FARMING SYSTEMS AND SOIL MANAGEMENT IN SERENJE, ZAMBIA

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TO DINA AND NASON

DECLARATION

I, Sikazwe J. Chisha, hereby declare that the work contained in this dissertation submitted for the degree of Master of Science is my own original work, except where due reference is made to other authors, and has not previously been submitted by me for a degree at this or any other Universtiy.

Signature ....

Date ....29-09-86.... Norwich, U.K ....

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ABSTRACT

Under increased population pressures, extensive methods of arable cultivation give way to intensive ones. The whole agricultural policy area then becomes central in influencing and further determining production trends and, consequently, the farming system that evolves.

In most developing countries, political considerations dominate agricultural policy. Rarely is sufficient attention given to the efficient use of scarce natural resources, let alone to soil conservation measures. This neglect usually leads to lower incentives to producers and to soil problems which reduce yields and could eventually make cultivation uneconomic.

Extension methods are often simplistic and crop based, with emphasis on yield maximisation. Resource poor farmers are often neglected by extension services, nor do they benefit from cheap agricultural credit.

Whereas the chemical fertility of the soil can easily be restored, the maintenance of the physical properties of the soil requires continuous careful husbandry and conservation measures. Husbandry practices that maintain maximum plant cover and raise the organic matter content of the soil and thereby improve water and nutrient availability, are seen as more appropriate than

mechanical conservation measures that are costly to construct and maintain. Intercropping and rotations of maize with legumes and other cash crops (each with an attractive incentive) and application of agricultural lime is seen as a way forward in evolving a more sustainable and efficient farming system.

This dissertation analyses, within the above framework, the farming system and soil management in Serenje District - Zambia. Whereas most analyses and examples are for Serenje, generalisation could be made for other rural districts of Zambia.

Chapter 1

1. Introduction

Since the 1970's agriculture has become Zambia's priority sector. With an area of 750,000 km^2 and a population slightly over 6 million, Zambia still has extensive areas of unused arable land and a relatively reliable climate suitable for many crops. With growing food shortages, not only in Zambia but in neighbouring countries as well, agriculture is one sector of the economy which could expand. This has been recognised, increasingly, by the Government. Another reason advanced for the emphasis on agriculture is the desire to reduce rural-urban migration.

Over many years, the performance of agriculture has far fallen below expectations and by the mid 1970's it had become clear that the poor performance of the agricultural sector was contributing to the country's difficult foreign exchange situation. In particular, large quantities of fertilizers, packaging material and even food had to be imported. Agriculture had failed to meet the growing demands for food, and imports had grown by 1980 to over three times the level at independence in 1964. (G.R.Z., 1982 c pp 38-41). By the late 1970's food imports were becoming a threat to the country's political stability (Wood, 1984).

The causes for the poor agricultural performance in Zambia, like many other Third World countries, are many and varied but according to Dodge (1977), Elling (1981), Elis, et al (1985), the problems have been those of agricultural policy in three main areas: - marketing and pricing, research and extension, and credit; as well as constraints pertaining to infrastructure.

Certainly, agricultural policy plays a major role in influencing farmers' decision making and, consequently, the farming systems practiced. The other side of this argument is that the farming system practiced has an important bearing on the cultural practices adopted in general and to soil management in particular.

To support the above argument, an assessment of arable agriculture in Serenje District of Zambia is presented.

In the opening chapters, an account of the physical environment is given. This is followed by an analysis of the main aspects of Government agriculture policy and its impact on the farming systems. The main aspects of agriculture policy addressed include pricing and marketing, credit, and agricultural research and extension.

In the discussion, special attention is also paid to soil management and husbandry methods that help maintain the soil's fertility. The importance of applying agricultural lime, given the natural acidity of the soils in Serenje and most parts of Zambia in the high rainfall belt is emphasized.

From an assessment of the farming system in the study area, the conclusion is reached that there is a case for the development of a farming system which takes into account the maintenance of soil fertility. Such a farming system, it is proposed, should include the diversification of the cropping pattern to include a wider range of cash and food crops (each requiring an attractive producer price and marketing arrangements), crop rotations,use of lime and the inclusion of livestock.

Rotation and intercropping of maize with legumes and liming is seen as a cropping regime that employs and efficiently uses the small farmer's scarce resources. An economic analysis to compare the net returns per unit of labour under different cropping regimes is presented to bring out the relative advantage of the proposed cropping regime.

This study can only be regarded as a preliminary investigation. The lack of primary data, especially on labour utilization and efficiency, is a major shortcoming. However, it is hoped that the paper will at least help to identify some worthwile directions for further research, together with alternative policies which could be associated with the evolution of a more sustainable farming system.

1.1 Assumptions

In the dissertation, the following assumptions are made:

(i) The farming system based on monoculture of maize supported by high inputs of fertilizer and pesticides is not sustainable.

(ii) Because of the natural acidity of the soils, liming will be beneficial to any cropping pattern adopted.

(iii) Institutional arrangements and services do exist to promote the desired farming system. These institutions could, however, be strengthened and made more efficient.

1.2 Sources of data

The dissertation draws upon the following sources:

- Reports on the natural resources of the district conducted by Booker Agriculture International Limited (1982).
- Data from the Monitoring and Evaluation Team of Integrated Rural Development Programme (IRDP) (Serenje, Mpika, Chinsali) and other IRDP publicatons.

- Unpublished reports (progress reports of various development committee meetings which I have attended and contributed to working in the district from 1983 - 1985).
- Land use map of the district.
- Other published literature on related subjects.

1.3 The study area

1.3.1 Location, population and communications

Serenje district of Central Province is located between latitude 12 - 13.5^{o}S and longitutde 30 - 31.5^{o}E (see Figure 1a). The altitude ranges from 1,100 to 1,500 m. The district has an area of about 24,000 km^2. The population is estimated at 73,480 (1980 census). The population growth rate is about 3.1% per annum. The average population density ranges from about 3 persons/km^2 in the less populated areas in the North West and extreme South East, to about 8 persons/km^2 in Central Serenje.

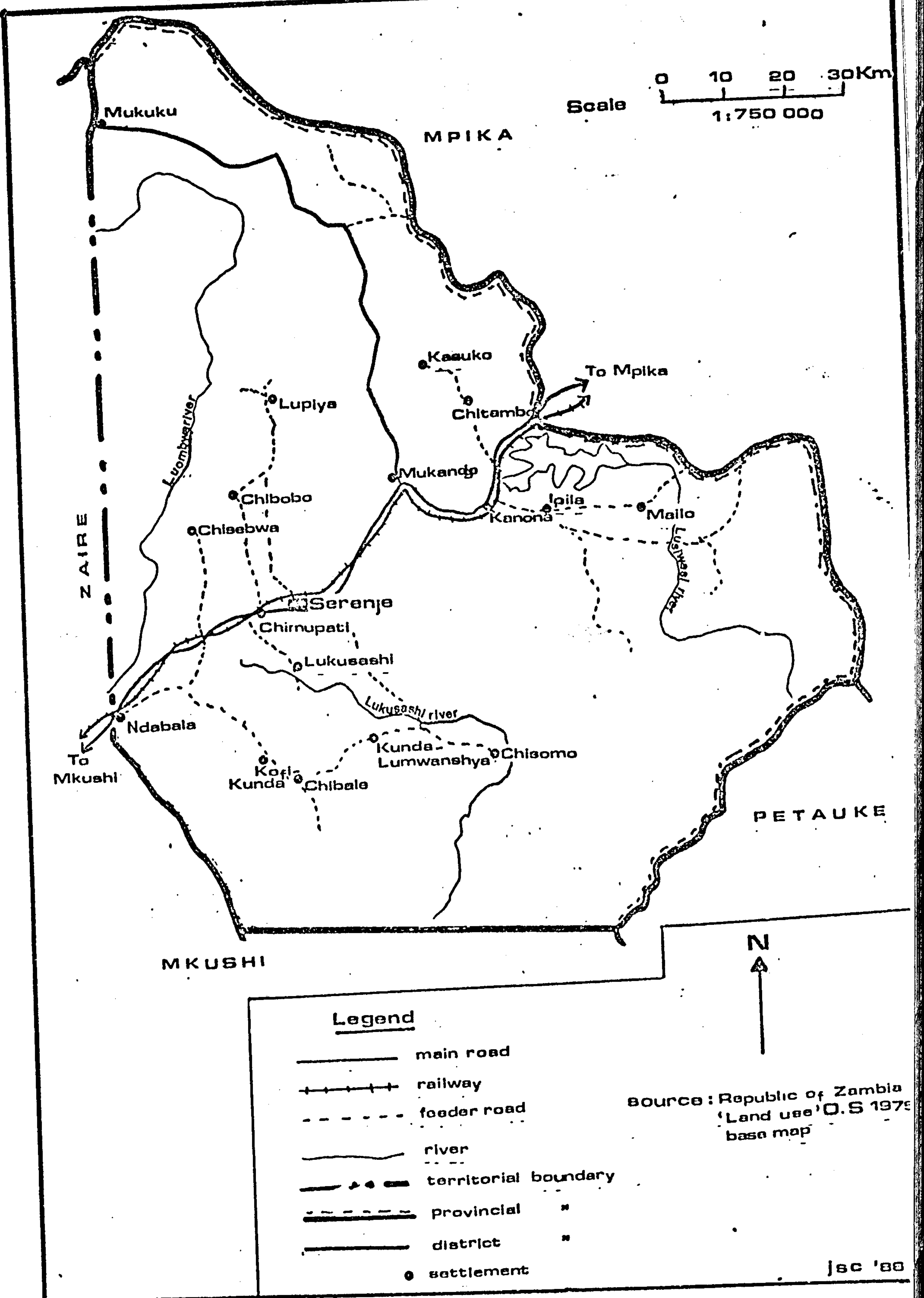
The district is served by an all weather road from Kapiri-Mposhi, which passes through the district from the South West corner to the North East and another from Serenje to Samfya (Figure 1b). From these main roads, there is a network of feeder roads, though these are in poor condition especially in the rainy season, giving access to the main settlements. The district is also traversed by the Tanzania-Zambia Railway from Kapiri-Mposhi to Nakonde in Northern Province.

Fig. 1a

LOCATION OF STUDY AREA

Source : Davies(1971)

FIG.1b SERENJE: Main roads and settlements



There has been a general improvement in the district's infrastructure since the inception, in 1981, of the British funded IRDP.

1.3.2 Economic activities

The economic activity of the majority of the population in the district is based on subsistence agriculture. The traditional farming systems of the upland have centred on citemene cultivation. The major crops include maize, finger millet, cassava and beans. Other sources of income include handicrafts, brewing and fishing.

Chapter 2

2. Climate

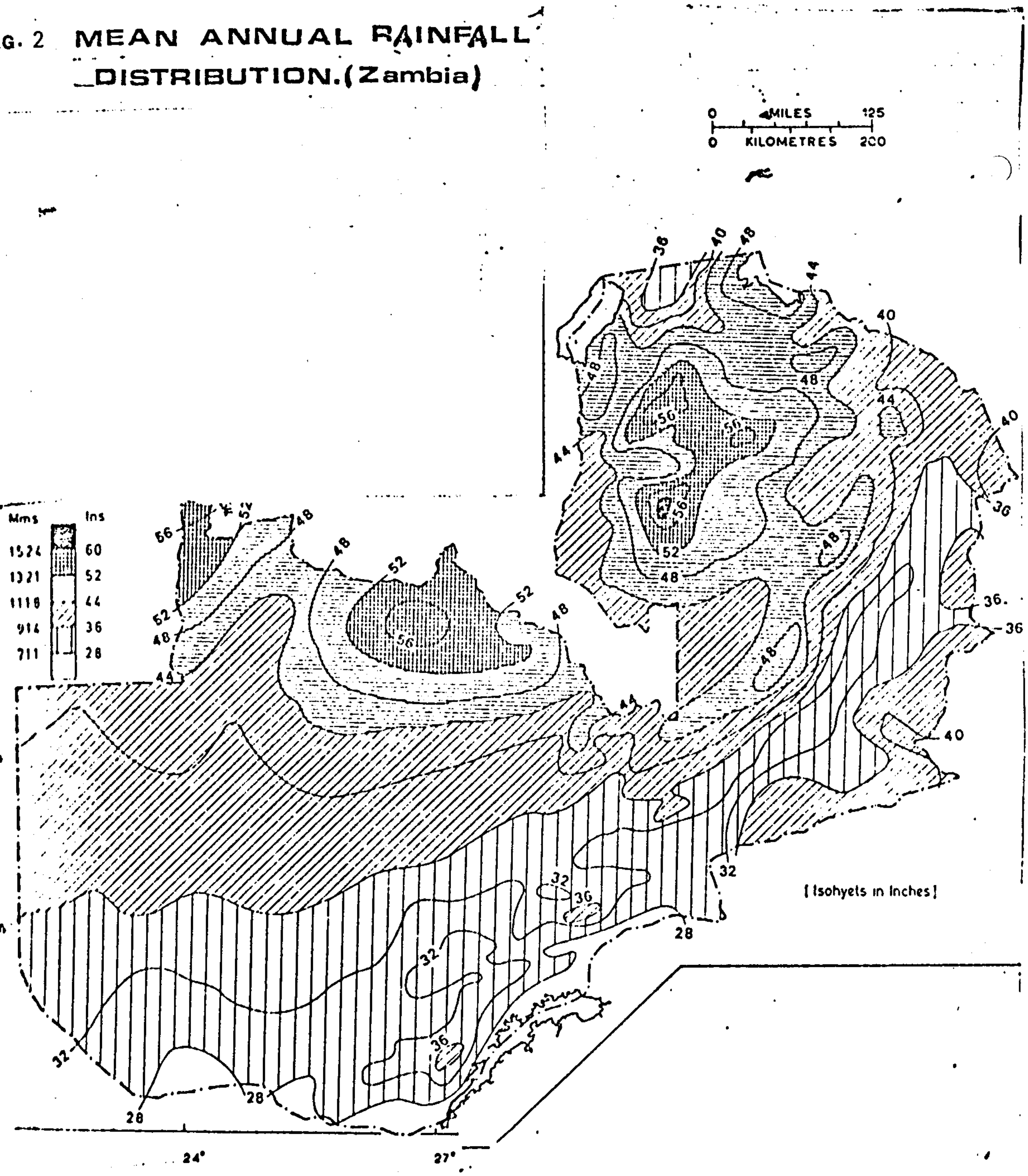
The climate of Zambia is charactarized by distinct wet and dry seasons. This climatic regime, and particularly the seasonal distribution of rainfall, imposes a strong rhythm on most of the rural population. For the subsistence farmer, cultivation is concentrated in the rainy season which lasts from November to March or April, while the long dry season is a period of dependence on stored crops.

2.1.1 Rainfall

The most notable feature of the distribution of mean annual rainfall in Zambia is the general decrease in amount from North to South (Figure 2).

The study area falls in what is known as the high rainfall belt, i.e. the area lying North of 1,000 mm isohyet (Hutchinson, 1974). The mean annual rainfall for Serenje is about 1150 mm. This is above the mean annual rainfall for most districts in Central Province. Table 1 shows the mean annual rainfall for districts in Central Province.

G. 2 MEAN ANNUAL RAINFALL DISTRIBUTION.(Zambia)



Source: Davies 1971

Table 1 <u>Mean annual rainfall (mm) - Central Province</u>

	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Kabwe[1]	0	2	2	22	94	242	258	190	123	22	2	0	951
Mkushi[2]	0	0	2	13	87	240	228	207	138	14	3	0	929
Kapir-Mposhi[3]	0	1	1	19	117	238	276	922	148	25	3	0	1038
Mumbwa[4]	0	0	2	18	116	230	217	192	108	22	3	0	844
Serenje[5]	0	2	1	12	107	269	259	248	188	38	4	1	1130

Source: Department of Meteorology, Lusaka.

(Notes 1,30; 2,53; 3,44; 4,66; 5,57 year mean)

The rainfall tends to be intense and has a high erosivity, especially on bare soil (Booker Agriculture 1982).

2.1.2 <u>Temperatures</u>

The temperature of most of the Province and indeed Serenje district is tempered by its altitude (900 - 1,380 m). Table 2 gives average monthly temperatures for three sites in Central Province. Maximum temperatures are experienced in October, whilst July records the lowest temperatures.

Table 2 Average monthly temperature (^{o}C) in Central Province

Month	Mumbwa	Kabwe	Serenje
Nov	23	23	22
Dec	22	22	21
Jan	22	22	21
Feb	22	22	21
Mar	21	21	21
Apr	20	21	20
May	17	18	17
Jun	15	17	16
Jul	15	16	15
Aug	18	19	17
Sep	21	22	19
Oct	24	24	22

Source: Starmans and Stalash, 1972.

Generally, there is a cool period from May - October with a risk of ground frost in July. In Central Province, only parts of Serenje have a regular frost hazard, although frost damage is not unknown in other parts of the Province, especially in dambos.*

* Dambo is a local term for a relatively flat or gently sloping, generally treeless depression. Dambos are seasonally waterlogged and sometimes contain a distinct channel.

2.1.3 Growing Season

The growing period could be defined as the period when temperatures exceed minimum for growth and moisture is available within rooting zone (FAO 1978a). It ranges from 120 to 135 days. The short growing season is in itself a constraint to crop production.

The length of the growing season for rainfed crops is effectively from the date sowing is completed (assuming soil moisture is sufficient) until growth ceases in April due to soil moisture stress. The lengths of the growing season are given in Table 3.

Table 3 Length of growing season (days) for rainfed crops in Mpika, Serenje, Chinsali for end of season on 11 April

	Sowing day		
	75% probability of earliest sowing	Median	75% probability of latest sowing
Silty and well structured clay soils	141	134	126
Friable sandy loams and loamy sandy soils	153	149	135

Source: B.A.I. (1982)

For farm planning, the length of the growing season at 75% probability of the latest sowing should be used which gives an effective growing season of between 126 and 135 days depending on the soil type. The soils with a loamy sand to sandy loam topsoil can be cultivated by hand-hoeing or ox plough when dry before the advent of the rains. The well structured red clay soils, however, need to be sufficiently moist to improve their workability.

Previously, it had been assumed by many agriculturalists that the length of the growing season in the three districts quoted above was about 165 days. But for practical purposes, and for the purpose of selecting suitable varieties, an effective growing period of about 130 days would be more probable.

2.1.4 Temperature, sunshine and radiation

From the preceding sections, it is apparent that the effective growing season for rainfed crops lasts from November through to early April. Climate records show that temperature, sunshine and radiation, which are the other major climatic factors influencing crop growth, vary little throughout this period. The climate of the growing season can, therefore, be summarised in terms of the mean values for December to March. The mean climatic values are given in Table 4 for temperature, sunshine and radiation.

Table 4 Climatic regime during the growing season Dec. - March

Station	Mean Temp °C	Mean Min. °C	Mean Max. °C	Mean day Temp. °C	RH %	Sunshine (hours)	Radiation Intensity (Cal/cm^2/hr)
Serenje	20	16	26	23	83	-	-
Mpika	20	16	25	22	82	5	35
Chinsali	21	16	26	24	-	-	-
Kabwe	21	17	27	24	78	6	40
Kasama	20	16	26	23	80	5	36
Isoka	22	18	25	24	-	-	-
MEAN	21	17	26	23	81	5	37

Source: Booker Agriculture (1982)

During the growing season, temperatures are uniform but rather low for the optimum growth of a number of crops grown in Zambia. The damping effect of cloud cover during this period reduces the diurnal range so night temperatures rarely fall below 15°C. This may favour vegetative growth at the expense of grain or seed formation in some crops. The high humidity favours rust and other fungal diseases, which makes crop variety selection for disease resistance particularly important (Booker Agriculture, 1982).

According to F.A.O. (1978(b)), crops can be grouped in terms of their temperature and radiation intensity requirements. This grouping is illustrated in Table 5 which is based on the climatic requirements of individual crops (Sims, 1981).

Table 5 Crops grouped according to temperature and radiation requirements

Crop group	1	2	3
Optimum temp for photosynthesis °C	15-20	25-30	30-35
Radiation intensity of maximum photo-synthesis $cal/cm^2/hr$	12-36	18-48	48-60+
Major suitable crops within group	Barley Cabbage Potato Wheat Tomato Onions	Banana, Cassava, Castor Citrus, Cow pea, Groundnut, Mango, Sunflower, Soya bean, Sweet potato, Tobacco, Finger millet (Mean min 18°C Mean max 27°C)	Cotton Lablab Maize Rice Sesame Sisal Sorghum

Source: Sims, 1981

The data above supports the contention of Mansfield, et al (1975) that, instead of cultivated annual crops, the area is more suited for timber and perennial tree crops which can exploit the presence of deep ground water during the warm-dry season with a high radiation.

2.1.5 Soil-Water balance

From March onwards the principal constraint on production of raidfed crops is the increasing soil moisture deficity, as the rains become less frequent and eventually cease. The date on which growth finally ceases, but before permanent wilting point is reached, is the end of the growing season. Other things being equal, under irrigation, advantage could be taken of the higher temperature and higher radiation from August to November but the cool-dry season restricts the choice of irrigated perennial crops to those which either require or can withstand the cool season, e.g. citrus and coffee respectively.

The warm dry season could also be exploited for short season annual crops by the use of irrigation.

2.2 Vegetation

The dominant vegetation type in Serenje and indeed in most parts of the plateau regions of Zambia is the "miombo" woodland. A distinct vegetation catena is often observed (Figure 2) as follows:

The interfluves are dominated by an open to lightly closed "miombo" woodland 10-20m high. It is characterized by species of *Brachystegia* (*B.boehmii*, *B.longifolia*, and *B.spiciformis*) and *Julbernardia* (*J.paniculata* and *J.globiflora*). The dominant species vary from area to area.

Plateau miombo grades imperceptibly into "hill miombo" woodland of inselbergs, rock outcrops and escarpments in which *Brachystegia Microphylla* dominates and in which relic evergreen thickets are found. Hill miombo is especially prevalent in Southern Serenje and on the Muchinga Escarpment.

The woodland floor becomes covered by a grass/saffrutex* layer following the onset of the rains. Suffrutices are a marked feature of the miombo woodland with the following genera being especially common: Abrus, Combretum, Desmodium, Diospyros, Dolichos, Fadogonia, Indigofera, Lannea, Tehprosia and Vernonia.

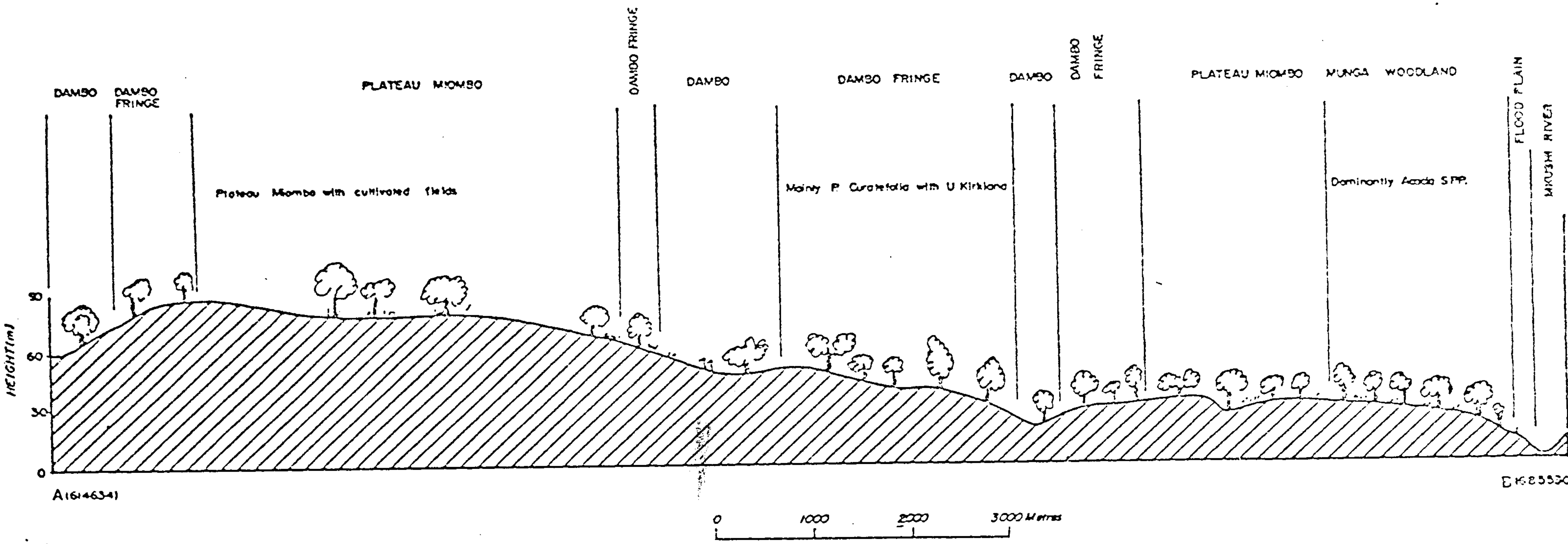
The common grasses are species of: Andropogun, Aristida, Brachiaria, Digitaria, Eragrostic, Hyparrhenia, Panicum, Rhynchelytrum, Setaria, Sporobolus and Tristachya.

On the lower slopes the woodland gives way abrubtly at the dambo margin to grassland. Most of the damos are covered with a moderately dense mat of grasses, sedges and perennial herbs. The grasses are perennial bunch-grasses, cushion like or tussocky with Loudetia Simplex as the characteristic species.

The dambos often carry a stream or incised drainage channel in their centres where water may flow all year or where stagnant pools may form in the dry season. Swamp vegetation is usually associated with such conditions, with Cyperus Papyrus and Phragmites dominating.

*Saffrutex: herbaceous plant with woody persistent stem-base

Fig.3 SECTION THROUGH A-B DISTRIBUTION OF VEGETATION TYPES



Source: Adapted from Mukanda (1986)

Nearly all "miombo" woodland today is regrowth from one year old to apparently mature woodland. Mature woodland grows back usually unchanged following fire or cultivation. Past population pressure on the plateau has been so high that all, or nearly all, "miombo" woodland has been cultivated at one time or another, even those areas which today look as if they have never been touched. (Clayton 1975)

Miombo woodland is economically important in populated areas for the supply of timber, poles, firewood and charcoal.

2.2.1. Pasture

The quality of pasture is variable but the following generalisations could be made depending on which time of the year:

Rainy season: The best grasses are usually found on the upland areas, rather than the dambos and, if grazed fairly frequently, will remain reasonably palatable. The tall-growing, fibrous Hypethenia grass is unpalatable to cattle and should not be encouraged by widespread bush clearance (I.R.D.P. 1985). The ideal upland vegetation is a low density of trees with all the small scrubby bush removed but with an almost continuous canopy to minimise the spread of Hyparrhenia. Late dry season burning help to encourage this type of vegetation, because the hot burn kills the shrubs.

Dry season: During the dry season, dambos could provide grazing pasture. However, dambo grasses tend to be coarse and unpalatable. As there is sub-surface water even in the dry season, once the dambo is burnt the grass can regrow and this fresh regrowth is much more palatable.

2.3 Soils

The first soil legend in Serenje district was produced by Sorensen (1976). Other works especially at reconnaisance level include: Clayton (1976), Woode (1979a, 1981c) and Brammer (1973). Booker Agriculture (1982) provides an analysis of most soils in the district, including their associated major land-uses. This chapter largely draws upon Booker (1982).

2.3.1. Factors of soil formation

A dominant factor influencing the soils is the age of the land surface and, therefore, the time over which pedogenesis has occurred. The bedrock is precambrian, some 1,600m years old, but most of the soils have developed on surfaces from 2-60m years old (Bramer 1973a).

The Climate is the second most important factor of soil formation. Climate has interacted with the age of the soils. Although the soils have been highly leached at various periods during their formation, the present rainfall regime considered generally cooler and drier than earlier climates, is not leaching the soils significantly, especially under the natural vegetation.

There seems to be a well developed catenary effect in the district and surrounding regions to the North (Surensen 1976, Van Sleen 1976a, 1976b, Woode 1979a, 1981b). The most common catena is as follows:

- Crest to mid-slope -
  red to yellowish red, well drained soils.
- Lower slope -
  brownish yellow, well to moderately well drained soils.
- Lower slope (dambo ridge) -
  pale brown, imperfectly drained duplex soils.
  This often occurs as a narrow fringe.
- Dambos -
  pale brown, poorly to very poorly drained soils
  of variable textures.

This catenary pattern corresponds to that described by Young (1976) on a gently undulating surface mantled by weathered ferralitic soils that become less red down slope, with a sandy mottled dambo fringe.

Vegetation differences are not well related to soil differences in the district. The vegetation reflects the effect of fire and cultivation with modifications due to topography. Some vegetation soil relationships are mentioned by Mansfield et al (1976) but their conclusion is that vegetation is a continnum with an overlap of species and groups of species in a complex relationship. This is supported by the Zambian Soil Survey observations and as a rule, it is not possible to determine the soil type from the vegetation, except in very obvious (e.g. swampy) situations.

2.3.2 Sandveldt soils

The dominant upland soils in Serenje are of the leached sandveldt type (Ferralsols, FAO) covering about 55% of the arable area (see Appendix I for extent of soil and land types). These sandveldt soils are sandy loam to sandy clay in texture; yellowish brown to yellowish red in colour (brown when poorly drained). Sandveldt soils are usually acid, deeply weathered, low in organic matter and leached. They are usually arbitrarily divided into those North and South of the 1,000 isohyet. The Southern sandveldt soils (ferralitic soils and Ferrisols) are less leached and less acidic than the Northern ones. Soils North of the 1,000m Isohyet lack 2:1 lattice clay minerals and are dominated by kaolinite. Their cation exchange capacities are low, as is the base saturation percentage (Booker, 1982). Consequently, the level of exchangeable bases is low. Soil reaction is very variable throughout the district. Chemical analysis of most soils in the study area review that the soils are acutely deficient in phosphate and low in potassium and nitrogen and while not too acid under natural conditions, need liming to counterbalance the acidity caused by fertilizer application. Although the soils are highly weathered, they are no longer leaching and retain fertilizer well.

2.3.3. Some aspects of soil management

An important feature of the different soil types is that the sandy soils (Sandveldt type) and the red clay loams can be cultivated when dry, but the silty loams need rain before cultivation. The sandy soils are more prone to drought. The soils are particularly prone to erosion in that at the beginning of the rainy season when the soils are bare with least vegetation cover to intercept the raindrop impact.

Little effort has been made to estimate the rate of soil loss in Zambia. In Serenje, soils on almost flat interfluves were observed to suffer from sheet erosion over large areas whereas similar soils under cultivation on slopes up to 12% showed no observable erosion. (Woode 1979a, 1981b) This demonstrates the role of cover in protecting the soil from being eroded.

The Soil LOss Estimation Model for Southern Africa (Stocking 1981) was used by FAO Agriplan Project in South East of the district. This was carried out under the traditional farming system with the objective of providing the "best estimates" from which to deduce which practices are harmful and how to ameliorate them. The results, though tentative, provide useful insights into the role of plant cover in keeping soil loss at acceptable levels. According to Stocking (1981), acceptable levels of soil loss are considered to be those close to natural erosion rates. In Zimbabwe, soil formation was estimated by Stocking to be in the region of one tonne/ha/year or less. It is inconceivable that at the current stage of development, soil loss rates could be brought down to this level! In the Study referred to above, soil loss was estimated to range between 3 to 55 tonnes/ha/year.

2.3.4. Factors affecting erosion hazard

The most serious form of soil degradation is accelerated erosion. Soil erosion is a severe and increasing problem in Zambia. The loss of soil renders the land less able to absorb rainfall and, therefore, less able to supply water and nutrients to the crops.

The assessment of risk of soil erosion is not straightforward because erosion is the result of the combination of land use with land (Dent, 1981). For example, a land use type that causes no problem on gently-sloping land that is mantled by permeable soils may cause severe erosion on steeper land, or less permeable soils. Conversely, intensive use may be made of sloping land if good conservation practices are maintained.

A number of factors influence the magnitude of an erosion hazard, but vegetation cover, slope angle and slope length, rainfall and soil and the interaction of these factors are critical.

2.3.5 Land-use practices that combat soil erosion

Good management can protect soil and maintain or increase crop production with little extra cost. The following land-use practices can help combat soil erosion and it is such practices that the extension service should encourage farmers to adopt. Whereas the immediate rewards to the farmer in terms of output per hour may not be very great, the long term productivity of the soil may be sustained for a longer period.

(i) Maintain the maximum possible cover. The better the crop, the more protection it gives to the soil. Vegetation cover determines the erosion hazard principally by the degree of protection offered to the soil surface. Bare soil is the worst of all. The longer the period of bare soil, especially during periods of intense rainfall, the greater would be the erosion hazard. Most arable crops give little cover for much of their growing period.

late 1 . A maize field in Serenje.
Bare soil, especially before plants are established, is very prone to erosion. Notice the small rills.

nter-cropping nearly always gives more cover than a single crop, hen a crop offers little cover, a mulch of dead vegetation could e used to cover the surface.

ii) Cultivating the plant crop rows along the contour, not up and down the slope. Contouring should be done accurately, otherwise runoff will be concentrated into a few channels, which is worse than a dispersed surface runoff.

(iii) Tie the furrows between ridges to form a series of contoured basins. These hold the water on the soil surface, giving it time to soak in.

(iv) Plant alternate strips of different crops along the contour, with dense crops like grass at intervals to trap the soil washed from weakly-protected strips above. Filter strips of dense vegetation along streams are also effective in intercepting soil before it reaches the water course.

(v) Rotate crops: by their different forms of growth and length of growing period, different crops offer varying degrees of protection. Rotations, preferably including a break of dense grass/legume cover, ensure that the same parcel of land is not exposed every year to the same risk of erosion. Organic matter content and soil structure is rebuilt during the break crop by the dense fibrous root system of the grass.

(vi) Control grazing: by fencing and the adjustment of stocking rates, avoid excessive trampling and overgrazing so that the land can continue to provide adequate feed for stock and keep the top soil permeable to rainwater.

Chapter 3

3. Role of Agricultural Policy

3.1 Introduction

Since Zambia launched its First National Development Plan (F.N.D.P.) (1966-1970); agriculture's role in national development has been fourfold:

- To aid in diversifying the economy.
- To increase personal incomes and employment, especially in rural areas.
- To decrease dependence on food imports.
- To increase purchasing power in the rural areas and thus provide an expanded market for the industrial sector.

But, as Dodge (1977) observed, the performance of the agricultural sector has been disappointing. In this Chapter, an attempt is made to bring out the main features of Government agricultural policy, (mainly crop pricing, marketing, credit research and extension) and the way these aspects of policy interact positively or negatively, with other factors in farmers' economic environment.

3.2 Marketing Services

The Government has put much effort and money into marketing services. The main marketing board operational in Zambia is the National Agricultural and Marketing Board (NAMBOARD). Recently, the Provincial Co-operative Marketing Unions have also been involved in the marketing of agricultural produce. The major shortcomings of the marketing facilities are that agricultural requisites frequently arrive late for planting and supplies of inputs are often inadequate.

The small-scale farmers, especially, are severely affected by the fact that inputs of seeds and fertilizers are sold in quantities too large for the areas that they cultivate (Average - 3.5 ha). It is only in recent years that this trend has, to some extent, been reversed. Further, small-scale producers are adversely affected in that the marketing agencies often buy the farmers' produce late and only certain standard quantities (e.g. 90 kg bags) are purchased. Moreover, farmers must frequently wait months for payments.

The above mentioned factors have resulted in a situation whereby many small scale farmers' efforts are demoralized or frustrated altogether to produce a surplus to sell to the marketing institutions. These farmers, as Elling (1981) observed, will seek ways to sell privately or will produce different crops for home consumption and barter.

3:3 Pricing Policy

Agricultural producer prices for most crops are below world market prices (Berg et al 1981). At the national level, the pricing policy has tended to favour the large scale producers. Thus, until recently, crops and products which are most suited to and preferred by small scale producers such as millet, cassava, sorghum, beans and ground nuts, have received less incentives and the marketing board would not consider buying them (Elling 1981).

Zambia's economy has been dominated by export of mineral resources and is urban centred. The overriding objective of state agricultural policy has been to secure a flow of cheap food (through the consumer subsidy) to urban areas and thereby reduce the level of inflation directly, and indirectly by reducing wage demands (Berg et al 1981, Ellis et al 1985). Subsidized urban food prices have caused increasingly obvious problems for farmers' output, food imports and government budgets. Nevertheless, the Government cannot easily raise the cost of food to the urban population, because of the immediate impact on consumers, the rate of inflation and wage demands (Bates 1982). Some way, however, must be found to make the price rise acceptable (Ellis et al 1985).

Government interventions in agricultural pricing usually create new economic and political interests. New groups emerge with a vested interest in the continuation of the official intervention (Bates 1982). But smallholders are in a very weak position to bring pressure on the Government to raise agricultural prices.

Traditionally, expatriate farmers had played a vital role in food production. They were treated very favourably by the agricultural policy and often tended to attract government services (research, credit, extension, etc.). But, since independence in 1964, there has been a steady emigration of these expatriate farmers.

More recently, governments in Africa are being advised to change their policies (Berg et al 1981) as a result of the desperate financial situation in which they find themselves and the conditions attached to the only remaining sources of credit. The fall in copper prices on the world market since the 1970's has greatly affected Zambia's balance of payment.

3.4 Agricultural Credit

One of the major services the government provides is agricultural credit through the Agricultural Finance Company (A.F.C.). Credit through A.F.C., as opposed to commercial banks, might offer the best solution of overcoming the resource constraints of small farmers.

In principal, agricultural credit can be used to purchase inputs and draught power or hire labour etc. In reality, however, credit as provided by A.F.C. does little for small farmers. For example, no credit is available for subsistence crops such as cassava, beans, finger millet and sorghum which are major crops for a large group of farmers. Furthermore, the smallest areas from which A.F.C. makes loans available (1 ha) are generally larger than the area cultivated by most small farmers. As a result, most of A.F.C.'s funds are used for the larger scale farmers, many of whom would have been able to get credit from commercial banks anyway. As a result, most small farmers for whom A.F.C. originally was intended, are excluded from this relatively cheap credit source as they are from commercial sources.

Another aspect of A.F.C.loans which limits the small farmers' access is the so-called "loan package". By this arrangement, the contents of these packages are pre-determined in co-operation with the Department of Agriculture and packages exist for all major marketed crops and for three different levels of management: learner, improved and top .

Table 6 below shows an example of the 1979/80 maize package.

Table 6 A.F.C. 1979/80 Maize package

Kwacha per hectare

Management Level	Learner	Improved Tractor Hire	Improved Tractor Owned	Top
Seeds	11.90	19.20	19.20	22.50
Fertilizer	93.18	116.30	116.30	151.16
Pesticide	7.00	12.00	12.00	12.00
Herbicides		13.00	13.00	13.00
Labour		36.00	36.00	36.00
Ox hire	25.00			
Tractor hire		40.00		
Fuel/oil			41.59	41.59
Repairs/maintenance			76.80	76.80
Transport	21.00	35.00	35.00	43.40
Bags	12.30	20.50	20.50	25.42
Insurance		5.00	5.00	5.00
Living		5.00	5.00	5.00
Contingency	9.62	18.00	19.61	18.13
Total support level per hectare	180.00	400.00	320.00	450.00

Source: A.F.C. Provincial Headquarters, Kabwe.

These standard procedures may not be very appropriate to the small farmer. Firstly, the smallest loan package is designed for a hectarage larger than is generally cropped by small farmers, thereby overestimating small farmers' loan requirements and seriously affecting their capability to repay this excessive loan. Secondly loans are not often geared to the needs of the individual farmer, as the package reflects the overall cash crop and maize mono-cultural thinking of many decision makers in the agricultural sector in Zambia. Small farmers diversify their activities as much as possible in order to minimise their risk of crop failure as well as increase variation in diet. A.F.C., on the other hand, only makes loans available for cash crops plus "small scale" technology including ox hire. Thus, to secure a loan, the farmer is obliged to 'put all his eggs in one basket' and thus become extremely vulnerable to institutions and procedures he cannot influence, as well as the hazards of the weather. The system of using standard loan packages, although facilitating the assessment and administration of small loans, may be considered as limiting to the resource poor farmers.

The performance of A.F.C. has left much to be desired. Loan recovery rates are not satisfactory, the main reason being the extremely low level of supervision. Another reason for low recovery rates is that A.F.C. depend entirely on other parastatals, especially the co-operative unions, for loan recoveries.

3.5 Research and Extension

In Zambia, there now exists a countrywide extension service. The extension service, however, has to contend with serious difficulties notably inadequate transport and staffing. Lack of transport reduces the number of farmers who can be reached by each exension worker as well as the supervision by the senior staff. These factors lead in turn to lowering of morale.

But a problem that is much more difficult to overcome in the short run is the general extension approach and message of the service. Agricultural research and extension are often based on the assumption that the aim is to increase yields, when land is not scarce. However, it is labour that is scarce; partly because of small total population but mainly because of the made believe existence of wage-labour opportunities in the non-agricultural sector. Generally, for most households, output per unit of labour and not per hectare may be more important (sect. 4.5).

Another problem with the extension service is that there is a considerable bias toward farmers who are already better off. No extension services, for example, exists for traditional crops or for traditional production techniques, or nutritional and food security aspects of agriculture production. The extension service lays much emphasis on crop techniques and, especially, hybrid maize.

3.5.1. The Lima Programme

The Lima Crop Extension Programme began in 1980. The objective of the Programme was to raise production and incomes of small farmers. As far as possible, straightforward methods are applied, for example, using 25 metres rope to measure an area equal to a quarter of a hectare or 2,500 square metres, which represents one Lima. One standard 50 kg bag of fertilizer is evenly applied per Lima with beaker and/or cup. In this way, cumbersome numerical conversions for extension workers and farmers are avoided.

Crop memos were issued for each of the nine Provinces in Zambia and indicated input and yield levels. Implementation of the Lima concept met with varying success. The Lima approach is 'top-down'. Continuous adjustments of recommendations and feedback from the farmers as required in Farming Systems Approach (Biggs 1985) for example, did not take place (Figure 5.).

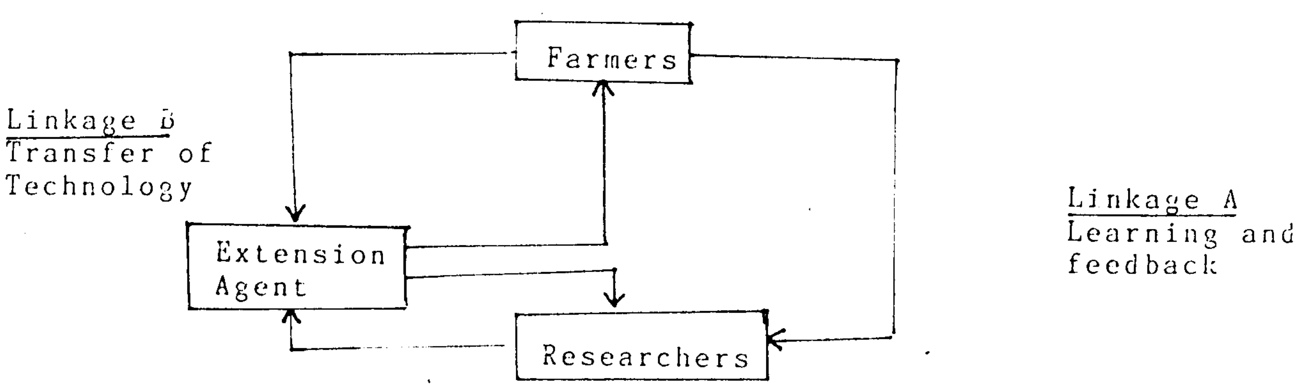


Figure 4: Farmer, Researcher and Extension Linkages (Biggs 1983)

Eklund (1985) observed:

> "The expected feedback did not take place from extension staff in the provinces to researchers at Mount Makulu. Application rates, and yields under the farmers' conditions would have been monitored. Deviations from expected yield levels would have been followed up through research .... This monitoring process did not function as expected."

It is only recently that research and extension approaches are emphasizing farmers' participation in problem diagnosis and implementation. Such approaches include the Training-and-Visit System, Adaptive Research Training Teams, etc.

Chapter 4

4. Farming Systems

This Chapter describes and analyses some of the main trends in the farming systems that have occurred in Serenje since the1950's. It is shown how the agricultural policy and especially marketing and pricing of maize have greatly contributed to the farming systems that have evolved. Attention is also paid to the labour constraint (see Figure 8) and other social and environmental factors. The Chapter concludes that the farming system practiced or being pushed is unsustainable and might lead to serious soil management problems if not redressed.

4.1 Background to the farming system

The traditional agriculture in Serenje was dominated by the small circle Citemene system. This form of ash cultivation consisted of cutting a large area of woodland (typically around 7 hectares) at breast height, stacking the wood when dry into small circles or strips and burning it (Figure 6). Finger millet was then broadcast on the ash patches.

Plate 2 : Citemene field.
Notice the relatively young regenerated trees being felled as population pressure on land has increased.

Near the villages, the traditional systems included subsidiary hoed gardens made near the village in which sorghum was the principal crop. These were started by clearing the land as for Citemene and stacking and burning the wood. The land between the circles was then mounded and planted with sorghum. Other subsidiary gardens were planted with sweet potatoes, maize, beans and cassava in small quantities (Peters 1951).

Plate 2 : Citemene field.

Notice the relatively young regenerated trees being felled as population pressure on land has increased.

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These gardens were found both on upland soils and along the dambo margins. In the case of upland sites, the area was first cleared of trees and bush and the branches laid in circles as for citemene. The branches are usually burnt at about the same time as the citemene gardens. The ash circles are then planted with sorghum or with finger millet. The intervening ground is made into mounds which can be planted with a number of different crops. The usual arrangement, however, was beans or groundnuts which were harvested in April. Then at the beginning of the next rainy season, sorghum was sown and this was harvested in the following May or June. Thereafter, the garden was left to cassava, individual roots being dug up as required.

Other types of hoe-cultivated gardens included mounds made in the wetter dambo margins and used for Livingstone potatoes (coleus esculentus). Maize and beans were also grown on seepage sites within the dambos.

But as the population has increased and the cash economy become more pronounced, the citemene farmers have adjusted to the growing land degeneration by reducing their citemene areas and at the same time increased the acreage under hoe cultivation (Long 1968).

4.2 Changing patterns of farming

As early as 1946, a survey of the agricultural system in Serenje district was undertaken by Peters (1950), who concluded that the citemene system of cultivation was on the point of breakdown in that there was a shortage of sufficiently well regenerated trees available for cutting. This he attributed to the fact that the density of population had exceeded the critical population or land carrying capacity of the system. Under citemene cultivation, the critical population was calculated to be about 6 persons per square mile but the actual overall population density for the district was 7.3. Further, it was observed that 75% of all trees felled were not fully regenerated, the average of growth being about 17 years. Estimates for the period required for regeneration range from 35 years by Peters (1950) to 25 years by Alder (1958) for the northern part of Northern Zambia.

In 1958 a follow up study was made by the agricultural staff at Serenje to test the general validity of Peter's work (Smyth 1958). The original study was found to be reasonably predictive of subsequent trends. The maximum regeneration period possible at the rate of consumption at that time was calculated to be 17.8 years for the whole district, slightly higher than Peter's figures.

MAIZE PRODUCTION : SERENJE, MPIKA, CHINSALI (1975-1984)

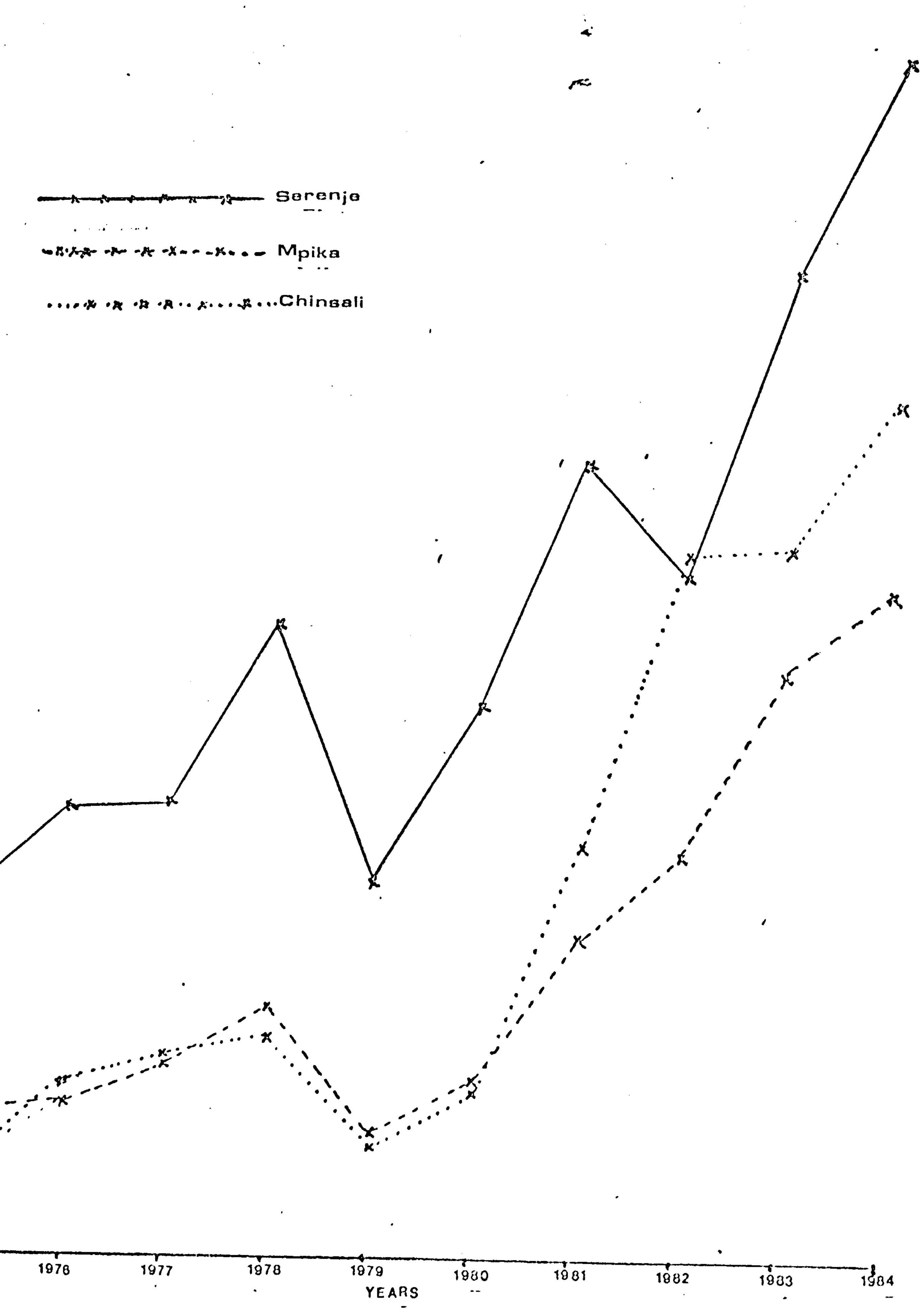
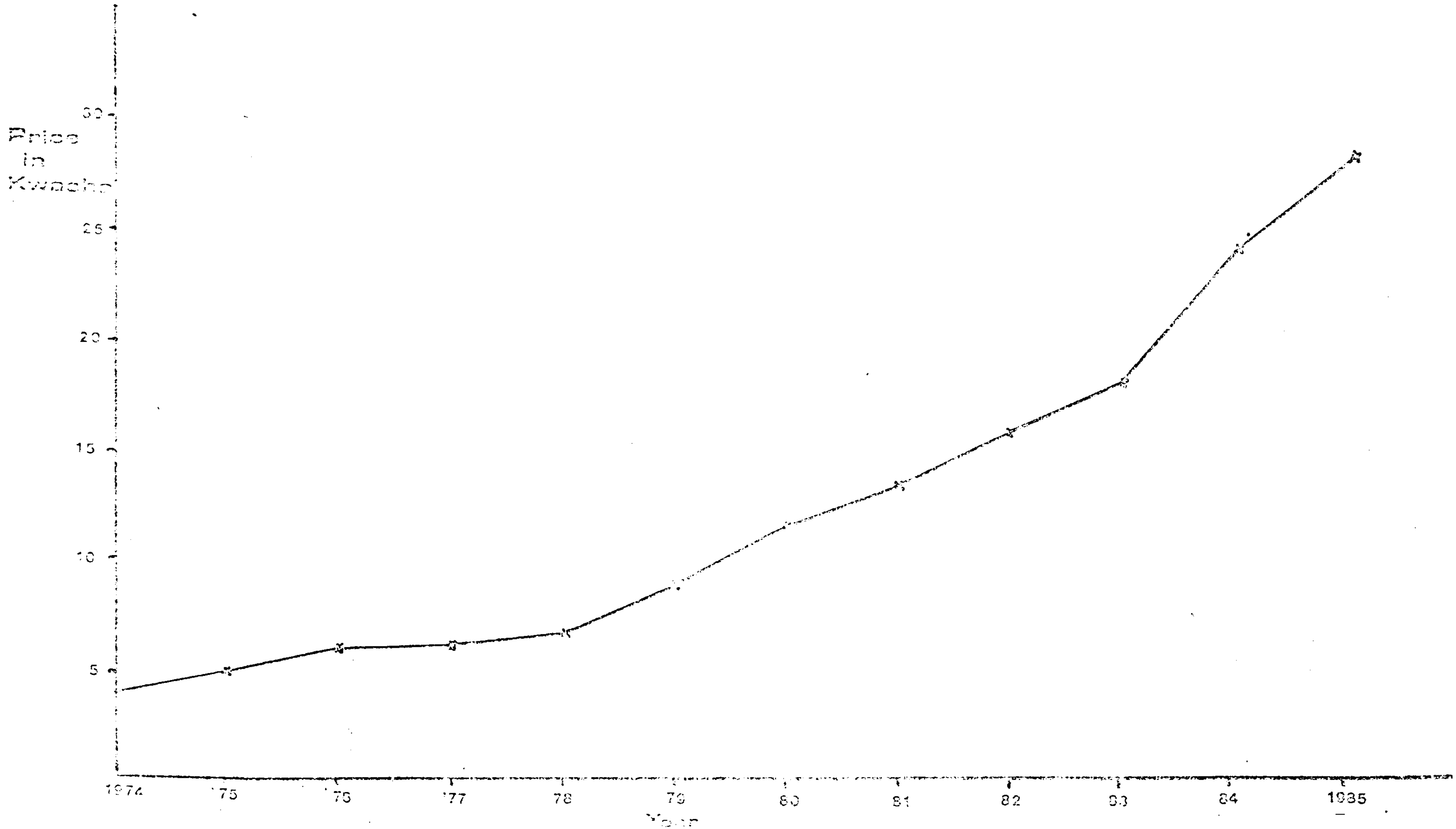


FIG.6

CHANGES IN PRICE OF MAIZE 1974-1985.



While citemene persists and remains economically important,there has been, especially since the 1950's, a steady and accelerated shift from this form of cultivation to settled agriculture, with maize becoming the principle crop. In most parts of the district, maize has replaced finger millet as the principle crop and is also the main cash crop. Figure 5 shows maize production sales for Serenje, Mpika and Chinsali Districts.

The maize production trends in figure 5 illustrate a dramatic take-off in production in Serenje from a period around 1975. The reasons for the changes in production are complex as many factors affect farmers' attitutdes to production such as agricultural extension, credit, technology, producer prices, availability and cost of inputs, etc.

However, over the ten year period there had been no apparent improvement in the provision of agricultural extension, credit or access to new technology, which could account for these positive trends (IRDP Occasional Paper No. 5). But as can be seen from Figure 6, there has only been a significant increase in price since 1979 and the increases in maize sales only have been significant and sustained since 1980 (Figure 5). This may, therefore, be partly explained by farmers responding to the continued price increases since 1979. (See Appendix II for producer prices 1966 - 1985).

4.3 Barriers to sustained production

The trends in maize production described above, however, are unlikely to be sustained for a number of reasons. Mainly these are related to:

(i) The erratic quality of services provided (inputs, credit, marketing, extension, etc.)

(ii) Increasing soil acidity associated with increased use of chemical fertilizers with virtually no liming to ammeliorate the lowered pHs. This problem is being worsened by inappropriate research and extension message such as the mono-cropping of hybrid maize at high fertilizer rates (Section 3.5.1).

(iii) A technology barrier as farmers reach the threshold of hoe cultivation (about 60 bags), labour becomes a major constraint as farmers want to expand their areas under cultivation. To alleviate this constraint, the use of oxen is seen as a way forward given the problems associated with the use of tractors such as shortage of spare parts, fuel, etc.

It is with problems (ii) and (iii) above that the remainder of this chapter is devoted.

4.4 Use of Lime

As discussed in Section 2.3, the physical properties of arable soils in Serenje impose a more serious constraint on land management. The chemical constraint, on the other hand, could be overcome by the correct use of lime and fertilizer. The use of lime has not been pushed with as much vigour as that involving conventional fertilizer.

Farmers in Zambia are now becoming increasingly aware of acidity to observed yiels depression. A 10 year trial at Misamfu Agricultural Research Station in Kasama, NOrthern Zambia, demonstrates that maize yields decline at recommended fertilizer rates without lime application. In the Misamfu experiment, yields declined from about 6 tonnes/hectare in 1965, to less than 2 tonnes in 1970. Lime was applied at a rate of 1 to 1.5 tonnes in 1971 and 1975. This was equivalent to annual average rates of 200 - 300 kg per hectare. Maize yields recovered once lime was applied (Figure 7).

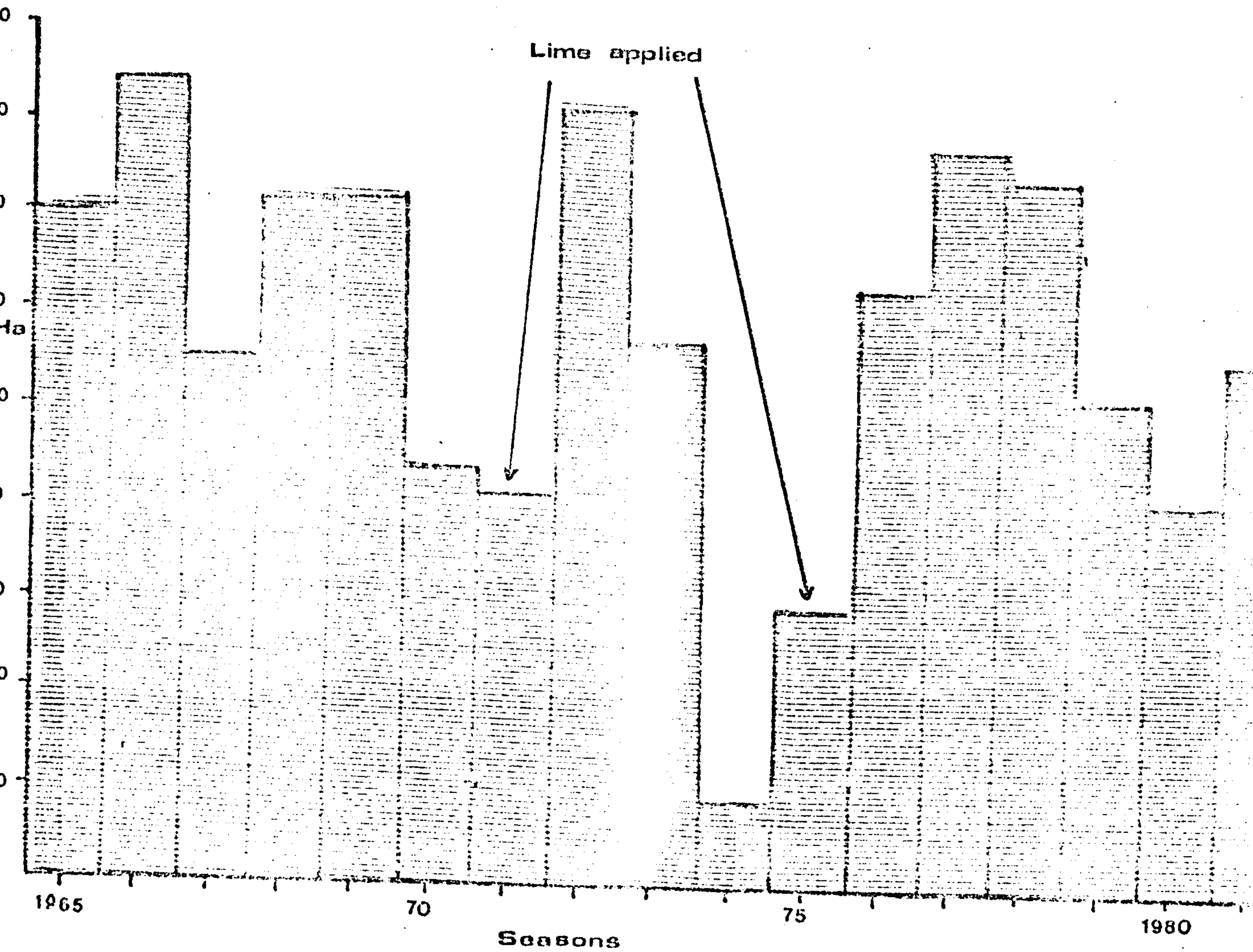
Liming observations were conducted by Booker Agriculture (1982) in Serenje at Kofi-Kunda, Chibale, to obtain field results for comparison with trials elsewhere in Northern and Central Provinces where the need for lime applications to acid soils had been established. The soil analytical results were found to be typical for the weathered ferralitic soils of the plateau which have received adequate fertilizer at rates equal to or exceeding the standard Lima recommendations. The yields (bags/ha) on the Serenje trial showed that all crops responded to application of limestone on the acid soils. Yield increases of between 40 and 70% over the control (no lime) plots were observed (for details see Appendix III).

Apart from its bulkiness, lime is relatively cheaper than the conventional fertilizers. Evidence from field trials done by the Central Research Station, Mt-Makulu, indicate that the effective residual value for limestone applications will last for more than four years. In the Misamfu Research Station experiment, lime was applied at a rate of 1 to 1.5 metric tonnes/ha in 1971 and 1975. This translates to annual average rates of 200 - 300 kg per hectare.

Lime, when used in rotation with crops such as groundnuts and soya beans, can greatly improve the farmers' gross margins. (Section 4.5).

FIG. 7

EFFECT OF LIME ON MAIZE YIELDS: MISAMFU RESEARCH STATION



Source: McPhillips 1984

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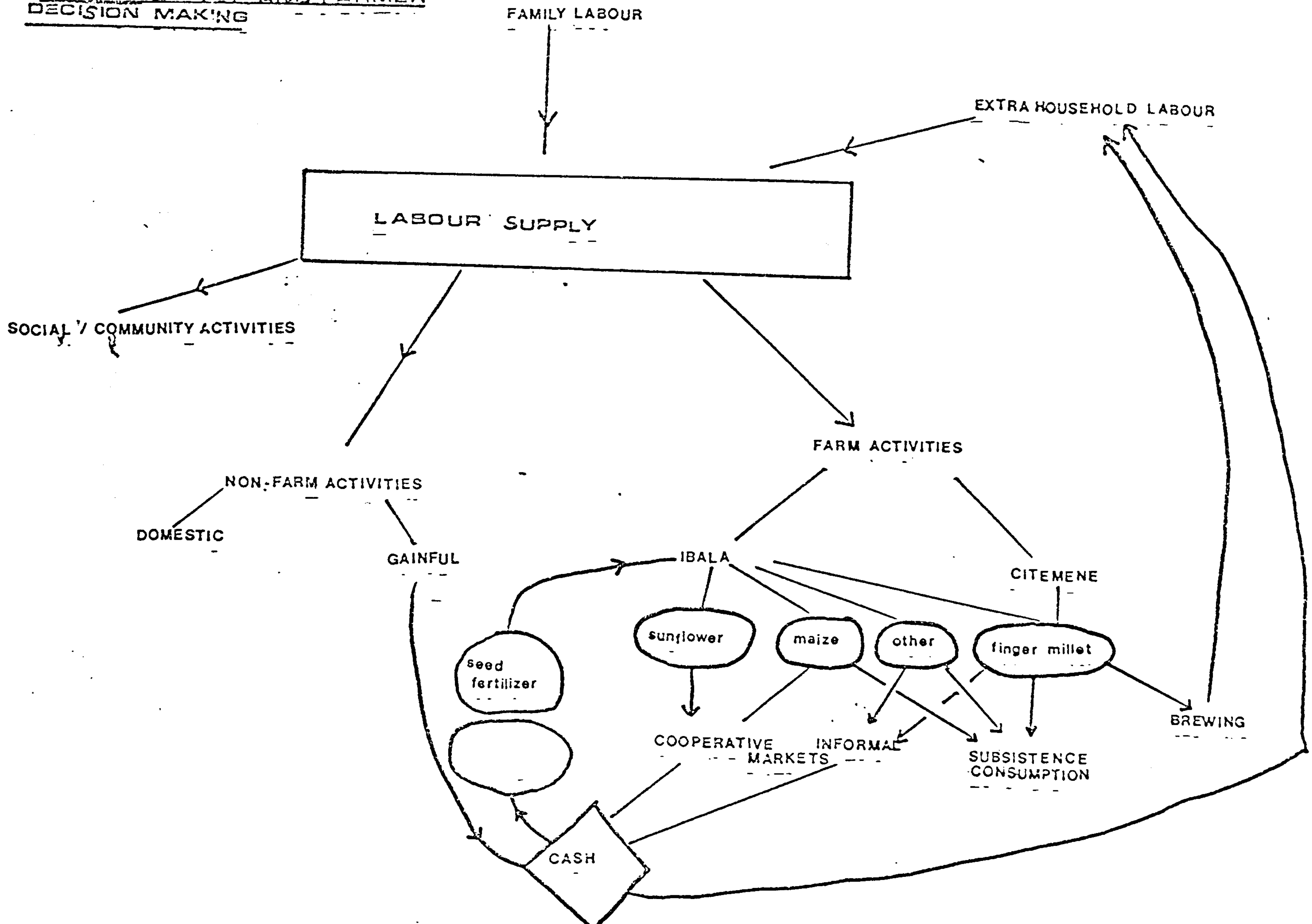
4.5 Labour Constraint

Generally, production can be increased by improving yields per hectare or by increasing the hectarage cultivated. Small farmers are usually constrained by lack of motive power (oxen, tractor, etc.) to increase the area cultivated. Usually, the more access a farmer has to motive power, the larger will be the area cultivated and the more chances to produce a surplus for the market.

Thus, the efficient use of scarce labour is central to the many small-scale producers (Figure 8). It follows, as discussed in Section 3.5, that any crop technology to be diffused to the farmers must seek to raise the output per hour and not necessarily the maximising of yields. The intercropping and rotation of maize and legumes is seen not only as a better cropping pattern in terms of soil husbandry but also more rewarding to the farmer than memo-cropping of maize (Table 7). Full and detailed computations are contained in Appendix IV.

FIG. 10 LABOUR SUPPLY AND FARMER DECISION MAKING



Source: IRDP Occasional Paper No. 5

Table 7 Returns on Crops Under Different Cropping Regime

CROPPING REGIME (1985 costs and prices)

	Mono-cropping maize	Inter-cropping maize composite + beans		Inter-cropping maize composite + cow peas		Rotational cropping maize composite + beans + soya bns			Rotational cropping maize + beans + groundnuts		
		Maize	Beans	Maize	C.Peas	Maize	Beans	S.Beans	Maize	Beans	G/nuts
Yields kg/ha[1]	2250	2250	360	2250	720	1296	163	900	1296	163	960
Return (K)	708	948		1508		1261			1312		
Production costs (K)	357*	464		384		496			520		
Net return (K)	350	483		1123		765			792		
Person-day of labour[2] required per ha per season	135	135		135		127			207		
Net return per person day of labour (K)	2.6	3.6		8.32		6.03			3.83		
Net return per Kwacha of production costs	1.98	2.04		3.9		2.54			2.52		

* Costs and returns rounded to nearest kwacha

Notes:
1. Yield figures based on IRDP Occasional Paper No:5 and research branch data of MAWD.
2. Labour data based on IRDP Farm Household Surveys in Chibale, Serenje (IRDP Occasional Paper No.5) (For soya beans labour is assumed to be 117 person days/ha/season and groundnuts 278 person days.

As can be seen from Table 7, the input requirements for the cropping pattern involving maize and legumes are more attractive than the mono-cropping of maize. The mono-cropping of maize compared to other cropping regimes has a relatively low net return, but with a high labour input. Also, the net return per man-day of labour is relatively lower.

Thus, the single-minded concentration on mono-cropping of maize, in light of the above evidence, could be recognised as not necessarily respresenting the most efficient use of the farmer's resources.

Chapter 5

5. Some Aspects of Soil Management

The weathered ferrallitic soils found in most parts of Serenje district are inherently low in nutrient reserves and organic matter. The maintenance of top-soil organic matter and the encouragement of a cropping pattern that involves intercroppings, rotation, resting of land, etc., is seen as necessary for the proper management of the soils in Serenje. The loss of soil under cultivation could be reduced by the adoption of conservation methods such as contour ploughing, minimum tillage, and planting of cover crops.

5.1 Rotations and fallows

Rotation and intercropping of maize with legumes will not only improve the farmers' ouput per unit of labour (section 4.5) but the inclusion of legumes such as beans, cowpeas, etc. in the cropping pattern will help improve the nitrogen reserves in the soil. The fixing of nitrogen is done by bacteria found at the root nodules. The inclusion of legumes in the cropping system will, additionally, help enrich the local diet by providing a relatively cheap source of protein. Disease and pest control could also be improved by rotations.

Mixed cropping with a ground cover will also offer protection of the soil surface than for a mono-culture crop. Further, when roots of deep rooting legumes decay, they leave organic residues deep within the soil profile and open channels along which crop roots can subsequently grow. Additionally, this increases the effective volume of soil available for exploitation by the crop.

5.2 Importance of Fallow

Whatever sequence of arable crops practiced, a period of rest under either fallow or cover crop is essential. Leaving the land fallow as part of the crop rotation helps maintain the physical fertility of the soil and also forms an effective cover to erosion. A rotation which allows for a minimum fallow period equivalent in length to the cropped area is usually preferable (Young 1976, Booker Agriculture 1982).

With the introduction of oxen to the farms (Plate 3) to alleviate the labour constraint, the fallow areas will be able to provide quality grazing at a time when the oxen will need extra food. Thus it is essential that the farmer understand ands accepts the idea that a break is an essential part of a farming system. At present, cropping on most farms make a continuous demand upon the soil as cultivation is carried on in the same plot each season.

Plate 3 Oxen Cultivation on a farm in Serenje.

As Mukanda (1985) observed, areas that may be left fallow could only be due to lack of time, implements or inputs, rather than any planned fallow system.

5.3 Minimum tillage

The advantages of the minimum tillage over the conventional land preparation methods is increasinly being recognised in Zambia. The Technology Development Advisory Unit (T.D.A.U.) of the

University of Zambia for instance, has devoted research effort into the development of minimum tillage equipment. 'A rotary injector planter is one such implement that has been designed by the T.D.A.U.

The overall advantage of the minimum tillage practice over the conventional approach has been the reduction of post emergence weed population. This is of great significance as weeding could be very labour demanding, especially in maize.

Minimum tillage also has the advantage of maintaining an open soil structure by not risking compaction by conventional ploughing. At the same time, it is more favourable for maintaining organic matter and nutrient levels in the top soil without dilution by ploughing into the subsoil (Booker Agriculture, 1982). But, such a system can only work satisfactorily where previous cultivation has not caused a pan within the soil profile. In such cases, the pan needs to be broken up using tines before adopting a system of minimum tillage. Compaction or sealed capping of the soil surface is commonly a cause of poor germination and growth. Consequently, it is the well structured red clay soils which are less likely to cap that are the more suitable soils in the district for minimum tillage.

The soils with a loamy sand to samdy loam topsoil can be cultivated by hand hoeing or ox plough when dry before the advent of the rains. Nevertheless, it is still important not to over-cultivate these soils in order to avoid forming a puffy seedbed which can slump under the impact of the first rains.'

For most soils, only a minimum amount of cultivation is necessary in order to prepare a coarse tilth which will withstand the pounding by the rains before the crop has developed sufficient leaf cover to protect the soil. Some protection to the bare soil early in the season when annual crops are in their early stages of growth can be obtained by adopting a system of trash farming where previous crop residues are spread over the surface before ploughing or cultivating. This trash is most effective at the beginning of the season and as the effect declines with the decay of the trash, so the young crop progressively provides increasing crop cover.

One other cultivation practice commonly used is ridging. Care, however, needs to be taken when ridging is done on an undisturbed farrow surface as this may hinder the penetration into the sub-soil of deep rooting crops such as maize and sunflower.

Chapter 6

6.1 Summary and Conclusion

Under increasing population demands on arable land, shifting cultivation (citemene) has given way to semi-permanent agriculture with maize as the principal crop.

Productivity of the sandveldt soils is generally low and inputs such as fertilizer and lime are necessary to maintain reasonable yields.

Agricultural policy incentives have mainly been concerned with maize and in most parts of the district traditional staples such as millet and sorghum have declined in importance.

Generally, labour is a major constraint to a majority of the small scale producers. The efficient use of scarce labour is, therefore central to the proposed farming system.

The intercropping and rotation of maize with legumes is seen as more attractive in the efficient use of land and labour.

The maintenance of the soil's physical properties is very importan in any farming system. This is even more crucial for the sandveld soils.

The adoption of soil husbandry methods such as minimum tillage, trash farming, including fallows, will help to maintain the physical fertility of the soils. From an agronomic point of view, improved soil structure could improve seed germination and encourage more vigorous plant growth.

Intercropping of maize with legumes will improve the nitrogen reserves in the soil and reduce the need for nitrogen fertilizer. Legumes will also provide a cheap source of protein in the local diet.

The use of lime needs to be encouraged to ameliorate the natural soil acidity of the soils, especially under the intensive fertilizer use. In most parts of the high rainfall areas of Zambia, soils are rapidly being destroyed and productivity threatened (Eklund, 1985). Therefore, availability of agricultural lime should receive high priority. The role of pricing and marketing in influencing the farmers' decision making process has been recognised. If farmers are to diversify the cropping patterns, price incentives and marketing arrangmeents for a wider range of food and cash crops need to be encouraged and strengthened.

Agricultural credit should benefit a majority of resource-poor small scale farmers. The administration of credit to such a category of farmers is usually difficult to handle. It requires require constant appraisal of the agricultural policy framework. The cost of not adopting such a farming system with some of the soil husbandry methods discussed, is production foregone and the perpetuation of the inefficient use of the farmer's scarce resources.

From the soil management point of view, it is important to recognise that once the fertility of the soil is lost through inappropriate soil management practices and cropping patterns, the consequence will be to lower yields per unit of inputs and consequently higher food prices.

References

Alder J. (1958)

A report on an investigation into Citemene Control in the Abercon district. Department of Agriculture, Lusaka.

Bates R. H. (1982)

Food Policy in Africa: Politicial causes and social effects. Food Policy November 1982.

Berg E. et al (1981)

Accelerated Development in Sub-Saharan Africa: An Agenda for Action, World Bank, Washington.

Biggs S. D. (1985)

A Farming Systems Approach: Some Unanswered Questions, Agricultural Administration 18, pp 1 - 12.

Biggs S. D. and Clay E. (1983)

Generation and Diffusion of Agricultural Technology: A review of theories and experience. ILO Working Paper No. 122.

Booker Agriculture International Limited (1982)

Integrated Rural Development Project, Serenje, Mpika, and Chinsali Districts, Planning Study - Final Report. Volumes 5 and 6.

Brammer H (1973)

Soils of Zambia, Ministry of Agriculture and Water Development, Lusaka.

Brammer H (1973(a))

Soil Profile descriptions, Analytical Data and an Account of Soil Genesis and Classification. Soil survey report No. 11. Soil Survey Unit, Mount Makulu, Chilanga.

Clay D. B. (1975)

The Sandveldt Soils of Central Province. Soil survey, Department of Agriculture, Zambia.

Clayton D. B. (1976)

The Sandveldt Soils of Central Province. Soil survey Report No. 32. Ministry of Agriculture and Water Development, Lusaka.

Davies D. H. (1971)

Zambia in Maps, Hodder and Stoughton, London.

Dent D. and Young A. (1981)

Soil Survey and Land Evaluation George Allen and Unwin (Publishers) Ltd., London.

Dent D. and Ridgeway (1985)

Sri Lanka Land Use Planning Handbook FAO/Department Land Use Policy Planning, Colombo.

Dodge J. D. (1977)

Agricultural Policy and Performance in Zambia. History, Prospects and Proposals for Change. Institute of International Studies, University of California, Berkeley.

Du Plooy J. (1966)

Less Tillage, More Profit, Farming in S.A.)

Eklund P. (1985)

The Lima Crop Extension Programme Evaluation, Strategy and Indicative Plant 1986-90. Planning Division Special Study Report No. 8. Ministry of Agriculture, Lusaka.

Elling M. (1981)

Background to Agricultural Development in Central Province, Zambia. FAO, Rome.

Ellis F. et al (1985)

Agricultural Pricing Policy in Mozambique, Tanzania, Zambia and Zimbabwe, I.D.S.

FAO (1967)

Guidelines for Soil Profile Descriptions
Food and Agriculture Organisation, Rome.

FAO (1978(a))

Methodology for Assessing Soil Degradation
FAO - UNEP. Expert Consultation, Rome.

FAO (1978 (b))

Report on the Agro-Ecological Zones Project Vol. 1. Methodology and Results for Africa. World Soil Resources Report 48, FAO, Rome.

G.R.Z (1966)

First National Development Plan , Lusaka: Ministry of Development Planning and National Guidance.

G.R.Z. (1982C)

Annual Agricultural Statistical Bulletin, Lusaka: Central Statistical Office, Lusaka.

Hudson N. W. (1971)

Soil Conservation. B. T. Batsford Ltd., London.

Hutchinson P. (1974)

The Climate of Zambia. Occasional Study No. 7, Zambian Geographical Association, Lusaka.

I.R.D.P. (M.S.C.)

Farming Systems and Family Economy in Chibale, Serenje District. I.R.D.P. Occasional Paper NO. 5.

I.R.D.P. (M.S.C.) (1985)

Draft Report on Serenje District Ox Programme (unpublished report)

I.L.O. (1978)

Regional Project on Farm Tool and Equipment Technology, Basic needs and Employment. Appropriate Farm Equipment Technology for the Small Scale Traditional Sector: the case of Zambia, I.L.O., Geneva.

Mart A. and Honeybone D. (1976)

The Economic Resources of Rural Households and the Distribution of Agricultural Development, Unza, Lusaka.

Mukanda Nawa (1985)

Land Evaluation for Multi-purpose Land Development in Masansa Area, Mkushi District, Zambia. Unpublished MSc Dissertation, U.E.A., Norwich.

Lal R and Muarya P. R. (1982)

Root growth of some tropical crops in uniform columns Plant and Soil 68, 198 - 206.

Long N. (1968)

Social Change and the Individual - A study of the Social and Religious Responses to Innovation in a Zambian rural Community. Manchester University Press, Manchester.

Mansfield J. E. et al (1975)

Land Resources of the Northern and Luapula Province, Zambia, a reconnaisance assessment, Vol. 1. Introductio Conclusions and Recommendations. Land Resources Study 19. Land Resources Division, Ministry of Overseas Development, England.

Mansfield et al (1976)

Land Resources of the Northern and Luapula Provinces, Zambia. A Reconnaisance Assessment. Vol. 4. The biophysical environment. Land Resources Study 19. Land Resources Division, Ministry of Overseas Development, London.

Marter A. (1978)

Cassava or Maize. A comparative study of the economics of production and market potential of cassava and maize in Zambia, Rural Dev. Studies Bureau, Unza, Lusaka.

Meteorological Department (1972)

Totals of Monthly and Annual Rainfall for Selected Stations in Zambia. Met. Department, Lusaka.

Minster Agriculture Ltd. (1981)

Development of Maize Production in Kabwe Rural and Mkushi Districts. Minster Agriculture Ltd., and P. E. Internationall Department of Agriculture, Lusaka.

Peters. D. U. (1950)

Land Usage in Serenje District. Rhodes - Livingstone Paper No. 19.

McPhillips J. K. (1984)

The Lima (A Zambian Approach to Better Fertilizer use by Small Scale Farmers). Research Branch, Ministry of Agriculture and Water Development, Lusaka.

Schultz J. (1974)

Exploratory Study to the Land Use Map of Zambia with Special Reference to the Traditional and Semi-commercial Land-use Systems. Ministry of Agriculture, Gaborone.

Sims D. (1981)

Agro-Climatological Information, Crop Requirements and Agricultural Zones for Botswana. Land Utilisation Division, Ministry of Agriculture, Gaborone.

Starmans K. and Stalash S. (1972)

Water Balance of Zambia. Department of Water Affairs, Lusaka.

Stocking M. (1981)

A Working Model for the Estimates of Soil Loss Suitable for Underdeveloped Areas. Development Studies Occasional Paper No. 15, Norwich.

Sorensen R. (1976)

Reconnaissance Soil Survey. Mutala-Kabundi area Soil Survey Report No. 33. Soil Survey Unit, Mount Makulu, Chilanga.

Wood A. P. (1984)

Foreign Assistance to Zambia's Rural Development. Rural Development Studies Bureau, University of Zambia, Lusaka.

Woode P. R. (1979)

Rapid Reconnaisance of part of Chief Kafinda's area Serenje District, Central Province. Soil Survey Report No. 52, Soil Survey Unit, Mount Makulu, Chilanga.

Woode P. R. (1981 b)

Reconnaissance Soil Survey of Katibunga/Mukungule area. Soil Survey Reort NO. 76. Soil Survey Unit, Mount Makulu, Chilanga.

Wood P. R. (1981 c)

Exploratory Soil Survey of Mubanga Area. Soil Survey Report No. 77, Soil Survey Unit, Mount Makulu, Chilanga

Young A. (1976)

Tropical Soils and Soil Survey. Cambridge University Press.

Van Sleen L. A. (1976a)

Detailed Soil Survey of the Lubu Valley Settlement Scheme, Northern Province. Soil Survey Report No. 40. Soil Survey Unit, Mount Makulu, Chilanga.

Van Sleen L. A. (1976b)

Detailed Soil Survey of the Chifwesa Groundnut Scheme Northern Province. Soil Survey Report No. 38, Soil Survey Unit, Mount Makulu, Chilanga.

APPENDIX I

Approximate Extent of Soil and Land Types in Serenje District

Land/Soil Type	Dominant Soil Types (FAO Classification)	Associated Soil Types (FAO Classification)	Approximate Km^2	% of Total Area	% of Plateau
Plateau					
Dambos	Gleysols	Gleyic acrisol	1400	6	10
Imperfectly drained soils	Gleyic acrisol, xanthic ferralsol, albic/ferralic arenosol	-	700	3	5
Shallow land	Ferralsols	Lithosols	1200	5	9
Deep sandy soils[(a)]	Xanthic ferralsols albic/ferralsols ferralic arenosol	-	250	1	2
Leached sandveld soils (sandy)[(b)]	Orthic/xanthic ferralsols, albic/ ferralic arenosol, ferralic arenosol	Xanthic ferralsols, orthic ferralsol	5950	25	42
Leached sandveld soils (silty)[(c)]	Ferric acrisol, orthic and xanthic ferralsols	Eutric cambisol rhodic ferralsol orthic ferralsol	4600	19	32
Total Plateau	-	-	14,100	59	100

<u>Other Land Types</u>					
Highland	Lithosols	Albic/ferralic arenosol, xanthic ferralsols, ferralsols, ferralic-arenosol	500	2	-
Escarpment	Lithosols	Ferralsols	5300	22	-
Valley	-	-	3400	14	-
Flood plains	Dystric fluvisol	Gleysols, dystric/eutric fluvisol	500	2	-
Swamps	Gleysols	-	250	1	-
Total Other Land	-	-	9950	41	-
TOTAL	-	-	24050	100	-

Notes: (a) Soils with a texture of sand or loamy sand to a depth of 90 cm or more.

(b) Leached sandveld soils with a topsoil (0-15 cm) field texture of loamy sand to sandy loam.

(c) Leached sandveld soils with a topsoil (0-15 cm) field texture heavier than sandy loam.

Source: Booker Agriculture International Ltd. (1982)

APPENDIX II

Agricultural Producer Prices

Commodities Grade "A"	Unit of Measure	1965/66	66/67	67/68	68/69	69/70	70/71	71/72	72/73
Maize	90kg	3.72	3.10	2.90	3.20	3.20	3.50	4.00	4.30
Shelled groundnuts	80kg	9.60	10.20	9.90	10.20	10.20	10.20	10.20	10.20
Canadian wonder beans	90kg	-	-	6.70	6.70	6.70	6.70	9.50	9.50
Mixed beans	90kg	-	-	3.20	3.20	3.20	3.20	4.40	4.40
Sugar beans	90kg	-	-	10.20	10.20	10.20	10.70	14.00	14.00
Soya beans	90kg	-	-	3.70	3.20	3.20	3.20	8.40	8.40
Sunflower	50kg	-	-	2.45	2.45	2.45	2.45	8.40	6.00
Velvet beans	90kg	-	-	3.20	2.45	2.45	2.45	2.45	2.45
Cow peas	90kg	-	-	2.45	2.45	2.45	2.45	2.45	2.45
Sorghum	90kg	-	-	4.70	4.70	4.70	4.70	4.70	4.70
Harricot beans	90kg	-	-	7.20	5.20	7.20	7.70	10.50	10.50
Seed cotton	1kg	0.07	0.07	0.07	0.07	0.07	0.08	0.18	0.18
Paddy rice	80kg	-	-	-	-	-	-	-	-
Sunhemp	90kg	-	-	-	7.20	5.20	5.20	5.20	5.20
Millet	90kg	-	-	-	-	6.00	6.00	6.00	?
Wheat	90kg	16.00	16.00	16.00	20.00	20.00	26.00	26.00	?

Commodities Grade "A"	Unit of Measure	1973/4	74/75	75/76	76/77	77/78	78/79	79/80	80/81	81/82
Maize	90kg	4.30	5.00	6.30	6.30	6.30	6.80	11.70	13.50	16.00
Shelled groundnuts	80kg	12.60	17.00	17.00	25.00	25.00	18.60	32.00	35.00	42.70
Canadian wonder beans	90kg	9.50	9.50	12.00	12.00	12.00	12.00	12.00	12.00	12.00
Mixed beans	90kg	4.40	-	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Sugar beans	90kg	14.00	14.00	17.00	17.00	17.00	17.00	17.00	17.00	17.00
Soya beans	90kg	8.40	13.20	13.20	17.00	17.00	21.50	25.00	32.00	36.30
Sunflower	50kg	6.40	8.95	9.40	10.00	10.00	12.50	13.70	16.40	17.60
Velvet beans	90kg	2.45	-	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Cow peas	90kg	2.45	-	8.00	8.00	8.00	8.00	8.00	8.00	8.00
Sorghum	90kg	4.70	5.00	6.00	6.00	6.00	6.00	6.00	9.00	9.00
Harricot beans	90kg	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50	10.50
Seed cotton	1kg	0.18	0.25	0.30	0.40	0.40	0.46	0.46	0.46	0.46
Paddy rice	80kg	-	12.00	12.00	14.40	14.40	14.40	16.00	18.00	18.60
Sunhemp	90kg	5.20	-	-	-	5.72	5.72	5.72	5.72	6.00

Commodities Grade "A"	Unit of Measure	1982/83	83/84	84/85
Maize	90kg	18.30	24.50	28.32
Shelled groundnuts	80kg	48.00	71.50 55.00	91.67
Soya beans	90kg	42.31	52.50 45.00	60.90
Sunflower	50kg	20.75	21.50	27.88
Sorghum	90kg	16.00	18.65	26.90
Paddy rice	80kg	28.00	40.00	40.00
Cotton	1kg	-	0.52	0.67
Wheat	90kg	32.00	42.50 35.00	45.20
Barley (malting)	90kg	?	35.75	45.20
Virginia tobacco	1kg	?	2.70	3.25
Millet	90kg		29.50	38.10
Cassava	1kg	?	0.20	0.30
Burley tobacco	1kg	?	?	2.09
Milk	1kg		0.47	0.48

APPENDIX III

Lime treatments. Kofi-Kunda, Chibale, Serenje.

The site was in the centre of a large field which had been cleared and cropped for the previous five years. The previous crop was sunflower.

Soil samples were taken from each plot for analysis on 1st November 1980 and again for pH determination on 28th January 1981

Lime treatments were applied on 2nd November. The maize and groundnuts were planted during the period 4th to 6th December and the sunflower and beans were planted during the period 5th to 8th January 1981.

Leaf samples were taken from the maize crop on 28th January 1981.

The soil was a red weathered ferrallitic sandy loam to 15 cm over sandy clay loam.

Soil analytical results

Plot/treatment		Depth cm.	pH Nov.1980	pH Feb.1981	Available Phosphorus ppm	Exchangeable Potassium me/100g
1	NL	0-15	4.8	5.5	33(R)	0.20(M)
		15-30	5.0	5.4	12(M)	0.20(M)
		30-45	5.0	4.8	21(A)	0.17(M)
2	C	0-15	4.6	4.6	27(R)	0.33(R)
		15-30	4.3	4.4	11(M)	0.18(M)
		30-45	4.3	4.4	15(M)	0.16(M)
3	C	0-15	4.4	4.2	11(M)	0.22(A)
		15-30	4.4	4.4	19(A)	0.16(M)
		30-45	4.4	4.5	6(D)	0.11(M)
4	LL	0-15	4.5	5.3	28(R)	0.19(M)
		15-30	4.5	5.1	26(R)	0.20(M)
		30-45	4.4	4.9	13(M)	0.14(M)
5	LL	0-15	4.8	5.7	24(A)	0.19(M)
		15-30	5.0	5.3	24(A)	0.10(M)
		30-45	5.2	4.7	11(M)	0.15(M)
6	NL	0-15	4.6	5.0	9(M)	0.21(A)
		15-30	4.3	5.2	9(M)	0.19(M)
		30-45	4.4	4.5	15(M)	0.11(M)

		Ex. calcium me/100g	Ex. magnesium me/100g
Plot 1	0-15	1.15	1.02
	15-30	1.50	1.15
	30-45	1.15	0.10

Where: D = Deficient

M = Marginal

A = Adequate

R = Rich

The three treatments tested were:

a) C - Control - no limestone

b) NL - Ndola - calcium limestone

c) LL - Lusaka - magnesium limestone

Leaf Analysis

Plot/treatment		% N	% P	% K
1	NL	3.2	0.34	2.60
2	C	3.1	0.32	2.15
3	C	2.8	0.38	2.60
4	LL	2.8	0.31	2.50
5	LL	2.9	0.32	2.30
6	NL	2.8	0.32	2.45

Yields (bags/ha) on the same trial were observed as follows:

Serenje	Control no lime	Ndola lime	Lusaka lime	% increase in yield with Lusaka lime
	42.8	45.1	59.9	40
	6.6	11.1	11.2	70
	18.3	20.5	26.5	45
	1.8	2.7	2.7	50

The results show that all crops responded to applications of limestone on the acid soils with the Lusaka (magnesium) limestone superior to the Ndola (calcium) limestone.

APPENDIX IV

Indicative Farm Budgets

(per ha 1984/85 prices)

Mono Cropping Maize Composite[1]

Cost of Inputs

Seed maize:	25kg MMV 600 at K40/kg	20.00
Fertilizer[2]:	Basal X, 4 bags at K26.75	107.00
	Top Urea 4 bags at K26.75	107.00
Herbicides:	3 litres Primagram at K17.20/5 litres	10.32
Pesticides:	12 kg Carbofuran 10g at K7/20g	4.20
	2kg Endosulfan at K12/kg	24.00
Labour:	25 man days at K2/man day	50.00
Empty bags:	25 bags at K1.05/bag (K0.95 refundable)	2.50
Transport:[2]	at K1/bag	25.00
	Sub Total	350.02
	Contingency 10%	32.50
	Total Variable Costs	382.52

Revenue[3]

25 bags at K28.32		708.00
	GROSS MARGIN	325.48

Notes:

1. Composite is MMV 600
2. Flat rate of K1/bag
3. Yields for maize assumed at 2.6 tonnes/ha.

Indicative Farm Budget

(per ha 1984/85 prices)

Intercropping : Maize Composite and Beans

Cost of Inputs

Seed Maize:	25 kg MMV 600 at K40/50kg	20.00
Beans:[1]		67.50
Fertilizer:	Basal X, 4 bags at K26.75	107.00
	Top Urea 4 bags at K26.75	107.00
Herbicides:	3 litres Primagram at K17.20/5 litres	10.32
Pesticides:	12 kg Carbofuran 10g at K7/20g	4.20
	2 kg Endosulfan at K12/kg	24.00
Labour:	25 man days at K2/man day	50.00
Empty bags:	20 bags at K1.05/bag (K0.95 refunded)	2.90
Transport:	at K1/bag	29.00
	Sub total	421.92
	Contingency 10%	42.19
	Total Variable Cost	464.11

Revenue

Maize:	25 bags at K28.32	708.00
Beans	4 bags at K60/bag	240.00
	Total	948.00
	GROSS MARGIN	483.89

1. Seed rate is 45 kg for intercropping
Local price is estimated at K1.5 per kg.

Indicative Farm Budget

(per ha 1984/85 prices)

Intercropping: Maize Composite and Cowpeas

Cost of Input

Seed Maize:	25 kg MMV 600 at K40/50kg	20.00
Cowpeas:		24.00
Fertilizer:	Basal X, 4 bags at K26.75	107.00
	Top Urea 4 bags at K26.75	107.00
Herbicides:	3 litres Primagram at K17.20/5 litres	10.32
Pesticides:	12 kg Carbofuran 10g at K7/20g	4.20
	2 kg Endosulfan at K12/kg	24.00
Labour:	25 man days at K2/man day	50.00
Empty bags:	33 bags at K1.05/bag (K0.95 rufundable)	2.90
Transport:	at K1/bag	33.00
	Sub total	349.42
	Contingency 10%	34.94
	Total Variable Cost	384.36

Revenue

Maize:	25 bags at K28.32	708.00
Cowpeas:	8 bags at K100	800.00
	Total	1508.00
	GROSS MARGIN	1123.40

Indicative Farm Budgets

(per ha 1984/85 prices)

Rotational Cropping : Maize Composite & Beans + Soya Beans

	Rotational Cropping	
	Maize Composite[1] & beans 0.5 ha	Soya Beans Fert = L-Mix 0.5 ha
Cost of Input		
Seed Maize	10.00	
Beans[2]	33.75	
Soya Beans[3]		30.00
Fertilizer[4]	214.00	
L-Mix		45.00
Bags at K1.05/bag (K0.95 refundable)	1.70	1.00
Pesticides & Herbicides	38.52	
Labour 25 man days at K2/man day	50.00	
Transport	17.00	10.00
Sub Total	364.97	86.00
Contingency 10%	36.50	8.60
Total	401.47	94.60
	496.07	

Revenue

Maize:	14.4 bags x 28.32	409.07	
Beans:	162.5 kg	243.75	
Soya Beans:	900 kg		609.00
	Total	652.82	609.00
		1261.82	
	GROSS MARGINS/HA	765.75	

Notes:

Source: Rotational Cropping Data based on Research Branch Data, MAWD.

1. Composite is MMV 600

2. Seed rate is 45 kg for intercropping.
   Local price estimated at K1.5/kg.

3. For soya beans the official market price of K60.90 per 90 kg bag is used; seed rate is 80 kg/ha

4. Fertilizer application is equivalent of 400 kg of X/ha applied only on maize and beans.

Indicative Farm Budgets

(per ha 1984/85 prices)

Rotational Cropping : Maize Composite + Beans and Groundnuts

	Maize Composite[1] and Beans 0.5 ha		Groundnuts 0.5 ha
Cost of Input	(K)		(K)
Seed Maize	10.00		
Beans[2]	33.75		
Groundnuts			55.00
Fertilizer	214.00[3]		
L-Mix			45.00=
Bags at K1.05/bag (K0.95 refundable)	1.90		.60
Pesticides & Herbicides	38.52		
Labour 25 man days at K2/man day	50.00		
Transport	19.00		6.00
Sub Total	367.17		106.00
Contingency 10%	36.72		10.60
	403.89		116.60
Total costs		520.49	

Revenue			
Maize:	409.07		
Beans:	243.75		
Groundnuts:			660.00
Total	652.82		660.00
		1312.82	
GROSS MARGIN/HA		792.33	

Notes:

Rotational Cropping Data based on Research Branch Data - Ministry of Agriculture and Water Development.

1. Composite is MMV 600.
2. Beans seed rate is 45 kg for intercropping. Local price estimated at K1.5/kg
3. For soya beans the official market price of K60.90 per 90 kg bag is used, seed rate is 80 kg/ha.
4. Fertilizer application is equivalent of 400 kg of X/ha applied only on maize and beans.
5. Yields for maize assumed at 2.6 tonnes/ha. Beans .325 tonnes/ha and groundnuts 0.960 tonnes/ha.