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Working Paper

59

ENVIRONMENTAL CHANGE AND DRYLAND MANAGEMENT IN MACHAKOS DISTRICT, KENYA 1930-90

FARMING AND INCOMES SYSTEMS

Mary Tiffen

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Preface and Acknowledgements

ODI Working Papers present in preliminary form work resulting from research undertaken under the auspices of the Institute.

This Working Paper is part of a study which aims to relate long term environmental change, population growth and technological change, and to identify the policies and institutions which are conducive to sustainable development. The first stage, published in these Working Papers, is to measure and assess as precisely as the evidence allows the changes that have occurred in the study area, the semi-arid Machakos District, Kenya, over a period of six decades. Degradation of its natural resources was evoking justifiable concern in the 1930s and 1940s. By several measures it is now in a more sustainable state, despite a five-fold increase in population. A long-term perspective is essential, since temporary factors, such as a run of poor rainfall years, can confuse analysis of change if only a few years are considered. The study is developing a methodology for incorporating historical, physical, social and economic data in an integrated assessment. The final report will include a synthesis and interpretation of the physical and social development path in Machakos, a consideration as to how far the lessons are relevant to other semi-arid environments, and recommendations on policies for sustainable economic growth.

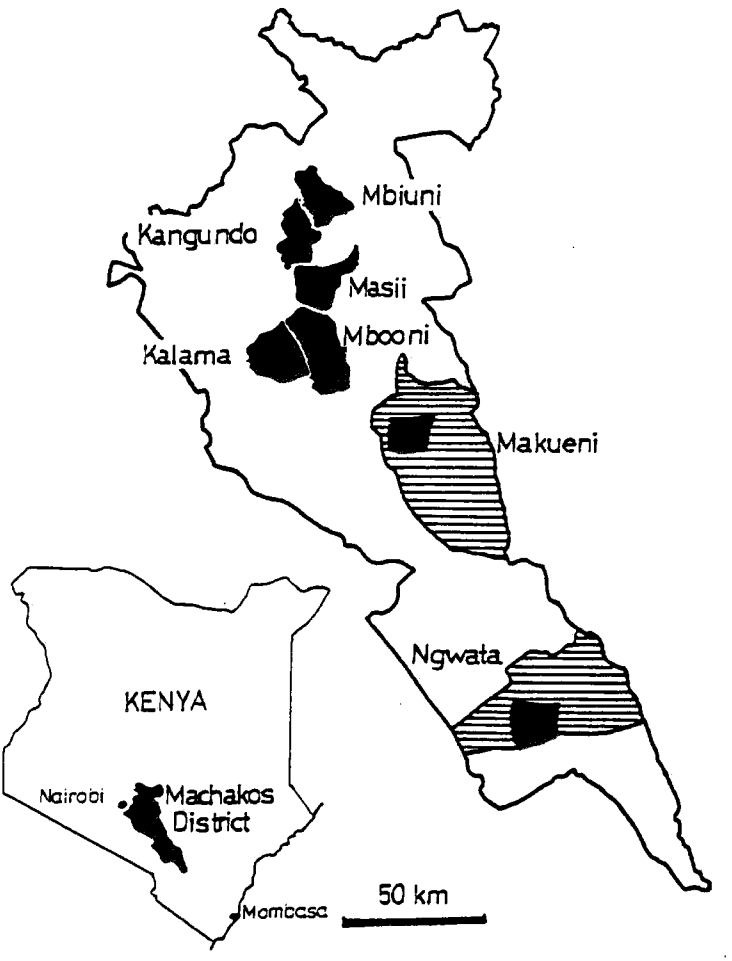
The project is directed at ODI by Mary Tiffen, in association with Michael Mortimore, research associate, in co-operation with a team of scientists at the University of Nairobi, and with the assistance of the Ministry of Reclamation and Development of Arid, Semi-Arid Areas and Wastelands in Kenya. We are grateful to Professor Philip Mbithi, Vice-Chancellor of the University of Nairobi, for his support and advice. We also thank the Overseas Development Administration, the Rockefeller Foundation and the Environment Department of the World Bank for their financial support. Views expressed are those of the authors and do not necessarily reflect the views of ODI or supporting institutions. Comments are welcome, and should be sent directly to the authors or project leaders.

Other titles in this series (in which more are planned) are:

Machakos District: Environmental Profile
Machakos District: Population Profile
Machakos District: Production Profile
Machakos District: Conservation Profile
Machakos District: Technological Change
Machakos District: Land Use Profile
Machakos District: Institutional Profile

Mary Tiffen is the author of this paper. She is a Research Fellow of the Agricultural Administration Unit of the Overseas Development Institute.

Preface Figure: **Machakos District, Kenya, showing study locations**
(In Makueni and Ngwata Locations, field studies were mostly within the areas shown black.)



CONTENTS

1. THEORETICAL FRAMEWORK

1.1 Structure of the Analysis

The objective of this Working Paper is to examine the dynamics of change in farming and income systems during the period 1930-90. The two elements of continuity during this period are, firstly, the household, which utilises its resources of labour and capital to generate income from both farming and non-farming activities, and secondly, the variable, risky, semi-arid environment. The two main forces of change are the growth of population, leading to the need to find new ways of retaining and improving productivity as land-extensive methods of farming and livestock-raising became steadily less viable; and improvements in access to markets and the aspiration for a greater range of goods and services. The latter was an aspect of greater integration with the rest of the Kenyan economy and particularly with its developing urban markets, the nearest of which were Nairobi and Mombasa. We begin, therefore, by some theoretical considerations of these influences, which provide the framework for understanding the changes that took place in farming and income systems. In particular, we highlight the way in which intensification results in increased need for, and new roles for, capital. Capital flows to and fro between the farm and non-farm sector, and is also invested in education which has pay-offs in both sectors. The Paper also includes an analysis of an attempt to short-cut evolutionary change at the Makueni settlement, which was only very partially successful despite its considerable costs to government funds, and contrasts this with the evolution of more intensive farming systems in spontaneous settlement areas.

In a historical study of development we have to make the use of the literature and analyses made at past points in time, taking into account their particular shortcomings and viewpoints. There are no farming systems studies before 1962 and few after 1981. Farming systems underwent considerable modification in the 1980s partly because there was no new land to settle and average farm size decreased more rapidly than in the period 1960-80. For the situation before the 1960s and since 1982 we are mainly dependent on our own interviews with village leaders in five study areas, and with a quick non-random survey of 40 farmers in the same areas. The village-level interviews authenticate much of what we have found in the literature, and we feel, therefore, that they give a reliable broad picture of the development of farming down to the present. The interviewing schedule for village leaders are given in the Appendix to the Institutional Profile; that for farmers are given in the Appendix to this paper. They were slightly modified in each area, according to settlement history.

The farming system in the 1930s in all the settled areas (then only AEZ 2, 3 and 4) was based on subsistence foods and livestock. We begin by trying to see why it was in crisis in the 1930s and 1940s. Intensive, commercialised farming in response to the market developed first in AEZ 2 and 3, with repercussions on farming in AEZ 4, 5 and 6, for which they provided both a local market and an example. Income sources in these areas became increasingly diversified as the opportunity for non-farm jobs increased. By the late 1970s the highland areas were facing a new crisis, due to escalation of population growth and reduction in farm size (both limited till then by emigration to new farm lands) and to the fall in the price of their main cash crop, coffee. This led to a new series of rapid changes in farming strategy, some of which again spun off into the lower potential areas.

Two studies in the 1960s give us a basis to examine the changes that took place after 1965 in AEZ 4 in the older and more densely populated areas, and to compare and contrast this with the development path of the Makueni settlement, and with unsupervised settlement in other parts of AEZ 5 and 6.

Farm and income strategies vary not only according to AEZ, but also according to particular household endowments of land, labour and capital. In so far as the data allows, we examine how constraints varied for small and large farmers, and the reasons why recommended field crops such as cotton have had limited success. Access to capital is even more important than farm size in determining farm income. We look at the role of non-farm income, and changes in its nature as the rural economy diversified.

Finally, we survey the limited evidence on changes in living standards before examining the extent to which our theoretical models have been fulfilled.

1.2 Centrality of the Household

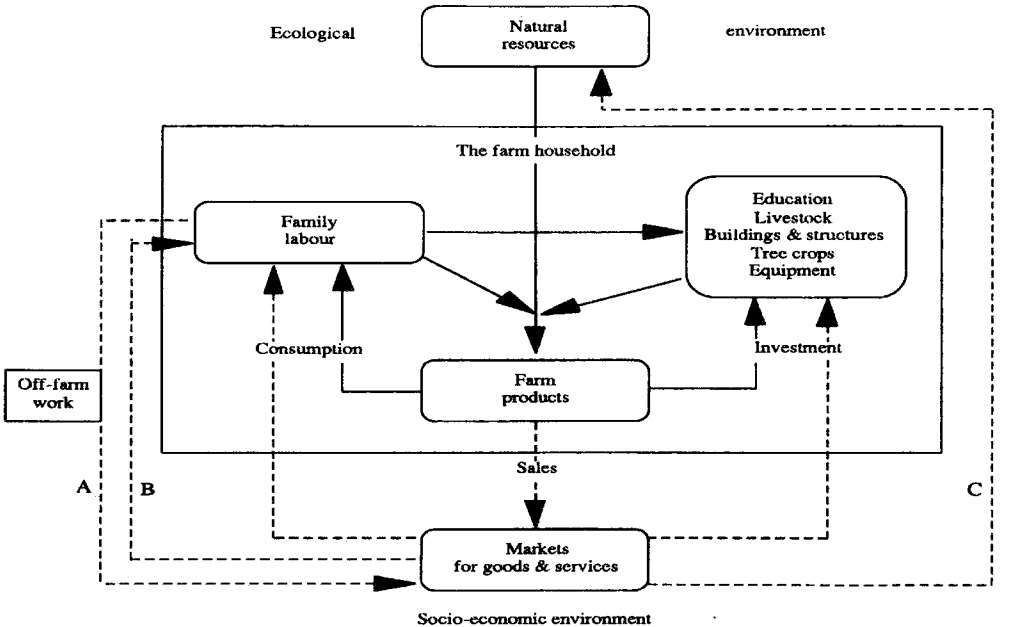
The time of its members is the basic household resource, which households seek to allocate as efficiently as possible to on-farm and off-farm opportunities (Low, 1988:29; Moock, 1986). Because women are more tied to the house by their child-rearing role, occupations involving distance from the home are pursued more often, but not exclusively, by men. The degree of male participation in farming changes according to the economic attractiveness of on- and off-farm occupations, and the particular assets of the household. Figure 1 shows the relationships, with off-farm work detracting from the labour available for farming activities, but contributing to family consumption and to the possibility of farm investments. Incidentally it also brings in more information, which can improve farm management. It therefore has both positive and negative aspects for the raising of farm output. The degree of scarcity in the factor, labour, depends in part on the other opportunities available.

Households are also endowed with land and capital, and, over time, reallocate their resources in response to changing conditions, within and without the farm. The inadequacies of the historical data do not permit a classic analysis of factor relationships and output in the farm element of household activities. However, the general trend has been towards intensification, meaning by that, the application of increased amounts of labour and capital to land, in order to maintain or expand the value of output in the face of a gradually diminishing ratio of land to people. This trend to increasing land scarcity has not been steady, since at times the land resource was increased either by the opening up of new water resources which endowed hitherto useless land with utility, or by the removal of other impediments to settlement in new areas, whether political or physical (see Population Profile).

1.3 Influence of a Semi-arid Environment with Variable, Bimodal Rainfall

The development path has also been conditioned by the climate. As has been shown in the Environmental Profile, Section A: Rainfall, Machakos farmers have on average no more than a 60% probability of getting the minimum rain needed for a maize crop, and bad seasons tend to come in sequences. Hedging against drought risk has always been important. The normal

Figure 1: **A family farm system**



Note: A = Off-farm work
B = Labour hire
C = Purchase or renting land

strategy is to supplement cropping both by livestock, as a store of wealth which can be cashed in bad seasons, and by an off-farm activity. In the nineteenth century the main off-farm activities were trade, hunting, and the sale of labour to more fortunate neighbours, such as the Kikuyu, when famine struck. The climate is most restrictive in AEZ 5 and 6, least in the highland areas of AEZ 2 and 3 which, however, are still subject to quite frequent droughts (see graphs of rainfall at Kangundo, Figure A.3, Rainfall Profile).

The off-farm income strategy is common in Kenya; Hunt was one of the first to point out both the extent of off-farm income in Mbere, Embu District, and its importance in enabling farmers to take the risk of innovation (Hunt, 1975). The importance of non-farm income is a national phenomenon. In 1974-75 the farm operating surplus formed only 57% of rural incomes (Central Bureau of Statistics, Integrated Rural Survey 1974-75). It is important to note this was a period of widespread drought; the percentage might be higher in years of average rainfall. Non-farm income may be a permanent part of a household income, as where one member has a local non-farm job or business, or where a husband, son or daughter working away sends a regular sum home. It contributes both to new capital investment and to what Carter and Wiebe call ex-post capital, an insurance substitute against the risk of complete harvest failure (Carter and Wiebe, 1990). Relatives can also be called upon to make a greater than usual contribution either in drought or when a new lumpy investment is needed, for example, the purchase of a grade cow.

Secondly, as was also found in Botswana,

> *The greatest single determinant of overall productivity is how effectively farmers make use of limited amounts of water. The availability of labour and capital (particularly draft animals, tractors, etc.) are particularly important in facilitating more efficient use of available water by improving 'timeliness' of operations* .... (Norman and Baker, 1986:49).

To 'timeliness' one can add in Machakos a variety of other water-conserving techniques, including terracing, ridging, weeding, etc. Unfortunately, none of the existing studies examines farming systems in terms of their return to rainfall or soil moisture[1], and all we can do is cite some farmer evidence for its importance.

1.4 Population Growth and the Development of Farming Systems

There is an extensive literature on the interrelations of population, environment and poverty, which cannot be reviewed in full here. There are two main schools. In the first, population growth is seen as leading to diminishing returns in agriculture, leading to environmental decline and famine, following the Ricardian and Malthusian analyses. Associated with this is a literature on the safe human carrying capacity of agricultural systems in various ecozones, much of it derived from Allan (1965). This has since been developed to propose that carrying capacity will vary according to technological level, while still setting very definite limits to the population density that can be supported without environmental degradation

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1. Returns to water have been examined in some irrigation studies, amongst others, Mary Tiffen, (1990).

and/or increasing poverty (e.g. FAO, 1986; Bernard, Campbell and Thom, 1989). Thus in Machakos Bernard saw clear evidence in 1977 of the District being involved in a spiral of population pressure, soil deterioration, use of poor lands, and declining living standards (Bernard, Appendix 1, Consortium Report No.6, 1978). Bernard noted that carrying capacity will also vary according to the degree of reliance on non-farm income sources, but not all proponents of carrying capacity have looked at farming systems in the context of total income systems.

Ester Boserup stated that on the contrary, population growth stimulates changes in farming systems that make them capable of supporting a larger population (Boserup, 1965). In her most recent development of her theory she makes the following points (Boserup, 1990:11-20):

- population growth leads to greater frequency of cropping. This was the main emphasis in her first book and has led to a taxonomy of farming systems largely according to cropping intensity, developed in Ruthenberg (1980), leading from shifting cultivation to bush fallows, short grass fallows, and then to permanent cropping and, possibly, multiple crops per year. Greater frequency of cropping leads to a higher labour requirement, and a larger output per unit of land, but a reduced reward per labour day. Therefore, people do not intensify a farm system unless they have to: long fallows are the cheapest way to maintain fertility while plenty of land is available.

- increased intensity of cropping demands increased labour inputs, not merely into current farming activities, but also into labour investments to improve farm productivity (terracing, irrigation, etc.). Therefore, a labour surplus rarely develops. The adoption of the plough overcomes labour constraints in land preparation, but they remain in other activities.

- as population increases, the cost of transport infrastructure per head decreases, leading to the emergence of small market towns, and new centres of consumption near to new farm areas. The decrease in the cost of transport and the increase in market demand will normally lead to higher prices at the farm gate. If this happens, there will be greater incentives to invest labour and capital in improving output.

- new mechanical and chemical technologies have changed the constraints on population growth from the single one of land area to those of energy supply and costs, and capital investment, and made the raising of output more than ever dependent on the improvement of rural infrastructure (roads, electrification, etc.).

- as frequency of cropping increases, so tenure develops from a tribal or feudal basis towards private property.

Writing in 1965, Boserup was concerned principally with the move from shifting cultivation to permanent cultivation in the arable areas, which takes place as population density rises over 30 per km^2. In the settled parts of Machakos District densities in the 1930s were already over 80 per km^2 in AEZ 2 and 3, and over 50 per km^2 in AEZ 4 (see Population Profile, Table 6). Only one third of cropped land was reckoned to be fallowed in 1930 (see below). By Ruthenberg's taxonomy it was moving from short grass fallows to permanent cultivation (Ruthenberg, 1980).[2] At this stage, the plough is often adopted (Boserup, 1981; Pingali et al., 1987). Manuring is adopted quite early in the process of intensification, followed by terracing and irrigation (if feasible) as the density rises nearer 100/km^2, followed by stabling (Ruthenberg, 1980: Table 6.1 based on Ludwig, 1968). The latter, which involves keeping the cattle in the same overnight location to collect their manure, seems to be associated with a population density of over 150 km^2, reached in the northern hills of Machakos by 1948. In this study, therefore, we are looking at the later stages of intensification.

The need to find substitutes for fallowing to replenish fertility accompanies the increase in frequency of cultivation. As Ruthenberg puts it, the 'basic principle of farming is to change the natural (vegetation) system into one which produces more of the goods desired by man..... Farming thus implies the abolition of an unproductive[3] 'steady state' in favour of a man-created, more productive but unstable 'state', and much of the farm input (tillage, fertilizers, weeding, etc.) is nothing but an effort to prevent the new state from declining towards an unproductive low-level steady state' (Ruthenberg, 1980:9). The reduction in fallowing in the early stages of intensification generally leads to an increase in manuring. Later changes in the proportion of livestock to arable land lead to additional methods of fertility management in tillage methods, increased attention to soil conservation and weeding, and the use of various supplements to manure such as fertiliser and compost. Because additions of the same inputs - weeding labour, seed, etc., suffer from diminishing returns, progress in intensification requires, from time to time, shifts to a new technology.

A question raised by Lele and Stone is whether, in the circumstances of rapid population growth, at rates much higher than those upon which Boserup was drawing her conclusions in 1965, autonomously induced change due to shifts in relative factor prices will be sufficient to counter the decline in fertility following from fallow reduction. They argue that active government policies in agricultural research and other matters are essential to bring about change (Lele and Stone, 1989). The experience of Machakos District shows that certain government policies and investments, particularly in research, extension, transport and water development, have assisted the process of intensification, but they have been most successful when they were operating in accordance with farmers' perceptions of the factor price relationships, and when they have complemented the farmers' own investments, innovations, and changes of farming system. Farmers also intensify because of new market opportunities, leading to changes in farm-gate prices. Large areas of Machakos have been handicapped by poor market access. In 1970 there were only 12 km of classified road per 100 km^2; this had

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2. Ruthenberg does not discuss the bimodal rainfall regime, associating double cropping with irrigation. In Machakos it is possible to get two crops per year, provided the short rains crop can be harvested and the land prepared before the long rains begin.

3. The key phrase is 'more of the goods desired by man'. An uncultivated area may of course be biologically productive.

increased only to 19 km in 1983. In 1970, 15 more advantaged Districts already had over 30 km of roads per 100 km^2 (Gyllstrom, 1991, Appendices 1 and 2).

Characteristics of the later stages of population growth are a fall in the ratio of pastoral to arable land (Boserup, 1981:17). The corresponding fall in the importance of livestock production is not in proportion to the reduced area of land allocated to grazing, because of intensification of the livestock component of the system. The intensification of the livestock component has had less attention in the literature than the arable component. In Machakos, we can distinguish three stages. At low intensities, livestock are fed mainly from communal grazing lands. The cattle post is on the grazing land. A characteristic management method to maintain grassland and prevent bush encroachment at this stage is burning. This technique is suited to areas where grazing land is plentiful in relation to both labour and demand, since it can only be used to control bush when the grass has been allowed to grow long.[4] At medium intensity, they derive most of their nourishment from private grazing land and crop residues, and they are brought back to a stable or *boma* at night where their manure can be collected. At high intensities, crop residues and specially grown and cut fodder crops are carried to the livestock in zero grazing systems, which increase the output of manure. Each step increases labour costs. If farms become ever smaller through sub-division as the population increases, the cost of feeding draught animals may exceed the value of their draught contribution, and on small farms, people may drop livestock, and revert to hand tools. They then need to seek replacements for manure to maintain fertility.

1.5 Population Growth and Capital Requirements

The new elements which Boserup has introduced into her original theory are a greater emphasis on the importance of capital, both on the farm and in rural infrastructure, in the process of agricultural intensification. In its later stages intensification requires the application not only of increased labour, but also increased capital to each unit of land in order to raise or maintain its productivity as land becomes an increasingly scarce factor of production. In an environment such as that of Machakos, land must be united with water and some of the most crucial uses of capital have been for water conservation - through use of tillage techniques made easier by the plough and through soil and water conservation structures. However, capital has also always been short, since in this hazardous agricultural environment, capital resources in form of livestock can easily be wiped out, and the first call on capital tends to be the reserve needed to tide families over bad seasons. Capital can not easily be engendered from agriculture itself, partly because of the hazards, partly, in the early days, and still to an extent today, because of difficulties in market access. Hence, it has often to be brought in either from a non-farm occupation, or from government, or created through direct work.

The process of intensification increases the importance of capital, which plays more varied roles. Initially, capital, primarily in the form of livestock, was chiefly important as an

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4. Morrison undertook a study of the relative costs of clearing bush by burning, hand clearance and two mechanical methods in 1958. Burning was the cheapest; its cost was mainly in the loss of revenue (for ranchers) during a nine month pre-burn rest and nine month post-burn rest.

insurance substitute, and as a means of acquiring wives to work more land. Currently it is utilised in several forms:

Fixed:
1. Farm structures: fences, hedges, terraces, dams, irrigation channels, farm buildings, etc.
2. Trees.

Moveable:
1. Livestock.
2. Equipment - ploughs, hoes, etc.
3. Assets or liquid resources held as an insurance substitute - grain in store, money in the bank, cattle, etc. Goodwill and reciprocal obligations amongst neighbours and kin are also worked for and created in this context.
4. Education - skills and knowledge, useful for better farming, but transferable to a better-paying job. While the considerable investment families make in education have to be seen in the context of their total income strategy, it nevertheless also has a pay-off in farming. Heyer showed that managerial skills meant that better farmers made 4 times as much as poorer farmers with similar land and labour resources (Heyer, 1967a:iii).

Working: Fertiliser, seed, animal feeding stuffs, hired labour, etc.

We generally think of capital in terms of the investment of cash, which has been obtained either from farm profits, or from savings from another occupation, or by loans or gifts. However, capital assets can also be created by investing labour and the sacrifice of leisure or more immediate gain, or by saving materials such as seed, rather than consuming them. However capital is acquired, it is not invested unless there is a realistic expectation of adequate reward, taking into account the risks. Investment in fixed capital requires security of land ownership or control.

Few studies in Machakos have given adequate attention to the factor of capital. Even in those studies which have given working capital or equipment attention, capital in the form of farm structures, trees and even, in some cases, livestock, has been ignored.

1.6 Variations in Access to the Factors of Production

Families are not, and never have been, equal in terms of their access to capital, labour and land. Land distribution has always been skewed. The situation in the 1960s is shown in Table 1. A few large holders create the situation where the typical, modal farm is smaller than the arithmetical average. This applies also to the distribution of cattle. About 30% of farmers in the 1960s owned no cattle. In Masii, where there was a high proportion of cattle owners, 74% had 1-10 cattle, 13% had 11-20 cattle and 3% had 20-40 cattle (Owako, 1969). Earlier there are frequent references in official reports to 'cattle barons' with large herds (Forbes Munro, 1975:218; Lambert, 1945:100).

Table 1: **Percentage of farmers by land ownership category**

		Land owned, hectares								
AEZ	*Location*	*0-0.4*	*0.4-1.2*	*1.2-2*	*2-3.6*	*3.6-6.8*	*6.8-12*	*12-20*	*20-40*	*Over 40*
1964										
2 & 3	Iveti	7.5	35.8	24.2	15.0	5.0	3.3	5.8	3.3	-
2 & 3	Kangundo	1.8	15.0	19.6	34.6	20.6	7.5	0.9	-	-
2 & 3	Mbooni	-	7.5	19.2	41.2	24.2	5.8	1.7	-	-
4	Masii	-	4	11	35	23	15	6	3	3
4	Nzaui	-	6.9	6.9	18.4	25.3	14.9	16.1	8.0	3.4

Source: Owako, 1969, Table 10, and own calculations.

		Land owned, hectares						
		0-0.4	*0.4-1.2*	*1.6-2.8*	*3.2-4.0*	*4.4-6.0*	*6.4-8.0*	*8.4-12.0*
1977								
4	Machakos and Kitui	1.2	18.0	27.7	18.7	12.0	10.4	11.9

Source: Consortium for International Development (1978), Report 3, Table 2.

Standard theory would lead us to expect that at any given time, the reward to family labour on the farm is below the market wage for those with a high ratio of labour to land, while access to capital, and hence its price, should tend to be easier for those with large farms and herds. This was found to be the case recently in a study of farms in Njoro, Kenya. It led to different farming systems on small and large farms; in the Njoro case, the smallest farms with least insurance and working capital devoted all land to the main staples, maize and beans; the medium sized farms brought in pasture and fodder, and only the largest went for the most profitable crop, wheat (Carter and Wiebe, 1990). We test this in regard to Machakos, and show that while a similar relationship appears with regard to cotton in AEZ 4 and 5, it does not hold for coffee in AEZ 2 and 3, where the risk factor is less. The relationship is also strongly modified by the availability of non-farm work; some of those with small farms are able to put most of their labour into such work, and capitalise their small farm area. While concentrating on maize and beans, they obtain high returns to the labour and capital invested.

2. THE CRISIS IN THE LIVESTOCK AND SUBSISTENCE FOOD CROP SYSTEM, 1930-60

2.1 Characteristics of the Farming System 1930-60

The few descriptions of farming in the 1930s do not differentiate between AEZ 2, 3 or 4. Typically a small area for cultivation of food crops was combined with extensive livestock raising. A man and his wife were said to cultivate about 0.7 ha. in the more productive areas, and about 1 ha. in the less productive ones. About 56,000 ha. were said to be cultivated and 28,000 ha. under fallow, i.e about one third of the cultivated area (see Table 7, Land Use Profile). There is no description of the fallowing system: an earlier description says fields were fallowed for three or four rainy seasons (i.e. two years) if fertility was perceived to be falling (Lindblom, 1920:503). The size of the cultivated area would have been limited by the tools used - the most important was the digging stick. Lindblom also says no manure was used; in his observations circa 1912 fertilisation was only by burning the dry remains of plants, weeds and other rubbish before cultivation. Seeds were broadcast. Some people had outlying shifting fields, and if the home fields became exhausted, a new homestead would be established in this area. This was a process which led to a general movement northward into such areas as Kangundo and Matungulu, away from the oldest settled area, Mbooni, noted by administrators in the 1920s. With two rainy seasons, either of which could fail, cropping was taking place in both by the 1940s.[5] By 1930 the main crops were maize and pulses, with some sorghum and millet. Lindblom describes maize and beans as the principle foods. Occasional surpluses were sold, but the aim was to have enough in store to cope with a bad year (KNA: Hopkins, 1943?). As population grew in

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5. The Reconditioning Committee in 1946 and 1947 had long arguments as to whether fallowing in one season was to be recommended. Some white settlers considered that the Wakamba 'planted an excessive amount of maize during the short rains little of which was likely to produce a harvest'. Amongst the ten farmers we interviewed who had started farming before 1950 only one said he had initially planted only in the long rains; the others said they had always used both seasons.

the 1920s, these surpluses seem to have become less frequent for the majority, although possibly continuing for the very small minority of plough-owners (see Population Profile, 6.3.2). The more fortunate farmers had a small piece of valley bottom or irrigable land, used for sugar (for making beer), arrowroots, bananas, vegetables, etc.

In the more densely settled areas, adjacent grazing areas were reserved for private use, and by the 1930s northern parts of the reserve were said to be entirely cut up into grazing areas used by one or more families. From 1938 the government promoted their enclosure by sisal hedging. Their owners also continued to use the large communal areas that were still unclaimed, or which, as in the Yattas, had been designated by Government for grazing only. Livestock numbers were not, on average, large; the Kenya Land Commission reckoned the average family of five[6] had five cattle and 6.5 shoats. An agricultural census in 1940 in Nzaui found only 3.3 cattle and 9.6 shoats per family (KNA: DC/MKS/Nzawi).

Livestock were the main local source of cash around 1945, according to the recollections of older farmers, shown in Table 2. However, this source of cash was not very secure. The accumulation of livestock was limited by periodic droughts and outbreaks of disease. An elderly informant in Kangundo, Mr Thiaka, said his father had about 50 cattle in 1922, when he lost 39 due to rinderpest. Marketing was frequently interrupted by quarantines, and demand, and prices, were low. Compulsory destocking and enforced sales at low prices to Liebigs in 1938 was greatly resented and successfully resisted. Although rinderpest began to be curbed by vaccination from the late 1920s it would seem that the marketable surplus was not increasing in line with the human population. Losses were incurred during droughts, the grazing deteriorated and cattle were killed for local consumption especially during the hardships of the 1940s. An average of 105,000 tins of ghee were sold in 1928, 1929 and 1930. Ghee sales had fallen to a few hundred tins by the 1950s. There are quite frequent administrative references to unwillingness to sell cattle except in case of dire necessity, but the records show the importance of goats, with more being sold in the 1930s, 1940s and 1950s than in the 1960s. In the 1950s cattle prices and sales rose (see Production Profile B: Livestock).

In the 1950s most of the cash income came from remittances from migrant workers, according to a careful estimate then made (Figure 2).[7] At this stage, the District's locally derived crop income came from fruit and vegetables grown mainly in AEZ 2 and 3, which we examine in a later section. Coffee only began contributing from about 1957. AEZ 4 contributed livestock, sisal in years when the price justified the labour of decortication or when crop failures made an alternative income vital, as in 1951, and a handicraft, carvings, which was centred on a single village (Elkan, 1958). Maize and bean exports were only significant in exceptional years such as 1957. Peberdy's estimate of cash income in Figure 2 does not include cash income earned from agricultural sales within the district, so is not comparable with later survey data.

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6. This may be based on those sleeping under one roof rather than the larger number dependent on the same set of fields and livestock.

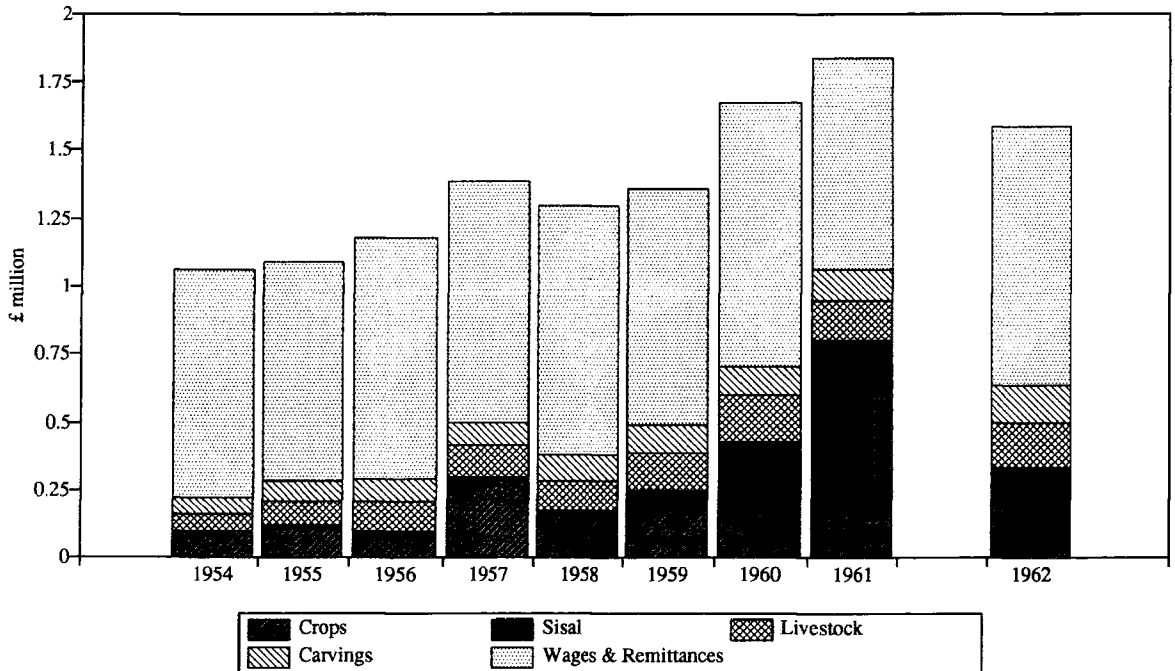
7. Wage income was estimated as all that earned within the District (30-40% of total) plus 20% of the estimated wages of those working outside, the amount they probably remitted home.

Table 2: Main farm cash income sources, 1945-90

		1945	*1960*	*1990*
Kangundo		Wheat, grams, coriander, sugar, bananas, other food crops, cattle, milk	Fruit, vegetables, coffee	Coffee, French beans
Mbooni	(men)	Livestock, sugar, bananas	Sugar, English potatoes, wattle, livestock	Coffee, vegetables, trees
	(women)	Livestock, food crops	Food crops, livestock	Coffee, vegetables, handicrafts
Masii	(men)	Cattle, millet	Livestock, millet	Cotton, fruits, pawpaws, tomatoes, beans, maize, livestock
	(women)	Ghee, cattle	Goats and cattle	Peas, beans, maize, mangoes
Makueni		—	Goats, peas, beans, maize, grams	Fruits, cotton
Ngwata	(men)	—	(1965-70) Charcoal, honey, ivory	Maize, beans, livestock, pigeon peas, cotton, grams
	(women)	—	Remittances and help from home	Grams, sorghum, cowpeas, charcoal, livestock

Source: Interviews with village leaders, 1990

Figure 2: **District cash income, 1950s**



Source: Based on Diagram 17, Peberdy 1961.

The income system can be described as cropping , goats for minor cash with cattle kept for the emergency reserve, and migrant labour to provide major cash needs including emergency food. Table 2 reports the chief farm cash income sources in 1945, 1960 and 1990. It shows an interesting gradient, in which livestock initially form the chief cash source. This is followed by sales of food crops, and then by cash crops, particularly high value crops such as coffee (where feasible), fruits, and vegetables. Strongly promoted field crops for semi-arid areas such as sunflower and cotton come out as relatively unimportant. The gradient flows from the old settled areas with high population densities (Kangundo, Mbooni and Masii) to the area settled in the 1950s (Makueni) and the areas settled from the late 1960s (Ngwata). There appears also to be a second gradient, by which fruit and vegetables appear first in the higher potential areas well served by markets (Kangundo), spread to high potential areas less well served by markets (Mbooni) and then spread into lower potential zones, starting again in those best served by markets (Masii) and passing on to less well served areas (Makueni) as population density increases.

2.2 Stresses on the Extensive Farming Systems

Ruthenberg describes short fallow systems as inherently unstable under the population growth. They either evolve into permanent cropping with cash crops (which can include food crops) that enable purchases of fertiliser and other inputs to be made, or they deteriorate to a lower level of output, since the fallows are shortened without compensating inputs. Without cash cropping, 'the returns to soil-preserving measures (green manuring, compost, terracing, etc.) is too low in relation to the disutility of effort', particularly if there is not yet a perceived scarcity of land (Ruthenberg, 1980:101). We shall see that this lack of incentive held in the AEZ 4 area of Masii in 1962-63, despite its location less than 30 kilometres from Machakos town. At the time, although land was becoming short in the older settled areas, it was not perceived as truly limiting since there was vacant land which was barred by a political force which people hoped to overcome (see Population Profile).

Ruthenberg's description of the deterioration process on the livestock side is as follows:

> *As long as there is sufficient grazing land available, the herds per family are of good size and the cattle well fed. An increase in the area needed for arable farming necessitates a reduction of the grazing area. Simultaneously, the proceeds of crop farming are partly being invested in cattle, to obtain security and status. The results are an increase in the cattle population and a reduction in the grazing area, causing complementary damage. The condition of the cattle deteriorates, and erosion increases. On over-grazed land, a high proportion of the rain runs off. Over-grazing encourages the thickening of bush, particularly those species on which livestock do not browse. Thus, in the long run, overgrazing reduces the carrying capacity of the grazing area, reduces the length and effectiveness of the fallow period, and increases the amount of clearance work required* (Ruthenberg, 1980:102).

This analysis ignores the role of burning. As the ratio of cattle to available lands for grazing increases, (whether by increase in the number of cattle or reduction in the area available for grazing) burning ceases to be a viable management method, just as shifting cultivation ceases

to be a viable cultural practice. The lack of burning combines with the increased grazing to encourage the thickening of the bush, damage to soil structure and increase in run-off, etc. An introduction or evolution of a new management method becomes necessary.

It does not seem that in Machakos, there was any steady increase in the livestock population. There may have been some increase in the late 1920s, due to the introduction of rinderpest inoculations (see Production Profile, Section B). However, what evidence there is suggests a largely static livestock population between 1930 and 1960, although with ups and downs. The lowest point may have been in the 1940s.[8]

The deterioration of the grazing, which seems undoubtedly to have occurred, was rather due to the reduction in the grazing area, and therefore, a rise in the ratio of livestock to land. In the first three decades of the century, the Akamba were prevented from using grazing land which they had previously used occasionally, because it was either taken over for white ranches, or was deemed Crown Land, on whose use the government could impose restrictions (see Population Profile). In the 1930s there is some evidence of extension of the cultivated area within the Reserve, which would have reduced the nearby grazing areas. The main technological innovation of the period was the plough, which enabled some farmers to increase arable cultivation. In 1932 plough owners seem to have been owned by only about 1% of families (600 ploughs, about 40,000 families, Kenya Land Commission, 1934). However, the proportion may have been higher in the northern hills, where, due to proximity to Machakos, commercialism was most advanced. Plough owners could expand their cultivated area to 1.6 ha. (Kenya Land Commission, 1934). By the 1960s, 20%-60% of farmers owned ploughs (Table 3).

The most perceptive report on the stresses which led to the degradation of the environment by the 1930s was by a DC, Gerald Hopkins, who had spent 3 years in the District, written about the end of 1943 (KNA: Hopkins, DC/MKS/8/3).[9] He thought increasing population density in the northern hills had led to increased cultivated areas and increased separation of the cropping and livestock enterprises. The northern hills were getting an influx of people and cultivation was more extensive and continuous than in any other District he knew. In consequence, the stock were forced further afield, and application of manure became more difficult (see map of the Mbiuni study area in 1948, Land Use Profile; cultivation was even more extensive in hill areas better endowed than Mbiuni).

As fertility fell, Hopkins says people tried to increase the cultivated area with the aid of the plough, so cultivation spread down the slopes, and the livestock receded further. We can observe a rapid reduction in the proportion under fallow. By 1960-61 it was estimated that the reserve area had over 112,000 cultivated hectares and only about 6,000 fallow (Table 7, Land Use Profile). The fallow proportion of the cultivated area had therefore fallen to 4%. Further evidence of the expansion of the cultivated area comes from Nzaui, where data was

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8. The increase in stock as compared with some unspecified time in the past was frequently mentioned in administrative reports. Livestock numbers went up and down according to the incidence of droughts and epidemics, but there is simply not enough evidence to establish what the general trend may have been in the period 1900-30.

9. It does not seem to have influenced subsequent policy.

collected for the World Agricultural Census in 1940. In 1940 10,400 people were said to cultivate 10,000 acres, or roughly 0.4 ha. per head (KNA:DC/MKS/Nzawi file). In 1964, amongst Owako's sample in this location, the measured average arable was 0.5 ha. per head. It is likely arable was increasing at a faster rate than population growth due to the increased use of the plough; Owako found 56% of Nzaui farmers had ploughs in 1962; there were only 10 in the location in 1940 (DC/MKS/Nzawi).

Hopkins' analysis that decreased fertility led to the extension of the cultivated area is in line with Ruthenberg. An intelligent farmer in AEZ 3, who had lived through the process, put more emphasis on the attractiveness of a plough for enabling farmers to get a surplus for sale than for increasing the area to maintain subsistence. However, he recalled the impact of this on the grazing areas. Mr Thiaka was born in Kangundo in 1906, shortly after his father had moved there. Originally, there had only been a few outlying shifting farms, unproductive because of wild animals. As these were shot by the Mission established in 1900, people moved their houses to the area, and practised shifting cultivation. By the 1920s the move to permanent cultivation had taken place. By 1932, density was up to 96/km^2. Mr Thiaka said that in the 1930s the grazing areas were getting less because of the plough and the increase in people. As newcomers to the plough the Akamba initially ploughed in any direction to cover the broadcast seed, which would have increased erosion rates. The cattle finished up the grass and in the rains the soil was carried away, so the place was becoming a desert. He thought the turning point for the grazing areas came with their demarcation and the establishment of sisal hedging in 1938; after that, people could only ruin their own land.

According to Hopkins, pastures had deteriorated partly because the Veterinary Department's inoculations had led to increased stock, but also because grass burning had been discouraged by the government with 'the utmost severity' which meant more grass could be used all the year round, leading to more stock increases that eventually led to all grass being closely cropped all the time, so that burning could not be restarted even if it was desirable.[10] The lack of burning had encouraged thorn bush, bringing in train tsetse fly and big game (see Environmental Profile, Section D). He thought the occupied southern land had become steadily smaller even in his 3 years as DC, but people were badgered by game scouts and police if they killed game. 'In my view, and apparently in that of the Akamba too, there is no satisfactory middle course. Either the big game must go, or the people must go. In this District, for the last few decades, it has been the people who have been giving way'. (This was probably more true in the south; in the north, as people came in, the animals retreated or were killed).

With decreasing ability to feed themselves, or to raise cash through their livestock, when livestock numbers were at best remaining static while population grew, more and more men resorted to out-migration and soldiering in the 1940s. While this eventually brought in some inflow of private capital (gratuities, etc.) in 1946, the immediate result was a reduction in private sector capacity to create capital through labour inputs into land improvements such as terracing. Between 1940 and 1960 there were major government investments in water

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10. If the management technique of burning requires access to a larger area of grazing than management without burning, burning would have diminished because of this pressure in areas where cultivation was being extended.

supplies[11] and a major drive for 'better farming' - terracing, cash crops, cattle sheds, manure (ALDEV, 1962). Dams and terraces were initially enforced by compulsion rather than undertaken voluntarily (see Conservation Profile). The Akamba at this time would have preferred to solve their problems by spreading into new lands rather than by intensifying production in the older areas.

3. FARMING AND INCOME DEVELOPMENT IN AEZ 2 AND 3

The densely settled hill areas were the leaders in farming systems change, particularly where there was good access to markets. Unfortunately, there is little information on farming systems in the hills. The main data comes from three sub-locations studied by Owako in 1964, two of which we revisited in 1990 (Muisuni in Kangundo and Nzeveni in Mbooni), and various studies carried out in support of health and nutrition research in Matungulu in the 1970s. A Mbooni area was also studied in 1979 (Jaetzold and Schmidt, 1983).

The northern hills were always well-placed for provisioning Nairobi, and a new road improved the situation still further in 1956. The northern hills therefore provide a good demonstration of the effect of commercialisation and cash cropping. Even in 1985 there were only three significantly important markets in Machakos District which met twice a week, which were all in the north. These were Machakos town, Tala (adjacent to Kangundo) and Matuu (serving the Yatta furrow area). All were then on tarred roads. The rest of the District is dotted with small markets meeting one day a week, with poor road connections that means they are visited by a restricted number of traders and the immediate local population (Musyoki, 1987). Kangundo illustrates the development path in an area well served by the market and Mbooni that of an area having less good market access.

Already by 1945 our Kangundo informants said their main cash came from foodstuffs sold mainly to Indian traders (Table 2). During the 1950s various fruits and vegetables were promoted both by the Agricultural Department and by Indian traders and were eagerly taken up (see Technology Profile). They also secured the right to grow coffee, which started contributing importantly to incomes in the 1960s. Owako estimated that in Mbooni 0.2 ha. produced Ksh 1,400-1,800 under tomatoes, compared with Ksh 900-1,200 under coffee, and less than Ksh 100 under maize (Owako, 1969:259). Over time coffee and vegetables have maintained a higher profitability than maize although exact ratios have fluctuated considerably.

By 1964 densities in Kangundo were 250-270/km^2 and in Mbooni 140-155/km^2, at which stage we should expect, according to Ruthenberg, to see manuring, terracing and stabling of animals. Owako indeed found farms were small and predominantly arable, with an average size of 3 to 3.5 hectares, of which 80% was arable and only 20% grazing (Table 3). The progress of terracing has been illustrated in the Land Use Profile. Farmers already ploughed

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11. 52 large dams, 269 small dams built by ox-scoops and communal labour, 226 sub-surface dams, 22 boreholes, 6 pipe systems, 3 rock catchment systems.

their land early and some already planted ahead of the short rains (Owako, 1969:217). There was no communal grazing and livestock ownership averaged only 2.4 cattle and 1.2 shoats (Table B.4, Production Profile). In Kangundo, what manure there was, was concentrated on coffee. In Mbooni, the cattle were on the lower slopes and the manure was not carried up. In Kangundo, 22% of the land was under coffee, but only 5% in Mbooni. The average amount under coffee was relatively small, between 0.2 and 0.4 ha., although in Kangundo about 40% of farmers had more than this (Owako, 1969).

With this degree of cash cropping, highland farmers could take the risk of not fully covering their subsistence needs. Unfortunately, the only study carried out in a more or less normal rainfall conditions (short rains above average and long rains a severe drought) looked at two areas north and south of Kangundo (Kolkena and Pronk, 1975). The northern area, which they called the high potential coffee area, contained relatively more AEZ 2 and 3 land. They found that no less than 60% of households did not grow enough to cover their needs of maize and bean, with the area growing less coffee worse off in this respect (Table 4). They estimated average subsistence staple food needs as the equivalent of Ksh 1,250; the amounts achieved are shown in Table 4. Their sample may be biased towards the smaller households.[12]

A study by Onchere carried out in 1975 (Onchere, 1976), in approximately the same areas, differentiated more clearly between AEZ 2 and 3 areas such as Kangundo and neighbouring AEZ 4 areas. It took place in a year with two major droughts which would have reduced both food and cash crop income and enforced a higher than normal level of livestock sales. Onchere did not differentiate between the two areas when he said that families had to rely on cash purchases of food for an average of 5.7 months. Table 5 shows that Kangundo farmers produced less food in the drought than the AEZ 4 farmers. This probably means they do not aim to plant enough food crops to cover themselves in bad seasons. Onchere described Tala as the main market of the area, with 68% of dealers getting their maize from 'Kikuyu' traders, rather than from the agents of the Maize and Produce Board. It is unfortunate that we cannot see whether in a normal year the neighbouring AEZ 4 farmers could market their food in the coffee areas.

In Kangundo, land under coffee probably expanded during the coffee boom in the late 1970s, but farmers still maintained a degree of diversity. Onchere, (who did not measure areas) found Kangundo farmers in 1975 had an average of 348 coffee trees (grown by 100%), but 87% also had macadamia trees (average 14) and about half had passion fruits. Two thirds also grew tomatoes and cabbages (Onchere, 1976). Cash crops formed a third of their total income, by contrast with neighbouring AEZ 4 farmers who produced food crops and livestock (Table 5). Kangundo farmers had less dependence on non-farm income, although in this drought year it formed 40% of the total.

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12. The sample was based on the medical survey, which used the census definition of a family as those sleeping under one roof. As they found that two or more of such families might share a farm, they left out half the joint families in their randomly selected sample to correct for what was thought to be their unequal chance of selection. As a result, their sample had an average family size of 6.5, whereas Owako, in a not very dissimilar area, had found 8.7. Households included such non-farming groups as two schoolboys, bar girls, etc., though only 5% were completely without land.

Table 3: Average farm size in hectares, 1964

	Arable (%)	*Pastoral*	*Total*	*Mode*	*Plough owners (%)*
AEZ 2 and 3					
Iveti	2.82 (81)	0.69†	3.46	1.2 - 2	n.a.
Kangundo	2.36 (80)	0.6	2.96	2 - 3.6	34
Mbooni	2.28 (75)	0.76‡	3.04	2 - 3.6	23
AEZ 4					
Masii *	4.16 (25)	12.32‡	16.48	2 - 3.6	n.a.
Nzaui	4.46 (42)	6.24‡	10.70	3.6 - 6.8	56

Source: Owako, 1969, Appendix V, and own calculations.

* omitting two farmers with 528 and 262 ha. each
† plus some grazing land in Yatta
‡ plus communal grazing

Table 4: Incomes in a high and medium potential coffee area, 1972/3, in Ksh

	High		*Medium*	
	Mean	*Median*	*Mean*	*Median*
Subsistence crops	1,267	992	911	742
Coffee	816	n.a.	396	n.a.
Net farm income [(a)]	1,800	1,490	1,056	732
Off-farm, local	1,361	n.a.	1,326	n.a.
Remittances	781	n.a.	539	n.a.
Total net income [(b)]	3,829	3,140	2,879	1,795

Source: Kolkena and Pronk, 1975.

Notes: (a) Subsistence, coffee and miscellaneous crop income after deduction of costs. It probably includes livestock subsistence income, but the source gives no details.
(b) After deduction of monetary costs.

Table 5: Incomes in Kangundo (AEZ 2 and 3) and two AEZ 4 villages, 1975

	Kangundo		*Two AEZ 4 villages*	
	Ksh	*%*	*Ksh*	*%*
Food crops	197	7	490	18
Cash crops [a]	887	33	99	4
Livestock [a]	548	20	685	26
Sub-total, farm	1,632	61	1,274	48
Non-farm	1,044	39	1,386	52
Total	2,676	100	2,660	100

Source: Onchere, 1976:66

Note: (a) Milk and vegetables omitted, although both are mentioned in the text as quite important.

Rabeneck, in a coffee area of Matungulu in 1979-80, in a sample of 210 families having children under five, found 22 coffee-growing households and 15 households without coffee who grew no staple foods - a total of 16%. She also found the highest food availability in two contrasting groups - those who grew neither staples nor coffee (mainly businessmen) and those growing more than 500 kilocalories per person of staples and having more than 200 coffee trees (the larger farmers) (Rabeneck, 1982:137 and 146).

It seems that coffee provided the insurance previously derived from cattle or off-farm work, enabling farmers to cut down on food areas in favour of a more profitable crop; as Kangundo leaders told us in 1990 'Now, coffee is the cow'. Coffee incomes apparently are less affected by drought than food crops, as we can see by the way in which they held up in 1975. However, most households with land still cultivated a proportion of food crops, and in the good short rains of 1972 this was an important part of total income. (Subsistence income is apparently higher in 1972-3 partly because Kolkena and Pronk included milk, whereas Onchere did not). Coffee also provided the cash for farm inputs: Onchere found that 67% of farmers in Kangundo purchased fertiliser for their coffee and 40% for their maize. In the neighbouring area of Kathama, where there was no coffee, only 17% purchased fertiliser for maize. Onchere describes an active market in farm inputs, with many outlets.

The need for insurance against bad seasons was further reduced by investments in education which secured higher-paying non-farm jobs. Kolkena and Pronk found that in about one third of households, the family head had a non-farm occupation locally, and in a further quarter, the family head was away working. In both places, incomes were highest where the household head had a regular, local, off-farm income (Table 6). For many people in the less

productive area, farming alone would not have secured the minimum reasonable standard of living, which Kolkena and Pronk estimated at Ksh 1,500 for a household of six persons. The important change from the situation earlier, and from the contemporary situation in villages which could not generate cash from farming, was the increase in local jobs.

Table 6: Average household income in coffee areas, 1972-73 according to main occupation of household head (Ksh per year)

	Farming only	*Migrant*	*Local non-farm work*
High potential	2,696	3,510	5,230
Medium potential	2,134	2,943	3,800

Source: Kolkena and Pronk, 1975.

Coffee and coffee incomes generated some of these jobs. As the coffee boom proceeded during the next few years there was an inflow of workers from the drier areas to neighbouring coffee areas, which was noted to recede as prices fell in 1979 (van Ginneken et al., 1986). The variety of occupations in Matungulu in 1979 of the husbands of 243 women with pre-school children was recorded by Rabeneck, shown in Table 7. This understates the importance of farming, since her study omitted older men without pre-school children, who will form a large proportion of the owners of the larger farms. It also omits unmarried men and youths. Nevertheless a substantial range of jobs is shown, with 17% as artisans. Coffee and fruit generated larger cash incomes, and more jobs servicing the farmers' consumer needs as well as more work in processing, picking. (Not all the labourers worked for small farmers; there were also adjacent large estates). By 1979 density in the coffee areas of Matungulu had risen to 280/km^2.

In the central hills, such as Mbooni, the improvement in transport possibly came later and population densities were substantially lower. Livestock have always played a greater role in Mbooni than in Kangundo. By the 1960s, however, Mbooni had a substantial export of tomatoes to Mombasa (Bottrall, 1969), but we have no information on incomes.

In 1978 the average Mbooni farm was 4.5 ha. - larger than that recorded by Owako in 1964 (Table 3).[13] On average, in this area in 1978, 55% was under pasture, 28% under annual crops (mainly maize and beans) 8% under coffee, (with an average holding of 0.3 ha.), and 4% under fodder crops. Cabbage, English potatoes and tomatoes were noted as minor crops. The average farm had 4.67 zebu cattle, 0.9 grade cattle and 6 shoats (Jaetzold and Schmidt,

13. The two surveys were in slightly different areas. Conditions can vary considerably within a single location, which might provide an explanation. The level of population growth would have led one to expect a reduction in average farm size.

Table 7: Occupations of husbands, Matungulu, 1979

	% [a]	% [b]
Farmer, no other occupation	21	26
Tailor, butcher, carpenter, mason	17	21
Unskilled labourer	13	16
Driver, machine operator	10	12
Clerk, manager	8	10
Teacher, pastor, professional worker	6	7
Shop-keeper, small business	4	5
Soldier, police	3	3
No husband	11	
Missing information	7	

Notes: (a) Percentage of all 243 women.
(b) Percentage of 201 women, ignoring those without husbands or with the information missing.

Source: Rabeneck, 1982.

1983). What is interesting is that in Mbooni, both large and small farms put down 0.3 ha. to coffee, and employed labour (Table 15). Coffee at the time was very remunerative, and intensively cultivated to produce high yields (see Production Profile, Section A). Small farmers may have had difficulty with more risky crops. Table 14 shows it was the large farmers who had 0.5 ha. under other crops, including high-value crops such as sugar, English potatoes, cabbages and tomatoes as well as pulses.

Between 1979 and 1989 population density rose from 367 to 518/km^2 in Kangundo[14] and from 239 to 317/km^2 in Mbooni. In Kangundo, community leaders in 1990 were desperately worried by the ever smaller size of farms, the difficulty in finding jobs even for educated young people, and the burden of educational expenditure for longer periods in the desperate hope of fitting children for jobs. They thought younger farmers were only inheriting about 1.2 ha. They described their society as consisting of the rich, who were business people, the middling, who were farmers, and the poor, who worked for the farmers. In Kangundo, change of crops seemed to be hampered by the large areas under coffee, although they had moved into French beans. French beans provide a very high income from a small area; one study found the return from a 17 by 10 metre plot was Ksh 300 (Ayako et al., 1989). Livestock holdings had been still further reduced, and we were told few were able to afford grade cattle, although Onchere had noted 600 grade cattle in the area in 1975. Losses in subsequent droughts do not seem to have been replaced. Leaders felt people were becoming poorer; the only hope, they thought, was processing industries if the area could secure electrification. They were developing what cottage industries they could.

14. These figures are approximate. Urban areas appear differently defined in 1989 and the census details are not yet officially finalised.

In Mbooni, where coffee had never been quite so dominant, and where land was slightly more plentiful, our 1990 interviews show the farming system had developed into a combination of dairying, with a crossbred cow kept under zero grazing, with planted fodder on the terrace banks, coffee, a small but productive area of export vegetables, and maize and beans. Leaders said most farmers had acquired a crossbred. In both Mbooni and Kangundo leaders in 1990 said that smaller farms and a shortage of grazing meant that fewer people kept draft oxen, and more used hand tools. There was a consequent shortage of manure, and problems in maintaining fertility.

Areas in AEZ 4 and 5 which have irrigation, such as people near the Yatta furrow, show a resemblance to AEZ 2 and 3 farmers in a heavy reliance on fruit and vegetables, which has generated a lot of non-farm business in places like Matuu. Matuu is showing rapid growth and is about to be designated a municipality (local informants). The Yatta furrow was built in the late 1950s with detainee labour, mainly to provide water to what were then pastoral areas. Another small scheme near Kibwezi was constructed at the same time. Both seem to have come into their own when tarred roads connected them to Nairobi Airport and export vegetable production took off in the late 1970s.

We can conclude that the opportunities provided by the market have enabled a degree of specialisation on farms which has in turn generated local off-farm jobs. Market opportunities have been seized rapidly, but population growth has now reduced farm size in some areas to such an extent that even more rapid formation of non-farm jobs has become necessary as further farm intensification is hampered by lack of water. This process is currently held up by lack of new infrastructure such as electricity (available in Kangundo town but not in the sublocation we visited) and by a decay in existing infrastructure, such as the roads linking the northern hills to Nairobi. Further farm specialisation is also limited by the bad roads linking the Machakos highlands and lowlands, and by the restrictions on the movement of grains. Unfortunately, there is currently so little data on farming systems in the hills, and their links with the plains, that it is difficult to delineate these relationships clearly. Movement out of coffee and into even greater production of vegetables than at present is also being hampered by regulations forbidding coffee to be up-rooted. Without non-farm jobs, farms in such areas as Kangundo are becoming too small to support even a dairy cow under intensive conditions from farm-produced fodder, given the currently felt need to keep a certain amount of land under food crops.

4. THE DEVELOPMENT OF FARMING SYSTEMS IN AEZ 4

4.1 The System in the 1960s

Farming systems in the early 1960s in AEZ 4 remained centred on food crops and livestock. In 1964 only 10% of farmers in Masii and 20% of those in Nzaui planted tiny areas of cotton (Table 8). As already noted, the chief difference with the situation around 1932 was an increase in the size of the arable area, and increased use of the plough. This is shown for Nzaui in Table 9. Average farm size was large, being over 16 ha. in Masii and over 10 ha.

Table 8: **Average farm size and arable activities, (1964) and circa 1980, AEZ 4**

Source	*Year*	*Area*	*Farm size (ha.)*	*Arable %*	*Arable ha.*	*Cash crop*	*Food sales*
1.	1978 (1964)	Mbumbuni & Masi (sic)	5.6 (16.48)	43 (25)	2.4 (4.16)	Average 0.1 ha. cotton (Average 0.0035 ha.) (10% of farmers)	40-50% of production (n.a.)
2.	1980-81 (1964)	Nzaui	5.2 (10.7)	50 (42)	2.6 (4.46)	Cotton (50%) (Cotton average 0.013 ha.) (20% of farmers) (Sugar average 0.011) (20% of farmers)	26% sold maize in Short Rains 19% in Long Rains
3.	1979-80	Mwala	7.5	26	1.95	75% grow cotton 9% grow sunflowers	60% sold pigeon peas
4.	1980	Mbiuni	n.a.	n.a	1.23	13% grow cotton 43% grow sunflowers	n.a.
5.	1978-79	Mbiuni	5.4	46	2.47	90% grow cotton	n.a.
6.	1979-80	Okia, Kalama, Mbooni, Kiteta	3.9	60	1.5-2.0 (mode)	6% grow cotton 6% grow sunflowers	15 % sold maize 23% pigeon peas

Sources:
1. Jaetzold and Schmidt, 1983
2. Pollard, 1981
3. Rukandema, 1981
4. Gielen, 1982
5. Mukhebi, 1981
6. Meyers, 1982 (non credit takers)

(1964) Owako, 1969

Table 9: **Farming methods, [1940], (1964) and circa 1980, AEZ 4**

Source	*Year*	*Owning plough*	*Solo crop maize*	*Sowing pre-rains*	*Using manure*	*Using fertiliser*
1. Masii, etc.	1978	n.a.	31%	n.a.	Average on maize SR 0.5 tons/ha. Average on maize LR 0.8 tons/ha.	On maize SR 2kg/ha. On maize LR 5kg/ha.
	(1964)	(n.a.)	(7.5%)	(n.a.)	(65% used a little)	
2. Nzaui	1980-81	62%	Long rains only	50%	46%	2%
	(1964)	(56%)	(27%)	(rare)	(39% used a little)	
	[1940]	[0.05%]			[0.02% of area]	
3. Mwala	1979-80	78% plough 72% oxen	n.a.	15%	68%	0%
4. Mbiuni	1980	61%	n.a.	n.a.	63%	13% (free trial)
5. Mbiuni	1978-79	n.a.	n.a.	n.a.	n.a.	n.a.
6. Okia, etc.	1979-80	54%	n.a.	n.a.	n.a.	n.a.

Sources:
1. Jaetzold and Schmidt, 1983
2. Pollard, 1981
3. Rukandema, 1981
4. Gielen, 1982
5. Mukhebi, 1981
6. Meyers, 1982

(1964) Owako, 1969
[1940] KNA:DC/MKS/Nzawi

in Nzaui but in both locations the arable area averaged only about 4 ha. (Table 3). Although much of the older land had been terraced by 1948, there had been some loss of terracing by 1961 (Land Use Profile). There were still areas of communal grazing between farms, to supplement private grazing areas, and people also took their livestock to the Yatta Plateau.

Mixed cropping was almost universal in Masii although there was some solo maize in Nzaui (Table 9). Unlike the position in the highlands, farmers did not begin ploughing until the onset of the rains, so that planting was considerably delayed, especially for those with no ploughs. The local white maize was generally harvested by end of February. This led to what Owako calls 'overlapping cropping'; there was no time to plough the land after the harvest before the long rains set in, and the next lot of seeds were simply inserted amidst the weeds and stubble of the short-rains crop in early March without tillage. Because of weed competition, harvests were generally low. The amount of effort put into cultivation, sowing and weeding in the long rains depended on the magnitude of the short-rains harvest (Owako, 1969:219). After the exceptionally good short rains of 1962, that effort may have been low. Heyer thought that agriculture in this season was unimportant, saying

> *The yields of second rains crops are generally low, and the acreages involved are small. The main purpose of planting maize and beans again appears to be for the preservation of fresh seed for use in October again. Only in exceptional years when the October rains have failed, is planting substantial in the second rains* (Heyer, 1967a:7).

This may be an overstatement of the case, for both in 1957 and in 1960/61 agricultural officers reported on production in Machakos in terms of two seasons (see Production Profile, Table A.1). Generally, the second crop was planted on different land to the first crop, where farms were still large enough to allow this (personal communication, Bennison, 1992). Owako said overlapping cropping, as he termed putting the second crop in on land which had already had a short-rains crop, was generally caused by lack of land or labour to clear bush, or by an early start to the Long Rains giving no time to plough.

Heyer analysed the constraints on the arable side of farming in Masii during the short rains in 1962-3 by linear programming, using a small sample of 7 households which covered 16 farm management units (including wives making their own farm decisions in regard to their own plots in extended families). The sample was selected to be typical while covering a variety of situations. Family labour averaged one person per management unit, not strictly full time, since she notes that many had another rural occupation (Heyer, 1967b:7).

Heyer found labour at weeding, ploughing and some harvesting times was a key constraint, although at other times of the year, it was not scarce. The only items of capital considered to limit production were oxen and ploughs, to which some people could not get access at the optimal time. She considered soil conservation works as part of the residual management variable, rather than as capital. Five units were considered to have good conservation works, eight fair and three poor. Other techniques of production included in the management variable were manure use and row planting (Heyer 1967a:70). Row cultivation was said to

be good in five cases, fair in eleven.[15] In most cases the fields had been cultivated for over 25 years. Owako found that 65% of the farmers used manure in Masii. Heyer found it was only applied in patches on the nearer plots. She found the best managers were able to make 3-4 times as much as the worst with any given level of labour and land resources (Heyer, 1967a:69). At the time of observation only traditional varieties of maize were used, but Heyer used experimental results from Katumani synthetic to calculate its potential impact. She also looked at the impact of the introduction of cotton as a cash crop. It was being grown in 1962-3 for the first time by a few farmers. Her observations related to a season of very good short rains with relatively high yields (averaging about 1.3 tons maize/ha.) and consequently, low prices, but she also ran her model for average and low rainfall scenarios.

Her general conclusion was that cotton, at then prices, and under optimistic assumptions, made only a marginal improvement in incomes, particularly in low rainfall years. Katumani maize was likely to be superior to cotton and traditional food crops, particularly in low rainfall years, when its lower but more reliable yield was compensated by high prices. If Katumani, by increasing supply in low rainfall years, reduced the price fluctuations, then Katumani became less attractive in comparison with cotton.

One of her more important findings was that although there was unemployed labour, people were not prepared to work as casual labourers unless the wage was attractive. The additional returns attainable by growing cotton with the help of casual labour at peak periods were too low to cover the wage demanded. With traditional food crops and average managerial skills, the return to labour, including the value of food, was equivalent to Ksh 33, 59 or 75 a month, depending on rainfall conditions. The average wage in Masii for unskilled work was then Ksh 50 to 70 per month (with few jobs available), and 'anything from Ksh 120 in Kenya's urban areas' (Heyer, 1967a:63). In the circumstances, it is not surprising that over 60% of the adult men were absent.

Looking at the role of capital, she found working capital only a problem after famine, when oxen and people were in poor condition and seed was in short supply. Fixed capital in the form of structures she felt could mainly be supplied by labour at no real cost, in seasons when family labour was underemployed, although she acknowledged that soil conservation works were best constructed and maintained when the soil was soft, thus conflicting with planting. The problem was that any investment in farming, other than in ploughs and oxen, was unprofitable. Loans were available from informal sources, and were frequently used to finance cattle trading. She found instances of considerable investment in shares for a ranch, in a bus company, and in social capital such as schools, dams and dispensaries. All the traders she consulted agreed 'it was unwise to lend for farming, both from their own and from the farmers' point of view, because it is too risky and unprofitable to be worthwhile'.

Heyer considered whether livestock might be a more profitable outlet for investment, and decided that keeping livestock on arable land would give considerably smaller returns than keeping it under crops. However, this was not the alternative which faced the farmer. Livestock, as she acknowledged, were generally kept on the poorer land that was not regarded

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15. Row planting was just beginning. It was being pushed at the time by the extension staff (Heyer, 1992, personal communication).

as fit for cropping, and this type of land was still, in the early 1960s, relatively plentiful both within Masii and in grazing areas freely available beyond the location boundaries. In consequence, the return to labour was more important than the return to land. We have no information on this, but judging by the readiness to invest in a ranch, and the fact that village leaders of both sexes in 1990 told us that farming was orientated to livestock, and that livestock in 1960 were the most important cash earners at this time (Table 2) it is likely to have been more attractive than the return to labour in crop production.

It can be seen that arable farming in AEZ 4 still yielded an unattractive return, even in a good year. Despite considerable government inputs of capital in the previous twenty years in the form of tools for conservation work, dam building and experimentation on conservation methods and improvement of pastures, farmers relied very much on livestock and migrant labour for a great part of their incomes.

4.2 Farming Systems in the Older Settled Areas of AEZ 4, circa 1980 and Since

4.2.1 Food crops and husbandry

Some key data about farming in AEZ 4 in 1979-80 is summarised in Tables 8, 9 and 10, and where possible, compared with 1964. Table 8 shows a clear reduction in average farm size. More of this smaller farm was cropped, although Mwala remained exceptionally specialised on grazing and livestock. There was virtually no communal grazing by this stage. Nevertheless, the average farm appears to have supported more livestock than in 1964 (Table 10). This means methods of livestock feeding and keeping had become more productive, for all the evidence is that there was no great deterioration of grazing lands from 1960-80 (see Environment Profile, Section B).

The crops grown did not change much between 1960 and 1980. Maize, beans, cowpeas and pigeon peas remained the main food crops, occupying 75-85% of the arable area in 1979. (This can be seen for Masii in Table 15). There was a larger area under cash crops such as cotton, compared with 1964, but arable farming remained primarily subsistence-orientated. From about 1980 commercial fruit production entered the system.

More important than the relatively small change in crops grown were changes in methods of husbandry, which led to better use of available rainfall and more stability in yields. Masii leaders, both men and women, commented that the effect of bad seasons were worse in the 1960s and earlier, when they were taking arable farming less seriously, and livestock were more important in their farming system. The women said the improvement was because they now plant enough. Before they had experienced famine, but now there was better knowledge of ploughing and other farming techniques. Before they had relied on cattle. Table 8 in fact shows a fall in the average size of the area planted in a single season, because average farms were smaller, although a rise in the proportion of the farm under cultivation. However, both seasons are now fully utilised. In 1978 the Jaetzold and Schmidt sample for Masii and Mumbuni showed 67.8 ha. planted in what they called the first rains (falling between March and September - the long rains) and 52.2 ha. being planted in the short

Table 10: **Average livestock owned, [1940], (1964) and circa 1980, AEZ 4**

Source	*Year*	*Cattle owned*	*Shoats*	*Stock Units***	*Grazing ha. per stock unit*	*Feeding systems*
1. Masii, etc.	1978 (1964)	4.14* (7.0)	16.2 (8.1)	9.75 (8.62)	0.32 (1.43)	n.a.
2. Nzaui	1980-81 (1964) [1940]	11 (9.6) [3.4]	26 (10.3) [10.1]	16.2 (11.66) [5.4]	.18 (0.54) [n.a.]	100% use maize stover, 60% pulse residues
3. Mwala	1979-80	7	13	9.6	0.64	81% grazed own land 10% stall fed, 8% planted fodder 17% purchased crop residues 92% used crop residues
4. Mbiuni	1980	5.8	6.15		n.a.	56% had paddocks 52% cleared shrubs Crop residues used; some bought in grazing.
5. Mbiuni, etc.	1978-79	n.a.	n.a.		n.a.	n.a.
6. Okia, etc.	1979-80	4.7	7		n.a.	n.a.

Sources:
1. Jaetzold and Schmidt, 1983
2. Pollard, 1981
3. Rukandema, 1981
4. Gielen, 1982
5. Mukhebi, 1981
6. Meyers, 1982

(1964) Owako, 1969
[1940] KNA:DC/MKS/Nzawi

Notes:
* The actual figures given by Jaetzold and Schmidt were higher. I have assumed their average of 9.20 bull calves was a typographical error for 0.92, since there were only 0.73 female calves.
** Stock unit: 5 shoats = 1 cow

rains. In some areas in some years a little land was still unutilised in the long rains. In Nzaui, only 6% did not plant any crop at all in the long rains (Pollard, 1981). The great majority planted on average 1.7 ha., out of a feasible 2 ha. (the short-rains cotton crop more or less ruling out long-rains planting).

There was also, probably, a higher average yield, particularly in the long rains. In 1962-3, after exceptionally good short rains on which Heyer comments, and which shows up prominently on the graph in Figure A.4, Rainfall Profile, maize yields in the typical maize bean mixture in 1962-3 averaged 1,295 kg/ha. Jaetzold and Schmidt presumably mean by the 1978 second rains crop that which was harvested in 1979 from the 1978 short rains, when the rainfall was below average.[16] Maize in pure stand then averaged 1,807 kg/ha. Unfortunately, Jaetzold and Schmidt give no yield figures for a maize and bean mixture from the short rains, though they say 24% of the area was under this mixture, and 32% under pure maize. In the long rains, which were slightly above average, the pure maize yield was 1,756 kg/ha., and the yield of maize in a maize-bean mixture was 1,093 kg/ha. In consequence of higher yields even when the rains were not remarkable, farmers were able to sell 40-50% of their production in both seasons (Jaetzold and Schmidt, 1983). Therefore, crops were now in their mind the more important part of their farming system, despite the increase in the average livestock holding.

Both the yield and area data show much better use was made of the long rains compared with the position in the 1960s. Basing himself on Heyer, Lynam thought an important benefit of Katumani maize varieties was that they enabled farmers to double crop, (Lynam, 1978:158). Rather, it was one of the elements that enabled farmers to get an earlier start in the second season, and plant more, on time. Farmers we interviewed ascribed their improved results now compared with earlier by saying they were better organised. Early planting, more dry planting, and use of a mixture of maize varieties including Katumani (see Technology Profile) means the short rains harvest is earlier and the land is better prepared for the long-rains season.

More careful husbandry compared with 1965 is shown by:

(a) The traditional (as Owako describes it) broadcasting method has been replaced by row planting, which requires more labour but is also more productive. According to Owako, who took random samples in the field, the plant population under the broadcast method was 20,000-27,500 per ha.; in row cultivation it was 37,500-100,000 per ha.; (Owako, 1969; 226). He also quoted a research finding by Hemingway (1957) that maximum maize yield were to be obtained at densities of 37,500-75,000 plants per ha., so row cultivation was clearly nearer the optimum. Owako does not state how widespread broadcasting was in the 1960s, nor where it was most common.

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16. Despite the importance of variations in rainfall for yields, many surveys do not give clear information on the characteristics of the rainfall in the season of the survey. In the Farm Management Handbook the only clue is one map, which has the title: Machakos Small Farm Survey Areas (1978). They also give data which shows they called the long rains the First Rains, and the short rains the Second Rains (Jaetzold and Schmidt, 1983:176).

Masii leaders told us that it was the usual practice in 1960, but that they soon afterwards adopted row planting. Mixed cropping continues, but it now takes the form of intercropping; alternating rows of different crops. Row-planting has also led to an increase in the percentage of both maize and beans which are sole-cropped (Table 9). In Nzaui, mixtures of maize and pulses remained common in the short rains. Pollard's survey found that though maize yields in mixtures were, as to be expected, less than when grown in pure stands, the variability was also less, which he supposed was the reason farmers preferred planting in mixtures. However, in the long rains, maize was planted in sole stand. This appears a general practice; a CBS survey in 1980 found 86% of maize was intercropped in the short rains, with more mono-cropping in the long rains.

(b) The increase in row planting has enabled an increase in weeding with ploughs, at least the first time. This has cut or reduced one of the labour bottlenecks observed by Heyer. Lynam found a reduction from 17 to 11 man days weeding per hectare compared with Heyer's sample due to ox-weeding. While in Heyer's sample, only 12 of 74 plots were ox-weeded, by Lynam's observation in 1974, most farmers were so doing (Lynam, 1978:121). The technique is described in the Technology chapter. Plough weeding has a double effect on productivity, through more timely control of weeds, and through ridging up leading to better utilisation of rainfall. It is difficult to say if the proportion using the plough had increased since the 1960s; in Nzaui, the greatest increase in the use seems to have taken place between 1940 and 1964, with only a slight increase after 1964 (Table 9). However, it was undoubtedly being used more skilfully.

(c) More use is made of quicker maturing varieties. The Jaetzold and Schmidt sample had 46% using 'improved' varieties, presumably Katumani. We found in Masii that most farmers interviewed in 1990 planted both Katumani and a local variety, presumably as a safety strategy since different varieties will do better under different rain conditions. The Nzaui survey found 82% used local varieties but 38% bought Katumani.

(d) Early planting and dry planting is more frequently practised (Table 9). Shorter maturing maize means that it is easier to get a timely start in the second season. This is particularly so if the plough is used, and if seed is planted before the rains begin. Lynam found in 1974 that 78%, 61% and 24% dry planted in his three study areas, (Lynam, 1978:170). As farms become smaller, the proportion that it is possible to plant at optimum time, given constraints of labour and equipment, become larger.

In Masii our own 1990 interviews indicated some farmers planted dry, some in the rains, and some both. They were conscious of the need to trap all the available rain, but not all farmers could work their soil when dry. However, the practice has undoubtedly spread since Owako and Heyer made their observations. Only one of Heyer's sixteen managers dry planted, (Heyer 1967b:24).

(e) An increase in the use of manure. It was already being used in 1964 in Masii, by 65% of farmers, but in Nzaui use seems to have risen from 2% in 1940, to 34% in 1964 and to 46% in 1979-80. By 1990 the farmers we interviewed in Masii were acutely conscious of the importance of manure for maintaining fertility, and most felt they could not get enough. There are still important constraints through transport difficulties, even if animals are kept; the survey data in all locations indicated only 20%-25% of farmers had ox carts. Those without enough animals have to buy manure, which needs capital. In neither Masii nor Nzaui did farmers use fertiliser to any extent, according to the surveys (see Table 9).

Almost unnoticed, because taken for granted as essential to many of the other techniques, was the considerable investment in terracing, with the result that 100% of the expanded arable area was terraced by 1978. The extent of this effort between 1961 and 1978 can be seen from Figure 16, Land Use Profile. This was a period when terracing was receiving comparatively little attention from government or NGOs, though tools were provided in some places in the 1970s. Most of it was accomplished by hired labour or participation in *mwethya* groups (see Conservation Profile).

The increased food production on the average farm does not mean that farmers no longer have to buy food. This still occurs on small farms, and in bad seasons, particularly when two or more bad seasons follow in sequence.

4.2.2 Cash crops

Cotton has always appeared to agronomists to be the most suitable cash crop for AEZ 4 though sunflower was being promoted and enjoying a brief success at the time most of these surveys were made (Table 8). Farmers in 1990 did not refer to sunflower. Cotton was cultivated for a longer period, (see Production Profile Table A.6) but by 1990 many farmers had given it up. It was associated particularly with the larger farms, which had spare land after satisfying consumption needs. Constraints on its production will be discussed in the section on Makueni.

Farmers have recently, on their own initiative, turned increasingly to fruit trees, particularly oranges, pawpaws and mangoes. A few fruit trees, including bananas, have long been grown for family consumption. Most of the surveys of 1979-80 list fruit trees as being grown, but say little about sales. Those early into citrus certainly made good incomes - Meyers quotes a rural teacher in his sample with a large orange grove from which he made Ksh 17,000 in 1978 - approximately 3 standard deviations from the mean cash crop income in his sample (Meyers, 1982:99). In Masii and Mbumbuni it was noted in 1978 that medium and large farmers had an average of 0.1 ha. under this crop, with an average of 0.2 ha. per grower, which suggests about half the farmers in these categories had already moved into commercial production. A marked increase in fruit tree planting in Masii occurred shortly afterwards (Hayes, 1986:213), and Production Profile data suggests this must have been general. This may be associated with the continuing decrease in farm size, which makes it attractive to secure a high income from a small area. In the 1980s population density in Masii

increased to 174/km^2 by 1989. Farmers have also observed that citrus trees survived the 1983-84 drought better than cattle. Between 1980 and 1983 49% of Hayes' sample of 87 had planted orange trees, the majority obviously aiming at sales - 29 farmers had 10 or fewer trees, 40 had 11 or more. A local resident specialised in grafting sweet oranges on to rough lemon stock, selling young trees from his private nursery. There was also a government nursery. Mangoes were also grown mainly for sale. Commonly, there were 3-10 trees on a farm. Pawpaw planting began in the mid-1970s and accelerated after 1980. These trees normally have a life of only 3 years but produce an income quickly. While 28 households had 1-5 trees mainly for domestic use, 18 had 11 or more. The importance of fruit for income was confirmed by our interviews with village leaders in 1990, in both Masii and Makueni (Table 2).

4.2.3 Livestock and indigenous trees in the farming system

Table 10 shows average numbers of livestock per farm in Nzaui had slightly increased compared with those recorded by Owako in 1964, despite the considerable decrease in grazing land. While the average holding of cattle had remained remarkably similar, the holdings of shoats had increased by 1980. Numbers were already reduced in Masii by 1978, compared with 1964, and, according to our informants, were still smaller in 1990. Caring for them has become more labour-demanding, since they have to be tethered to prevent damage to fruit trees. Grade cattle represented only 9% of the herd in 1978. People in 1990 were showing interest in improving the breed through AI for milk output according to the leaders in 1990, but an important constituent of the herd are the (zebu) plough bulls or oxen. Leaders also said that by 1990 there was a higher proportion of people without cattle than in the 1960s. Table 9 shows that in 1980 between 55 and 75% of AEZ 4 farmers owned ploughs, with use being higher because of borrowing. The percentage not owning cattle is not generally given, but all surveys agree that such farmers are severely handicapped because they cannot plant in timely fashion. The complete integration of livestock and arable farming was confirmed by community leaders not only in Masii but in all five of the villages where we interviewed, who said the importance of cattle now was for ploughing, manure, cash, food security and milk (see Production Profile, Section B, p.58).

The method of keeping cattle has become much more intensive. The loss of grazing on distant Crown lands in the Yattas, which have now been taken up for settlement, or on common *utui* grazing land, which was converted into private, enclosed grazing land when demarcation and registration took place in the late 1960s and 1970s, has been compensated by an increased use of crop residues, so that there is a two-way flow - manure to the crops and crop residues to the livestock. Cattle are now confined to enclosed permanent grazing land belonging to the farm. These areas are generally too small to be divided into rotational paddocks, but they are often grazed only in the wet season. In the dry season, when they show signs of deterioration, the livestock are confined and fed on crop residues. Notes on livestock management as shown by the surveys are shown in Table 10; further information is given in the Production Profile, Section B, and the Technology Profile.

The grazing fields are carefully managed with three purposes in mind: to produce an income from charcoal and building timber, fuel for domestic use and grazing for the animals. Men and women leaders in Masii in 1990 both said there were more trees now than in the 1960s because now they were on private land and people took care of them. This means, inter alia, that people can no longer collect fuel wood wherever they fancy. It is mainly derived from their own farm, or collected by permission on other peoples' farms. Borrowers have to obey rules and restrictions on the types of wood that can be gathered, such as not taking from the fence or from green or standing trees, taking only in places which are indicated, etc. Hayes found that in 1982 ten households (12%) sold firewood, 6% sold charcoal and 10% sold bricks, using wood as fuel for the kiln, 5% sold whole trees (mainly for building) (Hayes, 1986). Examples of the management of trees on the pastureland in Masii is also given in the Environmental Profile, Section C.

5. EVOLUTION OF THE PLANNED FARMING SYSTEM IN MAKUENI

5.1 The Makueni Scheme and its Planned Farming System

Makueni falls on the border between AEZ 4 and 5. In the 1940s it was covered with thick bush which hosted dangerous animals and tsetse fly. The aim of the settlement scheme was to relieve population pressure in the reserve and to bypass a haphazard and slow process of learning to deal with the new environment by imposing from the start a scientific farming system.

A 1950 memo stated it was necessary to recognise

> *... the peasants are primitive, historically several generations behind modern agricultural technique (sic), and a time interval is absolutely necessary to allow development in efficiency and must be accepted .... The technical problem is straightforward, involving entry into relatively unknown marginal country, and the solution of a technique which will permit permanence of productivity. There are infinite variations of this theme, at extremes extensive and intensive practices .... The intensive treatment has been selected because:*
>
> *a) It concentrates supervision.*
>
> *b) It enables efficient exploitation of Capital Works, i.e. water supplies.*
>
> *c) It concentrates the population so that communal responsibilities become easier to deal with viz. control of bush regeneration.*
>
> *d) It focuses the attention of the farmer within a reasonable area.*
>
> *The simplest and most economical approach to intensive farming practice, commensurate with the climatic and ecological marginal conditions, involves*

> *mixed agriculture, controlled intensive grazing, provision and storage of fodder crops, the manufacture and use of manure and the culling and sale of surplus stock. Most, if not all of this, is alien to the evolutionary stage of the agricultural development of the settlers ....* (KNA: DC/MKS/1/29)

The plan was based on a minimum holding. This varied from 20 acres (8 ha.) on the better soils to 30 or 40 acres on those considered less good. The size was based on a cultivated area of 5 or 6 acres (2-2.4 ha.) plus the grazing area for the 8 cattle and 16 shoats considered necessary to supply the manure to maintain its fertility, if supplemented by silage and some cultivated fodder. Thus, 75% or more of the farm was to be under grazing. The detailed 'Makueni rules' provided that in the third year and every year thereafter the farmer was to plant two of his cultivated acres (0.8 ha.) to grass, and to bring in to cultivation 0.8 ha. of the existing uncultivated area. Every year he was to clear and stump 1.6 ha. of bush until none remained. He must demarcate his boundaries and divide the grazing area into paddocks of approximately 0.8 ha., also demarcated by cut bush, sisal etc. He must construct a cattle *boma* that could be roofed and dig a silage pit which must be filled with green fodder. Cattle *bomas* were to be emptied at least once a year and the manure applied to the cropped land. There was a demonstration farm with quite an elaborate rotation, but the 1955 report on its 'economics', which purported to show what a family could make by following the system, does not inform us how many staff were employed on it. The 23 rules minuted by the location council in 1955 (KNA: DC/MKS/Makueni) represent some simplification of the original system, in which it was also specified that half the food crops were to be sorghum and millets, half maize. An obligatory 0.1 ha. of cassava as a famine reserve remained a requirement.

5.2 Labour and Capital Constraints on the Planned System

The continual risk in Makueni, as L. H. Brown put it in a 1958 report, was the reversion of the area under grass to bush. He estimated that measures of bush control required 8 man days per acre, (0.4 ha.), that is, 120 days per year if 15 acres were under grass on the smaller farms, more on the 30 acre and 40 acre farms. Brown considered this unrealistic, and considered the option of a 15 acre farm, even if it did not give the then target income of £100 per farm. It was acknowledged some settlers were dividing their farms. A 1957 report on the possible extension of the Makueni settlement said that up to 1955 the bush problem appeared insuperable in the eyes of the settlers. 'They slashed, and the bush came back thicker than ever'. In that year there was 'Operation Harris' (details unavailable) in which 1,840 ha. were mechanically stumped in 1955 and 2,890 ha. in 1956.

It can be seen that the labour demands for maintaining the system were high. Apart from the recurrent 120 days for bush control on 15 acres of grazing, there was daily recurrent labour in moving the cattle round the paddocks and taking them to watering points. (The latter averaged one hour a day in the wet season and 2 hours in the dry in the 1980s (Hussein et al., 1982:20) and is not likely to have been less in the 1950s). For the farming operations, Heyer divided the agricultural year into 19 x 10 day periods, and showed that in 4 of them, more than 10 days work was required, while in a further 6, 7-9 days were required. Thus in 13 weeks out of the nineteen, the average arable farm, which in her sample was 1.1 ha., required full-time or more than full-time work by one adult. The Makueni farm, with 2

arable ha., would have required two adults solely on arable activities at certain times in the year. Other recurrent activities, apart from livestock care, were fuel collection, marketing, domestic chores, etc. Providing additional labour to stump 0.8 ha. of the grazing area each year and plant it to grass was not feasible for most families. Equally, it would not have been feasible to plant with grass 0.8 ha. of arable as required in the planned rotational ley system.

Bush clearing for arable land is even more labour intensive than clearing for grazing, because stumping is necessary. It was estimated in 1950 to take 120-160 days per ha. (KNA: DC/MKS/Machakos Betterment). The authorities recognised these high initial labour requirements for clearance. Settlers were given paid labour to clear the first 5 acres, and the first ploughing was by tractor. In 1957 the agricultural officer noticed the settlers were still having difficulty with some of the establishment costs, particularly in regard to boundary fencing and paddocking and agreed to lend a Departmental lorry for carrying in sisal. By contrast, the recurrent labour budget was ignored in the reports (KNA: DC/MKS/Betterment).

5.3 Capital Costs in Establishing the Makueni Settlement

The Makueni scheme absorbed considerable government funds. During the period 1946-62 government expenditure was £324,192[17], 8% of ALDEV's income for its Kenya-wide projects. This amounted to £148 for each of the 2147 settler families (ALDEV, 1962). These costs covered dam and borehole construction, clearance of the bush against tsetse, organised shoots of rhino and other wild animals, rations for the settlers prior to first harvest, assistance to the settlers in building houses, staff costs, mechanical terracing, as well as the clearing labour and ploughing services noted above. More than half was spent in the period 1946-51 when there were small numbers of settlers.

Settlers provided some of the capital requirement, bringing in livestock, bearing most of the costs of farm buildings, acquiring ploughs, making fencing, clearing, etc.

5.4 Abandonment of the Ley System and Developments in Livestock Keeping

After 1960 the Makueni rules were no longer enforced, and farmers evolved a new system, with a greater emphasis on livestock. Heyer observed the situation in 1974, when the average farmer had about 10 cattle, with 20% owning 10-14 and 21% owning 15 or more (Heyer, 1975). It was estimated the location had 80,000 cattle and 260,000 shoats in 1971 but that numbers were limited by shortage of water and poor marketing facilities (MoA, 1971:15). Heyer did not enquire the number of shoats; if the 1971 ratio is accurate the average farmer must have had about 30, double the number originally permitted. Makueni leaders say that goats were a chief income source in the early 1960s (Table 2). Goats are also useful in bush control.

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17. Equivalent to about Ksh 101 million in 1988, in terms of maize purchasing power (see Production Profile) - Ksh 46,000 per settler family.

In 1974 about 40% of the farms cultivated 2.4-4 ha. and 53% still had farms of 12 ha. or larger. In the adjacent, traditionally settled area of Mumbuni, the modal farm size was 4 ha. As they had a similar number of livestock to Makueni, this suggests much more intensive management (Heyer, 1975). Maize and pulses were the predominant food crops, with only 40% growing a little sorghum and only 20% any cassava. Makueni farmers had abandoned the ley system. Reasons cited for not opening up new arable land were lack of money, lack of labour, lack of enough good land (an answer confined to certain sub-locations), lack of equipment (Heyer, 1975). Few farmers divided the grazing area into paddocks. Farmers in 1990 told us that if the grass was rested, bushes grew very fast and destroyed the grazing. The making of silage, so much preached to the early settlers, was not practised even by the former agricultural officer, Mr Onesmus Musyoki. He said white ants destroyed it, and in any case, people did not like to cut maize when it was nearly ready for harvesting. In 1990 most farmers fed their livestock on their own grazing and crop residues; a few had to buy in grass and a few cultivated fodder. He reckoned he could keep a cow on 0.4 ha. (Musyoki, personal communication, 1990). Such a semi-intensive system was probably adequate in most years; an investigation in 1982 found that many farmers were not able to feed their animals adequately for draft purposes; many blamed late planting on the poor condition of their oxen (Hussein et al., 1982). (Hussein et al. omit to state that there had been a light drought in the short rains of 1980 and a severe drought in those of 1981).

Theoretically, the large farm should encourage the use of tractors, which have always been available in Makueni. Heyer found that in 1974 only 12% used tractors for first cultivations, although this rose to 26% when it was a case of breaking new land. The reasons farmers gave for preferring ox cultivation were that it was cheaper than the tractor, quicker than the hoe, more easily available than the tractor, and retained soil fertility. (The third most quoted reason for not using tractors was that they destroyed soil fertility). If they had ploughed greater areas, they might have encountered labour bottlenecks with weeding or harvesting, though this was not mentioned.

5.5 Cotton, Oranges, and Livestock

Cotton growing was strongly encouraged in the 1960s, with free seed distribution. The acreage under cotton dropped sharply when this was stopped in 1970-71 (MoA, 1971:11), suggesting cotton was only marginally profitable. Heyer found the most common cash crop to be grams. In the period 1978 to 1981 cotton prices were relatively high (see Production Profile). This seems to have resulted in a switch in the direction of more arable farming and somewhat less emphasis on livestock. By this stage, the population density had risen to over 50/km^2, many farms had been subdivided, and there would have been pressure to raise income per hectare by increasing the proportion of arable to grazing. The 1982 report says farmers in Makueni averaged 2.3 oxen, 0.5 grade cows, 3.9 local cows and 17.5 shoats. This represents a drop in the average number per holding since 1974, suggesting farmers had not attempted to rebuild their herds to the old levels after the droughts of the 1970s. Hussein et al. thought numbers large in relation to some theoretical carrying capacity but at over 1 ha. per livestock unit it was much less intensive than in most AEZ 4 areas (Table 10). By 1982 the average farm had increased its arable area to 5.2 ha. nearest the dwelling, including about 1 ha. of cotton, with 10 ha. of permanent grazing further out (66% of the farm).

According to Hussein et al. (1982), the competition between maize and cotton for the available labour and equipment in the short optimum planting limited the amount of cotton grown and the yields obtained. Cotton was generally treated as of secondary importance to food crops, so that it was generally planted late. Yields were low, with three quarters of farmers getting less than 750 kg/ha. Hussein et al. estimated the average return from cotton to be only about 16 Ksh per labour day, compared with the then casual labour rate of about 15 Ksh/day. They thought that most farmers included it in their system partly as a diversifying tactic against risk, and partly because of its guaranteed market. They failed to note that these yields and returns apply to a season with a severe drought. Returns are probably better in average or good years. However, when the Cotton Board delayed payments in the late 1980s, many farmers gave the crop up or reduced the area planted. In 1990 it was still grown by some farmers, but there were many complaints of high labour costs, high costs of and delays in getting chemicals for spraying, and delays in payments.

By 1990, when we interviewed, there had been a move away from livestock and into fruit. By this time, population density had risen to 60/km^2 and the average farm must have been smaller, although we have no data on this. With delays in payment and increases in the price of inputs, cotton had lost its popularity. In 1982 fruit was mainly a subsistence crop, grown by 60% of farmers (Hussein et al., 1982). By 1990 we were told that the main sources of cash were oranges and surpluses of maize and pulses (Table 2 and farmer interviews, 1990). Those who went into orange trees commercially reduced their goat holdings; we were told goats are very partial to orange trees. Amongst the 8 farmers we interviewed only two still kept goats though all said they had large numbers at an earlier stage.

There also appears to have been a move towards keeping fewer, but better grade cattle. The average number of cattle kept by the farmers we interviewed, who represented the older and best established farmers, was 8.5. Smaller numbers of cattle might partly be a temporary phenomenon; at the time of our interviews in 1990, farmers had suffered stock losses from disease outbreaks in 1989. They may not have made a complete recovery from the 1984 drought in which losses had been severe. Despite the risks in cattle ownership, leaders thought many farmers had acquired crossbreeds during the 1980s. This was partly in response to rising milk prices (see Production Profile, Section B). A co-operative dairy was established in 1981, reselling to local hotels, etc. It still existed in 1990, but active membership had fallen from a peak of 42 to 30. The manager blamed high transport costs and unreliable transport for outlying farmers. Farmers also made direct local sales through the local markets and to local hotels. Dairying expansion is probably limited at present by lack of local demand, with most farmers able to meet their own needs, and unable to transport the surplus to urban centres. Sales of live cattle remain important. We were told there were many cattle traders in the area, and that marketing live animals was no problem. Nevertheless, because of transport costs, prices are about a third of those in Machakos town. Makueni still suffers from isolation by appalling roads.

5.6 Lessons of the Makueni Settlement

The lessons of Makueni show that it is difficult to make an evolutionary leap to intensive farming in an area of low population density. The endeavour to impose such a system,

rather than to assist farmers to find their own solutions, meant heavy costs to government both in capital expenditure and in the high level of supervisory costs. The conversion of bush to grazing land is not easy, because of the regeneration problem. Arable areas remain limited if there is no market for crops, but expand if either there is a commercial outlet for crops such as cotton, or if rising population density increases the need for food crops. As in other areas, terracing has increased, and such investments mean that rotation between grazing and arable is difficult. Makueni farmers have found means to grow their preferred food crop, maize, and to maintain their livestock in such a way that they contribute to income generation and to family subsistence on a steadily reduced grazing area. Farming is less intensive than in other areas of traditional settlement, partly because of the large farms initially imposed. The settlement history stands in marked contrast to that of the Yattas and southern Machakos, settled without control a decade or two later.

6. UNCONTROLLED SETTLEMENT AREAS IN AEZ 5

6.1 Attitudes to Uncontrolled Settlement

Spontaneous settlement has long been perceived as a problem[18] by the authorities. In the colonial period this was because it was feared it would lead to land degradation. In the 1970s the Government, and many academics, feared that migration by farmers without knowledge of appropriate farming techniques into the drier areas would increase degradation, vulnerability to famine, and government expenses in food aid (Mbithi and Wisner, 1972; Lynam, 1978). It was thought farmers would 'mine' the land - cultivating it briefly before moving on, leaving it greatly 'degraded' (Heyer, 1992, personal communication). Observers tended to look for evidence of bad farming methods rather than to consider how far the methods of new settlers were necessary adaptations to their factor endowment. This included a severe shortage of liquid capital and livestock, since, unlike the Makueni settlers, they received no food rations in their first year, no assistance with clearing and first ploughing, etc., and little help in developing water resources. Whereas in Makueni roads, schools and a cattle dip were provided by government, in Ngwata Location these were provided by self-help groups (Mbithi and Barnes, 1975:147).

The Yattas began to be settled from the late 1950s and the Ngwata area from the late 1960s. Our evidence about the early days of the new settlements is limited to the Mbithi and Barnes study in Yatta and Ngwata in 1972 and the recollections of those we interviewed in 1990. For the situation in the 1980s we have two additional sources: Neunhauser et al., 1983, for north Yatta (Masinga); Mukhebi et al., 1991, for southern Machakos in areas neighbouring those where we interviewed.

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18. The spontaneous settlement problem was the title of a book, Mbithi and Barnes, 1975.

6.2 Methods of Settlement

Observers disapproved of the 'shifting cultivation' said to be adopted by the settlers. Mbithi and Barnes said Ngwata settlers 'simply burn the bush and weeds and plant seeds on the hard exposed surfaces' (Mbithi and Barnes, 1975:171). Thom described the newly settled areas of Lower Makueni as a slash-and-burn bush-fallowing system around a settled base, with a rather similar situation in Yatta Plateau (Consortium, Report 6, 1978:68). In fact, shifting cultivation is an appropriate agricultural method in face of land plenty and labour shortage, and in these areas the population density was still below 50/km^2 in the 1970s.[19] Settlers had also another motivation. They had no land title from the Government (unlike those at Makueni), and Mbithi and Barnes record a whole series of clashes until about 1972, as Government forces tried to chase away illegal settlers (Mbithi and Barnes, 1975:128-133). Cultivation gave a claim under Akamba custom (see Institutional Profile). Any area cleared was therefore immediately cropped. There was no question of clearing for grazing only. It is in any case logical to plant crops to take advantage of the stored fertility and to recoup the costs of clearance. In the following years settlers cultivated a new area - the motivation being to secure land rights rather than fallowing (personal communication, Mr Maithya, who settled in Matuu in the 1960s). Farms were demarcated by local elders, since the Government gave no assistance (Mbithi and Barnes, 1975:145-6, and village leaders, 1990). Community leaders told us that people tried to get about 4 ha. under food crops and to claim 20 to 40 ha. in the vicinity for grazing when the tsetse retreated. To get 4 ha. under food crops when at this stage they had no oxen, it was necessary to revert to the extensive farming methods generally practised at the beginning of the century, burning the bush, using the ash as a natural fertiliser, and broadcasting seed. Burning is in any case the cheapest method of clearing; the Makueni settlers had the help of labour and tractors for the thorough clearance and stumping necessary before the first ploughing of their fields by tractor.

For new settlers these costs would have been virtually nil, since they could in any case not bring in livestock till the bush had been reduced and the tsetse eliminated. Burning also provided an income from charcoal (Morrison noted that ranchers could sometimes get land cleared of bush free of charge in return for rights to make charcoal) (KNA: DC/MKS/Makueni).

Mbithi and Barnes found settlers in 1972 compared badly with more settled areas of east and central Kenya in respect to:

Low investment in fruit trees
Low adoption rate for Katumani maize
Growing of cotton or grams for cash
Using manure or compost
Using ploughs to get a good seed bed.

Much of this can be explained by shortage of initial capital. Community leaders said that at first they were unable to keep livestock because of tsetse; this explains the lack of ploughs

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19. Netting has described how the Kofyar tribe in Nigeria, who practised a very intensive system of agriculture on the Jos Plateau, adopted shifting techniques to develop new land in the plains (Netting, 1965).

and manuring. Shortage of cash probably impeded purchase of Katumani seed or cotton seed, and this plus lack of secure legal rights would make for low investment in fruit trees. Mbithi and Barnes agree with the current village leaders that the main sources of cash were products of the bush: charcoal, honey and ivory, together with remittances and help from home areas (see Table 2).

While people aimed to claim large grazing areas and keep livestock, community leaders said many people instead sold the land they claimed at very low prices to newcomers, since they need help of more people to keep the game away. Mbithi and Barnes noted such sales as taking place in 1972 at up to Ksh 100-150 per acre. By 1990, according to women leaders, land prices had risen to Ksh 4,000 per acre for grazing land, with terraced land costing Ksh 5,000 per acre. Terracing, according to the leaders, was done in the late 1970s and 1980s, with, they insisted, no government help. They used hired labour or rotational groups.

The introduction of cattle made use of the plough possible. Ngwata people also hire tractors, since about half, according to the leaders, still have no cattle, or have lost what they acquired through disease - a 1989 epidemic was mentioned. Almost every farmer keeps goats, the average, according to the men being 50, and to the women, 5 or 6.[20] Initially, cattle if kept could graze anywhere; now they stay on their own farm or go to another after the agreement of the owner has been negotiated. They are also given crop residues.

Unlike the Makueni people, the Ngwata people find that deep ploughing by tractor improves yields on their soils. Ploughing, whether by purchase of an ox-plough or hire of a tractor, made possible contour ploughing, ridging, planting in rows, better spacing and it assisted terracing. Crops and livestock then became the main sources of income, although according to the women leaders, charcoal remains important (Table 2).

By 1990, therefore, in the opinion of the leaders we interviewed, the average farm was only 4 to 8 ha., with about 40% for crops and 60% for grazing. (This appears confirmed by a survey by CARE International in Kibwezi in 1990, which found an average of 2.8 ha. of cultivated land per household (CARE International, 1991). Their system appears to have evolved rapidly into a variant of the Masii system, including some cotton, but, as yet, little fruit. Cash was derived from surpluses of food crops in good years including sorghum when the price was high. Maize, however, remained the dominant cereal. They had in fact adopted a semi-intensive system more rapidly than in the older areas. Farms were smaller and more intensively cultivated than in Masii in the 1960s, although population density was still only 50/km^2 in 1989.

The impressionistic information from leaders can be compared with data from a random sample of 106 farms in neighbouring areas of southern Machakos, Kasikeu, Makindu and Mtito Andei, made in 1985 (Mukhebi et al., 1985 and 1991). These were in AEZ 4, 5 and 6. The objective was to compare the impact of the 18-month 1983-4 drought on the farming and livestock systems in southern Machakos, where farmers combined livestock-keeping with arable crops, and the ranching system with very little cropping in the immediately adjacent Masai district of Kajiado, in AEZ 4 and 5. They found in Machakos an average farm size

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20. Men were probably quoting for the extended family and women for their own unit.

of 10 ha., with a range of <1 ha. to 50 ha. Before the drought, all the Machakos farms had grown maize and a mixture of other crops whose residues were usable as fodder, compared with about 16% of the ranches. The average pre-drought holding was said to be 36 cattle, 45 goats and 13 sheep. Post-drought holdings averaged 18 cattle, 25 goats and 7 sheep (Mukhebi et al., 1985). Their losses in the drought were lower and recuperation rates after the drought were higher than on the ranches, showing the value of the mixed farming system that had been evolved (for further details, see Technology Profile).

6.3 The Yatta System in 1981

Settlement of the Yatta Plateau and North Yatta (now known as Masinga) began ten years before settlement in Ngwata, and population density had reached 50/km^2 by 1979. Neunhauser et al. describe the situation in 1981. The average farm size varied from 2 ha., an exceptional case, representing an estate that had been divided up, to 4 to 8 ha. in freely settled areas. About 45% was under crops. Thus, farms were smaller and proportionately more arable than in Makueni, approximating more to the farms in the older settled areas such as Masii and Nzaui. Cropping patterns were also similar, but more farmers practised inter-cropping, mixtures being thought to save land and to give greater yield security. Although sorghum is the recommended crop for the area, farmers did not plant much, giving as the main reasons, their preference for maize as a food, the bird problem, and lack of a market. The short rains of 1981 in the area were very poor (in our terms, a severe drought (see Environmental Profile, Section A). Nearly 40% of the farmers said they harvested only 10% of usually expected maize yield. In consequence, 50% of farmers had to buy in food, with 36% able to sell a surplus and the remainder just meeting their needs. Of those needing to buy food, most resorted either to livestock sales or to casual labour, with smaller numbers selling charcoal (in the most newly settled area). Neunhauser et al. concluded that farmers first aim is to satisfy the subsistence requirements of their family; 94% of the farmers interviewed therefore planted their food crops first, with cash crops and low-preference food crops such as sorghum being planted later. Farmers allocate land to food crops bearing in mind the possibilities of low yields and the need to keep a reserve against a following poor season. In good seasons, they have a surplus for sale, substantial judging by the numbers selling in a poor season. Fruit trees near the house or in the cropped land supplied family needs. Indigenous tree species in the grazing area were preserved and cropped, according to species, for browse, fencing construction and fuel. Euphorbia was planted as a hedge, for fuel, and to check gullies. Although most farmers thought fuel was becoming scarce, about a third made sales of charcoal. A majority of farmers had partly terraced their farms, though only 30% had in 1981 consolidated the terrace with grass. The area was at the time targeted for renewed government assistance to terracing, under the Machakos Integrated Development Programme.

Farmers had an average of 8 cattle and 13 shoats, which were integrated into their farming system. Nearly 80% owned a plough, used for terracing, ploughing and weeding, and 90% used *boma* manure on their farms. Own grazing land was supplemented by crop residues, but the condition of livestock deteriorated in bad seasons and there were losses to disease. Sales of livestock were important for the necessary purchase of food and other cash needs. However, largely because of these losses, Neunhauser et al. calculated that livestock production was not particularly profitable, and that, as we were told in our 1990 interviews,

the value of livestock lay rather in their use as a capital reserve for food purchases, and their contributions of milk, manure and draught power (Neunhauser et al., 1983).

7. INCOME SYSTEMS IN AEZ 4, 5 AND 6 IN THE 1970s AND 1980s

7.1 Total Incomes and Farm Incomes

Farm incomes in an area of erratic rainfall vary according to rainfall, and may be strikingly different from one year to the next. However, relatively few farm income surveys give adequate information on the timing and quantity of the rainfall at the period of the survey, nor do they usually enquire whether farmers thought yields were above or below average (exceptions include Heyer, 1966, and Neunhauser et al., 1983). Quite apart from the difficulty of assessing whether the reported farm income was something near the average, reported incomes cannot easily be compared over a period of time because of changes in prices and differences in the methodologies of the surveys. It follows that it is also difficult to relate information on either farm or total rural incomes to a standard of welfare that measures poverty, or which enables comparison with other parts of Kenya.

The best estimates of Kenyan rural incomes are still considered those from the 1974-5 Integrated Rural Survey (Heyer, 1990). This estimated incomes in the zone in which the AEZ 4 areas of Machakos falls as Ksh 2,479, of which 26% was derived from the farm operating surplus. This takes into account losses of Ksh 1,300 in livestock and in stored farm produce, due to drought during the period of observation. Without these losses, which are not taken into account in many other estimates of farm income, total income was Ksh 3,790, of which the farm operating surplus contributed 52% (Consortium, Report 3, 1978:83). The poverty line for smallholders in 1974-5 was estimated at Ksh 2,000 per household (Collier and Lal, 1980). Some 60% of smallholders fell below it in the eastern dry zones compared with 40% nationally, and income distribution was more unequal than nationally (Consortium, Report 3, 1978:84 and 91). The drought may have been more severe in Eastern Province.

Central Statistical Office carried out another rural household budget survey in 1981-82. Heyer reports its summary District figures. Average rural household income in Machakos was said then to be Ksh 864 per month (Ksh 10,368 per annum), more or less in the middle of the national range at district level (Heyer, 1990). According to Ondiege, this survey found 50% of income derived from the farm operating surplus, which may be more reflective of the normal position in a non-drought year than the 1974-5 survey (Ondiege, 1992). The remaining income came from salaries, wages, off-farm enterprises and other sources. We have no information on income distribution, nor on what was then considered the poverty line. However, it gives us a standard by which to judge some of the rural income surveys made within the District 1978-81.

The calculation of farm incomes depends on the prices used to value the subsistence element. Heyer noted that these varied by District in the 1981-2 survey. They also vary within Districts, and by year, according to the degree of scarcity in local markets. Assessment of

income will therefore differ according to whether subsistence production is valued by prices prevailing locally at the time of the survey, or by official national prices. Some surveys do not value subsistence production; others value some subsistence production, e.g. crops, but not home consumption of milk or poultry. Livestock income presents considerable problems, as it should theoretically be calculated with reference to the stock of livestock held. Most surveys producing estimates of livestock income in fact simply give the total of livestock sales, without indicating whether or not this represents a rundown of stocks, or an off-take that keeps stock equal, or an off-take at a level which has in fact permitted the increase of the stock. Other surveys overcome the problem by calculating income per cow-calf unit - but ignore shoat and poultry income. In addition to problems related to on-farm income (which should include wood and charcoal sales as well as crops and livestock), there are further problems with assessing the level of non-farm income, especially when these are derived from the profits of a non-farm business such as a shop, irregular income from craft sales, or irregular remittances from non-resident family members.

The effects of differences in methodology are shown in crop budgets for maize and cotton produced by Pollard for Nzaui in 1980/81 and Mukhebi for Mbiuni in 1978/9, shown in Table 11. As the years were rather similar in respect of good long rains and poor short rains, the difference in maize prices is surprising. Pollard used local prices, which he said were higher than usual due to the drought; Mukhebi used official prices. This makes a 100% difference to the value of maize output. In 1977 more than 60% of those who sold maize sold it to local traders, who tended to pay a higher price than the Board (Consortium, Report 3, 1978:44). As those who purchased also bought locally, local prices are the more valid standard. There is also a different treatment of variable costs. Pollard treated these very skimpily, not valuing seed retained from the previous harvest, nor counting any inputs unless these were used by the majority of farmers. Mukhebi dealt with the input of oxpower by including it in variable costs at its rental cost. Pollard notes most farmers used their own oxen and treated it as an overhead, at lower cost. In consequence, actual difference in incomes per ha. between the two places and the two years are likely to have been substantially less than appears in Table 11.

In regard to seasons, Pollard said that both relevant rainfall seasons were very poor. (The Long Rains of 1980 do not seem to have been generally poor but Pollard says that in his survey area rainfall is locally influenced by Nzaui Hill). On his calculation, which understates variable costs, total farm income less overheads was Ksh 8,302. This was the major part of total income, but most of it was for subsistence. He found the most lucrative farm enterprise was dairying, for subsistence (although his output estimates were lower than Mukhebi - an output of 225 litres milk per cow at Ksh 1.50 per litre, compared with Mukhebi's 630 litres per cow at Ksh 1.04 per litre). The average 3 cows produced milk worth Ksh 1,755. He did not include in total income sales of poultry and goats. However, as it appears to have amounted to an average of Ksh 671, and as such livestock sales are included in most other surveys, we have added it in Table 12 in the calculation of the percentage of income received from livestock. Crop sales provided only Ksh 780 of the total crop income of Ksh 6,547. Goats and poultry are important in providing regular small cash sums, and, in this poor season, nearly equalled crop-sale income. The half who grew cotton had an average of 0.6 ha. It provided a gross margin of Ksh 1,391 per ha. compared with Ksh 1,634 for short-rains maize. Maize provided a further Ksh 886 per hectare in the long rains. Cotton provided most of crop-sale income, with pigeon peas in second place. Only

Table 11: **Maize, maize mixture and cotton budgets**

	Season	*Crop*	*Yield kg/ha.*	*Ksh/kg*	*Value of Output Ksh*	*Variable costs Ksh*	*Gross margin/Ksh/ha.*
Pollard (Nzaui)	Short rains 1979/80	Maize in mixture[a]	817 (maize only)	2	1,634	0[b]	1,634
	Long rains 1980	Pure maize	443	2	886	0[b]	886
Mukhebi (Mbiuni)	Short rains 1978/9	Pure maize	811	0.94	763.34	419.8[c]	342.54
	Long rains 1979	Maize + beans	525 + 293	0.94 + 1.89	1,047.27	472.66[d]	472.66
Pollard (Nzaui)	Short rains 1979	Cotton	488	3.34	1,630	239[e]	1,391
Mukhebi (Mbiuni)	Short rains 1978/9	Cotton	592	3.20	1,894.4	710[f]	1,184

Notes: (a) Budget is for maize element only.
(b) Used own oxen, own seed, family labour (seed should have been costed and ox costs imputed)
(c) Hired oxen @ Ksh 210, Ksh 84 for fertiliser (no cost for seed) incidentals, and 3% interest.
(d) As for 3, but includes seed.
(e) Only insecticide. Seed said to be provided free by Nzaui Co-operative - own oxen, no hired labour (although 32% used it)
(f) Seed, hired oxen, some hired labour, sprays, incidentals and 3% interest.

Source: Pollard 1981; Mukhebi 1981.

about 20% sold any maize or beans. The cattle provided draft, manure and milk, and the emergency reserve for any necessary heavy expenditures. Pollard ignored other farm income such as charcoal, honey and hiring out of draft, as this was earned by only 30% of his sample. Of the cash income, 60% of the sample had an average of Ksh 3,118 from off-farm sources, or an average of Ksh 1,807 for the whole sample. We have used the latter figure to calculate a total income of Ksh 10,700. Many had one member of the household living away from home, most of whom sent money home. Over 40% received income from the regular employment of a resident household member.

Table 12: Incomes in AEZ 4, 1978-80

		Total income Ksh	*Arable %*	*Livestock %*	*Off-farm %*	*Subsistence as % of farm*
Mbiuni	1978-79[a]	6,090	55	25	20	n.a.
Nzaui	1979-80[b]	10,780	54	20	26	c.84
Mwala	1979-80[c]	4,586	n.a.	n.a.	51	72

Source: (a) Mukhebi 1981
(b) Pollard 1981
(c) Rukandema et al. 1981

Pollard's income estimates look in line with the District calculation for the following year, quoted by Heyer. However, they are considerably above those derived by Rukandema et al., for Mwala. One of their seasons overlapped with that of Pollard (Long Rains, 1980), and the two relevant short rains seasons were similarly poor. It is therefore surprising they found a net farm income of only Ksh 2,218, 71% subsistence and 29% cash, a quarter of the level found by Pollard. Of the farm cash income, 65% came from livestock sales and 35% from crops. 88% of their farmers reported they valued cattle for their cash income, a higher percentage than those mentioning milk (73%) so they may have had a slightly different strategy to Nzaui farmers. Cotton did not rate a mention. It is difficult to see why estimates of farm income differ so much since Rukandema et al. give no information on their method of computation, nor of the prices used, saying only these were local averages and somewhat higher than normal. There may have been some real difference due to poor soils in Mwala, on which Rukandema et al. note farmers' comments. However, there may also be an undetectable methodological difference. Rukandema et al. found an average off-farm income of Ksh 2,368 which approximates more to Pollard's finding.

What is clear, from these and other surveys, is that the main purpose of arable farming in AEZ 4 circa 1980 remained to provide for subsistence, although there were shortfalls and surpluses in different food crops by different farmers that led to buying and selling; that the livestock element was important for subsistence, cash and its contribution of inputs to the

arable enterprise; and that off-farm income provided an important proportion of cash resources.

The above conclusions apply also to AEZ 5. We have no income estimate for this zone, but Neunhauser et al. made an unusually careful estimate of the probable value of output in a sample drawn from Masinga (North Yatta) for the short rains of 1981. In their crop budgets they costed in and out the value of crop residues, draft and manure, so as to be able to value the contributions of crops and livestock accurately. They did this for three different yield levels, since their survey was in a bad season. They used three different prices for food crops; the market price in Matuu for the consumed crops, since Matuu market was where the farmers purchased food, and two prices for crops sold, according to the price offered by the NCPB and the (higher) price offered by local traders. In years of shortage farmers pay quite a heavy penalty in having to purchase at high prices to make up for any shortfall in production - in the year in question some farmers reported they had to pay Ksh 5-8 per kg for maize, compared with a 'normal' Ksh 1-2. The returns on the average sized farm would vary from Ksh 2,276 to Ksh 5,220 according to yield level, though, as they observe, the latter figure is unlikely, since if yields generally are high, prices drop. Their analysis also shows that food-crop sales must be important in good years, since even after the severe drought in the short rains of 1981, 36% had been able to sell something.

On livestock, they estimated that roughly one third of its output value was its contribution to crop production. They allowed for losses, which must have been high in the drought. This means their figures are not comparable with the Nzaui and Mwala surveys quoted above. After allowing for a contribution to crop production of Ksh 1,538 from their cattle and Ksh 100 from their goats, the remaining return was only Ksh 357 and Ksh 60 respectively. Poultry made a useful contribution since they took no inputs in the extensive keeping system.

As in other areas, farmers did not rely entirely on farming. Just under half had one alternative income source and another 17% had two other income sources. 50% of those with surplus crops and 80% of those with a deficit had an alternative income, suggesting that alternative incomes were sought mainly by those with smaller crop output.

The Neunhauser et al. analysis for the Masinga area shows that even in AEZ 5, crop production was the most important element of incomes, with livestock contributing farm services, some subsistence income, and the cash that was particularly useful to finance food purchases in bad seasons. Neunhauser et al. found cotton production only made sense for a minority of farmers who could safely provide food for their families even in bad seasons, confirming the linear programming analysis made in AEZ 4 by Lynam based on 1974 figures (Lynam, 1978).

All these analyses apply to the period around 1980. The proportion of cash income generated by the farm may have changed by 1990, due to the increasing importance of fruit in areas such as Masii and Makueni. The variations in income between those with more or less land and capital resources are examined in Section 8.

7.2 Sources of Non-Farm Income

In a sample of 87 households in Masii in 1982, Hayes found 7 widows. Amongst the remaining 80 husbands, 50% had no employment off the farm, 26% had local waged work, 18% had waged work which kept them away from home, and 6% were traders. Local waged work included construction, teaching, transportation, repair work, hotel and restaurant work, and a variety of other occupations. Evidently, much of it was in the informal sector. Only 6% of the wives engaged in waged work. Some younger members of the family also had jobs. Compared with 1962, when Heyer says there were few local jobs, more of the off-farm income was earned locally. This implies a considerable drop in out-migration for work, the most usual resort at the time of Owako's and Heyer's observations in the 1960s. Masii, with good bus connections to Machakos, might have an above average number of persons with local waged work. In the 1985 ADEC survey of the whole district (ADEC, 1986), 41% of households in AEZ 4 reported some income from wages/salaries (Table 13) but this does not differentiate between local jobs and those necessitating living away from home.

Table 13: Household income sources - percentages mentioning (District level)

	AEZ		
	2&3	*4*	*5*
Wage/salary	48	41	46
Cash crops	74	53	53
Food crops	38	48	58
Cattle	28	52	56
Goats	29	56	65
Milk	19	15	14
Chickens	38	53	49
Eggs	20	21	19
Hides/skins	21	34	40
Crafts	36	43	36
Pombe (beer)	<1	2	3
Honey	0	9	18
Charcoal	7	11	14
Firewood	9	5	5

Source: ADEC 1986, Table 3.10.

7.3 The Marketing Position in AEZ 4, 5 and 6

Neunhauser et al. (1983) repeated the criticisms of Heyer, 1966, Consortium, 1977 and many others who have looked at the wider Kenyan economy, of restrictions on food-crop movement, under which licences are required from the main District NCPB office to move more than 10 bags within the District, or to export more than 2 bags. Although these

regulations are not always observed, they add to the costs of traders. The NCPB has little effect in preventing high prices in bad seasons (see Production Profile, Section A).

Trade is also hampered by an inadequate road network, little bigger in extent in the 1980s than it was in the 1950s. Some roads are now tarred, and this has been observed to improve market activity, as in the case of Matuu, served by the trunk road from Nairobi to Garissa. Other once-tarred roads have become a series of potholes, as in the case of the Kangundo-Thika-Nairobi road, the commercial lifeline of the northern hills. South of Machakos the only tarred road is the one running east to Kitui. Important farming areas such as Makueni are still dependent on roads passable only with difficulty in the rains.

The railway line from Mombasa to Nairobi passes along the eastern side of the District, and it made possible the dairying activities of the white ranches in the adjacent AEZ 5 and 6 areas. It is parallelled by the Nairobi-Mombasa trunk road, which has been improved and is carrying increasing traffic. Feeder roads from Mbooni and Kilungu have helped to develop the export of coffee, fruit and vegetables. The railways stations such as Kibwezi did not develop into towns in the colonial period because there was virtually no population in their hinterland; however, recently, with the development of settlement and farming in southern Machakos, Kibwezi and Mtito Andei have expanded rapidly (Ministry of Planning, District Plan, [1988]).

The development of Kibwezi, Mtito Andei and Wote (which became the headquarters of the new Makueni District in 1992) into new areas of wholesaling activity may eventually cut trading costs and provide new centres of local demand. In 1979 these places had less than 2,000 people, and only 6% of the District population lived in urban areas (Population Profile). In 1985 most of the many small markets in AEZ 4, 5 and 6 were served by buses and *matatus* operating out of the three major northern markets (Musyoki, 1987).

7.4 Income Sources at District Level

The diversity of income sources suggested by these few surveys was confirmed by ADEC's District-wide survey of 2,000 farm households in August-September 1985, which omitted only the urban areas and ranching areas (ADEC, 1986). The main economic activity was described as crop production by 54% of those in AEZ 2 and 3, and by 50% of those in AEZ 4, 5 and 6. The next largest group described it as both livestock and crops - 29% in AEZ 2 and 3, 34% in AEZ 4, 5 and 6. It is notable that even in AEZ 5 and 6, more mention crop production than crops and livestock. Farming by the 1980s was very definitely orientated to arable activities. Only 10% gave wages as their main economic activity, and only 3% trade and business.

When farmers were asked to say if they obtained any income from certain activities, the variety of income sources and their variation by AEZ became apparent, as shown in Table 13. Income from wages, salaries and crafts was available everywhere; cash crops (which probably to the farmer include fruits and vegetables when grown for sale, as well as coffee and cotton) were most frequently mentioned in AEZ 2 and 3; income from food crops was more frequently mentioned in AEZ 4, 5 and 6; cattle, goats, hides and skins and charcoal showed the expected increase in AEZ 4, 5 and 6, but not milk or firewood. It is worth

noting the frequency with which chickens and crafts are mentioned. Sales of chickens are used by most families to meet small expenses, and crafts are pursued by many. Sisal string baskets provide a small income to many women. Making them frequently accompanies another activity such as selling in the market. The other major craft, wood carving, is pursued by men, mainly round Wamunyu village, and provides a fairly substantial income source to a more concentrated group of people.[21]

Peberdy gives data which suggests that in the period 1955-60 about 4,500 men were employed in the formal sector within the District (Peberdy, 1961). We also know that 4,700 men and 500 women worked on the large white-owned farms in 1960 (Ministry of Finance and Economic Planning, Agricultural Census 1962, 1963). Thus, total formal employment within the district was about 9,500-10,000, or about 4% of all adults. The Statistical Abstract series shows a considerable jump after Independence, as the following figures show:

	Employment in Machakos	*% of Kenyan formal employment*
1963-70	15,000-17,400	5-6%
1972-75	19,500-26,750	3%
1980-88	32,300-44,100	3%

In the period 1980-88 formal sector employment provided between 32,000 and 44,100 jobs, providing for about 9% of the adult population available for work, although the growth of this sector has not been as rapid as in Kenya nationally. Much of it was in the service sector (schools, government services), although there were still some large estates. The formal sector comprises government and large-scale private-sector enterprises. The village-level surveys we have quoted indicate that what was also important was small-scale enterprise and artisan activity which is difficult to quantify. The only available figure is the 7,000 licensed business premises in the District in the 1980s, compared with 1,600 in 1957 (Institutional Profile). Some of these would have been part-time enterprises, but in other cases they certainly had employees as well as an owner-manager. A survey in Central Province found 1.6 employees per informal enterprise, (Livingstone, 1986:55, quoting Norcliffe and Freeman 1979). If it was similar in Machakos, licensed owners and employees might total about 18,000 people. This is a minimum, since it is certain that there are many people who escape the local authority revenue collectors. We have no information on the numbers employed as permanent labourers in the small-farm sector, except that the 1974-5 Integrated Rural Survey showed it as averaging 0.13 per holding. This is already higher than Owako observed in the mid-1960s and it is likely to have expanded since, due to the growth of the coffee and horticultural sectors. Considerable but unknown numbers commuted daily to Nairobi or Thika.

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21. Kenya's exports of Akamba wood carvings averaged £1.4 million in 1985-9; those of sisal baskets averaged £2.9 million (information from the Ministry of Commerce, 1990). Both these figures will include the earnings of traders and transporters, but they exclude sales made within Kenya to tourists and residents. (They can be compared with the value of cotton production in 1987 of K£6 million).

There is strong evidence, therefore, of an increase in the number and diversity of local occupations in the 1980s as compared with the situation in the 1950s.

7.5 Expenditure

ADEC reported total cash expenditure as averaging Ksh 15,731. However, this was the sum of averages of valid replies for each item, and, in some cases, considerably less than half the sample reported such expenditure. Modified to take account of the percentage of valid responses, average cash expenditure was Ksh 6,910, as shown in Table 14. In 1985 farm expenditures amounted to 14% of total cash expenditure if we assume the wage bill (incurred by 30% of farmers) is for the farm. Other farm expenditures in 1985 were reported by between 25 and 40% of the sample, except for fertiliser, reported by only 12%. The expenditure on building materials and furniture in 1985 was incurred by 25% of the sample. Given the proportion of cash income that comes from wages, it is likely that a lot of the farm expenditure was financed out of wages, although 1985 was a good year for crop production (see Production Profile, Section A).

Table 14: Household expenditure (total) and percentage of total

		1985
Food and other consumables		26
School fees		12
Clothing		9
Medical costs		5
Transport		5
Farm requisites		7
Implements	1	
Livestock	3	
Fertiliser	1	
Seeds/seedlings	1	
Pesticides	1	
Veterinary	<1	
Wages		7
Fuel		4
Building material and furniture		10
Other hardware and utensils		2
Payments to family members		9
Harambee, church, etc.		3
Other		1
(Total in Ksh)		*(6,910)*

Source: 1985: Modified from ADEC, 1986, Table 3.6.

It can be seen that the cash available for investing in the farm is limited by alternative investment expenditure on education which took 12% of available cash, as well as by expenditure on foods (which include tea, sugar, meat, etc., as well as staples). In bad years, when food expenditure rises, sums available for the farm, never large, diminish.

8. LAND, LABOUR AND CAPITAL RELATIONSHIPS

8.1 Data Availability

Owing to the difficulty of collecting income data, relatively few thorough economic analyses have been performed in the farming-systems surveys in the area. The first economic analyses, Heyer (1966) and Lynam (1978), were based on linear programming, and largely ignored the livestock element. Heyer incorporated high and low rainfall variants, while Lynam dealt with risk by analysing the farm sizes at which minimum needs and crop diversification could be met. Neither looked at non-farm income.

Meyers (1982) was particularly concerned with the relationships between credit adoption and household assets and resources including non-farm income. His analysis has defects because he took as crop income the value of cash sales, ignoring both subsistence values and the cash costs of crop production. He viewed livestock primarily as assets, ignoring their cash contribution and their services to the crop economy. However, his analysis is useful in showing some of the relationships between assets and non-farm income on the one hand, and farm strategy on the other.

Studies by Rukandema et al. and by Mukhebi are useful in showing the different strategies pursued by farmers with different farm sizes.

8.2 Land

8.2.1 Unequal land ownership

We have already seen that land in Machakos has never been equally distributed. The distribution shown by Owako in the 1960s in Table 1 showed that in Iveti, there was already an effectively landless category, with less than 0.4 ha. In AEZ 4 locations, such as Nzaui and Masii, modal farm sizes were between 2 and 6.8 ha., but a minority had over 12 ha., and in a few cases, over 40 ha.

Most survey data since 1964 continue to find a large range in farm size held. The 1978 survey in Mbooni and Masii found that in both areas the land holding of the upper quartile was four times the amount held by the lower quartile (Jaetzold and Schmidt, 1983: Tables 9a and b). Rukandema et al. found an even greater difference in Mwala, with the bottom 25% averaging 1.3 ha. and the upper 25% 17.8 ha. Meyers excluded outliers more than three standard deviations from the mean in the final analysis of his sample, finding that these outliers often had both a high amount

of off-farm income (e.g. rural teachers or officials) and a much larger than average farm size. Removing the outliers reduced his sample size by 7% but resulted in the mean farm size falling from 4.52 ha. to 3.66 ha. (Meyers, 1982:97-100).

There is an active land market. Meyers found in his 1979-80 survey that 21% of those not taking credit and 45% of the richer credit-taking households had bought land in the previous five years. Land purchases imply there were also land sellers. The landless without good alternative incomes (e.g. shopkeepers, government workers) were estimated at 7% of rural households in Eastern Province in 1975-6 (Collier and Lal, 1980:25-26). We have no information on land borrowing, renting, etc.

8.2.2 Land scarcity as a constraint on production and incomes

It does not seem that land scarcity was the main constraining factor on production and incomes between 1960 and 1980. Some farms were already small and/or unproductive in the older settled areas before 1960, but between 1960 and about 1980 many of those who felt themselves so constrained moved to the Yattas and southern Machakos (see Matingu, 1974, and Population Profile, 6.4.2). Heyer found in Masii in the early 1960s that the sale of land was rare, and there was only occasional renting (Heyer, 1967a:61). Our informants in Masii said land about 1960 did not have to be bought; if you wanted land, you could clear some according to your strength. Masii women leaders said that emigration then was because of famine rather than because of a land shortage, which was, however, being felt by the 1980s. From about 1980 this option was only open to those with substantial cash resources, for almost all the unoccupied land had been claimed. In Kangundo, land became scarce much earlier and our informants said land sales were commonplace in the 1960s but that prices were lower than in 1990, even allowing for inflation.

However, as household size and farm size vary, for some families, land is short and labour plentiful, and in others vice versa. This leads to differences in farming strategy. The larger farms have more land under grazing, as can be seen in the figures for Mbooni and Masii in Table 15. The same situation was found in Mwala, where nearly 80% of very small farms, and only 20% of the largest farms is cropped (Table 16). Rukandema et al. found that total farm income is greater, and proportionately more is derived from livestock, on the larger farms. However, the larger farm gets a much smaller return to its land, as shown in Table 16. They use their available capital to purchase labour (average cost Ksh 1,007) to increase the area cultivated, but use only Ksh 438 on other farm inputs. Their farming method is more extensive than intensive.

In our interviews with village leaders in 1990, land shortage, viewed as a result of the increased population, was seen as the leading problem in Kangundo. Even there, however, this was associated with water shortage (with water they could irrigate and intensify further) and with lack of alternative employment opportunities. In other areas, lack of water, lack of employment opportunities despite heavy investments in education, low prices and lack of social and infrastructural facilities, were more frequently identified as the source of current problems than shortage of land. In other words, although farms had become smaller, further intensification of farming and income diversification were still seen as possibilities, but were

Table 15: Farm strategies by farm size, 1978

	Mbooni		*Masii*	
	Small farm	*Large farm*	*Small farm*	*Large farm*
Total size (ha.)	1.5	10.4	1.3	10.5
Maize, beans, SR	0.6	1.6	0.9	2.2
Maize, beans, LR	0.6	0.9	1.0	1.9
Coffee	0.3	0.3	0	0.1
Citrus	0	0	0	0.1
Others, SR*	0	0.5	0	0.7
Cotton	0	0	0.1	0.6
Sunflower, LR	0	0.1	0	0.5
Grazing (ha.)	0.4	6.9	0.2	5.9
Grazing, %	27	66	15	56
Cattle, local, LU**	2.3	3.2	2.8	4.9
Cattle, grade, LU**	0.1	1.5	0.6	1.0
Shoats, LU**	0.5	1.0	0.8	2.1
Total LU**	2.9	5.7	4.2	8.0
Family adults on farm	2.2	2.8	2.1	2.5
Hired labour	1.1	1.0	0.3	0.7

Source: Jaetzold and Schmidt, 1983:178-9.

* In Mbooni, others were cabbages, tomatoes, English potatoes, sugar, millet. In Masii they were cowpeas, pigeon peas, sorghum and millet.

** 1 improved cow = 1 LU. 1 zebu = .65 LU. 1 shoat = .15 LU.

impeded by lack of the water that is essential to support humans and livestock, or by the lack of private or social capital for other developments. Pollard found a similar response in Nzaui in 1980. Asked about the main problems facing them in farming, over half referred to lack of finance, a half referred to lack of water or rainfall, and a half to lack of other farm inputs and services. He concluded that for some farmers 'land and associated moisture' could be the main limiting resource.

8.3 Labour Availability

8.3.1 Types of farm labour

Owako identified three types of farm labour force:

- family members including men;
- women family members only where all the males were working away;
- family members plus waged labour.

Table 16: Farm strategies on large and small farms in Mwala, 1980

	1	*2*	*3*	*4*
Farm size (ha.)	1.3	3.24	7.54	17.8
Cropped area (ha.)	1.02	1.62	1.92	3.24
Cattle owned	4	5	8	11
Shoats owned	7	12	16	16
Cash expenses (Ksh): labour	287	164	23	1007
Cash expenses (Ksh): other inputs	338	309	320	438
Cash inputs/cultivated ha.	331	191	167	135
Return per cultivated ha. to inputs	4.89	3.19	1.6	1.14
Total net farm income	2,105	1,980	2,050	2,736
Net cash farm income	636	464	803	605
Subsistence farm income	1,469	1,516	1,248	2,131
% subsistence in farm income	70	77	61	78
% farm cash from livestock	57	60	78	66
Net farm income/ha.	1,619	611	272	154
Off-farm income	3,529	1,503	1,811	2,628
Per capita income*	626	387	429	596

* Assumes 9 persons per family in each class. No data given to show if family size varied by farm class.

Source: Rukandema et al., 1981, and own calculations.

Owako found that with an increase in cash cropping went an increase in the number of family men participating in farming; in Mbooni where both coffee and tomatoes were important, 86% of the farms were worked by male and female family labour. Thus, as elsewhere in Africa, male participation in farming expands when farming is profitable. The proportion of farms in the second class, where wives and children only formed the arable labour force, varied from 6% in Mbooni to 45% in Masii, where Heyer has shown farming was then unprofitable compared with wage labour. The third class, employing waged labour, showed less clear differences as between AEZ, and formed the smallest group. In Iveti, 22% of the farmers employed labour; in Kangundo it was 18%, in Masii and Nzaui only 15-16% and in Mbooni 8%. Heyer found that labour, particularly at peak periods, was the factor limiting an increase in production in Masii.

Most surveys in the late 1970s show the average farm household contained one person in full-time off-farm work (e.g. Consortium, Report 6, 1978; Pollard, 1981; Gielen, 1982; Mukhebi, 1981). Taking into account of schooling (see Population Profile) most families would have only 2 persons available for work on the farm, domestic work, livestock care and small-scale marketing. Thus on larger farms labour shortage could be a limiting factor.

Not all farmers can raise the working capital to relieve this by employing hired or casual labour, which is, in any case, not always profitable. In the drier areas, Rukandema's studies in Mwala in AEZ 4 show only 16-18% of farms had permanent labourers, although about 33% made use of casual labour, (Rukandema et al., 1981). Other surveys confirm this level of use of hired labour in the drier areas. In Mwala, this labour was concentrated on the farms in the upper quartile for size, who spent an average of Ksh 1,007, nearly four times as much as any other group (Table 16). Rukandema ascribed the need for labour to the larger cropped area on the large farms rather than to their larger holdings of cattle. The return to this expenditure in terms of income per ha. was very poor. However, it freed some family members for off-farm work; this group had the second highest off-farm income and the second highest income per capita. Those with least land relied most on off-farm income. They invested heavily in cash inputs and casual labour and obtained a return per hectare of Ksh 1,619. This group did best on a per capita income basis. Those in the middle group appeared to have the best balance between land and family labour, requiring little hired labour. However, they also earned relatively small amounts off-farm, spent less on inputs, and obtained less revenue than the smallest farms on a per hectare basis. Compared with the first group, they had distributed their labour badly, obtaining the least of the four groups on a per capita basis.[22]

Only one survey analysed the purposes for which labour was hired. Hayes found in Masii that 32% of her families hired labour. Three were employed on home duties (amongst the 5 females employed). Of the remaining 37, of whom 35 were male, 14 were employed solely on livestock care, 12 combined livestock care with other duties, 8 were on agricultural work only, and 1 was engaged to dig a dam and fetch wood. Hayes also found most of the labour employed were young boys (Hayes, 1986:121-2). Only two of the labourers were aged more than 25. Hayes' data suggests that in AEZ 4, before the importance of fruit farming, hired labour was strongly associated with livestock. Meyers, in the same zone, found a strong statistical association between livestock assets and use of hired labour (Meyers, 1982:104) though his information could not explain it. The use of relatively cheap young labour for livestock care releases family labour for other activities, including crops.

In the highland areas, where coffee and vegetables generate higher cash incomes, more labour is employed; in Mbooni, Table 15 shows both large and small farms employing an average of one hired labourer per farm household. This suggests a considerable rise in employment of hired labourers in the AEZ 2 and 3 zones since Owako made his 1964 survey. Owako found that in Mbooni, only ten families out of 117 employed labour. The increase in labour hire coincides with the increase in coffee planting. From our own incidental interviews it is clear that labour employment also takes place in vegetable and fruit areas which have increased since 1980.

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22. Rukandema et al. use the sample average of 9 persons in the household to calculate these per capita figures. They presumably found no significant differences in family size between the four groups. If there was any tendency for the larger farms to have larger households, their per capita income would have been even lower.

8.3.2 Labour as the constraining factor

Mukhebi (1981) analysed farms in the AEZ 4 location Mbiuni according to the ratio of adult labour to hectares owned, dividing his sample into 3 classes according to labour availability per hectare. He excluded labour engaged in other occupations. Unfortunately, he does not indicate if the differences between the three groups were significant. In many cases differences the three classes were surprisingly small. Table 17 (which omits his medium class) shows that those with most labour in relation to their land actually hired slightly more labour than those with more land per adult equivalent labour unit. On-farm income per hectare was Ksh 896 and 880 respectively. The only really substantial difference was in income per family person, which due to larger farm size, was Ksh 961 on farms with much land per adult, and Ksh 498 on those with little land per adult (Mukhebi, 1981:64). As far as it goes, this suggests that land rather than labour was the constraining factor on incomes.

Table 17: Land-poor and land-rich households in relation to labour availability, Mbiuni, 1978-79

	Low land availability	*High land availability*
Household size	10.00	8.20
Farm size (ha.)	4.28	7.44
Cropped area (ha.)	2.01	2.92
Pasture area (ha.)	2.27	4.52
Pasture %	53	61
Adults available for farming	4.8	2.8
Adults living off-farm	1.0	1.2
Hired labour, man days	125	107
% growing cotton	100	78
Crop income Ksh	1,218	2,189
Livestock income Ksh	2,547	4,480
Off-farm income	1,213	1,213
On-farm total income/ha.	4,978	7,883
Income per capita	498	961
Farm income, Ksh/ha.	880	896

Source: Mukhebi, 1981.

Meyers found no statistical relationship between amount of hired labour and land owned. Several surveys find labour hire is associated with the upper category of farmers in terms of general assets (Hayes, 1986:124; Meyers, 1982:104). This suggests it is linked to capital availability rather than land availability.

Mukhebi included livestock income as well as crop income in his analysis of on-farm income. Lubega carried out a production function analysis on crop production alone in another AEZ 4 area and found that labour inputs had the strongest impact on crop

output, followed by equipment, and then land (Lubega, 1987:56). It seems likely that labour is more limiting in an enterprise consisting of crops alone, than in an enterprise which includes both crops and livestock. The larger farms tend to put a higher proportion to livestock, as is seen in the Mwala example shown in Table 16, and in both Mbooni and Masii in Table 15.

Rukandema's figures for Mwala shows clearly the importance of looking at labour in the context of the total household activities. In the late 1970s in AEZ 4, when the only cash crop was cotton, returns to labour were still, as in the 1960s, higher off-farm than on-farm. Labour could not be considered the limiting factor to farm production; if it had been rewarded, more labour could have been found.

In the coffee and vegetable areas the returns to labour may be different.

8.4 Capital

8.4.1 Types of capital in use in the 1960s

Many researchers neglected certain types of capital. In particular, fixed capital such as farm structures like terraces and dams are normally omitted, and only one analysis includes farm buildings.

Heyer found in Masii in the 1960s working capital requirements were very small, and not much of a problem except after famine, when seed purchase was needed (Heyer, 1967a:56). She found that neither working nor fixed capital was a limiting factor, since capital was available for non-farm investments. Loans were not being made or taken for farming because of its low level of profitability and its high risks. The low level of profitability was such that farmers even found it difficult to purchase hoes. Heyer subdivided fixed capital into items that could be acquired through labour and free local materials, such as stores, fencing and soil conservation works, and items requiring cash outlays, such as oxen, ploughs, sprayers, etc. By the 1990s this distinction was no longer valid; cash was involved for some terraces; many farmers reported having used hired labour to construct or rehabilitate terraces (both in the socio-economic farm interviews and those carried out in connection with the Conservation Profile).

8.4.2 Returns to capital under current farming systems

Working capital requirements are now high, and equipment and fixed capital are now also essential to a productive farming system. In the AEZ 2 and 3 areas, working capital for fertiliser, hired labour and other inputs is needed for coffee and vegetables. In all areas, as the numbers of livestock fall, those farmers with few livestock need to buy in manure or chemical fertiliser for their food crops. We asked farmers whether they felt their maize yields were better, worse, or the same than when they started farming. The 38 respondents were strongly biased towards the older farmers, who were regarded as leaders in their community. Sixteen farmers felt yields were better or had been maintained, and 22 thought yields were worse. Amongst the 16

who felt yields were better, eleven ascribed improvements to more use of manure, and nine credited terraces. Of the 22 thinking fertility had fallen, fourteen mentioned lack of manure, of whom 9 referred to money for manure or fertiliser purchase. Despite the small and imperfect sample, two things are apparent. One is the importance farmers put on manure as a means of combatting soil erosion and fertility loss, and the other their consciousness of the need for capital either to acquire manure if they had not enough animals, or to use fertiliser, build terraces and make other improvements. The capital shortage is likely to be more strongly felt in the farming community as a whole.

High returns to working capital are demonstrated in Table 16. In Mwala, the smallest farms invested Ksh 331 per ha. in non-labour inputs, and got back in cropped income per ha. 4.89 times this amount. The largest farms invested only Ksh 135 in non-labour inputs, and received back only 1.14 times this amount. In contrast, Mukhebi's data shows that high family labour availability per ha. made little difference to income/ha. (Table 17).

Another critical capital element is the plough. Onchere (1982) found a significant positive relationship between ownership and use of oxen and quantity of food produced and consumed. As many studies note, ownership of a plough is crucial because farmers without ploughs inevitably plant and weed late. (This may not affect very small farms).

Fixed capital requirements have also increased. As already noted, farmers credit terraces with maintaining and improving levels of output. An economic analysis showed high returns to terracing for maize and beans (see Conservation Profile). In AEZ 2 and 3 farmers through their co-operative societies have invested in the facilities required for initial processing of coffee. Initial capital is also required for a switch to grade cattle, not only for the beast, but also for housing and watering etc. Many farmers have invested in brick houses, tin roofs, guttering and roof-water catchment tanks, which reduce time spent in obtaining water for domestic and livestock use, at least for part of the year. Orange and other fruit tree cultivation on a commercial scale requires fixed capital for the initial planting material, and very probably, purchases of manure and hired labour to prepare the planting site.

Mukhebi calculated some investments in Mbiuni farms in 1978-9. He included farm buildings and stores, but not the terraces or cut-off drains, etc. which farmers credit with yield improvements. He also omitted fruit and timber trees. The value which farmers put on some of these missing items can be seen in the prices they are prepared to pay; in 1990 land in Kangundo with coffee trees cost Ksh 200,000 per ha., compared with Ksh 100,000 without. In Ngwata, unterraced grazing land cost Ksh 5,000 per ha., compared with Ksh 12,500 for arable with terraces (interviews with village leaders). Due to the missing items and a possible error in his livestock figures, we cannot use Mukhebi's figures to calculate the return on fixed capital.

8.4.3 Credit schemes and capital constraints

The analysis of Rukandema's findings on farm size has shown the importance of capital, and that an important section of the farming community has difficulty in obtaining sufficient. In an effort to overcome the capital constraint the government has from time to time launched credit schemes. One of these, as described in the Production Profile, Section A, aimed to provide credit for a food crop and cotton/sunflower package. It failed, because farmers were unable to repay loans given the unreliability of yields.

Meyers began his investigation of AEZ 4 farming with the intention of looking at relationships between farmers taking or not taking the credit package, making the assumption that capital, especially capital to hire labour at peak periods, might be limiting crop production.[23] He in fact found that hired labour was not associated with credit, but primarily with what he termed the high income group[24], particularly those receiving remittances from absent members, but also those with high non-farm income from local sources, and high crop sales and livestock assets. Credit acceptance was linked to cash income from crops, (to be expected as it was tied to a cotton or sunflower package). He ended, therefore, by confirming the importance of off-farm income, both in providing farmers with that extra amount of capital which enables crop production to become more profitable, (through increased inputs of fertiliser, soil conservation, manuring, etc.) and for providing the cushion which protects them from overwhelming losses in bad seasons (Meyers, 1982:148-9). In Meyers' sample, those taking official credit were on the whole wealthier, better educated, more tied to cash-crop production, made more use of exchange labour, than non-loanees. They represented a middle level of wealth. Those in the upper level of wealth were characterised by the importance of non-farm earnings, and remittance income from non-farm earning relatives. This group did not on the whole take the credit available for cotton and sunflower packages, since it was not worth the trouble. In any case, they tended to be more interested in food crop production (Meyers, 1982:133). His model might have had more explanatory power if he had looked at total crop production including subsistence, rather than at crop sales only.

The flows of capital to and from the farm are illustrated in a recent study of 16 farms, including some in Machakos. This found:

> *Five of the participating farmers had invested surplus resources in the ownership or management of a shop in a nearby town. In two other*

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23. His sample consisted of 67 recipients of MIDP credit in four AEZ 4 sub-locations, (87% of all such recipients) and a systematic sample of 40 of the remaining households from randomly selected *motui* (villages) in each of the four areas, i.e. 160 households. Results were given separately for each group; we quote here for the non-credit takers unless otherwise stated, since these were the majority.

24. Wealth was measured by a Guttman scale score indicating how many of nine household items households possessed. Income was the total of remittances, off-farm income (including locally earned salaries) and cash crop receipts. It therefore ignored subsistence income, cash expenses in farming, and livestock receipts.

> *cases, the male head of the farm household had permanent off-farm work. In a further six cases, other members of the farm household had permanent off-farm work, and contributed either to the maintenance of the farm household or to re-investment in the farm .... In some cases, sons who had received higher education and were employed in well-paid positions... re-invested capital in their parents' farm and met the costs of hired labour, thereby effectively replacing their own previous labour input to the farm. On one farm, off-farm earnings were used for establishing citrus terraces and the hiring of tractors to re-develop old terraces for cropping* (Ockwell et al., 1990).

Credit has succeeded in the coffee areas, where it is associated with a profitable crop, and where deductions of credit for inputs can be made easily when the coffee is brought to the co-operative for sale. The problem is how to make farming profitable, which is a prior condition for a successful credit scheme. Farmers seem to have been able to obtain capital from family or other unofficial sources to move into grade cattle and fruit trees. We have little evidence on the role of off-farm income in generating capital in the coffee areas. It may have played an important part in the 1950s and early 1960s, when coffee was first being planted, and when out-migration for work from these areas was high. During the 1970s when coffee prices were high, coffee itself may have provided capital which could be used to cushion the farmer against shortfalls in food production, or to increase farm output, or to diversify into non-farm occupations. This is suggested by the Kangundo leaders, who said 'Now coffee is the cow'.

8.4.4 Capital accumulation and the market

Meyers did not examine why production of subsistence food crops is the priority. It is related to the fluctuating food crop prices. A shortfall in bad years means that farmers have to buy at high prices, since the NCPB does not operate as an efficient stabilising mechanism in rural areas (see Production Profile, Section A). Instead, the licensing system for grain movements increases trading costs, which are already high in rural areas because of poor roads. Not putting enough land into food crops is severely punished in bad years. When farmers produce surplus food in good years, prices naturally fall. On such occasions the NCPB has often refused to buy. This leaves food crop farmers unable to generate much capital from profits; as the expenditure figures show, what they do generate tends to go into school fees to enable children to obtain the non-farm income that is both a more rewarding return to labour and less subject to climatic fluctuations. Cattle still function as assets; as Ngwata women leaders said 'A family with cattle is the same as a family with a graduate' - both are sources of hedging and investment capital. Currently, with ever smaller farms, farmers know that capital is needed to maintain food crop production, by improving terracing, buying in manure, fertiliser etc. Their problem is how to obtain it, especially when marketing inefficiencies delay and reduce payments for crops such as cotton.

The current allocation of over 80% of land to the production of maize and pulses would not necessarily be the best income strategy for AEZ 4,5 and 6, under improved

market conditions. Mukhebi, in his study of Mbiuni, thought that specialisation on cotton and cattle would offer better incomes. Jaetzold and Schmidt thought AEZ 4 (their UM 4) should be a sunflower-maize zone and AEZ 5 a cattle and sorghum zone (although farmers themselves have consistently preferred maize to sorghum). Farmers find cotton an acceptable crop, but only provided prices are adequate and payments prompt. They have found means to grow citrus, where private traders seem able to provide favourable market conditions, but there is a limit to the amount of citrus which the market can absorb before prices fall. There is also a danger from what farmers call the greening disease, which has devastated citrus production in some parts of Kenya. Fruit sales, and milk sales in areas with good market access, may provide the cash necessary for working capital and building up fixed capital.

8.5 Capital as the Major Constraint

Returns to capital emerge as clearly higher than returns to land or labour in the later stages of intensification. Where yields of field crops such as maize, cotton and beans remain fairly low and where prices react strongly to shortages and gluts farmers with small farms do not necessarily have lower incomes than those with large farms, provided they can obtain a non-farm job and import capital to make a small land area intensely productive.

9. STANDARD OF LIVING, c. 1980

When we interviewed in 1990, both community leaders and individual farmers referred to the problems of poverty, and in particular, the burden of school fees. In 1985 many households still depended in part on wages from absent household members or relatives. According to ADEC 27% of households said they had received income in the form of remittances from absent family members, and 21% said they had received gifts in kind. Although conscious of the problems of poverty, two thirds of our small sample thought themselves better off than their fathers, and one third worse off. Those who thought life had got worse complained of having to work harder, having smaller farms and inflation. As one woman said: My father could sing and dance, but I have no time. Those who felt better off generally referred to the way they had developed their farms and credited their better organisation and greater information. (Farmers seem to support the Boserup thesis that as farming becomes more intensive, work increases, but so does output).

The impression this small and non random sample gives of improvements for the majority in standard of life since the 1940-60 period, though at the cost of harder work, is confirmed by Some statistical indicators. By 1981-2 the Machakos farmer was, as we have seen, in the middle of the income range for Kenya[25], whereas in the 1940s and early 1950s the District

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25. It is possible that the buying power of agricultural incomes declined after 1982, due to the fall in the real prices of coffee and cotton (see Production Profile, Section A). However, this would also have affected other agricultural areas, and there is no reason to think that Machakos's place in the rank order would have materially changed by 1990. Because of the skewed distribution of agricultural incomes, at any one moment

was seen as a problem area, needing famine relief in most years. By the first half of the 1980s the assets of the people were above the national average in terms of improved housing and benefit from education. The main deficiencies they suffer are in physical infrastructure: their lack of transport facilities is confirmed, and their difficulties with water.

One other indicator of welfare is nutrition. The nutrition studies of 1974-81, despite the droughts of the period, found the habitual diet of good quality but somewhat low in quantity compared with recommended intakes. The energy intake was sufficient in women 'to support adequate foetal growth and lactation performance with maintenance of maternal health throughout the reproductive cycle'. Amongst pre-school children severe malnutrition was rare, occurring mainly in socially deprived households. After the age of six months, weight for age and height for age dropped to 83% and 92% respectively of Harvard standards (Kusin and Jansen, 1984:209-10). A later national survey found Machakos in line with Kenyan averages in this regard (Table 18 below).

Table 18: Social indicators, 1982-3

		Machakos %	*Nation* %
1.	**Education**		
	Population within 2 km of: primary school	71.3	75.6
	adult education centre	51.4	68.0
	% males able to read	68.3	61.1
	% females able to read	42.1	38.4
2.	**Housing quality***		
	% of households with a thatch roof	52.2	56.3
	% of households with a mud floor	76.7	84.9
	% of households with mud wall	49.4	74.4
	% of households with electric lighting	0	0.9
3.	**Infrastructure**		
	% less than 2 km to: water in dry season	83.3	88.1
	cattle dip	40.8	53
	market	30	41
	bus/matatu route	53.5	67.4
	maize mill	40.4	58.4
	postal service	17.6	21.3
4.	**Child health**		
	Height for age	94.0	94.2
	Weight for height	99.4	100.7

Sources: Central Bureau of Statistics, Kenya, 1985, *Social Indicators*
Central Bureau of Statistics, Kenya, 1983, *Third Rural Child Nutrition Survey, 1982*

Note: * Percentages show those with low quality housing - thatch instead of an improved material, mud wall instead of brick, etc.

of time, more than half the farm households get less than the average income. This also would apply to other Districts of Kenya.

10. CONCLUSIONS

10.1 Data Quality

Existing farm studies have ignored some important issues, such as returns to water, and to capital. They have given insufficient attention to farm gate prices and the way these vary according to rainfall, to distance from markets, and to marketing systems. There is evidence of an active land market, but little information on it. Income studies have provided little information about the nature of employment off-farm, though they have highlighted its importance. Nevertheless, by putting together the evidence from these studies and from the oral evidence of our own informants, we can come to some conclusions on the theoretical scenarios propounded in the introduction.

10.2 Increases in the Ratio of Labour and Capital to Land

The Boserup thesis that population growth leads to a greater frequency of cropping is confirmed. There is now no regular fallow in Machakos. The greater part of arable land is double cropped, with an equal intensity of effort in both rains.

We have defined intensification as the application of increasing amounts of capital and labour per unit of land in order to raise the value of output. In the older settled areas intensification in the highlands took the form of an increased proportion of cash crops, especially coffee, fruits and vegetables, more careful husbandry, a continuation of food crops and a diminution of livestock from the 1950s. This required increased inputs of labour, working capital for labour and fertiliser, and fixed capital for farm structures, especially terraces, tree crops, etc. and co-operative processing facilities. Structures and trees have both been ignored in most farm surveys, but the increase in both has been demonstrated in the Land Use Profile. In AEZ 4 the farming system remained orientated to food crops and livestock. Intensification took the form of more careful husbandry particularly in the Long Rains, with a need for ploughs, terraces, and livestock. Cotton was added on larger farms when the market conditions justified it. In both areas, there has been a steady increase in the importance of fruit and vegetables, and, where conditions justified it, in grade cattle for dairying.

Boserup's thesis that at the later stages of intensification the ratio of pastoral to arable land decreases is confirmed by the difference shown in the 1960s surveys and those of the late 1970s. (It is also dramatically confirmed by land use maps - see Land Use Profile). This has been accompanied by more intensive use of the grazing areas. The enclosure of grazing land close to the cultivated areas took place first in the densely populated highlands. With the settlement from the 1960s of former communal grazing areas in the Yattas, cattle are now everywhere either grazed relatively near the arable fields, or stall-fed, leading to close integration of livestock and arable systems. By making full use of crop residues, fodder planted on banks, hedgerow fodder, etc., livestock are supported on far less land than previously. Their contribution first of draft power and secondly of manure has become essential to a system of farming which manages the small amounts of rainfall as effectively as possible. In consequence maize and pulse production, with a surplus for the market in

good years, has become the main farming activity even in AEZ 5, with livestock as the secondary activity.

10.3 Intensification and Farm Size

Intensification has proceeded furthest on small farms as compared with large farms, both in terms of the percentage of land under crops, and in terms of the amount of working capital invested per ha. This capital is often available because some members of the family can engage in off-farm work while still satisfying most of the labour requirements on a small intensively cultivated plot. Medium size farms in AEZ 4,5 and 6 may have had the greatest difficulty in raising capital for intensification, because most of the available family labour is taken up by farming, which in many years has low profitability. They are less able to engage in off-farm work without a reduction in farm output. Larger farms seem to have more access to capital. They pursue a more extensive mode of farming with more reliance on livestock, but hired labour makes large claims on available capital, and their arable output per ha. may be relatively low in the absence of sufficient complementary inputs. In the right conditions, these medium and large farms put land into cash crops such as cotton, after satisfying subsistence needs, and the cash profits provide capital for ploughing back, in accordance with the model propounded by Ruthenberg.

We cannot, therefore, support the theory that labour is necessarily cheap on small farms, and that capital is cheaper and more available on large farms. The price of labour depends on its opportunity cost, and for many households, that is set by the off-farm work opportunities. Off-farm work is now becoming more difficult to find, but at least until the 1980s, its local availability appeared to be greater than it was before 1960, in part as a consequence of the increase in cash cropping.

10.4 Intensification and Migration for Farming

Intensification is only undertaken if the ratio of land to labour impels it. It was unpopular in Machakos 1930-60 because many farmers would have preferred to solve their problems by migrating to vacant land. When this became possible after 1960 the migrants suited their farming methods to their new conditions of plentiful land and initially reverted to older farming techniques such as shifting cultivation and the clearance of bush by burning. This land was settled more cheaply than the Makueni settlement area, and by the 1980s cultivation and livestock raising appears more intensive than in Makueni, using the water and soil saving techniques developed in the older areas. Shifting cultivation was also a means of establishing land claims. By 1979 population densities in AEZ 5 and 6 were building up to 50/km^2. Cultivation of this 'marginal' land has not so far led to the degradational and poverty spiral predicted in the 1970s.

Emigration from the older areas limited population growth in the older areas in the 1960s and 1970s to 1-2% per annum (Population Profile). This led to the pace of intensification being slower than it would otherwise have been, particularly in AEZ 4, and particularly in areas relatively remote from markets. After the end of the 1970s, farm size diminished more rapidly than before, as migration to new areas is no longer an option.

10.5 Intensification and the Market

Boserup assumed that as population increases, the cost of infrastructure provision decreases, leading to the emergence of new market towns, to increased demand, and higher farm gate prices. This has happened only to a limited extent in Machakos, with the exception of the northern part of the District. Machakos remains the only town of any size. Secondary marketing centres developed in the north in the Kangundo/Tala area in the 1950s, and in Matuu from the late 1970s, with the improvement of road communications. Elsewhere, road infrastructure is still poor, except along the line of the Machakos-Mombasa road.

A good marketing system is important in speeding intensification, since profits from sales provide both the incentive to invest in fixed and working capital to improve farm output, and one of the means to do so. When there are no opportunities for profitable sales, people satisfy their cash needs by migrant labour. Market production became an important part of total farm production in the northern hills first. There is some suggestion that some farmers in these areas have moved to a second stage of commercialisation, and regularly buy some of their staple food needs, but data is insufficient to be certain.

In the drier areas, market conditions affect both the priority which farmers have to give to food crops, and their willingness to produce alternative crops. Marketing infrastructure and policies are still such that purchase from better endowed parts of Kenya remains extremely expensive and risky in poor seasons. Farmers aim to keep enough land under staple foods to provide for their families in all but the worst seasons, selling surpluses in good seasons. The larger farmer moves into cotton when the price is right and the marketing system adequate. Livestock are important as a reserve cash source, but even more important in providing the necessary manure and draft for the food crops. In these circumstances, necessary improvements in their food production are largely still financed through off-farm work, which also helps to provide cash and stabilise incomes. Recently, in some areas, fruit production has become profitable.

Machakos farmers have proved very responsive to new market opportunities. We can perceive a gradient whereby, when farming is extensive and marketing infrastructure poor, the main cash income is derived from livestock. As the emphasis on arable increases, livestock sales are first supplemented and then overtaken by food sales. At this stage the main intention of arable farming is subsistence, but some surpluses are produced. At a third stage, investment is undertaken into crops produced purely for the market, such as coffee, cotton and horticulture, as and when the marketing infrastructure permits attractive farm gate prices. We can hypothesise a fourth stage, not yet reached in Machakos, when marketing infrastructure and market policies permit specialisation on the products for which the region has comparative advantage, and food is purchased from the regions of its comparative advantage.

Farming systems have intensified in accordance with the ecological gradient, but with a strong modification from market access. The most favourable areas for cultivation were settled first and became densely settled first. The northern hills had built up to population densities exceeding 100/km^2 by 1948, and led the way in food crop production for the market, in fruit and vegetable development, and in coffee growing. By the 1960s, livestock were already relatively unimportant in these areas, except to provide milk, and ploughing for the bigger

farms, and these areas led in using chemical fertilisers on coffee and maize. However, in the ecological similar southern hills, poorer market access delayed population build-up, and, with currently a little more land per capita than in the north, farmers have developed intensive dairying systems for zero-grazed dairy cattle, in combination with coffee, fruit and vegetables and food crops. These systems are now spreading into AEZ 4 and even 5. However, requirements of many of these changes are market access and a certain minimum of water.

10.6 Rates of Population Growth and the Pace of Change in Farming Systems

The most difficult period of adjustment to the necessity of adopting new methods of maintaining fertility and output appears to be when population densities are 50-100 km^2 (depending on ecozone) and it is necessary to shift to permanent cropping and private management of grazing lands. In Machakos, this took place without compulsion when population was growing at 2.5-3% per annum. However, the move to intensive farming with replacement of nutrients and integration of livestock was handicapped while marketing infrastructure was poor, urban demand small, certain crops forbidden, and farm gate prices low. The cycle of degradation and poverty did appear to be in process at this stage. The government tried to restore the situation by compulsory communal labour on terracing (Conservation Profile). We do not know how rapidly degradation would have been overcome without such measures, by relying on demonstrations of new farming methods (which also took place - see Technology Profile) and by public works such roads to improve the market access. Voluntary completion of terracing took place after 1960 in the older areas, when population growth rates had fallen to 1-2% per annum. In AEZ 5 and 6, which experienced an overall population growth of 7% per annum in the 1960s and 1970s, a comparatively rapid shift to permanent cropping, private grazing and terracing took place, without compulsion, using the knowledge brought from the older areas.

During the period 1960-80 population growth in the older areas was relatively slow, at 1 or 2% per annum, because of migration to new areas. As this came to an end population growth levelled in the 1980s to about 3% per annum in all areas. This is contemporaneous with more rapid farming systems change in all ecozones, with adoption of new elements such as fruit and vegetable growing and dairying. There is so far no reason to think farmers cannot adapt to the changes made necessary by high rates of population growth, providing the policy and marketing environment is favourable. There are, however, signs of strain in the very densely populated areas of the northern highlands. At population densities over 400 km^2 in AEZ 2 and 3, and some lower figure in AEZ 4, 5 and 6, land rather than capital may become limiting. Below this level, market access and the ability to capitalise appears more important to the ability to modify farming systems than the rate of population growth.

10.7 Carrying Capacity and the Cycle of Degradation

Bernard (in Consortium, Report 6, 1978) quoted Hance's list of 11 indicators of population pressure, defined as a long term process of deteriorating physical and human conditions. Contrary to his findings, which were based on observations after six consecutive dry years, one of the worst runs in a century (Environmental Profile, Section A), there is no evidence of Machakos being in this process. Of the eleven indicators,

1. Soil depletion and erosion - has been discussed in other Profiles.
2. Declining crop yields - not evidenced either in this Profile or in the Production Profile.
3. Use of marginal lands - has indeed occurred, but with no evidence that the farming system evolved is leading to long term degradation.
4. Changing crop emphases, especially to crops tolerant of poor soils - is not borne out by the continued preference for maize rather than sorghum, and by the swing into horticulture.
5. Reduction of fallow - has occurred, but is being compensated for by better husbandry and use of manure and other inputs. There is evidence of increasing felt shortage of manure.
6. Breakdown of (old) indigenous farming systems - has occurred, but have been replaced by new indigenous systems.
7. Food shortages and malnutrition - occur in exceptional years, but malnutrition was not severe except in socially deprived families even in the dry 1970s, and do not seem below general Kenyan levels.
8. Landlessness, land disputes, etc. - there is no hard evidence one way or the other to show how much these are increasing, although it is probable that they are.
9. Rural indebtedness - no evidence one way or the other.
10. Underemployment and unemployment - becoming a felt problem in some areas.
11. Certain types of outmigration - appears to have declined.

10.8 Cash Crops, Food Reserves and Income Diversity

There is a continuing requirement in the income system for coping with bad years due to the erratic rainfall and the way that food prices vary. However,

- Cattle are no longer the sole possible investment to supplement family grain stores. Coffee, with its relatively stable and high income, provides an alternative in the higher yielding areas, and a relative in a job, preferably high-paying, provides another. Hence, families invest heavily in education, which limits the availability of capital for other purposes.

- Most families have a strategy of at least one member in a non-farm job, or several members having supplementary occupations in trade, crafts, etc. In the 1930s-1950s this non-farm job meant out-migration by males. Since then, the development of cash cropping has meant there are increased employment opportunities in the district, in processing the crops, and supplying farmers with their needs, in shops and other distributive trades. Increased government activities, and increased investment, public and private, in schooling, has also

provided more local jobs. At the same time, there has been more competition for jobs in urban areas, and with this job shortage, out-migration appears to have declined (Population Profile). In 1990 many families were worried by limited employment opportunities for their children.

- Given the rise in food prices whenever sufficient food is not produced locally, food production is the first priority. The coffee areas may be an exception, because of the relatively steady income from coffee.

10.9 Underlying Constraints

Various studies tried to identify the constraints on improved farm incomes. Some of the studies of the 1978-81 period identified weeding, late planting, the condition of oxen prior to the rains, grazing for oxen. Underlying such constraints is the need to maximise the utility of water, whether in cropping or livestock management. That in turn requires capital, and capital can be generated more easily either when marketing is facilitated and transport costs are low, or alternatively, by movement, through education, into a well-paid job.

Perceptive administrators and farmers have long recognised this. Peberdy thought water supplies a priority for government investment because water shortages deprived people of time and energy for cultivation and hindered livestock improvement (Peberdy, 1961). Administrators in the 1950s and earlier noted the Akamba were always willing to respond to communal labour demands for schools or roads (see Institutional Profile).

It is appropriate to leave the last word on constraints to those who live in Machakos. When farmers in Machakos and Kitui were asked in 1977 to rate a list of possible problems as severe, frequent or occasional from a list of 13, drought was rated as severe by the largest number (64.5%), followed by food (49.6%) and water supply (47.5%). Erosion followed at 39%. When farmers were asked to suggest problems that had not been listed the most frequently mentioned severe problem was roads (230 mentions), which is probably linked with the 130 mentions of transport. Too few hospitals and schools were mentioned by 129 and 114 respectively (Consortium, Report 6).[26] Ten years later, when ADEC made a similar enquiry to a large sample in Machakos, the main perceived needs were for water supplies, improved roads and transport infrastructure, and enhanced health facilities (ADEC, 1986:1-15).

Despite a considerable investment in water during the period of the Machakos Integrated Development Project (MIDP), 1978-88, leaders in our interviews still generally listed water amongst the chief problems facing people in their area.

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[26] The authors note it is difficult to put comparable percentages on these figures since it was an open-ended question, with non-respondents, invalid replies, and a variety of answers. The sample was just over 2,000 farmers.

	Chief problems
Kangundo	Water, land scarcity, job scarcity
Mbooni (men)	Lack of income sources - poor prices and lack of land; lack of schools
(women)	Lack of finance for diversification into crafts
Masii (men)	Water shortage. MIDP dam a long distance.
(women)	Water. Expense of education and lack of jobs for children.
Makueni	Poor rains. Need to store water that washes away in rains. Very poor roads and traders buying at low prices.
Ngwata (men)	No secondary school. Water.
(women)	Unemployment. Lack of health facilities.

Farming and income systems in a semi-arid areas depend fundamentally on water, whether as stored in the land, or as available for domestic and livestock use. Non-farm incomes are one way of maximising the return to water. The story of Machakos is essentially a story of increasing efforts to maximise returns to the scarce factor, water.

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APPENDIX

FARMER QUESTIONNAIRE - Mbooni

1. Personal details

Tell the farmer we would like to learn about the conditions on the farm at three different times:

1. Now

2 About three years after he or she started farming here, when he/she had overcome any initial difficulties due to inexperience, etc.

3 Conditions on his/her parents' farm when he/she was aged about 16.

Ask him/her his name and age:

Name.... Sub-location.... Age (approx)...

Establish the dates we are enquiring about:

When did you start farming independently .... Period A.

In what year were you about 16 ... Period B.

(For both periods, check that this is not a severe drought year. Tell the farmer we want to ask about an average year about that time.)

2. Land tenure

a. How many pieces of land are farmed now ...

About how many acres are used for:
food and cash crops ... fodder crops ... grazing ...

b. How did you acquire these pieces:

Number inherited ... bought ... rented ...
Cleared from bush ... Other ...

c. Was your farm bigger or smaller at period A ...

Was it in this place? Yes/No
If in another place, where ...

If there have been changes, ask:

Why is it bigger or smaller? Why did you move?

d. Was your parents' farm at period B bigger or smaller than the farm you have now?

Bigger ... Smaller ...

Was it in this place or another? Here ... In ...

e. Is the whole or part of your farm demarcated with clear boundaries?

Whole ... Part ...

When was this done? ... (approx)

Why was it done? ... How was it done? ...

f. Do you have a registered title to the land? Yes/No

What is the advantage of registration?

3. Crops

a. What are the main crops which you sell now, in order of importance for income?

1 ... 2 ... 3 ... 4 ...

What were the main crops which you sold when you started farming, in order of importance for income?

1 ... 2 ... 3 ... 4 ...

If there are changes, ask about two of them:

Why did you introduce new crop 1? (Name it ...)
How did you learn about it?

Why did you introduce new crop 2? (Name it ...)
How did you learn about it?

c. Are there any crops which you now grow only for family food?

1 ... 2 ... 3 ... 4 ...

d. Did your father get much cash from any crops? Yes/No If yes, which ...

4. Maize

What type or types of maize do you plant now? ...

What type of maize did you plant at period A? ...

If this is different from what he/she used to plant, ask:

How did you obtain the variety you use now?
Why did you make the change?
Did you receive any advice about this variety, and if so, from whom ... (friend, trader, extension agent, etc.)

b. Nowadays, do you generally plant maize when the ground is dry, or only after the rains start?

Dry planting ... After rains ... Reason for your practice:

c. In period A. did you generally plant maize in the:

Long rains ... Short rains ... Both seasons ...

When do you plant maize now?

Long rains ... Short rains ... Both seasons ...

If there is a change, ask:

Why have you changed your practice?

d. Think of one of the fields where you have planted maize since the time you started farming. Is it more fertile than then, because of improvements you have made, or less fertile because of erosion or long use, or about the same?

More fertile ... Less fertile ... About the same ...

f. What are the difficulties in keeping the land fertile?

5. Livestock including poultry

a. What types of livestock do you keep now? ...
What types of livestock did you keep when you started farming? ...

(If he/she keeps animals, fill in the following information as appropriate. Otherwise go to the next section).

Adult cattle:
Number kept now and at start of farming in Mbooni:

	Now	In Period A.
Number of work bulls	...	...
Number of other bulls	...	...
Number of cows	...	...

Did your father have more cattle or less cattle than you have now?
Many more ... About the same ... Fewer ...

How do you feed them now?

Zero grazing or stall feeding ...
If so, Part year ... All year ...

Grazing on own farm ...
If so, Part year ... All year ...

Grazing on communal areas or away from this area ...
If so, Part year ... All year ...

Other: (Describe) ...

If he/she had cattle in Period A ask:

How did you feed them then?

Zero grazing or stall feeding ...
If so, Part year ... All year ...

Grazing on own farm ...
If so, Part year ... All year ...

Grazing on communal areas or away from this area ...
If so, Part year ... All year ...

Other: (Describe) ...

If he/she has made any changes, ask:

Why did you make the change?
Where did you get the means for the change (e.g. fencing materials, building materials for stall, etc.)?
Did you receive any advice about this, and if so, from whom ... (friend, trader, extension agent, etc.)?

Are any of the cattle you have now grade or another improved kind? Yes/No

If yes, When did you start keeping grade cattle or cross breeds? ...
Why did you start keeping them? ...
How did you obtain them? ...

What is the main reason for keeping cattle now? ...
What was the main reason for keeping them when you started farming?

Goats

Number of adult goats kept now ... In period A ...
Main purpose for keeping them now ...
Main purpose for keeping them in period A ...
How are they fed? ... Is this different from period A and if so, how is it different?

Poultry

Number of poultry kept ... Main purpose for keeping them ...
How are they fed? ... How are they housed? ...
Did you always keep poultry in this way, or was it different when you started farming? Same ... Different ...

If different, ask: How is it different? Why is it different?
How did you get the information for this change?

6. Soil Conservation

a. Is any of your arable land terraced? Yes/No

If yes: About how much is terraced?
All ... Most ... (70% or more) About half ... (40% to 60%)
Not very much ... (10% to 30%) Very little or none ... (Under 10%)

If some is terraced, ask:

When did you first have terracing on your farm? Date or decade ..
How was it done?

... Forced communal labour
... Government labourers or machinery
... Made by the family with their own means
... Voluntary self-help group with no outside assistance
... A self-help group that was given tools
... A self-help group that had food for work

Were these first terraces useful?
Did you keep them repaired? Yes/No.

If no, What was the problem? ...

Did you add more terracing later? Yes/No

(Note that there may have been more than one period of additional terracing. In the next questions, insert 1 for the first extra works, 2 for the second, etc.)

If yes, In what years or decades was this done?
Between 1945-60 ... 1960-75 ... 1975-90 ...

How were they built?

... Forced communal labour
... Government labourers or machinery
... Made by the family with their own means
... Voluntary self-help group with no outside assistance
... A self-help group that was given tools
... A self-help group that had food for work

Were these conservation works useful? Did you keep them repaired? Yes/No. If no, What was the problem ...

(Add here any extra comments on soil conservation:)

7. General

a. Do you think you and your family are better off or worse off than your father?
Better ... Worse ...

Why?

What is the chief problem facing you now?

THANK YOU VERY MUCH FOR YOUR HELP

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