THE SUPPLY RESPONSIVENESS OF COTTON FARMERS IN CENTRAL/EASTERN KENYA

BY

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A thesis submitted in partial fulfilment of the requirements for the degree of Master of Science in Agricultural Economics of the University of Nairobi.

Nairobi, September 1991.

DECLARATION

I, Kenyanito, Charles Okoth O, do hereby declare that this thesis is my original work and has not been presented for a degree in any other University.

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We, the undersigned, declare that this thesis has been submitted for examination with our approval as the University Supervisors.

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ABSTRACT

The broad objective of this study was to identify the reason(s) for the sluggish growth in annual seed cotton output and failure to attain its targeted supply levels for Central/Eastern Kenya over the last two to three decades. In an attempt to achieve this objective the trend in annual seed cotton output, yields of cotton, annual hectarage and nominal and real producer cotton prices were examined in addition to the supply response models for seed cotton for Embu, Kirinyaga, Kitui, Machakos, Meru and Murang'a districts being estimated. The estimated supply response models were used to test two hypotheses: that cotton farmers have responded perversely to increases in the real and nominal producer cotton prices and that the degree of price responsiveness is the same among cotton farmers in the six districts covered in the study.

It was found out that annual seed cotton output rose significantly over the last two to three decades for Embu, Kitui, Machakos and Meru districts. It declined significantly only for Murang'a District. Cotton yields declined significantly over the same period for most of the above six districts thereby occasioning the sluggish growth in annual seed cotton output and failure to attain its targets for the region over that period. The rise in the region's annual seed cotton output was due to that of the hectarage of cotton for most of the six districts.

The log-linear version of the Nerlovian Partial Adjustment model was used to estimate the price elasticities of supply for seed cotton for the six districts. The hectarage of cotton during any year in a district was assumed to be a function of the previous year's hectarage, lagged seed cotton price, lagged producer price of the most competing enterprise, current annual rainfall amounts and a trend variable. The first and second hypotheses were tested by means of student's t-test and Chow test, respectively. The results of testing the first hypothesis were inconclusive for most of six the districts while the second hypothesis was rejected at the 0.01 level of significance. The estimated price elasticities of supply for seed cotton for the region varied from a short run value of 0.92 for Machakos District to a long run value of 5.79 for Kitui District.

It is recommended that measures to improve the prevailing low and declining cotton yields for the region be identified and executed. The targets set for annual seed cotton output in the National Development Plans need to be realistic and district specific. The distortions in the crop's factor and product markets also need to be removed. The practising of district specific pricing policy or relaxing the control on the nominal producer cotton price could facilitate the attainment of the annual national targets for seed cotton production.

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I alone am responsible for any errors or oversights that may be found in this document.

Kenyanito, C.O.O

Nairobi, September 1991

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Acronyms and Abbreviations

AEZs	....	Agro-Ecological Zones.
Approx.	....	Approximately.
AR Cotton	....	First grade seed cotton.
BR Cotton	....	Second grade seed cotton.
CDP	....	Cotton Development Project.
C&F	....	Cost and Freight.
cm	....	Centimetre.
CPI	....	Consumer Price Index.
CPMP	....	Cotton Processing and Marketing Programme.
CV	....	Coefficient of Variation.
DSMS	....	District Subject Matter Specialists.
EDI	....	Economic Development Institute.
Fig.	....	Figure.
Ha	....	Hectare ≡ 2.471 Acres.
IADP	....	Integrated Agricultural Development Programme.
Kg	....	Kilogramme.
Km	....	Kilometre.
Kshs.	....	Kenya Shilling(s).
K£	....	Kenya Pound(s) ≡ Kshs. 20.
LINCPI	....	Lower Income Nairobi Consumer Price Index.
LM	....	Lower Midland.

LRE	....	Long Run (Price) Elasticity.
mm	....	Millimetre.
OLS	....	Ordinary Least Squares.
%	....	Per cent.
PSMS	....	Provincial Subject Matter Specialists.
SRE	....	Short Run (Price) Elasticity.
UM	....	Upper Midland.
UNCTAD	....	United Nations Conference on Trade and Development.
UNO	....	United Nations Organisation.
US $	....	United States (of America) dollar.

CHAPTER ONE:

INTRODUCTION

1.1: The Cotton Industry: A Historical Perspective

Cotton is presently grown in twenty two districts in Kenya. These districts fall in Central, Coast, Eastern, Nyanza, Rift Valley and Western Provinces. Table 1.1 below shows the "cotton growing" districts and the provinces in which they fall:

Table 1.1: The "Cotton Growing Districts" of Kenya

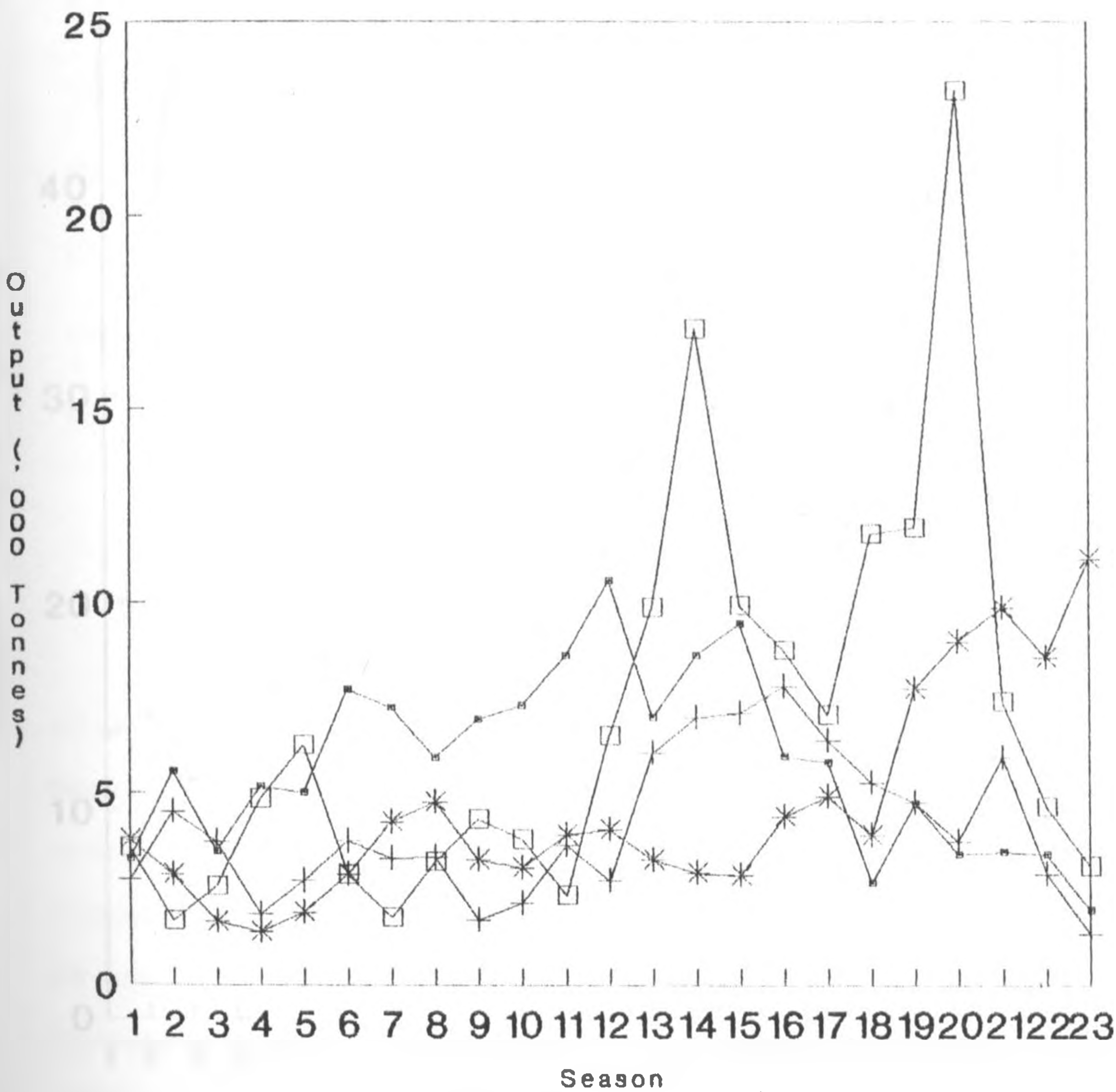
Province	"Cotton Growing" Districts
Central	Kiambu, Kirinyaga and Murang'a
Coast	Kilifi, Kwale, Lamu, Taita Taveta and Tana River.
Eastern	Embu, Isiolo, Kitui, Machakos and Meru.
Nyanza	Kisumu, Siaya and South Nyanza
Rift Valley	Keiyo Marakwet, Turkana, Kajiado and West Pokot.
Western	Bungoma and Busia.

Source: Republic of Kenya (1990b): Provincial Annual Reports, Ministry of Agriculture.

The main ecological determinants of the present distribution of cotton are rainfall and altitude (Acland, 1971 and Brown *et. al.*, 1972). The traditional area where cotton is cultivated is the Winam Gulf, generally known as the Lake Region. This is the oldest area of cotton cultivation, the crop having been introduced in the region around 1902 (Msemakwelli, 1979). The coastal strip bordering the Indian Ocean then followed the Lake Region around the 1920's (Talbott, 1973). Cotton was tried in the Central/Eastern region in the 1930's but failed because the measures then available to control the severe insect attack, which is a feature of this part of the country, were inadequate (Brown *et. al.*, 1972). Commercial cotton production in the region, however, began in the 1960/61 crop season. In Rift Valley Province, in Kerio Valley, cotton growing was started in 1974 (Gitu *et. al.*, 1990). Most of the country's cotton is grown under rain-fed agriculture. The only areas where cotton is irrigated to any large scale in Kenya are Bura and Hola irrigation schemes. Cotton production started at Hola and Bura irrigation schemes in 1958 and 1977 respectively (Barasa, 1989). During the 1988/89 crop season, Bura and Hola irrigation schemes contributed 42.28% of the annual national seed cotton output (Republic of Kenya, 1990). The total annual seed cotton output for the irrigated region, however, fluctuated between 6785 tonnes (in 1984/85) and 7470 tonnes (in 1986/87), with a mean of 7300 tonnes during the period 1984/85 to 1988/89. In contrast, the annual national seed cotton output decreased from 39,281 tonnes in 1984/85 to 17,638 tonnes in 1987/88 (Republic of Kenya, 1989a). Both the rain-fed and irrigated cotton crops are mostly grown on smallholder farms (Msemakelli, 1979).

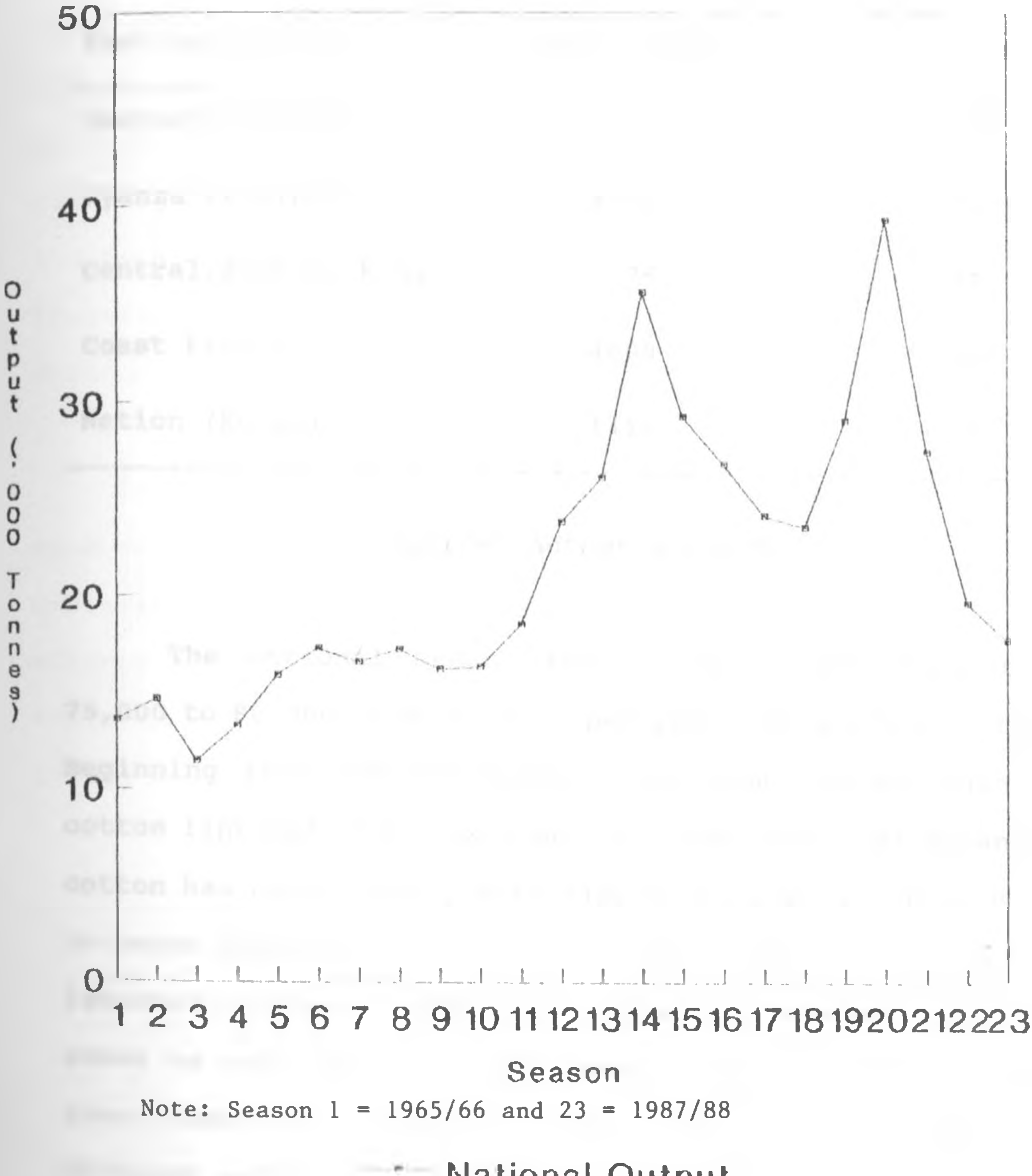
1.2: Problem Statement and its Justification:

There was a wide fluctuation in the national annual seed cotton output between 1965 and 1988. Its coefficient of variation during this period was 34%. During the same period the peak production of cotton lint was 70,147 bales obtained in the 1984/85 crop season while the minimum cotton lint production was 20,072 bales obtained in the 1967/68 crop season. The annual output of seed cotton has also varied between and within the provinces (regions) during this period. These variations are depicted by means of Figures 1.1 and 1.2 and Table 1.2. There was a slight overall increase in the annual national seed cotton output during this period. The fluctuation in annual seed cotton output was greatest for our study area, Central/Eastern Kenya. Table 1.2 below shows the mean annual output of seed cotton for various regions of the country during the period 1965/66 to 1987/88. The coefficients of variation of the annual seed cotton output levels for these regions are also shown in the table. The table is based on Table A 1.1 contained in the appendix.



Note: Season 1 = 1965/66 and 23 = 1987/88

Fig 1.1: Annual Regional Cotton Output



Note: Season 1 = 1965/66 and 23 = 1987/88

Fig 1.2: Annual National Cotton Output

Table 1.2: The Mean and Coefficient of Variation of Annual Regional Seed Cotton Output Levels for 1965/66 to 1987/88

Province (Region)	Mean (Tonnes)	C.V (%)
Western Province	5779	40
Nyanza Province	4094	45
Central/Eastern Kenya	6876	77
Coast Province	4608	58
Nation (Kenya)	21419	34

Source: Author's study

The national demand for cotton is estimated to be 75,000 to 80,000 bales of lint per year (Cotton Board, 1989). Beginning from 1987/88 season when about 10,000 bales[1] of cotton lint had to be imported the annual national demand for cotton has consistently outstripped its supply. In an effort to boost annual seed cotton production, the Cotton Board has launched vigorous campaigns to open up new cotton growing areas as well as to increase productivity for the existing zones (Republic of Kenya, 1990). The upward adjustment of producer cotton prices in early 1990 was expected to give

[1] This represents about 25% of the local consumption of cotton lint during that year.

farmers further stimulus to produce more cotton (Republic of Kenya, 1990).[2] The country has fifteen ginneries capable of ginning about 200,000 bales or 43.5 thousand tonnes annually if there is sufficient cotton (Republic of Kenya, 1989a). It can be noted from the foregoing that even at the peak annual national seed cotton production level, realised during the 1984/85 crop season, the output was only approximately 35% of the capacity of the ginneries. The capacity of the ginneries therefore does not pose an immediate constraint to increased cotton production in the country (Republic of Kenya, 1989a).

In the previous Development Plans, national targets for seed cotton output have been set. These targets have not been achieved during the implementation of the plans despite efforts to do so. Table 1.2 below shows targets and achievements of national cotton output for selected years during the post-independence era.

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[2] Seed cotton prices were raised in 1990 by 67% (approx.) from Kshs. 6.00 and Kshs. 3.00 per kilogramme of first grade(AR) cotton and second grade(BR) cotton respectively to Kshs.10.00 and 5.00 per kilogramme of AR and BR cotton respectively.

Table 1.3: National Targets and Achievements of Cotton Output

Year	Targeted Output (000'Tonnes)	Achieved Output (000'Tonnes)	Percentage Achieved (%)
1969/70	56.3	15.8	28.1
1973/74	20.0	16.2	81.0
1977/78	30.0	26.7	89.0
1982/83	34.0	23.5	69.1
1987/88	45.0	17.6	39.1
1988/89	48.6	13.8	28.4
1992/93	67.0	....	....

Source: Republic of Kenya,(1965, 1970, 1973, 1978, 1983 and 1988a): **National Development Plans.**

It can be noted, from the above, that the achieved annual national seed cotton output consistently fell short of its target during the last two or so decades. The highest percentage achievement of the targeted annual national seed cotton output was realised in the 1970s. This lack of attainment of the targeted annual national seed cotton output is likely to persist into the present plan period. In relation to the above, the following questions emerge:

(a) Why have the targeted annual national levels of seed cotton output never been achieved?,

(b) What guides cotton farmers on whether to continue growing or abandoning the crop?,

(c) Has the annual national demand for seed cotton risen rapidly in recent times and

(d) What has led to the sluggish growth in annual seed cotton production for the country over the last two to three decades?.

It is important that these questions are addressed and answered adequately if the country's cotton sub-sector is to prosper. It is difficult, however, to answer all of them in one study. This study attempted to provide answers to some of them.

Due to the worsening of Kenya's terms of trade in international trade a lot of emphasis has been laid on constraining imports (Republic of Kenya, 1983).[3] In the 1976/77 crop season, the Cotton Development Project (CDP) was launched under the umbrella of the Integrated Agricultural Development Programme (IADP) which was oriented to the small scale farm sector. This was followed by the Cotton Processing and Marketing Project (CPMP) which started operation in May, 1983 (Republic of Kenya, 1986a). Further concern by the Government was demonstrated by the enacting of the 1986

[3] During the period 1978 to 1981 Kenya's terms of trade, calculated as a ratio of the export price index to the import price index, deteriorated by 19% (Singh, 1983).

Cotton Bill to become the Cotton Act, 1988. The Act has led to the creation of the Cotton Board of Kenya to replace the Cotton Lint and Seed Marketing Board. Despite these concerns, as already seen, the annual national output of seed cotton remains lower than its demand and has risen only slightly during the last two to three decades.

The annual output of seed cotton for Central/Eastern Kenya has taken a downward trend since the 1985/86 crop season. However, Central/Eastern Kenya is still the second leading region in annual seed cotton production in the Republic. Presently, the leading region in annual seed cotton output is the Coast Province. From the 1982/83 crop season to date, Coast Province's annual output of seed cotton has been generally on the rise in comparison to those for the rest of the provinces.[4] In the 1969/70 crop season, the targeted output of seed cotton for the study area was 14,819 tonnes (Republic of Kenya, 1965). The actual output was, on the other hand, 6,248 tonnes (Republic of Kenya, 1977). This lack of attainment of targeted seed cotton output for the region has persisted to the present. The basic problem(s) with which this study addressed itself, therefore, was(were) the reason(s) for the sluggish growth in annual seed cotton

[4] The increase in annual seed cotton output for Coast Province during the 1980s is attributable to a general rise in seed cotton output from the irrigated areas of Bura and Hola, which fall in the province, during the period.

output and failure to achieve its targeted levels for the region for the last two three decades. It has been demonstrated by Barasa (1989) that for cotton to enter into the optimal farm plans for Busia District, seed cotton prices would have to be increased by at least 14%. Previous studies have also shown cotton to compete for resources with other agricultural enterprises at the farm level. The findings of these studies have implied that farmers lacked incentives to grow cotton.

One of the policy measures that could therefore be used to increase the rate of annual seed cotton output for the country is the pricing policy. The producer cotton prices are currently controlled by the Government. If the Annual Price Review is to be used as a policy instrument to increase the rate of growth of annual seed cotton output in the country, the responsiveness of cotton farmers to price changes needs to be estimated and hence the need for this study. This study also examined the price levels that would elicit the 1992/93 targeted cotton hectarage for Kitui District.[5]

[5] The original intention was to do this exercise for the whole of the region. This was impossible due to lack of data on regional annual cotton growth targets. Data on annual seed cotton growth targets for the other districts were also unavailable and hence our examination of the possibility to attain the 1992/93 targeted cotton hectarage only for Kitui District.

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The justification for this study derived, secondly, from the fact that cotton is a labour intensive crop. It has been estimated by Masefield that cotton requires 122 man-days per acre per year against 100 man-days per acre per year for coffee (Oloya, 1969). Cotton also requires more labour than food crops (Kennedy, 1964). There is therefore need to outline policy measures which if implemented would result in increased annual seed cotton output for the country. It can be inferred from its labour requirements that the achievement of the targeted annual national levels of cotton output would imply increased employment of farm labour provided labour productivity remains constant. This would go towards creating the six million new jobs that have to be created in the economy in the next nine years, as per Sessional Paper Number One of 1986. In 1985, the textile industries and cotton ginneries, employed 20,503 people (Republic of Kenya, 1988b). It also accounted for 6% of the total value added in domestic manufacturing in the same period. Cotton production also has linkages with the animal feeds industry. Thirdly, cotton is grown in the marginal areas where few alternative cash crops are grown. It is thus an important source of cash income for these areas (Barasa, 1989). To the extent that this study can lead to an improvement in annual cotton output for these areas without the crop's annual cost(s) of production rising more rapidly than its benefits it can lead to an improvement of farm incomes for those areas. It was estimated in 1988 that agricultural enterprises contributed approximately 55.22% of the household income for Kitui District (Republic of Kenya, 1988b). In recognition of its role in the incomes of these peoples, Prentice (1972) calls it the "crop of the poor". Finally, since agriculture is a location bound industry, the real alternatives faced by farmers of a given commodity can be formulated and the relevant variables such as relative prices defined more appropriately for a region than for an aggregate of heterogenous regions (Krishna, 1963). A past related study was conducted at the Provincial level while this one was carried out at a smaller administrative level, the District. This study was also carried out in order to provide guidance on what pricing policies can be pursued to achieve the targeted seed cotton output levels for this country. The choice of the study area was justified by its significant contribution to the annual national output of seed cotton over the last two to three decades as indicated in Table 1.2 and Figure 1.1 above.

1.3: The Study Area

In the Central/Eastern region of Kenya, cotton is traditionally grown in the six districts of Embu, Kitui, Machakos, Meru, Murang'a and Kirinyaga.[6] These districts have a total land area of 61,822 Km^2 (Republic of Kenya, 1982a and b). In this region cotton is grown in Agro-Ecological Zones (AEZs) Lower Midland (LM)3 and LM4. The AEZ best suited to cotton cultivation is LM3. These AEZs form about 10.75% of the combined surface area of the six districts. The crop competes for resources in these AEZs with maize, beans, Irish potatoes, sweet potatoes, sorghum, bulrush millet, cow peas, tobacco, pigeon peas and cassava in addition to the livestock enterprises (Republic of Kenya, 1982a and b). Most cotton in this region is planted during the "October rains". The rationale for doing this is to enable the peak rainfall to coincide with the crop's peak water demand (Brown *et. al.*, 1972). Exceptions occur in Machakos and Murang'a districts where it is planted in both seasons (Republic of Kenya, 1982a and b).

During the period 1965/66 to 1987/88 the study area contributed most, on average, to the annual national seed cotton output. However, between the 1985/86 crop season and the 1987/88 crop season its share of the annual national seed cotton output generally declined. In this region, the Cotton

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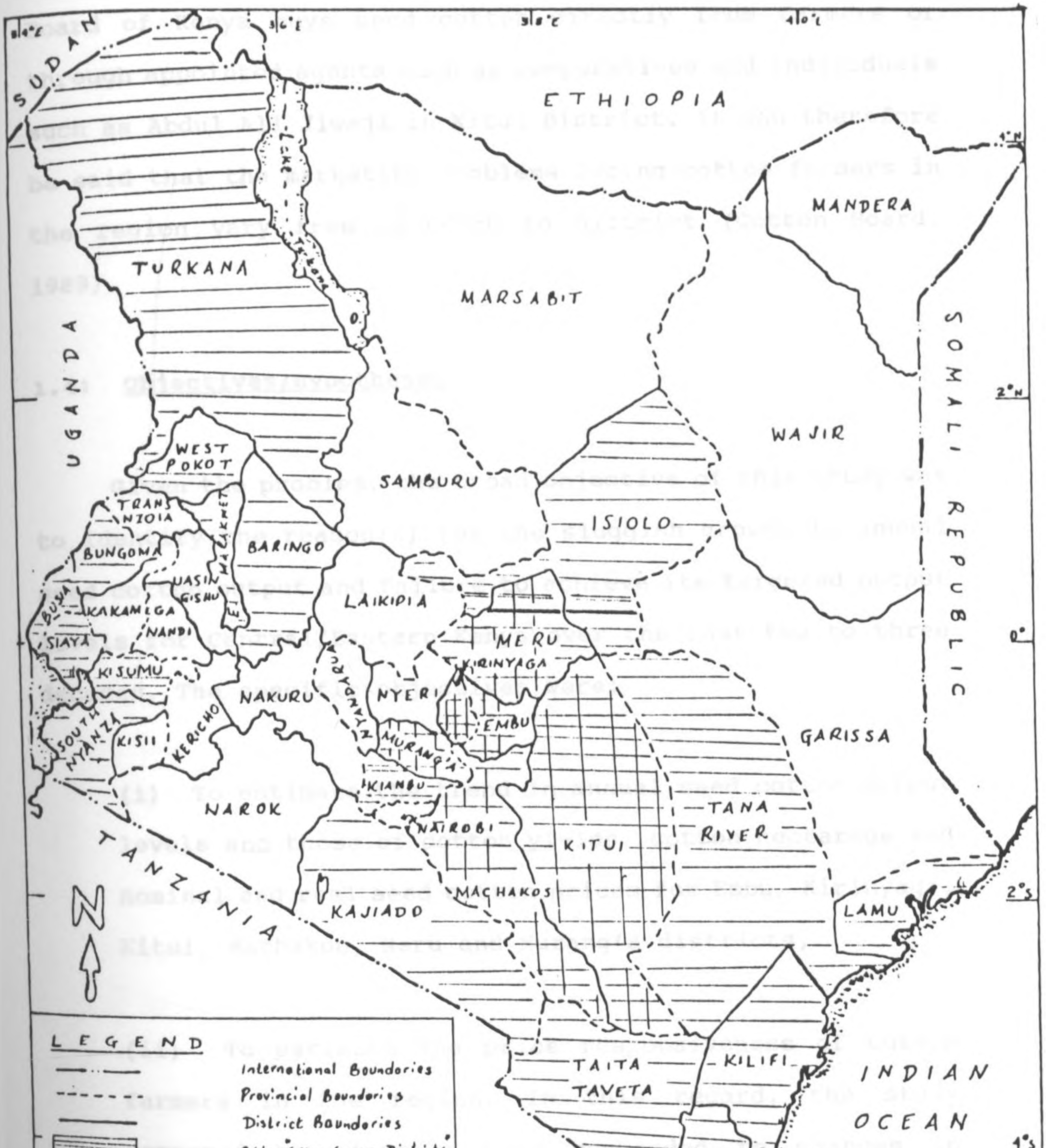
[6] Cotton is also grown in Isiolo and Kiambu districts. Due to paucity of data on cotton for these districts, and their little contribution to the regional output, they were not included in the study. Fig 1.3 below shows the position of the study area in the map of Kenya.



Source: Adapted from Bomso (1989).

Figure 1.3: Position Of the Study Area in Kenya.

Board of Kenya buys seed cotton directly from farmers or through appointed agents such as cooperatives and individuals such as Abdul Ali Jiwaji in Kitui District. It can therefore be said that the marketing problems facing cotton farmers in the region vary from district to district (Cotton Board, 1989).

1.4: Objectives/Hypotheses

Given the problem, the broad objective of this study was to identify the reason(s) for the sluggish growth in annual seed cotton output and failure to achieve its targeted output levels for Central/Eastern Kenya over the last two to three decades. The specific objectives were:

(i) To estimate the trend in annual seed cotton output levels and those of cotton yields, cotton hectarage and nominal and real seed cotton prices for Embu, Kirinyaga, Kitui, Machakos, Meru and Murang'a districts,

(ii) To estimate the price responsiveness of cotton farmers in the region. In this regard, the study compared how farmers have responded to changes in nominal and real prices of seed cotton in Embu, Kirinyaga, Kitui, Machakos, Meru and Murang'a districts over the last two to three decades,

(iii) To show whether manipulations of the producer cotton price can be used as a planning instrument to enable the targeted seed cotton output levels to be achieved and

(iv) To identify other variables, other than (together with) seed cotton prices, that affect the supply of seed cotton for Central/Eastern Kenya.

Given the study's objectives, the following hypotheses were tested:

(a) That cotton farmers have responded perversely to increases in the nominal and real producer cotton prices. If cotton farmers have not responded perversely to increases in the producer cotton prices then these increases must have not been rapid enough to induce them to produce seed cotton at a faster rate than the realised one and hence the perennial failure to attain the targeted output levels for the region.

(b) That the degree of price responsiveness is the same among cotton farmers in the six districts covered in the study. If the null hypothesis is rejected then it is possible to use the policy of price discrimination to further increase the growth of annual seed cotton output for the region and the country as a whole.

(c) That the annual output of seed cotton for the six districts where cotton is traditionally grown in the region has declined or remained static over the last two to three decades. If the null hypothesis is rejected for a majority of the six districts then the recent decline in annual seed cotton output for the region can be regarded as part of a fluctuating long term upward trend.

1.5: Organisation of the Study

The text of this study is organised into five chapters. The first chapter, introduction, covered: the cotton industry, the problem statement and its justification, the study area, the objectives and hypotheses and the organization of the study. In the second chapter, relevant literature on the methodology and related studies are reviewed. The methodology is outlined in chapter three. In chapter four the empirical results of the study are presented and discussed. The last chapter covers summary, conclusions and policy implications of the study.

CHAPTER TWO:

LITERATURE REVIEW

One of the policies that can be used to control the output of a crop, or any other commodity, is the pricing policy. This policy is only relevant where farmers, or other producers, react rationally to price changes. In the event that the contrary is true, the policy cannot lead to the attainment of its desired results. During the last two to three decades, the nominal producer price of cotton in this country rose by about 700% while there was only a marginal increase in the annual seed cotton output. It is thus not clear as yet to what extent the sluggish growth in the annual national seed cotton output over the last two to thee decades was due to inappropriate incentives to farmers. This study attempts to address this issue by estimating the supply responsiveness of cotton farmers in the six districts in which cotton has been traditionally grown in Central/Eastern Kenya. I concur in Nerlove's belief (1979) that;

> ..."Often the costs and returns which face individual farmers are expressible in terms of market prices, although the risks they face are usually not so easily quantifiable. Whether such market forces, however, impinge directly and visibly on individual farm entrepreneurs it will nonetheless be true, if we accept the presupposition of optimizing behaviour, that shadow prices and opportunity cost(s) are crucial determinants of agricultural supply."....

The need to understand the problem of low agricultural production can therefore be considered as one for identifying the changing opportunity cost(s) for the production of a commodity. The opportunity cost(s) of producing seed cotton must have changed over the last two to three decades as a result of changing commodity prices. If these opportunity costs were unfavourable for seed cotton production then the sluggish growth in annual seed cotton output for Central/Eastern Kenya over the last two to three decades can be attributed to the prices of its competing commodities rising faster than the producer cotton prices. It may not be possible to fully identify the opportunity cost(s) of cotton production over the years, however. Farmers of a given crop may react to changes in its price by changing the area devoted to its cultivation or its cultural practises. Since the annual output of the crop is a function of both its hectarage and yield (land productivity), important insights into the problem of low production may also be gained by examining the trend of these variables. This approach was adopted in this study.

The degree of supply responsiveness of a group of farmers of a given commodity is measured by the own price elasticity of supply for that commodity. The price elasticity of supply for a commodity is defined as the percentage change in its output (supply) as a result of one per cent change in

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The degree of supply responsiveness of a group of farmers of a given commodity is measured by the own price elasticity of supply for that commodity. The price elasticity of supply for a commodity is defined as the percentage change in its output (supply) as a result of one per cent change in its price. The price elasticity of supply for any commodity can be any rational number, depending on its nature. Economic theory, however dictates that it be a positive number. This restriction is violated in certain circumstances. The magnitude and sign of the price elasticity of supply for commodities produced in poor countries has been the subject of much debate (Falcon, 1964). Empirical results of studies carried out (Aldington and Wilson, 1968; Kere, 1986; Maitha, 1974; Mbogoh, 1980; Msemakwelli, 1979 and Odada, 1975) for Kenyan farmers of various commodities pointedly favour the hypothesis of a positive price elasticity of supply for those commodities. The magnitude and sign of the price elasticity of supply has varied from study to study. These differences can be partly attributed to the models used by different researchers, their sample sizes, nature of the commodities and psychological factors (Jhala, 1979 and Zaki, 1976). The models developed from supply response studies can also be used to forecast the supplies of the commodities in addition to providing guidance on the pricing policies to pursue for a given commodity (Krishna, 1963). Two models that have been widely applied in supply response studies of primary producers are the Nerlovian "Adaptive Expectations" model and its alternative, the "Partial Adjustment" model, proposed by Nerlove (1956 and 1958). These models, and their derivations, are presented in section 3.1.

In the estimation of the Nerlovian models, the current supply of a commodity is hypothesised to be influenced by the previous supply, its unit price, the unit price of a competing enterprise and "other" variables. The choice of which other variables to include in a supply function is not obvious. One variable that is often included in the models is the trend term. It is included to represent such things as technological change, improvement in transport network and better information which are not readily quantifiable. In the event that its coefficient is statistically significant, then the variables left out of the model are important in explaining the variability in the dependent variable (Nerlove and Addison, 1958).[7] In this study, the trend term was included to account for other variables such as technological change, improvement in transport net work and better information, not explicitly stated in the estimated supply response models.

Krishna (1963) estimated the price elasticity of supply for cotton, maize, sugar cane, rice, bajra, jowa, wheat, barley and gram in the Punjab area of Pakistan and India. Using the Nerlovian "Partial Adjustment" model he hypothesised that annual changes in cotton acreage were influenced by lagged acreage, lagged relative cotton prices,

[7] Nerlove (1958) argues that the inclusion of a trend term is an admission of ignorance about some of the variables that explain the supply of a commodity while Lim (1975) terms it an exercise in ignorance.

annual rainfall amounts, a trend variable and the lagged yield of cotton divided by an index of the lagged yields of alternative crops. His inclusion of the lagged yield of cotton divided by an index of the lagged yields of alternative crops was justified because of the advances in the yields of cotton that were then present in the Punjab region. Since the latest variety of cotton in Kenya was released about sixteen years ago it did not appear warranted to include it as an explanatory variable in the model used in this study. A cursory examination of the data in the appendix also revealed that there was no significant improvement in cotton yields after the release of the variety. The results of Krishna's study (1963) also showed that annual rainfall amounts significantly influenced annual changes in cotton acreage in the dry areas of the Punjab region. Since the study area includes some of those areas classified as semi-arid in this country, annual rainfall amounts was included as one of the explanatory variables in the estimated cotton supply response models.

Kere (1986) also included annual rainfall amounts as one of the explanatory variables in a wheat acreage response model. The results of his study do not provide conclusive evidence as to whether changes in annual rainfall amounts significantly influence annual changes in wheat acreage. Kere's study also suggested that the price elasticity of supply varied between districts, thereby emphasising the notion that agriculture is a location bound industry. His study was conducted at the district level. This was a reasonable approach since districts are generally more homogenous than provinces in terms of competing enterprises, soils and economic conditions. Some districts, such as Machakos District, are heterogenous, however. Ideally, supply response studies should be conducted for economic regions or smaller administrative units. In the first instance, data are not available by economic regions making this not to be a feasible alternative. Data are often also not available for a long period of time by smaller administrative units. Apart from the need for large amounts of resources, than may be available, the previous reasons make it reasonable for the present study to be conducted at the district level, rather than the provincial level. Kere (1986) deflated the price of wheat with that of the most competing enterprise in any district.[8] To identify the most competing enterprise, he regressed wheat acreage on its own price and those of the potentially competing enterprises. The enterprise with the most significant and negative regression coefficient was then chosen for deflating the producer price of wheat. Previous researchers who had used the same approach in Kenya include Odada (1975) and Msemakwelli (1979). However, Kere (1986)

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[8] In some instances he used nominal prices.

advanced the argument that deflating the producer price of wheat with that of the most competing enterprise reduced collinearity and introduced the element of opportunity cost, which serves to increase the justification for this approach. Incase the producer price of a crop of interest is not deflated with that of the most competing enterprise, one could deflate it with an index of input prices or a consumer price index or simply use its nominal prices (Askari and Cummings, 1974 and Singh *et. al.*, 1974).

The main reason for deflating the producer price of a crop with that of an alternative crop is lack of suitable indices to use in deflating it. In this study two approaches were used, use of nominal and real producer prices. The producer price of the most competing enterprise was included as an explanatory variable in our model to introduce an element of opportunity cost. Two main criticisms can be levelled against Kere's methodology. Firstly, his level of statistical significance, 0.20, was too low for the results to be reliable. Secondly, Kere did not use a statistical test to test the hypothesis of the price elasticity of acreage response being the same among farmers in the wheat growing districts. In this study, Chow test was used to test the hypothesis of acreage response being the same among farmers in the six "cotton growing" districts covered. For this test to be carried out,[9] the variables in all the estimated supply response models have to be the same. It is thus not possible to carry out between districts with different competing crops if we are to include the producer price of the most competing enterprise as one of the variables in the test. To carry out the test, data could be pooled for districts with the same competing enterprise. If the competing enterprises are not the same in all districts, as is usually the case, the data on hectarage, trend and annual rainfall amounts are pooled for the relevant districts. This procedure does not result in significant changes in the interpretation of the results since the test also captures inter-regional variations in competing crops.

Msemakwelli (1979) used the Nerlovian "Partial Adjustment" model to estimate the price elasticity of supply for seed cotton for this country. Like Odada (1975), he relied on provincial time series data for his study. His study showed that cotton farmers are, generally, responsive to increases in relative seed cotton prices. However, his statistical levels of significance were also too low. Out of the sixteen coefficients he estimated, only three were

[9] The test is detailed in section 3.4. It is able to capture differences in soils, competing crops, psychological conditions, technology, information systems and transport network between regions.

statistically significant.[10] He also did not take his study far enough. He ought to have used his models to show what prices would elicit particular hectarage or output of the crop for the provinces covered in his study. Thirdly, whereas it had been shown by Krishna (1963) that changes in the acreage of rain-fed cotton may be significantly influenced by annual rainfall amounts, his model only included lagged acreage, lagged relative prices and a trend variable as the explanatory variables. Fourthly, his analysis was done at the provincial level thereby not realistically showing the alternatives faced by cotton farmers. For instance, whereas he found out that sugar cane was the most competing enterprise with cotton in Nyanza Province, this is not necessarily true for every "cotton growing" district in that province. His study has also been criticised for his not explicitly incorporating risk and uncertainty in his estimating equations (Barasa, 1989). One form of risk that can face cotton farmers in this country, however, is removed by the Government's guaranteeing of the producer cotton price. The risk and uncertainty variables are also captured by the intercept and the lagged value of the dependent

[10] Only two coefficients of relative seed cotton price were significant at the 0.10 level.

variable (Msemakwelli, 1979).[11] There have been attempts to incorporate risk variables into farmers' decision making process using cross sectional data. One such attempt was by Odhiambo (1983). He compared and contrasted risk responsive and risk neutral models derived from both traditional and the stochastic production risk model proposed by Just and Pope (1978) using a cross-sectional sample of cotton farm data from Egypt. He concluded that the Just-Pope model was preferable to the multiplicative error model. Since the data used in this study was of a time series nature the Just-Pope model was considered inappropriate. The Just-Pope model is appropriate where a production function approach is adopted. In this study the risk of crop failure due to drought was incorporated by including annual rainfall amounts as one of the explanatory variables in the estimated supply response models. It is hypothesised that farmers adjust their acreage decisions during the early part of the "October rains" so as to avoid crop failure due to drought. If there are indications of drought, farmers can react by growing crops or crop mixtures that are drought escaping or that take a short time to mature. For this reason, if there is a possibility of the prices of food crops being very high as a result of

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[11] Technological uncertainty may not be fully accounted for by including the lagged dependent variable as one of the regressors in these models (Mbogoh, 1980). This calls for more elegant forms of supply response models than these ones. The more elegant supply response models are invariably highly demanding on data and computations than the Nerlovian ones and hence our preference of the latter.

drought less acreage of cotton is grown in any one growing season than would have been the case. Msemakwelli's lagging of the producer cotton prices in Coast, Nyanza and Western provinces was also erroneous since seed cotton prices are announced in advance of the planting of cotton in these provinces. This study therefore differed with Msemakwelli's in two main respects. Firstly, the price elasticity of supply for seed cotton (cotton) was estimated at a smaller administrative level, the district. Secondly, it was intended to use the models so developed for prediction purposes. Msemakwelli's study, however, represented a significant departure from earlier economic studies of cotton in Kenya. Previous researchers like Heyer (1967) and Kennedy (1964) underscored the importance of competition for labour and other farm inputs without determining the price responsiveness of cotton farmers. In this study, competition for farm inputs was introduced through the use of the most competing enterprise as an explanatory variable in the regression model used to analyze the data.

Kennedy's study (1964) was conducted among cotton growers in Nyanza and Coast provinces. It showed that cotton competes with food crops for labour during the critical periods of labour demand. He observed that

> ..."cotton is invariably planted late and if planted early, the standards of husbandry are low"....

His observations also underscored the need for including a risk variable such as rainfall in supply response models. Despite collecting input-output data for both cotton and food crops he did not go far enough to determine whether cotton would feature in these farmers' optimal farm plans. Had he done that he would have also demonstrated at what producer price levels cotton would go out of, or enter into, the optimal farm plans. Heyer (1967) went further than Kennedy (1964) to determine the optimal farm plans for peasant farmers in Masii Location, Machakos District, under different rainfall conditions. Her conclusions were that cotton was not much of an improvement over traditional crops in the area during years of low rainfall amounts and that livestock enterprises could not compete successfully for arable land with crops in that area. Since the conditions under which cotton is grown in the study area are similar to that of Masii, it included Masii, livestock enterprises were not considered to compete with cotton for land. Heyer's study also revealed that apart from labour bottlenecks being experienced during ploughing, weeding and harvesting, land was a constraint in the area. Heyer's study supports the incorporation of (a) competing crop(s) in the estimated supply response models. It also offers support for the inclusion of rainfall amounts as a risk variable in the study.

Etyang (1979) demonstrated that cotton had the least gross margin in Busia District in the 1970s. Barasa (1989), working on cotton in the same district, also showed that the crop would only feature in the optimal farm plans for the district if its price was raised by at least 14%. The studies by Barasa (1989) and Etyang (1979) go further to support the contention of Aldington (1973), Blume (1969) and Matovu (1980) that returns from the cultivation of cotton were low and hence impeded its progress in the country. The returns from the production of seed cotton can be increased by either increasing its yield or the prices of its grades, provided costs do not rise more rapidly than either of the two. Both approaches are relevant in the long run. In the short run, it is possible to increase the growth of annual seed cotton output through the pricing mechanism.[12] This is because it is easier to change seed cotton prices than its yield. In the long run it is possible to increase cotton yields by breeding it for that attribute. It is thus possible for one to attribute the failure to achieve the targeted seed cotton output to the "low returns" from cotton production. It is for this reason that the influence of seed cotton prices on its annual supply for Central/Eastern Kenya was investigated.

[12] In the short run it is also possible to increase cotton yields and output by practising improved crop husbandry, where a substantial gap exists between research recommendations and those obtained by farmers. The adoption of the recommendations by farmers are, of course, subject to their being simple, easy to replicate, affordable and compatible with the farming systems.

Even if the seed cotton prices were high enough to make the crop feature in the optimal farm plans for the region, its output cannot be raised if its factor and product markets are inefficient. This observation is underscored in the country's Sixth National Development Plan (1989-1993). It can be correctly said that if the product and factor markets for cotton do not remove some elements of uncertainty facing farmers, farmers will discount the returns from seed cotton production. The degree of responsiveness of cotton farmers in the study, to changes in the price of seed cotton, therefore depends on whether or not the farmers receive farm inputs such as pesticides, cotton seeds and labour in the appropriate amounts and at the appropriate time(s). It is also influenced by whether or not they are paid promptly for the produce they sell or there are unorthodox practices such as incorrect weighing procedures or grading of first grade (AR) as second grade (BR) cotton. Untimely return of sacks or bags used for packing cotton to their owners also influence the response. These aspects were considered in the methodology of the present study, which is presented in the next chapter.

CHAPTER THREE:

METHODOLOGY:

3.1: Theoretical Background to the Methodology

Linear regression has been widely applied to the measurement of economic relationships (Chow, 1960).[13] Such relationships include the consumption function, consumer demand, business investment, dividend policy, prices of corporate stocks, cost and supply functions and the trend in variables. The assumption behind such measurements is that of a causal relationship. The concern of this study was the measurement of supply functions of cotton growers in Central/Eastern Kenya and the estimation of the trend in the variables that influence the annual supply of seed cotton for the region. Economic theory suggests that the supply of a crop is influenced by the crop's price, the price of a competing enterprise, the levels of investment and the acreage sown to the crop. The technical relationship between the output of a crop and its inputs is known as the production function. The output of a crop is thus a function of the inputs which go into the process and non-economic

[13] For a discussion of the assumptions and limitations of the Ordinary Least Squares (OLS) technique see Johnston (1984) or Pindyck and Rubinfeld (1981) or Intriligator (1978) or Theil (1978) or Koutsoyiannis (1977).

variables such as weather fluctuations and different soils. This approach to the supply response for a commodity is the production function approach. Despite its being conceptually sound, and its adoption in various studies, the production function approach is extremely difficult to apply empirically when multi-products can be produced in farms (Kwon and Uhm, 1980). This difficulty arises because of the impossibility to disaggregate labour and capital for different enterprises. An alternative approach, which is empirically feasible, is the "supply function approach".

One facet of the supply function approach is based on the premise that the only input that can be disaggregated for a particular crop is the acreage sown to that crop.[14] In this case, yield is generally regarded as controlled by factors not under the farmer's control (Nerlove, 1956). As a result, this second approach measures acreage responses. In some instances, however, the quantity of a commodity has been used as the dependent variable.[15] Such an approach is applicable where there is unreliable data on acreage (Malima, 1971) or

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[14] In the event that crops are inter planted, it becomes even more difficult to disaggregate inputs. In such a situation, it is impossible to disaggregate land. Since it is not recommended that cotton be inter planted in most parts of the Republic (Brown *et. al.*, 1972) and in Kitui District, cotton is planted in pure stand in LM4 (Pagiola *et. al.*, 1990) we assumed that land can be disaggregated.

[15] See Alibaruho (1974a), Malima (1971) and Rukandema (1976).

where it is constant over time (Maitha, 1974b). For perennial crops, productivity responses and vintage capital models are applicable (Maitha, 1969 and 1974b and Nyang, 1989). Since cotton is grown as an annual crop, the acreage response model is applicable to this study.

It should be noted that there may be no perfect correlation between planted acreage and planned output (Wilson *et. al*, 1980). Acreage, however, is an attractive surrogate of planned output because annual variations in yield are largely due to uncontrollable variables, making acreage to be the main decision variable under the farmer's control (Kwon and Uhm, 1980). Further, so long as the crop yield is stable the elasticities of crop acreage are equivalent to those of crop supply (Jhala, 1979).

The "Supply Function Approach" was initially adopted by Nerlove (1956 and 1958) and subsequently by many researchers. Nerlove proposed two models, which came to be referred after him. These are the "Adaptive Expectations" model and its alternative the "Partial Adjustment" model.[16] The Nerlovian "Adaptive Expectations" model is based on the argument that farmers revise their price expectations for the period in

[16] The present derivation of the models is based on those by Lim (1975), Griliches (1967) and Johnston (1984).

proportion to the error they made in predicting current prices. If we represent the expected price in period t by P^*_t, the expected price in period t-1 by P^*_{t-1}, the actual price in period t-1 by P_{t-1} and the coefficient of price expectations by β, we can write this hypothesis in terms of the above variables as below:

$$p^*_t - P^*_{t-1} = \beta(p_{t-1} - p^*_{t-1}),\ 0 \leq \beta \leq 1 \tag{3.1}$$

Nerlove (1956) also postulated that the current supply (hectarage) was a linear function of the expected price. This can be written as equation (3.2) below:

$$x_t = a + bp^*_t + u_t \tag{3.2}$$

where a and b are parameters to be estimated, x_t is the supply (hectarage) of the crop in year t and u_t is a residual (disturbance) or error term. Due to their containing unobservable variables, equations (3.1) and (3.2) are not estimable. By rearrangement of equation (3.1) we obtain equation (3.3) below:

$$p^*_t = \beta p_{t-1} + (1-\beta)p^*_{t-1} \tag{3.3}$$

In equation (3.3) above, P^*_t is a weighted average of P_{t-1} and P^*_{t-1}. Lagging the variables in equation (3.3) once gives us equation (3.4) below:

$$p^*_{t-1}=\beta p_{t-2}+(1-\beta)p^*_{t-2} \tag{3.4}$$

If equation (3.3) is true, then equation (3.4) is also true. Equation (3.4) can be lagged successively to get rid of the unobservable values of past prices. Substitution of equation (3.4) into equation (3.3) gives us equation (3.5):

$$p^*_t=\beta p_{t-1}+(1-\beta)\left[\beta p_{t-2}+(1-\beta)p^*_{t-2}\right] \tag{3.5}$$

This is the same as equation (3.5a) below:

$$p^*_t=\beta p_{t-1}+\beta(1-\beta)p_{t-2}+\beta(1-\beta)^2 p_{t-3}+(1-\beta)^3 p^*_{t-3} \tag{3.5a}$$

It is seen from equations (3.5) and (3.5a) above that the expected price in period t is a weighted average of past prices. The weights are geometrically declining. Using summation sign, equation (3.5) can be rewritten as below:

$$p^*_t=\beta p_{t-1}+\beta\sum_{i=1}^{n}(1-\beta)^i p_{t-i-1} \tag{3.6}$$

Upon substitution of equation (3.6) into equation (3.2) we obtain equation (3.7) as below:

(3.7) $$x_t=a+b\beta p_{t-1}+b\beta\sum_{i=1}^{n}(1-\beta)^i p_{t-i-1}+u_t$$

As it stands, equation (3.7) poses estimation difficulties because of the presence of severe levels of multicollinearity or lack of sufficiently long enough observations of past prices. To solve the multicollinearity problem the Koyck (1954) reduction procedure is used. If we lagged equation (3.7) once and multiplied the result by $(1-\beta)$ we would obtain the following:

(3.8) $$(1-\beta)x_{t-1}=(1-\beta)a+(1-\beta)b\beta\sum_{i=1}^{n}(1-\beta)^i p_{t-i-1}+(1-\beta)u_{t-1}$$

Subtracting equation (3.8) from equation (3.7) gives us equation (3.9) below:

(3.9)

$$x_t-(1-\beta)x_{t-1}=a-(1-\beta)a+b\beta\left[p_{t-1}+\sum_{i=1}^{n}(1-\beta)^i p_{t-i-1}-\sum_{i=1}^{n}(1-\beta)^i p_{t-i-1}\right]+u_t-(1-\beta)u_t$$

Upon rearrangement and simplification of equation (3.9) we obtain the reduced form of equations (3.1) and (3.2) as below:

(3.10) $$x_t=\beta a+\beta b p_{t-1}+u_t-(1-\beta)u_{t-1}+(1-\beta)x_{t-1}$$

Equation (3.10) can be written more compactly as equation (3.11) below:

(3.11) $$x_t = \Pi_0 + \Pi_1 p_{t-1} + \Pi_2 x_{t-1} + v_t$$

in which: $\pi_0 = \beta a$,

$\pi_1 = \beta b$,

$\pi_2 = (1-\beta)$ and

$v_t = u_t - (1-\beta)\ u_{t-1}$.

Equations (3.1) and (3.2) are expressed in form of equation (3.11) in empirical work. Equation (3.11) has been used to estimate the price elasticity of supply for various crops such as cotton by Nerlove (1956) in the United States of America. An examination of equation (3.11) above indicates that it could be serially correlated since it contains both the current and lagged values of the error term.

The Nerlovian "Partial Adjustment" model, on the other hand, rests on the argument that farmers are always trying to bring the actual level of farm output to some desirable levels but due to some uncontrollable factors, such as weather fluctuations, such efforts are never completely rewarded in any single period (Nerlove, 1958). This long run or equilibrium acreage (x^*_t) is a linear function of the expected normal price. He further hypothesised that the change in the actual supply of a crop is proportional to the difference between its desired or equilibrium supply and the actual supply (hectarage). Finally, farmers revise their price expectations in proportion to the error they made in predicting the previous period's price. His three hypotheses can be written in algebraic terms as below:

(3.12) $$x_t^* = a + bP_t^* + u_t$$

(3.13) $$P_t^* - p_{t-1}^* = \beta(p_{t-1} - p_{t-1}^*),\ 0 \leq \beta \leq 1$$

(3.14) $$x_t - x_{t-1} = \lambda(x_{t-1}^* - x_{t-1}),\ 0 < \lambda \leq 1$$

In equation (3.14) above, λ is the coefficient of adjustment while the rest of the variables and parameters are as in equations (3.1) and (3.2) above. The magnitude of the coefficient of adjustment is an indication of the ability of farmers to change the fixed factors of production. The larger it is the easier it is for farmers to remove bottlenecks that inhibit them from achieving the long run (equilibrium) supply levels of a commodity (Nerlove, 1956). Equation (3.14) can be rewritten as equation (3.15) below:

(3.15) $$x_t = \lambda x_t^* + (1-\lambda)\, x_{t-1}$$

Substitution of equation (3.12) into equation (3.15) gives us equation (3.16):

(3.16) $$x_t=\lambda(a+bp_t^*+u_t)+(1-\lambda)x_{t-1}$$

If we substitute the expected price variable P^*_t with known values of the price, as we did with the "Expectations" model in equation (3.7), we obtain an equation which relates the current supply of a crop to its past prices and lagged acreage as follows:

(3.17) $$x_t=\lambda a+\lambda b\beta p_{t-1}+\sum_{i=1}^{n}(1-\beta)^i p_{t-i-1}+\lambda u_t+(1-\lambda)x_{t-1}$$

In its present form, equation (3.17) poses estimation difficulties due to the presence of severe multicollinearity and lack of sufficiently long enough observations of past prices. These problems are solved through the Koyck (1954) reduction procedure. Lagging equation (3.17) once, multiplying the result by (1-ß) and subtracting the result of the multiplication from equation (3.17) gives us the following upon simplification:

(3.18)

$$x_t-(1-\beta)x_{t-1}=\beta\lambda a+\beta\lambda bP_{t-1}+(1-\lambda)x_{t-1}-(1-\beta)(1-\lambda)x_{t-2}+\lambda u_t-(1-\beta)\lambda u_{t-1}$$

It is possible to write equation (3.18) more compactly as below:

$$x_t=\alpha_0+\alpha_1 p_{t-1}+\alpha_2 x_{t_1}-\alpha_3 x_{t-2}+v_t \qquad (3.19)$$

where, $\alpha_o = \beta\lambda a$,

$\alpha_1 = \beta\lambda b$,

$\alpha_2 = [(1-\beta) + (1-\lambda)]$

$\alpha_3 = (1-\beta)(1-\lambda)$,

and $v_t = \lambda u_t - (1-\beta)\lambda u_{t-1}$

In the event that there is no price uncertainty, β=1 and α_3 becomes zero (Hill, 1972). It is apparent that in such a situation $v_t = \lambda u_t$ and the error term is well behaved. If full adjustment can occur in one time period, λ =1 and α_3 again becomes zero. In both cases, where $\alpha_3 = 0$, equations (3.11) and (3.19) are comparable. Since as Griliches (1967) points out, the Nerlovian "Partial Adjustment" model is used in situations where price uncertainty is removed by the Government guaranteeing of producer prices, α_3 is always zero. The "Partial Adjustment" model can also be formulated in a log-linear form as below[17]:

$$x_t^*=ap_{t-1}^b \qquad (3.20)$$

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[17] In equation (3.21), in the text, λ is known as the elasticity of adjustment instead of the coefficient of adjustment as was in equations (3.14) to (3.19) above.

(3.21) $$\left(\frac{x_t}{x_{t-1}}\right) = \left(\frac{x_t^*}{x_{t-1}}\right)^{\lambda} e^{u_t}$$

Combining equations (3.20) and (3.21) gives us the following:

(3.22) $$\left(\frac{x_t}{x_{t-1}}\right) = \left(\frac{ap_{t-1}^{b}}{x_{t-1}}\right)^{\lambda} e^{u_t}$$

In this form it is hypothesised that the proportion of disequilibrium which is eliminated is smaller the greater the disequilibrium (Lim, 1975). This assumption is perhaps more realistic as it is likely that the closer the producers are to equilibrium the less there is to learn about it and, therefore, the more they are inclined to eliminate it. The closer one is to equilibrium the more likely one is to afford to change the fixed factors of production that inhibit one from attaining some desired level of supply of a given commodity. When equation (3.22) is expressed in natural logarithms we obtain:

(3.23) $$lnx_t - lnx_{t-1} = \lambda lna + \lambda blnp_{t-1} - \lambda lnx_{t-1} + u_t$$

Upon rearrangement of equation (3.23), it becomes

(3.24) $$lnx_t = \lambda lna + \lambda blnp_{t-1} + (1-\lambda) lnx_{t-1} + u_t$$

Equation (3.24) can be written more compactly as:

$$lnx_t = \ln a_0 + b_0 \ln p_{t-1} + b_1 lnx_{t-1} + u_t \quad (3.25)$$

where, $\ln a_0 = \lambda \ln a$, $b_0 = \lambda b$ and $b_1 = (1-\lambda)$.

One weakness of this form of the "Partial Adjustment" model is that the price expectation is assumed to static. The producer price of a crop for some period is assumed to be the one on which farmers base their acreage allocation decisions. Its strength lies in one obtaining the short run price elasticity of supply[18] for a commodity directly.

The "Adaptive Expectations" model emphasises price uncertainty as being responsible for farmer's adjustment lags whilst the "Partial Adjustment" model emphasises technological uncertainty as being responsible for these lags. There are conceivable circumstances when both forms of uncertainty are present (Johnston, 1984). Under those circumstances a "mixed model" is used. The "mixed models" are difficult to estimate. The reason for choosing between the "Adaptive Expectations" and the "Partial Adjustment" models

[18] The short run price elasticity of supply is defined as the elasticity over one production period. The long run price elasticity of supply, on the other hand, is the elasticity over the period when full adjustment can occur.

for use in empirical work has been attributed to Griliches (1967). He stated that;

> ... "In situations of price uncertainty, the *Adaptive Expectations* model is applicable whereas in situations where price uncertainty is removed by the government guaranteeing of producer prices, the *Partial Adjustment* model is applicable"....

Krishna (1963) also adds that the choice of which of the two Nerlovian models to use in any situation depends, firstly, on whether or not it is a plausible formalisation of the institutional, technological and expectational facts of the sector concerned. Secondly, it depends on the estimation difficulties posed by the model (Krishna, 1963). The Nerlovian "Partial Adjustment" model is easier to estimate than the "Adaptive Expectations" model (Krishna, 1963). It is for the above reasons that the log-linear version of the "Partial Adjustment" model has previously been used by Zaki (1976) and Jhala (1979) to estimate the supply responsiveness of cotton and groundnut farmers in Egypt and India, respectively.

Nerlovian models belong to the class of dynamic models. When analyses based on dynamic models are contrasted with those based on the more traditionally static approach, it is found that the former analyses explain the data better and that the coefficients are more reasonable in sign and magnitude (Nerlove, 1958). The Nerlovian models also make it for use in empirical work has been attributed to Griliches (1967). He stated that;

> ... "In situations of price uncertainty, the *Adaptive Expectations* model is applicable whereas in situations where price uncertainty is removed by the government guaranteeing of producer prices, the *Partial Adjustment* model is applicable"....

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Nerlovian models belong to the class of dynamic models. When analyses based on dynamic models are contrasted with those based on the more traditionally static approach, it is found that the former analyses explain the data better and that the coefficients are more reasonable in sign and magnitude (Nerlove, 1958). The Nerlovian models also make it possible to identify both the short run and the long run price elasticity of supply. One major limitation of these models, as well as of other dynamic models, is the possibility of them being serially correlated. In this study, the models were scanned for serial (auto) correlation by means of Durbin's h-test statistic. This is a suitable test for serial correlation when a lagged dependent variable is used as an explanatory variable in a regression equation (Durbin, 1970). Gordon-Breusch test can also be used to scan for serial correlation in models in which a lagged dependent variable is one of the regressors (Johnston, 1984). It has more computational complexity than Durbin's h-test and hence our use of the latter.

To be of value to planners, the calculated price elasticities of supply for a commodity should be determined for homogenous regions (Brennan, 1958 and Odada, 1975). Aggregated data normally conceal differences such as alternative crops, soils and climate, wage rates, and technological conditions which exist between regions. Ideally, each region should be defined in terms of homogeneity of crop substitutes, technology, climates, soils and wage rates (Brennan, 1958). It is these observations and the fact that data are not available by economic regions that strengthen the case for estimating the price elasticity of supply for seed cotton at the district rather than the provincial level.

A priori, one expects the price elasticity of supply to be positive and differ between the cotton growing districts in Central/Eastern Kenya. This is due to the differences in economic and non-economic conditions between them. Whether or not there are such differences was tested by means of Chow test, as outlined in section 3.4 below. To test the hypothesis that the regression coefficient of the price of cotton has a positive sign, as economic theory suggests, we used a one sided upper bound student's t-test. We should not expect cotton farmers to behave differently from their counterparts who grow coffee, pyrethrum, tea, maize, wheat and sugar cane and raise livestock in Kenya. The regression coefficient of the annual rainfall variable can take either sign. If cotton is regarded as a drought escaping (or drought tolerant) crop, then as rainfall amounts increase less of it is planted and vice versa. If we are to go by the results of studies by Jhala (1979) and Krishna (1963) we should expect it to be positive. Economic theory also suggests that the regression coefficient of the most competing enterprise should be negative.

3.2: Functional Forms

3.2.1: Estimation of the Trend in the Variables

The first specific objective of this study was met by regressing the annual cotton hectarage, the annual cotton output, the yield of cotton and nominal and real producer cotton prices for any district on a linear time trend. The relationship between these variables and time was assumed to be as in equation (3.26) below;

$$Y_t = \alpha + \beta T + u_t \qquad (3.26)$$

where Y_t = the observed values of annual seed cotton output, cotton yield, hectarage, and real and nominal producer cotton prices in year t,

T = a trend variable taking the values 1 to 28 if the data set stretched back to 1960/61 crop season. Where the data set began after the 1960/61 crop season, the value 1 was taken to stand for the year when the data began and

u_t = a well behaved stochastic error term at year t.

To complement our trend analysis we also calculated the means[19] and coefficients of variation of the above variables for the six districts.

3.2.2: Supply Response Modelling and Prediction of the levels of Seed Cotton Prices that can lead to the attainment of the 1992/93 Targeted Cotton Output in Kitui District

It has been argued before that the suitable model that can be used to meet the other three specific objectives of the study is the log-linear version of the Nerlovian "Partial Adjustment" model. Firstly, it is suitable because the producer cotton prices is set by the Government in this country. As we have seen before, the Nerlovian Partial Adjustment model is applicable where producer prices are set by some agency. Secondly it enables us to identify the short run price elasticity of supply for cotton directly. Thirdly it is easier to estimate than the "Adaptive Expectations" model. Lastly, it more reasonably formulates the farmers' behaviour than its alternatives. It is reasonable to assume that the closer one is to equilibrium the more likely one is to eliminate the disequilibrium since the costs of adjustment are lower, which is the assumption of our model. In this

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[19] For the definition of the mean and coefficient of variation see Spiegel (1987) or Wonnacot and Wonnacot (1990).

study, the present season's hectarage of cotton was assumed to be a function of the previous season's hectarage, the previous season's price of cotton, the previous season's price of a competing enterprise, the current annual rainfall amounts and a time trend variable. Two sets of prices were used in the analysis; real and nominal producer prices. The Nairobi Lower-Income Consumer Price Index was used to deflate the producer price of cotton and those for the competing enterprises to obtain real producer prices for each of the six districts. The use of this index was dictated by the fact that Nairobi is the nearest city (town), to the study area, whose Consumer Price Index (CPI) was available. Since the consumer baskets in the study area and Nairobi may be significantly different the results of our analysis with real producer prices need to be interpreted with this limitation in mind.

Our model can be written in mathematical terms as below:

(3.27) $$X_t = A X_{t-1}^{\hat{\beta}_1} (P_c)_{t-1}^{\hat{\beta}_2} (P_m)_{t-1}^{\beta_3} R_t^{\hat{\beta}_4} e^{\beta_5 T + u_t},$$

where X_t = the hectarage of cotton in season t,

X_{t-1} = the hectarage of cotton in season t-1,

$(P_c)_{t-1}$ = the lagged real or nominal producer price of cotton,

$(P_m)_{t-1}$ = the lagged real or nominal producer price of the most competing enterprise,

R_t = Annual rainfall amount in mm, during season t,

T = Time trend variable, ranging from 1 to 28,

$\beta_1, \beta_2, \beta_3, \beta_4$ and β_5 = Parameters to be estimated and

u_t = an error term.

As it stands, equation (3.27) cannot be estimated using Ordinary Least Squares (OLS) technique. Firstly, it is linearised by taking natural logarithms of both of its sides to give us equation (3.28):

(3.28)

$$lnX_t = lnA + \beta_1 lnX_{t-1} + \beta_2 \ln(P_c)_{t-1} + \beta_3 \ln(P_m)_{t-1} + \beta_4 lnR_t + \beta_5 T + u_t$$

If we let X'_t = ln X_t, X'_{t-1} = ln X_{t-1}, (P'_c) = ln $(P_c)_{t-1}$, $(P'_m)_{t-1}$ = In $(P_m)_{t-1}$, R'_t = ln R_t and β_o = In A we can rewrite equation (3.28) more compactly as equation (3.29) below:

(3.29) $$X'_t = \beta_0 + \beta_1 X'_{t-1} + \beta_2 (P'_c)_{t-1} + \beta_3 (P'_m)_{t-1} + \beta_4 R'_t + \beta_5 T + u_t$$

Since it is impossible to decide a priori what the most competing enterprise with cotton in any district is it is necessary to first of all run a regression with the prices of all the alternative crops to cotton as additional variables in the model (Msemakwelli, 1979). It is also possible to identify the most competing crop enterprise with a commodity for a given region by means of simple correlations (Askari and Cummings, 1974 and Singh *et. al.*, 1974).[20] The crop whose price is most negatively correlated with the current hectarage of that for which the supply response is being estimated is chosen for the next stage of analysis. The estimation of the simple correlation matrices of all the above variables constituted the first stage of our analysis. This procedure enabled us to test for multicollinearity at a later stage with ease.

The second stage of the analysis involved estimating the supply response models for cotton in each of the six districts in which it is traditionally grown in Central/Eastern Kenya. The estimating equation used in this case was equation (3.29). The third stage of the analysis involved estimating the price elasticities of supply for cotton from the results of the second stage for each of the six districts. From equation (3.29) above, the short run price elasticity of supply, η_s, for cotton was obtained as below:

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[20] Preliminary analysis also revealed that the use of the two procedures led to identical results.

(3.30) $$\eta_s = \beta_2$$

On the other hand, the long run price elasticity of supply, η_L, for cotton was obtained by dividing its estimated short run price elasticity of supply, η_s, with the estimated elasticity of adjustment, λ.[21] The procedure used is given below:

(3.31) $$\eta_L = \frac{\beta_2}{\lambda} = \frac{\beta_2}{(1-\beta_1)}$$

The fourth stage of the analysis, involved estimating the levels of seed cotton prices can elicit the cotton hectarage targeted for the 1992/93 crop season in Kitui District. This procedure can be represented by means of a simple flow diagram as below. In the diagram, N is the number of producer cotton prices calculated. From such an exercise it was possible to conclude whether the conscious manipulation of producer cotton prices could lead to the attainment of the 1992/93 targeted cotton hectarage for the district. The validity of our results with regard to seed cotton output rests on the assumption of stable cotton yields during the present plan period. On the one hand if cotton yields are declining then the targeted output levels will not

[21] It is obtained by subtracting the estimated β_1 from one.

be achieved while, on the other hand, if yield levels are rising then the targeted output levels will be surpassed. The attainment of the 1992/93 targeted cotton hectarage in the district is also contingent on the estimated supply responsiveness of cotton farmers for the region being static over the present plan period.

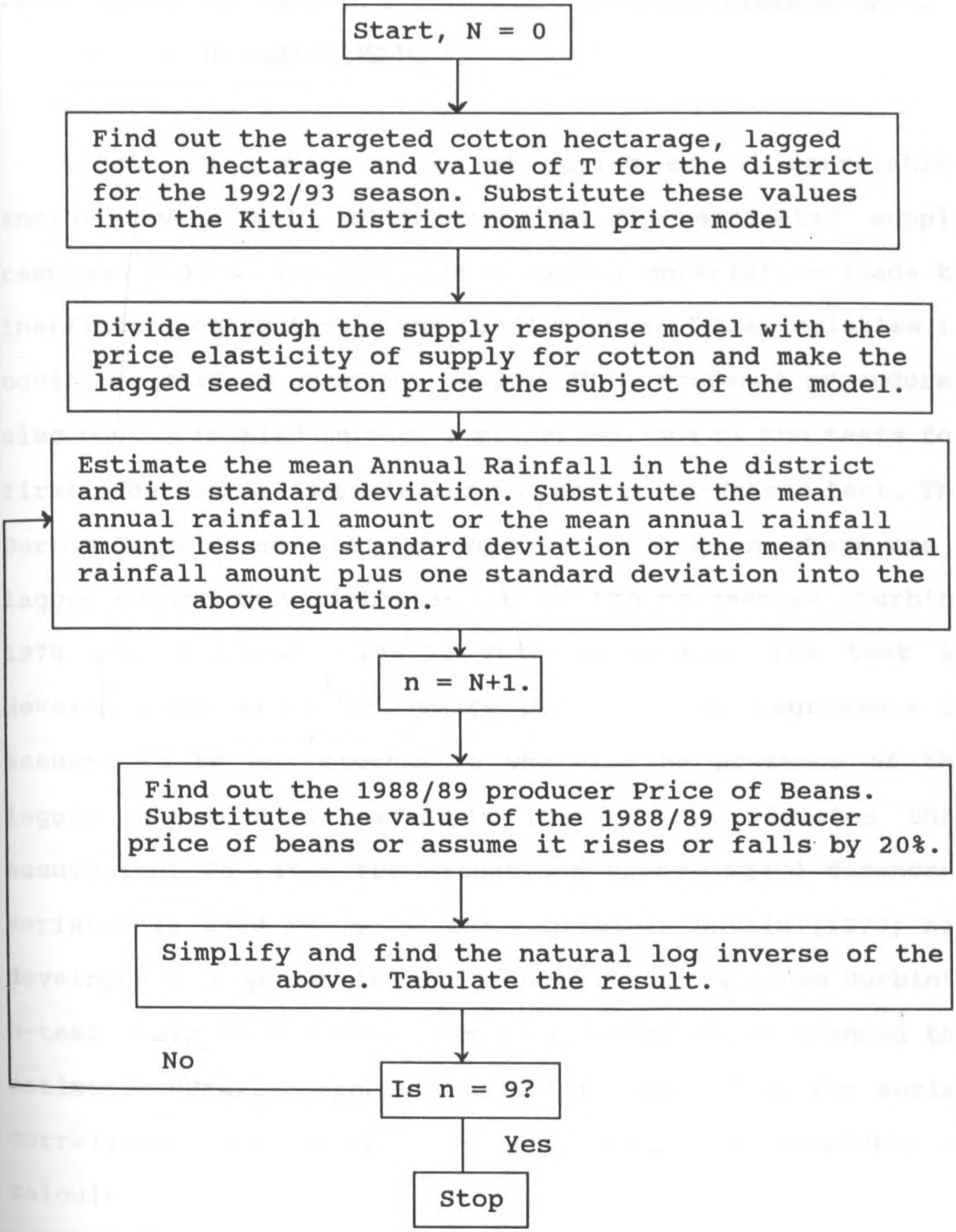

Fig 3.1: A Simple Flow Diagram of the Procedure used to Predict the prices of Seed Cotton that can lead to the attainment of the crop's 1992/93 targeted hectarage level for Kitui District.

3.3: Testing for Serial Correlation and Multicollinearity in the Estimated Models

There is a possibility of having serial correlation and/or severe multicollinearity in the estimated supply response models. The presence of serial correlation leads to inefficient estimates of the coefficients of the variables in equations such as equation (3.29). The inference procedures also become invalid in such a situation. One of the tests for first order serial correlation is the Durbin-Watson test. The Durbin-Watson test will not work in a situation where use a lagged dependent variable as one of the regressors (Durbin, 1970 and Griliches, 1967). This is because the test is developed for situations where the matrix of regressors is assumed to be non stochastic whereas the presence of the lagged dependent variable in that matrix violates that assumption. To cater for situations where lagged dependent variable is used as one of the regressors Durbin (1970) has developed a large sample test known with the acronym Durbin's h-test. Despite our small sample limitations we scanned the estimated supply response models for seed cotton for serial correlation with Durbin's h-test.[22] This test statistic is calculated as below:

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[22] Kenkel (1974) discusses the small sample properties of Durbin's h-test.

$$h = a\sqrt{\left(\frac{n}{[1-n\hat{V}(\beta_1)]}\right)} \sim AN(0,1) \qquad (3.32)$$

where n = sample size,

$\hat{V}(\beta_1)$ = estimated sampling variance of the coefficient of X_{t-1} in the OLS regression of equation (3.28), and

$$a = \frac{\sum_{t=1}^{n} e_t e_{t-1}}{\sum_{t=1}^{n} e_{t-1}^2} \approx 1 - \frac{1}{2}d \qquad (3.33)$$

Finally, d in equation (3.33) above is the Durbin-Watson statistic. Since h is asymptotically normally distributed, the hypothesis of non serial correlation is rejected if its absolute value is greater than 1.645 at the 5 per cent level of significance (Durbin, 1970).

To scan for multicollinearity, we used the simple correlation matrices of the variables. Klein (1977) states that "so long as the simple correlation, $r_{x,y}$, between two explanatory variables x and y is less than the multiple correlation, R, there is no serious collinearity between them". This rule of thumb was used to scan for multicollinearity in this study. For the purposes of better understanding the institutional framework within which farmers grow cotton, discussions were held with agricultural extension workers in the six districts.

3.4: Hypotheses Testing

Statistical procedures were used to test the hypotheses. The first hypothesis was tested by means of a one sided upper bound student's t-test. If the estimated β_2 in equation (3.29) above was statistically significant at 1% or 5% or 10% significance levels then the null hypothesis was rejected.

To test the second hypothesis, Chow test was used.[23] This test is made by means of an F-distributed random variable expressed as below:

$$(3.34) \qquad F_{(k,n_1+n_2+n_3+n_4+n_5+n_6-6K)} = \frac{(Q-Q_1)/K}{Q_1/(n_1+n_2+n_3+n_4+n_5+n_6-6K)}$$

where Q = the sum of the squares of residuals with the six data sets pooled,

Q_1 = the combined sum of squares of residuals from six separate regressions,

K = the number of parameters that were estimated,

[23] In this case we are testing whether the slopes and intercepts of the six regressions are the same (Johnston, 1984).

and n_1, n_2, n_3, n_4, n_5 and n_6 = the number of observations for each of the six regressions.

To carry out Chow test the regression was run for each district and the sum of squares of the residuals taken. The data sets were also pooled and the sum of squares of the residuals taken. If the coefficients of the regressions differ then the value $(Q-Q_1)$ is relatively large and the value of the F- statistic would exceed the critical value for the test (Chow, 1960 and Johnston, 1984). If this is so we would reject the hypothesis of the magnitude of the price elasticity of supply for cotton being the same among cotton farmers in Embu, Kirinyaga, Kitui, Machakos, Meru and Murang'a districts.

The third hypothesis was tested by means of a one sided upper bound student's t-test. If the estimated β in equation (3.26) above was positive and statistically significant at 1% or 5% or 10% significance level when we regressed annual seed cotton output on the trend variable then the null hypothesis was rejected for that district. Further, if the contributions of the districts for which it was rejected were more than those for the districts for which it was not rejected then we concluded that the recent decline in the region's annual cotton output could be part of a long term, fluctuating, upward trend.

3.5: Data Collection

The data used in this study were obtained from several official sources. Data on annual seed cotton output, annual cotton hectarage, producer cotton prices and prices of competing crop enterprises were obtained from two sources:

(a) Central and Eastern Provincial annual reports for the period 1960/61 to 1988/89, where the data stretched that far.

(b) District annual reports for Embu, Kirinyaga, Kitui, Machakos, Meru and Murang'a over the same period as in (a) above. The annual report of any administrative region, in our case the district or province, is compiled from the preceding twelve monthly reports for the region. It is thus meant to be a summary of the relevant activities, in our case agricultural, in the region for the preceding twelve months. This therefore implies that any errors made at the earlier stages of this process will be carried over into the subsequent ones. The final stage of this process involves the District Subject Matter Specialists (DSMS) coming together and compiling the district annual report from those of the divisions. At this stage, if it is felt that are some omissions or errors, the DSMS are meant to elicit more information from or verify the ones presented in the divisional annual reports with the Divisional Agricultural Extension Officers. The district annual report is, presently, required to be at the Provincial Director of Agriculture's office by 5th January of any year, in any case not later than 15th of the same month. It is from the district annual reports that the Provincial Subject Matter Specialists obtain the information they use to write the provincial annual report. The use of the two reports as sources of information was therefore to supplement one source with another. There were situations where one source was absent and the data used had to be obtained from the other. This procedure had one serious drawback, that of the two figures conflicting with one another. In such a case, the one in the district annual report was taken as accurate, since the provincial annual report is based on the former. The yield of cotton for any district for a given year was computed from the figures of annual seed cotton output and cotton hectarage obtained from the annual reports.

To ensure that the seed cotton prices obtained from the annual reports were realistic they were verified against the legislated producer cotton prices. To arrive at the average producer cotton price for a district for any year, the prices of AR and BR grades of seed cotton were weighted with their respective percentages, where these were available. The price (Kshs./Kg) of the competing crop enterprises were obtained by dividing the value (in K£) of the crop concerned with its output in any respective year. Some of the prices were reported in Kshs./Kg in the annual reports and such a conversion was unnecessary. It was not possible to include all the potential or actual competing crop enterprises with cotton in any one district due to paucity of data. Sweet potatoes, cassava and horticultural crops are obvious omissions in Murang'a District. The use of the price of only one of the products that can be obtained from an enterprise also biased our specification of the price of the most competing enterprise with cotton in any district. Examples of such crops are cow peas and pigeon peas.

Data on annual rainfall was obtained from the Data Bank of the Meteorological Services Department of the Ministry of Transport and Communications, Nairobi, while that of the Lower-Income Nairobi Consumer Price Index (LINCPI) was obtained from various issues of the "Statistical Abstract". Data on LINCPI did not stretch to the period prior to 1966. This led to loss in the degree of freedoms of the regression for some districts. The indexes were all converted to the January 1975 = 100 base. The annual rainfall amounts used in the analysis were for the rainfall stations that fell in the leading cotton producing regions in the districts; or where such areas had no rainfall recording station, any other station that falls in the cotton growing area was chosen. In some instances, some of the stations had been closed before 1989 and had to be replaced with other ones, while in a few cases we had to impute the values of rainfall amounts for some months for some stations. The data set used in this study is given in Tables A 3.4.1 to A 3.4.19 in the appendix, both tables inclusive. It is with the implicit data limitations, inherent in the data sources, in mind that the results of the study presented in the next chapter should be viewed.

CHAPTER FOUR:

EMPIRICAL RESULTS AND DISCUSSION:

4.1: The Estimated Means and Coefficients of Variation of Annual Seed Cotton Output, Cotton Yields, Producer Cotton Price and Annual Rainfall Amounts for the Six Districts

To complement regression analysis, we estimated the means and coefficients of variation of annual seed cotton output, cotton yields, producer cotton price and annual rainfall amounts. The sample size differed from district to district.[24] Due to heterogeneity of the crops competing with cotton for farm resources for the six districts, the means and coefficients of variation of the unit prices of these crops were not estimated. Table 4.1 below shows the means and coefficients of variation of these variables.

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[24] The period to which the statistics refer for each district are as below; a) Embu - 1963/64 to 1988/89 b) Kirinyaga - 1963/64 to 1988/89 c) Kitui - 1960/61 to 1988/89 d) Machakos - 1960/61 to 1988/89 e) Meru - 1964/65 to 1988/89 and f) Murang'a - 1964/65 to 1988/89.

4.1: The Means and Coefficients of Variation of Annual Seed Cotton Output, Cotton Yields, Producer Cotton Price and Annual Rainfall Amounts for the Six Districts

District	Yield (Kg/ha)		Hectarage		Output(tonnes)		Producer Cotton Price (Kshs./Kg)		Annual Rainfall(mm)	
	Mean	C.V(%)	Mean	C.V(%)	Mean	C.V(%)	Mean	C.V(%)	Mean	C.V(%)
Embu	234	65	2946	95	483	104	2.5	66	1129	26
Kirinyaga	426	64	1163	93	452	106	2.4	60	999	37
Kitui	162	66	7120	246	492	91	2.4	71	684	41
Machakos	200	46	11807	90	1988	100	2.3	71	770	35
Meru	482	74	8208	91	2744	84	2.7	57	1300	31
Murang'a	283	87	632	70	143	84	2.3	62	979	27

Source: Author's calculations

The table shows that the highest mean cotton yields were obtained by farmers in Meru District. Kirinyaga District's farmers closely followed Meru District ones in terms of mean cotton yields obtained. Kitui District's farmers realised the least mean yield levels. The most stable cotton yields were obtained by farmers in Machakos District while the least stable ones were obtained by those in Murang'a District. The variability in the yields of seed cotton is a reflection of variations in the time of planting cotton, incidence of pest infestation and the time of input acquisition between farmers in the six districts over the last two to three decades. The estimated mean yields of seed cotton are low in comparison to the recommended ones of no less than 1000 Kg/ha with good management practises. There is thus scope for an improvement of the mean cotton yields obtained by farmers in this region. The results of Barasa's study (1989) indicate that the problem of low mean annual seed cotton yields is also experienced by cotton farmers in Funyula Division, Busia District.

Farmers in Machakos District put the largest mean annual area under cotton during the period covered in the study area. The least mean area put annually under cotton over the last two to three decades was in Murang'a District. The most volatile annual area put under cotton for the same period was in Kitui District, while the least variations to the annual area of cotton was in Murang'a District. These variations reflect variations in the sizes of agricultural holdings in the six districts.

Meru District contributed the highest mean annual seed cotton output to that of the study area during the period 1964/1965 to 1988/1989. The least mean annual seed cotton output for the region was obtained in Murang'a District. The contribution of Kirinyaga District to the regional annual seed cotton output was least stable as indicated by the coefficient of variation of 106 of its annual seed cotton output. The contribution of Meru and Murang'a districts to the regional output were most stable. This is consistent with the closeness in the values of the coefficients of variation of the cotton yields and hectarages in the two districts.

Farmers in Meru District received the highest mean nominal producer cotton price in the region during the period 1964/1965 to 1988/1989. This implies that farmers in that district had a higher proportion of high quality (AR) seed cotton than lower quality (BR) seed cotton than those in the other districts over the period covered in the study. Farmers in Machakos and Murang'a districts received the lowest mean nominal producer cotton price during the period covered in the study. This low nominal producer price was largely due to the relatively higher proportion of BR seed cotton that was obtained by farmers in these districts. The most volatile producer cotton price was obtained by the cotton farmers in Kitui and Machakos districts while the most stable producer cotton price was accrued to the cotton farmers in Meru District. The stability in the nominal seed cotton price in Meru District implies that the proportion of seed cotton output that was of high quality was more stable in this district than in the other five districts. The stability of the proportion of high quality seed cotton output for any district is influenced by the changes that occur in the crop's factor and product markets in addition to those in the farmers' cultural practises. The three most important cultural practises which influence the proportion of AR cotton obtained by a farmer are early planting, early weeding and correct chemical pest control (Acland, 1971 and Brown *et. al*. 1972).

Mitunguu in Meru District recorded the highest mean annual rainfall for the region. The least mean annual rainfall for the region was recorded at Mwingi rainfall station in Kitui District. The most stable annual rainfall for the region was recorded in Embu District, at Siakago rainfall station. Mwingi station in Kitui District also had the most volatile annual rainfall amounts for the region. Cotton grows best in areas below 1400 metres in altitude and with a rainfall of 600 mm to 700 mm per annum. Variations to the upper extremes in mean annual rainfall amounts can lead to discolouration of the lint or reductions in yields. Rainfall much below this figure also cause yield reductions (Acland, 1971 and Brown *et. al*., 1972).

4.2: The Trend in Annual Seed Cotton Output, Yields, Hectarage and Producer Cotton Prices

Using OLS technique a trend line was fitted onto the data on annual seed cotton output, cotton yields, hectarage and the producer cotton prices for the last two to three decades. This was done for each district. The coefficients of the trend term for the above variables and the period for which the analysis was done for each district are presented in Table 4.2 below:

Table 4.2: The Trend in Seed Cotton Output, Yields, Hectarage and Producer Cotton Prices

		The trend coefficient of				
District	Period	Output	Yield	Hectarage	Nominal Price	Real Price
Embu	1963/64 to 1988/89	46.503 (4.476)***	-9.721 (-2.473)**	298.410 (6.046)**	0.205 (14.584)***	-0.002 (-0.213)
Kirinyaga	1963/64 to 1988/89	-18.183 (-1.389)	0.011 (1.678)*	-54.943 (-1.94)*	0.179 (14.737)***	-0.020 (-1.972)*
Kitui	1960/61 to 1988/89	21.785 (2.108)*	-5.943 (-2.467)**	323.429 (5.218)***	0.183 (12.271)***	0.001 (0.143)
Machakos	1960/61 to 1988/89	125.338 (3.051)***	-0.360 (-1.714)*	840.380 (4.406)***	0.166 (11.308)***	0.100 (5.497)***
Meru	1964/65 to 1988/89	175.506 (2.804)**	-27.328 (-3.562)***	855.783 (5.717)***	0.207 (18.848)***	-0.016 (-1.193)
Murang'a	1964/65 to 1988/89	-6.223 (-1.876)*	-16.849 (-2.560)**	6.410 (0.488)	0.178 (11.662)***	-0.001 (-1.027)

Source: Author's study

In table 4.2 above, the t-statistics are given in parentheses. The ones marked with asterisks are significant at the following significance levels;

*** - Significant at 5% significance level,

** - significant at 5% significance level and

* - Significant at 10% significance level.

Despite district wise variations in the trend term for the variables, some general conclusions can be made. During the period covered in the study, annual seed cotton output declined only in Kirinyaga and Murang'a districts. This decline was statistically significant in Murang'a District. The decline in annual seed cotton output from Murang'a District was occasioned by declining seed cotton yield levels since the area under cotton did not change significantly for the district for the last two to three decades. The annual output of seed cotton from Kirinyaga District did not fall significantly because of the improving cotton yields. The annual output of seed cotton from the rest of the six "cotton growing" districts increased significantly over the period covered in the study for each of them. The significant increase in annual seed cotton output from these districts was the result of a significant increase in the annual area farmers put under cotton in them. Cotton yields in these districts plummeted over the period covered in the study. Whereas it is not possible from the results of this study to identify the reason(s) for the declining cotton yields in Embu, Kitui, Machakos, Meru and Murang'a districts, tentative ones can be suggested. These are;

(i) Farmers' expanding cotton production into areas ill-suited to its cultivation:- This could be the consequence of a rapidly expanding human population.

(ii) Worsening nutrient status of the soils over time:- Cotton has a high nutrient requirement and hence continuous cultivation of crop on a piece of land will worsen the soil's nutrient status unless appropriate remedial measures are taken. Matovu (1979) found out that few farmers in two administrative locations in Machakos and Meru districts applied fertilizers on their cotton fields. Nyawira (1979) also found out that only a limited number of farmers covered in the Integrated Rural Survey in lower Kitui, Machakos and Mbere Division (Embu District) used chemical fertilizers.

(iii) Falling standards of cotton husbandry in Embu, Kitui, Machakos, Meru and Murang'a districts:- Infestation of cotton by its pests can cause the yields to decline significantly if not sprayed. Late planting of cotton, failure to thin the crop and not weeding the crop adequately have been reported in Machakos District by Matovu (1979). Acland (1971) pointed out that in Kenya there can often be a tenfold increase in cotton yield owing to a complete spraying programme and complete crop failure can occur due to lack of spraying.

(iv) Input costs rising faster than the price of seed cotton:- If input costs have risen more rapidly than the producer price of cotton over time then the economically optimal yield could have also declined. Delays in payment of the proceeds from the sale of seed cotton may also result in farmers discounting of the producer cotton prices and thereby lower the economically optimal yield level. Increasing inability for farmers to acquire inputs such as labour, seeds and pesticides may also lower the economically optimal yield.

Over the last two to three decades the nominal producer cotton price rose significantly in all the six districts. The real producer price, however, declined in Embu, Kirinyaga, Kitui, Meru and Murang'a districts over the same period. This decline was statistically significant only in Kirinyaga District. The significant decline in real producer cotton price in this district corresponded with decreasing area farmers put under cotton and decreasing annual output of seed cotton. In Machakos District, real producer cotton prices increased significantly over the last three decades. This was reflected in increasing levels of the area farmers put under cotton and increasing annual seed cotton output for the district for the same period.

The sluggish growth in annual seed cotton output for the region is partly attributable to the generally declining cotton yields for the "cotton growing" districts that comprise it. Viewed partially, farmers in Embu, Kitui and Meru districts reacted perversely to changes in real producer cotton prices by increasing their annual output of seed cotton and the crop's hectarage whilst these prices stagnated. In the same vein, cotton farmers in Kirinyaga and Murang'a districts appear to have reacted perversely to increases in nominal producer cotton prices by, respectively, decreasing and stagnating the area they put annually under cotton. The obtained perverse response to real producer prices may be the result of our not specifying the price that motivate producer behaviour well. As Nerlove (1979) points out, "the relevant prices motivating producer behaviour where markets are poorly organized or undeveloped may be difficult if not impossible to observe directly". This is the situation that prevails in most rural markets in the less developing countries. The task of estimating consumer price indices for rural areas is a daunting one. To reconcile the difference between our observations and traditional economic theory, the cost of living for farmers in Embu, Kitui and Meru districts must have risen less rapidly than that indicated by the Lower-Income Nairobi Consumer Price Index. The apparent disparity between farmer's response to increases in nominal producer cotton prices and economic theory in Kirinyaga and Murang'a districts may be due to farmers in those districts discounting the prices due to imperfections existing in the crop's factor and product markets in these districts. These issues are explored further in the next section.

4.3: The Estimated Supply Response Models and Price Elasticities of Supply for Seed Cotton

Using OLS estimation method the log-linear version of the Nerlovian Partial Adjustment model was fitted onto the data. The supply response models for each of the six districts can be written using the coefficients of the variables shown in Tables 4.3 and 4.4. The variables in the two tables are abbreviated as below:

X'_{t-1} = natural logarithm of the lagged cotton hectarage,

$(P'_c)_{t-1}$= natural logarithm of the lagged producer cotton price,

$(P'_m)_{t-1}$= natural logarithm of the lagged price of the most competing crop,

R'_t = natural logarithm of the current annual rainfall amounts,

and T = a trend variable taking values from 1 to 28 where the data is available from the 1960/61 crop season.

Table 4.3: Regression Results when Nominal Prices are used in the Analysis

Regression coefficient[a] of

District	Most Competi-ng Enterpr-ise	Constant	X'_{t-1}	$(P'_o)_{t-1}$	$(P'_m)_{t-1}$	R'_t	T	$\bar{R}^2$/h
Embu	Cowpeas	8.73	0.10	1.82	-0.05	-0.42	-0.25	0.78
		(2.34) **	(0.56)	(2.48) **	(-0.40)	(-0.84)	(-0.29)	0.72
Kirinyaga	Pigeon peas	-1.02	0.32	-0.58	-0.38	0.81	0.051	0.59
		(-0.43)	(2.83) **	(-0.77)	(2.17) **	(2.46) **	(0.66)	-0.61
Kitui	Beans	-2.36	0.67	1.91	-0.01	0.92	-0.14	0.84
		(-1.06)	(7.34) ***	(3.97) ***	(-0.08)	(3.02) ***	(-3.12) ***	-0.92
Machakos	Beans	0.04	0.70	0.92	-0.17	0.48	-0.05	0.92
		(0.02)	(11.97) ***	(1.99) **	(-2.15) **	(1.67) *	(-1.24)	0.25
Meru	Sorghum	3.84	0.14	1.04	0.04	0.37	0.02	0.80
		(1.43)	(1.41)	(1.55)	(0.42)	(1.11)	(0.25)	1.04
Murang'a	Sun-flower	4.11	0.64	0.05	0.10	-0.25	-0.01	0.29
		(1.12)	(3.14) ***	(0.06)	(0.67)	(-0.52)	(-0.19)	-32.43

[a] - The t-statistics are given in parentheses and the ones with asterisks below them are significant at the following significance levels:

* - Significant at 10% significance level,

** - Significant at 5%. significance level

and *** - Significant at 1%. significance level.

The above regression results indicate that lagged cotton hectarage significantly affected farmers' hectarage allocation decisions in Kirinyaga, Kitui, Machakos and Murang'a districts over the last two to three decades. Its significance indicates the presence of difficulties faced by farmers in these districts in adjusting the hectarage of cotton to some desired levels. This difficulty was least for Kirinyaga District among the above four districts. The size of the elasticity of adjustment[25] appears to be negatively related to the size of agricultural holdings in each district. The elasticity of adjustment is highest for Kirinyaga District and least for Machakos District. A possible explanation for this relationship is the labour intensive nature of the cotton crop. In Machakos District where the size of farm holdings is relatively large it is difficult for farmers to adjust their hectarage allocations to various crops to their long run or equilibrium levels. This is because as one farms on a more extensive basis with the same inputs one is more subject to adverse weather conditions during such critical operations as harvesting, planting and pesticide application (Just and Pope, 1978). Serious market imperfections in the market for seed cotton have previously been reported for Machakos District. These imperfections contribute to the delayed adjustments of cotton farmers in the district to changes in seed cotton price. This

[25] The time taken to attain 95% of adjustments to price changes can be calculated from the formula $(1-\lambda)^n = 0.05$ where n is the number of seasons and λ is the elasticity of adjustment (Jhala, 1979). Using the above formula the time, in seasons, taken to attain 95% of adjustments to price announcements in the six districts are 1.3 for Embu, 2.6 for Kirinyaga, 7.5 for Kitui, 8.4 for Machakos, 1.5 for Meru and 6.7 for Murang'a.

is the reason for the estimated elasticity of adjustment for this district being larger than for Kitui District. Variations in annual rainfall also affect the ability of farmers to adjust the hectarage under various crops to their long run or equilibrium levels. Farmers in Embu and Meru districts were faced with a relatively more stable rainfall regime thereby making it easier for them to adjust the hectarage of cotton to some desired hectarage level than the ones in Kitui, Kirinyaga, Machakos and Murang'a districts over the same period. Farmers in districts where annual rainfall amounts are unstable are more unwilling in the short run to substitute cotton for their staple crops than the ones where annual rainfall amounts are stable. Furthermore, the mean rainfall amounts for Embu and Meru districts are significantly higher than those for the other three districts. The mean annual rainfall amount for Kitui District was barely above the minimum needed for the growth of seed cotton. The adjustment difficulties in Murang'a District may also be due to a different reason. In Murang'a District variations in the yield of cotton are very large. Consequently, farmers find it hard to achieve some desired level of supply for the crop. The wild variations in cotton yields and low mean nominal producer cotton price thus militate against the efforts to improve the status of the crop in that district. Reduced yield variability is documented as one of the factors that increase the responsiveness of farmers to changes in the producer price of a given commodity (Nerlove, 1979).

The short run nominal price elasticity of supply for cotton is positive and statistically significant for Embu, Kitui and Machakos districts. The sign and significance of the short run price elasticity of supply for cotton for these districts are consistent with economic theory. The short run nominal price elasticity of supply for cotton is of the correct sign but insignificant for Meru and Murang'a districts. The low value of the short run price elasticity of supply for cotton for Murang'a District is partly attributable to the highly variable yield of cotton for the district. For Kirinyaga District the short run price elasticity of supply for cotton is not of the expected sign, but insignificant. In Kirinyaga and Murang'a districts cotton used to be marketed by cooperative societies for some time. These societies have been accused of overcharging on farm inputs and delaying to pay their members the proceeds from the sale of cotton thereby resulting in the Cotton Board taking over their functions recently. Essentially farmers in these districts have tended to discount the official seed cotton prices downwards. The short run price elasticity of supply for cotton was largest in Kitui District where farmers are paid cash on delivery of cotton at the buying centres.

It was only in Kirinyaga and Machakos districts that farmers' annual acreage allocations to cotton appeared to have been influenced by the variations in the nominal producer price of a competing crop. In the two districts, the nominal producer price of the competing crops have regression coefficients which have the expected sign and are statistically significant. The insignificance of the short run cross price elasticity of supply for cotton in the other four districts is not a conclusive evidence that farmers in these districts do not consider alternative crops to cotton in their acreage allocation decisions. Not all enterprises that compete for resources with cotton in a given district were considered in this study for the simple reason of lack of sufficient data on their producer prices. There were also situations where several products can be derived from one enterprise and not all these products were considered in our analysis. Taking the case of the cow peas plant, both its leaves and seeds are of economic value while in our analysis we only considered its seeds. The seeds of pigeon peas are also utilised when they are either green or dry while we only considered its dry seeds in our analysis. Lack of sufficient data relating to enterprises that compete with cotton for resources in this region implies the need for the development of a consistent and reliable data collection procedure among the staff of the agencies involved in the agricultural sector of the Kenyan economy.

Annual rainfall amounts significantly and positively influenced farmer's acreage allocation decisions in Kirinyaga, Kitui and Machakos districts over the last two to three decades. Farmers in these districts allocated more land to cotton as the annual rainfall amounts increased. This indicates that farmers in these districts preferred other enterprises to cotton during the periods when rainfall amounts are scanty. The results obtained for the three districts, with respect to the rainfall variable, are consistent with those of the studies conducted by Heyer (1967 and 1973) and Kennedy (1964). The results of those studies indicated that farmers prefer food crops to cash crops during periods when annual rainfall amounts are scanty. These results hold where commodity markets are not well developed (Oluoch-Kosura, 1978 and World Bank, 1981). Farmers tend to plant cotton late and practise poor crop husbandry when annual rainfall amounts are low for fear of being unable to meet their basic family food needs in such circumstances.

The trend term is negative and significant in Kitui District. This indicates, *inter alia*, the worsening of cotton growing technology and market infrastructure in the district over the last two to three decades. This is consistent with the declining annual seed cotton yield levels, seen earlier, in the district. Its insignificance in the other districts indicates that the supply shift variables have been more or less constant in those districts over the last two to thee decades.

The results of our analysis with real seed cotton prices are presented in Table 4.4 below.

Table 4.4: **<u>Regression Results when Real Prices are used in the Analysis</u>**

Regression coefficient[a] of

District	Most Competing Enterprise	Constant	X'_{t-1}	$(P'_c)_{t-1}$	$(P'_m)_{t-1}$	R'_t	T	$\bar{R}^2$/h
Embu	Cowpeas	4.31	0.22	3.75	-0.10	0.22	0.13	0.93
		(3.51) ***	(2.02) *	(6.49) ***	(-1.38)	(-1.56)	(5.85) ***	0.62
Kirinyaga	Pigeon Peas	1.16	0.23	-0.65	-0.37	0.76	-0.06	0.58
		(0.40)	(1.33)	(-0.96)	(-2.20) **	(2.19) **	(-2.30) **	-1.44
Kitui	Tobacco	-7.01	0.73	3.04	0.34	1.23	0.04	0.82
		(-2.85) ***	(6.32) ***	(2.71) **	(1.07)	(3.42) ***	(1.63)	-1.10
Machakos	Cowpeas	8.10	0.63	0.79	-0.10	-0.77	-0.09	0.66
		(2.24) **	(3.82) ***	(1.32)	(-0.46)	(-1.72) *	(-0.22)	-0.42
Meru	Millet	2.51	0.50	0.13	0.45	0.25	0.11	0.82
		(1.08)	(2.24) *	(0.30)	(2.50) *	(0.90)	(3.24) ***	-0.16
Murang'a	Pigeon Peas	7.77	0.29	1.60	-0.27	-0.58	0.02	0.30
		(2.43) **	(1.14)	(1.42)	(-1.59)	(-1.33)	(0.80)	....

Note: [a] - See Table 4.3 above.

The use of real producer prices leads to the lagged hectarage significantly explaining farmers' hectarage allocation decision to cotton in Embu, Kitui, Machakos and

Meru districts. The size of the estimated elasticity of adjustment[26] varies between the districts. It appears to vary inversely with the distance from Nairobi, whose Lower Income Consumer Price Index was used to deflate the nominal producer prices. Farmers in the more accessible districts were better able to adjust their hectarage combinations of various crops in response to changes in "real producer prices" than those in the more remote ones. The size of the elasticity of adjustment for Kitui and Machakos districts appear to be related to that of the coefficient of variation of annual rainfall amounts for the two districts. The risk of crop failure due to drought during any one season was greater for Kitui District than for Machakos District and thus the greater the elasticity of adjustment for the latter.

The short run "real price" elasticity of acreage response for cotton is positive and significant only in Embu and Kitui districts. It is only in Kirinyaga District that the short run "real price" elasticity of acreage response for cotton is not of the expected sign. The occurrence of mixed signs of the price elasticity of supply for a commodity for different regions is not uncommon in economic literature

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[26] Using the previous formula the time, in seasons, taken by farmers to attain 95% of the adjustments to changes in real producer cotton prices were calculated to be 2 for Embu District, 2 for Kirinyaga District, 9.4 for Kitui District, 6.6 for Machakos District, 3.4 for Meru District and 2.4 for Murang'a District.

(Jhala, 1979; Kere, 1986; Krishna, 1963 and Zaki, 1976). As we have argued before it is possible to obtain negative price elasticities of supply for a commodity when there are distortions in its product and factor markets. One of the interesting results of the analysis is the comparable magnitude of the short run price elasticity of supply for cotton for Embu and Kitui districts. Farmers in Kitui District were paid promptly for the seed cotton they delivered at the cotton buying centres. Cotton farmers in Embu District, though not paid promptly for seed cotton they delivered at the buying centres, were faced with a more certain rainfall regime. Farmers concern with uncertainty over variations in annual rainfall seemed to outweigh that for prompt payment in Kitui District. This is a logical reaction to a situation where crop failure due to drought is a major threat to farmers' subsistence. A possible logical step that farmers can take in the short run is to plant cotton later than the staple crops and to practise low standards of cotton husbandry. Farmers in the two districts are also more responsive to changes in "real prices" than to nominal ones. This means that small scale farmers in those districts are more concerned with changes in their standards of living than with changes in nominal producer prices. The insignificance of the "real price" elasticity of acreage response for cotton for the rest of the districts is not conclusive evidence that farmers in those districts react perversely to changes in "real" cotton prices. It is possible that the Consumer Price Index used to deflate the nominal producer prices did not accurately reflect the changes that have occurred in the standards of living of cotton farmers in the districts where the real price elasticity of supply was insignificant. It was not possible to develop a cost of inputs index or an index of the price of competing enterprises for the six districts. Our results would have, most likely, been different if we had deflated nominal producer prices with another index.

For real prices the short run cross price elasticity of hectarage response for cotton is significant only in Kirinyaga and Meru Districts. An examination of Tables 4.3 and 4.4 above also reveal that the most competing crop in any district is not necessarily stable when different sets of producer prices are used in correlation analysis. Deflation of the nominal prices with an index introduces the index's variations into those of the prices. The index used in our study was only available for a shorter period than our data set for Kitui, Machakos, Meru and Murang'a districts thereby leading to the instability of the most competing enterprises obtained for those districts in our study. Where the time framework was more or less the same the crop identified as most competing with cotton was stable when both sets of producer prices were used in the analysis. The instability of the most competing crops with cotton for Meru and Murang'a districts may also be a reflection of the poor quality of the data used in our analyses for both districts or misspecification of our estimated models. There is need for a critical evaluation of the prices used in any supply response study before basing policy prescriptions on the results of the study. If one could construct a cost of living index for a rural area, such as our study area, and use it to deflate the nominal producer prices then the policy measure(s) based on them would most likely lead to the intended effect(s). The construction of such an index, however, is a daunting task!.

The sign of the annual rainfall elasticity of supply for cotton obtained when we used "real prices" in our analysis is consistent with those for nominal prices for Kirinyaga and Kitui districts. For Embu and Machakos districts farmers allocated more land to cotton when annual rainfall amounts decreased. The results for Embu and Machakos districts, in this case, are inconsistent with the findings of Heyer (1973) that cotton did not represent much of an improvement over the traditional crops during periods of low rainfall amounts in Masii area of Machakos District. Our results are further complicated by the inconsistency in the sign of the rainfall elasticity of supply for cotton for Machakos District for both sets of prices. A possible cause of this inconsistency is the lower time framework, twenty two seasons instead of twenty eight seasons, that was covered in the study when we used "real prices" in our analysis. The mixture in the sign of the rainfall parameter between regions is not uncommon in economic literature (Jhala, 1979; Kere, 1986 and Krishna, 1963). This mixture in the sign of the rainfall parameter is due to differences in farmers' expectations of the annual rainfall amounts for any season, their crop preferences and attitude to the risk of the occurrence of drought.

The trend term is positive and significant in Embu and Meru districts. This implies that technological, institutional and other conditions have improved in these districts over the period covered in the study. The significance of the negative trend term for the Kirinyaga District real price model may mean that the cost of living of cotton farmers in that district have risen rapidly over the period covered in the study. The results also imply that the supporting infrastructure to cotton production and related institutions in Kirinyaga District have deteriorated during the period covered in this study.

The magnitude of the adjusted coefficient of determination of the estimated supply response models for seed cotton in Kirinyaga and Murang'a districts is comparatively lower than those developed for the rest of the six districts for both sets of prices. This means that the explanatory variables used in our analyses do not adequately explain the annual variations in cotton hectarage for the two districts. Possibly the estimated supply response models for cotton for these districts were misspecified.

The h-statistics presented in Tables 4.3 and 4.4 indicate that there is no serious serial correlation in our models except for the one for Murang'a District's seed cotton when nominal producer cotton price is used in the analysis. The problem of serial correlation in a model could be due to several sources, including model misspecification. When we introduce the yield of cotton lagged for one period as one of the explanatory variables[27] in the supply response model for cotton for that district, the problem is solved. This is consistent with the high coefficient of variation of the yield of cotton for this district over the last two to three decades, seen earlier. It was also impossible to calculate the h-statistic for the Murang'a District's cotton supply response model when we used real prices in the analysis.

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[27] In that case the nominal price supply response model for seed cotton in Murang'a District becomes:

$$X'_t = 1.291 + 0.589X'_{t-1} + 0.932(P'_c)_{t-1} + 0.085(P'_{sf})_{t-1}$$
$$(0.384) \quad (3.316)^{***} \quad (1.224) \quad (0.650)$$
$$+ 0.459Y'_{t-1} - 0.121R'_t - 0.065T$$
$$(2.465)^{**} \quad (-0.293) \quad (-0.979) \quad R^2 = 0.60, \; \bar{R}^2 = 0.46, \; h = 0.35,$$

$\eta_s = 0.932$, and $\eta_L = 2.27$; where Y'_{t-1} is the natural logarithm of the lagged cotton yield in the district and the rest of the variables are as in Tables 4.3 and 4.4 above.

There was an increase in serial correlation in the estimated supply response models for seed cotton in Kirinyaga, Kitui and Machakos districts when we used its real producer in the analysis. The increase in serial correlation in the estimated supply response models for cotton for these districts reflects the inadequacy of the changes in the Lower-Income Nairobi Consumer Price Index in reflecting changes in farmers' costs of living in those districts. For Embu and Meru districts there was a reduction in serial correlation.

The estimated supply response models were scanned for multicollinearity by means of Klein's rule of thumb. Multicollinearity was found not to be serious for most of the models. The simple correlation matrices of the variables used in the analysis are shown in Tables A 4.3.1 to A 4.3.6 in the appendix.

Based on the results in Tables 4.3 and 4.4 and using the procedure outlined in section 3.2.2, the short run and long run price elasticities of supply for cotton for the six districts were obtained. These are shown in Table 4.5 below:

Table 4.5: The Estimated Own Price Elasticities of Supply for Cotton[a]

District	Short Run Elasticity	Long Run Elasticity	R^2	$\bar{R}^2$	h
Embu	1.82 (3.75)	2.02 (4.82)	0.83 (0.94)	0.78 (0.93)	0.72 (0.62)
Kirinyaga	-0.58 (-0.65)	-0.85 (-0.84)	0.67 (0.68)	0.59 (0.58)	-0.61 (-1.44)
Kitui	1.91 (3.04)	5.79 (11.12)	0.87 (0.87)	0.84 (0.82)	-0.92 (-1.10)
Machakos	0.92 (0.79)	3.07 (2.19)	0.93 (0.74)	0.92 (0.66)	0.25 (-0.42)
Meru	1.04 (0.13)	1.21 (0.25)	0.85 (0.87)	0.80 (0.82)	1.04 (-0.16)
Murang'a	0.05 (1.60)	0.14 (2.25)	0.44 (0.47)	0.29 (0.30)	-32.43 (-)

[a] - The figures in parentheses were obtained when we used real prices in the model.

Source: Author's study

The short run nominal price elasticity of supply for cotton is greatest for farmers in Kitui District. This is reflective of farmers' being paid cash on delivery of seed cotton to the purchasing agents in this district. Our estimates of both sets of the price elasticities of supply for cotton are generally higher than those obtained by other workers such as Msemakwelli (1979), Nerlove (1956) and Zaki

(1976) on the supply response for cotton . The results of Msemakelli's study (1979) for Kenya's cotton are shown in Table 4.6 below for comparison purposes.

Table 4.6: Msemakwelli's Estimates of the Price Elasticities of Supply for Kenya's Cotton

Province	Price Elasticity of Supply Short Run	Long Run	R^2
Central Province	0.535	0.953	0.315
Coast Province	0.574	0.874	0.635
Nyanza Province	0.640	1.070	0.640
Western Province	0.489	0.664	0.520

Source: Msemakwelli (1979)

The values in Table 4.5 above are, however, comparable to the short run price elasticities (SREs) of supply of 1.73 to 2.26 and long run price elasticities (LREs) of supply of 3.05 to 4.67 obtained by Kwon and Uhm (1980) for Canadian Prairie rapeseed. Jhala (1979) also obtained a SRE of 0.60 and a LRE of 9.32 for groundnuts in Telangana, Andhra Pradesh in India. Using a similar model to the one used in this study, Zaki (1976) obtained a LRE of 1.79 for cotton farmers in Assiut, Egypt. Using an iterative procedure, Nerlove

(1956) estimated the price elasticity of acreage with the expected price of cotton for the United States of America to be 4.53.

Four reasons account for the differences between our results and those of previous workers on the supply responsiveness of cotton farmers. First this study was carried out at a smaller region than that at which Msemakwelli (1979) carried out his study. The price elasticity of supply for a commodity increases with decreasing size of regions for which it is estimated. This is one of the reasons why our estimates are larger than those of Msemakwelli. Secondly cotton has been grown for a comparatively shorter period in our study area than in the United States of America and Egypt. As the time span over which a crop is grown in a region increases the responsiveness of farmers to changes in the crop's price diminishes. Thirdly Msemakwelli's lagging of the producer cotton price in Coast, Nyanza and Western provinces was erroneous since these prices are announced prior to planting in the three provinces. Had he not lagged seed cotton prices he would have, most likely, obtained larger price elasticities of supply for cotton than he did. Lastly to the extent that farm sizes in different regions differ the price responsiveness of farmers also differ.

The estimated negative price elasticities of supply for cotton for Kirinyaga District is somewhat puzzling given that the nominal price of seed cotton for this region has been on the rise during the post-independence period. Analyses with sets of both prices, however, shows that the estimated negative price elasticities for the district are insignificant. The estimated trend in real seed cotton price for this district was significantly negative thereby indicating that farmers' cost of living rose rapidly in Kirinyaga District over the period covered in this study. It was learnt, during discussions with extension workers and Cotton Board Officials that there had been high incidence of delayed payments of seed cotton proceeds to farmers in Kirinyaga, Meru and Murang'a districts. This led to farmers' discounting of the nominal seed cotton prices. It is difficult to estimate the discounting factor used by these farmers. Theoretically, we can obtain the length of delayed payments of the proceeds from the sale of seed cotton to farmers through surveys. A relevant interest rate on capital would then be used to discount the nominal producer prices. It is not possible, however, to obtain this length of delay for several years. The Meru District data also appeared unreliable upon scrutiny. This affords some explanation for the insignificance of the estimated short run price elasticity of supply for cotton for this district. The significance of the short run price elasticity of supply for a commodity is also influenced by the importance of the commodity to a region's economy. In Meru District's cotton zone the crop is relatively more important than in, say, Kitui District.

4.4: Predicted Price Levels (Kshs./Kg) that can Elicit the 1992/93 Targeted Cotton Output/Acreage Levels for Kitui District

During the present plan period the national output of cotton is targeted to grow at the rate of 7.14% per year. It was only in Kitui District that the cotton output or acreage projections were made on a year by year basis among the six districts covered in the study. These projections, however, were unrealistic since almost twice of the 1992/93 target for the crop's area of 3831 hectares was achieved in the first year of plan implementation. It is also targeted that the cotton acreage (output) is to grow annually at the rate of 10% during the plan period. It is the latter target that enabled us to perform our calculations. If there is no shift in supply responsiveness and assuming the above growth rate is attained, the projected cotton hectarage for the 1991/92 and 1992/93 crop seasons are 11,866 and 13,052 respectively. The above projections are on the assumption that the cotton hectarage achieved for the district in the 1988/89 crop season was 8915. Table 4.7 below shows the nominal producer prices (in Kshs./Kg of seed cotton) that can elicit the 1992/93 targeted cotton hectarage for Kitui District, assuming various levels of the nominal price of its most competing enterprise (beans) and annual rainfall conditions. The prices in the cells were obtained using the procedure previously outlined in section 3.2.2.[28] Essentially the procedure involved substituting the values of the projected cotton hectarage for the 1991/92 and 1992/93 crop seasons, assumed values of the 1991/92 price of beans and different annual rainfall amounts into the estimated nominal price supply response model for cotton for the district and simplifying for the price of seed cotton. The nominal price supply response model for this district was used in this exercise because of its higher explanatory power and less serial correlation than the real price supply response model.

[28] We simplified for $(P'_c)_{t-1}$ and substituted assumed values of the other variables in the equation below;
$X'_t = -2.36 + 0.67X'_{t-1} + 1.91(P'_c)_{t-1} - 0.01(P'_B)_{t-1} + 0.92R'_t - 0.14T$. The natural log inverse of the estimated $(P'_c)_{t-1}$ was then obtained.

Table 4.7: **The Producer Cotton Prices (Kshs./Kg) that can Elicit the 1992/92 Targeted Cotton Hectarage for Kitui District.**

Annual Rainfall Amount (mm) received	Percentage Change in the 1988/89 Producer Price of Beans		
	-20	0	20
406.39	8.35	10.74	10.75
685.40	8.34	8.35	8.35
964.41	7.07	7.08	7.09

Source: Author's study

Our analysis reveals that the targeted annual growth rate of 10% for the cotton industry in Kitui District is not only feasible but can be modestly surpassed at the current AR and BR prices of Kshs. 10.00 and 5.00 per kilogramme respectively, provided there are average or above average annual rainfall amounts. If annual rainfall amount for the district fall one standard deviation or more below the its long term average it will be impossible to attain this target. To achieve that level of production under conditions of average or above average annual rainfall amounts farmers need to realise a AR seed cotton percentage of at least 51.4%. To achieve the target for cotton hectarage when the annual rainfall amounts are one standard deviation or more below its long term average, the 1991/92 seed cotton prices need to be raised to at least Kshs. 13.31 and Kshs. 6.66 per kilogramme of AR and BR respectively.[29] In comparison, the Import Parity Price of seed cotton for the 1991/92 crop season was estimated as Kshs. 13.02 per kilogramme of seed cotton.[30] The price of seed cotton is a weighted average of the prices of its AR and BR grades. Assuming farmers will achieve 70% of AR seed cotton and that the price of BR cotton is half that of BR seed cotton then their import parity prices for the 1991/92 crop season are Kshs. 15.32 and 7.66 respectively. It is therefore advisable to raise the price of the AR and BR grades of seed cotton to Kshs. 13.31 and 6.66 respectively when rainfall amounts are scanty. Annual rainfall variations of 40.71% induce a 28.66% change in the producer price necessary for farmers to be paid so as to attain the 1992/93 targeted level of seed cotton production

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[29] These figures were obtained by finding the prices of AR and BR grades of cotton that can yield Kshs.10.75. The price of BR cotton is normally half that of AR cotton. Further, it was assumed that farmers can obtain a AR percentage of 70%.

[30] The steps used to arrive at the Import Parity Price for seed cotton are outlined in Appendix A 4.4. It was calculated from the average price of Index A Outlook for the first four months of the 1991/92 crop season. The exchange rate used in the calculation was the average of the daily exchange rate quoted by the Central Bank of Kenya for the first four months of the 1991/92 crop season. These assumptions were considered realistic since the value of the Kenya Shilling as compared to the US dollar is declining. The decline in the value of the Kenyan Shilling is likely to be offset by the declining trend of the value of cotton lint in the world market.

for the district. There is thus need to find means of stabilising cotton yield and hectarage variations due to changes in annual rainfall amounts. On the basis of the above, seed cotton prices need to be reviewed upward by at least 33.1% in early 1992 if the targeted cotton hectarage for the district for the 1992/93 crop season is to be achieved under conditions of low rainfall amounts. The present situation where the national seed cotton output targets are seldom disaggregated to the district level needs to be corrected. This can ensure that the ones charged with plan implementation at the district level are aware of their place in the realisation of national goals and objectives.

4.5: The Results of Hypotheses Testing

The results in subsection 4.3 indicate that farmers in Embu, Kitui and Machakos districts do not react perversely to increases in the nominal producer cotton prices. Farmers in Embu and Kitui districts have also been shown to respond rationally to changes in the real producer cotton prices. For the other districts, the regression results were inconclusive. The results of trend analysis, however, indicate that farmers in Embu, Kitui, Machakos and Meru did not react perversely to changes in the nominal producer cotton prices. It was only farmers in Kirinyaga, Machakos and Murang'a districts who did not react perversely to changes in for the district. There is thus need to find means of stabilising cotton yield and hectarage variations due to changes in annual rainfall amounts. On the basis of the above, seed cotton prices need to be reviewed upward by at least 33.1% in early 1992 if the targeted cotton hectarage for the district for the 1992/93 crop season is to be achieved under conditions of low rainfall amounts. The present situation where the national seed cotton output targets are seldom disaggregated to the district level needs to be corrected. This can ensure that the ones charged with plan implementation at the district level are aware of their place in the realisation of national goals and objectives.

4.5: The Results of Hypotheses Testing

The results in subsection 4.3 indicate that farmers in Embu, Kitui and Machakos districts do not react perversely to increases in the nominal producer cotton prices. Farmers in Embu and Kitui districts have also been shown to respond rationally to changes in the real producer cotton prices. For the other districts, the regression results were inconclusive. The results of trend analysis, however, indicate that farmers in Embu, Kitui, Machakos and Meru did not react perversely to changes in the nominal producer cotton prices. It was only farmers in Kirinyaga, Machakos and Murang'a districts who did not react perversely to changes in the real producer cotton prices. The results of testing this hypothesis is therefore inconclusive for farmers in Kirinyaga, Machakos, Meru and Murang'a districts. The inconclusiveness of our results for these districts may be due to our estimated models being misspecified with regard to its functional form and included variables. Due to that possibility, as exemplified by the nominal price supply response model for cotton for Murang'a District, it is considered possible to increase the rate of increase of annual seed cotton output in Kenya through the pricing mechanism. The inconclusiveness of our results for the four districts could also be a reflection of the poor quality of the data for those districts. For Embu and Kitui districts greater area could have been put under cotton if the nominal price of seed cotton had risen faster than it did during the last two to three decades. This would have helped in achieving the regional target(s) of seed cotton output, other things constant over the same period.

To carry out Chow test for the second hypothesis the data on annual cotton hectarage, lagged annual cotton hectarage, lagged producer cotton prices, annual rainfall amounts and a trend variable were pooled for the six districts. Due to the non uniformity of the most competing crop with cotton between the six districts, its price was ommitted in the regressions used to carry out the test. This therefore meant that only four variables, instead of five, were used to test the second hypothesis. This was considered reasonable since, Chow test also captures differences in competing crops between regions. The results of the test between the six districts are given below:

(a) Using nominal producer cotton price:

From the procedure previously outlined we obtained the following:

$Q = 83.85357, \qquad Q_1 = 39.896943$

$n_1 = 25, \quad n_2 = 25, \quad n_3 = 27, \quad n_4 = 28, \quad n_5 = 23, \quad n_6 = 24$

and $K = 5$

$$\therefore F_{(5,122)} = \frac{(83.8536 - 39.8969)/5}{39.8969/122} \simeq 26.883$$

Since the tabulated $F_{0.99\,(5,100)} = 6.90$, we reject the second null hypothesis in favour of its alternative hypothesis: " That the responsiveness of cotton farmers to price changes is not the same in magnitude among the six districts covered".

(b) Using real producer cotton price.

From the above procedure we obtained

$Q = 62.97595$, $Q_1 = 32.72457$, $n_1 = n_2 = n_3 = n_4 = n_5 = n_6 = 22$

and $K=5$.

$$\therefore F_{(5,102)} = \frac{(62.9760 - 32.7246)/5}{32.7245/102} \simeq 18.858$$

Since the tabulated $F_{0.99\,(5,100)} = 6.90$ and the calculated $F_{(5,102)}$ is larger than the former, we reject the second null hypothesis, at a significance level of 1%, in favour of the alternative hypothesis: "That the responsiveness of cotton farmers to price changes is not the same in magnitude among the districts covered in the study". We see from the results of Chow test that seed cotton farmers' responsiveness to price changes is not the same among the six districts covered by the study. There is thus some scope for district specific pricing of seed cotton.

The trend term for annual seed cotton output was significantly positive for Embu, Kitui, Machakos and Meru districts thereby leading to our rejection of the third hypothesis. These districts contribute more to regional annual seed cotton output than Kirinyaga and Murang'a districts for which there was a decline. Further more, the decline in annual seed cotton output for Kirinyaga and Murang'a districts was less than its increase for the rest of the "cotton growing" districts in the region. The recent decline in annual seed cotton output from the region can therefore be considered to have been part of a long term, fluctuating, upward trend.

CHAPTER FIVE:

SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

5.1: Summary and Conclusions

During the last two to three decades, the Kenyan cotton industry witnessed a sluggish growth in annual seed cotton output and perennial failure to attain its targeted levels. Efforts to improve the industry during this period included the launching of the Integrated Agricultural Development Programme, implementation of the Cotton Processing and Marketing Project and the enacting of the 1986 Cotton Bill to become the Cotton Act, 1989. These efforts produced little or no success. The broad objective of this study was therefore to identify the reason(s) for this sluggish growth in the annual seed cotton output and failure to attain the targeted seed cotton production levels in the country, with a special reference to Central/Eastern Kenya.

The means and coefficients of variation of the annual hectarage of cotton, annual cotton output, nominal seed cotton producer price, cotton yields and annual rainfall amounts were calculated for the six districts covered in the study. The mean annual cotton output for the six districts varied between 162 Kg/Ha for Kitui District and 482 Kg/Ha for Meru District. During the last two to three decades, the area devoted to the cultivation of cotton for the six districts varied between 632 Ha per year for Murang'a District and 11807 Ha per year for Machakos District. Over the period covered in the study, Meru contributed the highest mean annual seed cotton output (2744 tonnes) to the regional seed cotton output while the least mean annual seed cotton output (143 tonnes) for the region was derived from Murang'a District. The least nominal producer cotton price[31] (Kshs. 2.3 per Kg per year) experienced in the region accrued to cotton farmers in Machakos and Murang'a districts. Farmers in Meru District, on the other hand, received the highest nominal producer cotton price (Kshs. 2.7 per Kg per year) over the period covered in this study. For the region, the least mean annual rainfall (685.4 mm) was recorded at Mwingi Divisional Headquarters in Kitui District while the highest mean annual rainfall (1300 mm) was recorded at Mitunguu in Meru District. From the calculated mean cotton yields for the six districts it is seen that there exists considerable scope for increasing the annual output of seed cotton for the region, and the country through improved yields of the crop.

The trend in annual cotton output, cotton yields, annual hectarage of cotton and nominal and real producer cotton

[31] To the extent that the percentage of cotton of grade AR obtained by farmers varies between the districts, the nominal producer seed cotton price also varies. The legislated prices do not vary between districts, however.

prices for the six districts were also examined in the study. The results of trend analysis indicated that over the period covered in the study:

(i) Annual seed cotton output rose significantly for Embu, Kitui, Machakos and Meru districts. This rise was most rapid for Meru District and least rapid for Kitui District. For Kirinyaga and Murang'a districts, annual seed cotton output declined. The rate of decline in annual seed cotton output was more significant for Murang'a District than for Kirinyaga District.

(ii) The yield of cotton declined for Embu, Kitui, Machakos, Meru and Murang'a districts. The decline in yield was most rapid for Meru District and least rapid for Machakos District. Cotton yields improved slightly in Kirinyaga District.

(iii) The area of land devoted annually to the cultivation of cotton rose significantly for Embu, Kitui, Machakos and Meru districts. The increase in annual cotton hectarage was most rapid for Meru District and least rapid for Embu district. The area devoted annually to the cultivation of cotton did not change significantly in Murang'a District while it declined significantly for Kirinyaga District.

(iv) The average nominal producer cotton price increased significantly over the period covered in the study for all the six districts. The increase in the average nominal producer cotton price was most rapid for Meru District and least rapid for Machakos District and

(v) The real producer cotton price[32] was more or less static for Embu, Kitui, Meru and Murang'a districts. For farmers in Kirinyaga District it declined significantly while for farmers in Machakos District it rose significantly.

The results of trend analysis thus indicate that, *ceteris paribus*, farmers in Embu, Kitui, Machakos and Meru districts did not react perversely to fluctuations in the nominal producer cotton price. If we are to go by the above, it is only farmers in Kirinyaga, Machakos and Murang'a districts who did not react perversely to changes in the real producer cotton price. The inconclusiveness of our results is due to the difficulty in modelling the prices which motivate producer behaviour in developing countries.

At the statistical levels of significance of 1%, 5% and 10% used in our supply response analysis for cotton, farmers in Embu, Kitui and Machakos districts responded positively to increases in the nominal producer cotton prices. The

[32] Real producer cotton prices used in our analysis were constructed by deflating the nominal producer prices by the Lower-Income Nairobi Consumer Price Index.

reactions of farmers in Meru and Murang'a districts were positive but insignificant. When the analysis was done with real prices it was found out that only farmers in Embu and Kitui districts reacted significantly positively to the price increases. Farmers in Machakos, Meru and Murang'a districts reacted positively but insignificantly to increases in real producer cotton price. Those in Kirinyaga District reacted negatively but insignificantly to increases in the real producer cotton price. The estimated price elasticities of supply for cotton were seen to be generally higher than the previous estimates made at the provincial level by Msemakwelli (1979). This was logical since individual farmers have greater scope for change than an aggregate of farmers (Nerlove, 1956 and 1979). The estimated short run price elasticity of supply for cotton was greatest for farmers in Kitui District when we used nominal producer prices. This was considered reflective of farmers being paid most promptly in the region for seed cotton delivered to the buying agents. The estimated short run nominal price elasticity of supply for the crop was least for Murang'a District. Since the model used to estimate this short run nominal price elasticity of supply was serially correlated our inferences based on it are invalid. The low level of the estimated short run nominal price elasticity of supply for cotton for Murang'a District is also reflective of farmers being concerned about the highly unstable yields of cotton that face them in this district.

When we used nominal producer prices to estimate farmers' response to price changes, annual rainfall amounts were seen to significantly influence annual cotton hectarage allocation decisions for Kitui, Kirinyaga and Machakos Districts. It was for Embu, Meru and Murang'a districts that farmers' annual hectarage allocation decisions were not significantly influenced by annual rainfall amounts when we used real producer cotton prices in our analysis. The results obtained for nominal producer prices suggest that farmers in Kirinyaga, Kitui, Machakos and Meru districts do not regard cotton as a security crop against crop failure during years of scanty annual rainfall amounts. The results of the analysis for real producer prices also indicate that farmers in Kirinyaga, Kitui and Meru districts do not regard cotton as a "security crop" against crop failure during conditions of drought. The instability in the sign of the annual rainfall amounts elasticity of supply for cotton for Machakos District is the result of the different time frameworks used in our analyses. Annual rainfall amounts for Kirinyaga, Kitui, Machakos and Meru districts were relatively unstable compared to the other three districts over the period covered in the study. The prices of foodstuffs can rise too high during famines in such areas and hence the staple crops being preferred to cotton when there are indications of a drought. Farmers' concern during any year, therefore, would be to ensure that their basic food needs are met before they grow other crops such as cotton. It is also possible for farmers to profit from the sale of surplus production of food crops in a situation of crop failure in other parts of a region. Our results lend credence to the observations by Kennedy (1964) and Heyer (1967), respectively, that cotton was planted later than food crops in Coast and Nyanza Provinces and that it did not represent much of an improvement over the traditional crops grown in Masii area of Machakos District during years of low rainfall amounts. Oluoch-Kosura (1978) found similar results for tea farmers. The results hold where the markets are not well developed (Oluoch-Kosura, 1978 and World Bank, 1981).

The price responsiveness of cotton farmers in Embu, Kirinyaga, Kitui, Machakos, Meru and Murang'a districts was shown not to be the same among them by means of Chow test. This difference reflects differences in soils, microclimates, competing crops, technical know-how, transport and communication network and input costs facing farmers in the six districts.

From the foregoing we concluded that the main reason for the sluggish growth of the annual seed cotton output and failure to achieve its targeted levels in the region over the last two to three decades was declining cotton yields. The slight upward trend in annual seed cotton output for our study area was the result of farmers expanding the area devoted to the cultivation of cotton for Embu, Kitui, Machakos and Meru districts.

5.2: Policy Implications

The results of this study have several policy implications. First, the low and declining yields of cotton for Embu, Kitui, Machakos, Meru and Murang'a districts indicate that there exists considerable scope for increasing annual seed cotton output for the region through improved cotton yields. There is need to make the agronomic recommendations more available to bridge the gap between cotton yields obtained by farmers and the ones obtained in research stations. The reason(s) for the wide gap between the yields obtained by farmers and those obtained in research stations need(s) to be identified and comprehensive solution(s) provided. The reason(s) for the decline in cotton yields for Embu, Kitui, Machakos, Meru and Murang'a districts need(s) to be identified and solution(s) provided as well. Efforts to improve the annual output of cotton in this country should therefore be mainly directed at improving the low cotton yields prevailing in the industry. However, no single policy alone can lead to greater growth in the country's cotton industry.

Second, the estimated price elasticities of supply for cotton indicate that there is some scope for using the pricing mechanism to increase the annual supply of seed cotton in this country. If the policy objective is to ensure self-sufficiency in seed cotton, its prices have to be reviewed from time to time, in line with the growth in demand for cotton lint and input costs. The recent increase of the producer cotton prices should go a long way towards ensuring self-sufficiency in cotton lint. However, there is need to raise the current producer cotton prices for Kitui District by at least 33.1% if the 1992/93 seed cotton targets are to be achieved when the annual rainfall amount received decrease by at least 40.1% from its long run average. It is advisable to do so since the estimated 1991/92 import parity prices of AR and BR seed cotton are Kshs. 15.32 per Kg and Kshs. 7.66 per Kg respectively.

Third, it is seen that there is scope for increasing seed cotton output through the practising of the policy of price discrimination. Cotton farmers with relatively low price elasticities of supply for cotton could be paid lower prices than those with higher price elasticities of supply for the crop. In the short run, the recent 67% increase in seed cotton prices would lead to an increase in cotton hectarage in the order of 122%, 128%, 63% and 70% in Embu, Kitui, Machakos and Meru districts respectively, *ceteris paribus*. The long run effect is greater. The focal point of the "District Focus for Rural Development Strategy" is the district and for this reason it is recommended that seed cotton pricing could be district specific. The producer cotton prices in the districts could be based on the respective price elasticities of supply for cotton and the ginning capacities of the existing or planned ginneries in the districts.[33] Such a policy would be untenable, to some persons, on political or social grounds. Such opposition needs to be examined critically, however. It is also necessary that the problem of lack of adequate planning at the district level be corrected. It is hoped that the establishment of Data Documentation Centres, as reported recently, at the district level will go a long way towards providing consistent and reliable (accurate) data for planning. It is sad to note that the data on growth targets was only available for Kitui District. It was not clear how the current District Development Plans relate to the National Development Plan. This disparity implies the need for strengthening planning at the district level.

[33] This kind of pricing mechanism is only feasible where the differences between the prices in the districts does not make arbitrage possible.

Lastly, it is necessary that the marketing system for seed cotton be streamlined in the region and in the country as a whole. The present distortions in the crop's factor and product markets lead to farmers discounting the nominal producer cotton prices. Since cotton farmers are generally price responsive, it is possible to leave the marketing of seed cotton to the private sector. In particular, seed cotton prices need not be set by the Government as is presently the case. If price control is to remain then the prices set should reflect the import parity ones. It was observed that the highest long run price elasticity of supply for cotton was obtained for Kitui District, where farmers are paid promptly by a private entrepreneur for cotton they delivered to the buying agents. The first step in liberalising the sub sector would be to sell the ginneries presently owned by the Cotton Board and cooperative societies to individual entrepreneurs. The performance of the ginneries owned by cooperative societies and the Cotton Board have been dismal thereby not encouraging greater response to changes in the producer nominal seed cotton prices in their catchment areas. The policy advocated would leave the Cotton Board largely with regulatory roles. The Government should concentrate its efforts on the provision of the necessary infrastructure such as transport, agricultural credit and extension services which facilitate the production and marketing of seed cotton in the Republic.

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APPENDICES

Appendix A 1.1: Annual Cotton Production between the Provinces

Table A 1.1 : Seed Cotton Production by Province 1965-1988

Province/ Year	Western	Nyanza	Coast	Central/ Eastern	Rift Valley	TOTAL Production (Tonnes)	Lint(Bales)	%Contribution of Central/Eastern Kenya to National Output
1965/66	3,282	2,732	3,779	3,562	-	13,555	23,430	26.67
1966/67	5,570	4,517	2,866	1,678	-	14,631	23,915	11.47
1967/68	3,480	3,721	1,645	2,593	-	11,439	20,072	22.67
1968/69	5,152	1,856	1,381	4,839	-	13,228	23,029	36.58
1969/70	4,994	2,719	1,901	6,248	-	15,862	27,752	39.39
1970/71	7,707	3,751	2,896	2,875	-	17,229	30,228	16.69
1971/72	7,242	3,296	4,244	1,758	-	16,540	29,017	10.63
1972/73	5,921	3,317	4,763	3,217	-	17,218	30,210	18.68
1973/74	6,926	1,687	3,254	4,317	-	16,184	28,892	26.27
1974/75	7,289	2,130	3,062	3,789	-	16,270	25,544	23.29
1975/76	8,576	3,649	3,907	2,332	-	18,464	31,533	12.63
1976/77	10,534	2,714	4,050	6,497	-	23,795	34,747	27.30
1977/78	6,969	6,028	3,253	9,834	-	26,084	46,867	37.70
1978/79	8,577	6,978	2,929	17,082	-	35,566	62,179	48.03
1979/80	9,413	7,075	2,849	9,875	-	29,212	51,250	33.80
1980/81	5,940	7,776	4,366	8,710	-	26,792	46,987	32.51
1981/82	5,782	6,373	4,890	7,043	-	24,088	42,557	29.24
1982/83	2,661	5,246	3,888	11,735	-	23,530	42,053	49.87
1983/84	4,711	4,733	7,703	11,880	-	29,027	49,424	40.93
1984/85	3,392	3,719	8,947	23,201	22	39,281	70,147	59.06
1985/86	3,459	5,914	9,814	7,381	862	27,430	49,052	26.91
1986/87	3,388	2,899	8,512	4,619	166	19,584	36,261	23.59
1987/88	1,956	1,341	11,089	3,093	159	17,638	30,602	17.54

Source : Cotton Board of Kenya (1986), Statistical Abstracts (various) and Economic Survey of Kenya 1990.

Appendix A 3.4; The Data Set Used in the Analysis

Table A 3.4.1 : Cotton Hectarage Production, Average Producer Price and Yield for Embu District.

Season	Output(Tonnes)	Hectarage	Average Producer Price (Kshs./Kg)	Yield (Kg/Ha)
1963/64	6.349	30.77	0.96	206.34
1964/65	86.354	418.51	0.87	206.34
1965/66	39.461	121.46	0.79	324.89
1966/67	42.686	769.23	0.68	55.49
1967/68	49.882	101.21	0.90	492.86
1968/69	112.315	245.00	1.03	458.43
1969/70	566.612	900	0.80	629.57
1970/71	193.907	455	1.01	426.17
1971/72	99.192	534.75	1.05	185.49
1972/73	232.105	602	1.14	385.56
1973/74	177.506	837	1.11	212.07
1974/75	196.799	478.2	1.32	410.65
1975/76	107.373	1535.7	1.66	69.92
1976/77	572.989	2930	2.23	195.56
1977/78	957.553	4000	2.80	239.39
1978/79	65.700	4605	3.41	14.27
1979/80	629.822	6562	3.25	95.98
1980/81	734.485	6038	3.42	121.64
1981/82	696.203	6224	3.51	111.86
1982/83	1059.944	6400	4.10	165.62
1983/84	398.436	6400	4.50	62.26
1984/85	2000	10000	4.37	200.00
1985/86	1400.00	5000	4.90	280.00
1986/87	431	3000	4.66	143.67
1987/88	478	3200	5.22	149.38
1988/89	1214.356	5200	5.34	233.53

Source 1. Ministry of Agriculture, Embu District Annual Reports for 1964 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports for 1964 to 1989.

Appendix A 3.4; The Data Set Used in the Analysis

Table A 3.4.1 : Cotton Hectarage Production, Average Producer Price and Yield for Embu District.

Season	Output(Tonnes)	Hectarage	Average Producer Price (Kshs./Kg)	Yield (Kg/Ha)
1963/64	6.349	30.77	0.96	206.34
1964/65	86.354	418.51	0.87	206.34
1965/66	39.461	121.46	0.79	324.89
1966/67	42.686	769.23	0.68	55.49
1967/68	49.882	101.21	0.90	492.86
1968/69	112.315	245.00	1.03	458.43
1969/70	566.612	900	0.80	629.57
1970/71	193.907	455	1.01	426.17
1971/72	99.192	534.75	1.05	185.49
1972/73	232.105	602	1.14	385.56
1973/74	177.506	837	1.11	212.07
1974/75	196.799	478.2	1.32	410.65
1975/76	107.373	1535.7	1.66	69.92
1976/77	572.989	2930	2.23	195.56
1977/78	957.553	4000	2.80	239.39
1978/79	65.700	4605	3.41	14.27
1979/80	629.822	6562	3.25	95.98
1980/81	734.485	6038	3.42	121.64
1981/82	696.203	6224	3.51	111.86
1982/83	1059.944	6400	4.10	165.62
1983/84	398.436	6400	4.50	62.26
1984/85	2000	10000	4.37	200.00
1985/86	1400.00	5000	4.90	280.00
1986/87	431	3000	4.66	143.67
1987/88	478	3200	5.22	149.38
1988/89	1214.356	5200	5.34	233.53

Source 1. Ministry of Agriculture, Embu District Annual Reports for 1964 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports for 1964 to 1989.

Table A 3.4.2 : Average Producer Price (Kshs./Kg) of Enterprises Competing with Cotton in Embu District.

Season	Maize	Bulrush Millet	Sorghum	Cow peas	Mixed Beans	Sunflower	Tobacco	Pigeon Peas
1963/64	0.30	0.23	0.13	0.29	0.45	0.50	3.03	0.67
1964/65	0.25	0.22	0.13	0.27	0.45	0.52	3.36	0.45
1965/66	0.30	0.35	0.19	0.35	0.40	0.52	3.52	0.50
1966/67	0.20	0.38	0.31	0.39	0.31	0.53	0.33	0.61
1967/68	0.31	0.40	0.20	0.42	0.26	0.49	3.70	0.97
1968/69	0.24	0.32	0.13	0.35	0.34	0.36	3.95	2.11
1969/70	0.38	0.28	0.39	0.66	0.34	0.40	4.05	0.42
1970/71	0.60	1.11	1.00	1.33	0.60	0.40	3.43	1.10
1971/72	0.39	1.09	1.10	0.80	0.80	0.45	3.46	0.72
1972/73	0.24	0.37	0.24	0.36	0.56	0.63	4.13	0.97
1973/74	0.54	0.45	0.61	1.00	1.04	1.18	5.45	1.19
1974/75	0.67	0.89	0.47	1.60	1.54	1.14	6.72	2.00
1975/76	0.78	1.89	0.62	2.00	2.64	1.45	10.01	3.07
1976/77	0.65	0.39	0.30	1.60	1.29	2.18	5.87	1.20
1977/78	1.33	1.43	0.33	0.04	12.87	1.60	7.80	1.20
1978/79	0.79	8.17	0.33	0.04	12.87	1.40	16.67	1.20
1979/80	1.14	1.59	0.33	0.04	2.22	1.80	2.66	2.00
1980/81	10.00	1.00	1.00	3.33	3.67	1.80	5.20	3.33
1981/82	1.33	1.00	0.99	3.33	1.67	1.80	6.78	3.33
1982/83	1.44	1.00	1.00	1.33	1.67	2.00	11.02	2.22
1983/84	1.44	1.00	1.80	4.00	4.00	2.13	15.26	6.00
1984/85	1.95	1.10	1.40	1.80	4.32	3.50	13.59	4.50
1985/86	2.52	1.60	1.40	3.00	4.90	3.07	14.00	4.50
1986/87	3.00	1.80	1.40	3.00	4.90	2.87	14.00	6.50
1987/88	3.00	1.80	1.40	2.99	5.10	3.07	14.00	4.50
1988/89	3.00	1.26	1.40	2.57	5.39	3.07	14.03	4.50

Source: 1. Ministry of Agriculture, Embu District Annual Report for 1964 to 1989.
2. Ministry of Agriculture. Eastern Province Annual Report for 1964 to 1989.

Table A 3.4.3: Monthly Rainfall Amounts (mm) at Siakago, Embu District.

Month Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1963	13.2	55.3	270.1	413.6	269.1	3.8	0.0	0.0	16.5	133.8	478.9	219.7
1964	0.0	17.0	369.8	596.9	13.7	7.0	0.0	0.0	0.0	99.8	174.0	129.8
1965	67.3	0.0	120.4	480.2	17.0	3.8	0.0	9.9	0.0	30.5	270.3	60.8
1966	114.4	8.6	323.5	221.4	23.9	22.4	0.0	0.0	0.7	219.3	244.4	7.6
1967	12.2	0.0	62.2	252.0	368.4	6.6	0.0	0.0	16.3	308.2	359.0	0.0
1968	0.0	189.4	222.3	351.8	37.3	7.6	0.0	0.0	0.5	93.9	583.7	184.4
1969	10.2	154.7	175.3	76.9	205.0	0.0	1.0	7.6	0.5	94.6	219.8	37.8
1970	124.4	0.0	160.2	476.1	69.9	4.6	0.0	10.9	0.0	8.9	241.0	42.8
1971	0.0	0.0	37.2	318.4	204.0	9.8	0.0	0.0	0.0	74.5	230.6	59.6
1972	125.0	17.7	48.9	33.2	113.2	26.8	0.0	0.0	32.3	213.2	316.3	43.0
1973	48.0	24.2	7.6	334.1	38.6	0.0	8.2	0.0	25.9	20.6	168.1	2.3
1974	0.0	57.1	186.3	388.5	1.1	0.0	6.1	0.0	0.0	30.2	174.1	45.6
1975	0.0	57.1	70.7	343.4	121.4	0.0	6.5	0.0	61.9	171.2	171.7	0.5
1976	0.0	50.2	25.5	98.8	32.5	35.7	0.2	0.0	0.0	107.4	143.9	139.1
1977	47.1	19.1	179.2	440.4	75.2	0.0	0.0	26.1	59.0	0.0	874.2	142.9
1978	41.4	120.2	227.9	370.8	22.0	0.0	0.0	0.0	0.0	116.1	268.1	123.8
1979	158.5	65.0	154.6	372.2	126.7	7.0	5.5	0.0	0.0	74.2	351.2	86.1
1980	14.0	0.0	39.0	240.8	110.0	0.0	0.0	0.0	0.0	122.2	412.3	90.6
1981	12.0	12.0	225.7	502.0	197.0	0.0	0.0	0.0	6.0	86.3	156.0	8.4
1982	0.0	6.0	95.0	384.0	154.0	0.0	0.0	0.0	12.0	378.0	264.0	114.0
1983	10.0	13.0	9.0	478.0	22.0	8.0	0.0	0.0	2.0	76.0	112.0	162.0
1984	8.0	0.0	34.0	252.0	18.0	0.7	0.0	0.0	1.5	345.0	34.4	112.3
1985	24.0	10.1	15.4	277.2	195.6	6.3	0.0	0.0	21.7	153.0	227.6	26.7
1986	1.7	0.0	86.5	369.8	141.3	3.0	0.0	0.3	0.9	149.0	362.0	63.5
1987	14.0	1.8	180.1	271.0	159.4	14.3	0.4	0.0	3.7	185.0	216.0	27.2
1988	2.9	17.6	149.6	562.7	214.9	0.6	0.0	0.0	0.5	104.1	357.2	217.9
1989	29.5	14.2	103.1	291.2	175.3	2.6	0.0	0.0	51.0	192.9	265.0	58.3

Source: Department of Meteorological Services,Nairobi,Data Bank.

Table A.3.4.4: Cotton Production, Hectarage, Average Producer Price and Yield for Kirinyaga District.

Season	Output(tonnes)	Hectarage	Average Producer Price (Kshs./Kg)	Yield (Kg/Ha).
1963/64	18.47	18.22	1.03	1013.72
1964/65	30.06	285.43	0.58	105.31
1965/66	539.937	1012.15	0.94	533.46
1966/67	455.343	1075.71	0.90	423.30
1967/68	690.542	2109.41	0.95	327.36
1968/69	1782.464	2396	1.00	743.93
1969/70	1865.127	4860	0.98	383.77
1970/71	494.864	3371.4	1.04	146.78
1971/72	119.374	704.0	1.14	169.57
1972/73	562.627	1224.5	1.24	459.47
1973/74	200.263	780.4	1.69	256.62
1974/75	56.705	400	1.67	141.62
1975/76	41.939	150	1.84	279.59
1976/77	175.213	350	2.26	500.61
1977/78	753.607	1620	2.97	465.19
1978/79	1003.74	1905	3.07	526.76
1979/80	400.009	1630	3.45	245.40
1980/81	215.772	1110	3.57	194.39
1981/82	206.063	530	3.65	388.80
1982/83	201.000	537	3.89	374.30
1983/84	54.450	1089	3.42	50.00
1984/85	37.000	726	3.42	50.96
1985/86	321.000	378	3.70	849.21
1986/87	467.000	550	4.51	849.09
1987/88	639.200	799	5.43	800.00
1988/89	416.000	620	5.16	800.00

Source: 1.Ministry of Agriculture, Kirinyaga District Annual Report, from 1964 to 1989.
2.Ministry of Agriculture,Central Province Annual Reports from 1964 to 1989.

Table A 3.4.5: Average Producer Price (Kshs./Kg) of Enterprises competing with Cotton in Kirinyaga District

Season	Maize	Mixed Beans	Millet	Sorghum	Pigeon Peas	Cow peas	Grams	Sunflower
1963/64	0.33	0.56	0.48	0.44	0.56	0.78	0.44	0.42
1964/65	0.44	0.53	0.50	0.44	0.54	0.58	0.44	0.47
1965/66	0.35	0.56	0.27	0.21	0.52	0.38	0.71	0.52
1966/67	0.31	0.50	0.27	0.20	0.51	0.39	0.67	0.58
1967/68	0.26	0.56	0.24	0.14	0.53	0.32	0.49	0.54
1968/69	0.31	0.51	0.21	0.14	0.56	0.37	0.63	0.36
1969/70	0.26	0.67	0.56	0.33	0.56	0.42	0.56	0.40
1970/71	0.25	0.60	0.83	0.60	1.00	1.00	0.80	0.67
1971/72	0.37	0.89	0.80	0.70	5.40	1.20	0.83	0.94
1972/73	0.39	1.11	1.11	1.11	1.67	1.33	0.81	0.89
1973/74	0.51	2.20	1.11	2.18	2.80	1.33	3.00	0.89
1974/75	0.57	1.44	0.93	1.01	4.56	2.23	2.31	1.00
1975/76	0.51	2.22	1.10	1.09	3.35	2.22	2.22	2.46
1976/77	0.89	2.78	2.22	2.29	1.89	5.37	6.28	1.00
1977/78	0.38	2.78	2.16	2.10	2.23	4.14	4.40	1.00
1978/79	1.44	2.56	2.30	2.16	0.25	3.66	3.08	1.60
1979/80	1.00	3.33	5.14	5.00	0.60	4.35	0.62	1.25
1980/81	1.00	3.89	0.92	0.80	4.28	4.00	0.33	0.37
1981/82	0.46	3.67	0.70	0.80	2.10	1.03	2.22	2.50
1982/83	1.99	3.89	1.00	3.20	2.02	4.35	2.78	2.65
1983/84	7.74	3.16	1.25	1.80	2.07	9.13	2.78	1.80
1984/85	1.94	3.16	1.00	1.80	8.79	9.13	3.80	1.80
1985/86	2.09	2.22	4.60	1.97	5.58	7.07	6.90	3.01
1986/87	3.18	7.99	8.19	3.33	6.48	5.00	10,00	1.54
1987/88	2.50	7.38	8.33	4.34	6.47	5.02	10.00	1.99
1988/89	2.78	6.58	10.71	4.38	5.42	5.99	10.35	1.99

Source 1. Ministry of Agriculture, Kirinyaga District Annual Reports from 1964 to 1989.
2. Ministry of Agriculture, Central Province Annual Reports from 1964 to 1989

Table A 3.4.6: Monthly Rainfall Amounts at Mwea Experimental Station, Kirinyaga District

Year/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1963	46.3	33.0	66.3	476.2	244.7	38.2	9.5	11.3	14.8	117.4	213.8	53.6
1964	23.1	25.9	80.7	260.1	165.3	20.7	12.9	11.3	15.8	120.9	213.8	53.6
1965	33.5	0.8	45.3	204.3	23.6	5.6	8.7	11.2	15.8	120.9	213.8	53.6
1966	23.1	25.9	80.7	260.1	165.3	20.7	12.9	7.8	15.8	120.9	213.8	53.6
1967	23.1	25.9	80.7	260.1	165.3	20.7	21.4	20.7	15.5	236.4	213.8	53.6
1968	0.0	149.7	122.9	305.3	92.8	17.1	19.9	9.0	0.3	168.4	335.0	136.1
1969	52.8	113.7	185.3	47.0	130.9	5.9	5.6	8.9	0.5	21.5	170.7	25.0
1970	61.9	0.0	187.9	425.1	147.7	1.1	7.9	15.6	2.1	26.9	115.2	33.8
1971	0.0	4.1	30.9	290.9	170.2	13.2	8.0	0.0	1.2	30.6	80.2	54.8
1972	40.1	28.1	31.5	17.6	255.8	47.3	4.5	3.4	33.3	213.8	151.6	37.0
1973	58.2	65.6	33.9	110.3	49.6	7.0	9.2	2.2	30.6	70.4	230.3	9.0
1974	0.0	26.2	63.5	225.9	60.7	82.1	100.2	41.8	11.6	14.8	149.3	28.1
1975	0.0	14.7	26.3	229.2	142.9	7.5	71.0	4.3	51.9	112.2	57.5	20.4
1976	0.0	5.6	5.7	180.0	110.9	95.0	5.2	2.1	18.2	88.4	136.3	36.8
1977	24.5	39.2	61.8	479.0	138.0	12.8	4.4	6.0	18.7	51.5	336.4	53.4
1978	14.4	89.1	138.2	369.7	730.0	3.7	7.6	4.0	48.5	269.0	978.0	55.7
1979	102.9	5.3	158.7	333.7	109.1	27.3	13.6	3.0	4.3	41.0	220.8	58.1
1980	4.7	0.0	39.2	108.2	219.9	0.2	0.0	24.4	0.0	49.2	290.8	10.8
1981	29.0	2.4	261.5	379.5	315.8	0.4	1.7	6.0	18.2	153.9	93.1	39.2
1982	8.4	0.0	116.7	199.2	220.7	31.1	22.5	1.0	31.4	379.5	78.1	23.0
1983	1.5	21.8	1.1	318.4	1.1	23.3	5.1	4.7	7.4	126.9	24.9	137.7
1984	5.8	0.0	11.4	144.1	8.9	3.9	4.6	3.7	23.0	218.5	147.5	42.3
1985	10.6	68.5	69.0	475.6	54.3	0.9	2.4	6.0	1.5	47.2	141.4	28.8
1986	3.2	0.0	90.3	303.8	105.8	15.5	0.0	5.8	17.6	52.0	224.1	51.1
1987	2.9	0.0	2.1	415.7	73.7	45.4	0.0	58.5	0.8	7.8	241.2	39.0
1988	16.7	12.4	98.4	504.6	142.3	20.1	2.6	5.7	14.7	73.6	123.1	160.6
1989	39.9	1.3	83.7	240.0	101.4	4.5	4.9	7.8	19.6	168.5	264.9	138.9

Note: The figures that are underlined are long term averages.

Source: Department of Meteorological Services,Nairobi,Data Bank.

Table A 3.4.7: Cotton Production, Hectarage, Average Producer Price (Kshs./Kg) and Yields for Kitui District.

Season	Output(Tonnes)	Hectarage	Average Producer Cotton Price	Yield Kg/Ha
1960/61	3.810	30.3	0.72	125.74
1961/62	19.236	125.644	1.15	153.10
1962/63	306.410	808	0.72	379.22
1963/64	148.673	1131.2	1.14	131.43
1964/65	850.091	2940.72	0.67	289.08
1965/66	1180.603	2832.2957	0.83	416.84
1966/67	232.525	3643.72	0.67	63.82
1967/68	n/a	n/a	n/a	n/a
1968/69	319.874	1800	0.88	177.71
1969/70	866.153	3640	0.81	237.95
1970/71	106.956	699	1.03	153.01
1971/72	29.669	463	0.90	34.25
1972/73	166.581	867	1.04	192.13
1973/74	69.281	510	1.02	135.85
1974/75	53.499	150	1.17	356.66
1975/76	13.690	50	1.78	273.80
1976/77	89.629	300	2.12	298.76
1977/78	1074.1505	6500	2.96	165.25
1978/79	1234.761	8060	3.28	153.20
1979/80	612.525	9000	3.88	68.06
1980/81	524.541	7500	3.16	69.94
1981/82	287.248	8500	3.53	33.79
1982/83	502.897	9000	3.88	55.88
1983/84	242.327	8000	4.42	30.29
1984/85	1418.104	9500	4.54	149.27
1985/86	860.358	8000	4.41	107.54
1986/87	606.869	6580	4.63	92.23
1987/88	641.7105	3200	5.57	200.53
1988/89	1313.371	8915	5.18	147.32

Source : 1. Ministry of Agriculture, Kitui District Annual Reports from 1961 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports from 1961 to 1989.

Table A 3.4.8: The Average Producer Price(Kshs./Kg) for Enterprises Competing with Cotton in Kitui District.

Season	Mixed Beans	Maize	Tobacco	Sunflower	Pigeon Peas	Millet	Cow peas	Grams	Sorghum
1960/61	0.89	0.67	7.47	0.47	1.11	0.44	0.11	1.11	0.44
1961/62	0.89	0.44	6.62	0.48	0.78	0.33	0.56	0.78	0.33
1962/63	0.29	0.45	6.62	0.49	0.54	0.22	0.54	0.80	0.42
1963/64	0.40	0.24	3.23	0.50	0.49	0.20	0.29	0.82	0.02
1964/65	0.30	0.24	3.95	0.51	0.44	0.32	0.27	0.57	0.12
1965/66	0.47	0.26	4.08	0.52	0.48	0.23	0.37	0.70	0.16
1966/67	0.65	0.56	4.85	0.53	0.45	0.23	0.37	0.68	0.21
1967/68	0.41	0.20	5.61	0.49	0.40	0.16	0.24	0.57	0.29
1968/69	0.42	0.20	3.70	0.36	0.45	0.26	0.34	0.49	0.20
1969/70	0.61	0.24	1.55	0.40	0.75	0.23	0.60	0.67	0.49
1970/71	0.85	0.39	4.20	0.40	0.84	0.21	0.47	0.89	0.48
1971/72	1.00	0.39	4.58	0.45	0.68	0.27	0.36	0.96	0.02
1972/73	0.81	0.39	4.77	0.63	0.78	0.38	0.89	1.09	0.25
1973/74	0.56	0.50	3.28	0.45	0.89	0.38	0.89	1.12	0.32
1974/75	0.94	0.50	7.27	0.49	1.33	0.50	0.94	1.17	0.35
1975/76	1.19	1.11	7.66	0.49	1.31	0.50	0.91	1.25	0.37
1976/77	1.33	0.11	6.60	0.89	1.89	0.75	1.22	2.44	0.63
1977/78	1.00	0.86	8.94	2.60	3.00	0.75	0.30	1.78	1.75
1978/79	1.00	0.70	10.91	1.50	0.03	0.10	0.33	0.29	1.75
1979/80	0.02	5.00	10.55	1.20	1.33	0.75	0.50	3.25	1.75
1980/81	5.00	1.20	11.08	1.60	5.00	1.00	4.00	5.00	1.50
1981/82	3.33	1.06	12.92	0.89	1.67	0.75	0.89	2.22	0.50
1982/83	1.67	1.44	14.75	1.33	2.22	1.00	1.33	2.78	1.13
1983/84	3.67	2.83	13.84	1.33	3.33	1.38	2.00	4.22	1.50
1984/85	1.69	2.38	15.06	3.15	4.45	3.90	4.40	4.40	2.19
1985/86	1.69	2.38	14.78	1.58	4.50	3.90	2.20	4.40	2.19
1986/87	3.78	2.09	15.37	1.58	3.89	1.31	1.80	4.45	0.15
1987/88	0.38	2.09	15.73	1.50	3.89	1.75	2.20	4.45	1.15
1988/89	2.28	0.60	21.12	1.50	0.77	10.71	1.93	2.12	2.00

Source : 1. Ministry of Agriculture, Kitui District Annual Report from 1961 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports from 1961 to 1989.

Table A 3.4.8: The Average Producer Price(Kshs./Kg) for Enterprises Competing with Cotton in Kitui District.

Season	Mixed Beans	Maize	Tobacco	Sunflower	Pigeon Peas	Millet	Cow peas	Grams	Sorghum
1960/61	0.89	0.67	7.47	0.47	1.11	0.44	0.11	1.11	0.44
1961/62	0.89	0.44	6.62	0.48	0.78	0.33	0.56	0.78	0.33
1962/63	0.29	0.45	6.62	0.49	0.54	0.22	0.54	0.80	0.42
1963/64	0.40	0.24	3.23	0.50	0.49	0.20	0.29	0.82	0.02
1964/65	0.30	0.24	3.95	0.51	0.44	0.32	0.27	0.57	0.12
1965/66	0.47	0.26	4.08	0.52	0.48	0.23	0.37	0.70	0.16
1966/67	0.65	0.56	4.85	0.53	0.45	0.23	0.37	0.68	0.21
1967/68	0.41	0.20	5.61	0.49	0.40	0.16	0.24	0.57	0.29
1968/69	0.42	0.20	3.70	0.36	0.45	0.26	0.34	0.49	0.20
1969/70	0.61	0.24	1.55	0.40	0.75	0.23	0.60	0.67	0.49
1970/71	0.85	0.39	4.20	0.40	0.84	0.21	0.47	0.89	0.48
1971/72	1.00	0.39	4.58	0.45	0.68	0.27	0.36	0.96	0.02
1972/73	0.81	0.39	4.77	0.63	0.78	0.38	0.89	1.09	0.25
1973/74	0.56	0.50	3.28	0.45	0.89	0.38	0.89	1.12	0.32
1974/75	0.94	0.50	7.27	0.49	1.33	0.50	0.94	1.17	0.35
1975/76	1.19	1.11	7.66	0.49	1.31	0.50	0.91	1.25	0.37
1976/77	1.33	0.11	6.60	0.89	1.89	0.75	1.22	2.44	0.63
1977/78	1.00	0.86	8.94	2.60	3.00	0.75	0.30	1.78	1.75
1978/79	1.00	0.70	10.91	1.50	0.03	0.10	0.33	0.29	1.75
1979/80	0.02	5.00	10.55	1.20	1.33	0.75	0.50	3.25	1.75
1980/81	5.00	1.20	11.08	1.60	5.00	1.00	4.00	5.00	1.50
1981/82	3.33	1.06	12.92	0.89	1.67	0.75	0.89	2.22	0.50
1982/83	1.67	1.44	14.75	1.33	2.22	1.00	1.33	2.78	1.13
1983/84	3.67	2.83	13.84	1.33	3.33	1.38	2.00	4.22	1.50
1984/85	1.69	2.38	15.06	3.15	4.45	3.90	4.40	4.40	2.19
1985/86	1.69	2.38	14.78	1.58	4.50	3.90	2.20	4.40	2.19
1986/87	3.78	2.09	15.37	1.58	3.89	1.31	1.80	4.45	0.15
1987/88	0.38	2.09	15.73	1.50	3.89	1.75	2.20	4.45	1.15
1988/89	2.28	0.60	21.12	1.50	0.77	10.71	1.93	2.12	2.00

Source : 1. Ministry of Agriculture, Kitui District Annual Report from 1961 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports from 1961 to 1989.

Table A 3.4.9: Monthly Rainfall Amounts (mm) at Mwingi Agricultural Office, Kitui District

Year/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1960	3.81	16.26	128.78	44.45	12.70	0.0	0.0	0.0	0.0	171.20	49.78	91.95
1961	2.29	76.96	22.86	162.81	73.45	0.0	0.0	2.29	6.1	241.05	558.8	104.14
1962	13.20	0.50	124.50	119.60	38.10	0.0	0.0	0.0	0.0	115.1	115.1	81.8
1963	6.30	12.80	128.50	184.90	8.9	1.0	0.0	0.0	2.5	2.5	239.5	235.2
1964	105.8	39.9	92.0	164.3	1.0	0.0	0.0	0.0	4.3	27.4	97.0	145.7
1965	17.9	0.0	16.3	141.7	0.0	12.9	0.0	0.0	0.0	88.1	340.8	4.8
1966	2.5	21.6	219.7	162.3	14.5	0.0	0.0	3.6	0.0	5.8	283.7	63.5
1967	0.0	0.0	0.0	178.7	116.6	0.0	0.0	0.0	46.0	113.7	385.2	0.0
1968	0.0	135.1	152.1	290.3	41.4	2.1	0.0	0.0	0.0	25.6	562.0	140.0
1969	38.1	63.8	118.0	46.9	27.9	0.0	0.0	6.3	2.0	78.0	231.1	22.6
1970	81.1	0.0	127.8	80.0	29.0	0.0	0.5	0.0	0.0	0.0	90.8	26.5
1971	0.0	0.0	28.0	164.6	23.7	13.0	0.0	0.0	2.5	0.0	113.1	141.5
1972	87.5	57.0	11.7	0.0	64.2	0.0	0.0	0.0	5.5	101.1	242.1	76.1
1973	8.1	32.6	9.9	123.1	0.0	0.0	0.0	0.0	0.0	0.0	205.3	38.4
1974	35.3	21.2	66.6	159.6	19.2	4.0	0.0	0.0	0.0	0.0	228.5	34.7
1975	0.0	0.0	0.0	17.2	43.1	0.0	9.5	0.0	15.6	19.0	92.1	9.4
1976	0.0	20.1	0.0	176.5	0.0	0.0	0.0	0.0	0.0	162.9	162.9	66.2
1977	85.3	42.5	52.5	371.6	47.0	0.0	0.0	4.6	0.0	0.0	388.7	46.3
1978	79.0	283.6	104.0	160.9	0.0	0.0	0.0	0.0	0.0	77.7	169.1	238.9
1979	241.2	22.1	138.5	159.6	42.1	8.8	0.0	0.0	4.0	12.6	169.7	121.9
1980	6.3	2.5	63.2	78.7	30.5	0.0	0.0	30.3	0.0	0.0	263.6	0.0
1981	0.0	0.0	138.4	115.4	5.4	0.0	0.0	0.0	0.0	47.7	145.6	85.7
1982	0.0	0.0	11.9	132.5	15.2	6.0	0.0	0.0	37.2	143.8	261.7	142.9
1983	0.0	0.0	0.0	65.0	0.0	0.0	0.0	0.0	0.0	4.5	26.6	109.2
1984	0.0	0.0	5.0	138.2	0.0	0.0	7.0	0.0	0.0	209.1	540.9	19.9
1985	4.0	2.6	93.4	243.5	46.6	0.0	0.5	0.0	0.0	41.6	129.4	52.2
1986	0.0	0.0	8.6	343.4	43.3	4.8	0.0	0.0	0.0	2.9	267.5	263.8
1987	37.5	0.0	16.4	179.9	3.6	5.1	0.0	7.9	0.0	0.0	179.3	0.2
1988	14.3	0.3	154.8	76.9	0.0	3.3	0.0	3.1	7.6	31.6	224.9	240.1
1989	8.3	3.1	48.1	311.9	42.1	3.1	0.0	0.0	0.0	46.0	299.0	115.9

Source : Department of Meterological Services, Nairobi, Data Bank.

Table A 3.4.9: Monthly Rainfall Amounts (mm) at Mwingi Agricultural Office, Kitui District

Year/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1960	3.81	16.26	128.78	44.45	12.70	0.0	0.0	0.0	0.0	171.20	49.78	91.95
1961	2.29	76.96	22.86	162.81	73.45	0.0	0.0	2.29	6.1	241.05	558.8	104.14
1962	13.20	0.50	124.50	119.60	38.10	0.0	0.0	0.0	0.0	115.1	115.1	81.8
1963	6.30	12.80	128.50	184.90	8.9	1.0	0.0	0.0	2.5	2.5	239.5	235.2
1964	105.8	39.9	92.0	164.3	1.0	0.0	0.0	0.0	4.3	27.4	97.0	145.7
1965	17.9	0.0	16.3	141.7	0.0	12.9	0.0	0.0	0.0	88.1	340.8	4.8
1966	2.5	21.6	219.7	162.3	14.5	0.0	0.0	3.6	0.0	5.8	283.7	63.5
1967	0.0	0.0	0.0	178.7	116.6	0.0	0.0	0.0	46.0	113.7	385.2	0.0
1968	0.0	135.1	152.1	290.3	41.4	2.1	0.0	0.0	0.0	25.6	562.0	140.0
1969	38.1	63.8	118.0	46.9	27.9	0.0	0.0	6.3	2.0	78.0	231.1	22.6
1970	81.1	0.0	127.8	80.0	29.0	0.0	0.5	0.0	0.0	0.0	90.8	26.5
1971	0.0	0.0	28.0	164.6	23.7	13.0	0.0	0.0	2.5	0.0	113.1	141.5
1972	87.5	57.0	11.7	0.0	64.2	0.0	0.0	0.0	5.5	101.1	242.1	76.1
1973	8.1	32.6	9.9	123.1	0.0	0.0	0.0	0.0	0.0	0.0	205.3	38.4
1974	35.3	21.2	66.6	159.6	19.2	4.0	0.0	0.0	0.0	0.0	228.5	34.7
1975	0.0	0.0	0.0	17.2	43.1	0.0	9.5	0.0	15.6	19.0	92.1	9.4
1976	0.0	20.1	0.0	176.5	0.0	0.0	0.0	0.0	0.0	162.9	162.9	66.2
1977	85.3	42.5	52.5	371.6	47.0	0.0	0.0	4.6	0.0	0.0	388.7	46.3
1978	79.0	283.6	104.0	160.9	0.0	0.0	0.0	0.0	0.0	77.7	169.1	238.9
1979	241.2	22.1	138.5	159.6	42.1	8.8	0.0	0.0	4.0	12.6	169.7	121.9
1980	6.3	2.5	63.2	78.7	30.5	0.0	0.0	30.3	0.0	0.0	263.6	0.0
1981	0.0	0.0	138.4	115.4	5.4	0.0	0.0	0.0	0.0	47.7	145.6	85.7
1982	0.0	0.0	11.9	132.5	15.2	6.0	0.0	0.0	37.2	143.8	261.7	142.9
1983	0.0	0.0	0.0	65.0	0.0	0.0	0.0	0.0	0.0	4.5	26.6	109.2
1984	0.0	0.0	5.0	138.2	0.0	0.0	7.0	0.0	0.0	209.1	540.9	19.9
1985	4.0	2.6	93.4	243.5	46.6	0.0	0.5	0.0	0.0	41.6	129.4	52.2
1986	0.0	0.0	8.6	343.4	43.3	4.8	0.0	0.0	0.0	2.9	267.5	263.8
1987	37.5	0.0	16.4	179.9	3.6	5.1	0.0	7.9	0.0	0.0	179.3	0.2
1988	14.3	0.3	154.8	76.9	0.0	3.3	0.0	3.1	7.6	31.6	224.9	240.1
1989	8.3	3.1	48.1	311.9	42.1	3.1	0.0	0.0	0.0	46.0	299.0	115.9

Source : Department of Meterological Services, Nairobi, Data Bank.

Table A 3.4.10: Cotton Output, Hectarage, Average Producer Price (Kshs./Kg) and Yield for Machakos District.

Season	Output(Tonnes)	Hectarage	Average Producer Price (Kshs./Kg)	Yield
1960/61	0.417	1.62	0.86	257.41
1961/62	5.21	20.24	1.15	257.41
1962/63	79.38	506.07	1.14	156.86
1963/64	589	1570.85	0.61	374.96
1964/65	1109.27	4612.96	0.80	240.47
1965/66	1920.24	11111.90	0.88	172.81
1966/67	625.58	11255.46	0.72	55.58
1967/68	1149.86	7255.51	0.85	158.48
1968/69	1672.12	11783.40	0.91	141.90
1969/70	1681.74	8093.72	0.91	207.78
1970/71	540.629	3437.18	1.00	157.29
1971/72	519.445	1338.5	1.06	388.08
1972/73	519.445	1338	1.11	388.22
1973/74	275.627	1804.7	1.14	152.73
1974/75	339.168	1137.4	1.26	289.20
1975/76	318.136	2223.4	1.76	143.09
1976/77	2345.1	7848	1.92	289.81
1977/78	5564	18098	2.75	307.44
1978/79	4850	25000	2.94	194.00
1979/80	3876.266	26000	3.23	149.09
1980/81	5617.915	27387	2.73	205.13
1981/82	3441.0195	27390	2.93	125.63
1982/83	4486.390	28000	4.15	160.23
1983/84	2140.931	30175	4.64	70.95
1984/85	7565.220	32000	4.52	236.41
1985/86	2398.5995	12000	4.53	199.88
1986/87	1381.9895	11000	4.52	125.64
1987/88	1675.2445	12000	5.35	139.60
1988/89	956.0580	18000	5.33	53.11

Source : 1. Ministry of Agriculture, Machakos District Annual Report from 1961 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports from 1961 to 1989.

Table A 3.4.11: The Average Producer Price(Kshs./Kg) for Enterprises Competing with Cotton in Machakos District

Season	Maize	Sorghum	Grams	Mixed Beans	Cow peas	Pigeon Peas
1960/61	0.44	0.89	0.58	0.78	0.56	0.78
1961/62	0.33	0.60	0.66	0.72	0.56	0.56
1962/63	0.23	0.46	0.75	0.43	0.18	0.39
1963/64	0.04	0.31	0.54	0.37	0.32	0.41
1964/65	0.37	0.29	2.31	0.44	0.31	0.58
1965/66	0.33	0.21	0.56	0.42	0.35	0.52
1966/67	0.33	0.16	0.73	3.88	1.04	0.43
1967/68	0.25	0.21	0.58	0.54	0.35	0.50
1968/69	0.24	0.22	0.60	0.13	0.59	0.43
1969/70	0.39	2.00	0.67	1.71	0.89	0.18
1970/71	0.24	1.54	1.30	1.18	0.70	1.74
1971/72	0.39	0.25	1.06	0.62	0.54	1.00
1972/73	0.39	0.25	1.00	1.16	0.55	0.78
1973/74	1.01	0.05	1.00	2.77	0.89	0.89
1974/75	0.73	0.10	1.23	1.75	0.94	1.33
1975/76	1.03	2.55	1.33	0.23	0.21	1.31
1976/77	0.89	1.00	1.25	0.14	0.21	1.89
1977/78	0.30	3.58	2.44	1.54	0.22	0.22
1978/79	0.28	1.75	1.78	0.11	1.60	3.14
1979/80	1.00	1.67	2.27	2.22	2.22	3.12
1980/81	0.11	1.00	2.22	3.66	1.12	1.66
1981/82	0.13	1.50	1.89	0.33	0.33	2.78
1982/83	1.41	1.94	6.00	5.00	6.00	3.45
1983/84	2.84	0.25	10.80	7.78	2.96	0.81
1984/85	3.00	6.28	15.60	9.71	5.00	5.00
1985/86	3.11	4.98	8.02	5.78	4.78	5.00
1986/87	3.20	4.00	7.63	8.70	3.28	3.95
1987/88	3.17	4.00	6.77	7.70	1.78	2.89
1988/89	3.65	4.00	6.63	7.56	5.38	4.90

Source : 1. Ministry of Agriculture, Machakos District Annual Reports, from 1961 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports, from 1961 to 1989.

Table A 3.4.12: Monthly Rainfall Amounts (mm) at Makueni D.O's Office, Machakos District.

Month Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1960	28.2	3.8	115.2	140.2	45.9	2.3	0.0	0.0	0.5	10.58	11.2	87.5
1961	1.0	13.2	29.5	115.4	66.2	6.4	3.0	3.0	14.0	299.8	538.1	114.8
1962	92.2	3.3	80.6	97.8	85.1	7.7	0.0	14.7	1.5	63.3	189.4	135.9
1963	37.4	56.1	172.6	95.7	114.2	30.8	6.9	0.0	7.9	12.2	309.3	187.9
1964	56.7	17.3	108.7	196.1	25.7	55.4	3.8	0.0	4.3	25.6	127.2	227.8
1965	39.9	0.0	13.2	173.6	17.3	4.6	0.0	0.0	0.0	120.2	208.1	23.9
1966	14.4	145.4	193.9	88.7	45.2	10.1	0.0	0.0	0.0	0.0	102.5	41.6
1967	0.0	58.5	28.9	307.4	72.6	2.8	0.0	29.8	28.2	198.1	191.9	7.4
1968	0.0	80.2	345.2	300.6	50.0	35.9	0.0	8.9	0.0	26.6	298.1	132.2
1969	84.9	194.8	105.6	66.8	21.2	0.0	0.0	0.0	0.0	55.8	215.2	39.7
1970	51.2	0.0	169.8	84.0	40.2	0.0	0.0	0.0	14.2	0.0	80.2	79.8
1971	47.5	0.0	0.4	9.9	3.0	0.9	0.0	0.0	0.0	6.5	59.8	186.2
1972	52.4	45.0	20.1	5.8	45.0	0.0	0.0	0.0	197.9	15.9	99.7	40.3
1973	99.9	7.3	0.0	53.8	0.0	0.0	0.0	0.0	0.0	10.3	189.1	5.0
1974	7.0	14.9	111.3	162.9	27.0	0.0	20.4	0.0	0.0	10.9	87.7	53.3
1975	30.3	0.9	14.5	165.0	52.5	20.3	0.0	0.0	27.0	0.0	195.6	28.4
1976	0.0	6.9	5.0	121.7	16.0	17.6	0.0	13.8	0.0	0.0	273.1	60.7
1977	33.5	31.3	31.5	215.0	57.7	3.3	0.0	22.8	12.1	2.0	138.1	138.1
1978	107.4	91.1	109.0	125.2	30.6	0.0	4.3	0.5	0.0	107.4	178.5	244.9
1979	279.8	18.0	66.8	187.9	102.3	9.0	0.0	0.0	0.0	43.7	330.8	25.4
1980	84.8	0.0	50.7	99.8	64.2	0.0	1.3	14.5	0.0	3.6	165.0	42.7
1981	4.3	0.0	220.8	127.5	65.2	0.7	0.0	0.0	4.9	182.2	174.3	83.6
1982	0.4	0.0	36.2	238.8	138.2	9.5	0.0	0.0	21.2	111.0	275.5	109.5
1983	0.0	21.3	65.1	126.6	29.1	0.0	0.0	0.0	0.0	8.0	72.0	235.7
1984	36.9	0.0	65.1	67.6	10.8	0.0	0.0	0.0	8.3	175.7	401.7	71.4
1985	9.3	99.7	99.8	239.4	103.5	36.6	0.0	0.0	0.0	97.9	189.7	92.4
1986	21.7	0.8	94.5	220.0	64.0	0.0	0.0	8.3	11.0	12.1	430.2	127.9
1987	0.0	0.0	0.0	88.5	33.6	55.8	0.0	12.1	0.0	0.0	160.1	41.0
1988	86.4	26.3	182.8	144.2	0.0	0.0	0.0	6.6	15.6	34.6	141.4	210.8
1989	108.8	0.0	102.2	322.1	40.8	16.5	0.0	12.2	3.4	114.5	286.2	245.5

Source : Department of Meterological Services, Nairobi, Data Bank.

Table A 3.4.13: Cotton Output, Hectarage, Average Producer Price and Yield for Meru District.

Season	Output(Tonnes)	Hectarage	Average Producer Price (Kshs./Kg)	Yield (Kg/Ha)
1965/66	19.0476	28.34	0.66	672.11
1966/67	455.06	809.72	0.87	562.00
1967/68	529.717	2500.00	0.79	211.89
1968/69	990.2195	1241.06	1.02	797.88
1969/70	1391.779	1618.74	0.89	859.79
1970/71	1042.997	2023.43	1.01	515.46
1971/72	830.946	1273.68	1.22	652.40
1972/73	1282.439	1170.96	1.30	1095.20
1973/74	3618.75075	3150.41	1.82	1148.66
1974/75	2706.4465	2906.71	1.89	931.10
1975/76	1813.056	2685.5	2.38	675.13
1976/77	3688.9425	7629	2.88	483.54
1977/78	3803.817	9839	3.16	386.61
1978/79	5413.1249	12448	3.21	41.22
1979/80	2753.5395	14670	3.23	187.70
1980/81	2160	10000	3.33	216.00
1981/82	2286	10000	3.55	228.60
1982/83	5304.5	15000	3.39	353.63
1983/84	3843.7	22000	3.12	174.71
1984/85	11202	28216	4.74	397.01
1985/86	2924	8270.24	4.66	353.56
1986/87	2198.648	8000	4.69	274.83
1987/88	2594.1895	15000	5.08	172.95
1988/89	2991.8525	16500	5.47	181.32

Source : 1. Ministry of Agriculture, Meru District Annual Report from 1966 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports from 1966 to 1989.

Table A 3.4.14: The Average Producer Price(Kshs./Kg) for Enterprises Competing with Cotton in Meru District.

Season	Maize	Millet	Mixed Beans	Sunflower	Tobacco	Sorghum	Cow peas	Grams
1964/65	0.22	0.35	0.32	0.50	5.51	0.29	0.51	0.50
1965/66	0.33	0.35	0.40	0.52	5.51	0.31	0.33	0.56
1966/67	0.33	0.38	0.56	0.53	5.51	0.31	0.34	0.67
1967/68	0.56	0.40	0.39	0.49	3.85	0.78	0.50	0.81
1968/69	0.20	0.44	0.44	0.36	3.85	0.20	0.37	0.31
1969/70	0.25	0.33	0.40	0.40	2.19	0.14	0.56	0.78
1970/71	0.32	0.31	0.58	0.40	2.22	0.41	0.67	0.80
1971/72	0.30	0.38	0.57	0.45	2.22	0.41	0.78	0.80
1972/73	0.38	0.38	0.60	0.63	4.11	0.25	0.89	1.18
1973/74	0.49	0.42	1.69	0.67	5.99	0.32	0.89	0.28
1974/75	0.72	0.42	1.95	1.13	6.61	0.32	0.94	0.29
1975/76	0.90	0.52	0.36	1.27	5.67	0.35	1.45	2.22
1976/77	1.56	0.75	1.65	2.50	7.42	0.35	0.10	2.57
1977/78	1.56	0.75	1.65	1.00	10.00	0.35	0.75	2.57
1978/79	0.50	0.75	0.33	0.77	9.00	1.13	2.78	3.02
1979/80	0.10	0.75	3.22	1.43	10.50	0.63	2.78	6.60
1980/81	1.00	0.75	4.38	1.44	13.83	0.90	2.03	3.33
1981/82	1.33	1.00	3.33	1.38	13.91	0.94	2.93	2.40
1982/83	1.30	1.25	3.15	1.14	13.46	1.00	2.04	3.26
1983/84	4.00	1.00	1.01	2.95	15.07	6.18	2.60	17.05
1984/85	2.50	0.23	3.30	2.95	15.07	6.18	2.66	17.07
1985/86	2.00	0.18	0.40	1.41	17.80	0.28	0.19	4.03
1986/87	0.27	1.99	0.40	2.80	19.85	0.28	0.19	3.90
1987/88	0.22	1.18	0.50	2.36	14.98	0.45	12.00	5.00
1988/89	0.83	1.75	0.40	2.46	14.98	1.25	9.00	5.00

Source : 1. Ministry of Agriculture, Meru District Annual Reports from, 1965 to 1989.
2. Ministry of Agriculture, Eastern Province Annual Reports from, 1965 to 1989.

Table A 3.4.15: Monthly Rainfall Amounts (mm) at Mitunguu, Meru District.

Month Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1965	76	0.5	73.9	251.7	120.4	0.5	3.8	13.2	18.8	98.3	411.7	5.4
1966	53.1	26.1	300.3	307.2	179.1	59.6	5.9	1.0	0.0	486.6	293.5	0.0
1967	0.0	3.0	67.3	416.4	404.4	5.3	13.3	11.7	10.9	462.7	616.0	0.0
1968	0.0	203.7	245.1	515.9	17.0	3.6	8.2	0.0	0.0	216.7	341.0	110.3
1969	12.7	172.5	181.3	12.0	117.5	0.0	1.5	3.6	27.7	127.1	342.3	80.1
1970	56.7	0.0	112.3	342.2	50.3	0.0	0.0	10.9	0.0	50.2	211.4	36.8
1971	0.0	0.0	105.1	355.8	143.7	0.0	10.4	2.2	3.2	95.1	334.8	50.7
1972	0.0	42.6	0.0	40.4	345.5	0.0	345.5	0.0	25.2	427.0	495.2	0.0
1973	114.5	0.0	0.0	191.3	47.8	7.8	0.0	8.0	18.3	35.2	282.0	13.8
1974	17.6	26.4	241.2	658.8	67.4	63.7	13.7	0.0	0.0	53.7	313.4	97.6
1975	3.2	21.1	79.5	239.1	105.4	21.6	7.1	2.2	8.7	180.8	183.7	96.5
1976	3.4	23.6	16.8	326.3	47.4	77.8	7.1	0.0	2.2	81.5	291.2	139.0
1977	42.5	48.7	265.6	362.0	105.7	0.0	10.3	8.9	13.2	94.9	664.3	267.7
1978	120.8	112.6	240.4	556.7	8.3	9.7	7.4	4.4	0.0	450.9	243.9	197.7
1979	227.0	33.5	108.5	293.1	105.2	0.5	0.5	12.6	0.0	65.4	506.8	116.8
1980	1.6	0.0	40.1	179.8	174.6	0.1	0.4	10.0	2.2	81.9	394.6	24.3
1981	3.1	8.7	200.2	422.7	198.4	4.0	3.8	6.9	22.2	319.1	208.4	49.1
1982	14.8	0.0	104.5	335.4	153.2	4.2	6.5	0.0	23.8	459.3	331.8	240.4
1983	17.9	44.4	4.7	292.4	148.8	0.9	3.2	6.0	23.0	83.9	165.4	65.4
1984	8.1	1.8	24.4	107.4	10.1	0.0	5.0	1.6	15.8	395.6	213.7	70.9
1985	32.6	10.1	198.6	583.8	219.6	9.6	0.6	4.6	0.8	151.4	206.3	137.5
1986	2.5	0.0	34.7	367.2	120.0	13.9	8.0	0.2	17.6	120.9	483.5	195.1
1987	41.6	0.0	17.0	248.0	92.1	8.9	0.3	20.6	0.0	0.0	303.2	78.9
1988	92.4	1,9	144.8	333.1	61.1	7.4	9.1	11.5	0.0	229.2	367.8	319.4
1989	29.4	6.3	110.8	367.7	69.0	2.8	12.3	5.4	42.3	258.2	230.5	78.8

Note: The underlined figures are long term averages.

Source: Department of Meteorological Services,Nairobi,Data Bank.

Table A.3.4.16: The Cotton Output, Hectarage, Average Producer Price and Yield in Murang'a District.

Season	Output(Tonnes)	Hectarage	Average Producer Price (Kshs./Kg)	Yield (Kg/Ha).
1964/65	8.0826	80.5	0.49	100.40
1965/66	39.9218	81.0	0.74	480.52
1966/67	30.362	296.0	0.82	102.57
1967/68	48.3123	112.1	0.75	430.98
1968/69	130.043	337.3	0.96	385.54
1969/70	382.090	779.0	0.78	490.49
1970/71	251.747	761.6	1.03	330.55
1971/72	247.008	653.0	1.10	378.27
1972/73	367.023	384.0	1.19	955.79
1973/74	363.329	576.5	1.19	630.23
1974/75	297.032	360.0	1.30	825.09
1975/76	121.190	1432.0	1.61	84.63
1976/77	277.174	1070.0	2.05	259.04
1977/78	175.505	1608.0	2.66	109.14
1978/79	138.049	1388.0	2.70	99.46
1979/80	150.070	1379.0	3.34	108.83
1980/81	56.450	589.9	3.07	95.69
1981/82	50.504	858.9	2.99	58.80
1982/83	40.000	345.0	3.08	115.94
1983/84	60.000	722.0	4.22	83.10
1984/85	63.000	727.0	4.23	86.66
1985/86	44.000	243.0	4.38	181.07
1986/87	13.5825	300.0	4.80	45.28
1987/88	99.0000	330.0	4.20	300.0
1988/89	114.0000	380.0	4.01	300.0

Source: 1.Ministry of Agriculture,Murang'a District Annual Reports for 1965 to 1989.
2.Ministry of Agriculture,Central Province Annual Reports for 1965 to 1989.

Table A.3.4.17: The Average Producer Prices(Kshs./Kg) of the Enterprises Competing with Cotton in Murang'a District.

Season	Maize	Cow Peas	Pigeon Peas	Sunflower	Mixed Beans	Millet	Tobacco
1964/65	0.30	0.27	0.58	0.52	0.45	0.35	3.62
1965/66	0.37	0.37	0.58	0.52	0.47	0.47	4.41
1966/67	0.39	0.50	0.61	0.53	0.49	0.40	3.46
1967/68	0.31	0.50	0.62	0.49	0.50	0.33	3.82
1968/69	0.24	0.37	0.56	0.36	0.62	0.30	4.00
1969/70	0.31	0.44	0.56	0.40	0.72	0.31	4.10
1970/71	0.44	0.44	1.56	0.40	0.69	0.38	4.14
1971/72	0.39	0.94	0.89	0.45	0.76	0.38	4.18
1972/73	0.39	0.89	0.83	0.63	1.50	0.48	4.79
1973/74	0.78	0.89	2.20	0.54	1.78	3.18	5.39
1974/75	0.75	0.94	2.52	1.43	2.22	3.30	8.00
1975/76	0.87	1.54	2.78	0.78	2.42	0.50	7.00
1976/77	1.11	1.54	0.33	0.50	2.63	0.75	5.00
1977/78	0.90	1.67	3.34	0.52	3.33	0.75	10.08
1978/79	0.94	2.98	2.67	1.58	3.66	0.75	10.52
1979/80	1.17	0.60	4.43	1.58	3.33	0.75	10.00
1980/81	1.07	4.00	4.26	1.60	3.33	0.75	10.25
1981/82	1.44	0.89	4.50	0.96	3.67	0.75	11.00
1982/83	1.47	16.19	1.12	1.48	5.00	1.00	11.40
1983/84	2.46	16.06	1.42	1.74	5.47	1.25	11.95
1984/85	2.36	16.06	16.22	2.00	4.44	1.00	11.91
1985/86	2.09	5.20	15.67	1.75	4.44	5.98	12.32
1986/87	2.09	2.20	15.67	1.75	8.00	5.67	12.74
1987/88	2.78	1.80	15.00	1.50	6.67	1.40	13.13
1988/89	2.22	1.80	12.31	1.51	5.93	1.40	13.60

Source: 1.Ministry of Agriculture,Murang'a District Annual Reports for 1965 to 1989.
2.Ministry of Agriculture, Central Province Annual Reports for 1965 to 1989.

Table A.3.4.18: Monthly Rainfall Amounts(mm) at Tana Power Station, Murang'a District.

Year/ Month	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sept	Oct	Nov	Dec
1964	34.8	52.5	103.2	309.5	8.9	14.4	7.6	66.5	4.1	93.6	22.4	88.1
1965	106.1	0.0	88.3	262.5	53.9	6.9	0.0	5.3	5.9	88.4	216.7	39.1
1966	62.2	1.3	114.7	128.7	44.7	1.3	0.5	12.7	19.0	73.5	233.1	36.4
1967	2.5	43.7	45.0	373.7	498.9	6.6	6.6	21.1	54.6	191.9	143.8	0.0
1968	0.0	162.9	141.9	330.8	186.0	33.5	9.1	3.3	0.0	99.8	346.7	110.7
1969	22.0	71.9	182.7	25.5	132.6	17.8	1.6	28.2	0.8	48.6	152.4	19.0
1970	60.9	0.0	22.7	524.7	166.5	0.0	7.2	12.1	0.0	33.8	121.4	36.5
1971	4.9	8.4	62.4	253.7	202.1	29.7	0.3	0.0	0.0	28.7	71.7	52.0
1972	40.2	89.7	47.5	90.7	222.5	32.8	3.1	1.5	31.8	254.4	219.4	32.8
1973	89.8	36.8	18.8	225.0	65.1	9.3	5.3	0.0	28.0	39.0	237.2	12.4
1974	0.0	40.8	60.1	301.5	85.6	61.7	97.9	86.7	1.5	6.0	186.5	26.1
1975	9.8	0.8	43.9	237.0	106.4	10.5	23.0	10.9	30.6	49.5	175.3	29.9
1976	0.0	17.9	5.1	193.8	30.5	45.1	3.3	1.3	6.5	54.7	130.5	65.6
1977	34.5	39.8	211.2	555.4	186.6	14.5	0.5	3.8	14.3	66.4	294.3	75.7
1978	35.5	117.9	124.9	308.6	55.0	4.2	6.1	2.7	45.4	303.6	85.0	83.1
1979	107.8	17.0	194.4	393.7	94.9	49.5	6.5	8.6	0.0	56.6	250.1	52.1
1980	6.1	0.6	39.7	157.1	220.4	0.2	0.0	27.7	0.0	2.3	220.3	10.2
1981	33.0	3.0	210.3	407.3	308.0	0.5	3.1	3.5	0.1	109.9	118.8	38.0
1982	6.4	0.0	75.7	247.1	141.0	3.7	10.9	0.0	18.6	370.5	134.5	128.0
1983	9.3	26.3	28.5	296.4	57.7	16.5	6.3	14.7	1.0	112.0	95.8	97.9
1984	7.8	0.0	11.0	135.5	7.9	0.8	11.6	7.1	19.4	178.3	182.2	86.2
1985	14.7	104.3	187.9	346.3	51.3	3.8	1.7	2.9	0.0	25.8	202.0	52.5
1986	7.7	0.0	98.3	95.0	169.8	15.9	1.0	0.9	3.8	87.8	337.1	29.1
1987	4.7	0.0	24.1	203.4	180.0	57.8	8.8	23.8	77.4	2.4	253.7	16.2
1988	25.2	5.0	135.9	475.8	133.0	46.5	12.2	12.2	6.1	77.5	175.3	233.7
1989	58.5	24.9	161.6	297.9	129.5	38.7	2.5	11.8	36.1	154.4	226.5	81.8

Source: Department of Meteorological Services,Nairobi,Data Bank.

Table A.3.4.19: Lower-Income Nairobi Consumer Price Index.

Year	Index (Base Jan 1975 =100)
1966	59.7
1967	60.8
1968	61.3
1969	61.3
1970	62.3
1971	66.9
1972	68.1
1973	78.0
1974	89.9
1975	107.4
1976	116.1
1977	136.4
1978	154.5
1979	168.7
1980	190.9
1981	227.6
1982	259.3
1983	283.7
1984	314.7
1985	347.2
1986	361.2
1987	381.3
1988	419.5

Note: The indices are for October each year.

Source: Republic of Kenya, Statistical Abstracts For 1966 to 1989.

Appendix A 4.3: Simple Correlation Matrices of the Variables in the Estimated Models

Table A 4.3.1: Simple Correlation Matrix[34] of the Variables Used in the Embu District Cotton Supply Response Models.[a]

Variable	X'_t	X'_{t-1}	$(P'_c)_{t-1}$	$(P'_m)_{t-1}$	R'_t	T
X'_t	1.000					
	(1.000)					
X'_{t-1}	0.789)	1.000				
	(0.845)	(1.000)				
$(P_c)_{t-1}$	0.903	0.852	1.000			
	(0.490)	(0.235)	(1.000)			
$(P'_m)_{t-1}$	0.217	0.230	0.300	1.000		
	(-0.207)	(-0.300)	(-0.578)	(1.000)		
R'_t	0.028	0.056	0.106	-0.162	1.000	
	(-0.042)	(0.068)	(0.034)	(-0.289)	(1.000)	
T	0.860	0.872	0.959	0.431	0.038	1.000
	(0.848)	(0.837)	(0.054)	(-0.101)	(0.080)	(1.000)

Note [a] - The ones for the "real prices models" are in parentheses in this case and subsequent ones

Source: Author's study.

[34] Since these matrices are symmetrical we have only shown their lower portions here.

Table A 4.3.2: Simple Correlation Matrix of the Variables Used in the Kirinyaga District Cotton Supply Response Models.

Variable	X'_t	X'_{t-1}	$(P'_c)_{t-1}$	$(P'_m)_{t-1}$	R'_t	T
X'_t	1.000					
	(1.000)					
X'_{t-1}	0.604	1.000				
	(0.620)	(1.000)				
$(P'_c)_{t-1}$	-0.296	-0.017	1.000			
	(0.133)	(0.083)	(1.000)			
$(P'_m)_{t-1}$	-0.570	-0.217	0.582	1.000		
	(-0.513)	(-0.455)	(-0.026)	(1.000)		
R'_t	0.380	0.064	0.047	0.079	1.000	
	(-0.355)	(0.028)	(0.175)	(-0.125)	(1.000)	
T	-0.298	0.053	0.964	0.878	-0.008	1.000
	(-0.493)	(-0.455)	(-0.451)	(-0.057)	(-0.045)	(1.000)

Source: Author's study

Table A 4.3.3: Simple Correlation Matrix of the Variables Used in the Kitui District Cotton Supply Response Models.

Variable	X'_t	X'_{t-1}	$(P'_c)_{t-1}$	$(P'_m)_{t-1}$	R'_t	T
X'_t	1.000					
	(1.000)					
X'_{t-1}	0.807	1.000				
	(0.786)	(1.000)				
$(P'_c)_{t-1}$	0.660	0.568	1.000			
	(0.436)	(0.142)	(1.000)			
$(P'_m)_{t-1}$	0.107	0.070	0.345	1.000		
	(-0.385)	(-0.367)	(-0.517)	(1.000)		
R'_t	0.206	-0.149	0.007	0.021	1.000	
	(0.395)	(-0.015)	(0.287)	(0.243)	(1.000)	
T	0.540	0.583	0.934	0.393	-0.082	
	(0.537)	(0.467)	(0.040)	(-0.084)	(-0.122)	

Source: Author's study

Table A 4.3.4: Simple Correlation Matrix of the Variables Used in the Machakos District Cotton Supply Response Models.

Variable	X'_t	X'_{t-1}	$(P'_c)_{t-1}$	$(P'_m)_{t-1}$	R'_t	T
X'_t	1.000					
	(1.000)					
X'_{t-1}	0.933	1.000				
	(0.814)	(1.000)				
$(P'_c)_{t-1}$	0.577	0.514	1.000			
	(0.617)	(0.603)	(1.000)			
$(P'_m)_{t-1}$	0.139	0.236	0.531	1.000		
	(0.028)	(0.008)	(0.158)	(1.000)		
R'_t	0.083	-0.117	0.211	0.005	1.000	
	(-0.190)	(-0.022)	(0.224)	(-0.117)	(1.000)	
T	0.644	0.660	0.931	0.553	-0.001	1.000
	(0.575)	(0.524)	(0.761)	(-0.006)	(-0.118)	(1.000)

Source: Author's study

Table A 4.3.5: Simple Correlation Matrix of the Variables Used in the Meru District Cotton Supply Response Models.

Variable	X'_t	X'_{t-1}	$(P'_c)_{t-1}$	$(P'_m)_{t-1}$	R'_t	T
X'_t	1.000					
	(1.000)					
X'_{t-1}	0.831	1.000				
	(0.864)	(1.000)				
$(P'_c)_{t-1}$	0.906	0.848	1.000			
	(-0.120)	(-0.169)	(1.000)			
$(P'_m)_{t-1}$	0.390	0.466	0.346	1.000		
	(-0.281)	(-0.486)	(0.339)	(1.000)		
R'_t	0.016	-0.076	-0.098	0.085	1.000	
	(-0.031)	(-0.152)	(-0.236)	(0.251)	(1.000)	
T	0.877	0.824	0.968	0.361	-0.164	1.000
	(0.859)	(0.875)	(-0.290)	(-0.584)	(-0.194)	(1.000)

Source: Author's study

Table A 4.3.6: Simple Correlation Matrix of the Variables Used in the Murang'a District Cotton Supply Response Models.

Variable	X'_t	X'_{t-1}	$(P'_c)_{t-1}$	$(P'_m)_{t-1}$	R'_t	T
X'_t	1.000					
	(1.000)					
X'_{t-1}	0.604	1.000				
	(0.620)	(1.000)				
$(P'_c)_{t-1}$	-0.296	-0.017	1.000			
	(0.133)	(0.083)	(1.000)			
$(P'_m)_{t-1}$	-0.570	-0.217	0.582	1.000		
	(-0.513)	(-0.455)	(-0.026)	(1.000)		
R'_t	0.380	0.064	0.047	0.079	1.000	
	(-0.355)	(0.028)	(0.175)	(-0.125)	(1.000)	
T	-0.298	0.053	0.964	0.878	-0.008	1.000
	(-0.493)	(-0.455)	(-0.451)	(-0.057)	(-0.045)	(1.000)

Source: Author's Study

Appendix A 4.4: **Projected Import Parity Price of Seed Cotton for the 1991/92 Crop Season**

Table A 4.4: **Projected Import Parity Price of Seed Cotton for the 1991/92 Crop Season**

Steps in the calculation		Value per Kg
Index A (Mexican Milling 1-3/32")	US$	1.39
Add Freight Charges to Mombasa	US$	0.15
C & F Landed Cost Mombasa	**US$**	**1.54**
Converted at official exchange rate of Kshs. 28.47 = 1 US$	Kshs.	43.84
Add Import Duty (25% C & F Mombasa)	Kshs.	10.96
Add Port Charges (7.5% C & F Mombasa)	Kshs.	3.29
Add Transport charges to Warehouse	Kshs.	0.70
Into-Mill Cost	**Kshs.**	**58.79**
Deduct cost of transport of lint to mills	Kshs.	- 1.08
Deduct charges for storage of lint	Kshs.	- 0.65
Deduct ginning cost	Kshs.	- 5.10
Add proceeds from sale of cotton seed	Kshs.	4.00
Deduct cost of transport of seed cotton from producing regions to ginneries	Kshs.	- 4.50
Deduct commission to buying agents	Kshs.	- 1.28
Deduct cost of Cotton Board Services to farmers	Kshs.	- 1.59
Deduct interest on borrowed capital	Kshs.	- 2.25
Deduct other overheads of Cotton Board	Kshs.	- 5.00
Net Value of Cotton Lint	**Kshs.**	**41.34**
Multiply with the ginning percentage expressed as a decimal fraction	Kshs.	13.02

$\therefore$ **The Import Parity Price of Seed Cotton at farm gate is Kshs 13.02.**

Sources: UNCTAD (1992) and Ministry of Planning and National Development (1992)