil and lithology relationships. (Page 129a).

Fig. 15 is the extended legend. (Page 129b).

CHAPTER 10

RECOMMENDATIONS

Taking an overview of the situation, the general recommendations would be as follows:-

10. AGRICULTURAL

i) Control of chitemene farming must be rigidly enforced because it takes place on steep slopes near settlements causing erosion and gullying. This can be done by educating the villagers.

ii) More use of the dambos by the local people especially in vegetable farming, rather than just an area for 'early maize'. With such use the potentials of other crops may be investigated and as shown earlier, small scale commercial farming should be the aim. This can be done with the help of the college or agricultural demonstrators.

iii) Kamena has potential for crops like beans, sunflower and groundnuts. However the seeds are sold in 50 kg bags which people cannot afford. Packing in small quantities could be an advantage.

iv) Trials for crops (field days), should be carried out by the agricultural assistants on some of these crops with potential in Kamena.

v) People must be influenced to keep livestock for ploughing their fields. Droppings from animals may supplement fertilizer in local gardens. Of course, tsetse fly prevention must be strictly followed.

vi) Credit facilities must be offered since the people are now regrouped.

vii) If a chitemene field is cut, a fire - break must be built, and certain important tree species be preserved.

10.2 SOCIAL, ECONOMICAL AND INSTITUTIONAL

The recommendations in the preceeding section are the main consideration of land use planning. These also need involvement in general upgrading and improving the social and economic structure of the area.

viii) Upgrading Kamena by providing social amenities is a must. A bus service to town is required, and so are a clinic and a store. None of these exist at present.

ix) The road to Kamena must be graded, using available materials (gravel of which there is an abundance). The Lukusashi river bridge must be repaired because it is falling apart. There is a large farming community to the south of the river bridge, which might be cut off if the bridge is not repaired.

x) Upgrading of other motorable tracks off the main road into the interior, to open up more farming land must be done. This is because a considerable percentage of the most suitable land facets are far from the main road.

xi) The government must re-organise the Serenje Farmers College, so that it functions perfectly for training the people.

xii) Kamena extension workers should be given bicycles to do their work effectively, and they must organize discussion groups.

10.3 FURTHER RESEARCH

xiii) Further studies or research in Kamena should be detailed to produce accurate soils and geomorphological maps and other work, such as quantitative studies of lengths of fallows.

xiv) On forestry, the period of regeneration for different species, needed for their optimum utilization must be investigated.

xv Detailed studies of the amount of fields (<u>chitemene</u>, subsidiary garden and permanent field) each person/family has should be researched, in so as to know the actual man-land ratio. This may greatly aid agricultural planning as well as other factors.

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APPENDIX 1

THE ZAMBIA LAND CAPABILITY CLASSIFICATION. (1977)

Definition of Land Classes in the Zambia Land Capability Classification.

(a) Arable Land. Land used intensively on a sustained economic basis. Soils have a degree of self control which means they are buffered against abrupt environmental changes like too much or too little rain.

Classes C1, S1: Good arable land. Land capable of being maintained at a high level of productivity under an intensive cropping system. There are no special limitations. Good management should include normal soil conservation practices, adequate use of fertilizers and lime as well as a suitable crop rotation.

Classes C2, S2: Moderately good arable land. Land capable of being maintained at a high level of productivity under an intensive cropping system, but requiring special attention to soil conservation or crop management because of moderate limitations, or land capable of being maintained at only moderate levels of productivity due to limitations of depth, texture, wetness and so on. Response to improvement in management is high.

(b) Marginal arable land. Introduction of ley (grass or grass legume) in the rotation is required in this type of land. The net income over a period of years tends to be low.

Classes C3, S3: poor arable land: Land with severe limitations for cultivation which either greatly increase the cost of production due to cost of erosion control, drainage, liming, etc) or reduce yields to marginal levels (due to droughtiness, wetness, salinity, difficulty of seed-bed preparation etc.) or severely restrict the range of crops that can be grown satisfactorily.

Class S4 (no class C4) Very poor arable land: This class is restricted to deep Barotse sands or other very deep sands occuring in moderate to high rainfall areas (more than 800 mm annually). These soils are easily cultivated but because of extremely low fertility and droughtiness, the range of crops that can successfully be grown is severely limited. It would be uneconomical to apply improvements to such soils which would make them suitable for medium or large scale commercial farming of general crops. (Cassava is possibly the only field crop suitable for commercial production on such soils; intensive vegetable production under irrigation may also be possible on certain soils). This class has only one serious limitation, its texture.

(c) Grazing land: Class G. This land is suitable for grazing as opposed to cropping. For instance, Gw describes land suitable for grazing but too wet for arable cropping. Gs, Gd, Gr and Gg indicates land suitable for grazing, but not arable cropping because of steep slopes, shallow soils, rocks, gravely or stony topsoil respectively. This land may be grazed during and shortly after the rains. Gw is too wet for grazing in the rains, and thus is suitable for winter grazing only.

(d) Unsuitable land:
Class U. This includes land with too severe limitation for arable cropping or grazing. Its uses may be wildlife, recreation, building sites or other non-agricultural uses. The symbol Uw indicates land remaining permanently wet, and thus unsuitable for arable cropping or grazing at any time of the year. This land is described as the very wet streamline area, within a dambo landscape unit. The rest of the dambo is generally useable for grazing and has been given the symbol Gw. Subclass Uw may be used for fishing, watering points, collection of thatching material and even for rice cultivation. Land unsuitable for arable, cropping or grazing due to very steep slopes, rocks, gravelly soils will be classified as Us, Ur, Uz respectively. It may be useable for watershed protection, forestry, recreation and engineering purposes.

From the above descriptions it can be seen that land subclasses can be used for lower land subdivisions. These are symbols reflecting the type of limitations used to further subdivide land into subclasses. Limitations are ranked according to their seriousness and no more than two symbols are given at one time even though the number of limitations are more. Land capability classes C1 and S1 are without limitations.

Land in classes C2, S2, C3 and S3 can sometimes be made highly productive for general agricultural crops, as land in classes C1 and S1. This however will require expenditure, and effort, which may reduce profitability and also be uneconomical. Intensive management may if employed produce high yields of crops like cabbages on low class soils, including S4 soils, by the use of kraal manuring and irrigation. (Woode 1980, L.U.B., 1977).

Permanent land improvements may re-classify land into a higher class, by removing or reducing the natural limitations, on which original classification was based. This may be done by draining non-arable wet lands, land levelling irrigation and so on.

Summary of the L.U.B. land capability classification

	Type of Land	Land class
	ARABLE	C1/S1
		C2/S2
	MARGINAL ARABLE	C3/S3
LAND		S4
	GRAZING	G
	UNSUITABLE	U

Symbols for land capability subclasses.

a - salinity/alkali

d - depth (to a limiting layer)

e - erosion.

f - fertility

g - gravelly or stony topsoil. (hindrance to cultivation)

m - large termite mounds (hindrance to cultivation)

r - rock outcrops, boulders or irregular surface relief. (hindrance to cultivation).

s - slope

t - texture (either heavy (cracking) clay in C-class soils or sand or loamy sandy to below or above class limit in S-class and C-class soil).

w - wetness

z - gravelly or stony subsoil.

Of interest in the land capability classes, is the placing of the upper parts of the dambo into class symbol Gw for grazing only. The subclass Uw is described as being suitable for rice cultivation, but without proper explanation it may be overlooked as just unsuitable land.

Soil fertility (f) is described as the ability of a soil to provide an adequate and balanced supply of materials for satisfactory plant growth. Soil fertility is regarded as a limiting factor where soil is:

- very strongly acid and has extremely low reserves of such minerals as calcium and magnesium, and/or
- has a very low cation exchange capacity (CEC) per 100g clay, indicating a low capacity to retain applied nutrients, or
- in areas of 800mm or more mean annual rainfall, has sand to sandy loam textures, extending to below 40 cm, or has similar textures extending for more than 40 cm, below a finer textured topsoil. In both cases, sandy texture provides the soil with a low capacity to retain applied nutrients, against leaching by moderate or high rainfall.

Soils over acidic rocks as in the study area are given a moderate fertility limitation, where the lower subsoil has a sandy clay loam or heavier texture, and a severe fertility limitation, where the texture remains sand to sand loam throughout the upper and lower subsoil.

The Land Capability Code

Effective Depth	Texture	Hindrance to Cultivation	Limiting Material	
Slope	Erosion	Wetness	Colour	Parent material

(i) Effective depth. It is the thickness of soil available for satisfactory plant root development (which is different for different crops). In other words, it is the depth at which certain soil conditions are met which impede root development, for example the water table, hard laterite, hard rock and so on. Symbols for effective depth are as follows:-

Code symbol	Depth of limiting layer	Name of depth class.
1	More than 90cm	Deep
2	60-90cm	Moderately deep
3	30-60cm	Moderately shallow
4	Less than 30cm	Shallow
5	Rocks, stones or gravel at surface	-

In gravelly places, an allowance has to be made for the fact that plant roots are able to penetrate into the gravel area, though their movement will be restricted.

(ii) Texture. This is the relative proportions of sand, silt and clay in a soil, and it is the most important single characteristic. There are 13 textural classes as follows:-

A - sand
X - loamy sand
B - sandy loam
C - sandy clay loam
D - clay loam
E - sandy clay
F - clay
G - cracking clay
I - silty clay
J - silty clay loam
K - silty loam
L - loam
S - silt

In the land capability code, four textures are determined and recorded. These in order are as follows:-

1. Texture of the layer from the surface to 20cm. This is the texture of the first two cans augered.

2. Texture of the layer between 20cm and 40cm. This is the texture of a mixture from the third and fourth cans.

3. Texture of the layer between 40cm and 60cm. This is the texture of a mixture from the fifth and sixth cans.

4. Texture of the bottom 30cm (the last three cans) i.e. 60 - 90cm.

(iii) <u>Hindrance to cultivation.</u> Gravel, stones, boulders, rock or laterite out-crop occuring within 20cm of the soil surface, or termite mounds, in sufficient quantities to hinder or prevent normal agricultural cultivation practices. They are indicated by symbols placed after the soil texture symbols in the code.

g - gravels stones or patches of gravel or stones.
m - termite mounds.
r - rock or laterite outcrops, including loose rock fragments and boulders.

The coverage is indicated by a number following the letter, as follows:-

Code symbol	Hindrance	Coverage
-	None	less than 1%
g1	gravel or stones	1 - 5%
g2	" " "	5 - 10%
g3	" " "	More than 10%
m1	termite mounds	1 - 5%
m2	" " "	5 - 10%
m3	" "	more than 10%
r1	rock/laterite outcrop	1 - 5%
r2	" " "	5 - 10%
r3	" " "	more than 10%

Gravel includes other rocks between 2 and 75mm in diameter. Stones are fragments 75mm to 250mm in diameter. Boulders more than 250mm. Large outcrops are indicated by a separable mapping unit or a symbol on the map.

(iv) Limiting material. This is rock, laterite, gravel, hand-pan, etc, which is limiting to crop root development.

The following symbols are used:-

H - Hardpan. This is a layer of compact soil, usually found in the subsoil of solonetzic (sodium affected) soils. The layer is dense and hard both when dry and wet.

L - Laterite. This includes sheet laterite (ironpan) or densely - packed ironstone concretions sufficiently hard or compact to restrict root development or seriously reduce moisture - holding capacity.

R - Weathered rock or rock. Weathered or partially decomposed rock, or sufficiently little weathered rock present to restrict moisture holding capacity as well as hard rocks.

Z - gravel or stones, usually quartz.

If two or more limiting factors occur within the soil profile down to 120cm, the symbol for the most limiting material will be given.

All the above soil and land characteristics, fall on the first line of the code in the order given. The following fall below the line of the code.

(v) Slope. This is the slope of land surrounding the sampling point, or the average slope within the mapping unit. The following are the symbols.

Code symbol	Percentage slope	Degrees and minutes
O	less than 1%	less than 30'
A	1 - 3%	30' - 1°.40'
B	3 - 5%	1°40' - 2°50'
C	5 - 8%	2°50' - 4°30'
D	8 - 12%	4°30' - 6°50'
E	more than 12%	more than 6°50'

(vi) Erosion. Visible evidence of erosion at or in the vicinity of the sampling point is assessed as slight, moderate or severe. The symbols are as follows:

- – – no apparent erosion.
- E1 – slight erosion. Slight loss of topsoil by sheet erosion.
- E2 – Moderate erosion. Loss of topsoil by sheet erosion or light gullies, at very wide intervals, not sufficient to interfere with cultivation on a normal field scale.
- E3 – Severe or very severe loss of topsoil by sheet erosion exposing the subsoil, or presence of many small and/or large gullies, sufficient to hinder or prevent normal cultivation.

(vii) Colour. This is the colour of the soil using the "Munsell Soil Colour Charts". It is written in the code after the wetness symbol. It is considered first here because, the determination of the wetness factor depends to a large extent on the soil colour. Colour is the most easily determined of all soil characteristics, and may help to infer as what soil type is present if considered with other observable features. For example red colour of soil is usually related to iron oxides, which are relatively unstable under moist conditions. Red colour will thus indicate good drainage and good aeration. However some red coloured soils have such colour 'inherited' from the parent material, and not from soil forming processes. A grey colour often indicates poor drainage.

The arrangement of the soil colour code is by hue, value, and chroma. Hue is the dominant basic colour, Value, the relative strength of the colour.

In the land capability code, the colour is written in brackets, after the wetness classification thus for example:-

(5 YR 5/8).

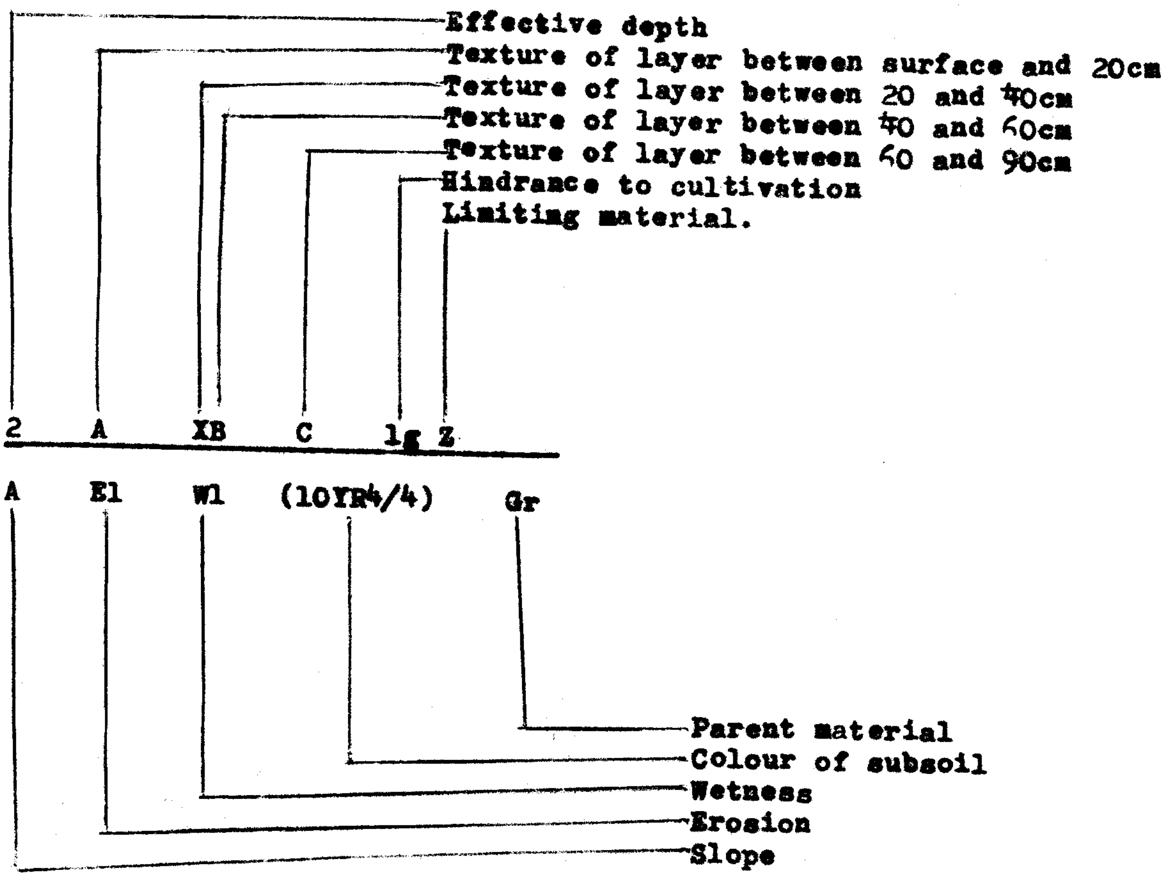
(viii) Wetness. This is measuring the degree of wetness within the rooting range during the rainy season (the growing season). A poorly drained soil will remain fully or partially waterlogged in the root region for long periods. This restricts the amount of air around the roots, and results in poor crop growth. Four wetness classes are defined in the land capability code:-

Code symbol	LUB Class	Description
-	No wetness	The soil is well to very well drained. Water is removed sufficiently quickly from the soil surface and rooting zone, that plant growth is not restricted by waterlogging.
W1	Slight wetness	The soil is moderately well drained. It is wet for short periods following heavy rainfall, or the water table rises to between 60-90cm from the ground surface during the rainy season. Drainage is sufficiently impeded to prevent the cultivation of deep rooting crops or crops particularly sensitive to wetness (e.g. cotton, virginia tobacco, some vegetables).
W2	Moderate wetness	The soil is imperfectly drained. It is wet for considerable periods during the growing season. Conditions are too wet for normal dry land crops unless these are cultivated on high ridges or beds or unless artificial drainage is provided.
W3	Severe wetness	The soil is poorly to very poorly drained: i.e. it is wet for most or all of the growing season, preventing the cultivation of dry land crops (without artificial drainage). Cultivation of rice and dry season grazing may be possible.

An aid to determine the wetness class is by first determining the characteristics listed in this order. Munsell colour at 50cm, depth of mottles, rusty root channels, position and vegetation, subsoil texture and other characteristics like weathered rock at a given depth. The Revised Standard Soil colour charts (Japan), were used for this study.

An additional symbol may be added below the code line on the extreme right, to represent the parent material e.g. Gr (granite), Gn (gneiss) etc.

A summary of the land capability code is given below:-



APPENDIX 2

SOIL PROFILE DESCRIPTIONS

Profile K1

Soil name: Ibala sandy clay loam

Mapping Unit: 1a

Date sampled: 29/8/79

Location: Kamena 156196 G.R.

Physiology: Interfluve crest

Slope: 0-1°

Parent material: Para-gneiss

Vegetation/land use: miombo/cultivation

Drainage: well drained

L.U. Class: S1

Depth (cm)	Description
0-10	Dull reddish brown (5YR4/4) dry, dark reddish brown (5YR3/4) moist, sandy clay loam, medium subangular blocky structure, slightly sticky and plastic, friable moist fine pores, fine roots, gradual boundary.
10-21	Bright reddish brown (5YR5/8) dry, reddish brown (2.5YR4/8) moist, sandy clay loam, medium subangular blocky structure, slightly hard, slightly sticky and plastic, fine pores, fine to medium roots, gradual boundary.
21-100	Reddish Brown (2.5YR4/8) dry, dark reddish brown (2.5YR3/6) moist, sandy clay loam, strong subangular blocky, fine pores, few fine roots but many medium, very sticky and plastic, gradual boundary not very clear.
100-125	Dark reddish brown (2.5YR3/6) dry, dark reddish brown (2.5YR3/6) moist, sandy clay, matrix, strong subangular blocky, strongly plastic and sticky, medium roots.

NOTE: G.R. refers to grid point reference number.

Profile K1 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002 %	Silt 0.002 - 0.05 %	F. sand 0.05 - 0.2 %	M.sand 0.2- 0.5 %	C.sand 0.5- 2.0 %
0-10	22.4	17.5	39.5	15.7	4.9
10-21	33.4	17.5	22.6	21.1	5.4
21-100	33.4	22.0	21.4	18.2	5.0
100-125	36.4	33.4	17.2	8.5	4.5

Chemical data

Depth (cm)	Ex.Ca. m.e.%	Ex.Mg. M.E.%	Ex.K m.e.%	Ex.Na m.e.%	C EC m.e.%	C E C m.e./100g clay
0-10	0.35	0.40	0.32	0.00	4.6	20.5
10-21	1.10	0.47	0.28	0.00	3.8	11.3
21-100	1.20	0.40	0.23	0.04	4.5	13.4
100-125	0.40	0.32	0.24	0.02	4.6	12.6

Depth (cm)	Org.C %	Total.N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat %
0-10	0.58	0.05	14.376	4.7	23.0
10-21	0.39	0.02	6.313	4.9	48.0
21-100	0.15	0.03	5.625	5.1	41.0
100-125	0.04	0.02	4.863	5.0	21.0

Mt. Makulu Reception nos. 80/1212-5.

Profile K2

Soil name: Ibala sandy loam

Date sampled: 10/9/79

Physiology: crest

Parent material: granite

Drainage: well drained

Mapping Unit: 1b

Location: Kamena 136127 G.R.

Slope: 1-2°

Vegetation/land use: miombo.

L.U. class: S2d

Depth (cm)	Description
0-15	Bright brown (7.5YR 5/8) dry, dark brown (7.5YR 3/3) moist, sandy loam, weak fine crumby structure, loose dry and moist, fine pores, fine roots, clear smooth boundary.
15-23	Brightish reddish brown (5YR 5/8) dry, dark reddish brown (5YR 3/6) moist, sandy loam, moderate subangular blocky structure, loose dry and moist, fine pores, fine roots, medium roots, clear boundary.
23-60	Reddish brown (5YR 4/8) dry, dark reddish brown (2.5YR 3/6) moist, sandy clay loam, massive, weak fine subangular blocky structure, few fine pores, hard when dry, slightly sticky and plastic, fine and medium roots.

Profile K2 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.2 %	M.Sand 0.2- 0.5 %	C.sand 0.5- 2.0 %
0-15	7.0	6.3	23.7	29.1	33.9
15-23	7.0	18.1	27.9	33.0	14.0
23-60	10.7	16.7	27.5	29.1	16.7

Chemical Data

Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	CEC m.e.%	CEC/ m.e. 100g clay
0-15	0.80	0.10	0.02	0.04	1.7	24.2
15-23	1.60	0.60	0.24	0.04	4.6	67
23-60	1.25	0.47	0.16	0.01	ND	ND

Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
0-15	0.31	0.02	4.629	4.5	56.0
15-23	0.66	0.05	5.813	5.2	53.0
23-60	0.39	0.03	7.626	4.8	ND

Mt. Makulu reception nos. 80/1257-59

ND - not determined. No chemicals at Mt. Makulu.

Profile K3

Soil name: Chibela sandy loam

Mapping Unit: 2

Date sampled: 10/9/79

Location: Kamena 176113 G.R.

Physiology: piedmont

Slope: 4-6°

Parent material: quartz-schist

Vegetation/land use: miombo/chitemene

Drainage: well drained

L.U. Class: S2e

Depth (cm)	Description
0-8	Reddish brown (5YR 4/6) dry, very dark reddish brown (5YR 2/4) moist, sandy loam, weak fine crumby structure, loose when dry, many fine roots, very fine pores somewhat clear boundary.
8-26	Reddish brown (5YR 4/8) dry, dark reddish brown (2.5YR 3/6) moist, sandy clay loam, slightly massive structure, slightly hard, slightly plastic and sticky, fine pores, fine to medium roots, gradual boundary.
26-50	Reddish brown (2-5YR 4/8) dry, dark red (10R 3/6) moist, sandy clay loam, medium subangular structure, slightly plastic and sticky, quite hard common fine pores, few fine roots, medium roots.

Profile K3 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.2 %	M.sand 0.2-0.5 %	C.sand 0.5-2.0 %
0-8	7.2	23.9	31.4	28.1	9.4
8-26	21.2	14.4	38.1	11.1	15.2
26-50	34.2	14.1	21.6	15.3	14.8

Chemical data

Depth (cm)	Ex.Ca. m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	CEC m.e.%	CEC m.e./100g clay
0-8	1.80	0.55	0.20	0.02	3.6	50
8-26	2.00	0.60	0.18	0.02	6.0	28.3
26-50	2.00	0.75	0.23	0.02	5.9	17.2

Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
0-8	0.78	0.06	25.00	5.3	71.0
8-26	0.78	0.05	17.430	5.1	46.0
26-50	0.19	0.04	12.00	5.1	56.0

Mt. Makulu reception nos. 80/1233-35.

Profile K4

Soil name: Fisebe sandy loam

Date sampled: 16/9/79

Physiology: woodland on dambo fringe

Parent material: granite

Drainage: moderately to well drained

Mapping Unit: 3

Location: Kamena 2632311 GR

Slope: 3-4°

Vegetation/land use: miombo.

L.U. Class. S2w

Depth (cm)	Description
0-10	Dull yellowish brown (10YR 5/3) dry, dark brown (10YR 3/4) moist, sandy loam, fine crumby structure, loose when dry, fine pores, fine roots, medium roots, smooth boundary.
10-30	Dull yellowish brown (10YR 5/4) dry, brown (10YR 4/4) moist, sandy loam, massive - subangular blocky structure, slightly hard when dry, fine and medium roots, fine pores, unclear boundary.
30-60	Dull yellow orange (10YR 6/4) dry, yellowish brown (10YR 5/6) moist, sandy clay loam, slightly massive structure to subangular blocky, hard when dry, faint yellowish - red mottles, few fine roots, fine pores medium roots, gradual boundary.
60-85	Yellowish brown (10YR 5/6) dry, dull yellowish brown (10YR 5/6) moist, sandy clay loam, strong brownish mottles, massive structure, hard sticky and plastic, very few fine roots, few fine pores, gradual boundary.
85-100	Brown (10YR 4/6) dry, dull yellowish brown (10YR 5/4) moist, sandy clay loam, otherwise as above (no fine roots).

Profile K4 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002	Silt 0.002 -0.2	F.sand 0.05 0%	M.Sand 0.2- %	C.sand 0.5- %
0-10	11.4	18.5	38.5	14.2	17.4
10-30	15.4	15.3	26.9	24.5	17.9
30-60	22.4	18.8	25.5	18.6	15.7
60-85	29.2	19.8	30.6	11.0	9.4
85-100	32.2	20.5	21.9	16.6	8.8

Chemical Data

Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	CEC m.e.%	CEC m.e./ 100g clay
0-10	2.35	0.50	0.12	0.02	2.2	19
10-30	2.65	0.45	0.12	0.02	3.7	24
30-60	ND	ND	ND	ND	ND	ND
60-85	4.30	0.95	0.44	0.03	6.3	21.5
85-100	12.65	2.85	1.20	0.12	ND	ND

Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
0-10	0.62	0.05	9.450	5.0	ND
10-30	0.66	0.04	8.563	5.0	87.0
30-60	ND	ND	ND	5.4	ND
60-85	0.58	0.05	4.692	6.0	90.0
85-100	2.02	0.12	1.189	6.5	ND

Mt. Makulu reception nos. 80/1228-32

N.D. not determined no chemicals at Mt. Makulu.

Profile K5

Soil name: Nika sandy loam — **Mapping Unit:** 4a

Date sampled: 22/9/79 — **Location:** Kamena 112254 GR

Physiology: low slope — **Slope:** 4.5°

Parent material: Granite gneiss — **Vegetation/land use:** miombo

Drainage: moderately drained — **L.U. Class:** S3w

Depth (cm)	Description
0-7	Brown (7.5YR 4/3) dry, brownish black (7.5YR 2/2) moist, sandy loam, weak fine crumby structure, loose when dry, common fine roots, fine pores, medium roots, clear boundary.
7-13	Dark brown (7.5YR 3/4) dry, brownish black (7.5YR 2/2) sandy clay loam, weak subangular blocky structure, slightly hard, slightly sticky and plastic, common fine and medium roots, few fine pores, gradual boundary.
13-45	Brown (7.5YR 4/6) dry, dark brown (7.5YR 3/4) moist, sandy clay loam, subangular blocky structure, faint yellowish mottles, hard when dry, sticky and plastic, few very fine pores, fine roots and medium roots.

Profile K5 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.2 %	M.sand 0.2- 0.5 %	C.sand 0.5- 2.0 %
0-7	14.2	22.8	24.1	21.8	17.1
7-13	20.2	16.9	40.2	10.9	11.8
13-45	25.2	6.9	27.5	24.2	16.2

Chemical data

Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	CEC m.e.%	CEC m.e./ 100g clay
0-7	ND	ND	ND	ND	ND	ND
7-13	3.40	0.85	0.38	0.02	ND	ND
13-45	2.00	0.85	0.38	0.02	6.0	23.8

Depth (cm)	Org.C %	Total N %	Avail.P ppm	PH ($CaCl_2$)	Base Sat. %
0-7	2.06	0.14	2.125	5.3	ND
7-13		0.04	2.189	5.1	ND
13-45	1.01	0.05	2.000	5.2	54

Mt. Makulu reception nos. 80/1239-41

ND not determined. No chemicals at Mt. Makulu.

Profile K6

Soil name: Nika sandy loam

Mapping Unit: 4b

Date sampled: 23/9/79

Location: Kamena 024084 GR

Physiology: seepage zone (dambo)

Slope: 4°

Parent material: granite

Vegetation/land use: miombo/ grass

Drainage: moderately drained

L.U. Class: S3w

Depth (cm)	Description
0-19	Brown (7.5YR 4/3) dry, brownish black (10YR 2/2) moist, sandy loam, massive, slightly hard, loose moist, slightly sticky and plastic, faint brownish yellow mottles, common fine roots, fine pores, clear boundary.
19-30	Brownish black (10YR 2/3) dry, brownish black (10YR 3/2) moist, sandy loam, massive, weak subangular structure, slightly sticky and plastic, faint brownish yellowish mottles, fine roots, very fine pores, many medium roots, clear boundary.
30-50	Dull yellowish brown (10YR 5/3) dry, greyish yellow brown (10YR 4/2) moist, sandy loam, weak subangular blocky structure, slightly sticky and plastic, distinct yellowish brown mottles, fine pores, medium roots.

Profile K6 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.2 %	M.sand 0.2- 0.5 %	C.sand 0.5- 2.0 %
0-19	8.4	18.3	37.4	26.2	9.7
19-30	8.4	15.3	33.2	26.0	17.1
30-50	18.4	16.5	42.1	10.8	12.2

Chemical data

Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	CEC m.e.%	CEC m.e./ 100g clay
0-19	3.45	1.15	0.46	0.04	6.2	73
19-30	1.754	0.75	0.28	0.02	4.0	58
30-50	1.20	0.60	0.32	0.02	4.8	26

Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
0-19	1.29	0.13	0.500	5.5	82
19-30	0.82	0.06	6.00	5.1	57
30-50	0.47	0.04	5.125	5.0	44

Mt. Makulu reception nos. 80/1216 - 18

ND. Not determined no chemicals at Mt. Makulu.

Profile K7

Soil name: Mika sandy loam

Mapping Unit: 4c

Date sampled: 23/9/79

Location: Kamena 024084 GR

Physiology: Upper wash zone

Slope: 4°

Parent material: granite

Vegetation/land use: grass/ few trees.

Drainage: moderate/imperfectly drained

L.U. Class: S3w

Depth (cm)	Description
0-12	Brownish grey (7.5YR 5/1) dry, brownish black (10YR 3/1) moist, sandy loam, massive slightly sticky and plastic, faint mottles, (blackish yellowish), many fine roots, fine pores, gradual boundary.
12-25	Black (7.5YR 2/1) moist, sandy loam, massive structure, rusty root chennels, blackish mottles, soft dry, slightly plastic and sticky, fine pores, fine ~~roots, medium roots~~, clear boundary.
25-31	Grey (5YR 4/1) sandy loam, weak subangular blocky structure, yellowish red mottles, slightly plastic and sticky, fine pores, medium roots, few fine roots, gradual boundary.
31-49	Grey (7.5YR 5/1) sandy loam, weak subangular blocky structure, slightly yellowish brown mottles, quite plastic and sticky, few very fine pores, few medium roots.

Profile K7 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.2 %	M.sand 0.2-0.5 %	C.sand 0.5-2.0 %
0-12	12.4	36.6	23.6	17.6	9.8
12-25	16.4	21.4	31.4	20.7	10.1
25-31	10.4	15.2	48.7	13.6	12.1
31-49	10.4	13.3	49.6	13.6	13.1

Chemical data

Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	CEC m.e%	CEC m.e./ 100g clay
0-12	8.40	3.65	1.26	0.76	ND	ND
12-25	2.80	0.70	0.22	0.02	9.8	59
25-31	1.30	0.40	0.12	0.01	3.2	30
31-49	1.10	0.47	0.09	0.01	2.1	20

Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
0-12	5.00	0.32	16.188	5.2	ND
12-25	1.60	0.12	11.625	4.8	38
25-31	0.51	0.05	7.563	4.9	57
31-49	0.12	0.03	10.313	5.3	79

Mt. Makulu reception nos. 80/1219-22

ND not determined. No chemicals at Mt. Makulu.

Profile K8

Soil name: Nika sandy loam

Mapping Unit: 4d

Date sampled: 23/9/79

Location: Kamena 024084 GR

Physiology: lower wash zone

Slope: 2.5°

Parent material: granite

Vegetation/land use: grass.

Drainage: poorly drained

L.U. Class: Gw

Depth (cm)	Description
0-11	Dark brown (7.5YR 3/4) dry, brownish black (10YR 2/3) moist, sandy loam, massive, rusty root channels, slightly plastic and sticky, very fine pores, many fine roots, clear boundary.
11-25	Brownish black (7.5YR 2/2) dry, black (10YR 2/1) moist, sandy loam, weak subangular blocky structure, slightly sticky and plastic, fine pores, rusty root channels, yellowish brown to blackish mottles, few fine roots, medium roots, gradual boundary.
25-35	Brownish black (5YR 3/1) clay loam, subangular structure, yellowish to brownish black mottles, sticky and plastic, fine pores, very few fine roots, few medium roots, gradual boundary.
35-51	Brownish black (7.5YR 2/2) clay loam, yellowish red to brownish black mottles, sticky and plastic, few pores, subangular structure clear boundary.
51+	Dark grey (N3/3) clay, strong subangular, granular structure, massive, very sticky and plastic, very few fine pores, no fine and medium roots.

Profile K8 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.2 %	M.sand 0.2-0.5 %	C.sand 0.5-2.0 %
0-11	10.4	21.1	13.3	25.4	29.8
11-25	11.4	14.9	10.4	28.5	34.4
25-35	33.4	29.1	19.2	9.6	8.7
35-51	31.4	27.4	10.1	11.9	19.2
51+	45.4	34.9	9.2	5.2	5.3

Chemical Data

Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	CEC m.e.%	CEC m.e./ 100g clay
0-11	3.75	1.50	0.22	0.06	ND	ND
11-25	2.75	0.85	0.22	0.03	ND	ND
25-35	6.60	0.90	0.36	0.07	17.6	52
35-51	8.15	2.00	0.40	0.08	19.4	42
51+	10.05	2.65	0.50	0.10	ND	ND

Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
0-11	2.11	0.12	19.250	5.4	50
11-25	1.25	0.03	14.125	5.1	49
25-35	2.22	0.13	13.063	5.1	50
35-51	1.95	0.11	10.688	5.2	54
51+	2.38	0.13	7.563	5.2	ND

Mt. Makulu reception nos. 80/1223-27

ND not determined. No chemicals at Mt. Makulu.

Profile K9

Soil name: Muchemga sandy loam

Mapping Unit: 6

Date sampled: 5/10/79

Location: Kamena 2120888 GR

Physiology: along river banks

Slope: 8°

Parent material: Paragneiss

Vegetation/land use: riparian/ miombo

Drainage: moderate to well drained.

L.U. Class: S3e, S3s, S3w, Uw.

Depth (cm)	Description
0-5	Brownish black (10YR 3/2) dry, yellowish grey (2.5YR 4/1) moist, loam sand, weak fine crumby structure, loose when dry and moist, fine pores, many fine roots, gradual boundary.
5-12	Brownish grey (10YR 4/1) dry, black (7.5YR 2/1) moist, sandy loam, weakly massive, fine pores, fine and medium roots, gradual boundary.
12-20	Brown (10YR 4/6) dry, brownish black (10YR 2/2) moist, sandy loam, fine pores, massive, fine and medium roots, gradual boundary.
20-30	Brown (10YR 4/4) dry, greyish yellow brown, (10YR 5/2) moist, sandy loam, weak subangular blocky, fine pores, fine and many medium roots.

Profile K9 Analytical Data

Grain size (mm)

Depth (cm)	Clay 0.002 %	Silt 0.002 -0.05 %	F.sand 0.05 -0.2 %	M.sand 0.2- 0.5 %	C.sand 0.5- 2.0 %
0-5	2.0	13.4	22.6	36.8	25.2
5-12	8.0	23.5	24.9	21.0	22.6
12-20	12.0	17.0	40.4	11.7	18.9
20.30	11.0	22.9	28.2	20.1	17.8

Chemical Data

Depth (cm)	Ex.Ca m.e.%	Ex.Mg m.e.%	Ex.K m.e.%	Ex.Na m.e.%	CEC m.e.%	CEC m.e./ 100g clay
0-5	1.60	0.35	0.12	0.06	ND	ND
5-12	8.40	1.85	0.64	0.06	ND	ND
12-20	2.40	0.60	0.35	0.04	ND	ND

Depth (cm)	Org.C %	Total N %	Avail.P ppm	pH ($CaCl_2$)	Base Sat. %
0-5	0.39	[illegible]	[illegible]	4.8	ND
5-12	1.95	0.15	2.189	5.2	ND
12-20	0.35	0.05		4.6	ND
20-30		0.03	2.000	5.3	ND

Mt. Makulu reception nos. 80/1267-70

ND - not determined. No chemicals at Mt. Makulu.