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CONTENTS

	Page
Summary	11
I Introduction	1
II Maali	2
THE ECONOMICS OF SMALL-SCALE FARMING	
III The Analytical Method	3
IN LOWLAND MACHAKOS	
(i) Traditional Food Crops	7
(ii) Cotton	15
(iii) National maize	18
(iv) Different Managerial Skills	20
IV The Prospects for Cotton in Maali	22
(i) The role of cotton in Maali	24
(ii) The validity of the cotton results	26
(iii) Cotton with constant price for maize	29
V National Maize	32
Judith Heyer	
(i) National maize with the current maize price	35
(ii) National maize with a constant maize price	38
VI Development Policies in Lowland Machakos	41
(i) The role of maize in Maali	43
(ii) The values of labour and land	45
(iii) The quality of labour and land, managerial skills	47
(iv) Policy implications	51
VII The Analysis of Maali-Farm Household Data	55

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CONTENTS

	Page
Summary	ii
I Introduction	1
II Masii	2
III The Analytical Method	3
IV The Data on which the Analysis Rests	6
(i) Traditional Food Crops	7
(ii) Cotton	15
(iii) Katumani maize	18
(iv) Different Managerial Skills	20
V The Prospects for Cotton in Masii	22
(i) The role of cotton in Masii	24
(ii) The validity of the cotton results	34
(iii) Cotton with constant price for maize	39
VI Katumani Maize	42
(i) Katumani maize with the current maize price	45
(ii) Katumani maize with a constant maize price	53
VII Development Policies in Lowland Machakos	56
(i) The role of capital in Masii	56
(ii) The values of labour and land	60
(iii) The quality of labour and land, managerial skills	67
(iv) Policy implications	72
VIII The Analysis of Small-Farm Production Data	79

SUMMARY

This paper summarises the results of research into the economics of small-scale farming in Masii location, lowland Machakos. It deals with the role of cotton, which was found to be only a marginal improvement on traditional food crops grown at present, particularly in the low rainfall years. The special position of maize, the staple food, and the high price of importing maize in the low rainfall years, is partly responsible for cotton not being more attractive in places like Masii.

The results of an investigation of the potential of Katumani maize, using somewhat optimistic assumptions about performance in the low rainfall years, are also summarised. Katumani maize is far superior to cotton and traditional food crops, given the present maize price fluctuations that the farmers face. But if Katumani maize provides a district surplus, even in the low rainfall years, the maize price fluctuations disappear making Katumani maize much less attractive again. Once the low rainfall year price of maize falls, cotton replaces Katumani maize as the most attractive crop, and Katumani maize plays a relatively minor role in optimal farming systems for Masii.

The original purpose of the research was to examine constraints on agricultural production in Masii. The most important resources used in peasant farming in places like Masii are obviously labour and land, and the role of these two was examined carefully. Although labour in general is not scarce, and there is unemployment locally, the way in which labour scarcities at different times of the year govern production patterns is

interesting. Labour bottlenecks at particular times of the year have an important influence on what is feasible and profitable in farming in Masii. The analysis of the influence these labour bottlenecks have on farm production patterns throws light on the working of many peasant farms, where production is determined to a very large extent by seasonal labour patterns.

It was originally assumed that credit would be a major constraint on production in Masii, but as fieldwork progressed this assumption had to be modified. Credit did not appear to be nearly as important as other operational constraints. Management, on the other hand, had originally been underestimated. Variations in managerial skills led to better farmers being able to make about 4 times as much as poorer farmers with the same labour and land resources, as is shown below.

Policy implications following from the analysis of constraints involve extension and research services. These are discussed in some of the final sections of the paper in which it is suggested that the traditional emphasis on these services as the major weapons of agricultural change is right, but that much can still be done to improve their effectiveness.

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inadequate, but that much can still be done to improve their effectiveness.

The first of these is the need for extension services to be more effective in

the way they are organized and staffed. It is suggested that extension

services should be organized on a farm-by-farm basis rather than on a

community basis. This would allow extension workers to concentrate on the

most important problems of individual farms and to provide more effective

I. Introduction

This report is intended to make the results of a study of small-scale farming in Masii location, lowland Machakos, more readily available, particularly to people in Government. Many of the theoretical issues discussed in the full account of the study,¹ are ignored, and the emphasis is on the practical policy implications instead. The most important conclusions as far as policy is concerned are on the relative attractions of cotton, Katumani maize and traditional food crops for farmers in lowland Machakos conditions, and on the role of different resources which may be limiting development at present: capital, managerial skills, labour and land. There are implications for credit policy, research and extension services following from the analysis of resource constraints.

The report also includes a brief discussion of the possibilities of using linear programming techniques for the analysis of routine farm production studies undertaken by the Kenya Government Farm Economics Survey Unit. It is felt that F. E. S. U. data could be exploited much more fully than at present, to answer vital policy questions.

The fieldwork and some of the initial analysis of the data was undertaken in 1962/63 under the British Government Social Science Field Research Scheme, now in the Ministry of Overseas Development. The bulk of the analysis, and the final writing up of the study, was undertaken at the Institute for Development Studies, University College, Nairobi, with Rockefeller Foundation support.

1. J. Heyer, Agricultural Development and Peasant Farming in Kenya, Ph.D. thesis, London 1966, unpublished.

The report begins with a brief introductory description of Masii, a summary of the analytical method, and a fairly detailed presentation of the data used, to enable an objective assessment of the validity of the results. The bulk of the report is devoted to a discussion of the results and conclusions that follow.

II. Masii

Masii is one of the more densely populated of the Machakos lowland locations, its central market lying 18 miles east of Machakos town on the Machakos-Kitui road. Most of the location is in the acacia combretum ecological zone, and it has an annual rainfall of about 25 inches, but this varies widely from year to year. Most of the rain falls in two rainy seasons, from October to January, and again from March to June. The soils are sandy clay loams.²

The population density in Masii is well over 300 per square mile³ and there are about 180 livestock units⁴ per square mile in addition to this. The land is extensively cultivated, with residual areas of poor and eroded grazing left for cattle. Masii farmers own both arable and grazing land individually, and most holdings consist of several fragments of land. Fragmentation is not severe, though, the average number of fragments being about 2 or 3, and the furthest distances between fragments 2 miles at the very most. Many holdings are not fragmented at all.

2. Kenya Government, The Soils of the Nairobi-Thika-Yatta-Machakos Area, 1963.

3. Kenya Government, Kenya Population Census 1962, 1964.

4. A livestock unit is defined as 1 head of cattle or 5 head of sheep or goats. The figure is based on a census taken in 1959.

Crops are planted behind ox-drawn ploughs when the October rain begins, in mixed combinations, on previously unprepared land. Maize, beans, pigeon peas, bulrush millet, wimbi and sorghum are the major crops. Small quantities of cowpeas, sweet potatoes, cassava, pumpkins, melons and gourds, castor, bananas, citrus, mangoes and pawpaws are grown among the major crops and in small patches near the homestead as well. Cotton was grown in Masii in 1962 for the first time since the war, and there has been a rapid extension of cotton-growing in Masii since. It is planted exclusively in pure stands. Pigeon peas, sorghum, wimbi, cotton and many of the minor crops continue through the two rainy seasons, but maize, beans and millet can all be harvested in time for a second crop to be grown in the March rains. The second crop is nearly always maize or beans.

Masii people work hard at peak seasons, many doing more than 8 hours a day, 6 days a week, for several weeks at a time. There appears to be no lack of incentives in the location which is generally recognised as one of the more progressive of the lowland locations in Machakos District. The problem is one of severe physical constraints.

III. The Analytical Method

Linear programming was used for the analysis of farm production in Masii. Basically this involved finding the maximum value of farm output that could be obtained, given the resources, techniques, and production alternatives open to farmers in Masii. Given the alternative crops that can be grown, and the techniques that can be used to grow them, and given the range of acreages and labour forces available on Masii farms,

the problem is to see what is the best use that can be made of these. What is the maximum value of output that can be obtained? What patterns of production give the highest returns? What major bottlenecks prevent production from increasing further?

The range of alternatives between which Masii farmers can choose includes cotton, Katumani maize and traditional food crops, grown in different ways. The choice between methods of growing different crops is as important as the choice between the crops themselves. For any crop or crop mixture, in which crops are interplanted, there is a choice of planting time, weeding intensity and weeding time, for example. Farmers have to decide which crops to plant early and which can best afford to wait; they have to decide where to put their major weeding effort; they have to decide which crops and crop mixtures to grow so that the harvests are spread and do not all coincide to make impossible labour demands. The factors they have to consider are how to make the best use of their limited acreages of arable land, and how best to use labour at peak periods as well. It is often as important to make good use of early ploughing labour, for example, as it is to make good use of limited quantities of arable land.

The scarce resources we consider in this analysis are land, and labour at critical times of the year. At some times of the year, of course, labour is not scarce at all. But at other times, at weeding, ploughing and some harvesting times, the availability of labour determines profitable crop production patterns. Other resources which are usually considered to have a major influence on production patterns are capital and managerial skills. Differences in managerial skills, enabling the better farmers to get higher outputs from given quantities of labour and land, are incorporated in the analysis. But the only items of capital that are considered to

limit production on Masii farms, in that some people cannot get access to them at the right time, are oxen and ploughs. Other capital items used in the production process are generally available in Masii. This point is discussed further below. We are saying, in effect, that there is no shortage of capital at present in Masii except possibly for the purchase of oxen and ploughs. Other resource constraints were considered and rejected as unimportant in Masii.

For any given set of assumptions about the resources available and the range of production possibilities between which there is choice, the linear programming solutions show the maximum value of output attainable, the crop production pattern that maximises output, and the relative importance of the major resources limiting the expansion of production on the farm. (Scarcity values attached to the resources show their relative importance in any given situation). The way in which the computer arrives at the solutions is very similar to the way in which farmers make their production decisions. Farmers try to maximise returns to resources that are scarce: they try to weed most where the returns to weeding are highest; they try to use early planting labour for crops that are most sensitive to planting delays. In doing this, on the basis of past experience and trial and error, they may come very near to maximising their returns.

In linear programming the computer finds the most scarce resource, such as early planting, or land, and examines all alternative uses until the one that gives the highest return is found. When the most scarce resource has been used to the full, the next most scarce is taken, and returns to this are maximised, and so on, until all scarce resources are

fully used. The process, similar to budgeting, and also similar to that which takes place implicitly on a peasant farm, is more systematic than either of these, allows a more thorough investigation of alternatives, and always gives an optimal result, on the basis of the data used. But the data are the key to the validity of the analysis and these can only be best estimates.

In order to perform the analysis, to choose between the different production alternatives and to maximise the value of production by combining them in the best possible way, it is necessary to have detailed information on the resources used in each alternative production process, and the total supply of resources available for use. For each alternative crop mixture and method of treatment, it is necessary to know how much labour per acre is used at different times of the year, and exactly what output this combination of labour and land produces. In other words, detailed input-output data are needed for all production processes to be included in the range of choice.

In the next section we present the data that are used in the analysis, to enable an objective assessment of the validity of results.

IV. The Data on which the Analysis Rests

Data were collected from 16 holdings in Masii in 1962/63. The holdings, the method of collection, the definitions used, and the raw data themselves, are described in the supplement to this paper. In the main paper, all that is done is to present the figures actually used in the analysis. A description of the way in which these were obtained from the raw data can be found in the full account.⁵

5. J. Meyer, Agricultural Development and Peasant Farming in Kenya, op.cit.

Although Masii farmers plant some crops, maize and beans, in the March rains, only the October-planted crops have been considered here. An initial analysis including both seasons showed that the March rains cropping patterns were completely dominated by October rains considerations, and that March rains activities did not introduce any important additional bottlenecks. The yields of second rains crops are generally low, and the acreages involved are small. The main purpose of planting maize and beans again appears to be for the preservation of fresh seed for use in October again. Only in exceptional years, when the October rains have failed, is planting substantial in the second rains.

(i) Traditional Food Crops: Outputs in Masii vary enormously from year to year, and the analysis takes account of these variations by considering high rainfall, average rainfall and low rainfall situations. The year in which the field data were collected, 1962/63, was a year in which rainfall was high and yields were well above average, and this is taken as representative of high rainfall years in general in Masii. High rainfall year outputs are thus based on detailed field data. For years when rainfall is average or low, such data are not available, so estimates have been made, using all information obtainable.

Yields observed in 1962/63 varied considerably, partly because methods of treatment and crop mixtures varied, but partly also because "managerial abilities", defined more precisely below, were different on the different farms. The analysis uses a wide range of yields associated with different crop mixtures, times of planting, and times and intensities of weeding, for any given management level. The range used for the modal level of management is shown in the table below.

TABLE 1. Range of Traditional Food Crop Yields, used in the Analysis,
High Rainfall Year, and Modal Management Level

(200lb. bags/acre, mixed and pure stands)

Beans	0.2 - 2.9	Millet	0.4 - 1.6
Maize	0.5 - 9.5	Sorghum	0.4 - 1.6
Pigeon Peas	0.3 - 3.3	Wimbi	0.5 - 0.9

This compares with ranges found in the field, in 1962/63, as follows:

TABLE 2: Range of Traditional Food Crop Yields observed in the
Field, 1962/63, all Management Levels

(200lb. bags/acre, mixed and pure stands)

Beans	0.3 - 5.9	Millet	0.2 - 9.5
Maize	2.9 - 12.8	Sorghum	0.3 - 6.7
Pigeon Peas	0.9 - 5.1	Wimbi	0.3 - 7.7

The differences between the range used and the range found in the field is partly due to differences in management levels in the field data, and partly to the fact that the range of alternative possibilities considered in the analysis is wider than that found in the field, including more intensive and less intensive methods of treatment at the extremes. The analysis uses yields lower than the field range because it was only very seldom in the field, for example, that a farmer planted late, weeded late, and weeded very little, but this possibility is allowed as a choice in the analysis.

Prices used for 1962/63 returns are those farmers received from marketing board agents and general produce traders in Masii in 1962/63. There is no reason to suppose that these were any different from normal high rainfall year prices in the area during the months when the bulk of the crop is sold. The actual figures are shown below.

TABLE 3: Traditional Food Crop Prices in Masii in 1962/63,

High Rainfall Year

(Sh. per 200 lb. bag)⁶

Beans	35	Millet	18
Maize	20	Sorghum	18
Pigeon Peas	35	Wimbi	30

For the analysis of the situation in average and low rainfall years no detailed field data were available and estimates had to be used. Yield fluctuations were estimated from discussions with local agricultural officers and farmers in Masii, and price fluctuations were discussed with traders as well. The changes in the relative positions of the different crops are marked, so the analysis should be valid even though these figures are not actually based on data directly from the field.

1962/63 returns were multiplied by the following factors to get low rainfall year returns:

6. Not all crops are put in 200 lb. bags, but prices have been converted to this standard measure here.

Beans	.24	Millet	1.39
Maize	.44	Sorghum	1.74
Pigeon Peas	.39	Wimbi	.32

Beans suffer more from drought than pigeon peas. Maize yields fall drastically, but returns fall much less because the reduction in yield is offset by a very considerable increase in price. Millet and sorghum do relatively well in low rainfall years, and their price tends to rise a little too, but their low rainfall returns may have been somewhat overestimated. Millet does not appear to be attractive in any of the situations considered, and sorghum is only attractive in one case, so any overestimation does not affect results.

The average rainfall year estimates are a combination of high rainfall and low rainfall figures. Price and yield boundaries were drawn, and average returns obtained from these. This resulted in high rainfall returns being multiplied by the following factors to obtain average returns:

Beans	.63	Millet	1.22
Maize	.82	Sorghum	1.32
Pigeon Peas	.78	Wimbi	.89

The inputs considered in the linear programming analysis are labour at different times of the year, and land. Management abilities are considered separately and these are discussed in another section below.

Both inputs and outputs are expressed in per acre terms, so all of the land coefficients are 1. The labour inputs that enter into the analysis as possible limits on production are: ploughing at the beginning of the October rains, weeding, and harvesting. Planting labour does not limit production as such, because planting can be done by young girls or old women where necessary, and it does not interfere with labour that is scarce at that time. The time of planting, which is critical, is determined by the availability of ploughing resources instead.

Observations of ploughing labour inputs varied, with a distinct mode between 2 and 3 man-days per acre,⁷ and 90% of the observations between 1 and 5 man-days. It is assumed that better managers take less time than poorer ones, and this is discussed in the section on management levels below, but for the average level of management it is assumed that 3.5 man-days of ploughing labour per acre is required. This figure is the same for all food crops, and also for all ploughing whether done sooner or later after the beginning of the rains. There was no observable difference in the amount of ploughing required as the rains progressed in 1962/63.

The amount of ploughing labour available per farm was defined as the amount of time for which a whole ploughing team, labour, oxen and ploughs, was available. Thus the ploughing constraints, which determine the amount of planting that can be done in different time periods after the beginning of the rains, are not strictly labour constraints, but include capital in the form of oxen and ploughs, as well.

7. A man-day is defined as one adult labour unit, working for 8 hours.

Weeding labour is treated somewhat differently. Weeding intensities vary, and are the subject of choice. Three different intensities are allowed as choices in the analysis, for each crop or crop mixture considered. Thus crop mixtures can be weeded very little (low), an average amount (medium), or a great deal (high), and the farmer always has the choice for any particular crop mixture of how much weeding to do. The choices allowed for beans mixtures, wimbi mixtures, and mixtures containing maize, pigeon peas, millet or sorghum, but no wimbi or beans, ("other mixtures"), are shown below:

TABLE 4: Choice of Weeding Intensity allowed in the Analysis

(man-days per acre)

	Beans Mixtures	Wimbi Mixtures	Other Mixtures
Low	2.5	9.0	2.2
Medium	7.0	13.0	6.2
High	10.5	16.0	9.6

This compares with field observations as follows:

TABLE 5: Range of Weeding Intensities found in the Field

(man-days per acre)

	Beans Mixtures	Wimbi Mixtures	Other Mixtures
Low	3.3	4.7	1.4
High	22.8	24.0	17.2

The figures used in the analysis were chosen to represent the lower extremes found in the field as well as the higher ones, but the weeding observations that were very high were discounted to some extent because they were usually inflated by couch grass problems on particular plots. Where a high value was due to couch grass, it could not be attributed entirely to a particular crop mixture. It was considered to include an overhead charge associated with the plot rather than with the crop mixture concerned.

Outputs are assumed to be reduced by 70% by low weeding and increased by 50% by high weeding, compared with outputs obtained from medium weeding.

Harvesting is not a problem for all crops, some of which can be harvested at leisure when there is very little else to do on the farm. Wimbi and sorghum harvests do not generally interfere with other work, for example, and maize only does for part of the time. The important bottle-necks come with the beans and millet harvests which coincide, part of the maize harvest, and the pigeon pea harvest in September, at the end of the agricultural year. Labour required for these harvests is shown below. It is assumed that the quantity of harvesting labour applied does not have any influence on yield. There is no choice of harvesting intensities in the analysis.

TABLE 6: Harvesting Labour Inputs used in the Analysis,

<u>Modal Management Level</u>	
(man-days per 200 lb. bag)	
Beans	4.5
Maize (excluding threshing) ⁸	1.5
Pigeon Peas	4.0
Millet	6.5

8. Maize threshing can be done at any time, when there is no pressure of work on the farm. Beans and peas have to be threshed at once.

For maize, 95% of the field observations were between 0.5 and 2, for beans 85% between 0 and 6, and for pigeon peas 75% between 2 and 6 man-days per bag. The millet observations had a mode of 4-6 man-days, with a wide spread around this mode, and an uneven distribution altogether, due to rather few observations in this case.

For other management levels, slightly different harvesting labour inputs are used, as is shown later.

The time of planting which depends on ploughing, and the time of weeding, also have important influences on yields. Planting dates are critical where the length of the rainy season is as short and unpredictable as in Masii. Planting is divided into three time-periods for the purposes of this analysis: (i) 1-9 days after the rain begins; (ii) 10-15 days after the rains, and (iii) any time later than this. It is assumed that different crops are affected differently by delays in planting, maize and wimbi being the most sensitive, subject to yield reductions of 15% if planted in the second time-period, 35% if planted later than this. Beans peas, sorghum and millet are assumed to be somewhat less seriously affected, being subject to yield reductions of 5-10% if planted in the second time-period, and 10-15% if planted later than this.

The time of weeding is important, both because the longer the weeds stay the more they influence yields, and because the bigger the weeds grow the less effective any given quantity of weeding labour is. Thus weeding was defined according to whether the bulk of it took place 4-7 weeks after the beginning of the rains, 7-10 weeks after, or later than this. Crops were all assumed to be equally affected by weeding delays, the effect of early weeding being 25% higher than medium, and the effect of late weeding 25% lower than this.

Thus the crucial inputs considered are land, and ploughing, weeding, and harvesting labour. The crop mixture, time of planting, time and quantity of weeding are all assumed to affect output per acre. In a high rainfall year on a farm with average managerial skills, it is assumed that yields can be as high as $9\frac{1}{2}$ bags of maize and 3 bags of beans or peas per acre, but they can fall as low as $\frac{1}{2}$ bag of maize and $\frac{1}{4}$ bag of beans or peas if the crop mixtures are neglected, or grown extensively. In years when rainfall is low, all yields are very low, but prices compensate to some extent. In average rainfall years, they are somewhere in between.

(ii) Cotton: Cotton inputs and outputs are less well covered by field data, because 1962/63 was the first year in which cotton was grown in Masii since the war. There were few growers, unusual labour inputs on a new crop, and climatic conditions that gave exceptional patterns of growth. The development of cotton growing in Masii is likely to be accompanied by increases in the efficiency of labour on operations such as picking, which are entirely new, and decreases in the use of unreciprocated community labour which was very prominent in the 1962/63 season. Yields have already been declining from the high 1962/63 level to somewhere near the district average as the enthusiasm of the farmers, the proportion of progressive farmers growing cotton, and the concentration of extension supervision, all decrease. On the other hand, farmers' experience of the crop should lead to improvements counteracting these other influences to some extent.

Observations on cotton are available for two holdings, and these are used together with Agricultural Department estimates on cotton cultivation elsewhere in the district. Although the data are thin, the position of cotton emerges very clearly in the analysis, which does not appear to be sensitive to data assumptions that are weak. Where there is any doubt, assumptions have always been made on the optimistic side, so if anything the role of cotton is overestimated. It is important to remember this, in view of the conclusions presented below.

The ploughing constraint is the same as for any other crop, although this may consist of a first ploughing before the rain at a time when ploughing resources are plentiful, followed by a careful second ploughing when the rain begins. In the crucial period at the beginning of the rains, cotton is assumed to require the same amount of ploughing per acre as any other crop. Cotton planting can be a time-consuming operation, and it cannot all be done in spare time with labour that is not scarce. This is true if manure is applied in each individual planting hole, as recommended in Masii. On one of the holdings observed, manure was applied in each hole, and 15 man-days were spent in planting per acre. The Agricultural Department estimate for planting with manure is 10 days, and as they tend to overestimate the efficiency of peasant farm labour, a figure nearer 15 is used in this analysis. When no manure is applied it is assumed that planting is no problem, as in the case of food crops.

Cotton weeding was more intensive in 1962/63 than weeding for other crops, but this may have been because cotton was new and heavily supervised by extension officials in that year. In the analysis, the possibility of weeding very intensively is allowed, but also the

possibility of weeding very little, the choices being 12, 8 and 4 man-days per acre. An additional 5 man-days per acre is required for the two thinning and replanting operations at weeding time. The Agricultural Department estimate is 6 man-days for weeding, thinning and replanting. Field observations were 10 and 14 man-days for the weeding operation alone.

High weeding is assumed to increase yields by 50%, and low to reduce them by 60%, over medium weeded yields.

Dusting and spraying normally begin in the 3rd week of March and continue through the 1st week in May, and this is the pattern the analysis assumes. There is a choice between spraying the recommended amount, half the recommended amount, or not at all, in the analysis. Returns are then assumed to be reduced by 20% by half spraying, and 50% by no spraying at all, the effect as likely to be felt through the quality as through the quantity of cotton harvested.

Cotton makes the heaviest labour demands at picking time, from May to September in Masii. Agricultural Department estimates suggest a rate of 20 lbs. per day for an inexperienced labourer picking and sorting, and 40 lbs. per day for a more experienced man. The rate observed in Masii was less than 9 lbs. per day. Observations of the methods and speeds of picking easily confirm this low rate, but it is assumed that it will improve with practice, and the figure used in the analysis is 24 lbs. per day for the average management level, an optimistic estimate.⁹

9. This is high compared with estimates from Uganda and Tanzania as well.

The yields assumed for the different possible treatments range from 110 to 1250 lbs. per acre for an average farmer in Masii in a high rainfall year. In 1962/63 average yields were higher than this, but it is assumed that they were unusually high for reasons already given. The district average in a high rainfall year is 600-700 lbs., so a range of 110-1250 seems reasonable, for average management levels. For years when rainfall is poor, yields are assumed to be reduced from an average of 650 lbs. per acre to 250 lbs.

Cotton prices for the 1962/63 season were 52cts/lb. for AR and 18cts/lb. for BR grades. The analysis assumes these 1962/63 prices, with 60% AR and 40% BR cotton, the average for the district as a whole. There was some investigation of higher and lower qualities and price levels, and this showed that as the price or quality falls cotton quickly becomes unattractive in Masii. And considerable increases in price do not improve its position very much.¹⁰

(iii) Katumani Maize: Drought-resistant varieties of maize developed at Katumani Research Station are continually improving, and recent developments suggest that it will not be long before a reasonable yield in years of drought can be combined with a high rainfall year yield that is nearly as good as that of local maize. But this stage has not yet been reached.

The variety that is being widely distributed in the district at present is Katumani Synthetic II, first developed in 1961 and distributed since 1963. Synthetics IV and VI and their derivatives are now also

10. When the quality increases to 80% AR and 20% BR, the equivalent of a price increase of about 18%, the maximum gain in total returns is 10%, and the gain is usually considerably less. When the quality falls to 40% AR and 60% BR, the equivalent of an 18% fall in price, cotton becomes unattractive and food crops predominate.

being tested, and these are said to be giving promising results.¹¹

Katumani Synthetic II, however, appears to have failed in many areas in 1966/67 in the field, contrary to earlier expectations and claims.

Detailed field data are not available for Katumani maize, which was not grown in Masii in 1962/63. The analysis therefore relies on information from Katumani research station together with scattered information on field results since 1963. The analysis assumes that Katumani maize yields about $2\frac{1}{2}$ bags per acre in low rainfall years when local maize yields less than 1 bag. This now appears to be a somewhat optimistic assumption, in view of 1966/67 results, and it may be necessary to interpret the analysis as referring to Katumani maize in a few years to come, rather than Katumani maize as it is now. In high rainfall years, Katumani maize is assumed to yield an average of 4 bags per acre compared with local maize which yields $5\frac{1}{2}$.

The inputs for Katumani maize are assumed to be very similar to those required for ordinary maize, but the timing of the harvest is changed. Katumani maize is a quicker maturing maize than local maize, and the harvest thus comes earlier, conflicting with the beans and millet harvests, unlike local maize.

Bearing in mind the qualifications on performance in low rainfall years, the conclusions that follow can be interpreted as conclusions on the potential role of Katumani maize. They should soon be applicable, given advances at the research level that are already taking place.

11. Private communication from Katumani Research Station June 1966.

(iv) Different Managerial Skills: The range of outputs associated with a given set of inputs of labour and land on different farms is sufficient to warrant some consideration. It was found that farms using almost identical quantities of labour per acre at different times of the year obtained differing outputs. In other words the quantity of labour measured in adult hours, and the quantity of land, are not sufficient to explain output in any particular case. Other factors also play their part.

The residual factors not quantified in the analysis are termed "management". The most important of these are the quality of labour which includes intensity and methods of work, the condition of oxen at ploughing time, and the quality of soil conservation works, all of which can be considered to be factors within the farmers' control, factors depending on managerial skill. But "management" also includes some independent factors, the most important of which is the intrinsic fertility of the soil, only partly determined by manure and crop rotation policies followed by the farmer in the past. "Management" is a residual variable, but after considering all the possible factors involved in this residual it was decided that most of them could be termed "managerial".

Data on the range of managerial skills are only available for traditional food crops, and only for a high rainfall year. But the variation is sufficiently interesting to be worth discussing in this context alone. Differences in managerial levels are taken from frequency distributions, the mid point of which is the modal level to which most of the analysis applies. Two points on either side of this represent higher and lower managerial levels.

The inputs that are assumed to change with managerial skills are ploughing and harvesting. It is assumed that the most efficient farmers use only 2.5 man-days per acre for ploughing and the least efficient use 4.5. (The average level was 3.5, as already indicated. The range of field observations has also been given, p. 11). For harvesting, it is assumed that beans require 3.5 to 5.5 man-days, depending on the management level, maize 1.0 to 2.0, pigeon peas 3.0 to 5.0, millet 5.5 to 7.5, sorghum 3.0 to 6.0, and wimbi 6.5 to 8.5, all per 200 lb. bag. (The field ranges from which these are taken have been given earlier, p. 13.)

Outputs are assumed to vary as well. It is assumed that the more efficient managers can get more from a given crop mixture, time of planting, time and intensity of weeding than the less efficient. Yield ranges assumed are given below. (These compare with field ranges already given, p. 8.)

TABLE 7: Range of Traditional Food Crop Yields used in the Analysis,
Different Management Levels

(200 lb. bags per acre)

	<u>Worst</u> <u>Managers</u>	<u>Best</u> <u>Managers</u>
Lowest maize	0.2	0.8
Highest maize	4.1	15.0
Lowest beans	0.1	0.3
Highest beans	1.0	4.8
Lowest pigeon peas	0.1	0.5
Highest pigeon peas	1.3	5.3

Cont.

TABLE 7 cont.

	<u>Worst Managers</u>	<u>Best Managers</u>
Lowest sorghum/millet	0.2	0.7
Highest sorghum/millet	0.7	2.6
Lowest wimbi	0.4	0.6
Highest wimbi	0.7	1.1

V. The Prospects for Cotton in Masii

In considering the results of the analysis, we turn first to the role of cotton on farms in Masii. Farm systems in which cotton is included are compared with systems in which traditional food crops alone can be grown. The analysis shows how cotton fits in with other crops, what sort of farm production patterns are possible with cotton, how much farm returns can be increased, and what the major bottlenecks are once cotton is introduced. These factors are explored for high rainfall, average rainfall and low rainfall conditions, and there is a consideration of the year to year variability that the different possible systems involve. This is as far as we go in a treatment of risk. While it is relatively easy to discuss the range of year to year variability, and the outcomes in high rainfall, average rainfall and low rainfall conditions, it is much more difficult to combine this in a discussion taking all rainfall conditions together. We know something about the range of yields and different rainfall conditions, but we do not know the distribution of yields that can be expected in the long run over the years. Nor do we know anything about the relative weights farmers attach to low rainfall outcomes compared with high

rainfall outcomes. We cannot just assume that farmers are equally concerned with both. They may attach a great deal of weight to the outcome in years when rainfall is low and there is the possibility of famine, and much less weight to the high rainfall years. Or alternatively they may feel there is little they can do to provide for the years of famine, and they may concentrate on doing well in high rainfall years. We would need much more information than we have for a thorough treatment of risk, but we have at least taken the range of rainfall conditions into account. Many of the conclusions hold for all of these in which case it is not necessary to know about relative weights.

As already mentioned, cotton data are only available for the modal management level, and results discussed in this section apply only to modal managers. This point will be taken up again in the section on the validity of the cotton results.

The analysis assumes constant returns to scale, so it is the ratios of labour to land that are important rather than actual quantities. Results are given for 0 to 6 acres of arable land per labour unit,¹² and these can easily be translated into results for individual farm situations by simple multiplication in any case.

The range of land/labour ratios for which results are given corresponds to acreages on the farms studied varying from 0.6 to 6.5, with an average of 2.8, and labour units from 0.5 to 1.8, with an average of 0.9.

12. A labour unit is defined as an adult man 20-60 years, or woman 20-40 years, available throughout the year. People older or younger than this, people working only occasionally on the farm, and people who are sick, are counted as fractions of these adult-equivalents. See J. Heyer, *Agricultural Production and Peasant Farming in Kenya*, op.cit., for a fuller discussion of this.

The number of acres per unit of labour varied from 0.8 to 4.2, with an average of 2.9. The farms had to feed between 1.5 and 8.3 consumption units,¹³ an average of 2.8 per unit of labour on the farm. The proportion of dependents is thus rather high in Masii.

(i) The role of cotton in Masii: The analysis shows that the gains from growing cotton on farms such as those in Masii are relatively small. Returns attainable per labour unit with traditional food crops are compared with those attainable when cotton is also grown, in diagram 1. If the productive systems are planned to maximise high rainfall returns, it is possible for farmers to make up to Shs.900/- per labour unit from traditional food crops in the high rainfall years, and up to Shs.960/- if cotton is also grown. Returns to labour depend on the acreage each unit can command. Returns per acre, in a high rainfall year, vary from Shs.150/- to Shs.304/- with traditional food crop systems, and from Shs.152/- to Shs.472/- when cotton can also be grown. These depend on the amount of labour available. Cotton brings more substantial improvements if labour is plentiful relative to land.

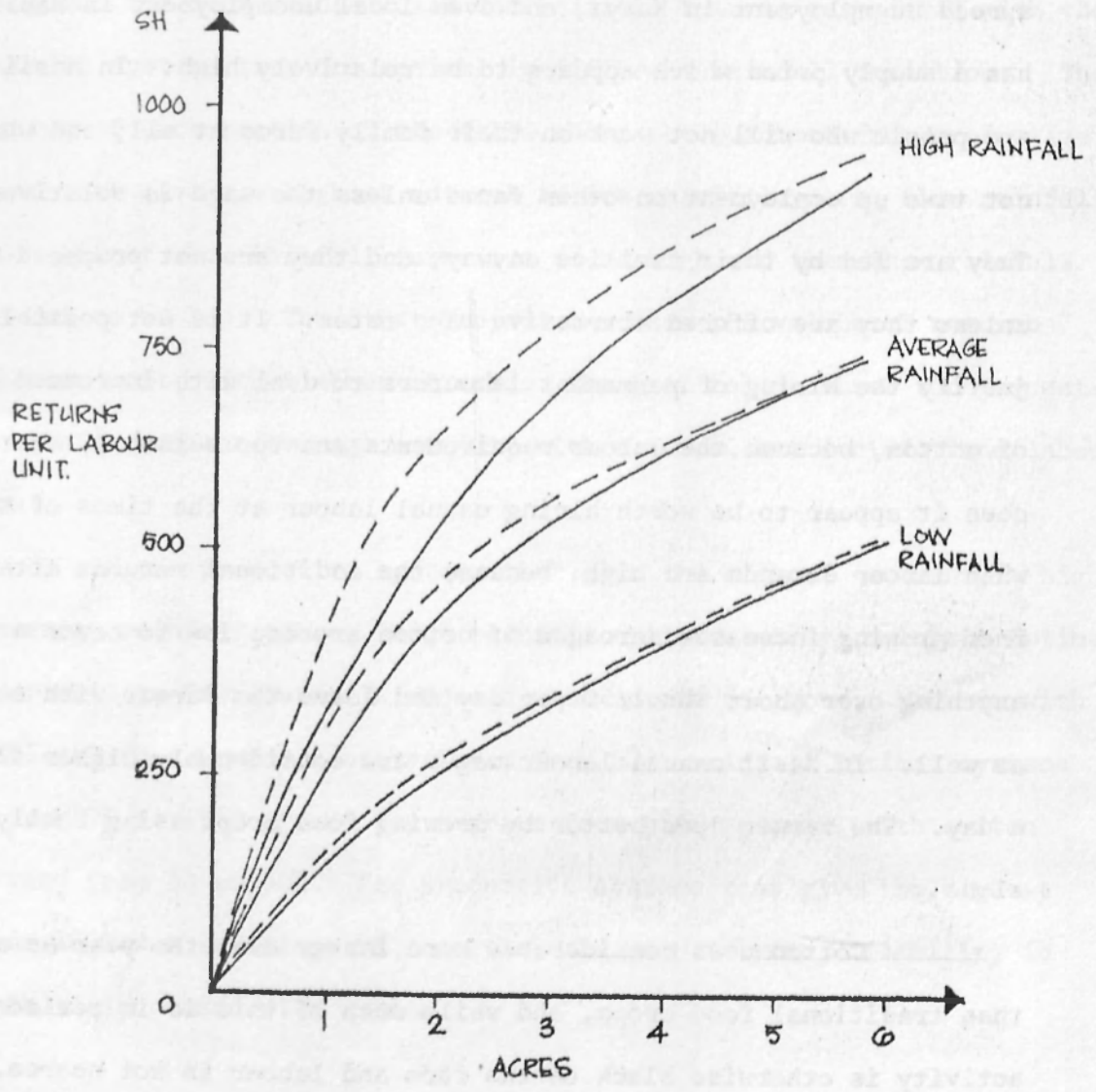
In low rainfall conditions, it is only possible to make about Shs.450/- per labour unit with 6 acres of land, and it makes little difference if cotton is also grown. The yield advantages of cotton when rainfall is low are outweighed by the increase in the price of maize making food crops as attractive. Returns per acre, in low rainfall years, vary from Shs.75/- to Shs.139/- with traditional food crops, and from Shs.75/- to Shs.172/- when cotton is also grown.

13. W.H.O. nutritional consumption units, in which children aged 0-10 years are counted as 0.5, and children aged 11-15 years are counted as 0.75 of an adult consumption unit.

DIAGRAM 1: THE IMPACT OF COTTON: RETURNS TO LABOUR IN DIFFERENT RAINFALL CONDITIONS

—— TRADITIONAL FOOD CROP SYSTEMS

----- TRADITIONAL FOODS WITH COTTON.



The advantages of growing cotton are more marked when labour is plentiful relative to land in Masii, because cotton is a labour-intensive crop. Farmers cannot concentrate on cotton as acreage rises in relation to labour available on the farm. This raises the possibility of using hired labour, at least at seasons of peak labour demand, to grow larger acreages of cotton. This possibility was investigated in the analysis, but additional returns proved insufficient to justify the hiring of labour unless available at a very low wage. Although there is widespread unemployment in Kenya, and even local unemployment in Masii, labour has a supply price which appears to be relatively high. In Masii, there are people who will not work on their family farms at all, and who will not take up employment on other farms unless the wage is relatively high. They are fed by their families anyway, and they are not prepared to work unless they are offered attractive wage rates. It is not possible to justify the hiring of permanent labourers to deal with increased acreages of cotton, because the labour requirements are too seasonal. But neither does it appear to be worth hiring casual labour at the times of the year when labour demands are high, because the additional returns attainable from growing increased acreages of cotton are too low to cover a wage of anything over about Shs.1/50 per day and leave the farmer with some extra as well. In Masii casual labour wages are considerably higher than Sh.1/50 a day. The farmer does better by growing food crops using family labour alone.

Cotton uses considerably more labour over the year as a whole than traditional food crops, and while much of this is in periods when activity is otherwise slack on the farm and labour is not scarce, farmers

might be reluctant to move into cotton with all the additional work it involves unless it offers very substantially increased total returns.

It is not only the absolute levels, but also the year to year variability in returns that is important in Masii. This is shown in Table 8 overleaf for the different productive systems, the first two sections being relevant to this discussion. Section 1 shows the position when traditional food crops are grown, and section 2 when cotton is also included. The table gives the high rainfall and low rainfall returns associated with the productive systems that are optimal in different rainfall conditions. The first row of each section of the table shows the outcomes from productive systems that give the highest returns in low rainfall years, (low rainfall optima) first when rainfall turns out to be high and then when rainfall turns out to be low. The first two columns show the values of returns per labour unit, with 6 acres of land. The last column shows the percentage variation around the average not just with 6 acres, but for all land/labour ratios.

In the productive systems that give the highest returns in high and average rainfall years, (high rainfall optima & average rainfall optima) the variability in returns is reduced when cotton is grown. Whereas with traditional food crops alone, returns from high rainfall optimal systems vary from 70 to 150% around the average from year to year, with cotton they vary from 30 to 90%. For productive systems that give the highest returns in low rainfall years, however, the year to year variability in returns is increased with cotton.

TABLE 9: Variations in Returns

	Returns/Labour Unit, 6 acres land, (sh.)		Returns/Labour Unit, 0-6 acres
	<u>High Rainfall</u>	<u>Low Rainfall</u>	<u>% Variation</u>
1. Traditional Food Crops: (current maize price)			
Low rain optima	620	450	40-70
Average rain optima	830	380	70-140
High rain optima	900	380	70-150
2. Food Crops & Cotton: (current maize price)			
Low rain optima	582	456	80-90
Average rain optima	946	402	70-90
High rain optima	958	394	30-90
3. Food Crops & Cotton: (constant maize price)			
Low rain optima	820	300	90
Average rain optima	850	270	90-110
High rain optima	900	240	100-120

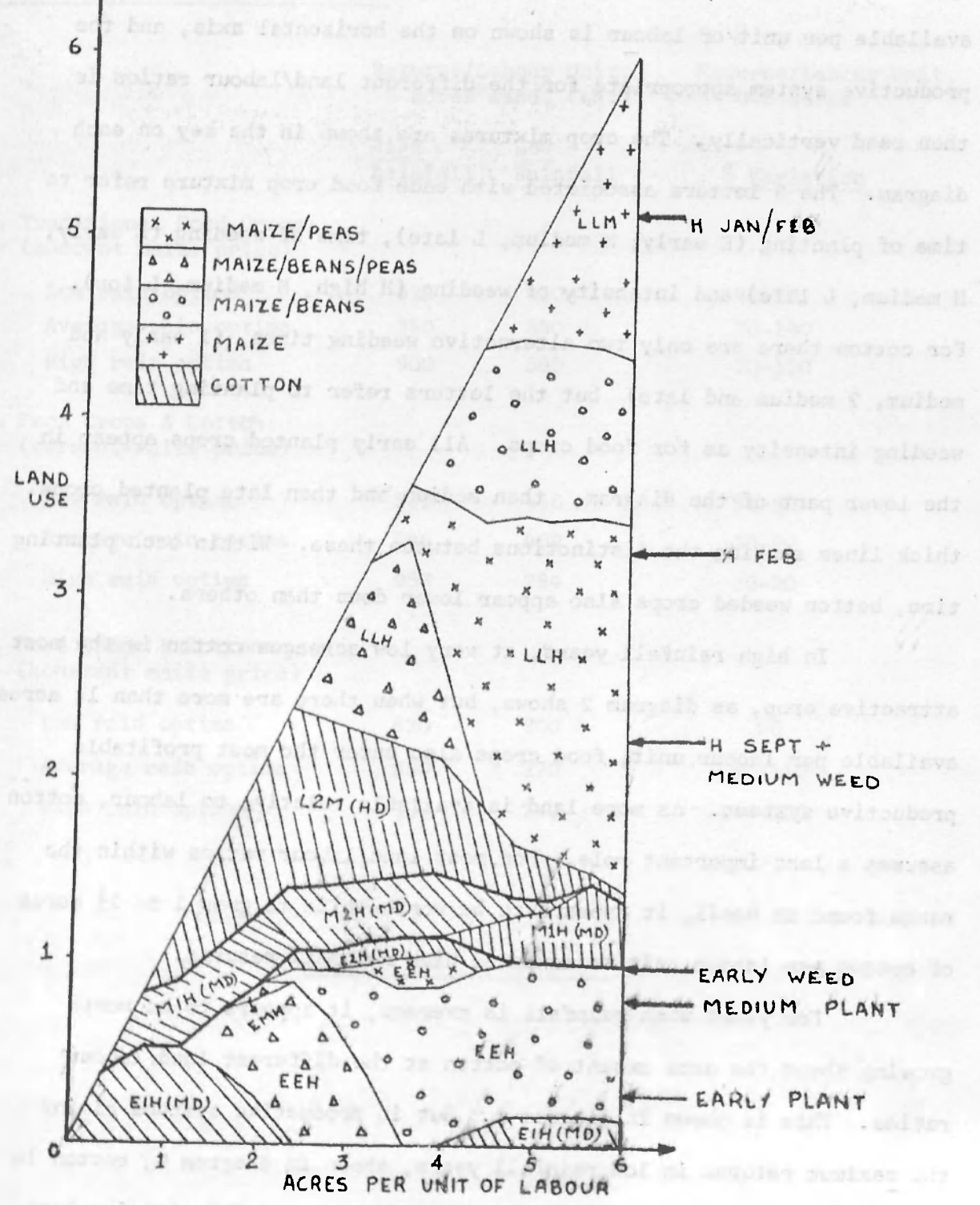
The way in which cotton fits into the traditional food crop systems is shown in diagrams 2, 3 and 4. In these diagrams, the acreage available per unit of labour is shown on the horizontal axis, and the productive system appropriate for the different land/labour ratios is then read vertically. The crop mixtures are shown in the key on each diagram. The 3 letters associated with each food crop mixture refer to time of planting (E early, M medium, L late), time of weeding (L early, M medium, L late) and intensity of weeding (H high, M medium, L low). For cotton there are only two alternative weeding times, (1 early and medium, 2 medium and late) but the letters refer to planting time and weeding intensity as for food crops. All early planted crops appear in the lower part of the diagram, then medium and then late planted crops, thick lines showing the distinctions between these. Within each planting time, better weeded crops also appear lower down than others.

In high rainfall years, at very low acreages cotton is the most attractive crop, as diagram 2 shows, but when there are more than 1 $\frac{1}{2}$ acres available per labour unit, food crops also enter the most profitable productive systems. As more land is available relative to labour, cotton assumes a less important role. For most land/labour ratios within the range found in Masii, it appears to be worth while to grow 1 to 1 $\frac{1}{2}$ acres of cotton per labour unit to maximise high rainfall returns.

For years when rainfall is average, it appears to be worth growing about the same amount of cotton at the different land/labour ratios. This is shown in diagram 3. But in productive systems giving the maximum returns in low rainfall years, shown in diagram 4, cotton is much less prominent. Except at very low acreages, cotton occupies less

30

DIAGRAM 2: HIGH RAINFALL OPTIMAL LAND USE PATTERNS AS RATIOS OF LAND TO LABOUR INCREASE TRADITIONAL FOODS WITH COTTON



31

DIAGRAM 3: AVERAGE RAINFALL OPTIMAL LAND USE PATTERNS AS RATIOS OF LAND TO LABOUR INCREASE TRADITIONAL FOODS WITH COTTON

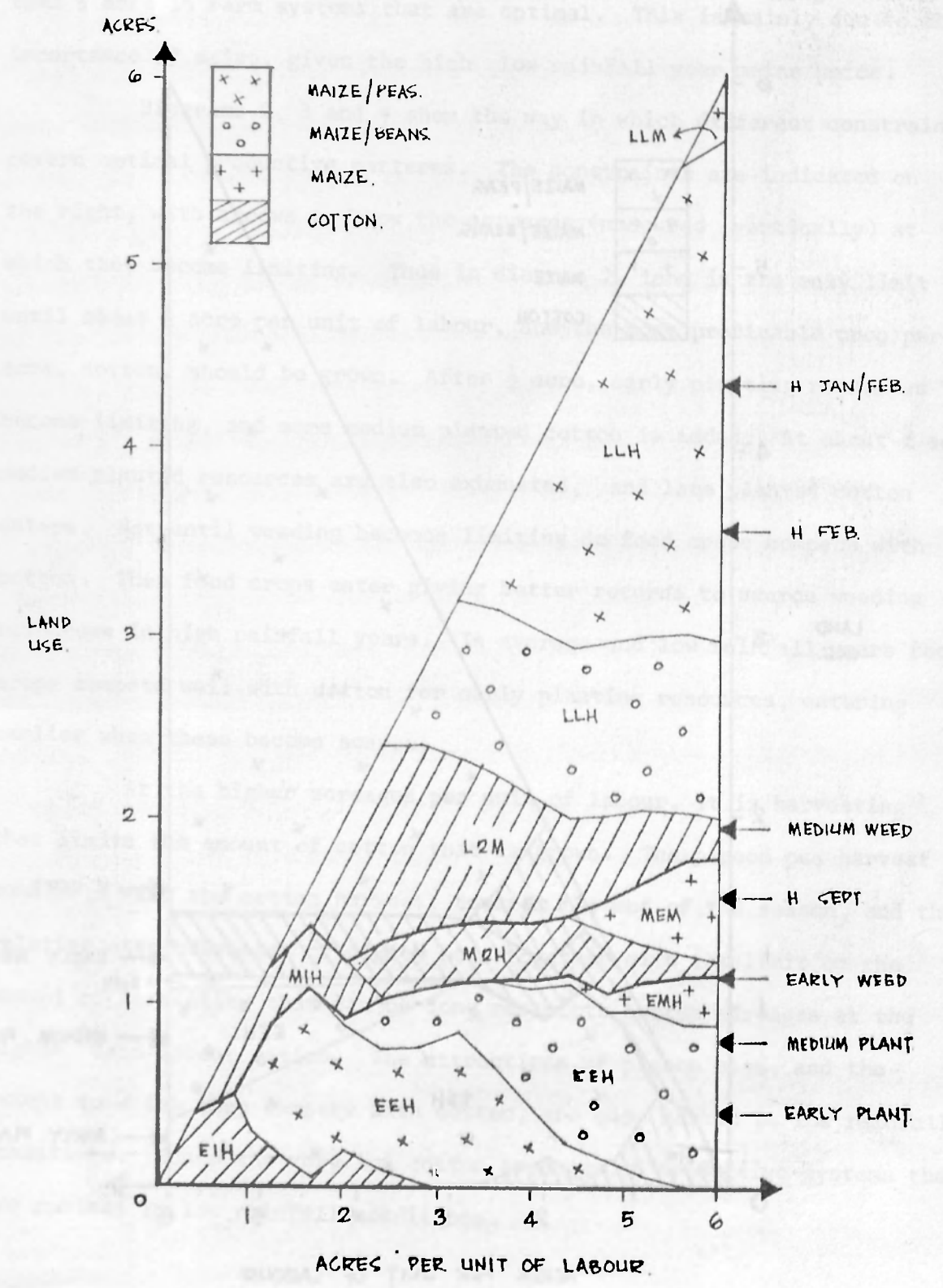
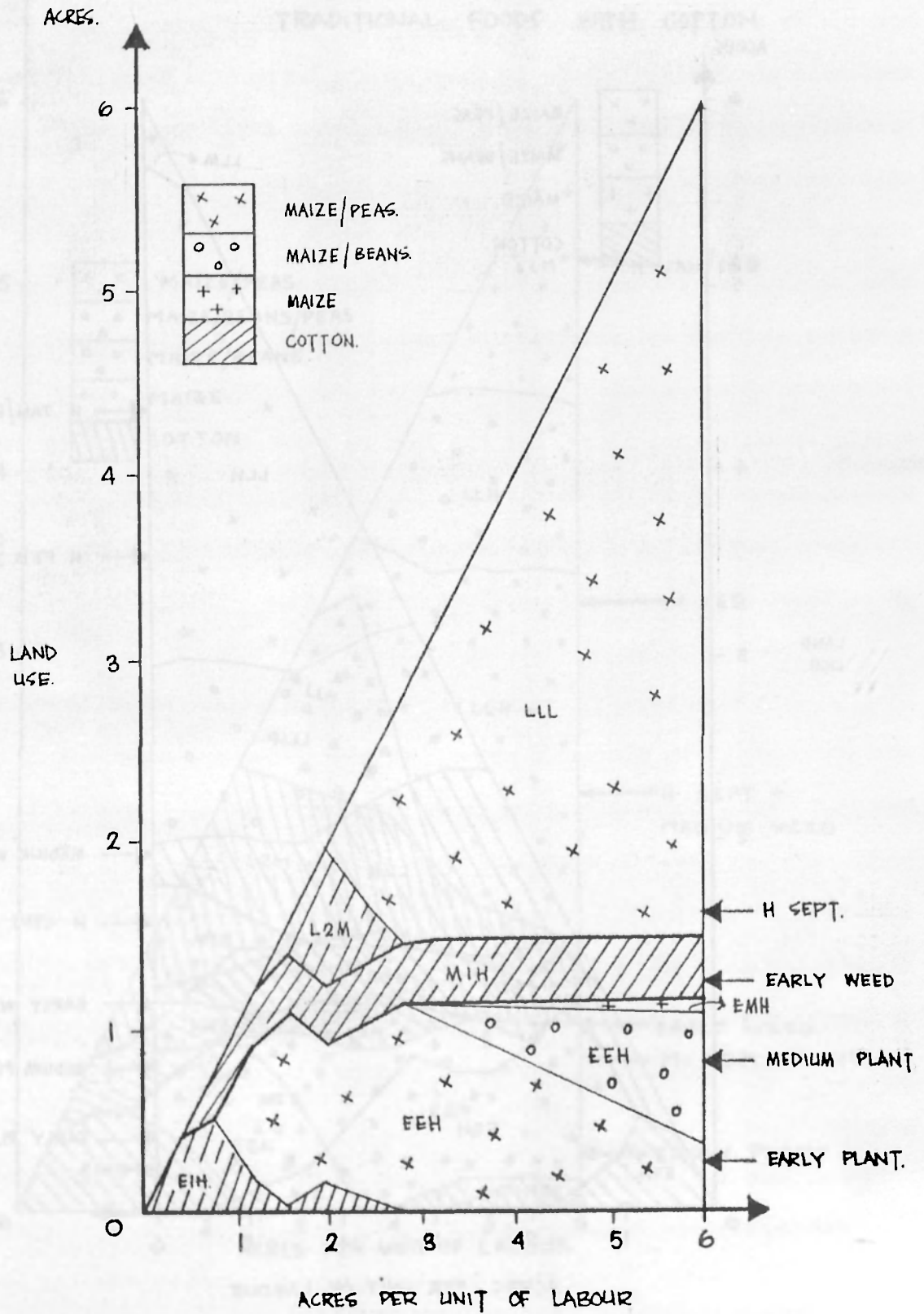


DIAGRAM 4: LOW RAINFALL OPTIMAL LAND USE PATTERNS AS RATIOS OF LAND TO LABOUR INCREASE TRADITIONAL FOODS WITH COTTON

32



than $\frac{1}{2}$ acre in farm systems that are optimal. This is mainly due to the importance of maize, given the high low rainfall year maize price.

Diagrams 2, 3 and 4 show the way in which different constraints govern optimal productive patterns. The constraints are indicated on the right, with arrows to show the acreages (measured vertically) at which they become limiting. Thus in diagram 2, land is the only limit until about $\frac{1}{2}$ acre per unit of labour, and the most profitable crop per acre, cotton, should be grown. After $\frac{1}{2}$ acre, early planting resources become limiting, and some medium planted cotton is added. At about $\frac{3}{4}$ acre, medium planted resources are also exhausted, and late planted cotton enters. Not until weeding becomes limiting do food crops compete with cotton. Then food crops enter giving better returns to scarce weeding resources in high rainfall years. In average and low rainfall years food crops compete well with cotton for early planting resources, entering earlier when these become scarce.

At the higher acreages per unit of labour, it is harvesting that limits the amount of cotton that is grown. The pigeon pea harvest conflicts with the cotton harvest, towards the end of the season, and the relative attractiveness of pigeon peas together with the limit on the amount of harvesting that can be done restricts cotton acreages at the higher land/labour ratios. The attractions of pigeon peas, and the extent to which they compete with cotton, are more marked in low rainfall conditions. Hence the very low cotton acreages in productive systems that are optimal in low rainfall conditions.

One might have expected the harvesting limit to be important in restricting cotton acreages, as cotton is well known for its heavy picking and sorting labour demands. More interesting is the fact that food crops compete well with cotton for early planting and weeding resources. Agricultural officials have long been known to complain that they cannot persuade farmers to give priority treatment to cotton. It may well be that farmers are right to resist, in this case, as our analysis suggests.

To summarise: for farmers who are preoccupied with returns in years when rainfall is low, cotton is hardly attractive at all, representing very little improvement over traditional food crop systems in the overall level of returns, and involving a greater year to year variability than these. For farmers whose main concern is with the outcome in high and average rainfall conditions, though, cotton represents both some overall increase in returns and a lower variability than traditional food crops do. These farmers, planning their production to maximise high or average rainfall returns, would do well to grow 1 to $1\frac{1}{2}$ acres of cotton, together with traditional food crops, but not to give it preferential treatment compared with food, except when farm labour is very plentiful relative to land. Whether farmers will think the increase in returns offered by cotton sufficient to compensate for the additional work involved is another question, though.

(ii) The validity of the cotton results: In view of the importance of the conclusion that cotton is not particularly attractive in places like Masii, even at present world prices, we review briefly the critical assumptions on which the cotton conclusions are based. We then consider

why cotton is less attractive in Masii than elsewhere in East Africa where it has long been established on peasant farms, and why it is popular at present even in Masii.

First we review the critical input-output assumptions. It was assumed that cotton requires the same amount of ploughing labour as other crops in Masii, but that it makes extra claims on scarce labour at ploughing time if manure is applied. It was assumed that cotton is somewhat more demanding than other crops at weeding time, both through higher quantities of weeding labour required, and because of thinning and replanting operations which are hardly necessary for traditional food crops. These two assumptions help to explain why it is advisable to give food crops priority over cotton in many of the land/labour situations considered above. But there are good reasons to believe that cotton is more demanding than other crops in these respects, and there is no justification for revising the figures to make them more comparable with the food crops here.

All other important input-output assumptions for cotton are on the optimistic side. The figure of 24 lbs. per man-day for picking and sorting at harvest time is considerably higher than that found elsewhere in East Africa. The assumptions about yields are also by no means pessimistic for cotton. An average of 650 lbs. per acre in a high rainfall year, and 250 lbs. per acre in a year when rainfall is low is high for East African conditions. In Nyanza which has a much longer cotton growing tradition, and on the Coast in Kenya, yields are much lower than this.

In Uganda and Tanzania these averages would also be considered high. Assumptions about quality are as important as yields in influencing returns, because the price differential is high. Our assumption that 60% of the cotton is in the 1st grade is optimistic for an area in which pest and disease problems are substantial as in Masii.

Thus the input-output assumptions cannot be regarded as pessimistic for cotton. If anything, they are on the optimistic side, over-estimating the attractions of cotton in farming systems in Masii.

It has been suggested that the resource combinations for which this analysis is valid are limited, in particular that insufficiently extensive methods of treatment have been considered. The analysis only applies, strictly speaking, to land/labour ratios falling between 0.8 and 4.2 acres per unit of labour, those actually found among the farmers studied in Masii. Where land is more plentiful, one should consider more extensive methods of growing the crops concerned, using even less labour relative to land. But in fact, we have considered very extensive methods of growing the different crops. We have considered extremes in which very little labour is used for the cultivation of cotton (and other crops), in which cotton is grown very extensively. Weeding of only 4 man-days per acre, which can all be done very late, and yields as low as 110 lbs., have been included as high rainfall year possibilities in Masii. It is difficult to imagine much less intensive methods being economic with any ratios of labour to land, because the corresponding yields would be so low.

More important, perhaps, is the question of managerial skills. No information on the response of cotton to managerial skills is available. It has been suggested that cotton may respond better to good management than food crops do. It is equally possible that its response is worse, poor managers doing better with cotton than with food crops because of the concentration of extension supervision that goes with cotton, and the lack of resistance to new methods with a completely new crop. There is no evidence to show which of these two hypotheses is correct, but it is worth emphasising that food crops were found to respond a great deal to managerial skills. It was found that the better managers obtain food crop yields 60-65% higher than those of average managers, and that poor managers obtain yields 50-70% lower than the average ones. To show that cotton responds even better to managerial skills, it would have to be proved that good managers can get cotton yields more than 60-65% higher than the average ones, cotton yields of up to 2100 lbs. per acre, compared with the 1250 lbs. maximum that is assumed for average managers here. It is well-known that a few farmers get more than this, but whether a sizeable group do is doubtful in lowland Machakos conditions. The very few also get higher food crop yields.

It is likely that all farmers do better in a new and heavily supervised crop like cotton, but there is no reason to suppose that good farmers respond any better than poor farmers, or vice versa. There is no reason to suppose that returns to management are particularly high for cotton, and that cotton is therefore more attractive than the analysis suggests for above-average managers.

It is difficult to see how the conclusion that cotton is relatively unattractive in lowland Machakos can be challenged on the grounds of the assumptions that have been made. But if the conclusion is basically sound, why is cotton growing expanding so fast in Masii at present? And why is cotton unattractive in Masii but attractive in other parts of East Africa, where it is an old-established crop?

In Masii, it is not easy to reconcile the present popularity of cotton with the conclusions here. But it is quite likely that it is still too soon for farmers to make their own judgements, and to become disillusioned with the crop. There is tremendous pressure from the Cotton Board and the Agricultural Department, both of which are trying to get as many people as possible to grow cotton. There are many farmers in Masii who are now extremely receptive to new ideas, who want to try anything that has a good chance of success. There is also a large group of people who want to do the right thing, and who always try to follow new Agricultural Department advice. At this stage, these people are all willing to try. It may take some time before they make sufficiently strong judgements of their own to decide that the Agricultural Department is wrong about cotton. In particular, Masii farmers have not had long enough to judge the year to year variability, and the long-run position.

The question of success in similar areas in East Africa over a much longer period is also interesting. There is a major difference between lowland Machakos and most other East African cotton-growing areas due to the special position of maize. Maize is the main staple food in Masii and in Kenya the maize price system puts a premium on growing maize

where it is consumed. It is extremely expensive to buy maize for consumption, in Kenya, at times of generalised local shortages of maize as in Masii in low rainfall years. And in Masii, unlike some other parts of Kenya, people do not have alternative staple foods to which they can switch when the maize price is high. Unless the high consumer price reflects real costs in providing maize from the surplus maize-producing areas (or from abroad), Kenya's present maize price policy cannot but have adverse effects on resource allocation in places like Masii. A high maize price in years of shortage encourages farmers to produce the maize they require for consumption purposes, where it may not be really economic to do so. It might well be cheaper to bring maize in from other areas, and encourage Masii farmers to grow crops such as cotton, which do much better than maize in Masii conditions. The present maize price structure does not appear to reflect the real cost of providing maize from other areas, though.

In order to explore the effect of a different maize price system, and in order to compare Masii with other East African areas where the price fluctuations for major food crops are not nearly as wide as they are in Masii, a constant maize price was postulated. This is a somewhat extreme hypothesis, but it highlights the role of fluctuations in the maize price. As we show, cotton becomes much more attractive if maize price fluctuations are removed.

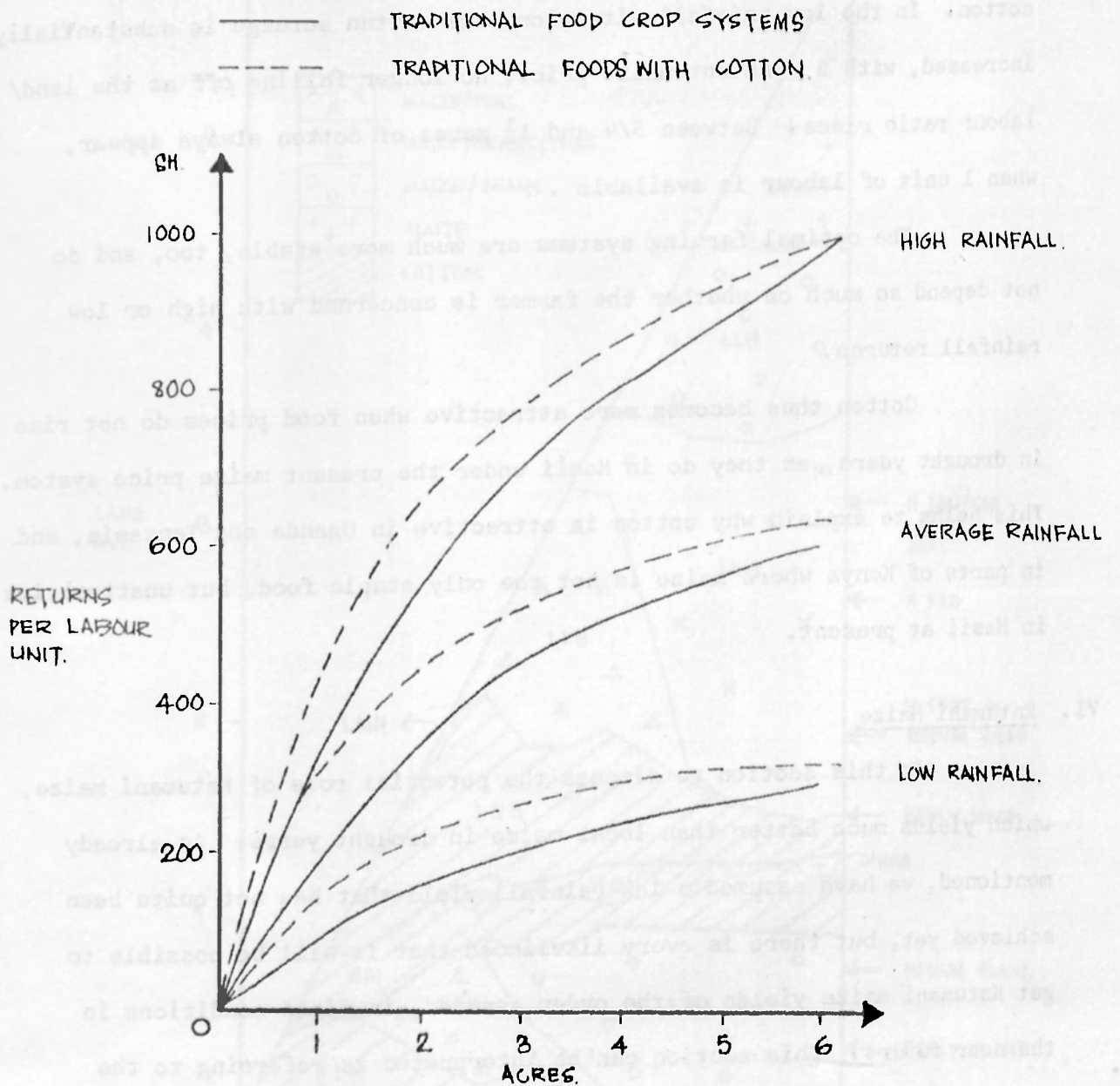
(iii) Cotton with a Constant Price for Maize: if maize is no longer subject to violent price fluctuations, making it very expensive not to produce food requirements in low rainfall years, cotton becomes considerably more attractive for lowland Machakos farms. For the purposes of discussion,

we assume a maize price constant at the Masii 1962/63 level, the national producer price after deductions, at Masii, with no increase in maize shortage years. Cotton then becomes more attractive in the average and low rainfall situations, as shown in diagram 5. (This compares with the current maize price situation shown in diagram 1, p. 25.) In low rainfall years, with the low maize price, it is only possible to make up to Shs.279/- with traditional food crops, compared with Shs.450/- before. Returns per acre vary from Shs.47/- to Shs.86/- with a constant maize price, instead of Shs.75/- to Shs.139/- at present. With cotton and a constant maize price, though, it is possible to make up to Shs.297/- and returns vary from Shs.50/- to Shs.175/- per acre, a considerable improvement over the traditional food crop position.

The variability in returns, with cotton and a constant maize price, is shown in the 3rd section of Table 8 (p.28). The current maize price system has a stabilising effect on returns, (though not on food supplies). In general, when the maize price is constant returns vary more from year to year. The variation in constant maize price systems with cotton is still less than in the present systems with traditional food crops though.

The food situation is also improved, with maize available at Shs.20/- instead of Shs.50/-. An average farm, with just under 3 acres of land, and 1 unit of labour, can feed more than 3 adult-equivalents with constant maize prices, by growing cotton, compared with only 2 adult-equivalents in the current maize price situation.

DIAGRAM 5 : THE IMPACT OF COTTON WHEN THE MAIZE PRICE IS CONSTANT (41)
 RETURNS TO LABOUR IN DIFFERENT RAINFALL CONDITION



The cotton acreage in the optimal production patterns, shown in diagrams 6 and 7, is much the same in the average rainfall situation as when the current maize price rules, but there is more early planted cotton. In the low rainfall situation, the cotton acreage is substantially increased, with a constant maize price, no longer falling off as the land/labour ratio rises. Between $3/4$ and $1\frac{1}{2}$ acres of cotton always appear, when 1 unit of labour is available.

The optimal farming systems are much more stable, too, and do not depend so much on whether the farmer is concerned with high or low rainfall returns.

Cotton thus becomes more attractive when food prices do not rise in drought years, as they do in Masii under the present maize price system. This helps to explain why cotton is attractive in Uganda and Tanzania, and in parts of Kenya where maize is not the only staple food, but unattractive in Masii at present.

VI. Katumani Maize

In this section we discuss the potential role of Katumani maize, which yields much better than local maize in drought years. As already mentioned, we have assumed a low rainfall yield that has not quite been achieved yet, but there is every likelihood that it will be possible to get Katumani maize yields of the order assumed, in field conditions in the near future. This section can be interpreted as referring to the potential role of Katumani maize, once this position is reached.

(i) Katumani maize with the current maize price. when Katumani maize yielding $2\frac{1}{2}$ bags even in low rainfall years is considered it dominates cotton and local maize in systems that give the highest returns in average and low rainfall years, though not of course systems that are optimal for high rainfall years. when local maize still gives somewhat higher yields. The returns from growing Katumani maize in average and low rainfall years are actually higher than those in the high rainfall years, because of the very high maize shortage price, and they are considerably higher than the returns from traditional food crops alone. This is shown in diagram 8. However, it is not returns so much as the food position that is important, and we come back to this below.

The variations in returns are shown in Table 9. Here there is a striking difference when Katumani maize is introduced, as well, returns varying much less from year to year than when traditional food crops alone are grown. This is due to the relative stability of maize returns, even with Katumani maize, and the dominance of maize in the Katumani maize farm systems.

The patterns of production that are optimal for average and low rainfall years, with Katumani maize, are shown in diagrams 9 and 10. Diagrams 11, 12 and 13 show the traditional food crop systems for comparison. Maize almost completely dominates the farming systems that are optimal for average and low rainfall years, when Katumani maize is introduced. When local maize alone is grown, there is a good deal of beans and peas in the mixtures as well. With Katumani maize, people would sell surplus maize in exchange for other foods in their diet.

46

DIAGRAM 8: THE IMPACT OF KATUMANI MAIZE :
RETURNS TO LABOUR IN DIFFERENT RAINFALL CONDITIONS
TRADITIONAL FOOD CROP SYSTEMS, SOME WITH
KATUMANI MAIZE

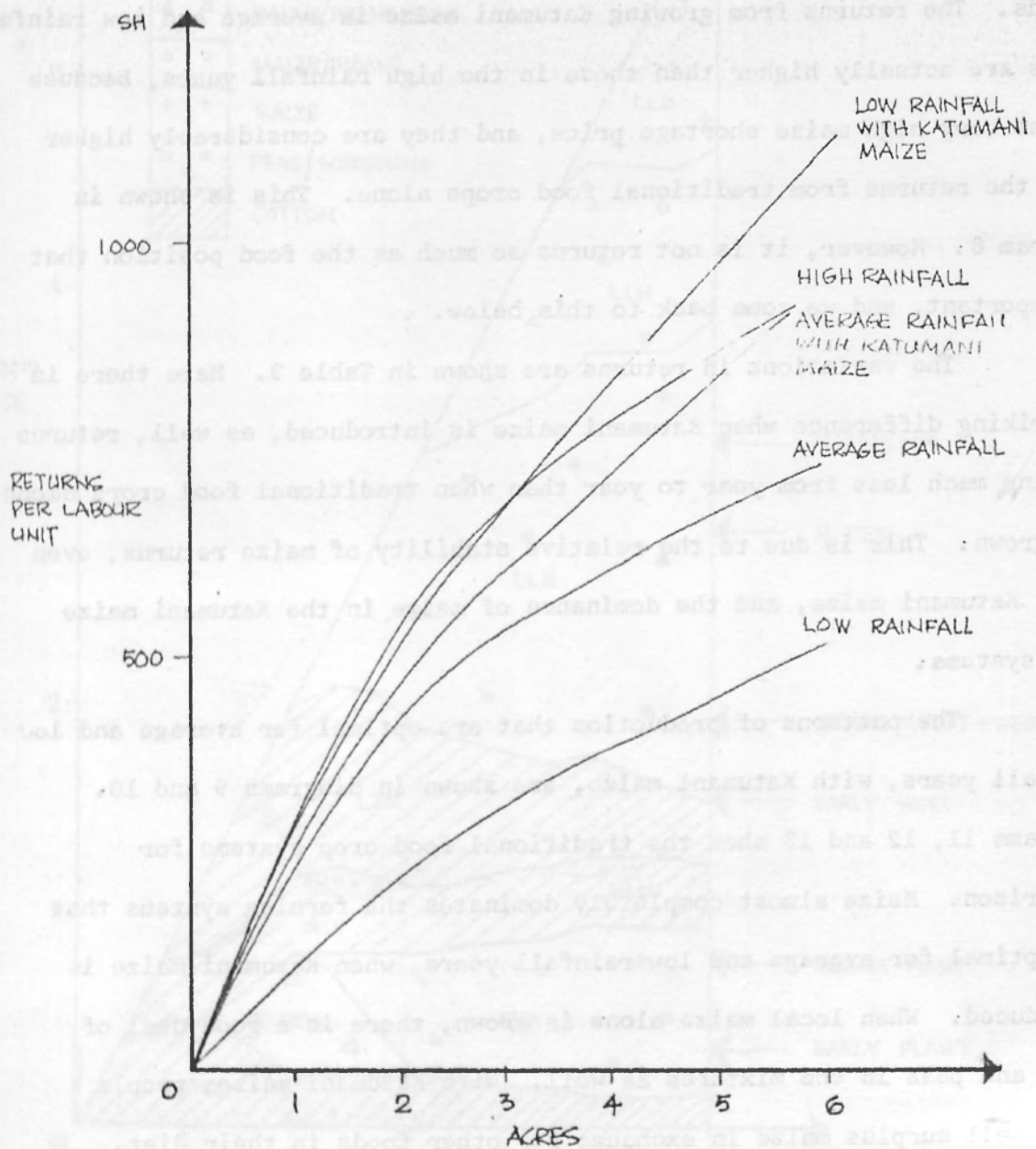


TABLE 9: Variations in Returns

	Returns/Labour Unit, 6 acres land, (sh.)		Returns/Labour Unit, 0-6 acres
	<u>High Rainfall</u>	<u>Low Rainfall</u>	<u>% Variation</u>
1. Traditional Food Crops: (current maize price)			
Low rain optima	620	450	40-70
Average rain optima	880	380	70-140
High rain optima	900	380	70-150
2. Traditional Foods and Katumani Maize: (current maize price)			
Low rain optima	780	1220	20-40
Average rain optima	850	1180	20-30
High rain optima	900	380	70

DIAGRAM 9 : AVERAGE RAINFALL OPTIMAL LAND USE PATTERNS AS RATIOS OF LAND TO LABOUR INCREASE TRADITIONAL FOODS WITH KATUMANI MAIZE

(48)

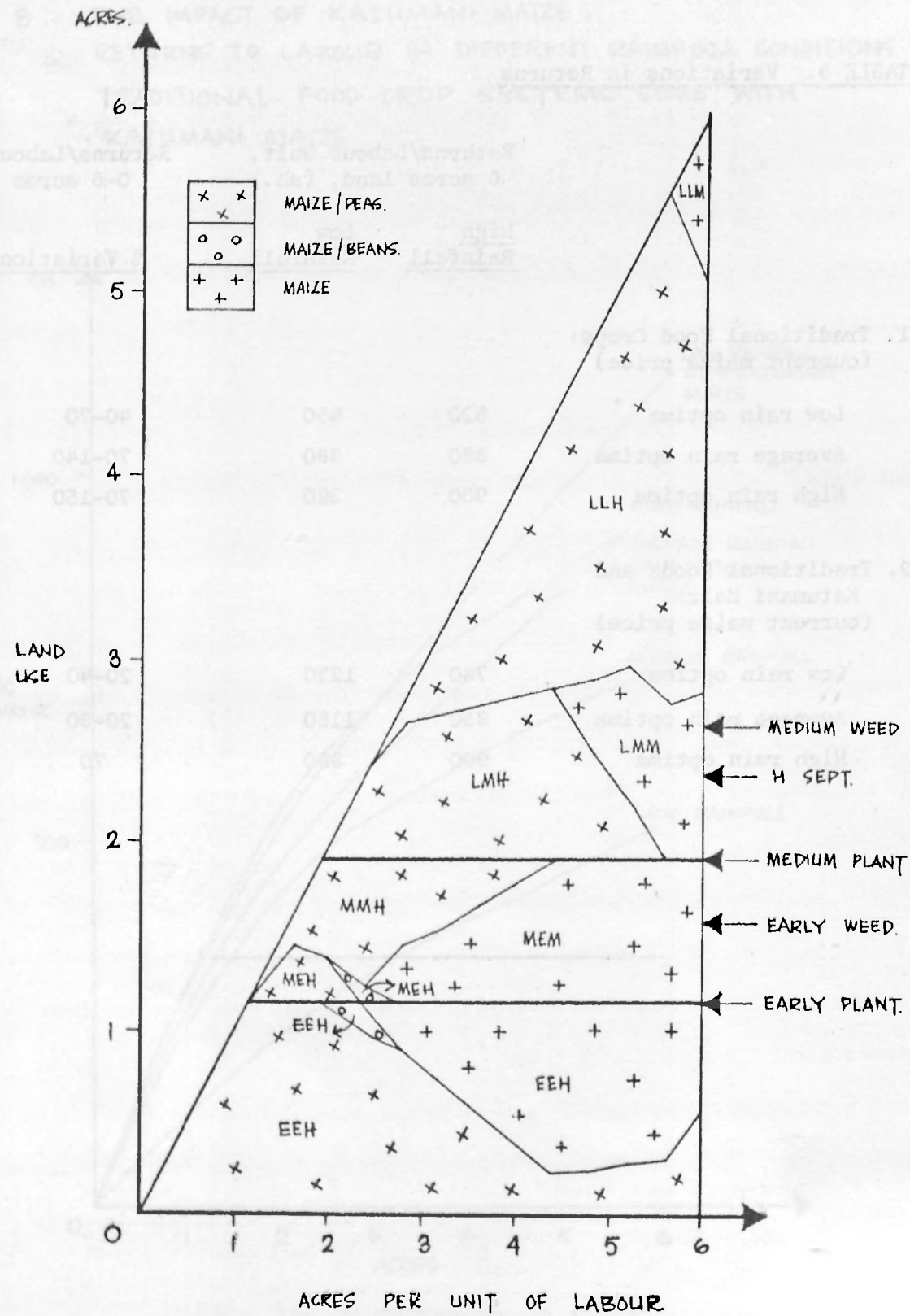


DIAGRAM 10: LOW RAINFALL OPTIMAL LAND USE PATTERNS AS RATIOS OF LAND TO LABOUR INCREASE TRADITIONAL FOODS WITH KATUMANI MAIZE

(49)

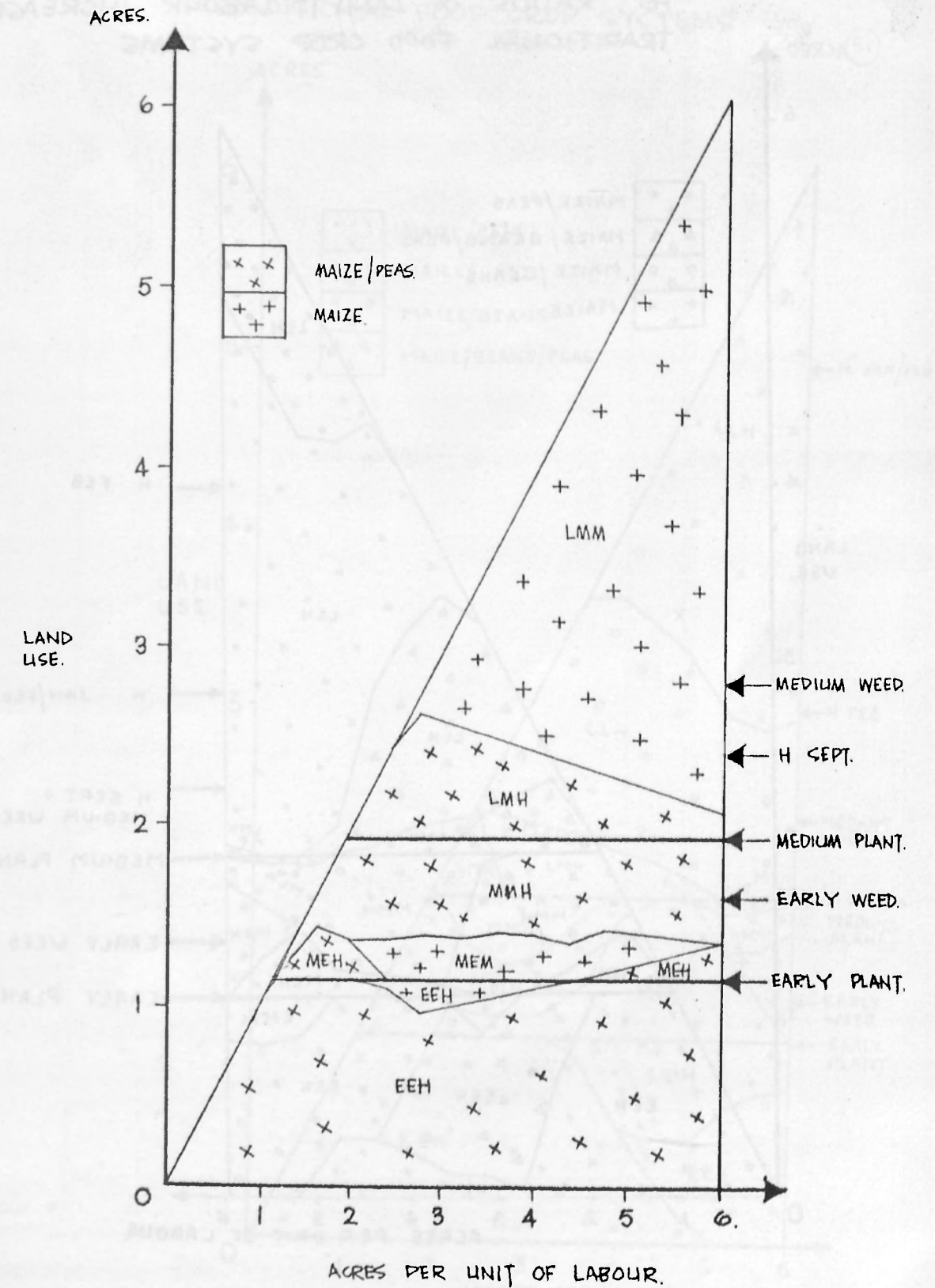


DIAGRAM 11: HIGH RAINFALL OPTIMAL LAND USE PATTERNS AS RATIOS OF LAND TO LABOUR INCREASE TRADITIONAL FOOD CROP SYSTEMS

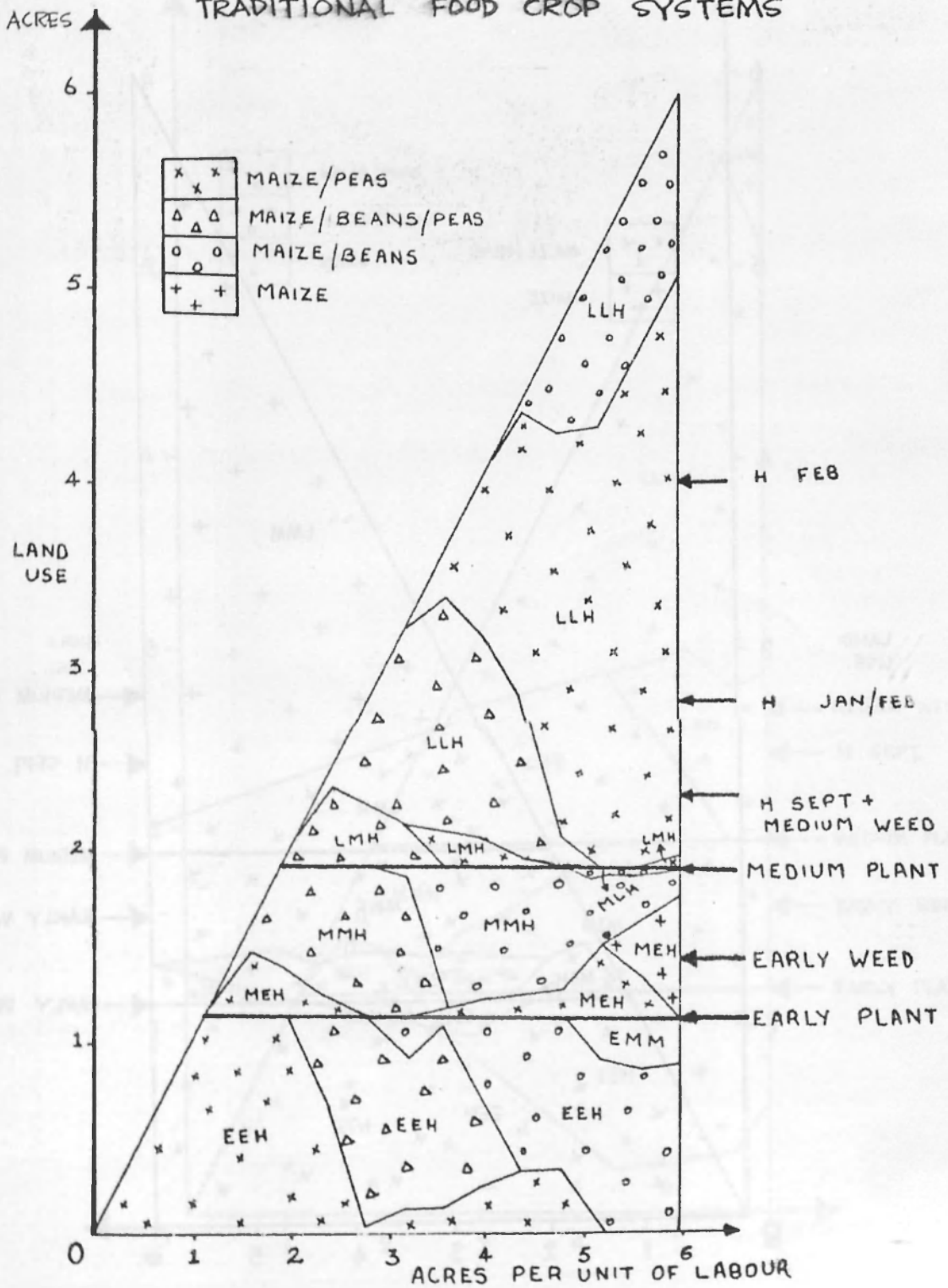


DIAGRAM 12 : AVERAGE RAINFALL OPTIMAL LAND USE PATTERNS AS RATIOS OF LAND TO LABOUR INCREASE
 TRADITIONAL FOOD CROP SYSTEMS

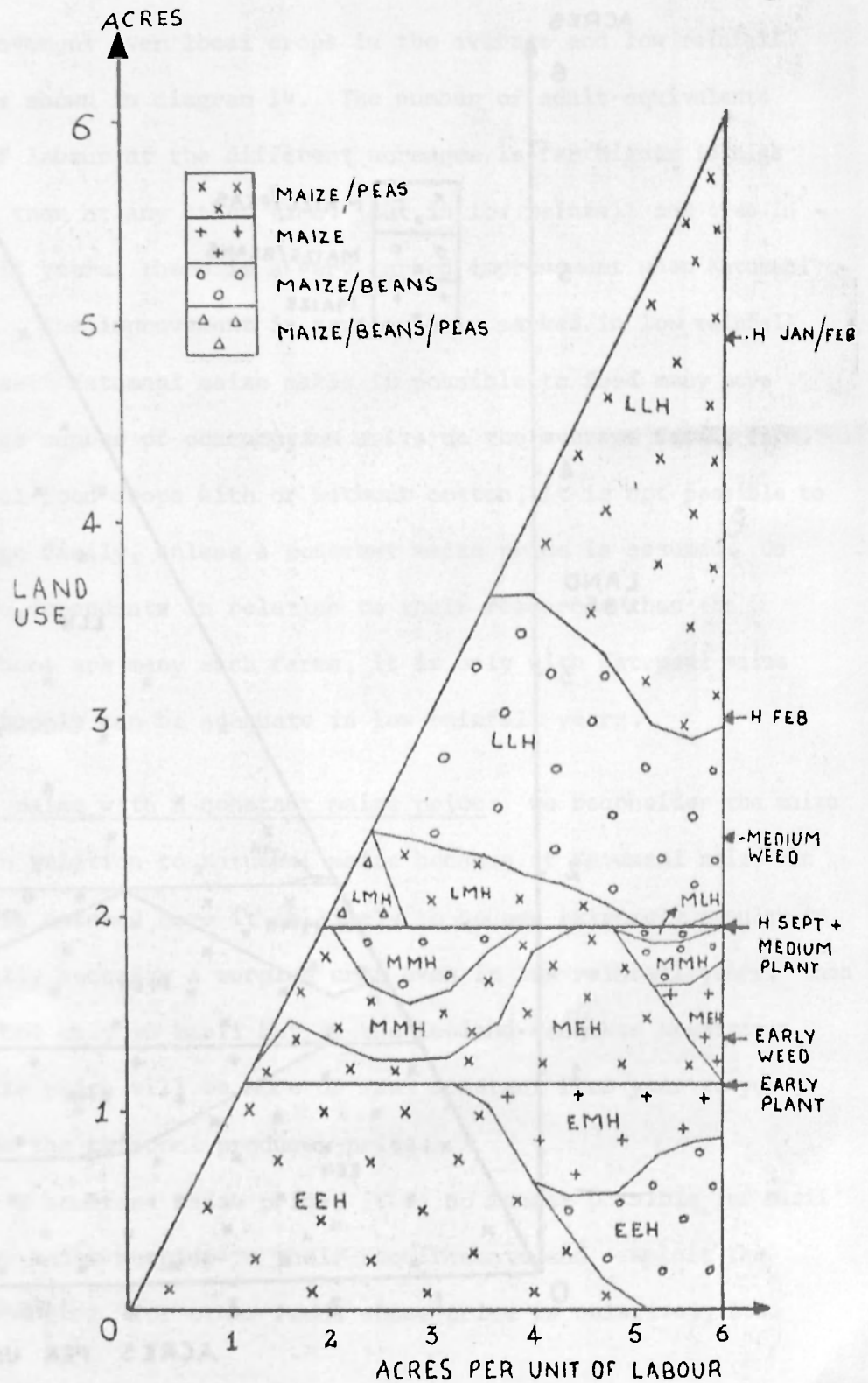
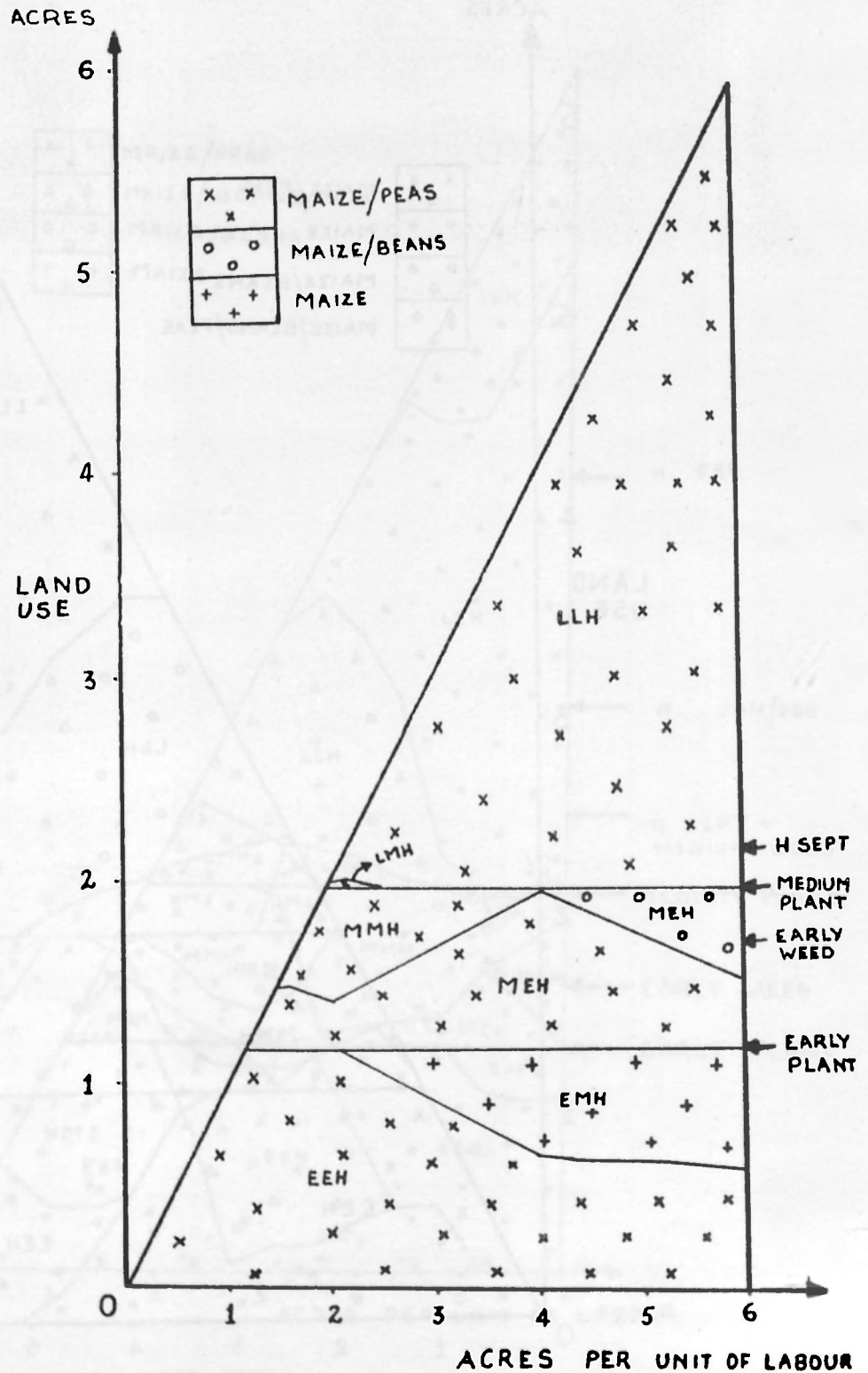


DIAGRAM 13: LOW RAINFALL OPTIMAL LAND USE PATTERNS AS RATIOS OF LAND TO LABOUR INCREASE TRADITIONAL FOOD CROP SYSTEMS

52



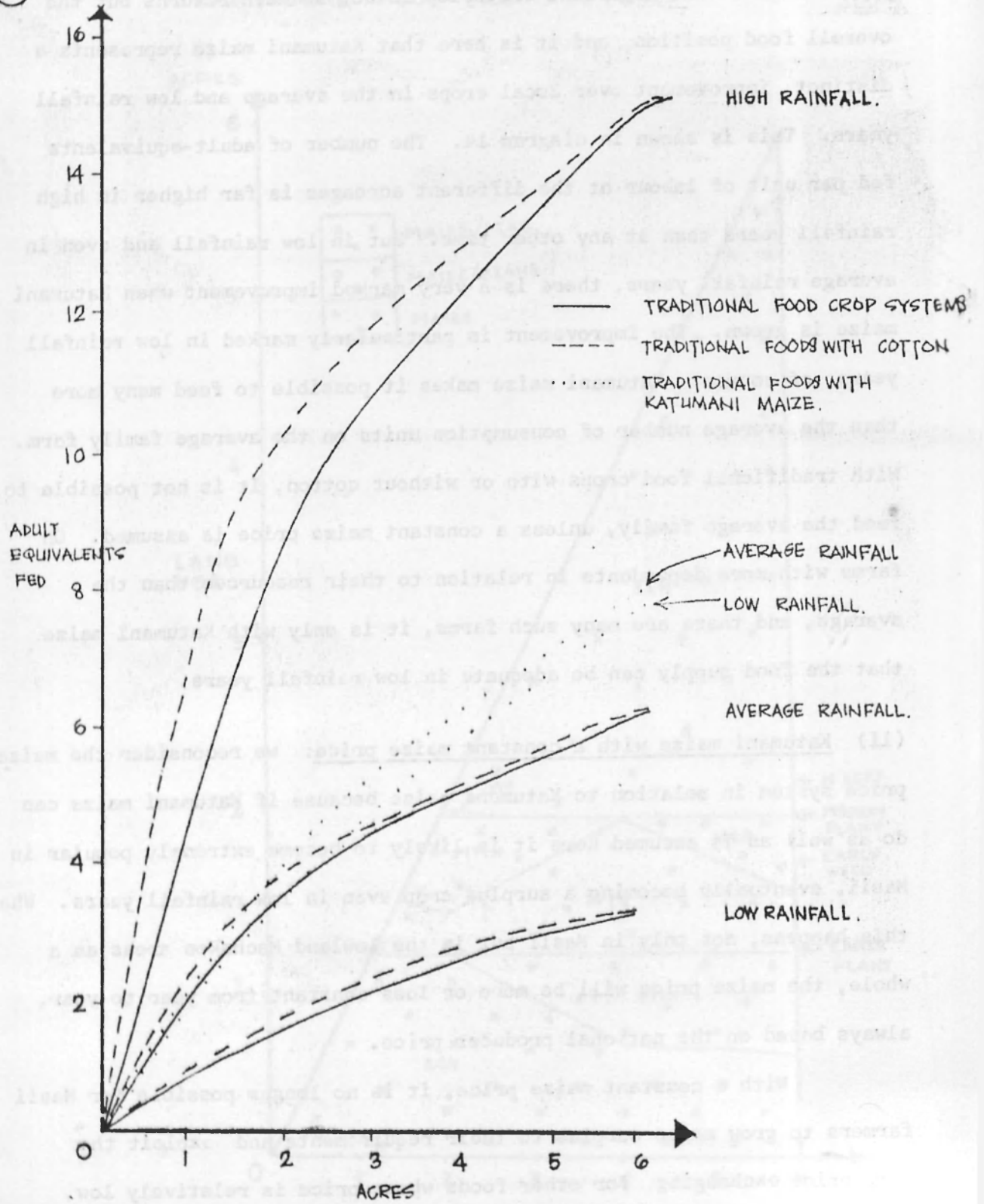
The most important criterion is not so much returns but the overall food position, and it is here that Katumani maize represents a distinct improvement over local crops in the average and low rainfall years. This is shown in diagram 14. The number of adult-equivalents fed per unit of labour at the different acreages is far higher in high rainfall years than at any other time. But in low rainfall and even in average rainfall years, there is a very marked improvement when Katumani maize is grown. The improvement is particularly marked in low rainfall years, of course. Katumani maize makes it possible to feed many more than the average number of consumption units on the average family farm. With traditional food crops with or without cotton, it is not possible to feed the average family, unless a constant maize price is assumed. On farms with more dependents in relation to their resources than the average, and there are many such farms, it is only with Katumani maize that the food supply can be adequate in low rainfall years.

(ii) Katumani maize with a constant maize price: we reconsider the maize price system in relation to Katumani maize because if Katumani maize can do as well as is assumed here it is likely to become extremely popular in Masii, eventually becoming a surplus crop even in low rainfall years. When this happens, not only in Masii but in the lowland Machakos areas as a whole, the maize price will be more or less constant from year to year, always based on the national producer price.

With a constant maize price, it is no longer possible for Masii farmers to grow maize surplus to their requirements and exploit the high price exchanging for other foods whose price is relatively low.

DIAGRAM 14: THE FOOD POSITION - CONSUMPTION UNITS FED PER LABOUR UNIT IN THE DIFFERENT SYSTEMS

(54)



Katumani loses its overwhelming attraction then. With constant maize prices, Katumani maize cannot compete with cotton, even in the low rainfall years. Cotton becomes attractive again, in combination with Katumani maize and other food crops, as before, but Katumani maize plays a relatively minor role.

Thus, if maize price fluctuations were eliminated in Masii, cotton could become an attractive crop with good prospects for widespread adoption in the area. The natural development would then be towards systems in which cotton, traditional foods, and Katumani maize, were all grown.

To summarise:

- 1) Cotton is not much of an improvement over traditional food crops grown at present, especially in the low rainfall years, given the high maize shortage price. When Katumani maize is considered, cotton cannot compete at all.
- 2) If a constant maize price can be assumed, cotton becomes much more attractive in all rainfall conditions. Even Katumani maize cannot compete, although some can be grown as a subsidiary crop with cotton.
- 3) The analysis of cotton has assumed the 1963 price. If the cotton price falls much below that, the prospects quickly deteriorate again, and cotton does not appear to have much of a future in Masii.

We now leave the question of crop patterns and resource allocation in Masii, and look at the resource constraints themselves.

VII. Development Policies in Lowland Machakos

The major aim of the study was to isolate the constraints development in lowland Machakos at present. The resource allocation aspects, discussed above, were incidental to this. The pressure of population is obviously one important constraint, but with unemployment problems in the economy as a whole this is likely if anything to increase. The emphasis was on limits which can be altered, in particular the quality of land and labour, and managerial skills. Capital was found to be relatively unimportant as a limit at present. The results of the investigation of constraints suggest that the impact of research and extension services can be very substantial still, but that the provision of credit is unlikely to be much help in Masii farm development at present.

We start by discussing the role of capital and we show why capital was rejected as a limit at an early stage. We then discuss the values of labour and land constraints. And finally we take up the quality of labour and land, and the whole question of managerial skills, which appear to be much more crucial than had been anticipated, in Masii.

(i) The Role of Capital in Masii: It is important to distinguish between fixed and working capital, in Masii. Masii farming is subject to violent fluctuations in yields and incomes, years of relative prosperity alternating with years of severe famine. Working capital is not generally a problem, but it can become a major constraint after famine. Good seasons following bad droughts are seldom exploited to the full in Masii because there are seed shortages, and also because both oxen and the family labour force are weak after prolonged months on famine rations. There can also be difficulties in obtaining insecticides.

It is difficult to advocate a simple remedy for the poor physical condition of the labour force, in the seasons after famine, as any real improvement would involve an extremely costly feeding programme to which there would be many objections, not only on financial grounds. Equally, there is little that can be done about oxen, although the provision of water and possibly even fodder supplies would help to get them into reasonable condition at the beginning of the rains. This might pay even in a normal year. Where something can certainly be done is in the preservation of district seed supplies. Seed supplies usually get used up before the arrival of famine relief which is only given when local food supplies are exhausted, and imported varieties of maize then get planted in the following season instead of the local varieties which are now fairly well suited to Machakos conditions. It is important not to lose the local stock of seed. It should be relatively easy to maintain it on a district basis and then perhaps even provide free seeds at the planting season after a bad famine year.

There may also be a case for the provision of credit for insecticides after a famine, particularly with the introduction of cotton, but the cash outlay these involve is small, and the local credit system should be adequate for these, even after a severe famine.

Fixed capital can be separated into capital that consists of labour and free local materials alone, and capital that involves cash expenditures. Stores, fencing,¹⁴ and soil conservation works are the most important items consisting entirely of labour and local materials, and

14. Fences are all of local thorn.

nearly all of these can be provided at times when labour is generally slack on the farms, i.e. at no real cost. There is some problem with soil conservation works, because these are most easily constructed and maintained when the soil is soft and oxen can be fed and before the crops are in the ground at the beginning of the planting season; the planting of grass on terrace edges also conflicts with important ploughing and planting work. But in general none of these is an insuperable constraint on the development of Masii farms.

Fixed capital that involves cash outlays is more of a problem, but the only important items are oxen and ploughs, and more recently cotton spraying and dusting pumps. There are very few additional capital items which can justify themselves in Masii farming at present. Most people own oxen and ploughs, either within the homestead or jointly with close relatives who live nearby. But there is a sizeable minority without, and these people rely on borrowing or hiring, usually possible only later in the planting season. There are real costs involved in having to wait until other people's oxen and ploughs are available, as Masii crop yields suffer badly from planting delays.

Cotton spraying and dusting pumps, more recent capital needs, were shared in 1962/63 among groups of growers organised by agricultural extension officials. As cotton spreads, it is possible that there will be difficulty in obtaining enough pumps, but as is argued below, this seems unlikely.

In Masii, then, capital needs are few. It is difficult to think of additional items of capital that might be profitable. The experience of the Government loans schemes, in operation since 1948 on a small scale,

confirms this. Lowland Machakos farmers who received credit from the Government have generally found that it has not been profitable. The same is true of individuals who have invested their own funds on their farms.¹⁵ People can always point to unsuccessful investments on farms in Masii; they can seldom give examples of investments other than in oxen and ploughs that have proved themselves in any sense. There does seem to be a shortage of profitable investment outlets in farming in Masii.

Where people were without even oxen and ploughs it was usually found that there were other serious bottlenecks operating. These tended to be people who could not justify investment at all. Their lack of managerial abilities and their unwillingness to work were the major obstacles to the development of their farms.

There is already something of a private credit system in Masii, and there is evidence of the existence of capital funds which might be put to good use if outlets were available. Traders frequently lend to farmers for non-productive purposes. Loans are always available in emergencies, for sudden sickness or sudden litigation claims. They are also available for cattle trading and sometimes for general trading as well. Traders seem quite prepared to discuss alternative uses for their capital reserves, but they all agree that it is unwise to lend for farming, both from their own and from the farmer's point of view, because it is too risky and unprofitable to be worth while. It is also generally true that farmers to whom it is worth lending can muster enough capital of their own, when necessary, as for the purchase of oxen and ploughs. These are seldom

15. During fieldwork, the author visited many farmers who had received Government loans, although none were specifically included as case studies. The common story was of expenditure on ox-drawn implements which had quickly fallen into disuse, but for which loan repayments continued for many years. Individuals using their own funds could choose their investment outlets freely, but most of these also turned out to be unprofitable in the end.

bought with borrowed funds. Farmers themselves have capital reserves if only in the form of local Zebu cattle, which serve as savings banks for many people in Masii. The very fact that such large numbers of Zebu cattle are still kept, although they bring in very low capital returns, suggests a lack of alternatives that are profitable on farms in Masii.

The availability of funds is amply demonstrated by the interest shown in the Lukenya ranching scheme in which Masii people bought shares, by the growth of a thriving bus company started in 1963 with 6 buses on the road by 1965, and by the relatively large sums that are collected for such things as schools, dams, and dispensaries. It does not appear to be difficult to mobilise funds if the cause is considered worth while.

This study was originally formulated as a study of credit, assuming that this was a major constraint on development in peasant farming in places like Masii. But, for the kind of reasons given above, it was soon decided that credit was not a major constraint after all, and that others were much more important. The emphasis of the study was therefore changed to an investigation of production constraints in general, and credit was discarded from these.

(ii) The value of labour and land: Apart from capital, which we have rejected as a possible limit on development at present, the important factors of production are labour and land. In this section we discuss the values of labour and land at the modal management level, ignoring differences in quality. In the next section we discuss quality differences and the management variable.

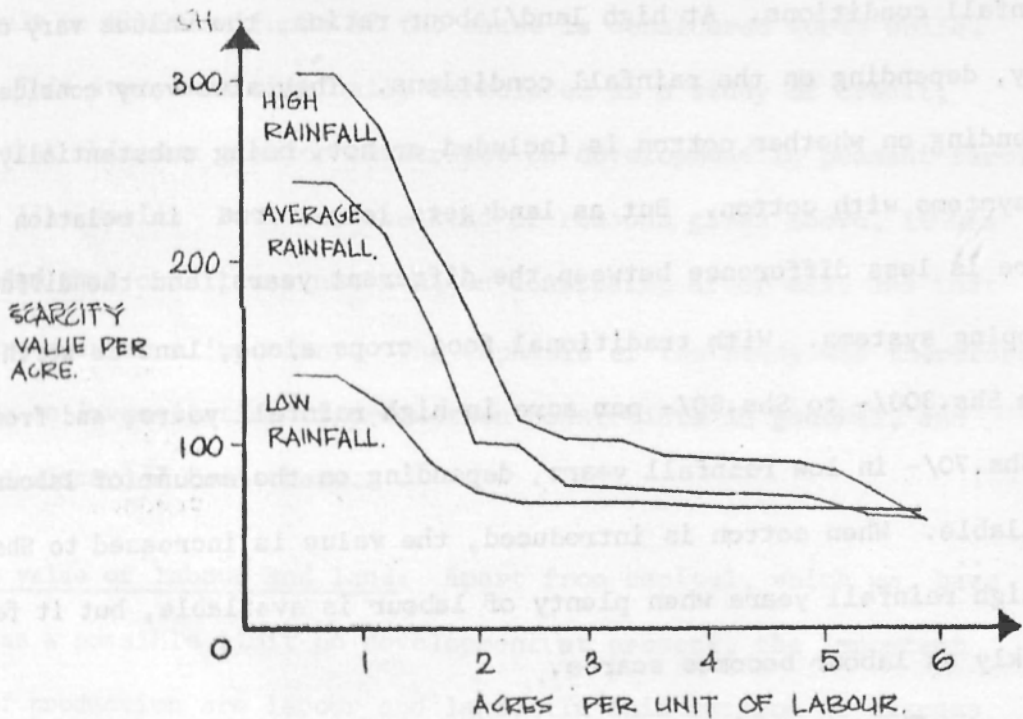
The linear programming analysis shows the scarcity values of labour and land in the different production systems. The programme solutions show how much an additional unit of labour or land would contribute to returns at any land/labour ratio. This obviously varies with land/labour ratios. If land is scarce relative to labour, the value attached to it is high: an additional unit of land can contribute substantially given the amount of labour available. If land is plentiful, its scarcity value is low, because it is labour that is the main constraint.

The scarcity values per acre of land are shown in diagram 15 for traditional food crop systems, in high rainfall, average rainfall and low rainfall conditions. At high land/labour ratios, the values vary considerably, depending on the rainfall conditions. They also vary considerably depending on whether cotton is included or not, being substantially higher in systems with cotton. But as land gets less scarce in relation to labour, there is less difference between the different years, and the different cropping systems. With traditional food crops alone, land is worth anything from Shs.300/- to Shs.60/- per acre in high rainfall years, and from Shs.150/- to Shs.70/- in low rainfall years, depending on the amount of labour available. When cotton is introduced, the value is increased to Shs.500/- in high rainfall years when plenty of labour is available, but it falls quickly as labour becomes scarce.

These scarcity values can be compared with the value of land in alternative uses. As the sale of land in lowland Machakos is rare, and only occasional renting or hiring of land takes place, there is little to be gained from a comparison between scarcity values and market values.

62

DIAGRAM 15 : SCARCITY VALUES OF LAND AS RATIOS OF LAND TO LABOUR INCREASE
TRADITIONAL FOOD CROP SYSTEMS



But what is interesting is a comparison between land in crops and land in livestock, as some farmers still keep livestock on arable land in Masii. It is not easy to estimate returns to livestock, but rough estimates from field data suggested a maximum of Shs.60/- per acre of arable land at the very most in years when rainfall is high. This does not make it worth keeping livestock on arable land in Masii, except at land/labour ratios considerably higher than those found, and while livestock do sometimes compete with crops, they are much more often kept on poorer land that is not fit for cropping at all.

The comparison takes livestock as they are at present, and it is possible that improved livestock could give higher per acre returns. It is also possible that livestock could make a positive contribution in a rotational cropping system including fallow breaks on arable land. But until these are realistic alternatives, livestock cannot compete with crops on Masii arable land.

Returns to labour that is on the farm all the year round have already been discussed in the comparison between traditional food crops, cotton and Katumani maize. These returns were shown in diagram 1 (p. 25) for traditional food crops and cotton, and in diagram 8 (p. 46) for Katumani maize. With traditional food crops and average managerial skills a man can get Shs.400/-, Shs.700/- or Shs.900/- a year, depending on rainfall conditions, with the highest acreages of arable land. This is equivalent to Shs.33/-, Shs.59/- and Shs.75/- a month, including the value of all food. The figures can be compared with wages of Shs.50/- and Shs.70/- in Masii, for the few unskilled jobs that are available, and anything from Shs.120/- in Kenya's urban areas. The people with better

managerial abilities can make somewhat more, but they can also command a higher wage, while the poorer managers might find it difficult to get a job at all.

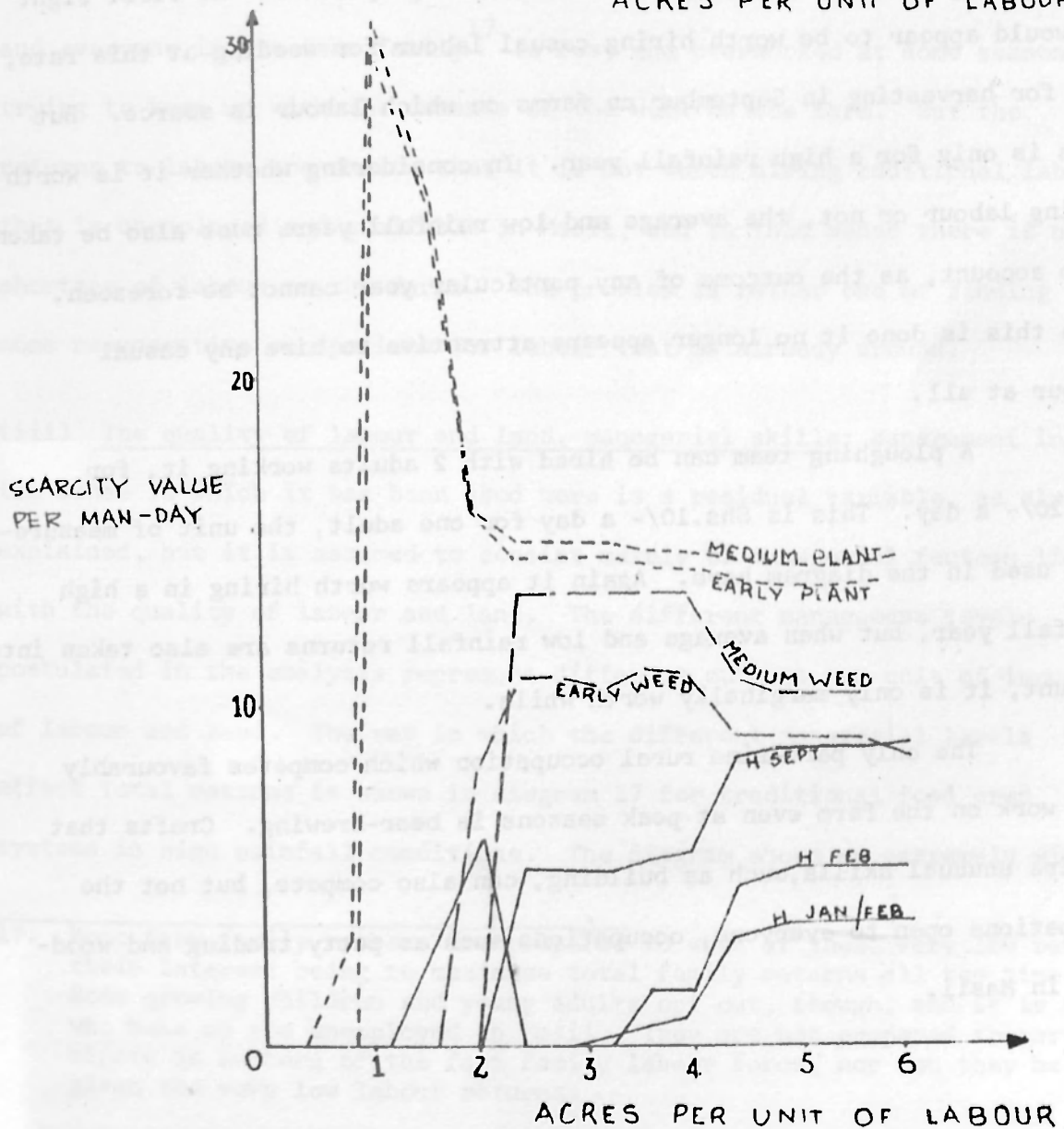
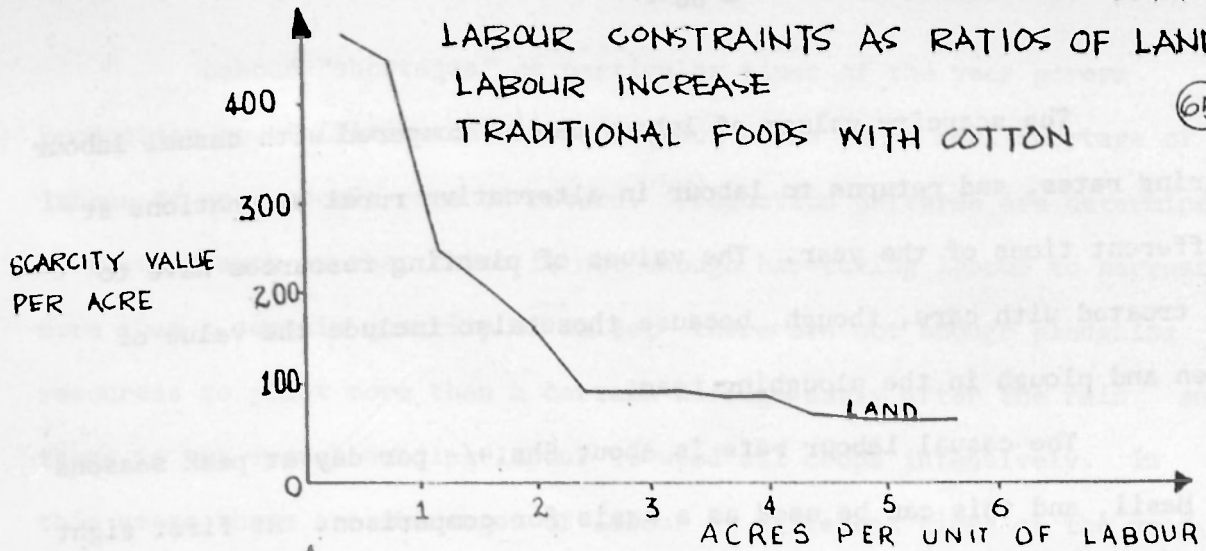
The figures show how unattractive farming is in Masii, and this is born out by the fact that about 67% of Masii's adult males are absent at any time.¹⁶ For those who remain, and especially for the women, who make up the majority of farmers in Masii, the alternative opportunities are few. It is extremely difficult for a peasant woman to get employment in the Kenya economy elsewhere.

It is important also to consider the seasonal pattern of labour values on the farm. There are times of the year at which labour is relatively valuable and contributes substantially to returns; there are other times when there is little work, and additional labour cannot contribute at all. As we have already seen in discussing data that are important for the analysis, the critical labour constraints are at planting, weeding and harvesting time. These have been subdivided into two planting constraints (and a third planting period that is unlimited), two weeding constraints (and a third weeding period that is unlimited), and three harvesting constraints. Just as scarcity values of land are shown in the linear programming results, so are the scarcity values of these different labour constraints. They also vary with land/labour ratios, but unlike land they interact with each other to give fluctuating values as shown in diagram 16.

16. Kenya Government, Population Census 1962, op.cit.

DIAGRAM 16:

HIGH RAINFALL SCARCITY VALUES OF LAND AND
 LABOUR CONSTRAINTS AS RATIOS OF LAND TO
 LABOUR INCREASE
 TRADITIONAL FOODS WITH COTTON (65)



The scarcity values of labour can be compared with casual labour hiring rates, and returns to labour in alternative rural occupations at different times of the year. The values of planting resources have to be treated with care, though, because these also include the value of oxen and plough in the ploughing team.

The casual labour rate is about Shs.4/- per day at peak seasons in Masii, and this can be used as a basis for comparison. At first sight it would appear to be worth hiring casual labour for weeding at this rate, and for harvesting in September on farms on which labour is scarce. But this is only for a high rainfall year. In considering whether it is worth hiring labour or not, the average and low rainfall years must also be taken into account, as the outcome of any particular year cannot be foreseen. When this is done it no longer appears attractive to hire any casual labour at all.

A ploughing team can be hired with 2 adults working it, for Shs.20/- a day. This is Shs.10/- a day for one adult, the unit of measurement used in the diagram here. Again it appears worth hiring in a high rainfall year, but when average and low rainfall returns are also taken into account, it is only marginally worth while.

The only part-time rural occupation which competes favourably with work on the farm even at peak seasons is beer-brewing. Crafts that require unusual skills, such as building, can also compete, but not the occupations open to everyone, occupations such as petty trading and wood-work in Masii.

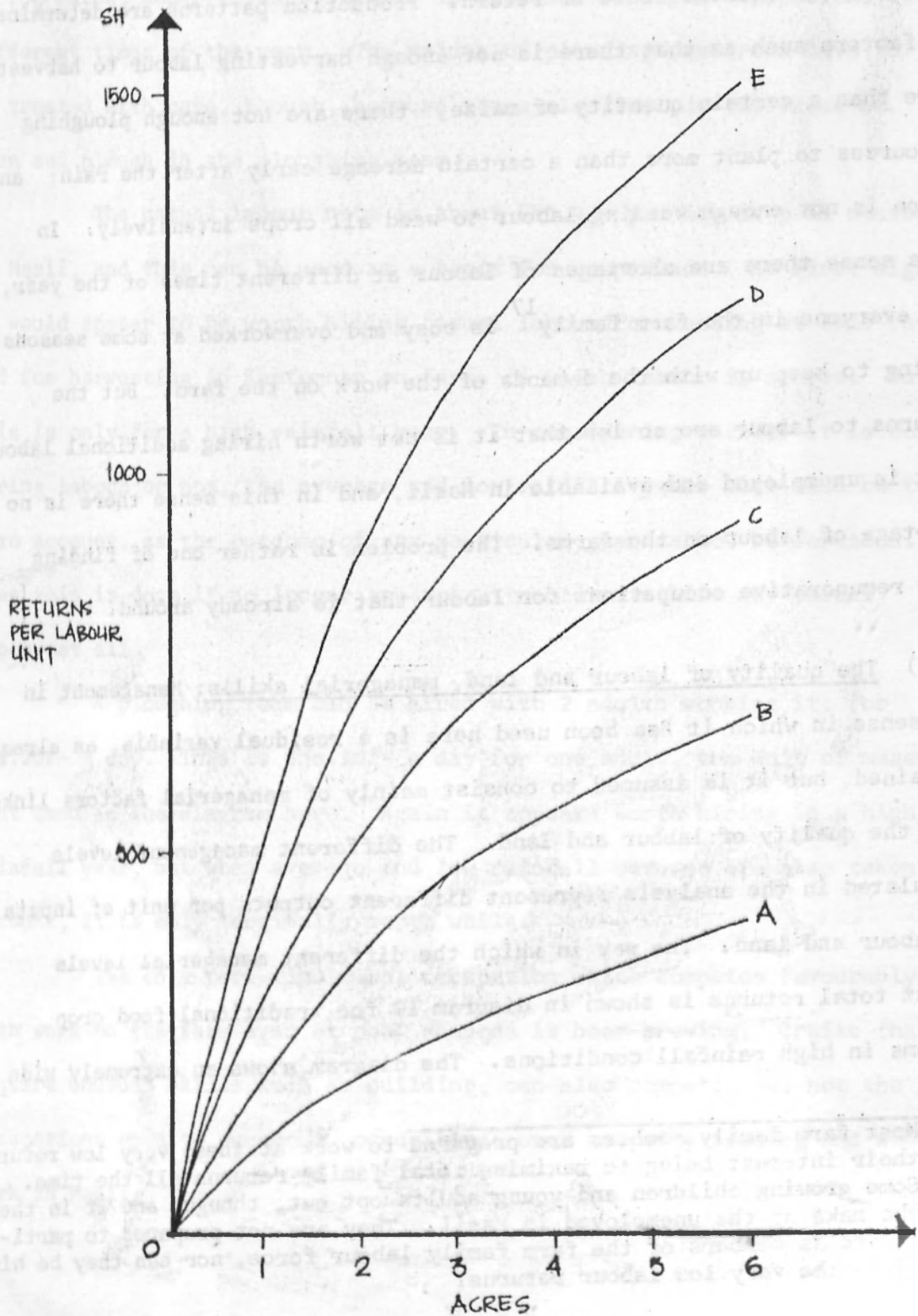
Labour "shortages" at particular times of the year govern production possibilities on the farms, but there is no real shortage of labour at an economic rate of return. Production patterns are determined by factors such as that there is not enough harvesting labour to harvest more than a certain quantity of maize, there are not enough ploughing resources to plant more than a certain acreage early after the rain, and there is not enough weeding labour to weed all crops intensively. In this sense there are shortages of labour at different times of the year, and everyone in the farm family¹⁷ is busy and overworked at some seasons trying to keep up with the demands of the work on the farm. But the returns to labour are so low that it is not worth hiring additional labour that is unemployed and available in Masii, and in this sense there is no shortage of labour on the farms. The problem is rather one of finding more remunerative occupations for labour that is already around.

(iii) The quality of labour and land, managerial skills: Management in the sense in which it has been used here is a residual variable, as already explained, but it is assumed to consist mainly of managerial factors linked with the quality of labour and land. The different management levels postulated in the analysis represent different outputs per unit of inputs of labour and land. The way in which the different managerial levels affect total returns is shown in diagram 17 for traditional food crop systems in high rainfall conditions. The diagram shows an extremely wide

17. Most farm family members are prepared to work at these very low returns, their interest being to maximise total family returns all the time. Some growing children and young adults opt out, though, and it is these who make up the unemployed in Masii. They are not prepared to participate as members of the farm family labour force, nor can they be hired, given the very low labour returns.

68

DIAGRAM 17: RETURNS TO LABOUR IN HIGH RAINFALL CONDITIONS AT DIFFERENT MANAGERIAL LEVELS TRADITIONAL FOOD CROP SYSTEMS



range of returns attainable at different management levels, the best managers being able to make 3-4 times as much as the worst with any given level of labour and land resources.¹⁸

Thus the quantity of labour, measured in man-hours at different times of the year, and the quantity of land, measured in acres, cannot explain more than a part of the variation in returns. Other factors, which we have called management, also enter in. We now discuss the content of the management variable.

Per acre yields vary partly because soil fertility varies. There may be an element of natural soil fertility which is specific to the land the farmer cultivates, and which is partly the result of the length of time for which the land has been under cultivation. The farmer can do little about this. But soil fertility is also influenced by the quality of soil conservation works, the quantity of manure applied, (no fertilisers are used in Masii), and the crop mixtures or rotations that are grown. Soil conservation is probably the most important of these factors in Masii, and the quality of soil conservation works varies considerably from farm to farm. Manure also explains soil fertility differences, but it is only used in patches on the nearer plots on each farm. There are no crop rotations, but the de facto sequence of crops, crop mixture proportions, and plant populations all have an influence on the fertility of the soil. Thus soil fertility is only partly connected with managerial levels, but through soil conservation works, and to a lesser extent the use of manure and crop sequences, good managers do

18. It is interesting to note that a Rhodesian study shows a very similar result. B.F. Massell and R.W.M. Johnson, African Agriculture in Rhodesia, An Econometric Study, The RAND Corporation, Report R-443-RC, June 1966, found that good managers make about 4 times as much as poor.

have an influence on the fertility of their soil.

Labour efficiency has not been taken into account in the analysis, except through the management variable. There are several aspects of labour efficiency. The intensity of work, the sheer effort put in, per hour or per day, varies considerably in the field. But this is not a very useful observation. More interesting are differences in labour efficiency resulting from the kind of tools, techniques and work methods used. Most Masii farmers use basically the same tools, and while there are variations in the condition of the pangas and jembes these are seldom serious enough to make for major differences in efficiency. Ploughs are nearly all of the same model, and although the plough shares are not always sharp and well-aligned here again variations appear relatively minor in their present impact on output on the farms. The efficiency of the ploughing team is much more seriously affected by the age, general condition and training of oxen, all of which vary considerably between farms.

Techniques of production and work methods could also be significant influences in the management variable. Techniques include practices such as row planting, which makes weeding with a plough possible, and which is said to make most operations easier; land preparation, which influences the weed growth that follows and hence the efficiency of weeding as well as ploughing; and other factors such as these. As for work methods, anyone who has watched completely unskilled labourers working will be aware of the kind of variations that can occur. In Masii, there was a good example in cotton harvesting. Cotton was usually picked by several people working together, with a cardboard box for each quality

of cotton in the centre of the plot, to which each picker had to walk every time his hands were full. The difference between working like this and working with individual containers which can be carried along, is obviously enormous. Similar examples for other agricultural operations could undoubtedly be found.

Factors not directly associated with either labour or land could also help to explain management differences. These include the variety and quality of seed used, the density of plant populations, the proportions of the different crops in the mixtures, the efficiency of pest control through rotations as well as insecticides, and the efficiency of storage provisions.

It is difficult to assess the relative importance of all of these different factors, and it is for this reason that they have been included in the residual management variable in the model. The most important factors contributing to management differences observed are probably soil conservation, natural soil fertility, the condition and training of oxen, techniques of production, work methods used, and the quality of seed. Factors which are at present unimportant, but which could have a substantial impact include tools and implements, and crop rotations. The use of a dutch hoe rather than a traditional jembe, and the use of a better designed plough economising on oxen effort, could change the whole pattern of labour shortages and thus of farming in Masii. The use of properly devised crop rotations could also have an important influence, particularly in the longer run.

Taken together, the factors mentioned make for very wide differences in efficiency at present, and potentially even wider

differences in future as innovations are usually taken up by good and not poor managers first. Many of the factors discussed are open to Government influence through the research and extension services.

(iv) Policy Implications: The most substantial impact Government has on agricultural production in Masii is through the research and extension services. This study suggests that a continued reliance on these services as the major stimulants to the development of agriculture in areas like Masii is right, but that there is a need for radical change within the two services if they are to have the greatest impact.

The major emphasis in research applicable to lowland Machakos in the past has been on the development of new varieties of seed, particularly maize and sorghum, rather than on husbandry methods, live-stock, soil fertility, and the development of tools and implements suitable for use on peasant farms.¹⁹ The lack of a clear policy with respect to the maintenance of soil fertility, rather than the conservation of the soil, is a serious limit on development at present. The past emphasis on soil conservation has resulted in tremendous progress, but there is now an urgent need for a policy on the maintenance of the fertility of the soil that is conserved. There are many key questions that need to be answered. Given the possibility of yields being decreased by the use of manure and fertilisers in low rainfall years, what is the best long run policy with respect to these? Although it may not even be worth using fertilisers in the short run, what are the long run consequences of avoiding their use? What else can be done, through the use of crop

19. Experimental work on hand, ox-drawn, single axle tractor and double axle tractor implements was started at Katumani in 1965. It is to be hoped that this work will be continued on a larger scale.

rotations for example, to prevent the deterioration of the soil? What role could livestock play, and what livestock breeds are really best in Masii conditions?

Tools and implements of greatly improved design are now being used in Asia and elsewhere on peasant farms, and while it is not always easy to transfer these for use in different conditions without adapting them, it should be possible to develop similar improved implements for East African farms. There has been little work on small tools and implements in East Africa as yet,²⁰ but simple innovations could be revolutionary through the reduction of ploughing or weeding bottlenecks, for example, in Masii. What has been lacking until recently has been a willingness to acknowledge that there are labour problems on peasant farms. Once this is accepted, an interest in tools, small implements, and labour productivity follows naturally.

A related area for investigation is that of the costs and returns to oxen as opposed to small mechanical cultivators or tractors, given the increasing shortage of land. An analysis of the costs of oxen and ox-drawn implements compared with the costs of tractors or mechanical cultivators would be the first stage of such an investigation, and the costs could be compared on a per acre basis. This could be followed by a more sophisticated analysis of returns. Both time factors and questions relating to the maximum or minimum economic size of farms would have to be included here. Oxen can be more expensive than tractors where there

20. Some work on small implements has been done in Uganda at Serere Research Station, and in Tanzania at Tengeru. Until very recently Kenya has been lagging behind in this field.

is a land shortage, as work in Uganda has shown.²¹

Finally, there is a need for research into the merits of different crop mixtures, and plant populations, on peasant farms, and into crop husbandry problems which are important too. There has been little research into the effects of planting delays on different crops. Even less has been done on alternative weeding strategies and the effects of delays at weeding time. These are crucial issues for peasant farmers in places like Masii.

It has been suggested that one of the main problems with East African agricultural research programmes is the lack of economic direction.²² Possible remedies include the requirement that agriculturalists engage in planning and directing research should have some economics training in addition to their agriculture, perhaps a diploma year, or alternatively that one or two agricultural economists should be actively engaged in the formulation of research programmes. One or two agricultural economists could be attached to head office but spend most of their time at the research stations in the field, taking part in the planning of detailed programmes. There is certainly a need to adapt the research programme more closely to the economic requirements of small farms. This could be a way of achieving this. Another stimulus could come from the farmers themselves, as is suggested in our discussion of extension services.

21. See ed. J. L. Joy, Symposium on Mechanical Cultivation in Uganda, 1960, for a discussion of this point.

22. D.G.R. Belshaw and M. Hall, The Analysis and Use of Agricultural Experimental Data, Paper read to the 2nd Conference of East African Agricultural Economists, Nairobi, January 1965, and D.G.R. Belshaw, Planning for the Grass-Roots. Extension, Education and Research, Paper read to the 3rd Conference of East African Agricultural Economists, Dar es Salaam, April 1967.

The extension services can obviously exert a major influence on management factors, but unless they are reorganised and their basic approach is changed, they will continue to absorb resources out of all proportion to their impact. There is evidence of a serious Government interest in the problems and potentialities of the agricultural extension services in Kenya now, which is encouraging.²³ It seems to be accepted that the old system in which agricultural instructors were employed as messengers, for the execution of simple technical jobs such as the measuring of plots and laying out of soil conservation works, and the transmission of very stereo-typed agricultural advice, is inappropriate, and it may not be long before we have a reasonably well-equipped agricultural adviser working with farmers at the lowest level. All agricultural instructors are now being given some agricultural training, an elementary pre-requisite that was missing before. There are proposals to upgrade the instructors at the lowest level to school certificate grades with 2 years of agricultural training as well. School certificate people may not be ideal as agricultural instructors living and working with farmers in the field. They will have to be very carefully selected if they are to get the necessary rapport with the farmers who need their advice. But in general the change to a better qualified field extension worker is encouraging and necessary.

The disadvantages of the old structure were very apparent in Masii in 1962/63. The agricultural instructors used to spend a good deal

23. See Ministry of Agriculture Agricultural Extension Seminar July 1966; University College Conference on Education, Employment and Rural Development in September 1966, Agricultural Education Commission due to report mid 1967; and discussions at the 3rd Conference of East African Agricultural Economists, Dar es Salaam, April 1967.

of time in the local market, liaising with other Government officials, and communicating with farmers whom they could always find there on market days. Some of this was important, but a lot of each day inevitably went sitting in hotels and drinking tea. On the remaining 2 or 3 days in the week, the instructors would visit the best farmers who had long been cooperating with the Government, and who knew quite a lot about agriculture themselves. The instructors brought messages, drank tea, and occasionally even helped out with urgent work on the farm. But there was little they could teach this farming group. Where they could perhaps have brought something new, on the more backward farms, they were unwelcome and unknown.²⁴

A problem that goes much deeper in the Kenya agricultural extension services, though, is the whole problem of approach. The old approach involved giving instructions rather than advice, and it was rare for extension officials to listen to the farmers' point of view.

In the words of Belshaw and Hall:

"the truly advisory attitude, which consists essentially of getting alongside, listening to and learning from farmers, has yet to replace the traditional mixture of exhortation, instruction and coercion." Belshaw and Hall, op. cit.

It is more difficult to advise and discuss than to give instructions, of course. A more flexible approach needs a higher calibre official. But as these become available, it is important that they be trained to advise and teach and not to order the farmers around. The whole ethos of the extension services badly needs to be changed so that farmers come to regard extension officials as sympathetic and useful advisors rather than as messengers from the agricultural department to be politely tolerated.

24. A very similar situation was found in Kericho in the field, when the author also spent some time.

There are many advantages in the advisory approach, not least of which is in the feed-back it enables from farmers to research and extension services. In East Africa, farmers tend to be poorly organised as a group, and they exert little pressure on extension and research. By making their needs and problems felt, through the extension officials, they could bring about welcome changes in the whole research programme. In countries like Britain and the United States, it is farmers as much as anyone else who bring problems to the attention of the research services and who are responsible for the initiation of much of the most useful research. This is not so in East Africa, but much could be gained by making it a feature of the East African scene.

Extension advice in lowland Machakos in the past has consisted of exhortations to plant early, to plant in straight rows, to weed more, to weed with oxen and ploughs as well as by hand, to make and use manure, to use good seed, to plant pure stands, to construct and maintain soil conservation works, and to reduce the numbers of cattle. Some of this advice is undoubtedly sound, and much has been widely accepted as such. Among the points adopted are the preparation and use of manure, and weeding with oxen and ploughs. Soil conservation works have been constructed, more through force than persuasion though, as one might expect. It is difficult to get peasant farmers to recognise the value of such long-term improvements as these. Advice that has never succeeded is that on dry planting before the rains, and on planting in pure stands. It might be useful to extension officials to examine and communicate the reasons for failure here, and to listen to farmers' objections to planting before the rains. There are many practical reasons for which this particular advice may be wrong for farmers in Masii. Extension

workers could listen to objections and then either devise ways of overcoming the problems that arise, or modify their advice accordingly.

A flexible approach in extension, at the individual farmer level, is likely to be more effective and more popular all round. If the better qualified extension personnel are to have the maximum impact, it is important to examine the content of their training programme as well as its level. Extension workers need to be trained in methods of teaching and advising as well as in basic agriculture, here. They could benefit from simple teaching aids to support them as well.

The potential impact of other educational services, both in promoting a more enlightened attitude among farmers, and in transmitting agricultural advice, should not be underestimated, either. All possible channels should be exploited and coordinated, in particular channels of communication such as the radio, adult literacy, community development, health, nutritional and educational services that extend to the rural areas anyway. The formal education system can probably also be used, although it is clear that some new thinking about the best way of doing this is needed. Farm work in schools has been notoriously unsuccessful in producing the desired results up to now, both in East Africa and in other parts of the continent.

To summarise this section: the key role of management cannot be over-emphasised. Many of the factors involved are subject to Government influence through extension services and research. The traditional emphasis on these two should not be abandoned in favour of what sound more radical and more attractive development schemes. There is a need for radical change, but this should be within the extension and research

services, rather than in services that are totally new. It is by adapting the traditional weapons of agricultural change that real progress can be made. More funds are always needed for expanded research and extension programmes, but these can be much more effectively used if coupled with some fundamental change. Extension services cannot do the job alone, they need more research results on which to base advice. But neither is there a lot to be gained from reorienting the programme of research unless this can be effectively implemented in the field.

VIII. The Analysis of Small-Farm Production Data

We end with a brief note on Kenya Government analysis of small-farm production data. The Government already collects substantial quantities of data on production on smallholdings, through the Farm Economics Survey Unit. These data are detailed and some of the recent studies have been quite comprehensive. But the analysis that is done is fragmentary and does not exploit the data to the full. Farm production data can be used to throw light on production constraints, to test the feasibility of production plans, to find farm systems that make the best use of resources, and to compare enterprises that compete. In some of Kenya's high potential areas there is a critical problem of choice between many and varied crop and livestock enterprises, and it would be extremely useful to know more about the relative advantages of these enterprises in different farming situations. In nearly all areas there are important questions of resource use. It would be useful to know how to improve the use of resources that exist. It would also be helpful to know which are the key bottlenecks so that attention can be concentrated on these.

Production data of the kind that are already collected by the Farm Economics Survey Unit could be used to answer all kinds of questions about Kenya's small-scale farming areas. The Unit should be able to contribute much more to important policy decisions than it does with the rather summary analysis that it does at present.

There are various methods of analysis that are possible. At the very simplest level, there is gross margin analysis that compares enterprises and shows which give the highest overall returns. Somewhat more sophisticated is budgeting in which costs and returns are compared in different possible farm systems, postulated on intuitive grounds. Partial budgeting is useful in comparing small changes, such as different levels of fertiliser use. Linear programming, which employs essentially the same procedures as budgeting, is far superior, though. It uses essentially the same data as budgeting, but exploits the data much more systematically. It not only compares farm systems chosen on a priori grounds, but it compiles farm systems that are attractive from among a range of possible enterprises. It can compare a much wider range of possibilities. Not least among its advantages, is the fact that it makes possible a thorough analysis of resource constraints. Linear programming can be used to analyse many different problems and many different situations, as we have shown.

It would be quite possible to use linear programming to analyse Government small-farm production studies. Much of the work involved can be routinised, saving the time of a senior agricultural economist. It is advisable for a senior economist to be involved in planning data collection with a view to linear programming. Possible constraints can be identified

so that information on resources that will not be limiting is not collected needlessly. The breakdown of enterprises into activities should also be decided at an early stage, to see how much detail is necessary in data collection. Pilot surveys may be needed to make these initial decisions, specially in areas where very little is known about the farming patterns.

Data collection can go ahead in the usual way. Input-output data should be collected from case-study farms chosen to cover as wide a range of enterprises as possible, including the atypical as well as the typical. data on resource availability and environmental conditions should be collected on a sample survey basis, so that generalisations can later be made. The input-output data collected from a few well-chosen case study farms can reasonably be expected to apply to all. It is only the range of different farming situations and different resource combinations that is needed on an area or district basis.

When the data have been collected, a list of observations on each input coefficient in each enterprise or activity is required, together with the outputs that have been obtained. Some averaging or other process of choice from the frequency distributions must then be undertaken. In associating inputs with outputs it is necessary to draw on evidence from experimental stations, and to use a certain amount of good judgement as well. Here a senior economist would have to put in more time.

The actual formulation of the programmes, the precise ranges of choice to be compared, the different farm situations to be covered, the extent of different resource combinations, etc. again needs the

attention of a senior economist, but once the overall decisions have been made the individual coefficients can be filled in at the clerical level. The computer processing unit can run the programmes, and results can be extracted from computer sheets by clerical staff. It is only in the interpretation of results that the senior economist should again be involved.

It appears from the published reports that some of the data already collected by the Farm Economics Survey Unit may be suitable for linear programming analysis. It might be possible to analyse some of the Nyeri data²⁵ in this way, for example. But in future Farm Economics Survey Unit work, it would certainly be worth considering the analysis at the initial planning stage, so that data can be collected in a suitable form, and provision can be made for the analytical work. At present all that is published is a set of averages giving such things as total costs and returns, and a rudimentary breakdown between major enterprises. This kind of information can be obtained at relatively little cost if it is all that is required. But given the much more extensive data available, it would be valuable to have an analysis planned to answer far more questions of concern at the policy level, an analysis of the kind made possible with the use of linear programming. This should not be difficult to organise within Kenya Government.

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25. Published in F.E.S.U. reports 21 and 24.