ANALYSIS OF GROWTH AND PRODUCTIVITY IN KENYA'S AGRICULTURAL SECTOR

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DECLARATION

This thesis is my original work and has not been presented for a degree in any other University.

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This thesis has been submitted for examination with our approval as University supervisors.

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ABSTRACT

The study is concerned with agricultural growth and productivity in Kenya between 1960 and 1980. The principal objectives were to determine the rates and sources of growth in output and productivity in economic and physical terms.

Two approaches were used. The first was growth accounting procedures using Laspeyer's Index and the index formula of Divisia. The second approach involved estimation of a Cobb-Douglas production function.

Total agricultural output grew at 3 percent per year between 1960 and 1980. The increase was most rapid after 1969, averaging 5 percent both in physical and economic terms.

Agricultural inputs increased more rapidly in the first decade before 1969 than after 1969. Total inputs increased at 2 percent per year from 1960 to 1980. Agricultural land, farm machinery, the ratio of land to labour, and non-farm current inputs had declining trends. Agricultural labour increased more or less continuously at a rate of 2 percent per year.

Growth in agricultural output was closely associated with productivity of the primary resources than with growth in total inputs, particularly after 1969. Productivity accounted for over 50 percent of the growth in output.

Prices of agricultural commodities also influence the pattern of production and value of output. Between 1969 and 1980, the prices of export crops and industrial crops were relatively more favourable than the prices for food crops. Export crops increased faster than food crops during this period.

Regression analysis, showed that the coefficients for labour and capital were significant at 5 percent level of significance, while the coefficients for land and current inputs were not significant at 5 percent level of significance.

Marginal productivity analysis yielded marginal productivity for labour of K£528 per worker. The marginal product for fertilizer was K£154 per ton, while those for land and capital were K£51 per hectare and K£6 per £ invested, respectively.

Future growth in agricultural output must come from increased productivity of the inputs, because growth in inputs, especially land input, has declined. The key factor to improvements in land productivity seems to be increased fertilizer use, which has a higher marginal product than land and capital. Increased use of labour rather than capital is also an important factor for future growth in output. In addition, a sound price policy which offers incentives to farmers is another important factor for sustaining rapid output growth in future.

CHAPTER ONE

1.0 INTRODUCTION AND STATEMENT OF THE PROBLEM

Economic growth, development, and improvement of the standard of living for the majority of the people, are among the basic goals every nation tries to achieve. In developing countries like Kenya, agriculture is the main potential source for economic growth. Essentially, agriculture forms the backbone of the national economy for these countries. Normally it is the largest sector, at least in the early stages of development, and therefore, it is the major source of employment, food, raw materials for domestic industries, and for earning foreign exchange. Above all, the agricultural sector forms the basic potential source of savings for non-agricultural investment. For these vital roles to be fulfilled, high rates of output growth must be sustained. In addition, some studies by Hayami and Ruttan, 1971, Johnston and Southworth, 1975, have so far revealed that low productivity in agriculture could limit economic growth.

In the Kenyan economy, agriculture accounts for over 30 percent of the total real Gross Domestic Product (GDP)[1]. In addition, 85 percent of the active population derive their livelihood from agriculture. Agriculture also contributes about 65 percent of the total foreign exchange earnings through the export of coffee, tea, pyrethrum and horticultural products.

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[1] 30 percent is the figure for 1980 indicated in Republic of Kenya (1981), Economic Survey Ministry of Economic Planning and Development Central Bureau of Statistics (CBS), Nairobi.

Due to a rapidly growing population, the demand for food has also increased enormously resulting in more pressure on the sector to increase food production. Therefore, for the sector to meet these demands, it is essential to improve productivity within the sector. This concern for a sustained growth of agricultural output is particularly emphasized in the government goal of self-sufficiency in food production[2], and poverty alleviation in the rural farming community.

Overall, agricultural production has increased substantially from 1960 upto 1980 mostly as a result of commercialization of small holder agriculture. However, the transition over the years has not been steady because of year to year fluctuations between poor and favourable performance. Unfavourable weather conditions and high cost of purchased inputs have generally been considered as the major contributors to the poor performance, while rises in producer prices have been considered as the source of most of the favourable performance. For instance, the highest growth in agriculture was observed during 1974-78 period when the value of annual output was about K£533 million. Immediately after, agricultural production tended to show a declining trend, and by 1980, agricultural output had decreased by K£11 million as shown in Table 1.1.

[2]This objective is spelt out in the Sessional Paper No. 4 of 1981 on Food Policy.

TABLE 1.1: AGRICULTURAL OUTPUT (VALUE ADDED) AT CONSTANT PRICES, POPULATION AND VALUE ADDED PER CAPITA

YEAR	VALUE ADDED Km£ (Constant prices)	POPULATION '000s	VALUE ADDED PER CAPITA (K£)
1978	533.3	14,760	36.1
1979	529.1	15,327	34.5
1980	522.0	15,894	32.8

Source: Republic of Kenya, 1981, Economic Survey 1981 pg. 104. Central Bureau of Statistics.

Changes in producer prices affect the value and quantity of agricultural production. In this case, prices of cash crops, particularly export crops, accounted substantially for the sharp rise in value of agricultural output in 1977-78 and also for part of the decline observed immediately after 1979. However, a breakdown showing the changes occuring in inputs and the productivity of these inputs, provides a complete picture and a better understanding of the whole process of agricultural growth and development. This need to understand agricultural growth and productivity is particularly relevant when per capita availability of agricultural products shows a continuous declining trend as shown in Table 1.1.

In general, an increase in agricultural output depends on an increasing use of inputs, particularly yield-increasing technical inputs[3] such as fertilizers for crops, and manufactured feeds for livestock. Sucn inputs, generally improve the productivity of the primary factors of production, land and labour.

Land and labour are among the most important inputs in Kenyan agriculture. They both determine the quantity of output that can be produced. The altimate growth of agriculture depends on the availability of land and labour to some extent, and therefore, a shortage in either of the two could limit the growth of output. Generally, land is believed to be most scarce compared to labour in view of the fact that the agricultural population has increased tremendously over the past years leading to shrinkage in holding sizes. Despite this absolute increase in population, majority of farmers experience acute labour shortage as people move out of farming areas possibly because of low farm wages. For instance seasonal bottlenecks have been experienced in relation to enterprises like coffee, tea, cotton and maize, by smallholders at peak periods such as weeding and picking (Republic of Kenya 1979 - Farm Management handbook Vol. 1 pg. 12). Thus outmigration of people from rural areas to urban centres is contributing

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[3]Yield-increasing technical inputs refer to non-farm current inputs that increase the poutput from a given piece of agricultural land, usually chemical fertilizers, herbicides and pestcides. In this study it refers to fertilizers and pestcides.

to seasonal labour shortage especially casual hired labour. Therefore, despite the rapid growth in the total labour force, agricultural labour input is still crucial in many farms and its productivity would influence the overall growth of total output.

In addition to determining total output growth, labour productivity is also an important indicator of the standard of living and can only increase if output per worker increases. However, since land is scarce, it is important to understand processes that would lead to an increase in the productivity of the existing land.

In studying agricultural growth in Kenya, the study aims to bring out a better understanding of the sources and rates of growth in agricultural production over the years. In this regard, the study aims to reveal the patterns of change in factor inputs, their contributions to total growth of output, and the contributions of changes in productivity to growth in output per capita. Thus, in distinguishing productivity growth from the growth of total factor input, the study hopes to reveal the key factors that has accelerated or hindered the growth of output and thereby suggest implications regarding future agricultural development in Kenya.

1.1 SPECIFIC OBJECTIVES OF THE STUDY

The first objective is to estimate the rates of growth in total agricultural production, factor inputs, "total" and "partial" productivities with respect to total factor input, land and labour. This will involve growth accounting procedures, showing the patterns in productivity change and in factor inputs from 1960 to 1980.

The second objective of the study is to estimate a production function for Kenyan agriculture and derive elasticities of production and marginal productivities of the various factor inputs

1.2 ASSUMPTIONS ON THE HYPOTHESIS

The following assumptions were made in connection with the hypothesis to be tested.

Management is a non-conventional input constituting one of the most important single factor, particularly on large farms. Its improvement over time, normally enhances the productivity of the aggregate inputs. This effect can be observed in the present analysis in the trends in land and labour productivities, especially where total inputs have remained constant or declined. Although the present study cannot isolate and analyse the effect of changes in management, its overall impact is indicated in the coefficient of time variable along with other infrastructural changes.

The second assumption concerns the input of land. Agricultural land was assumed to be homogeneous and no distinction was made between high, medium and marginal potential. Although the term homogeneous can be misleading since land can never be trully homogeneous even within a small area, the term was used to refer to the broad classification of agricultural land in Kenya. Since it was not possible to breakdown output quantities according to the different land categories this assumption was made. For large scale farms which form the basis for the test of the hypothesis, the assumption is fairly acceptable since majority of these farms are found in medium potential areas and only to a small extent in high potential areas in the Rift Valley.

Regarding current inputs, the exact quantities of fertilizers applied in large scale farms are used in the regression for the large farm sector. Although smallholders use chemical fertilizers, no assessment for this sector can be done on time series basis because the required data is not available. For the total agricultural sector, it was assumed that a lag of one year would be adequate for such handling activities on imported quantities of fertilizer before being used productively by farmers. Another assumption made with regard to current inputs, was that the quanties of fertilizer used were suitable to the local conditions.

1.3 THE HYPOTHESIS

The hypothesis in the present study concerns the effect current inputs have had in the growth of agricultural output and total productivity for the last 20 years. It states that fertilizer use has contributed significantly in raising agricultural output in Kenya.

1.4 SCOPE AND METHOD OF STUDY

By definition, agricultural productivity can be defined either in the context of a productivity index or in terms of a production function. In terms of a productivity index, productivity can be expressed in two ways. First, as output per unit of total factor input, conventionally referred to as "total productivity". In the second way, productivity can be expressed as output per unit of a single factor input usually land or labour, known as "partial productivity".

Both "partial", and "total" productivity estimates are important in aggregate productivity analysis and growth accounting. They have been used considerably in several countries for agricultural analysis, planning and management. Hayami and Ruttan (1971,; 1979), Yamada and Hayami (1979), have observed that productivity estimates can provide new insights into the process of agricultural growth. In addition, Hayami and Ruttan (1979) noted that, these estimates could be used in monitoring the results of micro-development investment decisions, programmes and agricultural activities. In this regard, they could provide a clear indication, in a general way, on the agricultural development strategy and management of a region, as well as help to determine the success of the sector's development strategy. For instance, estimates of productivity showed to some extent, the effectiveness of agricultural development strategy, programming and management in Taiwan, while in the Philippines the estimates revealed a need for re-examination of these activities to improve on efficiency (Hayami and Ruttan 1979).

In analysis and planning, "partial" and "total" productivities are most useful where the supply of a given factor input is relatively inelastic and where it represents a serious constraint on the growth of output. For instance, where land is most limiting to the growth of output, then the plan would be to monitor the productivity of land through efficient use of yield-increasing inputs such as fertilizers. Where labour is scarce, then the focus would tend to be on those technologies that raise output per worker.

Agricultural productivity can also be analysed within the framework of a production function. In this approach, productivity is normally expressed as a shift of the production function and measured by the production function estimates.

The extension of productivity analysis to include both the productivity indexes and the production function estimates permits a better interpretation of the rates of growth in output. This is because agricultural production depends not only upon the factors of production, but also it depends on factor-factor combinations and other factor effects which cannot be expressed in the index approach but can be represented in a production function.

This study uses both index and production function approaches. In the index method, agricultural output is compiled from crop and livestock data for the period 1960-1980, and aggregated into one output index using Laspeyers quantity index. Time series data for the inputs were also compiled from various sources and converted into indexes using the Laspeyers quantity index. An index for total factor input was also computed from the individual input indexes using the index formula of Divisia. The formulae specifications are discussed in the Chapter on "Theoretical framework and Methodology", while details on calculations and data sources are given in the Annex.

The Production Function method is based on the Cobb-Douglas production function in its unrestricted form. The analysis involved two regression models, one for the total agricultural sector for the purpose of predicting productivity change over the twenty year period of study. The second regression represents time series production function for Large Scale Farms, which have a better data base, from which marginal productivities of the various factor inputs are calculated.

1.5 ORGANIZATION OF THE STUDY

The study is divided into five chapters and an annex. Four of the chapters cover the core of the study, the fifth chapter gives the summary, conclusions and policy implications.

The annex gives supplementary information covering data sources and details on the index calculations.

Chapter I is divided into five sections each, covering on introduction and problem statement, objectives, assumptions on hypothesis, the hypothesis and scope of the study, respectively. In Chapter II, a review of previous studies relevant to the subject is presented, emphasising on method and interpretation of results. The third and fourth chapters, present the theoretical framework and method of analysis, and the results, respectively.

CHAPTER TWO

2.0 LITERATURE REVIEW

Studies on quantitative description of the agricultural sector require good data especially time series covering a long period of time. Many developing countries have not been able to keep good time series data, and as such, few studies have been carried out. In developed countries, such as the United States and Japan, good long-term data on the growth of output and productivity have been available for some time now, and the current ideas regarding aggregate productivity and growth analysis in agriculture are based on studies conducted in those countries.

The pioneering work in agricultural productivity growth was carried out by Hayami (1969) for United States and later by Hayami and Ruttan (1971) for United States and Japan. The method employed in these pioneering studies and in later studies in Korea by Ban (1979), in Taiwan by Lee and Chen (1979), and in Germany by Weber (1973), involved the production function approach, the productivity index approach alongside the "Induced Innovation Hypothesis". This hypothesis which was used in interpreting results was developed by Hayami and Ruttan (1970, 1971).

The basic principle in the "Induced Innovation Hypothesis" is the assumption that factor supply changes, as reflected in the relative prices, influence the direction and progress

explain in detail

in agricultural technology development, adoption and eventual agricultural growth. In the course of agricultural development, farmers are 'induced' to seek for technologies that relieve the constraint imposed by the most scarce resource so as to increase their output. Where land is very scarce, output is expected to grow through the use of yield-increasing technologies, while if labour is in short supply, mechanical techniques of a labour-saving type, tend to be adopted by farmers.

In the Hayami-Ruttan (1970, 1971) studies, sectoral production functions were estimated using time series data for Japan (1880 to 1960), and United States (1880 to 1960) agricultural sectors to analyse productivity growth rates. They observed high growth rates in output, labour and land productivities. Using the "Induced Innovation Hypthothesis", Hayami and Ruttan (1971) noted that in the United States where labour was scarce, relative to land, mechanical technologies in the way of farm machinery were adopted and led to high growth rates in output and in labour productivity, primarily due to increased land area per worker. In Japan where agricultural land was very scarce, the authors observed a progress in the use of biological technologies of a yield-increasing, land-saving pattern which accounted for growth in output per hectare.

Following Hayami and Ruttan (1970, 1971), other studies have been carried out in a number of countries, which have also indicated that, factor substitution of technical inputs

(Fertilizer for land, machinery for labour), for the scarce primary resources plays a big role in the growth of output and productivity. Yamada and Hayami (1979), extended the Hayami-Ruttan study for Japan (1880 to 1960) upto 1970. They observed that, improved varieties together with increased use of fertilizers and other current inputs that substitute for agricultural land improved labour productivity as a result of increased output per hectare.

Similar observations were made for German agricultural growth by Weber (1973). Weber (1973) noted that, similar to the "Induced Innovation Hypothesis" characterized in United States and Japanese agricultural development, Germany sustained high rates of growth through a system of "Choice" of technology, whereby industrial as well as non-industrial products were used as substitutes for scarce land resource. Labour was not scarce during that period (1880 to 1913) in Germany because of immigration of workers into Germany from the neighbouring countries.

Similar work on the subject in presently developing countries like Kenya which could form a basis for meaningful comparative assessments are very scanty. However, results of studies carried out in Taiwan, Korea and the Philippines, where the characteristics of the agricultural sector closely ressemble those prevailing in Kenya, could be used to represent developing countries.

The endowment position is charactirized by insufficient land resource, small scale farming, and a generally elastic labour supply with occassional shortages at peak periods (Ban, 1979; Crisostomo and Barker, 1979; Chen and Lee, 1979). Major crops include tea, sugarcane, maize, cotton and rice. The main differences between Kenya and these countries are the high rates of growth in output and highly developed agricultural sectors in the latter. In addition, existence of other sectors like mining and industry may account substantially to the development of agriculture in these countries. However, the central unifying feature as far as agricultural development is concerned is the challenge that faces all these countries imposed by the necessity for sustaining rapid growth in output per capita at times characterized by high population growth, scarce land base and rising costs of yield-increasing technical inputs.

Table 2.1 presents the productivity accounting estimates for the three countries in South East Asia. The authors of the individual studies give both similar and slightly divergent observations on the productivity gain obtained. Yamada and Hayami (1979) emphasised the role of biological innovations that improve a plant's capacity to respond to fertilizer use, in their explanation for high land productivity in Japan. In the Philippines, Crisostomo and Barker (1979) did not observe any direct relation between changes in the level of non-farm current inputs and land productivity. Instead they observed that growth in land productivity was mainly as a result of

TABLE 2.1: PRODUCTIVITY ACCOUNTING ESTIMATES FOR THE THREE COUNTRIES

ANNUAL GROWTH RATES (Percent).

COUNTRY	OUTPUT	PRODUCTIVITY				
		TOTAL	Y/A	Y/L	LAND	LA
TAIWAN 1960-1970	4.2	1.0	3.9	3.3	0.5	0
KOREA 1953-1969	5.1	3.0	3.5	5.6	1.0	1
PHILIPPINES 1959-1969	4.0	0.8	1.9	1.6	1.9	2

Where Y/A is Land productivity, Y/L is Labour productivity.

Source: Compiled from Ban, 1979 (Korea); Lee and Chen, 1979 (Taiwan) (Philippines); in Hayami, Ruttan, Southworth (ed.) 1979, A Taiwan, Korea and Philippines.

changes in yields of the major crops, whereaby food crops rather than export crops were the chief contributors. Thus, the use of technical inputs alone resulted in only a modest growth in output, while changes in the product mix and product performance due to breeding and selection had significant effect on the growth of output in the Philippines.

The authors of the Taiwan study noted remarkable advancement in agricultural technology as the basis for the high output growth (4.2 percent) and land productivity gains (3.9 percent). Similar to the Hayami-Ruttan model, substitution of new techniques for the scarce land resource was the chief source of the observed growth rates in Taiwan. The authors noted that the high growth rates were as a result of strategies involving the use of improved crop varieties, pest and disease control, improved cultural methods, and irrigation facilities coupled with intensive use of fertilizers.

Similar remarkable achievements in technology adoption were observed in Korean agriculture by Ban (1979). Ban (1979) also noted that the level of education and skill among farmers was a contributing factor to the high productivity of the farming community in Korea.

A similar quantitative discription for Kenya's agricultural sector is not yet available. However, some relevant comparison is provided by a study carried out by Weber (1981). Weber's study is essentially an energy output:input analysis covering the whole of the agricultural sector. However, within the context of the study, Weber (1981) included an economic analysis for the purpose of showing the changing values of the various factor shares. The data used by Weber (1981) was compiled from both local and FAO statistical publications. His findings showed to some extent the growing concern over shortage of agricultural land. However, Weber in addition, observed that fertilizer consumption which is the conventional substitute for land, did not grow as would have been expected. Instead, after reaching a peak in 1972, the fertilizer consumption per hectare showed a continuous declining trend of 2 percent per year. From this observation it is relevant to reconcile the observed trend with more information on factor productivity as it affects the growth of output.

Regarding agricultural productivity, Weber's study indicated a deteriorating ratio of output to input from 2.2 in 1962 to 1.3 in 1977. In Weber's opinion the impact of fertilizer on output was hindered by un availability of fertilizers after 1972, leading to the declining trend of 2% per year on fertilizer consumption per hectare. This opinion was supported by his marginal productivity results which showed the highest figure (13.4) for fertilizer compared to the other inputs, of land, labour and machinery.

Of the studies briefly reviewed, Weber's study, although not a growth accounting study, it represents a starting point for furthering our knowledge in the process of agricultural productivity change in Kenya. The studies carried out in South East Asia, however provide the foundation for the methodology, and interpretation of the results in the present study.

CHAPTER THREE

3.0 THEORETICAL FRAMEWORK AND METHODOLOGY

The analysis of agricultural growth and productivity for Kenya in the present study is carried out using the index approach and production function approach. The Index method provides the framework for deriving growth rates in output and productivity, while the production function analysis shows the factor-factor combinations as they affect total production.

3.1 THE INDEX NUMBER APPROACH

Agricultural productivity within the index number framework can be expressed in terms of output per unit of a single input, usually land or labour, or in terms of output per unit of total factor input. The latter gives a "total" measure of productivity while the former represents a "partial" measure in the sense that it does not account for the effects of other factor inputs. The important "partial" productivity indexes are land productivity and labour productivity i.e. productivity of the primary factors of production.

Labour productivity, normally expressed as output per worker or per man-equivalent, is important because it can provide useful information regarding the economic progress of a region. For instance, an estimate of labour productivity can be used as a major determinant of farm incomes. It has been used as such in Sierra Leone by Spencer and Byerlee (1976), in India and Israel by Evenson and Kislev (1975), and in the United States and Japan by Hayami and Ruttan (1971).

Land productivity is also important and has been used, mainly in a broader sense as an indicator of agricultural development. The two productivities are linked by the ratio of land area to labour as shown below:-

$$\frac{Y}{L} = \frac{A}{L} \cdot \frac{Y}{A} \text{ ---------------- } (3.1)$$

Where, Y is agricultural output in value (KSh.)

L is labour input in man-equivalents

A is land input in hectares

and, Y/L is labour productivity

Y/A is land productivity

A/L is land area per worker (ratio of land to labour).

This equation states, by "definition" that, labour productivity is equated to increase in yield and land/labour changes.

"Partial" productivities, however, become less adequate as measures of productivity on their own as the modernization of agriculture proceeds. Land and labour productivities tend to become biased estimates to some extent because they include effects of factor substitution together with effects of advances in production techniques. Christensen (1975) for instance noted that:-

> "--------as a general rule, it is better not to limit productivity indexes that purport to measure changes in efficiency to a comparison of output with a single resource. The broader the coverage of resources, generally the better is the productivity measure. The best measure is the one that compares output with the combined use of all resources."
>
> (Christensen, 1975, page 910)

The result of the inadequacy of "partial" productivities was that "total" productivity indexes were developed. Both "total" and "partial" productivity indexes are derived in the same way. The approach involves the computation of an Index of total output, indexes of individual factor inputs, and an index of total factor inputs. From this, the "total' factor productivity is obtained as the ratio of the output index to the index of total factor inputs. Similarly, the "partial" productivities are derived as the ratio of the output index to the respective factor input index as shown below:-

$$\text{"Total factor productivity} = \frac{\text{Index of total output}}{\text{Index of total factor input}} \quad \text{-------(3.2)}$$

$$\text{Land productivity} = \frac{\text{Index of total output}}{\text{Index of Land input}} \quad \text{------------(3.3)}$$

$$\text{Labour productivity} = \frac{\text{Index of total output}}{\text{Index of labour input}} \quad \text{-------------(3.4)}$$

In calculating the indexes of inputs, output and productivity, output is expressed in value terms, and the inputs in physical terms. However, because prices of agricultural products change considerably over time, constant prices have been used to minimise the fluctuations associated with estimates in terms of value. Physical units represented by grain equivalents are also used and are explained in Section (3.1.2).

3.1.1 THE DRAWBACKS INHERENT IN THE INDEX APPROACH AND THE INDEX NUMBERS USED

The problems that underly the empirical estimation of productivity indexes and growth accounting are; the Index Number problem, procedures to account for depreciation, and the procedures for incorporating inputs not adequately measured in conventional national accounting systems, such as quality of agricultural labour. According to Hayami and Ruttan (1979), these problems have been the centre of continuous debates in growth accounting.

The last two are problems involving measurements for fixed items such as buildings, machinery and for non-conventional input factors such as education, training, sex and age differences in labour, and research variable. The procedures followed involve the use of convertion ratios set for depreciation, and dummy variables or weighting factors for the fixed inputs, and non-conventional inputs, respectively.

The major problem reflected by the index approach is centred on what type of index formula to use, because the results may be different, depending on the formula used and the length of the period. Essentially, the index number problem refers to the choice of weights used in aggregating the input or output categories. For instance, the use of fixed price weights leads to a quantity index (Laspeyers), while fixed quantity weights leads to a price index (Paasche). In such a case, if there are significant shifts in the structure of the variables over the period, the resulting indexes may be biased upwards if a Laspeyers type of Index formua is used or biased downwards in the case of a paasche type of index. Thus, incomparability of indexes may result. However, no ideal solution has been agreed upon.

Evenson and Kislev (1975) used a price-weighted Laspeyer's quantity index to aggregate output categories into a single output index, and the Divisia index to aggregate factor inputs to a single total input index in their study for Israel and Indian agricultural growth. The Divisia index formula was also used by Lee and Chen (1979) for Taiwan Agriculture. According to Lee and Chen (1979) the Divisia index formula gives indexes of total factor input which are comparable over longer periods of time.

In symbol notation, the common form of a Divisia type of index can be written as:-

$$I_t = I_{t-1} \sum W_{i,\,t-1} \frac{Q_{i,\,t}}{Q_{i,\,t-1}} \text{ --------- } (3.5)$$

(t = 1, 2, 3, ------------ 20)
and 1 = 1960, the base year

where, I_t is the index of total factor input in year t.

$W_{i,\,t}$ is a weighting factor of input i in year t. W_i is computed as the factor-share of input i in the total cost.

$Q_{i,\,t}$ is the index of input i in year t. i.e., indexes for land, labour, current inputs, machinery, and they are computed separetely using Laspeyer's quantity index.

t - 1 refers to the year immediately before year t, and it permits the calculation of a series of chain-linked indexes.

The calculation involves a series of year to year ratios for each factor input index, (i.e. $Q_{i,\,t}/Q_{i,\,t-1}$) weighted by factor shares to give chain linked ratios. The sum of the ratios for each year (t) is finally multiplied by the total input index of the preceeding year (I_{t-1}) to give the next index in the series. The calculation is repeated for all years until a chained series of total input index is developed.

Factor-shares are used as the weights in the Divisia index rather than the prices of the individual inputs, because factor shares constitute proportions of the cost of the inputs in the total factor cost. According to Lee and Chen (1979 page 276), factor-shares do not fluctuate very much when averaged over a period of time, and therefore give indexes which are comparable over a long period. By definition, a factor-share of an input is the proportion of the cost of that input in the total factor caost. Its use in the Divisia Index has been preferred because the resulting indexes are relatively more accurate.

The use of the Laspeyer's index formula in productivity studies, stems from its ease of use and intuitively appealing interpretation. According to Freund and Williams (1958), and Christensen (1975), the most attrative feature of this index, is that prices are held fixed at base period levels, so that the resulting index shows the change in output or input that resulted from pure quantity changes.

In symbol notation, the Laspeyers Index can be written as:-

$$I_t = \frac{\Sigma q_t \, p_o}{\Sigma q_o \, p_o} \text{ -------------- } (3.6)$$

$$(t = 1961, 1962, \text{ ------------ } 1980)$$

where, q and p refer to quantity and price respectively.

The subscripts zero and t, refer to base year and comparison year respectively.

The main drawback inherent in a Laspeyer's type of index is that it is equivalent to a linear production function, which specifies, a priori, that all factors are perfect substitutes in the production process. Although this condition is unrealistic, the formula remains popular and gives reliable indexes.

3.1.2 THE INDEX CALCULATIONS

The data base for the calculations of the indexes is time series data on total agricultural output compiled from crop and livestock production statistics covering the period 1960 to 1980. Agricultural inputs, land, labour, current inputs and farm machinery (tractors) was compiled for the same period. This data is secondary and a number of difficulties were encountered in putting it together because of incompleteness and changes in recording system of the sources available. Details of these problems and how they were solved are given in the annex (A).

The computation involved aggregating all the commodities on an annual basis using the Lasperys index. This aggregation was done in value using constant (1970) prices, and also in physical terms using grain equivalents. The 1970 period was chosen for deflecting the prices of the agricultural commodities because it divides the study period into two halves making the reference not too far back. The grain equivalent measures were obtained by dividing the value of output by the price of maize, giving output in terms of maize, the main grain crop in Kenya.

Indexes of individual inputs were calculated using Laspeyers quantity index, while the total input index was derived using the Divisia Index. Factor-shares of the individual inputs, averaged over a five-year period were used as weights in the Divisia index. This procedure was preferred because it gives fairly accurate and comparable indexes of total input. For instance, Lee and Chen (1979) noted that,

> "------substantial changes in the factor-shares over the period of study, however, makes it inappropriate to use constant weights taken from a particular base period. Not only would the selection of the base period be arbitrary, but its choice would greatly affect the index, and comparisons made using the index would be less and less accurate the longer the period over which the comparisons were made."
>
> (Lee and Chen 1979, page 276).

To obtain the actual estimates of productivity, the output index was simply divided by each respective input index. Finally, growth rates which portray the changes in productivity and in inputs were calculated as compound annual rates of change between the initial and terminal values of estimates over the period investigated (1960-1980).[4] Further details of the calculations are given in the Annex (B).

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[4]As an a example, in 1970, indices for land, labour, fertilizer, machinery, total inputs and output were 99.29, 123.30, 340.58, 133.60, 118.8 and 105.74, respectively (1960-64 = 100).

3.2 THE PRODUCTION FUNCTION APPROACH

In the production function approach, producvitity is given by the production function estimates. Generally a suitable production function for the agricultural sector is specified and regression coefficients are estimated. The resulting estimates are indicators of elasticity of production with respect to the variable inputs. In addition, depending on correct specification of the model, the estimates can also be interpreted as indicators of relative importance of each factor in explaining productivity.

The production functions used in these studies are the Cobb-Douglas, constant Ellasticity of substitution and Input-output functions. The Cobb-Douglas has been used in this study, because of its basic consistency with established body of economic theory, its computational simplicity and the fact that it gives realistic fit to the data without excessive demands on data quality. Ban (1979) used it successfully for post-war Korean agriculture.

3.2.1 THE ADVANTAGES AND LIMITATIONS OF A COBB-DOUGLAS FUNCTION

Although the Cobb-Douglas production function is most popular in econometric research, some of its properties seem intuitively unrealistic, such as the assumption of unitary elasticity of substitution among factors, or the assumption of a strictly linear expansion path. According to Heady and Dillon (1961 page 76), the most relevant limitations of the Cobb-Douglas in production function analysis is that, the function is unsuitable in cases where there are ranges of both increasing and decreasing marginal productivities or for data that yields both negative and positive marginal productivities of the input.

Inspite of the above limitations, the function has been used satisfactorily in econometric work. From Heady and Dillon (1961, page 75) and Yotopoulos and Nugent (1976 page 52), the Cobb-Douglas function is believed to have become most popular because it provides a good compromise between adequate fit of the data, simplicity in form and computational feasibility and sufficient degrees of freedom for statistical testing. In addition Yotopoulos and Nugent (1976, page 52) observed that,

> "----Its estimation provides important information that is generally consistent with some a priori notions of economic theory, such as the extent to which a factor's marginal productivity declines as the level of input increases, -------measurements of returns to scale ------, which have important policy implications."
>
> (Yotopoulos and Nugent, 1976 page 52).

As far as estimating productivity is concerned, this function has been shown to be adequate for explaining productivity change in agriculture. Hayami (1970) and Hayami and Ruttan (1971) conducted statistical tests to check the acceptability of the Cobb-Douglas function in productivity analysis. The results of their tests showed that, both the property of unitary elasticity of substitution among factors inherent in the Cobb-Douglas function, and the test of the stability of the function over time, had little evidence against its use in productivity studies.

On simultaneous equation bias inherent in the Ordinary Least Squares Procedures (OLSE) of estimating the Cobb-Douglas, Hayami (1970) showed that it is minimum where most inputs are in stock terms. The problem arises from the assumption of profit-maximizing behaviour in the test of allocative efficiency. This introduces other relationships between the inputs and output which hold simultaneously with the technological relationship of the production function. For instance, the levels of the inputs in producing the output in a given equation may also depend on the error term. Since this violets the OLSE assumption that the inputs are independent of the error term, the equation cannot be estimated by this procedure.

3.2.2 THE MODEL

The present study employs the Cobb-Douglas production function to derive production function estimates for Kenya's agricultural sector. In symbol notation, a production function for homogeneous firms is expressed as,

$$Y = f\,(X_1, X_2, X_3, \ldots, X_n) \text{ ----------- } (3.7)$$

Where Y is output,

X_1, X_2, X_3,...X_n are the factors of production which determine the output Y.

Using the symbols in equation (3.7) for homogenous firms, the Cobb-Douglas, which is a power function can be written as,

$$Y = A\, X_1^{\beta^1} X_2^{\beta^2}\; X_3^{\beta^3} \ldots\ldots\ldots\ldots\ldots\ldots X_n^{\beta n} U \text{ ---------------- } \quad (3.8)$$

Where Y is the output, X_1,-----X_n are inputs, A is a constant term, and β_i defines the transformation parameter for the level of input.

In this study, the output is expressed in value, and the variables land, and labour in physical units, current inputs and capital in value terms.

For simplicity, the Cobb-Douglas function is normally transformed into logarithms (base e) which becomes a linear function. Thus, the Cobb-Douglas has been used in its linear form to estimate a time series production function for the agricultural sector to derive productivity change, and also in estimating production coefficients for the large scale farm sector. A time series regression for the small scale farm sector was not possible because of lack of data.

Thus the function to be estimated can be represented by the linear form of the Cobb-Douglas production function, in the logarithms of the variables as,

$$\ln Y = \ln A + \beta_1 \ln T + \beta_2 \ln L + \beta_3 \ln N + \beta_4 \ln F + \beta_5 \ln M + \ln U \text{ ----} (3.9)$$

Where, Y is output in value

L is agricultural land in hectares

N is agricultural labour as number of workers

F is acurrent inputs measured in terms of value of fertilizers and pesticides for the total agricultural sector, and in terms of tons of fertilizer applied in large farms.

M is capital in value

T is time in years

A is a constant

β_1 is the coefficient of time and indicates productivity change

$\beta_2 - \beta_5$ are the production coefficients for variable inputs.

3.2.3 VARIABLES IN THE REGRESSION

THE DEPENDENT VARIABLE

The dependent variable is agricultural output. In the model for the agricultural sector, it is defined as the gross value of production of crops and livestock products. [5]In terms of physical units, where output was expressed in grain equivalent, the resulting equation seemed unrealistic because both land and labour had negative coefficients. The measure of output in grain equivalent was subsequently dropped in the regression analysis. In large scale farms, the dependent variable was also expressed in value.

THE INDEPENDENT VARIABLES

These are the physical factor inputs which are assumed to explain the changes in the output variable. The process

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[5]To arrive at the grain equivalent measure, output was compiled in value terms and then divided by the price of maize. Details of computation given in Annex (page 96).

of agricultural production is influenced by many factors ranging from conventional to non-conventional inputs such as education and skill. However, only those of which reliable data was available were used to specify the production function. model. These included Land, Labour, current and non-farm inputs and capital.

Agricultural Land

There was no distinction made between land of high potential and that of medium to marginal potential. This variable includes arable land, land under permanent crops and pastures, in the case of the total agricultural sector. In large scale farms, the area under specific crops was used.

Land is an indespensable factor of production without which production cannot be realized. A negative sign of the coefficient for land would mean that an increase in the level of land input would lead to a decrease in total output, other factors ceteris paribus. A positive sign means total output increases with an increase in the level of land input, ceteris paribus. The negative sign is unrealistic, therefore, the expected sign should be positive.

Agricultural Labour

Labour has been expressed in stock terms. In the model for the agricultural sector, the labour input is represented by the number of people who are economically active in farming. For the large farm sector, hired labour as indicated in the large farm census report, was used. An increase in agricultural labour is expected to lead to an increase in total output especially in view of the fact that seasonal labour bottlenecks are common in most farms. The logic sign of the coefficient for labour is therefore positive.

Current non-farm Inputs

These are variable inputs originating from the non-farm sector. They are represented by imports, of fertilizer and pesticides estimated in value for the total agricultural sector model. In the analysis, a lag of one year was introduced into the model to take care of the time spent in handling activities until the inputs are productively used by farmers. For the large farm sector, the quantities of fertilizer applied each year on the farms was used.

In general, when the right current inputs are used and in the correct specified application rates, one would expect an increase in production. However, there are other factors also that tend to influence the success of this technology among farmers. For instance, the input has to be available at the right time for it to affect the production. Moreover, if the price of the input is too high compared to the value of the output, farmers might not adopt it. Similarly, the overall advantages of the use of current inputs, especially fertilizers which are yield-increasing, can only be realized if they are accompanied by availability and use of improved crop varieties, that are more responsive to high levels of fertilizer application. In this study, the model assumes that the above stated conditions hold, so that a positive sign of the coefficient is expected.

Capital Input

For Large Scale Farms, value of capital items indicated in large farm census reports was used. For the total sector, there was a problem of getting information on all capital items used by all farms. Small holders tend to use hand hoes or ox-ploughs, but data on these items is not available. For this reason, the value of tractors, depreciated at prevailing interest rates was used. This underestimates the capital input for the total sector, but is fairly acceptable for the Large Scale Farms which is the basis of the regression analysis. It is an important input especially on large farms and is expected to have a positive sign for the coefficient.

Time

This is a variable which was included in the regression for the agricultural sector. It represents the effects of certain important factors that have taken place since 1960, such as improvements in breeding, extension education, infrastructure and marketing. It is expected to have a positive sign of the coefficient, which is the indicator of productivity change.

The method of analysis adopted to estimate the production functions was the Ordinary Least Squares Estimation procedure. This gives the regression equations for each function, showing the production coefficients of the various inputs. These coefficients have important economic implications in the production process. For instance, if the coefficient of a given input is less than one, this implies that one percent increase in the level of that input (holding other inputs constant) would increase output by less than one percent. On the other hand, if the coefficient is greater than one, then for each one percent increase in the level of that input (holding other inputs constant), would increase output by more than one percent.

Another important result of the estimated equation is the extent of economies of scale which is indicated by the sum of the coefficients of the respective inputs, under perfect competition. If, for example the sum of the coefficients is less than one, then a one percent increase in the level of all inputs would result in an increase in output of less than one percent. This result indicates decreasing returns to scale. If the sum of the coefficients is greater than one or equal to one, it implies increasing and constant returns to scale, respectively.

CHAPTER FOUR

4.0 EMPIRICAL ANALYSIS OF GROWTH IN AGRICULTURAL PRODUCTION

Agricultural production in Kenya is considerably diversified, with commodities ranging from export crops, food crops, dairy and livestock products, to temporary and industrial crops. The leading export crops are coffee, and tea. Other important export crops include, wattleback, cashewnuts, sisal and horticultural products. The main food crop is maize, but other food crops include wheat, rice potatoes, pulses, vegetables and fruits. In the analysis, agricultural growth in Kenya was therefore computed in total output and also in commodity groups using growth accounting procedures. However, the fact product relations were also analysed using the regression analysis.

4.1 RESULTS OF INDEX CALCULATIONS

The results of the index calculations show the rates and sources of growth in agricultural production since 1960 upto 1980. These results are expressed in terms of value and also in physical units using grain equivalents.

In terms of grain equivalent, the growth rates in output and productivity were observed to be generally higher than those in value terms. This was thought to be due to the fact that the price of maize which was used to deflate value into grain equivalent is a controlled one and does not fluctuate much.

Thus the year to year price fluctuations which affect the value measure are minimised for output in terms of grain equivalent.

4.1.1 TREND IN TOTAL AGRICULTURAL PRODUCTION AND BY COMMODITY GROUPS

Overall, agricultural production in Kenya has grown substantially over the years, increasing to more than one and a half times (from KSh.3464 million in 1960 to KSh.6288 million in 1980) its level two decades ago, inspite of setbacks caused by unfavourable weather. An average annual compound rate of over 3 percent was observed for the twenty years under study (Table 4.1). The rate of growth was even higher in grain equivalent (averaging over 4 percent), implying that the price of maize has increased relatively slowly compared to the price of other farm products.

TABLE 4.1* GROWTH RATES IN TOTAL AGRICULTURAL PRODUCTION BY COMMODITY GROUPS (Constant 1970 prices), 1960-1980 IN VALUE AND IN GRAIN EQUIVALENT (Percent)

PERIOD	VALUE TERMS							GRAIN EQUIVALENT						
	TOTAL OUTPUT (1)	CEREALS (2)	EXPORT CROPS (3)	INDU-STRIAL CROPS (4)	OTHER CROPS (5)	TOTAL CROPS (6)	LIVE-STOCK (7)	TOTAL OUTPUT (1)	CEREALS (2)	EXPORT CROPS (3)	INDU-STRIAL CROPS (4)	OTHER CROPS (5)	TOTAL CROPS (6)	LIVE-STOCK (7)
1960-69	0.75	-1.08	-0.84	6.8	-0.14	-0.64	4.30	4.70	2.79	3.02	11.28	3.79	3.22	8.40
1969-80	5.53	5.07	6.82	15.69	6.39	6.66	2.57	4.76	4.03	5.66	14.48	5.25	5.54	1.65
1960-80	3.44	2.38	3.47	11.80	3.60	3.47	3.32	4.73	3.48	4.50	13.08	4.61	4.53	4.60

Note:
(1) Total output is composed of all crops and livestock products.
(2) Cereals include, maize, wheat, rice, barley, oats, sorghums and millets.
(3) Export crops include, coffee, tea, pyrethrum and cashewnuts
(4) Industrial crops include, sugarcane, cotton, tobacco, sisal and coconuts.
(5) Other crops include, potatoes, vegetables, fruits, and pulses
(6) Total crops is composed of (2), (3), (4) and (5).
(7) Livestock is composed of milk, beef, goat meat, mutton and lamb. Poultry meat and pig meat are excluded to avoid double counting of intermediate products from the farm used as feedstuffs.

Source: Compiled from results of index calculations.

*This table will be the basis of most of the discussions in the subsequent sections of this Chapter.

Inspite of the impressive overall growth rate, agricultural production grew relatively slowly in the first decade of the study period, increasing at an annual rate less than one percent in terms of value (in constant prices). The reason for the slow growth of output observed in the early 1960's was mainly due to the fact that Kenya achieved its independence and the government was committed to develop its agricultural sector (Senga, 1976). Most of the efforts were concentrated in structural adjustment in the way of land redistribution than direct production expansion (Kenya - Development Plan 1966-70). The government's efforts and funds[7] were directed to solving immediate problems such as the settlement of landless africans, land transfer programmes, and other broader issues such as land consolidation adjudication and registration leading to sound land tenure systems. Another reason for the slow growth rate in the 1960's, particularly in terms of value, was the low producer prices for most farm products between 1960 and 1969, since in grain equivalent a rate of over 4 percent was observed (Table 4.1). To illustrate the effect of prices on value of output Table 4.2 below shows the changes in average producers prices (nominal and constant 1970) for the major crops.

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[7]Over half of government expenditure in agriculture was used in land transfer and settlement programmes, see Chapter 6, Agricultural Sector, Kenya Development Plan 1966-70.

TABLE 4.2 AVERAGE PRODUCER PRICES FOR PRINCIPLE CROPS. NOMINAL AN

FIVE- YEAR AVERAGES (In KShs./100 kg.)

	NOMINAL				
	1960-64	1965-69	1970-74	1975-79	196
Maize[1]	34.0	33.0	37.0	79.0	4
Wheat	52.0	54.0	56.4	126.0	5
Sugarcane[2]	48.0	45.0	51.0	120.0	5
Pyrethrum[3] Extract (/kg)	4.3	382.3	381.7	503.0	
Tea	781.5	697.2	647.2	1390.5	89
Coffee	650.0	635.2	817.8	2629.0	74

[1]The price of maize (constant 1970), was used to derive grain equivale

[2]Sugarcane in Sh./ton.

[3]The price for pyrethrum in 1960, was quoted as Sh./kg of dry pyrethru

Source: Compiled from Republic of Kenya, Statistical Abstracts (seve Statistics, Nairobi.

The period of rapid growth in agricultural output was afer 1969. Table 4.1 shows that between 1969 and 1980, agricultural output grew at an annual compound rate of about 5 percent. In grain equivalent, total output increased at a rate of over 4 percent during 1969-80 period. Most of the rapid growth observed during this latter half of the study period was attributed to the high producer prices that prevailed at that time. Substantial improvements in physical quantities also occurred as a result of positive response by farmers to high prices, especially in export and industrial crops.

In order to obtain an idea regarding the changes in output growth by commodity group, the results are broken down into the various farm commodity groups. On average, both crop and livestock production grew at the same rate as total output both in terms of value and in terms of grain equivalent, increasing at rates of about 3 and 4 percent, respectively between 1960 and 1980. Table 4.1 illustrates the rates of growth.

In the first decade of the study period, crop production lagged behind livestock production, with a negative growth rate in terms of value. The production of livestock products was on the other hand, increasing at rates 4 times higher than crop production both in value and grain equivalent at 4 percent per year. Therefore, between 1960 and 1969, the growth in livestock production contributed more to total production than crops. However, after 1970, this relation was reversed. Between 1969 and 1980, crop production grew at an average annual rate of about 6 percent which was more than double the rate observed for livestock production (2 percent - see Table 4.1).

The observed difference in growth rates may be interpreted to indicate that, with increasing population, particularly in the high and medium potential areas, more land has been turned into arable farming at the expense of livestock systems. However, improvements in productivity of livestock especially in dairying through the use of improved livestock breeds (A.I.), and better husbandry methods, along with competitive prices for livestock products compensates for this effect.

In addition, crop production was further broken down to crop categories illustrating the diversity of Kenya's crop products. These crop categories are export crops, cereals, industrial crops and other food crops.

EXPORT CROPS

This category of crops has been the most important in Kenya's agriculture for a long time. In recent years (1970-1980) export crops have grown rapidly due to favourable world market prices. Between 1969 and 1980, the production of export crops increased by about 6 percent per year (5.7 percent in grain equivalents) as shown in Table 4.1. Before this period, export crop production was characterized by low rates of growth, both in value and in grain equivalents. The low growth rate was most apparent in terms of value than in grain equivalents, impying that world market prices achievable at that time were also low (Table 4.2). In addition, an outbreak of coffee berry disease in 1968, resulted into substantial reduction in coffee production.

The improvement observed in export crop production during the last decade of the study period, was in part due to substantial increases in acreages as more small scale farmers joined the production of crops like coffee and tea. Improved husbandry and disease control also contributed to the observed high growth rate, but the most significant factor was the sharp rise in world market prices particularly for coffee (whose price rose from KSh.1,068/kg in 1975 to KSh. 2,469/kg in 1976) and tea (Ksh.807/kg in 1975 to KSh.1,056/kg in 1976).

CEREALS

The production of cereals grew at an average rate of 2 percent per year during the twenty year period studied. However, like export crops, growth in cereal production was also low during the initial years from 1960 to 1969. After

1970, cereal production improved substantially, increasing annually at 5 percent.

The observed growth rates for cereals were lower than those for export crops in all periods both in terms of value and in physical quantities as shown in the Table 4.1. This low growth in cereals compared to export crops reflects to some extent, the history of Kenya's farming, and economic competitiveness between these two commodity groups. In the years before 1960, very few africans were allowed to grow export crops or any important cash crops such as wheat and barley. Majority of african farmers grew only indegenous crops. After the 1950's[8] to 1960, africans were allowed to grow crops like coffee and tea, and the output of these crops rose relative to cereals. Another reason for the slow growth of cereals was that important cereals like wheat required large scale mechanized operations which the majority of small african farmers could not afford. Thus small holders who were increasing in proportion to large scale farmers, concentrated on cash crops such as tea, coffee and pyrethrum in addition to dairying. Maize, sorghums and millets continued to be produced at lower levels almost as subsistence crops. In addition, lack of agronomic

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[8]For many years, african farmers in Kenya were probihited by the Colonial regime from growing crops like coffee and tea. This prohibition was relaxed in the 1950's. For example, by 1960, the Tea Ordinance (No. 61 of 1960) replaced the Tea Ordinance, 1950, Clause 27 "of which excluded from the operation of that Ordinance the growing of tea by Africans". LAWS OF KENYA, AGRICULTURE, CHAPTER 333.

information and improved varieties for the cereals, particularly maize, accounts for part of the low rate of growth for cereals relative to export crops. Price differentials between the two groups also explains the disparity in growth rate, with export crops having higher prices (Table 4.2).

The growth in cereal output accelerated in the 1970's through to 1980. Between 1969 and 1980, the production of cereals increased by 5 percent per year in value terms and over 4 percent in grain equivalent as shown in Table 4.1. Part of the improvement in cereal output was due to favourable prices which induced farmers, particularly small holders to grow maize as a cash crop. The break through in maize research which led to the release of hybrid maize varieties (begining 1965 to 1970), was another important factor that could account to the improved growth rate in the 1969-80 period.

INDUSTRIAL CROPS

Among all the crop categories, this group had the highest rates of growth throughout the study period and in subsequent sub-periods, both in value and in grain equivalent (Table 4.1). In addition, the growth rate of industrial crops was most rapid during the 1969-80 period when a rate of over 10 percent was observed both in value terms and in grain equivalent.

The main reason for the high growth rates observed for industrial crops was because they have been the main cash crops for small holders, especially in medium and marginal rainfall areas where tea and coffee or pyrethrum cannot do well.

OTHER FOOD CROPS

The growth rates obtained for this group of crops follow a trend similar to that observed for cereals, but with growth rates higher than those for cereal production both in value and in grain equivalent throughout the period of study and subsequent sub-periods. This group constituting potatoes, pulses, vegetables and fruits, had an average growth rate of over 3 percent in value (4 percent in grain equivalent) between 1960 and 1980, being slightly higher than cereals (Table 4.1).

PROPORTIONATE CHANGES OF COMMODITIES IN THE TOTAL OUTPUT

The relative importance of individual products and commodity groups, in the total value of agricultural production generally depends upon relative prices as well as quantity of production. Another factor that influences the patterns of agricultural production over time, is the change in economic structure of a country, usually reflected in changes in tastes and subsequent demand for the different farm products.

In Kenya, the observed differences in rates of growth for the various farm products, have altered the relative composition of agricultural output only slightly as shown in Table 4.3.

TABLE 4.3: PROPORTIONATE CONTRIBUTION OF AGRICULTURAL PRODUCTS TO VALUE OF TOTAL OUTPUT (CONSTANT 1970 PRICES) FROM 1960 TO 1980 (Percent)

PERIOD	CEREALS (1)	EXPORT CROPS (2)	INDU-STRIAL CROPS (3)	OTHER CROPS (4)	LIVESTOCK (5)	TOTAL
1960-69	21.53	28.93	1.87	22.65	25.02	100.00
1960-80	20.23	26.83	4.62	23.22	25.10	100.00

(1) CEREALS include maize, wheat, rice, sorghums and millets.

(2) EXPORT CROPS include, coffee, tea, pyrethrum, cashewnuts.

(3) INDUSTRIAL CROPS are sugarcane, cotton, tobacco, coconuts and sisal.

(4) OTHER CROPS, are potatoes, pulses, vegetables and fruits.

(5) LIVESTOCK are beef, mutton and lamb and goat meat.

Source: Compiled from results on index calculations.

The results imply that most of the changes in growth rates must have resulted from relative producer price changes rather than from absolute changes in quantity composition. For instance, the percent share of cereals in total production has remained at around 20 percent throughout the study period. Apparent changes have occurred in the proportionate contribution of export crops, and industrial crops over the years, the largest change being in industrial crops from 1 percent in 1960-69 to 4 percent in 1970-80. This increase in share of industrial crops in total output is supported by the remarkable growth rates observed for this crop category throughout the study period.

Overall, the share of food crops in total production has not changed much, averaging around 40 percent throughout the 20 years studied. Similar observations were made by Senga (1976). The share of livestock has also remained at around 25 percent despite expansion of arable farming, possibly due to intensive stall feeding practices particularly in small holder dairy farming.

4.1.2 TRENDS IN AGRICULTURAL INPUTS AND TOTAL PRODUCTIVITY

LAND

Agricultural land has increased only marginally over the years. Measured in hectares, total agricultural land has increased by about 7 percent over the twenty years of the study period, growing at an annual compound rate of about half percent, as shown in Table 4.4.

TABLE 4.4: GROWTH RATES IN INPUTS FOR THE PERIOD 1960-1980 (in percent)

PERIOD	TOTAL LAND	LABOUR	CROPPED* AREA	CURRENT INPUTS (Tons)	CURRENT INPUTS (KSh.)	MACHINERY	TOTAL INPUTS
1960-69	-0.09	2.70	0.29	11.84	17.22	4.25	2.41
1969-80	0.93	1.57	3.08	1.77	9.4	0.93	1.55
1960-80	0.48	2.07	1.86	6.72	12.80	2.38	1.93

*CROPPED AREA is comprised of Arable land and land under permanent crops (Tree crops).

Source: Compiled from the results on index calculations in the present study.

Measured in terms of cropped area, (i.e. arable land under permanent crops), an annual growth rate of almost 2 percent was observed between 1960 and 1980, increasing total cropped area by 35 percent. Most of this increase has been a result of outmigration into areas of less agricultural potential, steep slopes, and also incorporating traditional grazing areas into arable farming such as wheat growing in Narok and parts of Samburu.

LABOUR

The number of people engaged in farming, estimated as persons economically active in agriculture, has increased more or less throughout the period of study. The growth rate obtained for the whole period (1960-1980) was about 2 percent per year (Table 4.4), thereby increasing the total agricultural labour force by about 68 percent from 2.8 million in 1960 to 4.8 million in 1980. In later years (1969-80), the growth in agricultural labour has slowed down to about one percent per year, due chiefly to rural-urban migration. The result, has been serious labour shortage in enterprises like tea and coffee at peak seasons coinciding with other farm activities like weeding for annual crops.

NON-FARM CURRENT INPUTS

Expenditure on non-farm current inputs increased most rapidly compared to the other inputs, averaging 12 percent per year from 1960 to 1980. Expressed in physical terms, a rate of 6 percent was observed over the twenty year period, which is substantially higher than the rates observed for land, labour and machinery. In addition, the growth rate in current inputs was most rapid between 1960 and 1969, both in value and in physical terms, averaging around 17 percent and 11 percent respectively. After 1969, the rate of growth in current inputs, fell to just about one percent, in physical terms, and about 9 percent in value between 1970 and 1980 as illustrated in Table 4.4.

Current inputs, particularly fertilizers, are generally yield-increasing inputs in agriculture. However, the observed rates of growth for fertilizers both in value and physical terms, did not show this expected relation. Instead, high rates of growth in fertilizers were obtained during the period of low growth in total output, between 1960 and 1969, while low growth rates of fertilizer were observed after 1969 when growth in output was most rapid. Table 4.1 shows that during 1960-69 period, output grew at less than 1 percent in value or 4 percent in physical terms compared to rates over 5 percent in late 1970's.

This result, especially between 1960-1969 implies inefficiency in the use of this technology. It could also mean that other supplementary factors that enhance the success of this technology were lacking at that time. This includes crop hybrids (cereals mainly) that were released in late 1960's and early 1970's. Better husbandry and good prices are also important for the adoption and impact of this technology. However, it must be noted that the data used was also highly aggregated (import figures as an approxy for fertilizer used), and could have masked the significance of fertilizers. On the other hand, the observed high rates of growth in production between 1969 and 1980 must have come as a result of other factors such as better crop varieties and multiple cropping, particularly on small scale farms since growth in both land and current inputs was at low rates, point nine and 1 percent, respectively (Table 4.4).

AGRICULTURAL MACHINERY

This input was approximated by depreciation using interest charge for capital spent on tractors only. Other capital items such as buildings, ploughs and implements were omitted because of lack of data. An average rate of about 2 percent was obtained for the whole study period, but it declined in the later years (1969-80). These rates obtained are fairly acceptable for tractors alone since total number of tractors has remained at around 6 thousand. The fact that Kenyan agriculture has progressively become small scale, whereby majority of farmers tend to use human labour or ox-drawn ploughs explains the lack of direct impact of the declining rate of machinery on total output, since very few small holders use tractors power.

TOTAL INPUTS AND TOTAL PRODUCTIVITY

On average, total inputs have declined somewhat over the years. The rate of growth in total inputs dropped from a little over 2 percent during 1960-1969 period to about 1 percent between 1969 and 1980. This result implies that the growth in output observed in the late 1970's was due to other factors rather than growth in total inputs since the latter was declining (Table 4.4).

Dividing the aggregate total output index by the total input index yields "total" productivity. During the entire study period (1960-1980), "total" productivity grew at about one point five percent in value and about 2 percent in grain equivalent, per year. The lowest productivity growth rates were obtained between 1960 and 1969. During this period (1960-1969), productivity was declining, particularly when expressed in value terms (Table 4.5).

TABLE 4.5: GROWTH RATES IN TOTAL INPUTS, "TOTAL" PRODUCTIVITY AND RELATIVE CONTRIBUTIONS OF TOTAL INPUTS AND PRODUCTIVITY TO THE GROWTH IN OUTPUT (IN VALUE (Constant 1970 prices) AND IN GRAIN EQUIVALENT). (Percent)

PERIOD	IN VALUE					IN GRAIN EQUIVALENT				
	TOTAL			RELATIVE CONTRIBUTIONS		TOTAL			RELATIVE CONTRIBUTIONS	
	OUTPUT (1)	INPUT (2)	PRODUCTIVITY (3)	INPUT (4)=(2/1)	PRODUCTIVITY (5)=(3/1)	OUTPUT (6)	INPUT (7)	PRODUCTIVITY (8)	INPUT (9)=(7/6)	PRODUCTIVITY (10)=(8/6)
1960-69	0.75	2.41	-1.62	321.00	-216.00	4.70	2.41	2.29	52.00	48.00
1969-80	5.58	1.55	3.93	28.00	72.00	4.76	1.55	3.14	33.00	67.00
1960-80	3.44	1.93	1.50	56.00	44.00	4.73	1.93	2.77	41.00	59.00

Source: Compiled from results of Index calculations in the present study.

The results in Table 4.5 show that productivity growth between 1960 and 1969 in terms of value was negative. In general, a nagative "total" productivity growth would imply that diminishing returns to the primary factors, land and labour, had set in to the extent that productivity gains could not completely offset their effect. In the present study, however, the negative sign on the rate of growth in productivity is closely related to low value of output during that period (1960-1969) because of low commodity prices, since the growth rate in grain equivalent terms was positive.

The relative contributions of total inputs, and productivity gains, to the growth in agricultural output (indicated in Table 4.5) show considerable changes over the years of study. From 1960 to 1969, over half of the growth in total output was brought about by growth in total input, which accounted for over 50 percent of the growth in total output in grain equivalent, and more than 100 percent in value of output, since productivity growth in value terms was negative (Table 4.5). After 1969, the relative contribution of total inputs in the total growth of output, dropped substantially to about 20 percent (value terms), to 30 percent (in grain equivalent terms). This result is consistent with the observation that total inputs had also declined between 1969 and 1980.

The contribution of productivity gainsto growth in output, over the study period, averaged 50 percent. The highest contribution of productivity occurred between 1969 and 1980, when productivity accounted for over 70 percent and over 60 percent of the growth of total output, in value and in grain equivalent, respectively. Thus, productivity gains also play an important part in raising total production since total inputs had declined.

4.1.3 TRENDS IN "PARTIAL" PRODUCTIVITIES

Of the two primary factors of production, the rate of growth for land input was the least during the period of study, thereby being more scarce relative to labour. Therefore, the slow growth in land relative to labour, has been one of the limiting factor to the growth of total output.

In the twenty year period of the study, land productivity increased at an average rate slightly above 2 percent per year (Table 4.6).

TABLE 4.6: GROWTH RATES IN LAND AND LABOUR PRODUCTIVITY, CURRENT INPUTS PER HECTARE, LAND AREA PER WORKER (percent) 1960-1980 IN VALUE AND IN GRAIN EQUIVALENT

PERIOD	IN VALUE					IN GRAIN EQUIVALENT				
	PRODUCTIVITIES *			INPUTS		PRODUCTIVITIES *			INPUTS	
	OUTPUT	Y/A	Y/L	CURRENT/ HECTARE [1]	LAND/ WORKER	OUTPUT	Y/A	Y/L	CURRENT/ HECTARE [2]	LAND/ WORKER
1960-69	0.75	0.84	-1.89	25.63	-2.80	4.70	4.86	2.01	19.54	-2.80
1969-80	5.58	4.75	3.80	0.69	-1.26	4.76	3.74	3.02	1.27	-1.26
1969-80	3.44	2.94	1.31	13.15	-1.93	4.73	4.23	2.58	10.40	-1.93

*Y/A is land productivity; Y/L is labour productivity

[1]Current inputs per hectare expressed as KSh./ha.

[2]Current inputs per hectare expressed as tons/ha.

Source: Compiled from results of Index calculations in the present study.

The rate of growth in land productivity was highest between 1969 and 1980, averaging 4 percent in value and 3 percent in grain equivalent. Yamada and Hayami (1979), in explaining land productivity growth in Japan observed that,

> "....Increase in land productivity must be accompanied by increase in the inputs that substitute for land. These are primarily current inputs such as fertilizers, pesticides, and other agricultural chemicals."
>
> (Yamada and Hayami 1979, pg. 46.)

This relation was not observed in the present study. Instead, high rates of growth in land productivity, both in terms of value and grain equivalent were observed in a period when current inputs (fertilizers and pesticides) per hectare had low rates of growths, in 1969-80. An approximation of this relation was however noticeable using the grain equivalent measure, which showed a rate of 4 percent in land productivity growth associated with a 19 percent growth in tons of fertilizer per hectare between 1960 and 1969 (Table 4.6). This observation was, however, due to low prices of grain which resulted in a high growth rate in total output in terms of grain equivalent (over 4 percent) compared to value terms (less than 1 percent). Therefore, the observed high growth rate for land productivity at a time of low rate of growth in fertilizer input, must have resulted from more intensive land use or improvements on husbandry methods, as well as increased value of output.

The relation between land productivity and the growth of total output, could not be directly determined because of the effect of the sharp rises in producer prices, particularly in the later half of the study period, which resulted in increased value of total output. The grain equivalent measure could not completely offset this effect because its calculation was based on the price of grain (maize), which also rose but not at the same magnitude as for other crops like coffee and tea. As a result, the observed changes in the growth of output appear to be primarily due to changes in value of products, and only slightly as a result of land productivity. A slight increase in cropped land, also accounted for the growth in output.

On average, labour productivity increased at rates lower than land productivity, averaging about 1 percent per year between 1960 and 1980 (Table 4.6). Land productivity and labour productivity are however closely associated, since output per worker can only increase as land productivity (output per hectare) increases or through an increase in the number of hectares available per worker (ratio of land to labour). From Table 4.6, the rate of growth in the ratio of land to labour was negative throughout the study period with an average rate of about 2 percent. This result means that the number of hectares available per agricultural worker has been declining. This was because, although the population growth has resulted in an apparent increase in the agricultural labour force, similar increases in land have not occurred. Thus, labour productivity has depended primarily upon improvements in output per hectare. In addition, future improvements on the ratio of land to labour are not only almost nill, but in view of the rapid rate of population growth (about 4 percent) compared to the growth rate in Gross Domestic product (3.4 percent), the per capita income growth, in theory may not be sustained. Thus, while greater numbers in the labour force can add to the total product, a faster growth of the labour force implies a lower output per worker. Therefore, in the future, any growth in output per worker will most likely continue to depend on sustained high land productivity growth rather than increase in the labour force.

4.2 PRODUCTION FUNCTION ANALYSIS

Two regressions were estimated to depict agricultural production in Kenya over the last 20 years. One model was specified for the total agricultural sector to estimate productivity change. The other model represented large scale farm sector. A similar analysis for small holder sector was not possible because of lack of complete data.

4.2.1 RESULTS OF A TIME SERIES PRODUCTION FUNCTION FOR THE AGRICULTURAL SECTOR

The results are summarized in equation 4.1 below.

$$\text{LnY} = 1.299 + 4.2838\ \text{LnL} - 0.0061\ \text{lnN} - 0.0248\ \text{lnF} - 0.1047\ \text{lnM} + 0.019\ \text{ln T} \quad \ldots (4.1)$$

S.E.	(0.369)	(0.611)	(0.044)	(0.097)	(0.0178)
T.	11.6*	0.01	0.56	1.07	1.12

$R^2 = 0.99$

D.W. statistic = 1.46, test for autocorrelation was indicisive.

D.F. = 14

n = 16

*Means significant at 1 percent level of probability.

Where, Y is total agricultural production in million KSh. at constant (1970) prices.

L is agricultural land in million hectares.

N is agricultural labour in million workers

F is current inputs in million KSh. at constant (1970) prices.

M is farm machinery in million KSh. at constant (1970) prices.

T is time in years

Sum of coefficient = 5.456.

From economic theory, a sum of coefficients greater than one indicates increasing returns to scale, ceteri paribus. The results above imply that a simultaneous increase in each input by one unit, would yield 5.4 units of output. However, in the absence of a priori information on expected returns to scale in

Kenyan agriculture, policy options to be drawn from this must be taken with reservations, since inputs especially land cannot be increased indiscreminately.

The results also showed unexpected negative coefficients for labour, fertilizer and machinery. In addition, R^2 is very high both of which suggest the problem of multicollinearity. The correlation matrix also showed unexpected linear correlations between some independent variables (see annex page 108). To correct for this problem, several attempts were made. First, the equation was standardized per hectare, then per worker as well as omitting variables like capital. Other attempts involved combining fertilizers as well as machinery and fertilizers as well as alternating between stock and flow measures for the inputs. Improvement on data quality as suggested by Johnston (1972) Kmenta (1971) was constrained financially and by time limitation. For this reason, discussion will be based on the Large scale farm results.

According to Wonnacott (1970) it is permissable to make some guarded predictions in the presence of multicollinearity. For instance, Wonnacott (1970) suggested that,

".....where independent variables X and Z are collinear or nearly so, it is a problem of multicollinearity. For prediction purposes it does not hurt, provided there is no attempt to predict for values of X and Z removed from their lines of collinearity, but structural questions cannot be answered i.e., the relation of Y to either X or Z cannot be sensibly investigated......"

Wonnacott, 1970 (pg. 61).

in equation (4.1), X and Z could refer to the independent variables labour, current inputs, machinery and time which were nearly collinear. In this regard, no interpretation is drawn from equation (4.4) explaining the relation of output (Y) to either of the independent variables. The equation is only used to predict productivity change that might have occurred over time. This was indicated by the coefficient of time, which shows that productivity change occurred at a rate of 1.9 percent per year between 1960 and 1980. The rate is very close to the rate of growth in total productivity obtained in the index analysis of 1.6 percent.

4.2.2 RESULTS OF A TIME SERIES PRODUCTION FUNCTION FOR LARGE SCALE FARMS

Model: Y = f (L, N, F, M) ---------------- (4.2)

Where, Y is value of production in '000 K£.
L is land in '000 hectares
N is labour in '000 workers
F is fertilizer in '000 tons
M is capital input in '000 K£.

Two equations were selected for the model, the first having 3 variables in the set and the second having all the 4 variables in the set. The discussion is based upon the equation having all the variables in the regression set.

Best equation with 3 variables in the set:-

$$\ln Y = -21.466 + 2.047 \ln L + 1.508 \ln N + 0.968 \ln M \text{------}(4.3)$$

S.E.	(2.453)	(0.715)	(0.110)
T	0.83	2.11**	8.77*

R^2 = .95

DW = 1.65

DF = 12

n = 16

Sum of coefficients is 4.5 which indicates increasing returns to scale.

**Means that the coefficient is significant at 5 percent level of probability.

* Means that the coefficient is significant at 1 percent level of significance.

The test for Auto-correlation using the Durbin-Watson Statistic (DW) was inconclusive.

The negative intercept seems unrealistic because it implies negative output in the early years. However, this result is similar to the result obtained in the index method that showed negative productivity change over the early years in the study. This was interpreted to indicate that diminishing returns to the primary factors could not be completely offset by productivity gains.

Equation with 4 variables in the set:-

$$\ln Y = -24.536 + 2.262 \ln L = 1.816 \ln N + 0.207 \ln F + 0.843 \ln M \text{--}(4.4)$$

S.E.	(2.483)	(0.797)	(0.229)	(0.177)
T	0.91	2.28**	0.90	4.75*

R^2 = .95

DW = 1.68 - test for auto-correlation was inconclusive

DF = 11

n = 16

Sum of coefficients was 5.1 which indicates increasing returns to scale.

**Means that the coefficient of the variable was statistically significant at 5 percent level of significance.

*Means that the coefficient of the variable was statistically significant at 1 percent level of significance.

The discussion is based on equation (4.4) where the number of observations (n) was 16 and the degrees of freedom was 11. The correlation matrix for this production function showed negative linear correlations between some of the variables, implying some degree of substitution among the factors of production. These correlations were observed between land and fertilizer, labour and capital. However, the test for auto correlation was inconclusive.

The sum of the coefficients was found to be greater than one (equation 4.4). From the theoretical analysis stated in Chapter 3, a sum of coefficients greater than one indicates increasing returns to scale. Since the sum of coefficients was greater than one, then a one percent increase in the level of all inputs would result in an increase in total output by more than one percent. For correlation matrix see page 108 in annex.

The observed signs of the coefficients of the variables in the equation were in conformity with the theoretical expectations stated in Chapter 3. Using the 't' statistic, only labour and capital were found to be statistically significant in agricultural production. Labour was found to be significant at 5 percent level of significance with 11 degrees of freedom, and capital at one percent level of significance. This means that labour and capital have been important factors in raising agricultural output in large farms. The relation between land and output was not found to be statistically significant on large farms. Fertilizer use was also not found to be significant as is illustrated below in the test of hypothesis.

4.2.3 TEST OF HYPOTHESIS

The hypothesis advanced for statistical testing, states that, fertilizers have contributed significantly in raising agricultural output in Kenya. The test involves a null hypothesis (Ho) concerning the transformation parameter for fertilizer in the estimated production function, as:-

$$Ho : B = 0$$

against the alternative hypothesis H_A,

$$H_A : B \neq 0$$

The test is performed using the 't' statistic. If the observed 't' value in the equation is greater than the tabulated 't' at 5 percent level of probability then the null hypothesis can be rejected, implying that fertilizer use has significantly influenced the growth of output. The result showed that at 11 degrees of freedom, the observed 't' statistic was less than tabulated 't' using a 5 percent level of significance. Thus, the null hypothesis about the transformation parameter for fertilizer could not be rejected.

The result of the test, which indicates that the effect of fertilizer use, on output has not been significant is consistent with the observations made in the index calculations, where no direct relation between fertilizer use and agricultural productivity was observed. This observation suggests inefficiency in the use of fertilizers, and that production increases has been influenced more significantly by other factors than fertilizers.

The observed non-significance of fertilizers contradicts the expected yield-increasing effect on agricultural production. To understand this and in order to draw relevant policy options it must be noted that the success of this technology depends highly on availability of other factors, such as crop hybrids which respond well to fertilizers compared to indegenous varieties, as well as availability of fertilizers at the right time to farmers. In Kenya, crop hybrids particularly cereals were adopted widely in late 1960s and early 1970s. By this time, however, fertilizer input had declined as is shown by the index results. This means, fertilizers were not readily available, thus their yield-increasing impact was not fully exploited particularly by the new hybrids. Therefore, the non-significance must be due to under use directly resulting from non-availability of the input. In addition, the use of the highly aggregated data has also tended to mask the expected result.

4.2.4 MARGINAL PRODUCTIVITIES

The marginal productivity of an input X_i in producing output Y, can be expressed as -

$$MP_{x_i} = \frac{\beta_i Y}{X_i}$$

Where, Y is the estimated output

X_i are the factors of production (inputs).

β_i the production elasticity associated with input i, other factors held constant.

The marginal productivity of an input indicates the expected increase in output resulting from the use of an additional unit of that input, the level of other inputs held constant. It depends on the level of the input and also on the levels of the other inputs in the production process. According to Heady and Dillon (1961 pg. 590) the most useful estimates are obtained when the inputs are taken at their mean levels. Geometric means are usually preferred in deriving marginal productivities with the assumption that there is no zero level of input. The adoption of geometric means is most relevant when using the Cobb-Douglas production in its logarithmic linear form. According to Yotopoulos and Nugent (1976), the logarithm of variables' geometric mean coincides with the arithmetic mean of the logarithm values, and that the best fit in a linear regression is obtained at the sample mean. In this study, geometric means were used in calculating marginal productivities Table 4.7.

TABLE 4.7 RESULTS OF THE CALCULATION OF MARGINAL FACTOR PRODUCTIVITIES

VARIABLE	GEOMETRIC MEAN	PRODUCTION ELASTICITY	MARGINAL PRODUCTIVITY
Production (K£)	54878.49	-	-
Land (Ha)	2419.82	2.26	51.30;
Labour (persons)	188.52	1.82	528.64
Fertilizer (tons)	73.61	0.21	154.34
Capital (K£)	6663.81	0.84	6.94
Sum of coefficients*	-	5.13	-

*The sum is greater than 1 and it indicates increasing returns to scale.

Source: Results of marginal productivity calculations of present study.

The marginal products were computed as the product of the input production elasticity times the ratio of output to input. This computation yielded a marginal product of labour of K£528 per worker which was the highest. The second highest marginal product was obtained for fertilizer as K£154 per ton.

Direct comparison between the marginal products to determine allocative efficiency between the inputs requires information on relevant opportunity costs for the various inputs, such as land rent, wage rate or market costs for fertilizer or capital, which is not available. However, an important observation relevant to the study on agricultural growth and productivity could be noted. Both labour and capital were significant but the former had a higher marginal productivity than the latter. The policy implication that could be drawn from this regarding future agricultural development would be to focus on a more labour intensive pattern of production rather than capital intensive, since each extra unit of labour is expected to yield more output.

Regarding fertilizer and land, both were statistically insignificant. The reasons thought to have led to the non-significance have been discussed on page 70. In addition, under use or over use of an input can also lead to low impact on output. Based on prior information on agricultural iproduction in Kenya, and also the Index results, fertilizers have been under utilized in the past, mainly because of limited availability. Regarding land, Kenya's agriculture cannot depend on more land since it is not available, but rather on improved productivity of the existing land. This can be achieved through increasing the use of fertilizers and other factors that enhance the success of this technology.

4.2.5 SUMMARY OF RESULTS

In summary, from the Index analysis, total agricultural output has grown by about 3 percent per year from 1960 to 1980. The rate of growth in total production was however most rapid in the latter half of the study period, 1969-80, than in the earlier years (1960-69), averaging 5 percent and less than one percent in value terms, respectively.

Compared to output, total inputs increased most rapidly between 1960 and 1969 than during 1969-80 period, averaging 2 percent and 1 percent respectively. The trend in "total" and 'partial' productivities with respect to land and labour were observed to be similar to the growth in total output, being higher in the 1969-80 period than 1960-69 period. Relative price changes between commodities were also observed to have influenced substantially, the pattern of production and value of total output particularly between 1969 and 1980.

Overall, the growth in output was closely associated with intensive use of resources of land and labour rather than the growth in total inputs. No direct yield-increasing effects of current inputs particulatly fertilizers was observed to be related to the growth in output, since total output and productivity grew most rapid at the time the use of fertilizers had declined. This observation was confirmed by the results of the production function analysis which did not show that fertilizers had been significant in raising output in Kenya between 1960 and 1980. Other factors such as limited availability of fertilizers particularly in the 1970's, non-use of the input were used to explain the non-significance.

CHAPTER FIVE

5.0 SUMMARY, CONCLUSIONS AND POLICY IMPLICATIONS

5.1 SUMMARY AND CONCLUSIONS

The aim of the study was to present an empirical analysis of the agricultural growth in Kenya between 1960 to 1980, showing the sources and rates of growth in output and productivity. The main objectives were to estimate the rates of growth in total agricultural production, factor inputs, "total" and "partial" productivities with respect to total factor inputs, land and labour. In addition, the sources of the rates of growth were sought in the analysis using growth accounting procedures and production function estimates.

Two methods of analysis were employed in the study. The trends in the growth of total output, factors of production, total inputs and productivity were derived through index calculation and growth accounting procedures adopted from Hayami and Ruttan (1970, 1971). To supplement the findings obtained through the index approach, a production function for the agricultural sector was estimated for the purpose of predicting productivity change. However, the data for the total sector was secondary and highly aggregated, therefore another production function for large farms was estimated to determine relative importance of the factor inputs in the output growth, particularly current inputs (chemical fertilizers), using production elasticities and marginal products.

The analysis was done using secondary data obtained from local sources (statistical publications of the Central Bureau of Statistics), and from FAO Statistical Yearbooks. The data base presented a big limitation to the empirical analysis, especially in aggregate growth accounting, in way of quality of data and length of the period investigated. However the results, can serve the purpose of the study, in indicating the effectiveness, to some extent, of the agricultural development process since 1960 to 1980 and make possible policy suggestions, in perspective, for future sustained agricultural growth.

The results of the study showed that agricultural output grew at an annual rate of about 3 percent (1960-80) in terms of value. Using grain equivalent, the annual rate of growth was slightly higher, averaging 4 percent between 1960 to 1980. At this annual compound rate of growth, the results also showed that the value of total production increased by more than one and a half times from KSh.3464 million in 1960 to KSh.6288 million by 1980, at constant (1970) prices. In addition, the growth rate of total output was found to be much higher in the later decade between 1969 to 1980 compared to the earlier period 1960-1969, at annual rates of 5 percent and about 1 percent, respectively.

Among the crop categories, industrial crops had the highest growth rates both in terms of value and in physical terms, followed by export crops, temporary crops and finally by cereals. Between crop and livestock production, the rate of growth over the entire period of study and during the sub-period 1969-1980, was higher for crops than livestock production. Absolute price changes and realtive price change between commodities were observed to have influenced greatly, the pattern of production and value of output, particularly between 1969 and 1980. The value of industrial crops and export crops particularly tea and coffee rose sharply in the late 1970's (actually 1977/78) leading to the noted rapid rate of growth both in value and in grain equivalent in the two commodity groups.

In comparison, the rates of growth for agricultural inputs, both in total and according to input category, were quite low over the entire study period between 1960 to 1980. Both the land and labour inputs tended to decline more or less continuously throughout the study period. Between 1960 and 1980, total agricultural land expressed in hectares increased by less than 1 percent annually and agricultural labour by 2 percent per year. The use of current inputs approximated by fertilizers and pesticides, also declined and by 1969-80, the rate of growth was 6 percent annually compared to a rate of 11 percent between 1960 and 1969. Total inputs into agriculture, estimated using the total input index, grew at an annual average rate of almost 2 percent between 1960 to 1980 but at a lower rate of 1 percent from 1969 to 1980.

In terms of productivity, "total" factor productivity grew at an average rate of 1 percent in value and 2 percent in grain equivalent between 1960 and 1980. The rate of growth in productivity was more rapid between 1969 to 1980 than during 1960-69 period, averaging 3 percent and 1 percent respectively in value and 3 percent or 2 percent in grain equivalent.

The trend in "partial" productivities with respect to land was also similar to that observed for output and "total" productivity growth. Between land and labour, the growth rate was higher in terms of output per hectare compared to output per worker, at 2 percent and 1 percent in value, or at 4 percent and 2 percent in grain equivalent, between 1960 to 1980, respectively.

In general, the growth of output can occur as a result of more intensive use of resources (land, labour, capital and current inputs) with output per unit of total input remaining constant or declining. The growth of output can also occur as a result of advances in the techniques of production leading to higher output with a constant or declining aggregate resource input. In the present study, the observed growth of total output between 1960 to 1980 (3 percent per year) occurred, with a relatively low rate of growth in total inputs of a little less than 2 percent. Infact after 1969, growth of output increased rapidly while the growth of total inputs had declined to about 1 percent between 1969 and 1980. Therefore, over the entire study period, the growth in output was closely associated with intensive use of resources particularly land and labour, rather than the growth of inputs, since total inputs increased very slowly (1.9 percent 1960 to 1980).

In the earlier sub-period, 1960-69 the growth of output was more closely associated with an increase in aggregate inputs (2.4 percent growth in total inputs). However, the growth in output was lowest at this period (1960-69), increasing at a rate less than 1 percent in value and about 2 percent in grain equivalent. As a result, both land and labour productivities growth were low (0.8 percent and - 1 percent respectively). Therefore, the productivity of the inputs was low, leading to the observed low rate of increase in total output.

In addition, the characteristic of modern agricultural growth, whereby growth in output is generally associated with increased use of current inputs such as fertilizers, was not observed in this study, since between 1960 and 1969, the rate of growth in use of current inputs was quite high 19 percent (tons per hectare). Therefore, the use of yield-increasing current inputs was not a key factor in the growth of output between 1960 and 1969, since growth of output was low (0.8 percent per year).

In the latter half of the study period, between 1969 to 1980, when output was increasing at highest rates both in value and in grain equivalents (5 percent), the growth of total inputs had declined (1 percent), and thus productivity growth had increased. Infact, the results showed that productivity change, accounted for over 60 percent of the growth in output from 1960 to 1980. Similarly, productivity of both land and labour had improved substantially (4 percent and 3 percent, per year respectively). However, the method used was not able to adequately separate the effect of productivity of the inputs from the effect of producer prices, which tended to be very high between 1976 to 1978. In addition, yield-increasing inputs (fertilizers) had also declined, and their effect on raising productivity of land could not be determined from growth accounting.

The results of the production function analysis, also did not show that current inputs were a key factor to the growth of output in Kenyan agriculture between 1960 and 1980, since the transformation parameter for fertilizers was not statistically significant at the 5 percent level of probability. It was noted that this result contradicts the importance of fertilizers in agricultural production. Reasons given for the non-significance and masking effects included availability of fertilizers to farmers and at the right time, especially in the later half of the study period when the aggregate fertilizer input had declined. Therefore, it was concluded that fertilizers were under used in the past 20 years studied. Also the availability of hybrids which are more responsive to fertilizer application at a time when fertilizers had declined was another reason. Other factors important for the success of this technology and which the study was not able to determine are quality and correct use of the fertilizers. In addition, the highly aggregated data could have also hidden the effect of fertilizers.

Land input was found to be insignificant and its growth in the late 1970's had gone down. Labour was significant and infact had the highest marginal productivity, which means that in future, agricultural production should be more labour intensive ceteri paribus. However, regarding land, it was concluded that future output growth cannot rely on more land because this is not available. Instead increased productivity of the existing land will be the key factor. Since fertilizers have been under used in the past (at least between 1970-1980), substantial potential still exists to raise land productivity through higher fertilizer use together with supplementary inputs (hybrids and better husbandry). This would in turn help sustain a high output per capita. However, further research is necessary because of the masking effects observed in this study in order to give quantifiable policy options.

5.2 POLICY IMPLICATION

The policy recommendations that can be drawn from the study may be taken as more suggestive in nature than as wholly conclusive by virtue of the relatively crudeness and incompleteness of the data basis for the analysis.

The major implication of the study can be termed as the need to monitor growth in land productivity, as output per hectare, in order to sustain future high rates of growth in total output and in labour productivity, as output per worker. The results showed that both land and labour productivity increased at relatively low rates although total output increased at above 3 percent annually from 1960 to 1980. Since total inputs have shown a declining trend, and in particular the ratio of land to labour (i.e. agricultural area available per worker), future improvements in labour productivity which would improve income and standards of living for the rural community, must come about through higher output per unit of the land available.

The key factor in accelerating the growth of agricultural output has been considered to be the increase in the productivity of the inputs through the availability and use of yield-increasing current inputs. However, although current inputs have been used in Kenyan agriculture, the above relation was not observed, instead the results suggested inefficiency in the use of these inputs (high rates of growth in total output and land productivity - see Table 4.6). Therefore in order to benefit from technical change, embodied in availability of yield increasing technical inputs, there is need to improve on the efficiency in their use.

Another implication for future agricultural growth in Kenya suggested in the present study is to increase the availability and use of current inputs (fertilizers mainly), because the results reflected under use, particularly between 1970 and 1980. Increasing the use of fertilizers would raise output per hectare thereby sustain high output growth and output per capita since land is becoming more scarce.

Regarding labour, the study results suggest that future agricultural development in Kenya may not depend fully on mechanical power or tractorization per se. Infact from the analysis of marginal factor products, the availability of agricultural labour would add more to total output than any other factor input.

5.3 FUTURE RECOMMENDATIONS NOT ARISING DIRECTLY FROM THE STUDY

The objective of the study was to present empirically agricultural growth in Kenya from 1960 to 1980. In many ways, the study was incomplete since other important factors that affect the growth of output such as product prices, cost of inputs, availability of inputs, adequacy of supportive institutions (credit agencies, research and extension) could not be adequately represented in the analysis. This may be an area open for future research as more information on the agricultural sector becomes available. However, it can be pointed out here that, low agricultural price policy greatly retards the growth of output, since farmers would not participate in enterprises that are not economically attractive. It was in the course of the study that the rise in prices of export crops and industrial crops in 1977/78, greatly enhanced the growth of total output and general productivity in the 1969-80 period. It is therefore recommended, tentatively that future prices of agricultural commodities should be set where possible at levels where they act as incetives to farmers.

Availability of inputs such as fertilizers, or improved crop and animal types also are important factors that aid technical gains from modern technology. The availability at right time, and use of such inputs has greatly improved the productivity of the primary factors of production in other countries (Ban, 1979, Lee and Chen, 1979). An empirical comparison of the Kenyan study with other developing countries especially in East Africa was not possible at the present time because of lack of good data necessary for such comparison. However, the results of the present study for Kenyan agriculture could form a starting point from whereby intra-country comparisons in agricultural productivity within East Africa could be investigated.

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ANNEX A

A. DATA SOURCES

Obtaining data for the study presented special difficulties and quite a substantial part of the study was devoted to this. This section reports the major problems encountered and how some of these difficulties have been overcome.

Productivity studies normally requires time-series data for a sufficiently long period. In this study for Kenya, it has been possible to compile relatively reliable data for a twenty year period only, 1960 to 1980. The period prior to 1960 has been omitted because of lack of information on some of the major variables. The data collected covers the variables selected for the analysis which are, agricultural production, land, labour, current inputs and machinery.

A.1.0 AGRICULTURAL PRODUCTION

This has been defined as the gross value of production of crops, livestock and livestock products.

A.1.1. CROP DATA

The crops reported in Central Bureau of Statistics (CBS) Statistical Abstracts and Economic Survey, constitute only the main food crops and major cash crops. The data for other crops have been obtained from FAO production Yearbooks. A total of twenty five (25) crops were included and they are maize, wheat, coffee, tea, sugar cane, sisal, pyrethrum, rice, pulses, millets and sorghums, barley, oats, potatoes, sweet potato, cassava, banana and plantains, cashewnuts, coconuts, cotton, tobacco, vegetables and fruits.

For the major cash crops, marketed output has been taken as an aproxy for production figures. For other crops, particularly food crops, the marketed output cannot approx approximate sufficiently the amount farmers produce. For instance, the quantity of maize recorded by CBS or in National Cereals and Produce Board (NCPB) annual reports does not include the proportion consumed at home, retained as seed, given away or sold to local unofficial buyers. Similarly, for minor crops like millets, pulses, NCPB only records the quantities it handles. To obtain estimates that closely approximate the real annual production figures, FAO estimates based on acreages and yields for these crops were collected instead.

A.1.2 LIVESTOCK AND LIVESTOCK PRODUCTS DATA

Production of livestock is the value of production of meat adjusted for changes in animal inventories. However, because of lack of data on value of inventory changes for livestock, only livestock products (meat, milk and eggs were considered. This data was also obtained from FAO production yearbooks. Figures for pigmeat and chicken meat were not included because it would result in double counting as these two categories of livestock are mainly fed on intermediate products from the farm, which were not deducted from the gross figure of production.

To arrive at an aggregate gross figure of total agricultural production, crop output and livestock products were summed using prices which converts them into value (KShillings). This aggregate production figure was further expressed in physical terms known as "Grain Equivalent" (g.e.). This term expresses production in terms of value of wheat or maize. To obtain the grain equivalent measure, the aggregate value of agricultural production (KShs.) was divided by the price of maize (KShs./ton). Table (A) below gives the figures for total agricultural production in value (KSh.) and in grain equivalent (g.e.).

TABLE (A): TOTAL AGRICULTURAL PRODUCTION IN VALUE AND IN GRAIN EQUIVALENT 1960-1980

YEAR	VALUE $x\ 10^6$ KSh.	PRICE OF MAIZE KSh./ton	GRAIN EQUIVALENT $x\ 10^6$ MT
1960	3464.93	433.7	7.99
1961	3301.88	457.7	7.21
1962	3317.28	364.6	9.10
1963	3206.47	370.2	8.66
1964	3397.86	408.1	8.33
1965	3417.87	393.7	8.68
1966	3434.19	418.1	8.21
1967	3501.25	365.0	9.59
1968	3502.31	314.3	11.14
1969	3522.42	282.2	12.48
1970	3527.69	275.0	12.83
1971	3534.88	320.8	11.02
1972	3559.58	354.3	10.04
1973	3539.61	324.2	10.92
1974	3688.29	328.3	11.23
1975	3920.13	414.2	9.47
1976	4942.34	396.0	12.48
1977	5489.30	397.9	13.80
1978	5649.89	340.3	16.60
1979	5971.33	273.6	21.83
1980	6288.09	317.9	19.78

Source: Results of calculations in present study.

Generally, there are two kinds of economic measures of production used in productivity analyses. One is total agricultural output which prepresents the value of agricultural production net of intermediate products such as home produced feeds and seed, which are used productively within agriculture. It is different from total (or gross) production which takes no account of intermediate products. The output measure net of intermediate products. The output measure net of intermediate products is a better measure of the value of agricultural products because it shows the value of agricultural production ready for direct consumption or subsequent processing and export.

Another measure of agricultural production is gross value added which shows the value of output net of intermediate products and current inputs purchased from the non-farm sector such as fertilizers and imported manufactured feeds. It is also a good measure because it shows the direct contribution of agricultural products to the gross domestic product (GDP).

The present study has used the gross measure of production in contradiction to the net output measure because of lack of data on value of intermediate products necessary for the required deductions. Some form of balance sheet which would show these breakdowns is not yet available.

A.2. AGRICULTURAL LAND

The most reliable measure for this variable has been very difficult to establish. According to Shukla (1979), the measurement of the value of land has "----remained to date, un unfinished task."

Measurement in terms of space-area is not adequate enough because of locational and soil-climatic differences. Value of land in terms of shillings per hectare or land rent is also not an adequate measure of land as an input in agriculture, because it includes other factors not represented by investment. According to Shukla, (1979), Wember and Kariuki (1981) the use of land rent or value of land could lead to over valuation of land, especially in developing countries.

The measure of land that has been adopted for this study is the space-area measure which is comprised of all arable land and land under permanent crops and pastures. The basic assumption underlying this choice of measure is that the land has equal potential as an input in agriculture and no distinction was made between high potential and low potential areas. The data was compiled from Statistical Abstracts and FAO production yearbooks.

A.3. AGRICULTURAL LABOUR

The input of labour in agriculture depends not only on the supply and demand conditions within the sector but also on other factors outside agriculture. Most authors agree that reasonable measures of agricultural labour input must reflect:

i) the rate of participation by individuals in the economic labour force of the community.

ii) the age, sex, and skill structure of the labour force in order to account explicitly for differences due solely to different composition of the labour force with respect to these attributes.

iii) the apportionment of labour input between strictly defined agricultural activities and other activities that are not directly related to agricultural activities that are not directly related to agric agricultural production and marketing.

Another consideration is the distinction between stock and flow concepts of labour. For instance, where attractive opportunities exist to draw away part of the labour from agriculture, then the stock concept would be most relevant because the potential stock of the agricultural labour force is reduced. On the other hand, the flow requirement (man days, man equivalent etc.) changes with the prevailing production-marketing arrangements, prevailing technology and capital inputs.

The data for labour input was compiled in stock terms since the flow requirement for all activities was not available.

This data was compiled from FAO production yearbooks, as "persons economically active in agriculture" as the labour input at the total sector level. In large scale farms, large farms cencus data was used.

The development of the series for labour input from 1960 to 1980 presented problems because, the information for the whole sector was available for the years 1960, 1965, 1970 and 1975 to 1980 only. The figures for the intervening years had to be estimated through linear extrapolation procedures to bridge in the gaps. This procedure was adopted from Weber (1981) and from Crisostom and Barker (1979).

A.4 CURRENT NON-FARM INPUT DATA

These are defined collectively as variable inputs that originate outside the domestic farm economy, excluding durable machinery and equipment. This category normally includes imports of feeds, the services and physical inputs from the non-farm sector. Due to problems of quality and incompleteness of basic data, only the physical inputs from non-farm sector have been used, being approximated by fertilizers and pesticides. Manufactured feeds were excluded because the records show total value of the feeds while the data required was the fraction of value resulting from the activities of the non-farm sector such as processing and transport since the inputs originate from farm products.

Physical quantities of data for fertilizers (N, K_2O, P_2O_s) available to the agricultural sector for the period 1960-1978 were collected from FAO production yearbooks and FAO Fertilizer yearbooks. Data covering 1979 to 1980 was estimated by linear extrapolation method. Data on pesticides was obtained from annual trade reports of the Customs and Excise department, as Annual Imports. All these items were finally aggregated using constant (1970) prices to give estimates for annual expenditure flow of current inputs for the whole sector. Data for large scale farms was obtained from Large Scale Farm cencus reports of the CBS, as quantities applied.

A.5 FARM MACHINERY

This is represented by interest charge and depreciation on tractors. Other inputs such as buildings and permanent crops were not included because of lack of data.

ANNEX B

THE PROCEDURE FOR CALCULATION OF INDEXES OF PRODUCTION, INPUTS AND PRODUCTIVITY

B.1 THE PRODUCTION INDEX

The calculation of this index was based on the annual aggregated value of production which were computed using constant (1970) prices. To even out year-to-year random fluctuations these figures representing value of production were further converted to five-year moving averages so that the observation points are the centres of the five-year moving intervals.

To obtain the production index, the value for each five-year moving average was divided by the value at base period. The selected base period was 1960-1964 which marks the initial terminal of the five-year moving average. This calculation can be approximated by the Laspeyer's quantity index.

B.2 INDEXES OF THE INPUTS OF LAND, LABOUR, CURRENT INPUTS AND FARM MACHINERY

The indexes for land and labour have been constructed using the same procedure as the production index with Laspeyer's index. The basis is the physical quantities with the base period being 1960-1964.

The indexes for current inputs and farm machinery were constructed using a price weighted Laspeyer's index with 1960-64 as base period.

B.3 CONSTRUCTION OF THE INDEX FOR TOTAL INPUT

B.3.1 Factor-shares

The factor-share of an input is the proportion of that input in the total factor cost. It is the factor-shares which have been used to combine the four categories of inputs into one total factor input index. To obtain the factor-shares, the cost of each input was divided by the total factor cost, all costs estimated at current prices.

The costs for current inputs and farm machinery were determined using prices and depreciation, respectively. The annual cost for labour input was determined by multiplying the number of workers by the wagerate (average) of persons employed in agriculture and forestry.

To arrive at the cost of the services rendered by agricultural land has been difficult. The ideal evaluator is land rent according to most authors. However land prices were not possible to estimate. Average land prices from Kiambu District as compiled by Weber and Kariuki (1981) were used although these are not truelly representative for the whole country. They have been adopted with the basic assumption that they reflect, in a general way, the trend in most of the agricultural districts, being characterized by rapidly rising land prices due to a growing scarcity of land.

The procedure for determining the cost of land was adopted from Weber (1981), where the total agricultural land was first multiplied by the land price to give the value of the total stock of land. Then the current interest rate used by banks in each corresponding year was charged on the respective annual value of the stock of land.

The factor-shares for each input were computed by dividing the cost of each input by the total cost of all inputs. Five-year averages of the factor-shares were constructed to minimise the effects of irregular and unexpected fluctuations in any single year.

B.3.2 COMPUTATION OF THE TOTAL INPUT INDEX

The method used is a chain-link index formula which is represented by the Divisia Index, where by the factor-shares become the weights. Many of the authors do not use fixed weights but rather, they use averages over a defined period. According to Lee and Chen (1979):-

> ".....factor-shares change substantially over long periods, making the use of constant weights taken from a particular base period inappropriate".

With this procedure, comparisons over long periods become more reliable.

In this study the factor-shares are rounded up to five-year averages so that they vary every five-years. The procedure followed for construction of the index was adopted from Lee and Chen (1979) and is summarized below:

1. The first step was to calculate average factor-shares of the four categories of inputs for each successive five-year interval.

2. In the second step, the index of the quantity of each factor input was converted to a link index, i.e., to a series of successive year-to-year ratios.

3. In the third step, these linked indexes of the individual factor inputs in each interval were aggregated, using the average factor-shares in the respective intervals as weights.

4. In the final step, the annual link aggregates of total input were multiplied with the index of the previous year to produce the chained series for the whole period.

In symbol notation, the procedure is represented by the Divisia index formula and is given below:

$$I_t = I_{t-1} \sum_{i} W_{i,\,t-1} \frac{Q_{i,\,t}}{Q_{i,\,t-1}}$$

Where, I_t is index of total input in year t.

(I in t = 1962 is 100.0)

$W_{i,t}$ is average share of input i in total factor cost in the five-year interval that includes year t.

$Q_{i,t}$ is index of input i in year t.

B.4 CALCULATION OF THE PRODUCTIVITY INDEXES AND THEIR GROWTH RATES

The productivity indexes were calculated as ratios of the production index to the input indexes. Total productivity was calculated as the ratio of production index to total factor input index for each year. Similarly land and labour productivities were calculated as ratios of production index to the land and labour indexes, respectively.

Finally growth rates were calculated as compound annual rates of change between the initial and terminal values of the indexes over the whole period.

CORRELATION MATRIX FOR TOTAL SECTOR EQUATION (4.1)

	Y	L	N	F	M	T
Y	1.00	0.96	0.82	0.69	0.59	0.83
L	0.96	1.00	0.67	0.52	0.43	0.68
N	0.82	0.67	1.00	0.96	0.86	1.00
F	0.69	0.52	0.96	1.00	0.90	0.96
M	0.59	0.43	0.86	0.90	1.00	0.87
T	0.83	0.68	1.00	0.96	0.87	1.00

CORRELATION MATRIC FOR LARGE FARM SECTOR EQUATION (4.4)

	Y	L	N	F	M
Y	1.00	-0.33	0.24	0.71	0.91
L	-0.33	1.00	0.28	-0.53	-0.51
N	0.24	0.28	1.00	0.27	0.01
F	0.71	-0.53	-0.27	1.00	0.80
M	0.91	-0.51	0.01	0.80	1.00

Where, Y = Output in K£

L = Land in hectares

N = Labour as persons

F = Fertilizer in K£

M = Capital in K£

T = Time in years