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Working Paper

55

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

PRODUCTION PROFILE

edited by Mary Tiffen

A. Crop Production by S.G. Mbogoh
B. Livestock Production by C. Ackello-Ogutu

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November 1991

ISBN 0-85003-166-4

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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 aiming to relate long term environmental change, population growth, production 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. It now appears to be in a more sustainable state, despite a five-fold increase in population. The long-term perspective is required because temporary factors, such as a run of poor rainfall years, can confuse analysis of change. 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. We are grateful to Professor Philip Mbithi, Vice-Chancellor of the University of Nairobi, for his support and advice. We 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:	Conservation Profile
Machakos District:	Technological Change
Machakos District:	Land Use Profile
Machakos District:	Institutional Profile

The principal authors of this paper, Production Profile, are Professor Christopher Ackello-Ogutu, (B. Livestock Production), Chairman, Department of Agricultural Economics, Nairobi University and Dr S.G. Mbogoh, Senior Lecturer in the same Department (A. Crop Production). Their objective is to assess changes in the productive output of the District. Mary Tiffen, as editor, made a few additions to the authors' drafts, taking advantage of additional complementary material, since the final objective is a unified, synthesised study.

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A. CROP PRODUCTION

S.G. MBOGOH

1. INTRODUCTION AND BACKGROUND

1.1 Data and Data Sources

This paper presents the results of a longitudinal analysis of crop production data for Machakos District. Although we examined the Annual Reports of the District Agricultural Officers (DAO) from 1932 onwards, together with a summary of earlier reports which takes the series back to 1910-11 (Peberdy, 1958) we have not made much use of figures from the period before 1960-61. This is because the early figures relate only to crops exported from the district, and not to total production. In 1957 the first credible attempt at estimating the area planted to crops was made. This is given in Table A.1, where it is compared with the 1960-61 agricultural census in the African areas. This census was the first one where the whole District had been sampled, either by observations along transects, or, in two areas, by sample survey. Although Kenya had provided figures to earlier world agricultural censuses, the only reliable figures were those from the white-farmed areas, for which annual returns were collected. In regard to the African areas, the first census of 1929 was merely an estimate by the District Officer, considerably revised by the first agricultural officer when he was appointed in 1931. The only trace remaining of the 1940 census is a return for one location only, Nzaui.

Later censuses of the small farm sector are also open to doubt. The 1969-70 'census' seems to have been a sample survey, and its results are in conflict with both earlier and later data. It is not generally quoted. The problem with sample surveys is that there is no information on the number of farm families in Machakos. The farm-owning household is a larger unit than the household as defined by the census (see Institutional Profile), and not all households own farms. If the number of census households is used as the multiplying factor to get district production, the result is a considerable exaggeration. The same problem is encountered in relation to the only large district wide sample survey, that of 1985 (ADEC, 1986).

Given the sporadic nature and unreliable output of 'censuses', whose data also is affected by the particular climatic conditions of the time of survey, we have preferred to use the data from the Annual Reports of the DAO for information on long-term trends. They are the basis for most Kenyan agricultural statistics.

There is a major problem with food crop data. Before 1968 it appears to have been the practice to double count crops planted as mixtures - i.e. one acre of mixed maize and beans is listed as one acre of maize and one acre of beans. This is apparent from the footnotes to the 1957 Peberdy estimate and the 1960-61 Census, quoted in Table A.1. In consequence, the recorded area for food crops was extraordinarily high and shows a sudden drop in 1969.

The explanation is almost certainly the end of double counting. From 1969 the DAO food crop area figures show internal consistency, except for 1985, when it appears surprisingly high. This was a year of very good rains following three consecutive drought seasons, and it is possible that some land not usually cultivated was sown and that all possible land was fully cultivated in both seasons. Even so, the jump seems exaggerated. The other variations in year to year area figures, 1969-89, are more credible, since the actual area planted will have changed each year according to whether the timing and distribution of rain permitted farmers to plant all the land destined for food crops in both seasons. Most farmers, according to both our own survey and the ADEC survey in 1985 (ADEC, 1986), plant all or some land in both seasons, but they possibly plant more in the generally more reliable short rains. On some occasions, a very good crop in one season may have led them to decide to fallow part of the land in the other season. After cotton there may not be time for a second crop, so in years when cotton planting was widespread there could have been some reduction in the second season of food crops.

Food output data were recorded only as exports till 1969 and is then missing for 3 years. It resumes as total output in 1974. The food series therefore runs from 1970 for area and from 1974 for outputs, so the available series runs only from 1974 to 1988. The 1960-61 census provides a comparative base-line figure for areas cultivated, but not for yields, as 1960-61 was a drought year. The two main cash crops of the 1960s, coffee and cotton, were both subject to considerable supervision and their output was marketed through official channels. We therefore feel it safe to make use of the records for these two crops for the whole period 1960-88. Fruit and vegetable data is missing for 1971-3, so the series for horticultural crops is from 1974-88.

The current method of estimating agricultural yields, production and areas relies on the field staff in each Location. The crop yields are measured from their demonstration plots so they have a basis in reality. The demonstration yield is adjusted to an average yield taking into account the average performance of local farmers. The field staff assess how much land the average farmer puts to each crop, and the number of farmers for whom he is responsible. They also have to send monthly returns to monitor the amount being planted. Planted area plus yield gives the production. Senior staff monitor the credibility of returns. The method is probably fairly reliable in respect of trends in average yields, and their variation from year to year due to climatic factors. There may be more of a lag in respect to areas planted, particularly in relation to horticultural crops where there are a multitude of tiny plots and dispersed trees. However, market observations enable staff to pick up major changes in the availability of this type of output, and senior staff monitor purchases by the main wholesalers. During the early 1970s, when staff numbers were low (see Table A.2) the increase in cropping in newly settled districts may have only been picked up after a time lag of some years.

The only cross check possible comes from the Ecosystems aerial surveys for 1981 and 1985. These showed 277,500 ha under cash and staple crops in 1985, and slightly less in 1981. At first sight, this looks substantially below the DAO estimates of cultivated area for the same year, shown in Table A.3. However, the DAO figures are for two seasons, the Ecosystems for one only. Assuming food crops are cultivated twice, and the main cash crops, cotton and coffee, occupy the land in both seasons, DAO estimates are for about 211,000 ha in 1981, and

about 255,000 ha in 1985.[1] On this assumption, they underestimated cultivated area by about 20% in 1981, and 8% in 1985, the year they appear to have exaggerated it.[2] However, in many ways the area under maize in 1985 appears out of line (see Table A.4) and there may be an error in the records. It is not unlikely that there was an underestimate of areas and production by as much as 20% in the 1970s and early 1980s, owing to difficulties in picking up new cultivation in areas recently settled without agricultural staff. Accuracy may have improved due to improvements in staff numbers and quality since the mid-1980s, and to the slow down in settlement. We have also noted anomalies in 1976 maize data.

1.2 Data Analysis

Despite the deficiencies in the data, we can observe some major changes in trend, particularly in the period since 1974, when the DAO data becomes more reliable. We can contrast this with detailed observations made by agricultural officers in the 1950s (Peberdy, 1958) and a sample survey of five different locations in about 1964 (Owako, 1969). The breaks in the data, and the inconsistencies in data collected, make it impossible to test for correlations between production and other variables, since we have not yet a usable series with 20-30 observations, the minimum recommended for regression analysis. We are limited, therefore, to a descriptive use of the statistics, pointing out major apparent trends, and major coincidences with droughts or price changes.

1.3 Classification of Crops

For ease of presentation and discussion, the different types of crops produced in Machakos District will be grouped into three classes:

Food crops (FC):
major: maize, pulses
minor: sorghum, millet and some root crops
Food crops are grown mainly for consumption, but sold when there is a surplus.

Cash crops (CC):
major: coffee, cotton
minor: sunflower, sisal, tobacco and wattle bark.

Horticultural crops (HC):
bananas, cabbages/kale, chilies, brinjals, okra, onions, tomatoes, citrus fruits, mangoes, avocadoes, guava, macadamia, passion fruits, pawpaw, karella and Irish/English potatoes.
These are grown for both cash and food.

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[1] Since we have no information for most years on the amount cultivated in each season, an assumption of a 50:50 split has been made. Possibly, 60:40 would be more accurate.

[2] ADEC 1986 concludes DAO overestimated crop area, but they did not allow for the double season for food crops. ADEC's crop production discussion is marred by several arithmetical errors.

2. THE EXPANSION OF CROPPED AREAS AND PROPORTION UNDER FOOD CROPS

2.1 Cultivated Land Area

Mr Leckie, the Machakos District Agricultural Officer (DAO) in 1932, estimated the cropped area in the Native Reserves of Machakos District to be 56,000 ha. Mr Peberdy, the Machakos DAO from 1954 to 1961, estimated the cropped area to be 202,000 ha or about 101,000 ha in each of two seasons. This estimate of cropped land area in Machakos District in 1957 is close to the 220,000 ha reported by the 1960-61 African Agricultural Sample Census (Table A.1). Table A.1 omits the relatively small arable estate sector, about 16,000 ha in 1961. This would make the cropped land within the present district boundary about 140,000 ha in a single season in 1960-61.

As we have seen, the 1985 Ecosystems data suggests 277,500 ha for one season in 1985. The area data is not sufficiently reliable to identify the major period of expansion. However, the doubling of the cultivated area between 1961 and 1985 seems clear, with DAO data suggesting a slowing in the rate of expansion after 1980, confirmed by the small difference between the 1981 and 1985 ecosystems surveys (see Land Use Profile).

2.2 Crops Grown before 1960

Machakos District has produced a wide diversity of crops since the 1930s. Peberdy (1958) records the staple crops produced in the Reserve area in 1957 as: maize, beans, cow peas, sorghum, millet and wheat. Even though sorghum and millets are regarded as important traditional food crops, maize was already twice as important as sorghum and millet in 1929, according to the perceptions of the District Officer, recorded in the census (Kenya: Department of Agriculture, 1930).

Other recorded crops in 1957 were:

Cucumbers	Pineapples	French beans (green beans)
Egg plant	Passion Fruit	Grams (various)
Onions	Carrots	Bananas
Lettuce	Tomatoes	Oranges
Beetroot	Strawberries	Castor oil seed
Coriander	Cabbages	
Irish potatoes	Chilies	

The same diversity of crops was being produced in the district even in the 1940s, although on a smaller scale. Thus, Machakos District exported about 530 tonnes of various fruits and vegetables in 1943, consisting of:

428 tonnes of vegetables in general
7.8 tonnes of coriander
69 tonnes of onions
25 tonnes of fruits

(Peberdy, 1958). These crops were grown in the highlands (Owako, 1969, and village and farmer interviews, 1990). From this small base, a remarkable increase in the value of crop exports was achieved in the 1950s. According to Peberdy (1961), the value of crop exports in the district grew by an annual rate of 60% between 1949 and 1960, with coffee and vegetables being most responsible. Sisal was temporarily an important export crop, especially during the drought years, and when its price was relatively high in the 1950s. Wattle bark, used for tanning, was a smaller export.

Some crops grown or experimented with before 1963 are no longer important. Prior to the 1960s, some colocassia (arrowroots) were being grown in valley bottoms, as they still are today. Sugar cane (for beer) is in decline. Snuff tobacco has always been grown in small amounts, but trials with tobacco for cigarette production did not take off. Castor oil seed production has always been on a small scale. The mid-1960s wheat production trials were a revisit of what had actually failed in the late 1930s and early 1940s. Wattle bark has declined, though it still occasionally features in DAO lists.

2.3 Proportion of Land under Food and Other Crops

2.3.1 Proportion of cash crops and food crops

Machakos District would appear to have been characterised historically by having over 80% of cultivated land allocated to food crops, except in the highland areas. Based on a survey of five areas (Kangundo, Mbooni, Iveti, Masii, and Nzaui) in Machakos District by Owako in 1964-5, an average of about 90% was under food crops. The percentage under cash crops observed by Owako (1969) was as follows:

(i) 25.5% for Kangundo
(ii) 22.2% for Mbooni
(iii) 10.8% for Iveti
(iv) 7.0% for Nzaui
(v) 1.5% for Masii

These figures can only be taken as illustrative for the Agro Ecological Zone (AEZ) concerned; the first 3 locations are in AEZ 2 and 3, which covers only a small proportion of the District. The last two are in AEZ 4, which covers a larger area. AEZ 5, which at the time was only beginning to be settled, is not represented. The continued dominance of food crops in terms of area is shown in Table A.3. Cash crops have only very occasionally occupied as much as 15% of cropped areas. The Ecosystems 1985 estimate was 13% CC and 2% HC (see Table 4, Working Paper: Land Use Profile). Maize, beans and peas still remain the dominant food-cum-cash crops, occupying between 74 and 97 percent of the cultivated land area in the district, depending on the agro-ecological zone. Nevertheless, because of their higher unit values, the CC and HC are vitally important as income generators.

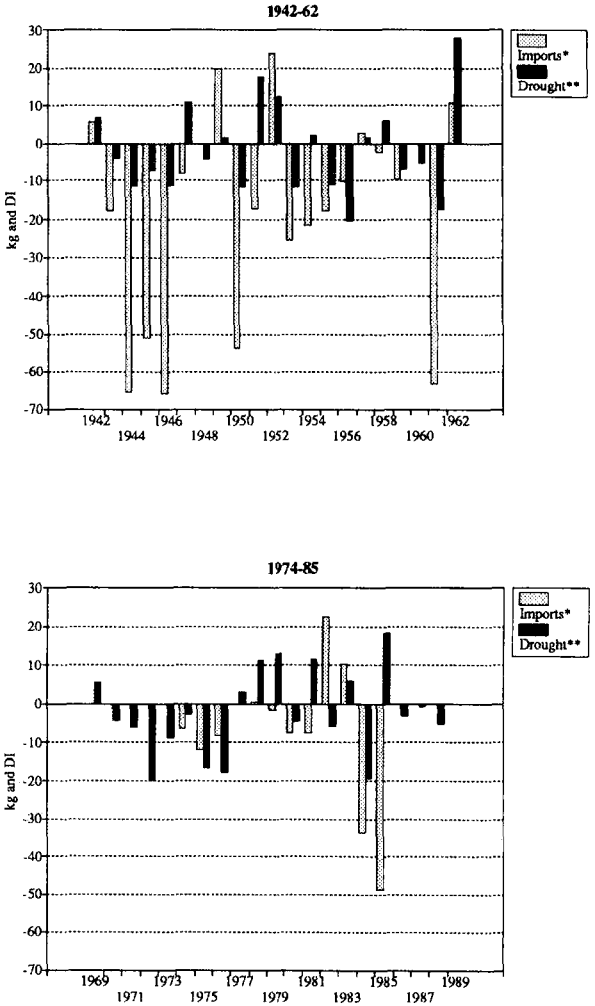
2.3.2 Trends shown in food availability

Drought and semi-drought conditions are a chronic problem in Machakos District. This was so even when the population was much smaller. For instance, District Annual reports refer to 1934 and 1935 as difficult years with poor crop yields and/or total crop failure in some parts of the district. Despite the large proportion of cultivated area given to food crops, whenever drought or semi-drought conditions have hit Machakos District, the district has depended on food imports, especially maize grain and maize meal, to feed its population. Such food imports have come sometimes as famine relief. On other occasions, sales of livestock, sisal and other cash crops, as well as labour remittances, have enabled people to buy food. Figure A.1 shows the imports of food grains, including both famine relief and purchases, and exports of maize, between 1942 and 1962, and 1974-85, years for which data is available. This is on a per capita basis. The correlation with rainfall is very good, allowing for some lag effect. For example, the 1984 output was low because of a medium drought in the short rains of 1983 and a severe drought in the long rains of 1984. The latter was the third successive drought season. Output in 1985 was high because of exceptionally good short rains in the latter part of 1984. However the harvest was not available till March, and in the first quarter of the year substantial imports and famine relief were required.

What is remarkable is that in the first series, 1942-62, net imports averaged 17.38 kg per capita. In the period 1974-85 they averaged 7.57 kg per capita, despite a substantial growth of population (357,802 in 1948 and about 1,125,000 in 1985), a move by many farmers to the more arid areas and a substantial increase in the local urban population (see Population Profile). It is possible that in the second period more food was imported informally - the figures relate to net exports and imports of the National Crop Production board and its predecessor, plus famine relief. However, the difference between the 1942-62 and 1974-85 figures is sufficiently great to allow us to conclude that, despite the large increase in population, food production in relation to district requirements in the 1980s is better than it was in the period 1942-62. The NCPB is the residual buyer and seller for maize, taking what farmers cannot sell or obtain locally.

The data above relates mainly to maize imports, though some pulses are included in the 1981-85 totals. ADEC (1986), Table 4.15, made an estimate of food requirements, 1980-81 to 1985-6, and found that although the District usually had a deficit in maize and sorghum, it normally had a surplus of pulses, except in severe drought conditions.

Figure A.1: **Net maize imports/exports *per capita***



Notes:
* Imports = maize imports plus famine relief minus exports. Positive figures show net exports.
** Drought = drought index for short rains previous year plus long rains current year, multiplied by 10. See Environmental Profile, Section A.

Source: 1942-62: Peberdy 1958 and Owako 1969.
1974-85: Kliest 1985 and ADEC 1986.

2.4 Production Trends in Specific Crops and Crop Classes, 1960-90[3]

Table A.4 shows land area and Table A.5, production of the major food crops (FC) in Machakos District since 1970. It indicates the dominant role of maize and pulses (i.e. beans, peas and grams) as food crops in Machakos District. Taking only the more consistent data from 1974, a feature is that the pulse area averaged 61% of the maize area in the period 1974-80 and 85% in the period 1981-89 - a swing towards additional production of pulses. Output of pulses appears to have risen more than maize, and was particularly high 1979-83 (even if the 1982 figure, which appears anomalous, is rejected).

The great variability in output, shown in Table A.5, reflects changes in yield and the degree to which cultivation can take place in both seasons. The variability of output and of areas cultivated is caused by the variability in the timing and amounts of rainfall. For instance, the low output levels in 1975 and 1984 are due to low yield in drought conditions, as illustrated for maize in Figure A.2. The other influence is price and market conditions, which are particularly noticeable in the case of cash crops.

Table A.6 gives the cultivated land area, and Table A.7 the output, for the main types of cash crops produced in Machakos District since the 1960s. Cotton and coffee have remained the major small farm cash crops over the years. Peak production of coffee was achieved between 1979 and 1980, before production started to decline, recovering after 1984. Coffee areas were regulated by quota in the 1960s, but this system began to decline in the 1970s when there was a substantial expansion in area as a result of the boom in real coffee prices. Once land has been planted to this crop, farmers are not allowed to uproot it. It therefore shows less responsiveness to market conditions than cotton. In any case, as a tree crop, there would likely be a lag of some years before changes in prices are fully worked through in changes in supply. Cotton shows major fluctuations in the hectarage planted that cannot be related solely to climatic conditions. After its reintroduction in 1962, production was relatively high 1965-70, falling steeply during the bad rainfall years 1971-75. Recovery to a new high took place 1977-85 with peaks in 1979 and 1985. Cotton prices peaked 1977-79 (see Figure A.4). Production collapsed after 1986. We know the second collapse was related to price, market and input availability conditions. Almost all farmers we interviewed in 1990 said they had abandoned cotton or reduced acreage, because of late payment, low prices for the output and high prices for inputs. Sunflower was briefly important 1979-80. Most of the sisal output comes from a few estates.

Tables A.8 and A.9 gives the development of the cultivated land area and output of fruits and vegetables since 1974. In 1957, fruit exports were only 475 tons (Peberdy, 1958). Fruit output was not recorded in the 1960s. By 1986 recorded output, which probably misses most domestic consumption and local sales, was over 110,000 tons. Table A.9 shows that citrus fruits, bananas, pawpaws and mangoes are now the major types of fruits. The steady increase

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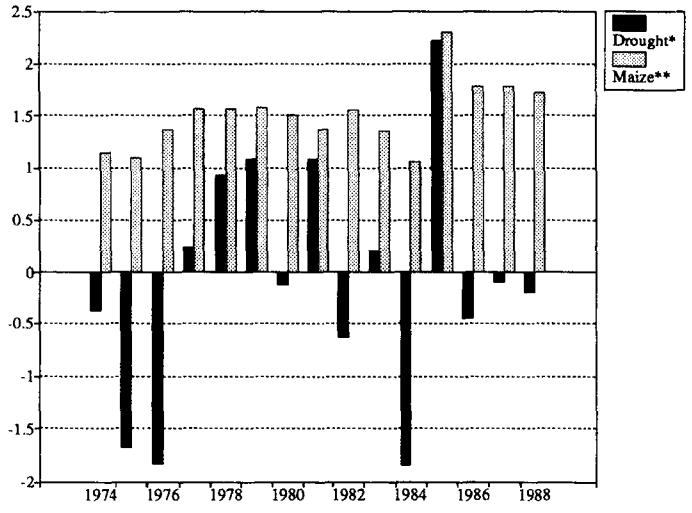
[3] Some data in available records (e.g. District Annual Reports and/or Study Reports) looked highly suspect in terms of their reliability, especially judging from trends and the relationships between cultivated land areas and recorded output levels. In obvious cases, e.g. where the recorded figures would appear to be tenfold of the expected figures, the author assumed that typographical errors were responsible and accordingly did the necessary adjustments. Notes are attached to the relevant tables.

Figure A.2: Maize production and droughts, 1974-88



Notes: * Drought = drought index, short rains previous year plus long rains current year.
** Maize = maize production in 100,000 tons.

in land under citrus after 1976 and in pawpaws in the 1980s is notable. This is reflected, a few years later in the case of oranges, in the increased output shown in Table A.9, especially after 1985. The output of pawpaw recorded for 1976-8 is difficult to reconcile with the land area shown in Table A.9. There is independent evidence of an increase in fruit tree planting from the late 1970s both from farmers we interviewed and from a survey in Masii (Hayes, 1986).

Table A.10 gives the development of cultivated land area under the different types of vegetables since 1974. Like production of fruits, production of vegetables appears to have gained ground after the mid-1970s, with cabbages and kale (*sukuma*), tomatoes, Irish potatoes, and onions being the major vegetables produced, but mainly for the domestic/local market. The Asian vegetables (primarily for export markets) appear to have gained ground in the 1980s, leading to a substantial increase in total area. Table A.11 gives the output of the various categories of vegetables since 1974. The total output in the 1970s ranged between 2,600 and 3,000 tons, but in the 1980s it averaged 37,000 tons, despite bad years such as 1982 and 1984. This should be compared with the 428 tons recorded for 1943 and 1,526 tons in 1957 (Peberdy, 1958). It is evident that a really large increase took place in the 1980s. In all cases, output refers to what is sold to major wholesalers and contract buyers only; the DAO has no information on local sales.

The increase in the area under horticultural crops is confirmed by the Ecosystems surveys of 1981 and 1985. This showed an increase from 0.1% to 0.5% of the District area under horticulture.

3. TRENDS IN YIELDS AND PER CAPUT PRODUCTION

3.1 Trends in Yields

Table A.12 gives yields for maize and pulses (FC) since 1974, coffee and cotton (CC) from 1960, and tomatoes and citrus, as examples of HC, from 1974. The table shows that yields of FC vary erratically according to weather conditions. It is unfortunate we have no good data on maize yields for the 1960s and 1950s, in order to see if the introduction of Katumani varieties and farmers' own experiments with variety development since about 1966 has had an impact. As the 1960-61 census figures were affected by drought, the only available data is Peberdy's estimate of yields in 1957, and a reference in De Wilde, 1967. Peberdy estimated 0.5 tons/ha for maize. The De Wilde report refers to low yields, varying from .22 tons/ha in a bad season to over 1.1 tons/ha in a good one. The impact to be expected from Katumani would be a reduction in the depression of yields by bad rainfall, rather than an increase in good years, since Katumani was bred as a drought evader rather than for yield increase. Increased use of drought evading types should therefore result in a higher average over a period of years. We have 14 years of relatively reliable data from 1974 to 1988. In the first half of this period, 1974-80, maize yields averaged 0.8 tons/ha; in the second half, 1981-8, they averaged 1.02 tons/ha. Each period had one very severe drought with an impact on yields. On the face of it, average yields have increased, despite the increased use of AEZ 5 land, but the issue requires further analysis in relationship to the rains experienced in each period. Figure A.2 suggests that farmers pursue strategies that successfully maintain yields in somewhat below average years, and which only fall severely in very bad years. However, they do not seem able to take advantage of very good rainfall. The year 1976 presents an anomaly; yield and production is likely to have been substantially lower than recorded, since we know there was poor rainfall and substantial food imports (see Figures A.1 and A.2).

Trends in the yields of tomatoes and citrus are clear. Fruits and vegetable crops show an upward trend in the 1980s. The relatively higher yield of tomatoes in the 1980s as compared with the 1970s is worth noting. This probably reflects a real increase in yields, with the use of more irrigated land, particularly in Yatta. However, it may also partially reflect the fact that a higher proportion of recent production has been on contract, and therefore noticed in the agricultural records, whereas previous production was mainly for local consumption or sale to Nairobi and Mombasa via traders in the informal sector, and therefore, under-reported. In the case of citrus, the increase in yields is probably due to the same factors, but also, to the increasing maturity of trees planted in the late 1970s and early 1980s, and to increased experience with commercial production of this crop.

For the ecozones where it can be grown, coffee remains the dominant cash crop that gets most of the farmers' attention when prices are reasonable (personal communication). Coffee producers appear to have performed well. Table A.6 has shown that there was a significant

increase in the area of land under coffee in the 1970s. This was associated with promotion of production by extension services and relaxation of the production control or quota that was being enforced earlier. This period also witnessed a significant increase in the price of coffee (the period of 'coffee boom' in Kenya - see Table A.18 and Figure A.3) encouraging more careful husbandry that led to significantly higher yields. Table A.12 shows a clear peaking of yield, 1977-80. This was just subsequent to the higher price in 1976 (Figure A.3) since there would have been a lot of young coffee planted from 1975 onwards (Table A.6). Coffee areas stabilised after 1982, but despite the maturing of the trees, the yield levels of 1986-8 have not recovered to the former peak, and nor have prices. The peak in the late 1970s was also encouraged because input prices then were low and subject to government controls and coffee was certainly the most competitive cash crop. Since the beginning of the 1980s, horticultural crops (particularly the Asian vegetables) have exceeded coffee in profitability, leading to the neglect of coffee in some areas and declining yields.

3.2 Trends in Per Caput Production of Different Crop Commodities

Unfortunately, we do not know the proportion of the labour force in Machakos that is engaged in the agricultural sector. We cannot, therefore, measure changes in agricultural labour productivity. We can, however, attempt to see how well the production of crops has kept up with the growth of population, by looking at output per caput over time.

Table A.13 gives the development in per caput cultivated land area in Machakos District for all crops and for the three main commodity groupings (i.e. FC, CC and HC) since 1970. The result suggests that in the last three decades:

- cultivated area per head has remained largely static since 1970. There is slight evidence of a peaking around 1982, followed by a fall (apart from the temporary anomalous increase in 1985). The suggestion that in recent years it has not been possible to find land for new farms agrees with information obtained from community leaders;

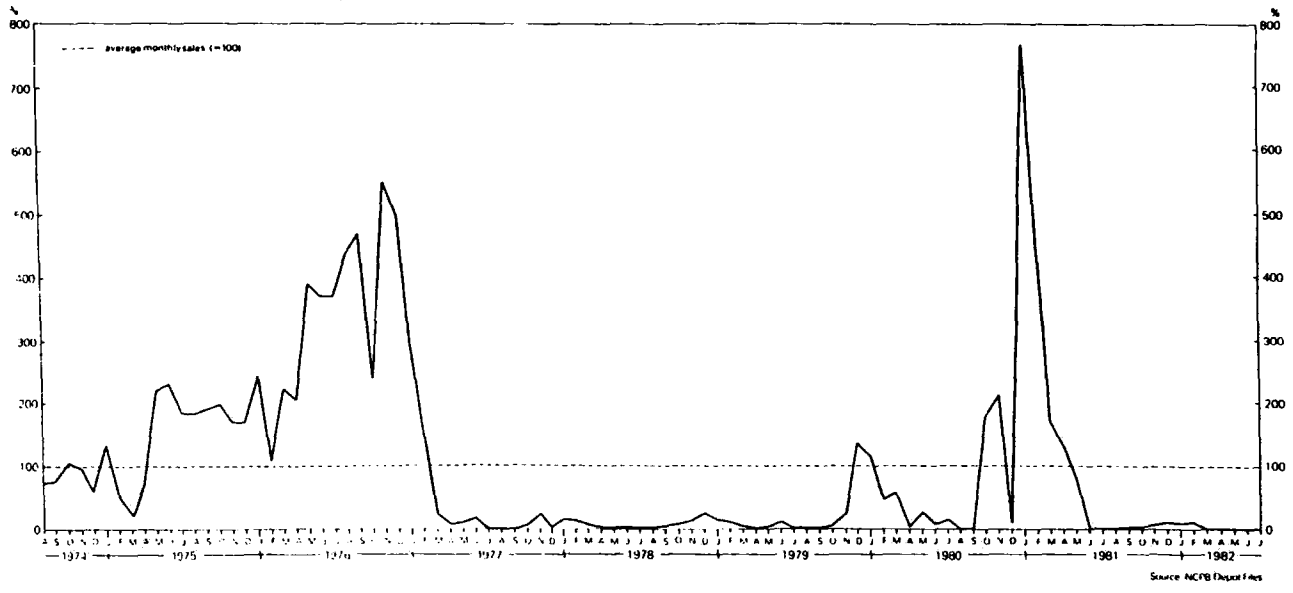
- there has been growth in HC area; it doubled per caput in the 1980s as compared with the 1970s despite the increase in population; total HC area per caput remains, however, very small (about 0.01 per caput);

- the per caput FC area has remained relatively constant;

- per caput cultivated land area under CC rose from an average of about 0.01 ha according to the 1960-61 census to 0.04-0.05 ha between 1978 and 1985. This was followed by a decline to 0.02 ha. This is largely due to fall in cotton production. (See Table A.6).

Thus, the increase in cultivated area appears so far to have kept pace with the increase in from AEZ 5, while before 1960 the population lived mainly in AEZ 2, 3 and 4. Nevertheless,

Figure A.3: **Monthly maize sales at NCPB Depot, Machakos, 1974-82**



Source: Kliest, T., 1985.

yields appear to have increased and output maintained except in drought years, or when there were unfavourable market conditions. The proportion allocated to cash and horticultural crops, while remaining a very small proportion of the total cultivated area, has increased, though it fluctuates according to the relative attractiveness of crops such as cotton in comparison with food crops.

4. FACTORS INFLUENCING CROP OUTPUT: PRICES, MARKET CONDITIONS AND EXTENSION SERVICES

4.1 Influences on Crop Production

Several factors influence crop production in any given year. The most important are:

- the amount and distribution of rainfall and the degree to which water conservation is practised;
- the price to be obtained for the output relative to other feasible crops;
- the varieties of seed used and their availability (in the case of annual crops);
- the age of the crop (in the case of tree crops);
- the activities of the extension services;
- the price and availability of fertilisers and other chemical inputs.

Other papers have concentrated on the rainfall variable and the conservation story. Since rainfall has not changed, and cultivation has spread to drier areas, there is a strong implication that the rises in yields showing in Table A.12 are partly due to better conservation. It remains to consider the effects of the prices of output and inputs, the availability of inputs, and the activities of the extension services.

Farmers can adjust relatively quickly to changes in price and availability of inputs and output in the case of annual crops. In the case of tree crops, they will increase plantings if they feel fairly certain that prices will remain attractive for several years ahead, and if not prevented by restrictions, quotas, etc. Once the trees are planted and have come to maturity the marginal cost of caring for the crop and picking is relatively low. However, a reaction to current prices can still be made, either by increasing or reducing the use of inputs such as fertiliser and weeding labour, or by increasing or reducing the number of times the crop is picked. Generally, the last picking is the most labour demanding in relation to the output obtained, and it will be abandoned if prices are low in relation to labour costs. These last considerations also apply to annual crops like cotton, where the price may not be known till after planting, as well as to tree crops.

If farm-gate prices for a tree crop have been on a downward trend for several years while prices for another feasible crop are rising, some farmers will want to uproot the tree crop and substitute another crop. This reaction, however, is curbed in Kenya in relation to coffee by regulations which forbid the uprooting of coffee. Regulations also try to impose a certain standard of weeding and other inputs, whatever the price level. Despite these regulations, the effect of low prices on coffee production is still visible.

4.2 The Effects of Erratic Supplies and Marketing Controls on Food Prices

The frequent droughts make it difficult for farmers to meet their subsistence in all years. We have seen that in many years they are food purchasers. However, there is a reasonable surplus for the market during and following good rainfall seasons. This background explains why Eastern Province, of which Machakos District is part, experiences some large fluctuations in the levels of staple food prices, as shown in Table A.22. The fluctuations in the levels of prices are both seasonal within the year, and cyclic, between years, reflecting the incidence of droughts. In good years, there is less difference between prices at different seasons; in years of shortage, as in 1985, the seasonal differences are larger. Figure A.3 shows farmers' purchases are concentrated at times that prices are highest. Table A.23 suggests that bean prices fluctuate more than maize prices. In general, prices drop when there is a surplus, inhibiting capital accumulation. In poor seasons, on the other hand, the poor harvests lead to relatively high prices, a situation that leads to household hardships and de-cumulation of whatever savings and/or capital the smallholders may have achieved in the past. Local prices vary even more than Table A.22 indicates. Thus farmers in Yatta in 1980-81 reported prices of Ksh 5-8 per kg for maize, compared with Ksh 1-2 when it was in local surplus (Neunhauser et al., 1983:77).

The Government of Kenya has always been concerned about such problems. This has led to the establishment of a number of agricultural produce marketing boards. The main objectives of such agricultural produce marketing boards have included:

- stabilisation and guarantee of prices of the produce at levels which ensure that neither the producers nor the consumers are exploited;
- a guarantee of a market for the producers in surplus areas and a guarantee of an efficient supply of produce to consumers in the deficit areas;
- control of both domestic and export marketing of important agricultural commodities (in order to enhance achievement of the other objectives).

Such agricultural produce marketing boards in Kenya have included the marketing boards for coffee, tea, grains and livestock products. Currently, the National Cereals and Produce Board (NCPB), whose forerunners were the Maize and Wheat Marketing Boards, is the most important board for food crops marketing in the country. The NCPB is expected to fulfil the objectives specified above and also ensure that a minimum national reserve stock of important food grains is maintained all the time. The NCPB has buying centres and storage depots

in almost every district in Kenya, including Machakos. Its sales fluctuate according to production levels within the District and also by season. Figure A.3 shows the record of sales 1974-82.

The existence of the formal agricultural marketing system through the NCPB channels does not deter the proliferation of private traders (which we will describe as the informal marketing system), particularly in the rural market centres. In most cases, the formal marketing system is not efficient enough in carrying out its functional roles, and this factor encourages the growth of the informal marketing system, even in cases where the formal marketing system is legally supposed to be the sole marketing institution. During most of the period under review, traders were not supposed to export more than 2 bags from the District without securing a permit from Machakos town NCPB office, nor to move more than 10 bags internally without a permit similarly obtained.

A study of agricultural produce marketing problems in Machakos District by Neunhauser et al. (1983) clearly demonstrates the unsatisfactory manner in which the NCPB has performed. According to this study, the difference between the farm-gate producer price paid to maize farmers by the NCPB and the farm-gate price for maize re-bought by the farmers for consumption from the NCPB in 1982 was about 146% of the farm-gate producer price. Neunhauser et al. (1983) therefore conclude that the NCPB is not an institution that serves the farmers' needs in a satisfactory manner. For this reason they note that the farmers' tendency is to market their produce through informal channels and that illegal trafficking of produce tends to arise. This raises the real cost and risks in marketing, all at the expense of the farmers.

Neunhauser et al. (1983) note that the farmers' strategy of primarily producing subsistence crops in Machakos District is clearly understandable under the existing marketing conditions, even though this strategy is not always to the farmers' advantage. They have to put most land to food crops to avoid the necessity of food purchases, but production of food surpluses is not necessarily profitable. Marketing problems affect other crops beside grains. Inefficiencies, particularly late payments, have been responsible for the difficulties in introducing and maintaining output of new cash crops, such as cotton and sunflower, which are also controlled by produce marketing boards.

One should not assume that all commodities are marketed through marketing boards. For many types of food crops, excepting maize, the marketing board (such as the NCPB) may be just one of the marketing channels that the farmers can legally use when marketing their farm produce. Private traders in the rural trading centres and markets constitute an important marketing avenue for most food crops, particularly for sales to other consumers within the District. In some cases, farmers may market their produce through their cooperative societies, and such societies may be viewed as being part of the formal marketing system, depending on to whom they eventually supply their members' produce. In 1977, about 30% of the marketed food produce in Machakos District was being channelled through the informal sector while the rest was being channelled through the Cooperative Societies and Maize and Produce Board (forerunner of NCPB) (Consortium, Report 3, 1978). The formal sector was dealing mainly with maize, pulses and sunflower while the informal sector dealt in these and also with sorghum, millet and fruits. Private traders usually sell their purchases in the local markets within the district, but they sometimes sell to distant markets outside the district.

4.3 National Prices and Local Prices

As noted earlier, the prices of agricultural produce in Machakos District tend to fluctuate widely from season to season and between years. This is especially true for food commodities. However, records on prices of most agricultural commodities on a longitudinal basis are generally scanty, especially for the pre-1980 period. A longitudinal analysis has therefore to assume that the trends in 'Average Gross National Producer Prices' of the agricultural commodities that are marketed through the formal channels influence the development of prices of the same commodities in individual districts. There is little doubt that the official producer (and consumer) prices influence the level of prices in the informal sector, though they are more clearly related to the actual prices paid in the case of export crops than in the case of food crops.

Table A.18 gives the trends in the average gross national producer prices for maize, cotton, clean coffee and sisal for the 1965 - 1988 period. Table A.19 gives trends in average producer prices for maize, cotton, mixed beans, clean coffee, pigeon peas, green grams, millet and sorghum for Machakos District for as much of the 1977 - 1988 period as are available. One can conclude that, except for minor differences due to grades, the Machakos District producer prices for clean coffee and cotton generally exhibit the same trends as the Average Gross National Producer Prices for the same commodities. However, the 'Machakos' maize price is about 50% higher than the 'National' price for the period 1983-8 for which comparisons are possible. This factor reflects the maize-deficit situation in Machakos District in most years.

Where recorded, the District 'average producer prices' refer either to the 'average price' for the produce delivered and sold through the various buying centres in a district in the case of the commodities that are marketed through the official (formal) channels, or to the 'average price' charged by large-scale producers to wholesalers/traders who buy produce directly at the farm gate from these producers in the case of commodities that are traded through informal channels (discussions with the senior agricultural officers in Machakos District). It is not clear how the averages are calculated - whether they are averages of monthly prices or whether they are weighted for the months in which most transactions take place. Prices from different sources and even in different pages of the same report may at times be at variance for a given commodity and for the same period. This problem was noted for the prices of some commodities in 1988 as recorded in the 1989-93 Machakos District Development Plan (compare 1988 figures in Tables A.19 and 21). Table A.19 reflect prices obtainable for sales through the official (formal) marketing channels. Table A.22 data was based on average market prices for the selected products in the district during the 1988 period. If we look at products common to both lists, such as maize, mixed beans and sorghum, it will be seen that the local price in 1988 was higher than the official price.

While rural market prices often tend to be much higher than those obtained in the formal channels, especially seasonally, it is worth looking at long-term changes in official prices, since these will affect rural prices.

4.4 Trends in Nominal and Real Prices

The price data given in Tables A.18-A.20 generally indicate a rising trend in nominal prices of agricultural products in Machakos District since the 1950s. For instance, the price per 90 kg bag of maize or beans is quoted at around Ksh 20 - 50 in the 1950s and at Ksh 50 - 60 during the 1960-61 period, yet the same bag of maize or beans will be costing between five and ten times as much today. When deflated by the Nairobi consumer price index (Table BB.8), national producer prices for maize were high in 1965-6, and 1975-7. Cotton was high 1975-80, but from 1981 was lower than it had been in the late 1960s and 1970s (see Figure A.4). Coffee was relatively stable, but showed a great surge during the coffee boom, 1976-9 (Figure A.5). Although real prices for coffee do not appear lower in the 1980s than they had been before the coffee boom, the removal of subsidies on fertiliser and other inputs means that returns to the coffee farmer were in fact less attractive in the 1980s. The real prices of maize may have been above that shown in Figure A.4, since local Machakos prices were generally higher than national prices.

Nominal prices are a poor guide to farmer behaviour, and real prices conceal all the options that are open to him. The farmer can react to a change in the purchasing power generated by the production of any single commodity by switching into another commodity feasible in his circumstances. He is therefore also influenced by the terms of trade between the products which he could feasibly produce - the kg of one type of commodity that is needed to 'attract in exchange' in the market place one kg of another type of commodity over a specified time period. It is a powerful measure of the relative development of the values of production of different types of commodities. Maize has been selected as the basis, since this is a commodity which most farmers buy occasionally, and which all of them can produce.

We have seen that beans, cotton, coffee, sorghum and a variety of horticultural products (especially tomatoes and oranges) have been produced in Machakos District over the years. Beef and dairy cattle can be viewed as competitive livestock production activities vis-à-vis crops production. Tables A.23-A.26 show that some commodities have become more highly valued while others have become less highly valued over the years in terms of how much maize is required in exchange for one unit of another commodity in the market place. It is found that:

- maize has 'appreciated' relative to coffee, cotton, tomatoes and oranges for the period between 1957 and 1987;
- maize has 'depreciated' relative to beef, milk, sorghum and, to some extent, beans since 1957.

Detailed analysis indicates that over the years, and for Machakos District:

- the maize terms of trade against beef cattle declined from an average of about 715.6 in the 1960s to 793.2 in the 1970s and to 796.4 in the 1980s;
- the maize terms of trade against milk only declined marginally from an average of about 1.5 in the 1960s to 1.7 in the 1970s and then declined drastically to an average of about 2.2 in the

Figure A.4: **Maize and cotton, Ksh per kg in realprices, based on national producer prices (1976=100)**

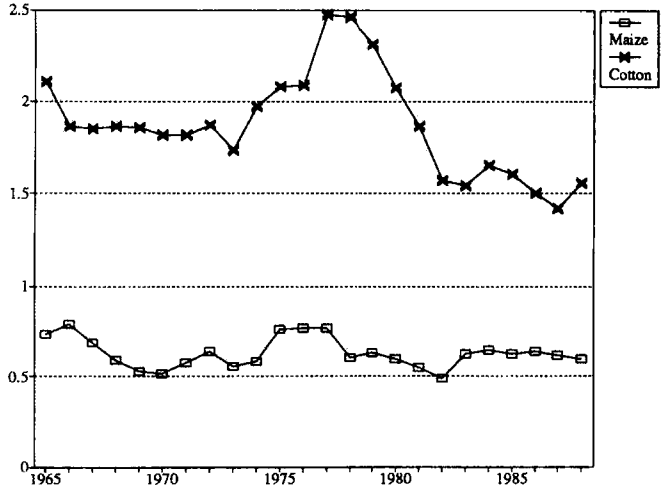
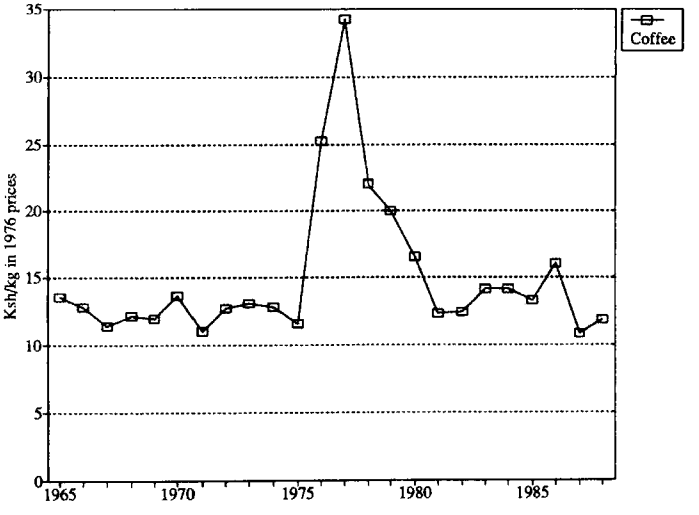


Figure A.5: **Real prices for coffee (1976=100) in Ksh/kg**



1980s, when dairy production became an attractive option - the Livestock Profile will show that dairy production increased in this decade;

- the maize terms of trade vis-à-vis clean coffee declined from an average of about 18.9 in the 1960s to about 27.3 in the 1970s, the period of peak profitability for coffee, falling back to about 22.7 in the 1980s;
- the maize terms of trade vis-à-vis cotton declined marginally from an average of about 2.9 in the 1960s to about 3.3 in the 1970s, and then rose to the 1960s level at about 2.8 in the 1980s. In the case of cotton the decline in production in the 1980s cannot be explained solely by its falling price in relation to maize. Responses of farmers to our enquiries, and other sources, show that the problem was late payments by the Marketing Board and a rising cost of inputs.

Table A.24 data also indicate substantial fluctuations of the real terms of trade of maize vis-à-vis the other commodities from year to year, primarily reflecting annual fluctuations in the levels of absolute production of the different commodities - which, as suggested elsewhere, reflect variations in the weather regimes. On the whole, livestock production would appear to have remained more attractive than maize production since the 1960s, while the performance of the other crops relative to maize has had a mixed picture, as depicted by coffee and cotton performance. The exchange rate between maize and cotton had changed in favour of maize in the period 1983-8 by comparison with 1968-83. This helps explain why maize production tended to increase and cotton decrease after 1983.

An important conclusion that can be drawn from the developments in the real terms of commodity trade is that, depending on relative yields per unit of land, it will make more economic sense for farmers who are short of land for food crops to put more resources into the production of the more highly valued commodities and, if necessary, buy food, if fluctuations in food prices could be reduced by marketing improvements.

A fairly average yield of maize is 1,000 kg per hectare. Let us assume that on good land such as might be used for horticulture, it is 3,000 kg per hectare. The same hectare can also produce, at the yields of the 1980s, 25,000 kg tomatoes or 15,000 kg citrus (Table A.12). Thus, although the terms of trade between maize and tomatoes have risen to favour maize, a farmer is nevertheless able to acquire far more maize by cultivating a hectare of tomatoes in preference to a hectare of maize. Of course the farmers will also have to discount heavily the risks associated with the production of each type of commodity, and the risks of surging maize prices in bad seasons.

If risk is discounted, it makes sense to put more land and commit more resources to beans, tomatoes and fruits rather than maize production in the 1970s and 1980s vis-à-vis the situation in the 1950s and 1960s. Farmers appear to have done this, but with caution. They did indeed increase horticultural production, but, partly because only some land is suitable, and partly because of high maize prices in times of shortage, maize remained a dominant element in their farm strategy. The situation regarding maize vis-à-vis sorghum is a little complex:

sorghum production is found to have increased during the early 1980s, but followed by a decline in the later 1980s despite a rising terms of trade for sorghum vis-à-vis maize. This development is attributable to the Machakos Integrated Development Project (MIDP) which initially emphasised sorghum production (as from 1981) by distributing free seed, a programme that came to an end by the end of the 1980s. Sorghum production also declined, primarily due to marketing problems, it being sold mainly to the NCPB.

4.5 The Role of Extension Services

An important force behind change and the development of agricultural production in most countries is the extension services.

Both the numbers and the quality of the personnel engaged in agricultural extension services are critical in determining the influence (or the effectiveness) of the extension services in terms of achieving their objectives. The agricultural extension services in Kenya at district level are organised under Agricultural Officers (AOs), who are trained at University level (degree holders). Under the AOs work Technical Officers (TOs), who are trained at College level (diploma holders). Under the TOs work Technical Assistants (TAs), who are normally trained at Institute (junior college) level, and Junior Technical Assistants (JTAs), who are usually trained on-the-job and through in-service-training seminars and workshops. Over the years, the JTAs rank has been phased out, by taking any holders of this rank for training at Agricultural Institutes after which they become TAs.

Extension efforts in Machakos District began during the 1930s, 1940s and 1950s, aiming primarily at fighting soil erosion which was primarily associated with overstocking and increases in human population (Owako, 1969). The single Agricultural Officer of 1932 was strengthened through the services of Soil & Water Conservation Specialists (SCS). In addition, the government engaged levellers to assist the local people with soil conservation works. The number of such levellers is said to have risen from 39 in 1940 to 137 in 1951. During the 1950s, under the Machakos Betterment programme, there was a great increase in the number of general Agricultural Officers at Divisional level (AOs and TOs). With the ending of special funding under the ALDEV programme, the level of staffing fell sharply in 1962 (Table A.2). Scanty data indicates increases again in the 1970s with the start of programmes for the arid lands, and in the 1980s, when additional funds were available from MIDP and other programmes.

The benefits of increasing numbers of staff in higher categories (AOs, SCSs and TOs) should be reflected mainly in increases in agricultural output in the 1950s and 1980s, when staff increased most rapidly. In both periods, horticultural output increased. However, it will be difficult to apportion credit for enhancements in agricultural development since farmers are also influenced by other changes, for example in prices, and in the development of infrastructure which improves market accessibility. There are also non-official extension agents, such as traders, agents of contract farming firms, NGOs and the example of innovative farmers and returning migrants. It is therefore impossible to prove any relationship between extension and production.

4.6 The Input Supply System and Use of Inputs

4.6.1 Seed

Organised production and distribution of good quality seed is a recognised method of promoting agricultural production. The role of the Katumani Research Station in developing new maize strains is documented in the report on Technology. Case studies and enquiries amongst farmers suggest Katumani varieties are relatively widely available, particularly since farmers can retain seed from the previous harvest, and that, when they are not purchased, this is either because a farmer makes a deliberate choice for a local variety or because shortage of cash impels use of saved seed. Use of drought-evading varieties has helped to stabilise production in low rainfall years, though severe droughts still reduce it sharply.

4.6.2 Fertiliser and agro-chemicals

Available records suggest increased use of modern inputs (especially fertiliser and other agro-chemicals, such as pesticides) in Machakos District, especially during and after good rainfall and hence good harvest years when farmers have cash (MIDP Evaluation Reports). For instance, Onchere (1976) notes that there was reduced use of fertiliser on coffee in the Northern Division of Machakos District in 1975 as compared with the level of fertiliser use in 1974, following a poor harvest that made the farmers short of funds.

Most farmers in Machakos procure their farm inputs through their District Cooperative Union or through the Kenya Grain Growers Cooperative Union (KGGCU). According to the General Manager of the Machakos District Cooperative Union, there has been a substantial increase in the use of fertilisers in coffee and maize production in Machakos District over the last ten or so years, especially since 1984 when the Union got government approval to import fertilisers directly (personal communication, March, 1991). However, it would appear that the coffee producer remains the single most important consumer of fertilisers in the district (compare Table A.16 and A.17). The increasing trend in the prices of the various types of fertilisers would be expected to limit its use to the production of high - value commodities, such as coffee.[4] The price of DAP rose from Ksh 292/bag in 1988 to Ksh 348 in 1989, which seems to have led to a temporary drop in sales (see Table A.16). It would appear that in 1988 about 138 kg/ha was applied to coffee, and 1.6 kg/ha to food and horticultural crops. However, the swing to marketable crops has been limited by the need to keep most land under foodcrops to avoid purchases at high prices in bad seasons.

4.6.3 Credit

Availability of farm credit is considered an important determinant of agricultural production as it enables the farmers who cannot afford to purchase inputs using cash from their own savings to acquire the needed farm inputs on time.

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[4] The data was derived from the 1988-9 survey by the District Agricultural Office, made possible by financial support from the Fertiliser Use Recommendation Project.

A number of credit programmes have been available in Machakos District since the late 1960s, including the donor-financed Integrated Agricultural Development Programme, IADP (World Bank -- IDA Project) and the Machakos Integrated Development Project, MIDP (EEC Project). These were linked to demonstrations and farmer training. Credit was available, amongst other things, for fertiliser for maize and insecticides for cotton (ODI, 1982)[5]. In 1977 the Machakos Co-operative Union had 12 strong and well established coffee societies, which handled credit for coffee-growers. It had 13 newly formed cotton societies. It was the latter especially who were made responsible for the new credit and input programmes for maize and cotton, and in 1977-8 about 3,000 new loans were granted. The Union itself complained that it was an unwilling agent of government policy, having to revive and register societies that lacked experience, training and staff. Under the MIDP programme the new societies were provided with stores, and the Union with a subsidy and lorries. External technical assistance was also provided. As a result, loans for cotton were popular and were repaid, in the period 1981-2. The loans for maize were never popular; in the conditions of Machakos, fertiliser for this crop is less important than good husbandry (ODI, 1982). However, since the withdrawal of MIDP external assistance, the drop in cotton prices and delays in payment by the Cotton Marketing Board, the cotton credit programme ran into deep trouble (ADEC, 1986 and Mwenge, 1989).

The operation of credit schemes in Machakos would appear to have been hampered by low or poor repayment rates, particularly after poor rainfall or dry seasons that are inevitably followed by low crop yields or outright crop failures. It has operated best for coffee, grown in areas where the rainfall is relatively more secure, and where it is easy to deduct advances from payments for produce.

5. CONCLUSION AND IMPLICATIONS

5.1 Major Commodities and District Productivity

Despite the wide range of crops that have been produced in Machakos District over the years, one can easily identify a few commodities that have remained dominant in terms of cultivated land areas over the years. Major commodities among the traditional food crops have included maize and pulses, with sorghum, millet and root crops playing a minor role. Among the major traditional cash crops have been cotton, coffee, sisal, wattle bark, and sunflower. Horticultural crops have included a wide range of fruits and vegetables expanding particularly from the late 1970s. Some crops recommended for their suitability for semi arid

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[5] There have also been some other minor sources of credit. Some crop development state agencies (e.g. the Cotton Seed and Lint Marketing Board (CSLMB) and the Horticultural Crops Development Authority (HCDA) have also given some advances or credit to relevant farmers. The Agricultural Finance Corporation (AFC) has also provided some credit to farmers in the past, and it still remains an important source of credit to those who can meet its conditions or eligibility criteria.

areas, such as sorghum, millet, cassava and sunflower, have failed to gain the adherence of farmers.

There has been an important structural change in the importance of the different crops produced in the district in terms of their share in the total cultivated land area, with an increase since the 1960s in the per caput production of cash crops and horticultural crops. However, over 80% of cultivated land is still under staple food crops.

In order to measure if total production of crops has increased over time, implying increasing productivity of the land resource, we have converted the major crops to maize values. This is done in Table A.26, which shows the value of production in terms of maize in 1977 and in 1987, years for which we have good price data. This shows that in 1977, the value of major output was equivalent to 752,940 tons of maize. Using the same 1977 values, output value had increased by 1987 to the equivalent of 1,456,340 tons of maize. This is an annual increase of 6.8%. Unfortunately, between 1977 and 1987 the world price of coffee dropped, and the price to the farmer dropped even more. In consequence, there was a considerable reduction in the value of coffee in terms of maize. Machakos farmers endeavoured to compensate by a substantial increase in the production of fruits and vegetables, with the result that the maize value of their production in 1987, in 1987 prices, was higher than 1977, at 888,350 tons, showing an annual increase since 1977 of 1.6%. Thus, on either value of maize, total production had increased over ten years, though in the latter case, at less than the rate of population increase. The difference cannot be imputed to rainfall, since the rains were somewhat more unfavourable in 1977 than in 1987 (see Figure A.2). There has not only been an increase in the value of production, due to differences of crop mix, but also increases in the yields of maize over time.

The Livestock profile will show that the increase in crop production has not been at the expense of livestock production. Animal production remains a favourable option for Machakos farmers, for both meat and milk, but especially the latter, having retained or improved their exchange value with maize.

We can conclude that there is no evidence that the productivity of the land fell between 1977 and 1987; indeed, there is some suggestion of an increase. Unfortunately, it is not possible to carry out a similar exercise at an earlier date, since the only available production data, from the census of 1960-61, was badly affected by drought. The implication of an increase in productivity is confirmed by apparently increasing yields in horticultural crops, and probably also in maize. Cotton and coffee yields fluctuate with prices. The evidence on District maize purchases suggest that maize production has more than kept pace with the increase in population, despite year to year fluctuations and the necessity for considerable imports in severe droughts. Maize yields show an increasing trend since 1974, although the use of chemical fertilisers is still very limited.

It remains to note that the maize conversion exercise carried out above does not measure changes in labour productivity. We know that the proportion of the total population engaged in agriculture has changed over time, partly due to the increase in schooling, and partly due to the increase in urban and rural non-farm occupations. However, due to lack of data, we are not in a position to quantify with any precision the agricultural labour force.

The increase in the value of production was obtained by a partial switch to more valuable crops (although the greater part of the land is still kept under food crops), by an increase in yields, especially when prices were favourable, and by an extension of the cultivated area in line with population increase. The data shows that Machakos farmers make considerable adjustments to their production strategies according to the variations in prices for different outputs, and for inputs. This has been shown by the abandonment of cotton in the 1980s, the way yields of cotton and coffee peaked during or shortly after high prices, and in the expansion of coffee and horticultural areas. It is therefore important to note that the local maize price is generally above the national official price, and that it is at its highest when farmers most need to purchase. This helps to explain the continued allocation of most land to food crops.

5.2 Inputs Supply and Use

A number of credit institutions have and still continue to support agricultural development in Machakos District. However, the use of modern farm inputs, especially fertilisers, is limited to production of high value crops, especially coffee. The prices of such inputs are on an upward trend, and the risks attached to fertiliser use are higher, and the benefits it can bring are lower, in the lower rainfall areas. The inputs delivery system is there, provided that the farmers can afford to buy the inputs to sustain the system. This, in turn, depends on profitability of farm enterprises, which depend in part on the weather, which the government cannot influence, and in part on a facilitating environment for marketing which it can affect by its policies on transport infrastructure, marketing regulations and subsidies.

5.3 Implications

With static per caput production of food crops, while the per caput production of cash and horticultural crops is rising, the farm households are likely to rely more and more on the market in order to procure what they do not produce on their farms. Hence the importance of strengthening the marketing organisation and improving the general infrastructure in order to enhance marketing efficiency cannot be overemphasised. What are needed are government policies that promote or enhance profitability of farm enterprises, e.g. through infrastructure development and adoption of marketing and pricing policies that keep farm gross margins remunerative to producers.

ANNEX A

TABLES

Note:

n/a	not available, or data not usable
n/m	not much (less than 0.1)
-	zero production

Table A.1: Estimated crop hectarages in Reserve area, Machakos District, 1957 & 1961

A. 1957

Food Crops	*Area (ha)*	*Cash Crops*	*Area (ha)*
Maize*	137,652	Castor oil seed	6,478
Beans*	109,312	Sisal	40,486
Pigeon peas*	8,097	Wattle	4,858
Cowpeas	6,073	Fruits	3,239
Sorghum	810	Bananas	4,049
Millet	6,883	Vegetables	4,858
Roots*	8,097	Grams	648
		Others	910

* Usually interplanted. Allowing for interplanted crops and for sisal and trees, estimated cultivated area was 202,500 hectares in 1957, or about 100,000 ha per season.

Source: Peberdy, 1958.

B. 1960/61

	First Cycle	*Second Cycle*	*Total*
1. Temporary crops			
Maize	94.1	93.7	187.8
Pulses	86.4	73.6	160.0
Millet	10.5	17.7	28.2
Sorghum	7.3	6.7	14.0
Arrowroot	8.6	3.6	12.1
Cassava	6.8	3.0	9.8
Sugar cane	0.7	1.5	2.2
Vegetables	0.4	0.2	0.6
Others	0.6	0.6	1.2
Aggregate crop area	215.3	200.8	416.1
Total area under crops[a]	110.9	110.9	221.8
2. Permanent crops			
Bananas			3.4
Other fruit			0.4
Coffee			0.5
Sisal			3.2
Wattle			1.5
	Total		9.0
3. Total area under crops[a]			228.6

[a] allowing for mixtures

Source: de Wilde, 1967:88, quoting African Agricultural Sample Census, 1960/61.

Table A.2: Numbers of agricultural staff in Machakos District, 1932-88

Year	*AO*	*TO*	*TA*	*JTA*	*SCS*	*Levellers*
1932	1	-	3	-	-	-
1936	1	-	12	-	-	n/a
1940	1	-	16	34	3	29
1944	1	1	19	n/a	7	n/a
1946	1	1	26	20	7	n/a
1950	1	2	36	42	4	n/a
1951	2	4	40	47	2	137
1952	2	8	47	198	3	n/a
1953	2	9	50	n/a	5	n/a
1954	2	8	52	212	4	n/a
1955	2	12	51	220	2	n/a
1956	4	16	82	256	2	n/a
1957	2	16	62	232	2	n/a
1958	2	16	60	222	1	-
1960	3	14	63	192	-	-
1962	1	6	56	162	-	-
1964	1	5	65	101	-	-
1976	8	8	47	105	-	-
1988	19	52	135	56	-	-

AO Agricultural Officer
TO Technical Officer
TA Technical Assistant
JTA Junior Technical Assistant (Agricultural Instructor in the 1940s)
SCS Soil and Water Conservation Specialist

Source: Owako (1969) and District Annual Reports.

Table A.3: **Recorded areas of food crops (FC), cash crops (CC) and horticultural crops (HC) in Machakos District, 1960-88**
(in '000 of hectares)

Year	*FC area (ha)*	*CC area (ha)*	*HC area (ha)*
1960/61	221.3	5.2	1.6
1963	n/a	10.9	n/a
1964	n/a	8.6	n/a
1965	n/a	17.4	n/a
1966	n/a	13.2	n/a
1967	n/a	9.4	n/a
1968	n/a	7.7	n/a
1969	n/a	12.9	n/a
1970	219.9	16.0	0.7
1971	226.2	5.8	n/a
1972	199.2	11.1	n/a
1973	189.1	10.9	n/a
1974	212.1	8.9	4.5
1975	213.7	23.5	5.6
1976	242.7	30.7	5.0
1977	275.6	42.8	5.7
1978	275.6	47.1	5.6
1979	218.9	40.5	3.7
1980	325.8	42.9	11.0
1981	312.3	42.3	13.1
1982	385.0	54.0	11.3
1983	288.4	54.1	11.7
1984	294.2	54.2	8.7
1985	410.0	46.4	17.8
1986	343.1	29.1	12.6
1987	355.9	25.8	12.6
1988	365.5	32.8	14.4

Notes:
1. Food crops (FC) includes maize, sorghum and millets, cassava, pulses, and root crops.
2. Cash crops (CC) include cotton, coffee, sunflower, snuff tobacco and some local vegetables and fruits. Wattle and sisal are only sporadically recorded, which accounts for some of the variations. See Table A.6.
3. Horticultural crops (HC) include bananas, cabbages and kale, onions, tomatoes, Asian vegetables, mangoes, pawpaws, guavas, macadamia, passion fruits, citrus and other fruits and vegetables.

Source: Computations by the author, based on District annual reports and publications, with the exception of 1960/61 which is Census data.

Table A.4: Cultivated land area, food crops, Machakos District, since 1970
(in '000 hectares)

Year	*Maize*	*Pulses*	*Pulses as % maize*	*Sorghum & millet*	*Cassava*
1970	137.5	69.0	50	2.1	0.9
1971	146.0	77.1	53	2.8	0.3
1972	129.6	67.9	52	1.6	0.1
1973	111.6	76.1	68	1.1	0.3
1974	114.5	95.0	83	1.1	0.6
1975	110.1	99.4	90	2.6	1.0
1976	137.1	100.3	73	2.8	1.8
1977	156.1	114.3	73	3.1	1.2
1978	156.1	114.3	73	3.1	1.2
1979	158.0	55.2	35	2.0	1.2
1980	150.0	104.9	70	2.1	1.7
1981	137.6	109.0	79	7.4	1.8
1982	154.4	144.3	93	4.9	1.1
1983	135.5	103.9	77	3.9	1.2
1984	106.0	92.0	87	15.5	1.4
1985	230.0	157.0	68	20.0	1.4
1986	178.9	160.1	89	n/a	2.4
1987	178.0	165.2	93	8.3	2.6
1988	172.0	180.6	105	12.9	n/a

Source: Computations by the author, based on data from various District annual reports and publications.

Table A.5: Output of major food crops, Machakos District, since 1974
(in '000 metric tons)

Year	*Maize*	*Pulses*	*Sorghum & millet*	*Cassava*	*Sweet potatoes*
1974	120.7	26.6	0.3	n/a	n/a
1975	48.7	21.7	0.9	2.7	n/a
1976	123.4	19.9	0.8	2.2	n/a
1977	141.1	44.8	1.0	2.5	1.7
1978	141.1	44.8	1.0	2.5	1.7
1979	142.2	73.4	n/a	5.7	10.7
1980	76.7	82.6	1.2	7.8	13.2
1981	173.4	97.4	6.0	3.3	8.5
1982	180.7	149.1	3.4	9.0	1.4
1983	127.0	84.8	4.2	6.0	4.6
1984	38.4	8.9	1.2	8.8	5.2
1985	174.0	68.7	6.5	10.2	7.3
1986	178.8	94.3	n/a	19.2	8.4
1987	182.0	91.1	4.3	13.0	10.8
1988	111.1	50.5	6.1	n/a	n/a
Average					
1974-78	115.0	31.6			
1979-83	140.0	97.5			
1984-88	136.9	62.7			

Source: Computations by the author, based on data from various District annual reports and publications.

Table A.6: Area under major cash crops, Machakos District, since 1960
(in '000 hectares)

Year	*Cotton*	*Coffee*	*Sunflower*	*Sisal*
1960	0.0	0.1	-	n/a
1961	0.0	0.7	-	n/a
1962	0.6	1.1	-	n/a
1963	2.0	1.9	-	6.0
1964	1.6	2.2	-	6.0
1965	9.2	2.2	-	6.0
1966	11.0	2.2	-	n/a
1967	7.2	2.2	-	n/a
1968	5.5	2.2	-	n/a
1969	7.6	2.2	-	n/a
1970	8.1	2.2	-	n/a
1971	3.4	2.4	-	n/a
1972	1.6	2.4	-	n/a
1973	1.3	2.4	n/m	7.0
1974	1.1	2.6	0.3	n/a
1975	2.2	3.7	1.1	4.8
1976	7.8	5.4	1.1	4.6
1977	18.1	7.1	0.7	10.7
1978	25.0	7.0	2.2	10.7
1979	26.0	9.3	3.3	n/a
1980	27.4	11.0	3.4	n/a
1981	28.0	12.1	0.2	n/a
1982	30.2	14.0	0.3	9.2
1983	30.2	14.2	0.3	9.4
1984	30.2	14.3	0.3	9.4
1985	32.0	14.4	n/m	n/a
1986	12.0	14.6	n/m	n/a
1987	11.0	14.8	n/m	n/a
1988	18.0	14.8	n/m	n/a

Notes: *Coffee*: (a) 1985 entry is average for 1984 and 1986 hectarages.
(b) 1964-70 entries are derived as the averages of 1963 and 1971 hectarages.

Cotton: (a) 1968 entry is derived from output for 1968 and the 1968/69 yield level.
(b) 1965 entry is derived from output for 1965 and 1964/65 average yield.

Sunflower 1975-77 area adjusted by author in accordance with probabilities (see footnote 3).

Source: Compiled by the author from various sources, especially District annual reports.

Table A.7: Output of major cash crops in Machakos District since 1960
(in '000 metric tons)

Year	*Cotton*	*Coffee*	*Sunflower*	*Sisal*
1960	0	0.1	-	n/a
1961	0	0.1	-	n/a
1962	0	0.2	-	1.3
1963	0.1	0.5	-	3.3
1964	0.1	1.0	-	8.2
1965	1.1	0.9	-	0.2
1966	1.9	1.0	-	0.2
1967	0.6	0.9	-	n/a
1968	1.2	1.0	-	n/a
1969	1.7	1.2	-	n/a
1970	n/a	1.6	-	n/a
1971	n/a	1.9	-	n/a
1972	n/a	1.9	-	n/a
1973	0.3	2.1	-	n/a
1974	0.3	2.1	n/m	2.1
1975	0.2	2.5	n/m	2.3
1976	2.3	3.0	4.6	2.1
1977	1.9	15.0	7.5	3.4
1978	4.3	17.0	1.1	3.4
1979	6.4	24.9	3.0	n/a
1980	3.8	25.6	0.9	6.7
1981	4.7	18.3	4.0	n/a
1982	3.4	11.7	n/m	13.8
1983	4.9	8.6	0.1	11.3
1984	2.1	24.1	0.1	12.4
1985	7.5	17.6	0.1	n/a
1986	2.4	28.4	0.5	n/a
1987	1.4	25.6	n/m	n/a
1988	1.7	27.0	n/m	n/a

Source: Compiled by the author from various sources, especially District annual reports. Output of cotton in 1963 and 1964 adjusted in accordance with probabilities.

Table A.8: Area under fruit trees, Machakos District, since 1971
(in '000 hectares)

Year	*Bananas*	*Citrus*	*Mango*	*Passion fruit & avocado*	*Pawpaw*	*Other fruits*	*Total*
1974	1.5	0.2	0.5	0.2	0.2	0.4	3.0
1975	2.0	0.2	0.5	0.3	0.4	0.4	3.8
1976	2.0	0.3	0.5	0.1	0.5	0.5	3.9
1977	2.9	0.6	0.6	n/m	0.5	0.4	5.0
1978	2.9	0.6	0.6	n/m	0.5	0.4	5.0
1979	1.6	0.8	0.7	n/m	0.5	0.4	4.0
1980	2.5	0.9	0.9	n/m	0.5	0.7	5.5
1981	3.0	0.9	0.9	n/m	0.6	0.7	6.1
1982	3.1	1.0	1.0	0.1	0.8	0.7	6.7
1983	3.0	1.3	2.4	0.1	1.1	0.7	8.6
1984	3.2	1.2	1.3	0.1	1.4	0.1	7.3
1985	4.5	2.6	3.5	0.1	1.4	0.1	12.2
1986	1.3	3.6	1.5	0.1	0.2	0.1	6.8
1987	1.3	3.5	1.6	0.1	1.2	0.1	7.8
1988	1.5	3.6	1.6	0.1	1.4	0.1	8.3

Source: Compiled by the author from various sources, especially District annual reports. Output of mangoes and pawpaws 1983 and guavas 1982 adjusted by author in accordance with probabilities (see footnote 3).

Table A.9: Output of fruits, Machakos District, since 1974
(in '000 of tons)

Year	*Bananas*	*Citrus*	*Mango*	*Passion fruit & avocado*	*Pawpaw*	*Other fruits*	*Total*
1974	1.1	-	0.3	-	-	-	1.4
1975	3.0	0.8	0.4	-	8.9	-	13.1
1976	1.3	1.0	0.4	-	10.0	0.1	12.8
1978	5.4	1.7	0.6	-	15.0	n/a	22.7
1978	5.	1.7	0.6	-	15.0	n/a	22.7
1979	0.9	2.7	5.8	n/m	2.6	n/a	12.0
1980	20.5	5.8	6.8	0.1	2.6	0.8	36.6
1981	23.0	6.8	8.4	0.1	1.3	0.9	40.5
1982	39.1	7.1	6.1	0.1	2.3	0.3	55.0
1983	18.6	8.2	3.6	0.9	2.4	0.7	34.4
1984	12.9	1.2	1.4	0.3	2.3	0.8	18.9
1985	15.1	8.7	7.0	0.3	6.5	0.1	37.7
1986	25.2	55.2	18.4	0.8	9.6	0.9	110.1
1987	26.4	53.8	18.7	0.7	9.8	0.8	110.2
1988	29.0	54.3	19.7	0.8	10.8	0.8	115.4

Source: Compiled by the author from various sources, especially District annual reports.

Table A.10: Area under vegetables in Machakos District since 1974
(in '000 ha)

Year	*Cabbages and kale*	*Tomato*	*Irish potato*	*Onion*	*Asian vegetables*	*Total*
1974	0.5	0.6	0.2	n/m	0.2	1.5
1975	0.3	0.9	0.3	n/m	0.2	1.7
1976	0.3	0.4	0.3	n/m	0.1	1.0
1977	n/a	0.5	0.1	n/m	n/m	0.6
1978	n/a	0.5	0.1	n/m	n/a	0.6
1979	0.3	0.5	0.2	0.1	n/a	1.1
1980	0.3	0.4	0.3	0.1	4.4	5.5
1981	0.8	0.5	0.2	0.2	5.2	6.9
1982	0.3	0.6	n/m	0.2	3.7	4.8
1983	0.5	0.7	n/m	n/m	1.9	3.1
1984	0.5	0.9	0.1	n/m	0.1	1.6
1985	2.7	2.3	n/m	0.1	0.4	5.5
1986	2.0	0.8	0.6	0.8	0.6	4.8
1987	2.0	0.9	0.5	0.8	0.6	4.8
1988	2.1	1.0	0.5	0.8	1.5	5.9

Source: Compiled by the author from various sources, especially District annual reports. Area of brinjal (in other vegetables) adjusted in 1980 in accordance with probabilities (see footnote 3).

Table A.11: Output of vegetables in Machakos District since 1974
(in '000 metric tons)

Year	*Cabbages and kale*	*Tomato*	*Irish potato*	*Onion*	*Asian vegetables*	*Total*
1974	1.0	0.9	0.8	0.1	0.5	3.3
1975	0.3	1.1	0.6	0.8	0.5	3.3
1976	0.4	0.7	0.8	0.3	0.2	2.4
1977	n/a	1.2	0.3	0.4	n/a	1.9
1978	n/a	1.2	0.2	0.4	n/a	1.8
1979	0.5	8.8	0.2	1.5	n/a	11.0
1980	1.5	12.5	5.4	1.3	18.1	38.8
1981	3.3	9.9	2.3	1.5	26.3	43.3
1982	3.2	1.1	1.9	1.9	10.9	19.0
1983	3.2	12.7	n/a	0.4	14.5	30.8
1984	2.5	13.0	0.3	2.0	0.4	18.2
1985	0.7	29.9	0.2	2.3	2.5	35.6
1986	4.9	19.0	4.1	9.0	3.9	40.9
1987	4.1	23.5	3.2	9.4	4.0	44.2
1988	12.7	25.3	3.4	9.8	11.2	62.4

Source: Compiled by the author from various sources, especially District annual reports. Output of cabbages and kale in 1986 and 1987 adjusted in accordance with probabilities (see footnote 3).

Table A.12: Yields of selected food, cash and horticultural crops in Machakos District since 1960
(metric tons per hectare)

Year	*Maize*	*Pulses*	*Coffee*	*Cotton*	*Tomatoes*	*Citrus*
1960	n/a	n/a	0.14	n/a	n/a	n/a
1961	n/a	n/a	0.14	n/a	n/a	n/a
1962	n/a	n/a	0.18	n/a	n/a	n/a
1963	n/a	n/a	0.26	0.05	n/a	n/a
1964	n/a	n/a	0.45	0.06	n/a	n/a
1965	n/a	n/a	0.41	0.12	n/a	n/a
1966	n/a	n/a	0.45	0.17	n/a	n/a
1967	n/a	n/a	0.41	0.08	n/a	n/a
1968	n/a	n/a	0.45	0.22	n/a	n/a
1969	n/a	n/a	0.55	0.22	n/a	n/a
1970	n/a	n/a	0.73	n/a	n/a	n/a
1971	n/a	n/a	0.79	n/a	n/a	n/a
1972	n/a	n/a	0.79	n/a	n/a	n/a
1973	n/a	n/a	0.88	0.23	n/a	n/a
1974	1.05	0.28	0.81	0.27	1.50	n/a
1975	0.44	0.22	0.68	0.09	1.22	4.00
1976	0.90	0.20	0.56	0.29	1.75	3.33
1977	0.90	0.39	2.11	0.31	2.40	2.83
1978	0.90	0.39	2.43	0.20	2.40	2.83
1979	0.90	1.33	2.68	0.15	17.60	3.38
1980	0.51	0.79	2.33	0.20	31.25	6.44
1981	1.26	0.89	1.51	0.12	19.80	7.56
1982	1.17	1.03	0.84	0.16	1.83	7.10
1983	0.94	0.82	0.61	0.16	18.14	6.31
1984	0.36	0.10	1.70	0.16	14.44	1.00
1985	0.76	0.44	1.22	0.24	13.00	3.35
1986	1.00	0.59	1.95	0.20	23.75	15.33
1987	1.02	0.55	1.73	0.13	26.11	15.37
1988	0.65	0.28	1.82	n/a	25.30	15.08

Source: Calculations by the author, based on Tables A.4-A.11 data. Since MoA's production data reflect their estimate of yields in the various locations, yield data is ultimately based on local observations, as explained in Section 1.1.

Table A.13: **Per caput cultivated land area in Machakos District for FC, CC and HC in 1961 and since 1974**
(in hectares per head)

Year	*FC*	*CC*	*HC*	*Total*
1970	0.29	0.02	0.00	0.31
1971	0.30	0.01	n/a	0.30
1972	0.25	0.01	n/a	0.27
1973	0.23	0.01	n/a	0.25
1974	0.25	0.01	0.005	0.27
1975	0.24	0.03	0.006	0.27
1976	0.27	0.03	0.005	0.30
1977	0.29	0.03	0.006	0.34
1978	0.28	0.05	0.006	0.34
1979	0.21	0.05	0.004	0.27
1980	0.31	0.04	0.010	0.36
1981	0.29	0.04	0.012	0.34
1982	0.34	0.04	0.010	0.40
1983	0.25	0.05	0.010	0.31
1984	0.25	0.05	0.007	0.30
1985	0.33	0.04	0.015	0.38
1986	0.27	0.02	0.010	0.30
1987	0.27	0.02	0.010	0.29
1988	0.27	0.02	0.011	0.29

Notes: Commodity grouping as in Section 1.3 of this report.

Source: Computations by the author based on Table A.3 data and the Machakos District past population data (as given in Table A.14 of this report). Note that food crop area is for two seasons.

Table A.14: Human population and development of per caput cultivated land area under maize and pulses in Machakos District in 1961 and since 1974

Year	*Human population*	*Per caput cultivated area*		*5 year mean*	
		Maize (ha)	*Pulses (ha)*	*Maize*	*Pulses*
1970	733,774	0.19	0.09		
1971	761,332	0.19	0.10		
1972	789,924	0.16	0.09		
1973	819,591	0.14	0.09	0.17	0.115
1974	850,371	0.13	0.11		
1975	882,308	0.12	0.11		
1976	915,444	0.15	0.11		
1977	949,824	0.16	0.12		
1978	985,496	0.16	0.12	0.144	0.114
1979	1,022,512	0.15	0.05		
1980	1,054,108	0.14	0.10		
1981	1,086,680	0.13	0.10		
1982	1,120,258	0.14	0.13		
1983	1,154,874	0.12	0.09	0.136	0.094
1984	1,190,560	0.09	0.08		
1985	1,227,348	0.19	0.13		
1986	1,265,273	0.14	0.13		
1987	1,307,370	0.14	0.13		
1988	1,344,675	0.13	0.13	0.138	0.12

Notes: Pulses comprise beans and grams, plus cowpeas and pigeon peas.

Source: Computations by the author for per caput cultivated land area.

Table A.15: Fertiliser distribution in Machakos District, 1984-87
(in metric tons)

Year	*Source*	*Type and quantity of fertiliser*							
		DAP	*TSP*	*20:20:0*	*ASN*	*20:10:10*	*CAN*	*Total*	*Remarks*
1984	MDCU	-	-	-	-	-	-	-	
	KGGCU	10.4	9.2	87.5	3.1	-	14.3	124.4	
1985	MDCU	-	-	-	-	-	-	-	MDCU records
	KGGCU	41.2	21.1	159.9	-	-	64.5	286.6	Not available
1986	MDCU	-	-	-	-	-	-	-	MDCU records
	KGGCU	55.1	14.8	241.4	7.4	12.6	81.8	412.9	Not available
1987	MDCU	-	-	997.9	519.4	291.3	1,230.7	3,039.3	
	KGGCU	45.44	13.40	1,291.0	511.0	520.3	75.5	2,456.5	

Notes: MDCU = Machakos District Cooperative Union
KGGCU = Kenya Grain Growers Cooperative Union

Source: Ministry of Agriculture (DAO), Machakos District, 1991.

Table A.16: Supply of fertiliser by KGGCU to farmers for food and horticultural crops production in Machakos District, 1988-90, on seasonal basis

		Type of fertiliser (bags of 50kg)							
		20:20:0	*20:10:10*	*DAP*	*CAN*	*ASN*	*TSP*	*MOP*	*23:23:0*
1988	L-Rains	2,571	206	2,716	1,303	4,590	-	-	
	S-Rains	11,991	4,685	1,860	2,965	56	-	20	
Total		14,562	4,891	4,576	4,268	4,646		20	
1989	L-Rains	2,268	946	1,924	1,479	119	-	11	
	S-Rains	288	171	802	1,131	185	24	0	2,877
Total		2,556	1,117	2,726	2,610	304	24	11	2,877

Notes: Data are from District Agriculture Office (DAO) of Machakos District. The survey was stopped after the long rains (L-Rains) season of 1990.

S-Rains = Short rains season
L-Rains = Long rains season

Table A.17: Supply of fertiliser for coffee production in Machakos District, 1987-90

	Type of fertiliser (bags of 50kg)				
Year	*20:20:0*	*20:10:10*	*DAP*	*CAN*	*ASN*
1988	13,826	7,590	-	5,495	13,946
1989	9,400	12,340	300	-	-

Source: Ministry of Agriculture, Machakos District (DAO), 1991.

Table A.18: Average gross national producer prices for various crops in Kenya, 1965-88
(in Ksh per kg)

Year	*Maize*	*Cotton*	*Clean coffee*	*Sisal*
1965	0.36	1.04	6.67	1.22
1966	0.40	0.95	6.54	1.08
1967	0.35	0.95	5.83	1.08
1968	0.31	0.98	6.40	0.93
1969	0.28	0.98	6.30	0.90
1970	0.28	0.99	7.48	0.78
1971	0.33	1.05	6.36	0.68
1972	0.39	1.15	7.79	0.90
1973	0.39	1.22	9.21	2.42
1974	0.46	1.55	10.08	4.43
1975	0.70	1.92	10.68	3.43
1976	0.77	2.09	25.24	2.63
1977	0.89	2.88	39.75	3.06
1978	0.77	3.15	28.18	2.82
1979	0.89	3.28	28.35	3.73
1980	0.95	3.31	26.35	4.23
1981	1.00	3.41	22.58	4.12
1982	1.08	3.52	27.80	5.03
1983	1.54	3.81	34.88	6.25
1984	1.75	4.48	38.44	6.74
1985	1.87	4.80	39.72	6.69
1986	1.98	4.70	50.20	7.43
1987	2.09	4.82	36.62	7.05
1988	2.24	5.86	44.65	7.45

Source: Statistical abstracts and farm management handbooks of Kenya, various annual publications.

Table A.19: Average producer prices for various crops in Machakos District, 1977-88

Year	*Maize*	*Cotton*	*Mixed beans*	*Clean coffee*	*Pigeon peas*	*Green grams*	*Millet*	*Sorghum*
1977	n/a	2.58	n/a	n/a	n/a	n/a	n/a	n/a
1978	n/a	3.23	n/a	n/a	n/a	n/a	n/a	n/a
1979	n/a	3.23	n/a	n/a	n/a	n/a	n/a	n/a
1980	n/a	3.27	n/a	n/a	n/a	n/a	n/a	n/a
1981	n/a	3.38	n/a	15.28	n/a	n/a	n/a	n/a
1982	n/a	3.63	n/a	18.98	n/a	n/a	n/a	n/a
1983	2.44	4.15	6.00	38.68	4.50	8.00	7.50	4.25
1984	3.56	4.64	7.50	27.04	6.50	9.00	9.00	5.25
1985	3.00	4.54	6.00	36.01	5.00	7.75	7.75	4.75
1986	3.11	4.53	6.50	50.25	5.63	8.75	7.88	4.00
1987	3.00	4.50	6.75	30.88	6.75	9.88	8.00	6.00
1988	3.22	5.43	6.75	45.44	8.75	9.00	9.00	3.94

Notes: (i) Prices for cotton and clean coffee are derived from the recorded purchases and the value of the purchased produce by the Machakos District Co-operative Union (it is assumed also that 6.5 kg of coffee cherry yield 1 kg of clean coffee).

(ii) Prices of the other types of produce are derived from the recorded production and the value of production in the Machakos District 1989/93 Development plan.

Source: As per above notes, but calculations by the author.

Table A.20: Producer prices of maize, mixed beans and clean coffee in Machakos District, 1956-63
(Ksh per kg)

Year	*Maize*	*Mixed beans*	*Clean coffee*
1956	0.29	0.38	-
1957	0.32	0.48	9.00
1958	0.36	0.56	7.75
1959	0.33	0.48	8.84
1960	-	-	-
1961	-	-	-
1962	0.33	0.77	5.57
1963	0.22	0.40	4.94

Source: Calculations by the author, based on recorded production and value of production in various back issues of Machakos District annual reports.

Table A.21: Reported producer prices of some agricultural produce in Machakos District in 1988

Commodity	*Price (ksh/kg)*
Maize	4.70
Mixed beans	7.70
Green grams	6.77
Cabbages/kale	6.72
Citrus fruits	5.00
Mangoes	1.00
Tomatoes	3.00
Okra	4.00
Passion fruits	2.00
Chillies	6.00
Brinjals	5.00
Karella	6.00
Pawpaws	2.02
Avocadoes	4.00
Sorghum/millets	4.00
Irish potatoes	3.00

Source: Machakos District Development Plan for 1989-1993.

Table A.22: Rural market prices for maize, beans and potatoes in Eastern Province, 1985-88
(ksh per kg)

Period and produce	*1985*		*1986*		*1987*		*1988*	
	March	*Sept.*	*March*	*Sept.*	*March*	*Sept.*	*March*	*Sept.*
Maize	3.30	2.27	2.90	2.86	2.43	2.54	2.93	2.74
Beans	9.97	5.70	4.66	4.12	3.96	4.35	6.97	5.55
Potatoes	3.00	2.83	2.57	2.55	2.41	2.18	4.34	3.67

Source: Economic Survey, 1989 (Central Bureau of Statistics, Kenya).

Table A.23: Maize terms of trade* relative to other commodities in Machakos District, 1957; 1977; and 1987

Commodity	*Terms of trade with maize*		
	1957	*1977*	*1987*
Clean coffee (kg)	28.1	29.5	10.3
Cotton (kg)	n/a	2.0	1.5
Sorghum (kg)	0.8	n/a	2.0
Mixed beans (kg)	1.5	2.7	2.3
Tomatoes (kg)	2.4	1.9	1.0
Oranges (kg)	2.8	n/a	1.7
Beef (meat, kg)	n/a	4.2	11.7
Cattle, head	470.2	583.1	717.7
Milk (litre)	1.6	1.5	3.1

* In terms of the kg of maize required in exchange of specified unit of the other commodities.

n/a = not available.

Source: Calculations by the author based on local price data from Peberdy, 1958 (for 1957), Onchere for 1977, Machakos District Development Plan 1989-93 for 1987.

Table A.24: Maize terms of trade* relative to beef cattle, milk, cotton and coffee in Machakos District, 1962-88

Year	*One head of cattle*	*One litre of milk*	*Kg coffee (clean)*	*Kg cotton*
1962	609.1	1.3	n/a	n/a
1963	666.7	1.2	n/a	n/a
1964	611.1	1.4	n/a	n/a
1965	647.2	1.5	18.5	2.9
1966	632.5	1.5	16.4	2.4
1967	760.0	1.6	16.7	2.7
1968	816.1	1.9	20.6	3.2
1969	982.1	1.9	22.5	3.5
1970	975.0	1.9	26.7	3.5
1971	863.6	2.1	19.3	3.2
1972	774.4	2.0	20.0	2.9
1973	887.2	2.0	23.6	3.1
1974	897.8	1.7	21.9	3.4
1975	677.1	1.2	15.3	2.7
1976	622.1	1.4	32.8	2.7
1977	583.1	1.5	44.7	3.2
1978	877.9	1.7	36.6	4.1
1979	774.2	1.5	31.9	3.7
1980	836.8	1.5	27.7	3.5
1981	960.0	2.2	22.6	3.4
1982	1018.5	2.0	25.7	3.3
1983	739.0	1.6	22.6	2.5
1984	628.6	1.4	22.0	2.6
1985	705.9	1.9	21.2	2.6
1986	757.6	3.0	25.4	2.4
1987	717.7	3.1	17.5	2.3
1988	803.6	2.9	19.9	2.6

* In terms of the kg of maize required in exchange of specified unit of the other commodities.

n/a = not available.

Source: Calculations by the author based on Tables A.19-A.21 and BB.7.

Table A.25: Maize terms of trade* relative to beef cattle, milk, clean coffee and cotton in Machakos District in the 1960s, 1970s and 1980s

Period	*Commodity and maize terms of trade*			
	Beef cattle (head)	*Milk (litre)*	*Clean coffee (kg)*	*Cotton (kg)*
1960s	715.6	1.5	18.9	2.9
1970s	793.2	1.7	27.3	3.3
1980s	796.4	2.2	22.7	2.8

* In terms of quantity (kg) of maize required in exchange of specified unit of the other commodities.

Source: Calculations by the author based on Tables A.19-A.21 and BB.7.

Table A.26: Value of production in maize terms, 1977 and 1987

	1977			*1987*			
	Output 000 tons	*Maize value[1]*	*Total value[1]*	*Output 000 tons*	*Maize value[2]*	*Total Value[1]*	*Total value[2]*
Maize	141.1	1.0	141.1	182.0	1.0	182	182.0
Pulses	44.8	2.7	121.0	91.1	2.3	246.0	209.5
Cotton	1.9	2.0	3.8	1.4	1.5	2.8	2.1
Coffee	15.0	29.5	442.5	25.6	10.3	755.2	263.7
Fruits	24.1	1.7	41.0	110.2	1.7	187.3	187.3
Vegetables	1.9	1.9	3.6	43.7	1.0	83.0	43.7
TOTAL			752.9			1,456.3	888.4

Notes: Mz value[1] = kg of maize obtainable from kg of product, 1977.
Mz value[2] = kg of maize obtainable from kg of product, 1987.
Total value[1] = Value of total output in maize terms, at 1977 exchange rate.
Total value[2] = Value of total output in maize terms, at 1987 exchange rate.

B. LIVESTOCK PRODUCTION

A.C. ACKELLO-OGUTU

1. DATA AND METHODOLOGY

The exogenous variables influencing development in the livestock sector are assumed to be rainfall; population growth and density; and government policies on prices, land tenure, resettlement and public services. Ideally, one would wish to quantify the correlation between these variables with the endogenous ones implicit in the farming system (e.g. crop-livestock mix, management, resource endowment and farm income), environment and livestock characteristics. Such an exercise would, however, be hampered by both data quality and quantity.

The interpretation of livestock data over time is made difficult by boundary changes, and changes in the methods of estimating numbers. In the early part of the period covered by this study Department of Agriculture[1] estimates were based mainly on a multiplication factor applied to the numbers of cattle inoculated in the rinderpest campaigns (Durand, personal communication). Currently, estimates are based on dipping statistics. There have been sporadic attempts to get more accurate figures through censuses and sample surveys or, recently, an aerial survey, but different methodologies have provided different answers. Each method has its own defects and the results are not comparable. As far as possible, livestock distribution is related to agro-ecological zones (AEZ).

We therefore adopt a descriptive approach whereby trends in the endogenous variable indicated above are rationalised on the basis of known changes in the exogenous factors. Even this compromise is no mean task for a span of over 60 years as ventured by our objectives. We rely heavily on information from District Annual Reports which, despite their unreliability, provide approximate information on major trends. Most of this information is reported in the Annex Tables BB.1 et seq.

In sections dealing with management, income and resource availability, the household rather than the individual owner is the general unit of analysis.

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[1] Livestock have sometimes been included in the Ministry of Agriculture, and sometimes have had a separate Ministry. Departmental is here used to refer to the District Annual Reports of whatever was the relevant Ministry at the time.

2. THE CONCEPT OF CARRYING CAPACITY, AND THE ROLE OF LIVESTOCK IN ENVIRONMENTAL DEGRADATION

2.1 Estimates of Carrying Capacity

The concept of a carrying capacity which must not be exceeded if environmental damage is to be avoided has caused a long conflict between expert views and Kamba practice. It is now generally recognised that overstocking may result either from large human populations with each family striving to keep enough stock for its survival, or, when farmers keep livestock far in excess of what is needed for survival. The main problem in Machakos has been perceived as the former, combined with maldistribution so that some farmers had large herds while other farmers had none. For the 1960s, Owako (1969) states that:

> *. . . the livestock problem now appears to be more of paucity in numbers and maldistribution in ownership, rather than one of excessive numbers and overstocking.*

The author further states that the relatively small numbers kept by individual households were often in excess of the available grazing. A similar conclusion was reached by the Carter Commission in 1933 (Kenya Land Commission, 1934).

Over-stocking was discussed from 1925 and stern measures were taken through coerced livestock sales and controlled grazing in order to halt the environmental degradation arising from it. In our limited field interviews, older farmers admitted that families used to have larger herd sizes in the 1930s and 1940s, and that there was over grazing. However, at the time, the elders blamed the negative environmental consequences on God for the droughts, and the government for confining them and their cattle to fixed boundaries (KNA: Lambert, 1945). By contrast, M.H. Grieves, the agricultural officer wrote, in 1946:

> *It is obvious to me that until the population and stock striving to live off the land in the Machakos Native Reserve are reduced to the figures shown in the schedule . . . the land . . . is bound to deteriorate still further despite reconditioning measures or even a spell of good rains* (KNA: DC/MKS/2/7/1362).

Grieves felt that the reserve including Yatta could only support 75,000 cattle instead of the 200,000 it contained, given the estimated carrying capacity in its then degraded state, which is shown in Table B.1. The District Officer realised that such a reduction in the people's main assets would be unacceptable, and that they needed at least 200,000 cattle to support themselves.[2]

Estimates of *potential* carrying capacity if the area were reconditioned were based on the practice of white farmers, without allowing either for the fact that most ranches were in AEZ 5, while most Kamba then lived in AEZ 2, 3 and 4, or that there were differences in manage-

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[2] Draft Machakos District Post War Development Plan, Rhodes House.

Table B.1: Estimates of carrying capacity

Zone	*Rainfall(mm/year)*	*Estimated carrying capacity ha/stock unit* [a]	
		1970s	*1940s*
2 & 3	Over 1000	1.0 - 3.0	6.0
4	750 -1000	4.0	12.0 - 18.0
5 & 6	below 750	6.0 - 15.0	20.0

a. In the 1940s and for some time afterwards, a stock or grazing unit (SU) was one zebu cow, taken as equivalent to 5 shoats. The modern standardised livestock unit (LU) is 250 kg.

Source: 1970s: Luning, 1973; Braun 1977 and Jaetzold and Schmidt, 1983.
1940s: derived from estimates quoted by Silberfein, 1989:68.

ment objectives. It was also generally felt the Kamba farmers could not attain the management standards of the European farmers:

> *In the Machakos Settled area [ie white-farmed] experienced farmers, after some 30 years skilled and intensive farming supported by a good deal of feeding, reckon their land carries one beast to 8-10 acres [3.2-4.0 ha]. These farms represent the better stock country, and large areas could never reach this standard, nor can it be expected that native farming would ever reach this degree of excellence in the reasonably near future. The permanent stock carrying capacity of the Reserve cannot therefore be put at a higher figure than 12 acres [4.8 ha] per stock unit . . .* (KNA: MKS/DC/1/8/1, 1945).

The whole concept of carrying capacity is now under question (see Environmental Profile, Section D: Natural Vegetation). It is likely that there were serious misconceptions by both the colonial government and Kamba farmers regarding carrying capacity and stocking rates, especially when viewed against the resilience of pastoral lands. Indeed, colonial officers were surprised by the quick recovery of grazing land on the experimental Makaveti square mile, and as a result by the 1950s, were estimating that with good management, cattle needed only 0.4 to 1.6 ha per beast (KNA: Machakos District, Annual Report, 1955). In the Makueni area, they reduced their estimates from 4 ha to 0.8 ha (Huxley, 1960:199), thus rating carrying capacity above the estimate for AEZ 4 made in the 1970s, also shown in Table B.1. Currently farmers in Makueni reckon that with good management, some planting of improved grasses and use of crop residues including sweet potato and cow pea tops, one cow needs only 0.4ha.[3]

Table B.1 shows that, however calculated, estimated carrying capacity improves as one moves up along the rainfall gradient; from zones 5 and 6 to zones 2 and 3. Carrying capacity is

[3] Mr Onesmus Musyoki, a former agricultural officer in the Makueni settlement, and currently farming, personal communication, 1991.

not necessarily positively correlated with stocking rates due to the intervening factors of population density, use of crop residues and hedgerow fodder and other management practices. Also, the standard estimate is for year-round weight maintenance, whereas Kamba owners accept periods when the animals will lose weight (ADEC, 1986:6-30). When talking about carrying capacity, it is important to note that it can be modified through management, for example by stall-feeding and watering, improvements in grazing land management, and by moving livestock seasonally. The latter was possible pre-independence but increased demand for farm land, privatisation and fencing of holdings has now made it virtually impracticable. The improvement in the estimated carrying capacity of the land has coincided with privatisation of grazing land.

2.2 Goats and the Environment

Goats were specifically blamed for much of the environmental degradation noticed in the 1930s. Pole-Evans summarised the reports of Maher and others as agreeing that 'goats are the worst offenders so far as erosion is concerned'. Maher recommended the elimination of all goats (Pole-Evans, 1939). Later, goats were given a partial official rehabilitation, and in the 1950s were recognised to play a useful role in preventing bush encroachment.

In 1977 there was still lack of information on this topic:

> *The proper role of both sheep and goats along with cattle and other species in management of land resources urgently needs clarification and exploitation. There is little doubt that the proper role will embrace the concepts of multi-species production systems and multiple use concepts of land.* (Consortium, 1978, Report 8:6, quoting a 1977 report by Winrock International Livestock Research and Training Centre).

Current literature and official documents rarely mention the goat as an environmental problem. The Kamba have always kept both cattle and goats, with lesser number of sheep.

3. CATTLE AND SHOAT NUMBERS[4]

3.1 Changes in District Livestock Population

3.1.1 Cattle

Estimates over time of cattle numbers are shown in the Annex, Table BB.1. There was a census in 1930 which we can take as our baseline. It estimated 248,800 cattle. A veterinary officer was posted to the District in 1924 with a specific brief to compile livestock numbers, so that the data then probably compares in general accuracy to the

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[4] Shoats: used to denote both sheep and goats.

efforts made in later censuses. He also organised inoculations against rinderpest. In Machakos reserve 86,000 cattle were inoculated in 1924, 51,000 in 1925 and 28,000 in 1926, so the 1930 estimate does not look unreasonable.[5] The 1960 census estimated 222,000 cattle, and most intermediate estimates lay between the 1930 and 1960 estimates. Both the cattle and the population figures for 1930 apply to the Reserve population only. They show about 1 cattle per person. As the population increased and the cattle numbers remained static, cattle per person had fallen to 0.4 by 1960.

For the years after 1963 the cattle figures shown are for the whole of the present District, including the white settled areas. To get an earlier figure comparable with these we must add the European and squatter owned livestock in the white settled areas, which were previously counted separately. These numbers seem to have more than doubled between 1930 and 1960, rising from 21,000 to 50,000. Thus, in the area comparable to the current District, there were estimated to be 268,500 cattle in 1930, and 271,000 in 1960. For the period from 1979 to 1989 estimates have ranged from 300,000 to 476,000. Thus, the number of cattle carried by the District appears to have fallen 1930-60, and to have risen quite considerably 1960-90. However, as population has increased at an even faster rate, the number per head has fallen to 0.3 or less (see Table BB.1).

Our field surveys confirmed that droughts in the 1970s and 1980s, especially the severe droughts of 1975/6 and 1984, coupled with outbreaks of disease, as in 1989, led to serious livestock losses. We can assume that earlier severe droughts had a similar impact. Farmers' ability to increase livestock numbers through purchase since the 1984 drought has been constrained by unfavourable economic conditions in the country, but they make considerable efforts to rebuild their herds after droughts, particularly of plough oxen.

3.1.2 Shoats

Table BB.2 in the Annex shows available estimates of small stock over time. They show great variation from year to year. The influence of the 1975 and 1984 droughts can be seen clearly. The average for the six years for which we have data in the 1970s was 392,000; for the nine years in the 1980s it was 466,000. Both numbers are below the 1956 estimate of 482,000 for the smaller area of the reserve alone, implying a considerable fall in the number of shoats per hectare, and an even steeper fall in numbers per household. It should be noted that estimates of shoats are very difficult to make.

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[5] Cattle were supposed to be inoculated once as calves, and again a year later. Thus, the entire herd would not be inoculated; indeed, as the fee was quite high, many owners would not have been able to afford inoculation for all their cattle in the right age group.

3.2 Distribution of Livestock by Area

Table B.2 shows the livestock distribution in the 1940s and 1950s. The number of stock units per hectare relates to the total area of the location concerned, ie including cropped areas, etc. The stock unit used at the time was 1 cow = 5 goats = 1 stock unit. It is apparent that in the 1940s grazing density was much higher than veterinarians then thought sound. This was particularly the case in AEZ 4. Of the total, 23% were recorded in AEZs 2 and 3, and 71% in AEZ 4 in the 1940s. Very few 'native cattle' were counted in AEZ 6, though in fact, much stock was moved seasonally to the Yattas. (There were, of course, European-owned cattle on the ranchlands.) By 1956 the shift of cattle population to AEZ 5 and 6 had begun, as shown by the numbers in the new settlement of Makueni and the increase in Kikumbuliu. The shift is exaggerated by the figures, in that this estimate shows livestock numbers during their seasonal move to Yatta. During this period, actual numbers in AEZs 2, 3 and 4 do not seem to have fallen, but the reserve was accommodating more cattle through the settlement of new areas in AEZ 5 and 6.

The only available location figures for the 1980s are those derived from the aerial count made by Ecosystems in 1981 (Ecosystems, 1982:1B). These differ substantially from those of the Ministry of Agriculture and Livestock Development (MALD) ground-level census conducted in 1983 through chiefs and sub-chiefs as recorded in ADEC, 1986:6-9, shown in Table B.3. We prefer the MALD figures (because aerial survey methods miss substantial numbers of shoats and stall fed cattle, especially in highland areas,) but they are unfortunately only available on a divisional basis. Surprisingly, the greatest discrepancy in cattle numbers between the two surveys is in Kibwezi division, where most animals are herded. Here, MALD found 145,000 cattle, compared with 26,000 in Ecosystems. Data from household level surveys, quoted below, suggests that herds are larger in this area than in other parts of Machakos. The MALD data may be exaggerated, but the Ecosystems data seems, on the basis of household evidence, to be an undercount.

Table B.2 shows the cattle and shoat population in the early 1980s, as estimated by Ecosystems Ltd by aerial survey, and converted into stock units for comparison with the earlier dates (Ecosystems, 1982:1b). Despite the defects in the figures, the scale of the differences with the situation in the 1940s is such that we can say with certainty that the numbers in the high potential highland zones have fallen very substantially. This statement would still hold good even if Ecosystems had missed half the livestock units. If we double their numbers, there would still be only 25,000 stock units in the highlands, compared with 40-80,000 in the 1940s and 1950s. In consequence, there is now less pressure on highland fodder resources, but also, substantially less manure to apply to highland fields.

The number of stock kept in AEZ 4 has changed less. The huge expansion has been in AEZ 5 and 6, which now contain at least 60% of the District's livestock - more if MALD is correct on the Kibwezi figure. These animals are supported on about 5 hectares per stock unit, according to Ecosystems, or about 2 hectares if one relies instead on MALD's figures for Yatta and Kibwezi Divisions (Table B.3). This compares with the 3 to 4 ha the white settlers estimated as needed (possibly for larger beasts) but, Kamba farmers in these areas are using a higher proportion of their land for crops.

Table B.2: Livestock distribution, 1944, 1956 and 1981

Location	*SU 1944*	*SU 1956*	*ha/SU 1944*	*SU 1981*	*ha/SU 1981*
Iveti	14,800	12,605	1.78	2,247	2.31
Kangundo	10,800	16,445	1.41	1,479	9.40
Kilungu	12,400	18,985	2.80	3,297	6.76
Mitaboni		15,810	2,504	3.95	
Mbooni	11,200	15,580	2.45	2,950	8.24
Sub-total 2 & 3	**49,200**	**79,425**	**2.11**	**12,477**	**6.06**
Percentage	*23*	*22*		*4*	
Kalama	11,200	8,385	1.36	2,212	7.73
Kisau	26,000	7,935	1.05	5,493	3.88
Kiteta	10,000	8,270	2.38	1,358	5.82
Masii	20,000	13,155	0.91	3,861	3.94
Matungulu	14,400	10,515	1.26	20,636	2.22
Mbiuni		8,015		4,808	3.08
Mbitini	11,600	12,430	1.79	22,460	1.03
Mukaa	19,800	19,980	1.33	21,913	3.61
Muputi	2,600	8,795	4.58	1,283	1.48
Muthetheni				5,780	2.65
Mwala	26,000	19,535	1.24	4,579	3.78
Ndalani		na		19,566	2.98
Nzaui	7,000	14,170	5.22	9,155	6.64
Okia	2,800	12,005	2.31	1,968	7.06
Sub-total 4	**151,400**	**143,190**	**1.56**	**125,073**	**3.13**
Percentage	*71*	*40*		*37*	
Kibauni	11,600	12,110	1.94	10,980	3.35
Kikumbuliu	1,850	25,790	10.92	27,136	6.20
Kinyatta		10,000		13,967	4.03
Makueni		12,660		42,367	3.12
Masinga		17,600		37,798	3.47
Ngwata				15,200	11.30
Settled Areas		40,098		44,189	2.93
Wamunyu		15,255		4,685	4.01
Sub-total 5 & 6	**13,450**	**133,513**	**3.18**	**196,324**	**4.30**
Percentage	*6*	*37*		*59*	
TOTAL	**214,050**	**356,128**	**1.79**	**333,874**	**4.38**

Source: 1944 - Silberfein, 1989, Table 4.2
1956 - Peberdy, 1958
1981 - Ecosystems, 1982, 1B

SU = Stock unit = 1 cow or 5 shoats
Sub-totals are for Agro-ecological Zones.

Table B.3: **Distribution of livestock by Division, 1983**

Division	*Grade cattle:*			*Indigenous cattle:*			*Total*	*Total*
	cows	*heifers*	*bulls*	*cows*	*heifers*	*bulls*	*cattle*	*shoats*
Kangundo	1,749	110	835	10,494	6,200	6,200	28,811	29,453
Iveti	14,259	10,632	8,661	23,986	18,159	18,218	93,915	62,237
Makueni	4,839	3,000	2,119	15,495	10,036	14,917	50,406	84,246
Mbooni	1,893	710	641	11,998	7,353	11,286	33,881	39,602
Yatta	1,626	1,202	931	38,818	27,171	19,940	89,688	91,239
Kilome	1,748	926	682	13,659	6,563	7,832	31,410	29,829
Kibwezi	14	6	7	54,563	44,050	46,624	145,264	239,776
Totals	26,128	17,586	13,876	169,013	119,532	127,240	473,375	576,651

Source: Adapted from ADEC, 1986, who quote Ministry of Agriculture and Livestock Development, Machakos.

Both sets of figures, even the higher MALD one, shows a considerable fall in the density of livestock per hectare compared with the position in the 1940s. The larger livestock population is now spread over a much larger area, due to the spread of settlement and the retreat of tsetse. Note that in both cases, the hectare figure includes cropped and other land in the administrative unit concerned. As shown in Section A, the proportion of land under crops has increased, but cropped land, as we shall see, still provides some fodder.

3.3 Distribution of Livestock among Households

Comments in District Annual Reports and observations by Lambert (KNA: Lambert: 1945) suggest livestock, and particularly cattle, have never been equally distributed amongst households. A few households have large numbers, some have a few, and a proportion own none.

Table B.4: Livestock per farm household in the 1960s

Location	*AEZ*	*% Cattle*	*% Plough*	*Average owned*	
				Cattle owners	*Shoats owners*
Kangundo	2-3	69	34	2.6	1.0
Iveti	2-3	48	na	2.8	1.1
Mbooni	2-3	66	23	2.0	1.8
Masii	4	88	na	7.0	8.1
Nzaui	4	77	56	9.6	10.3

Source: Owako, 1969: 170. Owako did not collect plough data in Iveti and Masii. Average includes those with zero holdings.

Owako's figures, shown in Table B.4, indicate that in the 1960s the proportion of farmers without cattle was as high as 50% in Iveti whereas in Masii only 12% of the farmers were without cattle. He also found a considerable range of herd sizes, with some extremely large owners, so that modal holdings were below the figures suggested by averages (Owako, 1969). Herds were on average already small in the highland areas in the 1960s.

Table B.5 gives an impression on the size and structure of herds at farm level in the late 1970s and early 1980s. It is important to note that the two entries for 1985 reflect the situation after the 1984 drought. We have no recent farm survey data for AEZ 2 and 3, except for our own limited interviews, tabulated in Table B.6.

Rukandema et al. (1982) found ownership of sheep to be invariant to farm size but the number of cattle and goats is reduced by about 50% as the farm size drops from 10.0ha to 2.0ha and below, as shown in Table B.6. It is also worth noting that there is a danger of overstocking at low farm sizes especially in divisions with limited off-farm grazing land. However, as we shall see, more intensive production techniques are being adopted in the more densely populated locations such as Masii, Kangundo and Mbooni.

Table B.5: Herd composition at household level, 1980s

Area	*Date*	*Cattle*	*Sheep*	*Goats*	*Shoat/cattle ratio*
AEZ 2 & 3	1979-80	4.9+0.9*	2.37	3.8	1.05
AEZ 4					
Nzaui	1979-80	11	9	17	2.3
Mwala	1979-80	7	3	10	1.8
Mbiuni	1980	5.8	1.4	4.75	1.05
4 locations	1979-80	4.7	1.6	5.4	1.48
AEZ 4 & 5	1985	36	13	45	1.6
District	1985	4.49	2.4	6.8	2.05

Source: Nzaui (Pollard, 1981); Mwala (Rukandema, 1981); Mbiuni (Gielen, 1982); 4 locations (Meyers, 1982); AEZ 2 and 3 (Jaetzold and Schmidt, 1983) Mbooni; cattle figures are for zebu and grade. AEZ 5 and 6 (Mukhebi *et al.*, 1985); District (ADEC, 1986).

* 0.9 grade cattle.

Table B.6: Livestock holdings and farm size

Farm size category	*Cattle*	*Goats*	*Sheep*
I. 0.1 - 2.0 ha	4	5	2
II. 2.1 - 5.0 ha	5	9	3
III. 5.1 - 10.0 ha	8	13	3
IV. Over 10 ha	11	13	3
All farms average	7	10	3

Source: Rukandema *et al.*, 1982, pp. 9 and 10 (survey in Mwala).

Table B.7 based on farm level interviews gives an impression of the changes over time in cattle herd sizes and structure made by older farmers in selected locations. The table confirms the disparity in cattle ownership between locations. The small herd sizes in the more densely populated locations such as Kangundo and Mbooni are easy to explain.

Many Makueni and Ngwata farmers reported that they lost cattle on their move south in the period c 1950-75, and therefore started with relatively small numbers (none for the early immigrants to Ngwata, because of tsetse). They implied they had subsequently built up

herds, but that the previous year, they had lost substantial numbers from disease. As we have already seen, herd numbers fluctuate.[6]

Table B.7: Herd size and structure per household at start of farming (before) compared to 1990

Location (sublocation)	*Before* [a]				*1990*			
	PO	*OB*	*C*	*Total*	*PO*	*OB*	*C*	*Total*
Kangundo (Muisuini)	4.2	2.0	2.0	8.0	3.3	2.5	2.7	8.5
Mbooni (Nzeveni)	2.0	0.0	3.7	5.7	2.0	0.0	1.9	3.9
Masii (Embui)	2.6	9.0	10.1	21.7	4.5	2.7	7.9	15.1
Makueni (Wote)	3.4	6.3	15.5	25.2	2.7	3.2	4.2	10.1
Ngwata (Muthingiini)	4.0	1.5	15.5	21.0	3.2	3.0	16.0	22.2

PO = Plough oxen
OB = Other bulls
C = Cows

Notes: a. Only 8 out of 41 respondents reported starting farming after 1970. We can therefore safely say that figures for 'Before' refer to years between 1940 and 1970.
b. Excluding zero entries.

Source: Author's Field Survey, 1990.

Three conclusions can be drawn from the above tables. The first is that livestock ownership at the household level has declined between 1940s and 1950s on the one hand and the period post-independence on the other. The reduction seems already apparent by Owako's 1964 survey. Secondly, inequality in livestock ownership exists not only among households within a location but also among locations and AE Zones.

The final conclusion is that there is a correlation between livestock ownership (in terms of numbers, herd composition and distribution) and the land/population ratio. This relationship directly influences long term trends in district livestock numbers, management and off-take.

[6] The early losses on the move are confirmed by interviews carried out amongst new settlers in 1973 (Matingu, 1974) which indicated that stock unit ownership averaged 17 before migration and dropped to 15 after migration to Makueni. For the Yatta immigrants, the figures were 12.6 and 5 respectively. The reports of losses through disease in 1989 were confirmed by the District Livestock officer.

4. LIVESTOCK TYPES, HERD STRUCTURES AND BREEDS

4.1 Livestock Types

The major types of livestock currently found in the district are cattle, goats and poultry. There are substantially fewer sheep than goats, since goat meat is the preferred food. As Annex Tables BB.2 and BB.3 show, pigs and rabbits are unimportant in this district, and there are very few donkeys (ADEC 1986). Honey collection is also important, particularly in the southern part of the district, where many farmers have hives.

4.2 Cattle Breeds and Herd Structure

The East African Zebu (live weight at 3 years 200-400kg) is still by far the most common but Boran, Sahiwal, Simental and crosses of exotic breeds are also gaining popularity as beef cattle. In the highland locations where dairy production under zero-grazing is gaining acceptance, Zebu crosses with Friesians, Ayrshires can be found (locally known as grade cattle).

It is reported by de Wilde et al. (1967) that in 1962 there were only 60 European type cattle in the Reserve area. Poor management and East Coast fever caused losses amongst early adopters, leading to the abandonment of pure breeds for some years. However, dairy cattle have been increasing by as much as 11% annually since 1983 compared to only 2% annually for beef cattle thus indicating farmers' responsiveness to prices (Ministry of Planning, District Development Plan 1989-1993). Numbers were estimated to have risen from 10,000 in 1980 to 32,000 in 1989.

The distribution of livestock according to the census conducted by MALD in 1983 has been shown in Table B.3. The high proportion (58%) of grade cattle in Iveti division may be explained by its proximity to Machakos town and hence veterinary services and milk marketing outlets. This Division also now contains some of the ranching area. The proportion of grade cattle, especially for dairying has grown rapidly since 1983, despite the drought. Farmers, particularly in the highland areas, but also in AEZ 4 areas like Masii with good communications to Machakos, are realising that it makes sense to have fewer, more productive beasts. We were frequently told that grade cattle produce more milk, and more manure.

The proportion of bulls is high for both grade and indigenous cattle, especially for the latter. The indigenous 'bull' figure includes plough oxen and bulls.[7] As farms, and herds, become smaller the plough oxen represent a larger proportion of animals owned. We can see this change most in Nzaui, where we were fortunate to find a record of herd structure in 1940, when the location had only 10 ploughs. Table B.8 shows that the proportion of bulls and oxen, taken together, had risen to 36% by 1980 compared to 12% in 1940. Plough ownership had risen from less than 1% to 62%

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[7] It appears that bulls as well as oxen are used for ploughing (Heyer, 1976),

Table B.8: Cattle herd structures, Nzaui 1940-80

Cattle	*1940*	*1960*	*1980*
Cows and heifers over 1 yr.	60%	n.a.	45%
Bulls and steers	12%	n.a.	27%
Oxen	0%	n.a.	9%
Calves	27%	n.a.	18%
Shoat/cattle ratio	2.9	1.05	2.4

Source: 1940 and 1960, KNA/DC/MKS, Nzaui file;
1980 Pollard, 1981, and own calculations.

4.3 Goats and Sheep

The dwarf or small types of goats (liveweight about 20-35kg) are the most common but the larger Galla and Boer crosses also exist. The Sheep and Goat Development project, aimed at popularising the dual purpose goat which has a higher milk output than the indigenous types, has not yet made a serious impact.

The sheep breeds found in the district are the fat-tailed black-headed Somali types (adult weight 35-45kg) and the Red Masai type. There is, however, considerable crossing.

4.4 Cattle/Shoat Ratios

Table BB.2 in the Annex shows the apparent fluctuations in the shoat/cattle ratio 1930-89. It has not changed much over time, being generally between 1.2 and 1.7. However, more detailed surveys at Location or household level frequently show higher ratios. Table B.8 has given the ratios found in Nzaui in 1940, 1960 and 1980. Findings in various household surveys 1979/1980 to 1985 have been shown in Table B.5. There is some indication from this table that numbers of shoats in relation to cattle are highest in those locations with most emphasis on livestock, and least in those where agriculture is more intensive. This is also the picture which emerges from Owako's observations in the mid 1960s (Table B.4). Our own interviews strongly suggested farmers had reduced the number of goats kept, especially if they had begun fruit tree farming.

5. LIVESTOCK USES, PRODUCTIVITY AND MARKETING

5.1 Cultural and Economic Value of Livestock

Many Kenyan tribes, the Akamba people included, have great affinity to livestock. Apart from livestock being used as a saving to be disinvested during hard times, they have other cultural and economic uses, including payment of dowry. Most households thus strive to keep stock but not all succeed.

Around 1945, community leaders said livestock was traditionally used for:

- dowry payment
- store of wealth and pride
- source of food (meat, milk, ghee)
- acquiring other property such as land or paying for taxes

With increased use of the plough and the advent of a more commercialised agriculture, livestock are now seen are seen as primarily valuable for

- cultivation (oxen and bulls)
- source of manure
- cash income
- food security in times of drought
- milk for sale or domestic use

While livestock are still important for income and emergency cash, there are now alternatives. In AEZ 2 and 3 a community leader said 'Now coffee is our cow.' In AEZ 5 another leader said 'A family with cattle is the same as a family with a graduate.'

5.2 Livestock Productivity

The measurement of productivity change in Machakos runs into the problem of the total absence of earlier bench mark data and the inadequacy of, or gaps in, information about the present status. Total livestock biomass per unit area can be used as a measure of productivity. However, this measure runs into problems either where livestock are not restricted to specified areas of land resource, as in pastoral systems, or where crop residues supplement grassland, as in agro-pastoral systems. In Machakos the best we can usually do is to measure livestock supported by location, including its cropped, grazing and non-farm land.

An alternative which is applicable to dairy oriented herds uses cattle performance traits such as cow reproduction, cow and calf viability, calf growth and cow weight to construct an index such as *total weight of weaner calf per cow per year* or *total weight of weaner calf per unit weight of cow per year*. These indices are related to weight of the breeding cow which in turn is related to costs of cow maintenance (ADEC 1986; Ackello-Ogutu 1990, Leeuw et al., 1984). Such performance measures have not been constructed for Machakos district thus

making it difficult to get an impression of trends in productivity as resource availabilities (land and labour) and management practices change. It is also difficult to say whether productivity in the highlands, where, due to land constraints, more farmers are zero-grazing dairy cows, is higher or lower than in the more arid zones such as Kibwezi and Makueni.

The following potential indices for smallholder farmers have been derived from the literature by ADEC 1986 who also state that the figures are considerably lower than those of large scale commercial ranches.

Productivity Index	*Range*
Calving (% per annum)	62-63
Cow survival (% per annum)	90-98
Calf survival (%)	87-95
Calf weight at one year (kg)	90-98
Cow weight (kg)	240-253
Milk off-take per cow to weaning (kg)	172-193
Productivity per 100kg cow per year (kg)	21-19

The only one of these measures where we have some data is milk off-take. Here it seems that the figures given above may underestimate the performance of the zebu, since an admittedly small survey which included six farms in Machakos District, which combined daily visits with some physical measurements, in the drought year of 1984, showed an average off-take of 1.54 kg milk per day after the calf had suckled, for a mean lactation length of 286 days, i.e., a total off-take of about 440 kg[8] (Tessema et al., 1985:38-41). The off-take might be 20-30% of total milk including that taken by the calf.

The Tessema average has to be contrasted with a survey in Yatta (Neunhauser et al. 1983), which found a lactation period of 150-180 days and a total off-take of less than 150kg. The ADEC survey in 1985, based on a single interview, reported 4-6 kg/day on average, which looks comparable with the Tessema figure if the calf's consumption is included. The Tessema survey also showed that more intensively managed cattle had higher productivity: off-take on small farms was 2.5kg milk compared with 1.8kg on large farms. There are genetic limitations to the productivity of the Kamba zebus, but they are well adapted to their harsh environment, and do respond to management factors. It is therefore likely that management changes introduced by many farmers, combined with the disease control measures instituted by government, have led to increased productivity, but we have no data from the 1950s on the estimated output of zebu cattle at that time. We have no information on the production of grade cattle in Machakos.

5.3 Marketing

Livestock products and by-products were mainly consumed or sold locally prior to independence in 1963. There was little sale of milk, though there were some ghee sales

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[8] Milk let-down in the absence of the calf at foot is very difficult to induce in the local zebu, (Tessema *et al.*, 1985:40).

(Peberdy 1958). Sales of milk appear on the district reports only post-independence and do not include unregistered local sales among households. Sale of hides and skins took place even in colonial times but they were also used locally for other purposes such as bedding, etc.

Because of the value of livestock as a hedge against drought and as a store of wealth animals used to be kept for as long as possible when favourable weather conditions prevailed. This of course meant that meat and hides were of poor quality and fetched low prices. There was, however, a difference between the low value of the meat for the export market, and the internal value of cattle. In 1929 it was reported (for Kenya generally) that:

> *Oxen as draught animals are paid for at a higher rate than they are worth as meat, and slaughter cattle are paid for at a much higher rate in local markets than would be possible were the export of meat and meat products the outlet.* (Cone and Lipscomb, 1972, quoting Harrison, 1929).

The higher value of cattle on the local market compared with the export market was one reason for the intense Kamba bitterness at forcible destocking and sales to the Liebig processing plant at low export prices in 1938. An African Livestock Marketing Organisation (ALMO) was set up in 1952 (ALUS, 1953, Annual Report for 1952). However, many veterinary officers continued to see marketing primarily as a means to destocking even in 1959 (according to a report on the marketing of African livestock) and tended to think that prices above the export value were in some way improper. It was reported in 1958 that ALMO could not compete with the 'inflated prices prevailing' (Jones, 1959:43).

Livestock sales outside the District were also discouraged by frequent and prolonged interruptions to movement from veterinary quarantines. The safeguarding of the 'valuable dairy industry' - the high-grade herds belonging to white farmers in the adjoining white-settled areas - was seen as even more important than destocking (ALDEV, 1962 and Jones, 1959:10). Nevertheless, there was an average annual export of 14,000 head of cattle from the District in the first half of the 1950s, after which the figures dipped. The high sales in the early 1950s are probably related to the frequent droughts in the period 1949-56 (see Annex Table BB.4). With the possibility of acquiring land or other investments (e.g. shops, transport vehicles, farm machinery, improved dairy cattle and children's education), new marketing patterns emerged, especially post independence. Table BB.4 shows external sales moved into a markedly higher gear from 1965 onwards. Figures are not available for the 1980s. Larger numbers are still sold during droughts; the role of cattle and shoats as a store of wealth and security against drought remains an element in owners' strategies.

External sales have always been supplemented by sales to the internal market which are largely reflected in the figures for hides exports. These seem to have remained remarkably constant at around 25,000 per annum from the 1930s to about 1968, which can only reflect a falling consumption of beef per capita as population increased. However, by the late 1970s the hides exports had risen to around 72,000 and in the 1980s to around 84,000 (Table BB.5).

Sales of shoats outside the District seem to have been an extremely important source of income in the 1930s and 1940s, when 45,000-60,000 were sold annually. After 1955 these sales fell substantially to between 10,000-20,000 annually. They only exceeded an average of 50,000 again in the 1970s, and that largely because of large enforced sales in the drought

years of 1975 and 1976 (Table BB.4). By contrast with cattle, shoat skin sales rose between the 1930s and early 1950s at a faster rate than population growth, indicating increased consumption. They then remained static or falling till about 1968, at around 115,000. From 1969 to 1981 they increased steadily, rising to 278,000. The figures suggest, however, quite a severe fall to 206,000 in the period 1985-89 (Table BB.5).

Taken together the hides and skins sales suggest a period of falling living standards (as reflected in meat consumption) 1950-68, followed by a steady rise, and a fall again after 1985. The latter finding is in accordance with the analysis of crop income in 1987 compared with 1977, in Section A.

5.4 Off-take Rates

Estimates of off-take[9] vary considerably thus suggesting their unreliability. For Machakos, ADEC (1986) estimated that the off-take rate for cattle was 17.5%, fairly close to an estimate of 19.0% obtained using 1985 MALD district hides and livestock population data. There is no information on sales on hoof outside the district. In 1985 off-take was probably low due to the drought and efforts to rebuild stocks. In some years it has apparently been higher. There is little consistency in estimates of off-take rates for sheep and goats.

A trend to higher off-take rates can be influenced positively by improvements in marketing infrastructure, farmer awareness and price incentives but negatively by adoption of more productive dairy breeds. Table B.9 seems to confirm this hypothesis, but it is not conclusive. The effect of the severe drought of 1975/76 is quite clear. After that period, sales of cattle, as judged by hides, seem to have remained at a level higher that of the 1950s and 1960s, and higher than the MALD estimate.[10] However, off-take figures must be interpreted carefully because of the difficulty of getting accurate records showing home consumption, purchases and trade in hides across boundaries. Occasional references in the literature mention purchases from the Masai. Slaughter and sale of cattle correlates with pasture conditions and provides a means of stabilising farm income (Silberfein, 1989).

Off-take rates for sheep and goats cannot be estimated from the available data, for, as we have seen, figures on total shoat population have many contradictions. Goats are slaughtered

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[9] A combined off-take rate (R) can be defined as:

$$R = [\text{sales} + \text{consumption}] - \text{purchases}$$

By adding annual net change in herd size (positive or negative) to R, a measure of total herd productivity could be obtained. Estimation of off-take rates, and its use thereof as an indicator of productivity for agro-pastoral systems, is problematic due to a strong tendency in such systems to retain surplus matures after they have reached market age. An important source of new stock is currently through purchase using funds from sale of land, wage employment or remittance from relatives employed mainly in urban areas. Off-take is impossible to calculate accurately from available data because of lack of information on consumption, local sales, and purchases.

[10] The 1957 and 1960 figures of cattle sales relate specifically to cattle exported live from the District. There is therefore no overlap with the hides collected from cattle slaughtered within the District. The 1976 cattle sales figure may include live cattle sold on to buyers within the District, or subsequently slaughtered.

more frequently than sheep or cattle for home consumption. About half of the combined off-take for small stock may thus be *market off-take* as far as we can deduce from figures provided by ADEC's household survey.

Table B.9: Commercial off-take

Year	*Cattle sales as % of total cattle*	*Hides as % of total cattle*	*Combined %*
1957	5.1	11.5	16.6
1960	5.3	13.9	19.2
1975	-	29.9	
1976	5.5	28.9	33.4
1985	-	19.7	
1986	-	23.0	
1988	-	20.3	
1989	-	15.6	

Source: Calculated from Tables BB.1, BB.2, BB.4 and BB.5

Note: Sales outside the District. Hides reflect numbers consumed and sold internally.

5.5 Sales of Minor Livestock Products

The data, especially for sales of livestock products such as milk, eggs and honey, are exceptionally scanty and thus difficult to graph. Milk sales, for which we were able to get records only for post-independence period, seems to be showing an upward trend but the effects of the drought years are readily seen (Table BB.6). Poultry are extensively sold and consumed locally but egg sales mainly are from a few producers. Honey is important in areas with bush land, but much probably escapes records.

6. LIVESTOCK MANAGEMENT

6.1 Feeding Systems

Potter (in Kategile, Said and Dzowela, 1987) summarised the feeding options available to smallholder livestock producers as follows:

- fodders and pastures
- on-farm by-products
- agro-industrial by-products
- bought-in roughage
- concentrates

Concentrates and agro-industrial by-products which are waste from processing of agricultural products such as sisal, coffee, sugarcane, pineapple, etc, are still not popular due to their unavailability and/or high cost. This section therefore looks at changes in the use of pastures, cut fodders, and on-farm by-products.

Table B.10 adapted from Potter (ibid.), gives a general picture relative to other relevant farm variables. The importance of grazing is apparent, as is also the inadequacy of a ration that depended solely on grazing and fodder crops. These foodstuffs are supplemented by crop residues but no accurate estimates of availability and use of these materials exist and they are not included in Table B.10. There is no information on whether livestock owners buy in roughage such as crop residues from non-livestock owners, but Potter observed them on sale by the roadside during the drought of 1984.

Table B.10: Characteristics of the livestock sector of smallholder farming in upper and lower parts of Machakos District

Variables	*Machakos*	
	Upper AEZ 2, 3 & 4	*Lower AEZ 4*
Farm holding size (ha)	4.5	5.6
Feed resources (ha/farm)		
- Fodder	0.2	0.0
- Grazing	2.3	2.7
Grazing and fodder as % of farm	27-66*	15-56*
Stocking rate (LU/ha)	1.3	2.6
Grade cattle (%)	20.0	7.0
On-farm forage production (Dry matter Kg/Year)		
- Fodder	440.0	0.0
- Grazing	2,150.0	3,320.0
- TOTAL	2,590.0	3,320.0
Kg/LU per day	2.2	1.3

* First figure for small farms, second for large farms.

Source: Potter, 1985, based on Jaetzold and Schmidt, 1983.

6.1.1 Pastures

Traditionally, the Kamba reserved areas for private grazing by establishing a cattle post, as well as moving seasonally to communal grazing in the Yattas or elsewhere. However, the grazing area, as distinct from cultivated land, was only private so long as it was used.

The authorities insisted on the demarcation of private grazing land with sisal or other hedging in 1938, as part of the campaign to halt degradation of communal areas. In

the more densely populated areas this affected most grazing land, but in less densely settled areas, such as Masii, private grazing was interspersed with areas still communally grazed as late as the 1960s (Owako, 1969). In addition to communal areas within some locations, there were more distant grazing grounds. Those on the Yattas were divided into Blocks by the authorities, which were grazed by licensed animals on payment of a fee, in rotation, in an attempt to prevent environmental degradation from overstocking. These restrictions became steadily more unpopular as the Kamba wished to settle these lands. At present, all grazing land is privately owned and demarcated. The proportions of farm land allocated to grazing land and fodder production in about 1979 is shown in Tables B.10 and B.11.

In Table B.10, the Upper Zone area sampled was Mbooni, where farmers have been the leaders in taking up improved livestock breeds, and where they have allocated a high proportion of their land to fodder crops and grazing. They also cultivate coffee, so that a relatively small portion of their farm produces crop residues useful as fodder. In the lower zones the average farm is bigger and has a larger area of arable crops, and the proportion of grazing land is smaller for any given farm size. In the lower zones indigenous livestock breeds still predominate.

Table B.11 is based on our farm level interviews in 1990, which were unrepresentative in terms of farm size, but covered a wider range of locations and agro-ecological zones than Jaetzold and Schmidt (1983). It is worth noting that in all the locations (except Kangundo), land allocated to grazing constitutes at least 45% of the total farm area, suggesting the important role livestock plays in the district. The proportion of land allocated to crops in high density locations such as Kangundo and Mbooni is higher than in lowland Machakos areas, reversing the finding of the 1979 survey. It is not claimed our sample was representative, but the combination of the 1984 drought and farm sizes which have grown smaller may mean that the proportion of land given to crops has increased in this zone.

Although a significant proportion of farm land is allocated to livestock as implied by the above table, several factors may be interacting to cause a reduction in grazing land available to families and restricted livestock mobility.

These are:

- rapid population increase;
- settling of dry season grazing zones and their conversion to arable land and private grazing land;
- labour shortage arising largely through increased school enrolment of children and non-farm employment of family members.

The enclosure of grazing lands has led to a change in labour requirements and roles. Young men no longer take the animals to seasonal, distant pastures. School children still play an important role in fetching fodder and water and herding of livestock before and after school daily and during weekends and holidays. Among the poorer

Table B.11: Land use averages, 1990

Zone Grazing	*Location*	*Farm size ha*	*Crops ha*	*(%)*	*Fodder ha*	*ha*
2 & 3	Mbooni	4.2	1.8	(43)	0.1	2.3
	Kangundo	8.4	4.4	(53)	0.1	3.9
4	Masii	18.6	4.0	(22)	0.1	12.0
5	Makueni	13.8	4.4	(32)	0.4	8.6
	Ngwata	16.2	5.8	(36)	0.0	10.0
Sample average		30.5	10.2		0.3	18.3

Notes: a. Land allocated to crops, fodder and grazing does not tally with total farm size due to inclusion of zero entries in averages.

b. Negligible land is allocated to fodder production in practically all the locations.

Source: Own interviews.

families, these activities may interfere altogether with school attendance if family survival depends on active and full participation of all family members, irrespective of age. With the adoption of zero-grazing and the tethering of goats, labour requirements and roles may have undergone a further change. However, fetching of fodder and water still remain as labour-intensive activities. Tessema et al. (1985:21) found that on 18 farms in 3 districts, including Machakos, livestock care took an average of 16 hours per day (more than one person taking part), with herding and watering accounting for 13 hours. This was in a drought year; when rains are good it is probably reduced to 1-2 hours per day. Smaller farmers with holdings less than 2.0 ha are relatively more heavily overstocked and have to rely more on external grazing land (unfenced communal or on other farms by payment of a fee). These are limited to walking distances. In Yatta, Neunhauser et al. (1983) report that a distance of 3km from the boma is on the high side.

Within the private grazing area, 83% of cattle in 1981 were what Ecosystems described as free range (Ecosystems 1982:1b). The remainder were observed to be tethered or in small paddocks. The percentage of free range varied from over 95% in the former ranch lands and Kikumbulyu to below 50% in AEZ locations Kiteta and Okia. It was apparently around 60% in AEZ 2 and 3 locations, but, as already observed, Ecosystems were probably unable to count all tethered and stall fed cattle in these areas.

In our own interviews in 1990 we found that although animals may be rotated seasonally from the cropped land to the grazing land, the grazing area is rarely divided into paddocks grazed in rotation, (which would require additional investment in fencing). However, on small farms owners tether both cows and goats. In the densely populated areas with small farms zero grazing is practised, either the whole

year round or seasonally. The variation among agro-ecological zones and also among families is shown in Table B.12.

Table B.12: Cattle feeding methods (number of farmers)

Location (Sublocation)	*Graze on farm*	*Paddocks on farm*	*Zero-grazing always*	*Zero-grazing partly*	*No stock kept*
Kangundo (Muisuni)	-	-	4	3	1
Mbooni (Nzeveni)	1	-	7	-	-
Masii (Embui)	5	-	1	3	-
Makueni (Wote)	6	2	-	-	-
Ngwata (Muthingiini)	5	-	-	1	2
Total	17	2	12	7	3

Source: Own interviews, 1990.

The main form of management of grazing areas, is cutting of bush and unwanted grass species depending on types of animals owned, planting of creeping grass on bare patches and fencing[11].

6.1.2 Fodder and cut grasses

In the upper zones, small farmers are now growing fodder, mostly on terrace banks. ADEC 1986 reports that only about 20% of the farmers in Machakos grew fodder. It may be becoming more widespread in AEZ 2 and 3, and in the parts of AEZ 4 that are going in for dairying.

In AEZ 5 and 6 farmers do not grow fodder but a few are able to make use of cut grasses from sources external to the farm. In Yatta, 8.5% of the farmers fed cut grass obtained from the river beds, especially to calves.

6.1.3 Crop residues

Fodder in the form of crop residues is also fed to animals either on the fields or when cut and brought into the boma or homestead. Common types are:

(a) maize stalks: with negligible digestible crude protein;

(b) bean straw: 45% digestible nutrients and 3% digestible crude protein;

[11] See interviews reported in Environmental Profile, Section D: Natural Vegetation. The bushes within the grazing area are managed to produce timber and fuel.

(c) pigeon peas and cowpeas residue.

In Yatta in the early 1980s 46% of owners let their animals on to the crop fields after harvest. The others used the more labour intensive method of cutting and storing crop residues (mainly in tree branches) to prevent erosion and damage to terraces (Neunhauser, 1983:43).

6.1.4 **Feeding methods, 1990**

The impression one gets (and it is only an impression due to the small sample size) is that one is likely to find the majority of farmers still grazing freely on their farms compared to those grazing in paddocks or zero-grazing.

Zero-grazing and paddocked grazing is likely to be common in the densely populated locations such as Mbooni, Masii and Kangundo.

6.2 Watering and Water Availability

Many farmers say that they are having to travel longer distances to get water than in the past. This may well be the case because increased arable farming activities (leading to increased siltation of dams) and cultivation along river beds may be lowering the water levels. It is also due to the enclosure of farms: livestock can no longer be grazed close to water sources unless the farmer's own land borders a river or dam. Farmers can acquire water through water use contracts or associateship. Water use rights can be awarded in exchange for specified services, as with grazing rights.

Recently, farmers with iron-roofed houses harvest rainwater. However, the water collected is usually enough only for domestic use, except in the short and long rains which, combined, last for hardly four to five months. Water availability has been a major problem in the district for several decades.

6.3 Drought Management

Droughts have a major impact on livestock numbers. Good harvests mean that food can be stored as long as possible to avoid unnecessary sale of livestock to purchase food. This was obviously not possible in 1975/76 drought. The same procedure of selling livestock is revisited each time there is drought and for those without adequate livestock, starvation can only be avoided through famine relief, which has a long story in the district.

After the 1975/76 drought, many livestock owners were left vulnerable to other economic factors as livestock keeping conditions became more strained due to a weak support from the cropping enterprises, poor pastures, limited land due to increased human population and a felt need to invest in children's education. All these factors have created a destocking pressure to cope with increased expenditures (school fees, taxes, hospital and food bills) or merely to match livestock numbers to the reduced land resource and herding labour. Even in the light droughts of 1980 farmers in Nzaui lost 23% of their cattle and 28% of their goats (Pollard,

1981). And then in 1984 there was another major drought. Farmers in southern Machakos lost 61% of their cattle and shoats through deaths (46% of cattle and 34% of shoats) or through sales, and slaughter for home consumption (Mukhebi et al., 1985 and 1991).

Until the District was fully settled, the main recourse in the event of drought was to seek out additional grazing land, if necessary a considerable distance from the farm. Thus, in the 1949 drought, the District Commissioner recorded 'repeated requests for extra grazing' (KNA: Machakos District Annual Report, 1949). In 1984 a move to distant grazing areas was still the main recourse of stock-keepers in the neighbouring Kajiado District, particularly amongst those with group rather than individual ranches. However, in south Machakos, 66% of farmers continued to graze their cattle mainly on their own farms in the 1984 drought (compared with 20% in Kajiado). Nevertheless, southern Machakos farmers lost a smaller percentage of cattle through death (46% against 70%) and were able to sell more (15% against 6%). There was a similar pattern for sheep and goats; goat owners suffered a 27% destocking from death, sold 29% and consumed 5%. The comparative figures in Kajiado were 37, 11 and 2%. In addition, the post-drought recovery in the number of animals kept was more rapid in southern Machakos than in Kajiado. This was due to:

> *availability of crop by-products, including crop residues because of crop failure; a higher percentage could be consumed, because of the smaller number per household; a large number could be marketed because of proximity to the farm; recuperation rates were higher because of the better general condition of the herd.* (Mukhebi et al., 1991).

The availability of early maturing or drought resistant (or drought evading) crop varieties has livestock benefits. The joint management of crops and livestock and the purchase of a few grade cattle to replace a larger number of less productive cattle and small stock are new elements in farmers' drought management strategies.

Within the livestock enterprise, drought strategies traditionally meant that herds featured high female ratios and that small stock were retained in large numbers, with the larger stock sold or killed last in case of drought. This strategy is still prevalent but as already noted earlier, shoat/cattle ratios have declined especially since the middle of 1970s, while the male element in cattle herds has been increased by ploughing needs.

6.4 Livestock Breeding Strategies

Droughts often initiate a change in strategies. The year 1975 seems to have been a turning point as far as family incomes are concerned. Apart from a prolonged drought in that year, stretching to the next, a host of other socio-economic factors further impinged on farmers and livestock owners, leading to lower standards of living, and a struggle to shift to smaller, higher quality herds. On the basis of past experience (poor management and frequent deaths of grade cattle), the Department of Agriculture has instituted rather stringent measures requiring farmers to install dips, sheds, dairy equipment and fences prior to getting grade cattle. These requirements can hardly be met even by today's farmers.

There is little information on farmers' breeding strategies in relation to the indigenous stock. Veterinary services for improved breeds are considered later.

7. RANCHING IN MACHAKOS DISTRICT

We have so far not mentioned ranching as a form of managing livestock. Before independence ownership of large ranches was confined to the white settlers. According to the Kenya Agricultural Census, 1962, the 'scheduled areas' in Machakos District comprised about 220,000 ha in 1962. There were some agricultural enterprises, but the majority were ranches, and uncultivated pastures amounted to 191,280 ha. There were 50 white settler livestock enterprises in 1960, reduced to 35 in 1962. Of these, 34 were over 2,000 ha. The stock owned was as follows:

(Thousand head)	*1960*	*1962*	*(Thousand head)*	*1960*	*1962*
Cattle	47.0	36.0	Cattle of employees	2.9	1.9
Sheep	10.3	5.2	Shoats of employees	1.2	1.8
Ha per stock unit*	3.7	5.0			

* Excluding those owned by employees.

The general pattern was a dairy herd of 150-500 animals (26 herds in this range in 1960), combined with a beef herd of more variable size (21 below 200 animals, and 19 of 500-2,000 animals in 1960). The dairy herds were the major income source, the milk being sold by rail to Nairobi. A common strategy in droughts was to protect the dairy stock as far as possible, and to sell off the beef animals (personal communication, Miss Anne Joyce, 1990). While some ranchers ran sheep, none had goats.

The following account of developments after independence is based largely on Livingstone (1976) and statistics obtained from Machakos District Livestock Development and Cooperative Development Offices in 1991. In 1961, 18,080 ha were acquired from the European settlers under the Million Acre Scheme with an initial objective of sub-dividing the land into 96 ha autonomous units. This idea of small units was later found to be unconducive to full utilisation of facilities such as roads, dams, dips and fences already in place at the time of takeover. The plan was therefore abandoned in favour of larger cooperative, company and individual ranches. Since 1961, more white owners have retired or for other reasons sold voluntarily to African purchasers.

The increase in, and changing structure of African-owned ranches in the district is shown by Table B.13.

There were two different categories of cooperative ranches namely, (a) Settlement Cooperative ranches bought under the Department of Settlement and (b) Ranching Cooperative Societies bought by groups of farmers assisted by the Cooperative Department and Range Management Division. Ranch performance appeared to be quite varied with the major factors being access to capital (share capital plus loans), management and supervision by Cooperative Department, Range Management Division (actual names have since changed) and lending institutions.

Management of most ranches was characterised by traditional methods and habits: for example retaining surplus old cows, depriving calves of milk through domestic human

Table B.13: Ranches in Machakos District, 1975 and 1990

Type of Ranch	*Number*		*Size (ha)*	
	1975	*1990*	*1975*	*1990*
Cooperative ranches	12	9	88,792	57,740
Company ranches	5	8	19,916	57,293
Individually owned ranch	3	16	7,164	38,572
Institutional	-	6	-	72,094
TOTAL	20	39	115,372	225,700

Note: A detailed structure giving, among other features, share capital, loans obtained and nature of enterprises in 1975 can be found in Livingstone (1976).

Source: Livingstone 1976 and District Livestock Office, 1991.

consumption and reluctance to improve internal ranch infrastructure of roads, dips, dams, fences and firebreaks. Managers were also not actively engaging in upgrading of stock breeds through purchase or breeding.

In the 1970s it was already being realised that many of the cooperative ranches were under pressure to apportion large pieces of their land for settlement by their official shareholders. In addition to official (registered) members, the cooperative ranches had 'shadow members' who had contributed livestock or money to registered members so as to enable them to acquire shares. The existence of 'shadow members' made it difficult (from an equity point) to dish out dividends because, apparently, they were recognised by ranch management. But the problem was escalated by the practice of allowing registered members to bring livestock into plots they were allocated thus establishing second homes in the ranch and giving hope to 'shadow members' that the same favours would come their way. The consequence of these developments was that many cooperative ranches turned into accidental and unplanned settlements where individual livestock tended to predominate over ranch livestock, thus creating chaos in the original grazing arrangements.

Ranches now occupy about 16% of the district land area. As shown by Table B.14, the number of cooperative ranches has declined since 1975 and so has the total area they occupy. There are now more company and individually owned ranches. By 1989 more cooperative ranches had either finalised procedures for sub-division or had already sub-divided portions of their ranches (list provided by Range Management Division but not for publication). For ranches already sub-divided, individual plots ranged from 2.6 acres to 100 acres. As already stated, many of the ranches left portions undivided but three sub-divided the entire ranch land and therefore no longer existed as cooperative ranches.

Statistics on enterprises, membership and livestock ownership were not complete and consistent. The general picture is that: co-operative ranches were engaged mostly in beef

Table B.14: Livestock on ranches, Machakos District, 1990

Type	*Cattle*	*Goats*	*Sheep*
Cooperative	10,782	3,250	-
Company	6,581	1,000	-
Individual	8,719	11,700	3,112
TOTAL	26,082	15,950	3,112

Ha per stock unit: 5.3 (excluding land and livestock owned by institutions)

Note: The table does not include the six Institutional ranches shown in Table B.13 since no information on their livestock was available. These ranches do not fit in the 'company' category even though some (e.g. Portland ranch) may be run by companies. The National Youth Service (NYS) runs such a ranch in Yatta.

or beef-dairy-shoats enterprises, with one of them (Lukenya) venturing into horticulture; company ranches were either for beef or dairy, one had dairy and beef while Kalebwani and Game Ranch had sisal and wildlife, respectively in addition to beef; the situation in institutional ranches was unclear as statistics were missing for most of them; most of the individual ranches were listed as beef ranches despite the large numbers of shoats reported in all of them. It is interesting to note that the goats now far outnumber sheep, and that the ratio of shoats to cattle in individually owned ranches is higher than the district average. This implies a traditional Kamba subsistence management strategy targeted at spreading risk of drought. We obtained no definite information about the use of goats for biological bush control in these ranches. Overall productivity on these ranches seems to have fallen since 1960, judging by the increased number of hectares per stock unit. We have no statistics measuring output such as milk yield, which could be compared with 1960 output.

Many problems were indicated to us either by the Range Management Division or by the District Cooperative Office who are in contact with the ranches in one way or other. Two categories of problems were highlighted: management and marketing. The following management problems were given:

- poorly trained managers;
- bureaucratic decision making procedures by committee of cooperative ranches;
- low turn-over rates leading to poor dividends payment records;
- infrastructural limitations e.g. water, dips, crushes, loading ramps, fencing;
- lack of credit.

Marketing problems were in relation to the following aspects which are by no means restricted to ranches:

- lack of organised marketing channels and infrastructure such as roads, organised auctions, holding grounds, etc.;
- untimely animal disposal (low off-take);
- monopolistic tendencies and practices at level of butchers;
- lack of weighing scales leading to visual appraisal of stock weight by managers and customers;
- no steady supply of immatures for fattening;
- lack of appropriate breeds among the small scale livestock farmers.

Overstocking tends to occur where land is communally grazed but livestock privately owned as in Machakos co-operative ranches.

8. LIVESTOCK SERVICES AND LIVESTOCK HEALTH

8.1 The Development of Livestock Services

From the colonial period, veterinary services have always revolved round the control and eradication of:

East Coast fever - ECF - (transmitted by ticks, and not fully understood till 1931)
pleuro-pneumonia
rinderpest
trypanosomiasis (transmitted by the tsetse fly)

A good account of early veterinary services is provided by Tignor, 1976. The main objective at first was to protect the valuable stock in European-owned herds. The spread of East Coast fever, rinderpest and pleuro-pneumonia into the white settled zones was checked by rigorously enforced quarantines and restrictions on movement. European farmers began dipping their cattle against ECF about 1913. African farmers maintained their traditional strategy of exposing calves to the infection while they still had some immunity from their mother's milk; some died, but the rest acquired immunity themselves. A dense livestock population was also used to destroy the vegetation harbouring ticks; the overstocking of which Europeans complained was partly an anti-tick strategy.

The veterinary department began work in the reserves in 1924, and has six posts in Machakos by 1927. The early vaccination campaigns against rinderpest have already been mentioned. The Kamba appeared to welcome this, and a high proportion of all inoculated cattle were in

Machakos District, despite the fee requirement. Pleuro-pneumonia was treated by quarantining and slaughter of visibly affected animals. The impact of these measures is uncertain. Some of those in authority feared it increased the livestock population and hence overstocking. It was thought the provision of more grazing land to the Africans, as they requested, would simply lead to more overstocking and degradation. The Hall Agricultural Commission of 1929 thought Machakos District was in the worst environmental condition in the country. Further investigations led directly to the confrontation on destocking in 1938 (Tignor, 1976:Chapters 14 and 15).

Animal health policy evolved into a strong effort to control rinderpest in all areas, coupled with a differentiated, area based policy for most other diseases. This means the establishment and maintenance of a Disease Free Zone with (free) compulsory vaccinations against other diseases and quarantine protection, in the 'high potential' areas, (which included the former white-settled zone in Machakos). Elsewhere, eradication was not attempted, but there was some preventative and curative work, usually for a fee (Chemonics, 1977:110). This applies to the former reserve areas of Machakos.

Dipping against ECF was considered and rejected for the new Makueni settlement in 1950, on the grounds that it might cause calves to lose such immunity to ECF as they possessed, and that it would be dangerous to have Makueni as a dipped island in an undipped area (RH: Memo, ME North to Commissioner ALUS, FIN 169). After independence the installation of cattle dips were amongst the most popular self-help projects (Shorter, 1974:123) but their story has not been documented. The dips were locally managed under the county council, and there were problems with under-strength dips, irregular dipping and the build up of resistance. In 1979 the Cattle Cleansing Act was extended to Machakos, with the government taking over responsibility for dip management (ODI, 1982:8.2). In 1990 the return of dips to local management was under way, largely because of shortage of government revenues. The benefits of using dips have been amply demonstrated and accepted, but access to dips is hampered by their poor maintenance; long distances to dips, a factor made more serious by shortage of labour required to drive animals back and forth between dips and homesteads; and frequent shortage of dip chemicals.

There are now 238 government-maintained dips in the district. The total number including private and community constructed dips is close to 300. Dipping is conducted once every week and many of the farmers and agricultural officers interviewed confirmed this but it would be in both parties' interest to exaggerate on this aspect. With only 300 dips serving over 400,000 cattle and the poor maintenance of dips due to lack of government funds, it is likely that the efficacy of tick control services is low.

Tsetse infestation in the Makueni area was reduced in the settlement period by mechanical and hand clearing of bush, together with shooting of the rhinoceros, elephants and other game. Elsewhere, the level of tsetse has been reduced by clearance of bush as farmers settle the land themselves (see Working Paper: Population Profile).

8.2 Veterinary Services in 1990

Veterinary services are offered by 270 core staff members with divisional distribution shown in Table B.15. This is a great improvement since independence. For 1964 de Wilde et al. (1967) gives a breakdown of one Veterinary Officer, one Livestock Officer, 13 Veterinary Assistants and 23 Veterinary Scouts giving a total staff number of 38. This represented a reduction from the staff available during the Machakos Betterment programme in the 1950s, when there were about 6 European officers and 67 African staff (Peberdy, 1958:122). The pattern has been a high level of staffing during special programmes (Machakos Betterment in 1950s, MIDP in the 1980s) with difficulty in maintaining this when the Department has to rely on normal government revenues.

Table B.15: Distribution of veterinary and livestock staff in Machakos District, 1990

Division	*Veterinary Officer*	*Livestock Officer*	*Hides/Skin Officer*	*Other Technical*	*Total Staff*
Kibwezi	1	1	1	22	25
Yatta	1	1	1	17	20
Masinga	1	-	1	14	16
Kilome	1	1	-	40	42
Mwala	1	1	1	39	42
Makueni	1	1	1	28	31
Kangundo	1	1	1	28	31
Central	2	-	1	15	18
Kathiani	1	1	1	18	21
Mbooni	1	1	1	25	28
Total	11	8	9	242	270

Source: District Veterinary Office records.

* Other technical staff include Animal Health Attendants for disease control and for meat inspection, and Dip Attendants.

8.3 Disease Control

Currently, rinderpest is under control. There is still some trypanosomiasis, but it is not the major problem it was, and is treated by curative measures. In some years there has been a shortage of rinderpest vaccine, but 200,800 cattle were inoculated in 1987. The major livestock diseases in Machakos district are now listed as follows:

Foot and Mouth Disease (FMD)
East Coast fever (ECF)
Anaplasmosis
Trypanosomiasis
Contagious Bovine Pleuropneumonia (CBPP)
Contagious Caprine Pleuropneumonia
Newcastle Disease
Fowl Typhoid
Rabies
Lumpy Skin Disease

In the 1980s the charging of fees for curative treatments of other diseases had to be increased, and access tends to be closely correlated with wealth. The poorer farmers cannot afford to pay for the medicines and veterinary services and in times of need may have to resort to traditional medicine-men.

Another problem which is widespread not only in the district but also in the entire country is the immobility of veterinary staff. Specific problems relate to drug shortage, and shortage of laboratory equipment, dipping facilities and funds for transport.

Apart from dipping, the disease control programmes carried out are still differentiated as between the former scheduled area and the rest of the District. They are as follows:

(i) Biannual vaccination against FMD in former scheduled areas in January/February and July/August. Elsewhere, tactical vaccination against FMD in disease-prone areas and in areas having actual outbreak. In 1987 there were 148,000 vaccinations.

(ii) Rinderpest vaccination is done alongside FMD campaign.

(iii) Continuous vaccination against rabies.

(iv) Screening for CBPP and slaughter of positives is carried out after every eight weeks in quarantined areas which in 1990 were Yatta, Kathiani and Makueni divisions.

(v) Tsetse survey and trapping in areas where trypanosomiasis has been detected.

(vi) Vaccination against Newcastle Disease and Fowl Typhoid is done on call because there is no organised poultry programme in the district.

8.4 Artificial Insemination

The artificial insemination services were launched in 1966 in Mua Hills Settlement Scheme. Initially the service operated as a single run which was later extended to cover Iveti, Kangundo, Mbooni, Masii and Kilome areas. Currently there are 4 motorised runs. The problems cited relate to the recent increase in charges for insemination services, inadequate funds for operating the service effectively, poor infrastructure especially bad roads during rainy seasons and poor acceptance by farmers arising from either the farmers' traditional beliefs or mismanagement of the service. Charges were raised in April 1990 from Ksh 5.00 per cow to Ksh 40.00. The farmers find this charge excessive especially in view of the fact

that insemination success rate has dropped partly due to irregularity and poor timing of A.I. runs with respect to heat period in farmers' cows. Part of this problem, however, arises from farmers' delays in detecting heat and placing the cows on the A.I. route. In view of the above problems, many farmers continue to use bulls. The average number of inseminations has consequently dropped.

9. LIVESTOCK INCOME, SALES AND PRICE TRENDS

9.1 Income

Income from livestock is derived largely from sale of cattle, sheep, goats, hides and skins, poultry, pigs, eggs, honey and beeswax and services of ploughing oxen. In the Annex we have put together tables showing exports of some of these commodities every year, as District-level income. Estimates of the amounts sold by families are difficult to obtain. The proportion of income derived from livestock varies according to rainfall, being particularly important when the rains are bad, crops fail, and more livestock are sold. At District level, income from sales of livestock and livestock products was 65 % of farm sales totalling K£ 15 million in 1983 (ADEC, 1986:3.1), and 30% of an estimated farm sales of K£79 million in 1986 (District Development Plan 1989-1993).[12] The two immediately relevant rains were not dissimilar, and the smaller role of livestock in 1986 probably reflects the continuing impact of the losses from the 1984 drought and the effort thereafter to rebuild stocks.

The surveys emphasise the importance of subsistence income from livestock, particularly in terms of milk, manure and ploughing services. Milk is a valued element in Kamba diet, especially for children, and the demand for it was said to be insatiable in the 1950s (Peberdy, 1958:122). The current degree of shortage is not known; certainly shops import supplies from outside the District. The tables do not include local sales, whose statistics are unknown.

9.2 Price Trends and Price Responsiveness

Apart from the current (nominal) prices, we have also constructed an approximation to constant prices (in a few cases only) by use of averaged consumer price indices for Nairobi. The latter have been obtained from Weber (1981), Ackello-Ogutu and Odhiambo (1986) and Central Bank's Quarterly Economic Review for July-September, 1990. We have done appropriate switches in base years and ended up with two, namely 1976 and 1989, as can be seen on Table BB.10. The 1990 prices were not available.

Figures B.1-B.3 show the price trends for beef cattle, mutton/goat meat and whole milk. It is clear from the figures that whereas prices received by farmers went up in nominal terms,

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[12] In both cases, the important horticultural sales discussed in Section A were omitted from official calculations, so the role of livestock in farm sales is somewhat exaggerated.

Figure B.1: **Current and constant prices for beef cattle**

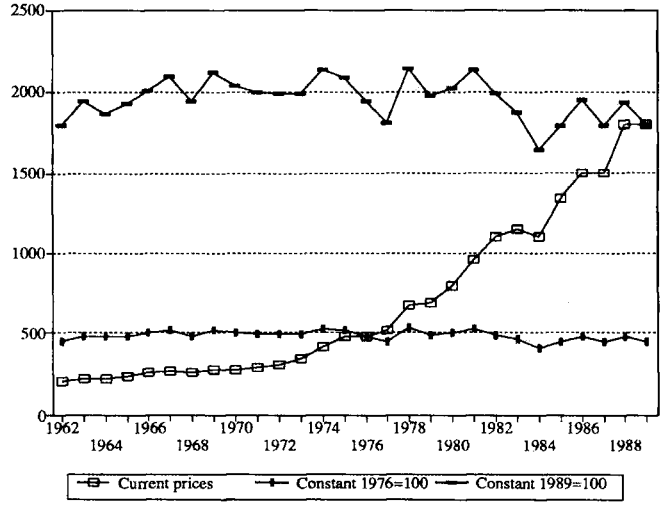


Figure B.2: **Current and constant prices for mutton/goat meat**

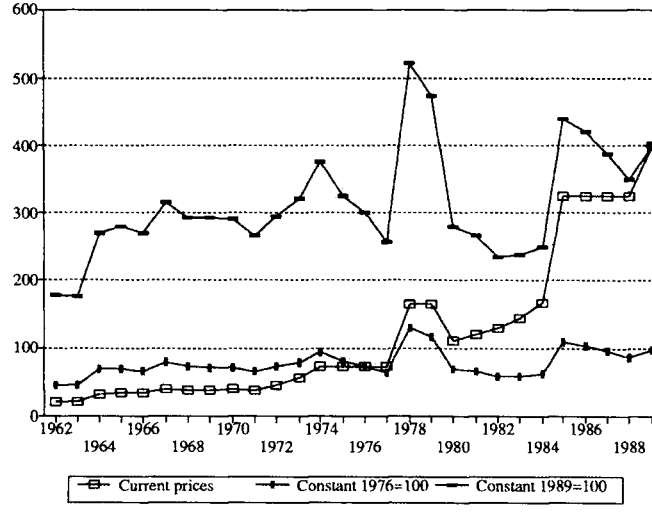
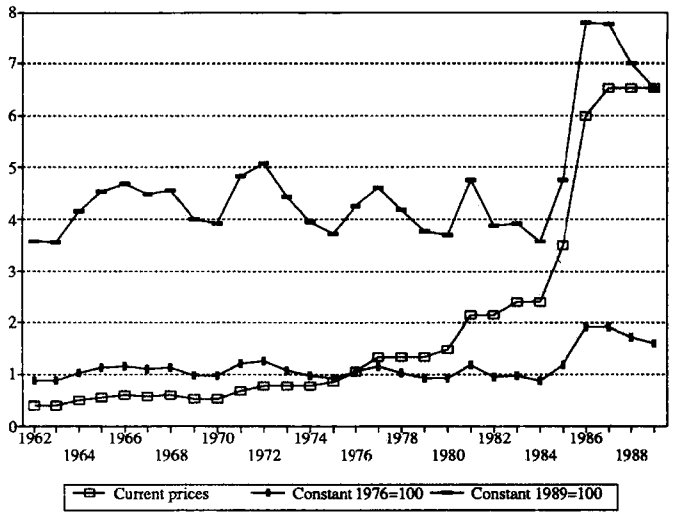


Figure B.3: Current and constant prices for whole milk



real prices have not been any better than those offered at the time of independence, using 1976 as a base for comparison. When we switch to 1989 as a base, one finds that there have been moderate improvements in real terms only for farmers selling small stock (mutton/goat meat) and milk but not for cattle sellers who have been hit more by inflation.

Increases in cattle prices did not keep pace with inflationary pressures especially starting 1982 but stagnation in real terms had persisted from early 1960s. In the case of both mutton/goat meat and milk there were real benefits after 1983 whereby farmers realised nominal price increases which more than compensated for increases in cost of living. Emphasis on dairy and small stock enterprises would therefore have been advisable for most of the 1980s but we are not so sure whether or not that is true for 1989 and 1990.

Due to data problems, we are not in a position to compute relative prices, nor can we quantify the responsiveness of the farmers to price changes. We have, however, noted that many farmers (especially in the more densely populated highland zones) have adopted non-traditional dairy production techniques such as zero-grazing. The population of grade cattle and cross-breeds is also on the increase. We have also seen that the proportion of goats on ranches has increased. All this suggests that Kamba livestock producers are responsive to price changes. Generally, the reduction in livestock numbers per holding, and shifts to food and cash crops, also reflect price responsiveness.[13]

[13] Maize:cattle price ratios are discussed in Section A.

10. FARMERS' PERCEPTION OF PROBLEMS IN THE LIVESTOCK SECTOR

Farmers' perception of major problems and constraints will be discussed in more detail in a later Working Paper on Farming Systems. Not unnaturally, drought came at the top of the list during the ASAL pre-investment survey in 1977 (CID, 1978:Report 6). The majority of farmers could then think of no remedy to protect themselves from drought effects, but 5% suggested the keeping of more animals - the traditional response. After the 1984 drought a similar enquiry yielded rather more suggestions on changes in agricultural practices, but 18% referred to livestock, including, preserving some land as fallow for livestock, preserving maize stalks and planting bananas to provide livestock fodder, and destocking (Kamau et al., 1989:221).

Another enquiry after the severe 1984 drought amongst farmers in southern Machakos, showed that 90% thought drought a main problem, 81% cited lack of capital, and no less than 74% mentioned livestock diseases (Mukhebi et al., 1985b).

When a drought is not uppermost in the farmers' minds because of its recent impact, other problems get mentioned. Those who mention lack of water or rain fall to about half. In 1981 lack of grazing was mentioned by 70% (especially smaller farmers averaging 2 ha of grazing) and cattle diseases by 35%. There were also substantial numbers complaining of the poor quality of ox tools and of spare parts (Pollard, 1981).

We can conclude that drought, disease and lack of capital for better inputs are the main constraints on the development of the livestock sector.

11. SUMMARY AND CONCLUSIONS

1. Numbers of cattle in the District have risen from about 290,000 in 1930 to between 300,000 and 476,000 in the 1980s. However, cattle per head of population has fallen from about 1 to 0.4 due to population growth. Shoat estimates show great variation and dubious reliability. Annual livestock numbers reflect the severe impact of droughts.

2. There are now fewer livestock in the high potential areas of the District. Livestock keeping has shifted towards the drier areas. Because livestock are now spread over a larger area there has been a fall in livestock density per ha, although this remains higher than recommended. Recommended densities do not take into account Kamba management methods or objectives.

3. Livestock have never been equally distributed between families. Some families have no cattle.

4. Bulls and oxen have become a more important part of the herd as family holdings have become smaller and draught services more valued.

5. There are no good data on livestock productivity, and conflicting information on the milk output of zebu cows.

6. Livestock sales vary according to drought and market conditions, but have always been substantial. Average cattle sales rose from about 12-14,000 per annum before 1960 to nearly 24,000 in the late 1960s, falling back to 18,000 in the 1970s when records cease. Hides sales remained steady at about 25-30,000 per annum until 1970, when they rapidly increased to reach nearly 85,000 by the late 1980s. Since hide sales reflect local consumption, this suggests increased local meat consumption. Shoat skin sales have been more variable but peaked at 278,000 in the 1970s, compared with 115,000 in the 1950s. Since then they have dropped back to 206,000. Off-take rates for cattle are usually estimated as 17%, but the combined hides and sales figures suggest much higher rates. However, we have no information on livestock purchases, which might modify this conclusion. Livestock income as a proportion of total farm income is high in bad years, low in years with good crop sales.

7. Livestock management has become more intensive, with crop residues playing an important part in feeding. Recently many animals are zero-grazed. Water is an important constraint.

8. Ranching still continues in the former white settled areas but many ranches have been sub-divided. They now carry goats as well as cattle. There is no indication of higher productivity on ranches, and some suggestion that losses in droughts are less on small mixed farms in a similar ecological zone. Ranch productivity may have fallen since 1960. Information on ranches is inadequate.

9. Livestock health services have brought rinderpest and ECF under control, but disease is still a major problem. Livestock health services are at a higher level in the ranch areas.

10. Recently shoat and milk prices have shown real increases. The rise in milk prices helps explain a rapid increase in 'grade' dairying cattle since 1983. Some farmers are replacing cattle lost in the 1984 drought by fewer, more productive beasts.

ANNEX B

LIVESTOCK PRODUCTION AND PRICE DATA

The tables in this Annex give the main historical features of livestock production in Machakos, as derived from District records. The Annex also gives the price series for the relevant years and products.

Table BB.1: Human and cattle population

Year	*Human population*	*Cattle*	*Cattle/pop.*
1930	227,398	248,805 *	1.09
1957	441,545	220,625	0.50
1960	517,598	222,264	0.43
1962	550,779 *	n.a	n.a
1963	570,779	251,000	0.44
1974	850,371	450,000 a	0.53
1975	882,308	402,500 a	0.46
1976	915,444	278,163 a	0.30
1977	949,824	491,744	0.52
1978	985,496	-	n.a
1979	1,022,512	299,350	0.29
1980	1,054,100	395,117	0.37
1981	1,086,600	410,484	0.38
1982	1,120,258	435,600	0.39
1983	1,154,874	473,375	0.41
1984	1,190,568	314,000	0.26
1985	1,227,348	348,392	0.28
1986	1,265,273	353,032	0.28
1987	1,384,675	388,335	0.30
1988	1,386,225	446,376	0.33
1989	1,537,507	476,577	0.34

Sources: * Census figures.
a. Consortium Report No. 8, p.4.
Rest of human population figures estimated.
Rest of cattle population figures estimated - District annual reports and MALD estimates.

Table BB.2: Available smallstock population data

Year	*Goats*	*Sheep*	*Pigs*	*Shoats*	*Shoat/cattle*
1930	261,648*	50,855*	-	312,503	1.3
1956	-	-	-	482,000[b]	1.6
1974	307,154	225,878	83	533,032	1.2
1975	461,000	229,100	73	690,100	1.7
1976	188,249	83,579	47	271,828	1.0
1977	350,000	19,258	49	369,258	0.8
1978	-	-	-	-	-
1979	267,358	141,535	179	408,893	1.4
1980	-	-	-	-	-
1981	528,888	220,612	203	749,500	1.8
1982	551,500	298,500	220	850,000	2.0
1983	471,002*	105,380*	400	576,382	1.2
1984	314,000	82,950	360	396,950	1.3
1985	211,513[a]	85,104[a]	260	296,617	0.9
1986	217,013	87,315	200	304,328	0.9
1987	249,565	96,047	117	345,612	0.9
1988	386,250	102,642	117	488,892	1.1
1989	409,325	172,041	502	581,366	1.2

Sources: * Census figures.
a. ADEC (1986) gives 1985 estimate of 717,150 goats and 256,200 sheep deemed too high considering drought of 1984.
b. Jones, 1959:43.
Rest of figures: District annual reports and Eastern Province annual reports.

Table BB.3: Available data on poultry, beehives and rabbits*

Year	*Poultry*	*B/hives*	*Rabbits*
1968	938,933	-	-
1969	1,503,115	76,986	780
1970	-	-	-
1971	-	60,000	3,250
1972	-	-	-
1973			
1974	453,319	52,210	7,885
1975	351,555	510,840	7,500
1976	156,195	22,904	3,899
1977	177,932	54,245	-
1978	-	1,940	-
1979	668,244	23,451	2,548
1980	-	-	-
1981	995,000	36,460	3,710
1982	1,009,000	-	5,100
1983	916,000	18,100	4,000
1984	269,580	79,259	4,000
1985	437,953	130,551	7,933
1986	516,026	137,541	8,324
1987	595,000	142,179	8,824
1988	655,012	158,399	10,103
1989	845,992	178,139	14,221

Sources: District and Eastern Province annual reports.

* These are not reliable data. It is unlikely that the agricultural officers could be able to estimate these figures with any known margin of error on an annual basis.

Table BB.4: Recorded livestock sales[a] and relationship to droughts

Year	*Drought Index[b]*		*Cattle*	*Shoats*	*Five year average*	
	LR	*SR*			*Cattle*	*Shoats*
1934	S		3,525	37,235		
1935	S	S	9,512	76,062		
1936		M	10,520	49,243		
1937			7,832	27,881		
1938	M		29,748	38,338	12,227	45,752
1950	M	M	18,108	51,567		
1951			26,535	142,440		
1952			17,918	84,895		
1953			5,857	10,700		
1954		M	3,107	4,053	14,305	58,731
1955	M	M	15,915	2,029		
1956	S		15,103	15,772		
1957			11,299	9,635		
1958			7,122	4,734		
1959	M		9,199	10,174	11,728	8,469
1960		M	11,769	23,387		
1961	S		20,694	40,255		
1962			9,929	25,866		
1963			8,544	12,103		
1965	S	L	26,971	13,329	13,228	18,310
1966			32,301	16,746		
1967			43,313	21,829		
1968			15,244	11,379		
1969	M		10,311	9,703		
1970		S	17,599	13,043	23,754	14,540
1971		M	52,244	20,000		
1974		M	14,060	24,673		
1975	S	S	-	106,320		
1976	S		15,333	80,962		
1977			11,315	55,667	18,590	57,524
1978			-	-		

Notes: a. Excluding home and local consumption.
b. Drought index - see Working Paper: Environmental Profile Section A: Rainfall. S = severe; M = moderate; L = light. First column refers to long rains, second to short rains. The main impact of a drought in the short rains (SR) is felt in the following calendar year.

Source: District annual reports. We were not able to get reasons for lack of sales data for most of 1970s and entire 1980s.

Table BB.5: **Sales of major livestock products**

Year	*Cattle hides*	*Shoat skins*	*Hides 5 yr av.**	*Skins 5 yr av.**	*Year*	*Cattle hides*	*Shoat skins*	*Hides 5 yr av.**	*Skins 5 yr av.**
1934	9,273	4,280			1966	24,343	127,441		
1935	13,613	8,914			1967	16,862	75,882		
1936	27,160	24,690			1968	19,953	96,420		
1937	32,482	48,530			1969	36,234	128,394	25,033	105,761
1938	17,841	35,893			1970	39,645	157,721		
1939	-	-			1971	264,844	151,224		
1940	-	-	25,828	36,371	1972	-	-		
1950	26,121	111,834			1973	-	-		
1951	18,231	85,397			1974	-	201,779		170,241
1952	-	-			1975	120,513	262,835		
1953	40,431	184,006			1976	80,321	448,847		
1954	15,519	83,222	25,076	116,115	1977	38,080	170,417		
1955	21,739	93,683			1978	-	-		
1956	33,336	150,367			1979	49,803	229,628	72,179	277,932
1957	24,759	101,420			1980	-	-		
1958	30,287	105,640			1981	57,886	244,334		
1959	43,958	121,200	30,816	114,462	1982	-	-		
1960	30,885	101,360			1983	-	-		
1961	21,092	72,920			1984	-	-		
1962	19,614	65,088			1985	68,714	155,722		
1963	17,865	82,912			1986	81,952	209,587		
1964	-	-	23,502	80,572	1987	-	-		
1965	27,774	100,668			1988	90,581	161,773		
					1989	81,158	248,038	84,563	206,466

Source: District annual reports

* Where there are entries for at least three years the average is computed for those number of years as an approximation.

Table BB.6: Recorded sales of minor livestock products*

Year	*Milk (kg)*	*Eggs (dozen)*	*Poultry (birds)*	*Beeswax (kg)*	*Honey (kg)*
1951	-	37,109	82,176	-	-
1952	-	123,774	198,413	-	-
1953	-	103,059	230,151	-	-
1954	-	74,771	92,269	-	5,968
1955	-	31,090	124,855	-	2,914
1956	-	9,715	57,855	-	
1957	-	15,866	65,332	-	-
1958	-	39,888	110,854	-	-
1959	-	32,486	121,007	-	-
1960	-	22,265	86,376	-	-
1961	-	23,530	55,884	-	-
1962	-	30,382	66,582	-	-
1963	-	-	-	-	-
1964	-	-	-	-	-
1965	-	-	-	-	-
1966	-	-	-	-	-
1967	1,072,270	60,829	-	-	-
1968	3,159,821	87,000	-	-	-
1969	3,162,412	127,957	-	895	13,430
1970	2,026	130,000	715,000	-	725,600
1971	7,621,554	157,000	470,000	-	123,122
1972	-	-	-	-	-
1973	-	-	-	-	-
1974	2,111,018	108,931	160,733	-	733,010
1975	2,715,934	31,339	135,068	8,516	510,840
1976	976,443	-	-	11,315	51,742
1977	1,023,115	-	-	-	21,940
1978	-	-	-	-	-
1979	1,025,087	-	-	3,601	35,000
1980	1,055,695	-	-	-	-
1981	1,067,652	-	-	2,000	14,000
1982	-	-	-	-	-
1983	-	-	-	-	-
1984	639,008	250,000	47,290	15,000	150,000
1985	3,918,681	416,666	-	8,155	396,520
1986	5,440,686	500,000	-	-	-
1987	5,706,579	541,666	-	-	-
1988	6,006,120	583,300	88,510	6,390	302,000
1989	5,902,191	708,333	801,092	7,840	329,735

* There are no regular channels for these products and a large proportion of sales is at domestic or local level with little or no records kept.

Source: District and Eastern Province annual reports.

Table BB.7: Current price trends, livestock and milk, Ksh

Year	*Cattle (head)*	*Shoats (head)*	*Milk (kg)*
1951	-	-	-
1952	-	-	-
1953	120	15	-
1954	150	20	-
1955	150	20	-
1956	150	20	-
1957	150	20	-
1958	150	20	-
1959	150	20	-
1960	200	20	-
1961	200	20	-
1962	201	20	0.40
1963	220	20	0.40
1964	220	32	0.49
1965	233	34	0.55
1966	253	34	0.59
1967	266	40	0.57
1968	253	38	0.59
1969	275	38	0.52
1970	273	39	0.53
1971	285	38	0.69
1972	302	45	0.77
1973	346	56	0.77
1974	413	73	0.77
1975	474	74	0.85
1976	479	74	1.05
1977	519	74	1.32
1978	676	165	1.32
1979	689	165	1.32
1980	795	110	1.46
1981	960	120	2.15
1982	1100	130	2.15
1983	1138	145	2.4
1984	1100	167	2.4
1985	1320	324	3.5
1986	1500	324	6.0
1987	1500	324	6.5
1988	1800	325	6.5
1989	1800	400	6.5

Sources: District annual reports and statistical abstracts.

Table BB.8: Average consumer price indices (Nairobi)

Year	*(1976=100)*	*(1989=100)*
1962	45.20	11.20
1963	45.80	11.30
1964	45.70	11.80
1965	49.20	12.10
1966	50.90	12.60
1967	51.30	12.70
1968	52.60	13.00
1969	52.70	13.00
1970	54.40	13.40
1971	57.80	14.30
1972	61.40	15.20
1973	70.40	17.40
1974	78.70	19.40
1975	92.00	22.70
1976	100.00	24.70
1977	116.10	28.70
1978	127.90	31.60
1979	141.60	34.90
1980	159.30	39.39
1981	182.60	45.10
1982	224.00	55.30
1983	246.70	60.90
1984	270.90	66.90
1985	298.30	73.60
1986	312.10	77.00
1987	338.90	83.60
1988	376.90	93.00
1989	405.20	100.00

Source: Adapted from A. Weber (1981); Ackello-Ogutu and M. O. Odhiambo (1986); Central Bank Quarterly Economic Review Vol. XXII No. 1 July-Sept. 1989.

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