Sources and Determinants of Agricultural Growth and Productivity in Kenya

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Abstract

Agriculture is the most important sector in the Kenyan economy given its contribution to employment, foreign exchange, food, and its linkages with other sectors of the economy. Indeed, the sector's performance directly mirrors that of the overall economy. However, in last ten years or so, the performance of the sector has been steadily declining, culminating in a negative growth rate in 2000. With over 80 per cent of the Kenyan population (the majority of whom are poor) living in the rural areas, the poor performance of the sector has had serious implications on poverty and living standards of the people. Declining agricultural growth has been identified as a major determinant of poverty in the country. Reversing this trend is no doubt an immediate development challenge for Kenya. Addressing this challenge requires knowledge of what drives agricultural growth and productivity.

This study explores the sources and determinants of agricultural growth and productivity in Kenya for the period 1965-2001. The 'growth accounting' approach is used to identify the sources of growth, while econometric techniques are used to assess the determinants. The study utilised secondary information from the World Bank Africa Database and the KIPPRA Agricultural Data Compendium. The study establishes that most of the agricultural growth in Kenya is attributable to factor inputs – labour, land and capital. Growth in output not attributed to factor inputs or total factor productivity has in the entire period accounted for only 10 per cent of growth. Labour has been the most important source of growth and accounted for about 48 per cent of the total growth. Land is also a very important determinant of agricultural growth and productivity. The study has also established that the Kenya's trade policy, climate, and government expenditure on agriculture are important determinants of agricultural total factor productivity growth.

Abbreviations

CD	Cobb-Douglas
GDP	gross domestic product
HCDA	Horticultural Crops Development Authority
KARI	Kenya Agricultural Research Institute
KCC	Kenya Co-operatives Creameries
KMC	Kenya Meat Commission
KNFU	Kenya National Farmers Union
NIB	National Irrigation Board
NCPB	National Cereals and Produce Board
KTDA	Kenya Tea Development Authority (Agency)
TFPG	Total Factor Productivity Growth
KENFAP	Kenya National Federation of Agricultural Producers

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1. Introduction

Although the contribution of agriculture to gross domestic product (GDP) has declined from 40 per cent in 1963 to only 24 per cent in 2002, the sector continues to be dominant in the Kenyan economy and a major contributor to economic growth. The sector generates about 60 per cent of the country's foreign exchange and provides employment to about 70 per cent of the total population. The sector also provides nearly all the food requirement for the nation and the bulk of raw materials required in the industrial sector. Because agriculture is a major sector of the Kenyan economy, its performance directly mirrors that of the overall economy. Therefore, whenever agricultural GDP declines, overall GDP for the whole economy correspondingly declines and vice versa.

While the agricultural sector performed exceptionally well in the early years of independence, its performance in recent years has been dismal. From an all time high average growth rate of about 6 per cent in the 1962-72 period, the sector dramatically declined to below 2 per cent in the 1990s. In the more recent past, the sector actually contracted, recording a rate of –2.4 per cent in the year 2000, down from 1.2 per cent in 1999. As a sector which is intricately linked to the rest of the economy, the performance affects other sectors and the overall-well being of the country. The poor performance of the agricultural sector, and particularly its declining productivity has been identified as an important determinant of poverty in Kenya. According to the recently concluded Poverty Reduction Strategy Paper (PRSP), declining agricultural productivity in Kenya has led to food shortages, underemployment, low income from cash crops and poor nutritional status, which has further reduced labor productivity (Republic of Kenya, 2001).

An immediate development challenge for Kenya in the face of overall poor economic performance and deepening poverty is to reverse the

adverse trends in agricultural growth and productivity. Indeed, it is now widely recognised that increasing agricultural productivity is the single change with the greatest direct benefit to the poor, given that 82 per cent of Kenyans live in the rural areas, the majority of whom are poor. This requires an understanding of what propels growth and productivity in Kenyan agriculture. The key questions are: what are the sources of agricultural growth? What determines agricultural productivity? What can be done to enhance agricultural growth and productivity in Kenya? This paper is an attempt to answer some of these questions. The specific objectives of the paper are to identify the sources of growth in agriculture and to empirically analyse the determinants of agricultural productivity. This is crucial in formulation of agricultural policy and in addressing the challenges facing agriculture in Kenya.

The rest of the paper is organised as follows. The next section is an overview of the structure and performance of the agricultural sector since independence. This is followed in Section 3 with an analysis of production relations in the sector by estimating a production function. Section 4 is an analysis of the sources of growth using the growth accounting method while Section 5 examines the determinants of agricultural productivity using econometric techniques. The conclusions and policy implications are drawn in the last section of the paper.

2. The Agricultural Sector in Kenya: An Overview

The current state of the agricultural sector in Kenya is a product of many factors including the country's colonial history, resource endowments, the prevailing socio-economic environment, regional economic relations and the general policy environment. This section of the paper provides a review of the sector focusing on the current structure of the sector, the evolution of policies and trends in inputs and outputs.

2.1 Current structure of the agricultural sector

Like elsewhere in the developing world, agriculture remains the most important sector in the Kenyan economy, contributing approximately 24 per cent of the country's GDP and employing approximately 70 per cent of the national labour force. The sector is also important as a major foreign exchange earner and provides nearly all the food requirements for the country. However, although the sector remains the most important in the Kenyan economy, its contribution to overall GDP has steadily declined over the years. Recent trends in the contribution of the sector to GDP in the last ten years are shown in Table 1.

The agricultural sector in Kenya is dichotomised into large and small production systems. Overall, the small-scale sector contributes about 75 per cent of the country's total value of agricultural output and about 85 per cent of the total employment in the agricultural sector. It is estimated that there are about 3 million smallholder[1] farms with an average of about 2 hectares in the country. Available statistics also show that the small-scale sector accounts for about 70 per cent of the total marketed output and provides most of the employment in the sector. It is estimated

1. In the Kenyan statistics, smallholders are defined as having between 0.2 and 12 hectares of land while large farms average around 700 hectares.

Table 1: Agricultural GDP as a share of total GDP (1990-2000)

Year	Agricultural GDP £ million (Constant 1982 prices)	Total GDP £ million (Constant 1982 prices)	Agriculture's share in GDP (%)
1990	1,192.04	4,223.63	28.2
1991	1,178.93	4,311.50	27.3
1992	1,134.83	4,332.22	26.2
1993	1,088.49	4,342.79	25.1
1994	1,119.29	4,474.58	25.0
1995	1,173.32	4,690.13	25.0
1996	1,225.35	4,907.59	25.0
1997	1,240.05	5,022.56	24.7
1998	1,256.08	5,112.60	24.6
1999	1,271.25	5,185.10	24.5
2000	1,244.80	5,172.82	24.0
2001	1,259.80	5,234.85	24.0

Source: Statistical Abstract, 2002

that smallholders produce about 60 per cent of the tea, 15 per cent of the marketed maize, and 50 per cent of the marketed coffee in the country.

The mode of production in Kenya's agriculture, like elsewhere in the developing world, differs widely by the kind of system. In the large-scale production system, the techniques used are typically capital intensive (e.g. mechanised harvesting). These techniques are in most cases inappropriate for the smallholder sector. Large-scale farmers also typically have higher use of inputs, better management skills and higher yields than the small-scale farmers. Production in the small-scale sector has historically been characterised by high labour intensity and the use of traditional technologies (e.g. ox-drawn carts), seasonal employment and low use of productivity enhancing inputs such as fertilisers and pesticides. Consequently, productivity in the small-scale sector has not

only remained low but also falls far short of the productivity in the large sector.

2.2 Evolution of policies in the sector

Kenya's economic policies since independence can be grouped into two distinct phases. The first phase was a period of government controls and direct participation in economic activities, including controls on foreign exchange, investments and production activities. Essentially, this was the era of controls. The second phase was characterised by a reduction in the participation of government in economic activities and an increased reliance on market forces and private individuals and organisations in agricultural production, marketing and investment.

The immediate concern of the government at independence was to bring the African into the fold by ensuring the participation of Africans in food production and income generation. To achieve this, the government embarked on an ambitious Africanisation programme outlined in the *Sessional Paper No 10 of 1965: African Socialism and its Application to Planning in Kenya*. The programme was designed to revolutionise agriculture by utilising unused and underused land through land consolidation, extension services and training as well as introduction of modern methods of farming and marketing. Therefore, in the early years of independence, agricultural policies were largely founded on equitable income distribution, employment creation, and self-sufficiency. The overarching principle in this period was state control. This continued until the early 1980s.

During the era of government controls, production and marketing for most commodities were organised under co-operative societies. These were to assist in the procurement of production inputs and in the marketing of agricultural produce. A majority of these co-operative societies were affiliated to the Kenya National Farmers Union (KNFU),

now the Kenya National Federation of Agricultural Producers (KENFAP). A number of state-run farmer organisations were also set up to support the production and marketing of most commodities. This included Kenya Tea Development Agency (KTDA) for tea, Kenya Co-operative Creameries (KCC) for milk, National Cereals and Produce Board (NCPB) for cereals, National Irrigation Board (NIB) for irrigated crops, and Horticultural Crops Development Authority (HCDA) in horticulture.

The country also inherited a system of agricultural marketing of major commodities from the colonial government based on control by parastatal bodies. Virtually all the most important commodities had state boards, which regulated the production and marketing of the commodities. These boards included the Sisal Board of Kenya, Kenya Sugar Authority, Coffee Board of Kenya, Tea Board of Kenya, Pyrethrum Board of Kenya, Kenya Dairy Board (KDB), the Cotton Board of Kenya, the Dairy Board, and the Kenya Meat Commission.

In production, the government over the years supported agricultural activities such as investment in research, extension and use of improved inputs (fertilisers, seeds and chemicals). These investments resulted in major breakthroughs in agriculture in the form of high yielding varieties of major food and cash crops. Besides the specific agricultural policies pursued during the time, the macro policies of the government also played an important role in determining outcomes in the sector. It is argued that through government controls on most activities of the economy, the agricultural sector suffered both implicit and explicit taxation mainly through unfavorable macro-economic policies especially over-valued exchange rates (Wagacha and Ngugi, 1999). Investment policies by the government at the time also gave the industrial sector undue advantage over the agricultural sector. This advantage was in the form of protection of the industrial sector through a variety of tariffs and quantitative restrictions.

Market liberalisation policies started from 1980s under the structural adjustment programmes (SAPs) of World Bank and International Monetary Fund. The focus was on gradual price decontrols and promotion of private trade in marketing of agricultural commodities that hitherto were controlled by the government through various marketing boards. The impetus of the reforms gained momentum in 1992 with the requirement by the World Bank for removal of distortions in the economy as a conditionality for disbursement of the Bank's loans (Swamy, 1994). However, it was not until 1986 that the government officially spelt out the wide range of policy reforms for the whole economy in *Sessional Paper No. 1 of 1986 on Economic Management for Renewed Growth*. The reforms focused on reduction of government controls with a shift towards increasing the role of the private sector in undertaking most of the activities in the economy. The government's role was to control and regulate private participation in the market guided by forces of supply and demand rather than use of direct interventions.

Although the policy reforms were started in Kenya in the 1980s, it was not until 1993 that rigorous implementation of the policy reforms began. Implementation of reforms in the early period was accompanied by considerable official ambiguity and covert and overt resistance (Ikiara, 1998).

The deregulation of markets, decontrol of prices, and trade liberalisation were aimed at encouraging the private sector to play an important role in the production, marketing and processing of agricultural commodities. The cotton, sugar, beef, dairy and maize markets have so far been deregulated. At the same time, although the government is yet to completely deregulate the marketing of export crops, mainly coffee and tea, it has substantially decontrolled their pricing and trade. Domestic controls and trade in cotton have been completely deregulated. Beef marketing and trading has also been opened up and occurs at various

country council levels while the Kenya Meat Commission has closed down. Dairy products are now openly marketed and Kenya Co-operative Creameries has lost its monopoly in processing.

At the macro level, policies were aimed at introducing price incentives to agricultural producers. Removal of restrictions on the exchange rate, foreign exchange retention and remittances, and liberalisation of interest rates are some of the monetary policy reforms that were implemented and were expected to allow farmers to benefit more from agricultural exports. Government spending has also been reduced through retrenchments in the civil service. This, together with reduced government borrowing, was expected to reduce inflationary pressures in the economy, therefore increasing real earnings to agricultural producers.

The major objective of the policy reforms for the agricultural sector was to provide incentives to farmers for increased production. Problems with implementing the policies, however, dampened the supply response, and agricultural production and food production have been on the decline (Nyangito, 1999). While the liberalised policies were accepted in principle, the legal framework to support them has not been put in place. Therefore, enforcement of the laws that govern the sector is weak, hampering efficient development of the institutions that serve the sector.

2.3 Trends in outputs and inputs

This sub-section examines the overall trends in agricultural output and input for the period 1965-2001. The entire period is divided into three sub-periods: (a) 1965-1972, (b) 1973-1984, and (c) 1983-2001. Each of these periods is characterised by distinct macro-economic and sectoral policies as well as outcomes (Wagacha and Ngugi, 1999). The period 1963-72 has severally been considered as the period of high growth rate in Kenya. During the period, GDP grew at an average rate of 7 per cent per annum. Agriculture as a sector performed exceptionally well in this period

achieving a growth rate of 4.8 per cent per annum. This period was generally characterised by a policy framework that emphasised rapid economic growth to raise the overall standards of living of the people.

The next period, 1972-83, was a period in which the performance of the economy slackened as the country went through a number of shocks with varied implications on growth. The commodity boom of 1976-78 and the two oil shocks of 1973 and early 1980 had the overall effect of slowing down growth to an average of about 4 per cent annually. Throughout the period, protectionism and massive public sector investment dominated policy. The result of the policies pursued in this phase was the creation of a highly inefficient industrial sector, an over-extended public sector and entrenched rigidities in the country's budgetary process. By the early 1980s, these problems had become so protracted that the government, with the instigation of the World Bank and the IMF embarked on structural reforms.

The third phase, the structural adjustment phase, has generally been characterised by sweeping economic and political reforms that included privatisation of parastatal organisations, liberalisation of the financial and energy sectors, price decontrols, and phasing out of import controls. The main thrust of the adjustment programmes was to effect a shift from a highly protected domestic market to a more competitive environment that would facilitate increased use of local resources. The period was generally characterised by outward oriented production policies that would promote employment creation and exports expansion. In terms of overall performance, the period witnessed a sharp decline in major macro-economic performance indicators.

Agricultural outputs

The growth pattern of agricultural output in Kenya is shown in Table 2 and Figure 1. It is evident that output has steadily declined since the

early 1970s. While agricultural output expanded considerably in the early years of independence with a growth rate averaging about 4.8 per cent, performance declined marginally in the period 1972-1983 to only 4.5 per cent before declining further to register a growth rate of only 1.9 per cent in the 1983-2001 period. The good performance of the agricultural sector in the early years of independence has been attributed to area expansion, the subdivision of large farms and the introduction of high value crops to small-scale farmers. The decline in the 1972-83 period was partly blamed on the external shocks that had the overall effect of lowering the export income by worsening the terms of trade for Kenya and other commodity-dependent less developed countries.

Table 2: Growth of agricultural outputs and inputs, 1965-2000

	1965-1972	1972-1983	1983-2001	1965-2000
Output	4.8	4.5	1.9	3.8
Land				
- Arable land area	0	0.7	0.4	0.4
- Land under irrigation	14.0	1.9	3.5	5.0
- Land under major crops	1.2	0.5	0.5	0.7
Labour				
- Agricultural labour force	3.4	3.2	3.4	3.2
Capital				
- Agricultural capital formation	5.1	5.7	1.7	3.8
- Imports of agricultural machinery	-	-	24.0	18.0
Fertiliser				
- Fertiliser consumption (Kg/HA)	12.6	7.1	6.2	7.2
- Fertiliser imports	13.6	7.1	7.2	8.5

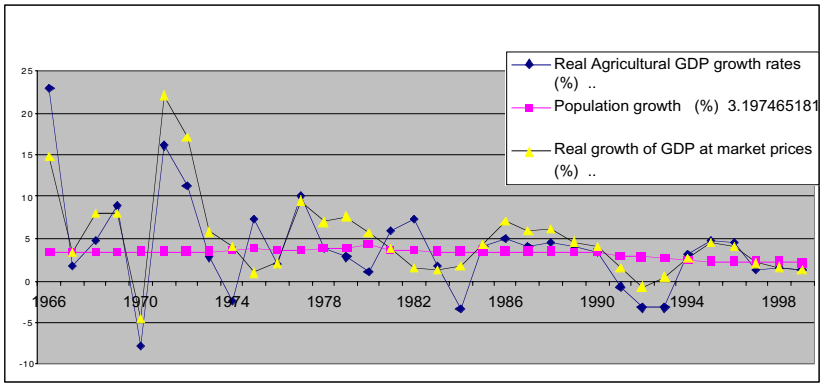
Source: Own computations based on World Bank Africa Database 2001; Gitu, W. K. and J. Nzuma (2003).

The period 1983-2001 was largely a period of reform. During the first period of reforms (1983-1990), the agricultural sector grew at a rate of about 3.6 per cent per annum. This ranged from 3.2 per cent per annum in the early 1980s to 4.2 per cent in the late 1980s. In the early 1990s, there was a steady decline in agricultural growth, reaching the lowest level in 1994. The sector recovered somewhat between 1994 and 1998 before declining again (Figure 1). In 2001, the sector recorded the lowest growth rate since independence. The apparent ineffectiveness of reforms in the agricultural sector has been attributed to, among other factors, poor sequencing of reforms and lack of synchronisation of reforms with other policies.

The overall output trend for Kenya for the entire post-independence period shows a close association between agricultural output and economy-wide output. In Figure 1, it is clearly evident that changes in national GDP reflect changes in agricultural GDP and vice versa. This implies that growth rate in the agricultural sector tracks that of the whole economy. According to a study by Block and Timmer (1994), the growth multiplier from the Kenyan agricultural sector to the whole economy is about 1.64. This implies that a 1 per cent growth in the agricultural sector brings forth a 1.64 per cent growth in overall GDP.

Another important observation evident in Figure 1 is that growth in agricultural output has for most of the period between independence and the 1990s been higher than the population growth rate. The only significant exception was the period between 1983 and 1984 when there was a drought in the country. In the 1990s, however, except for a short spell between 1994 and 1996, the growth of agricultural output has been lower than the population growth rate. This is not only indicative of the dwindling capacity of agriculture to meet domestic consumption needs, but also of increased poverty given than the majority of the population rely heavily on agriculture.

Figure 1: Real GDP, agricultural GDP and population growth, 1965-2000



Source: World Bank Africa Database 2001

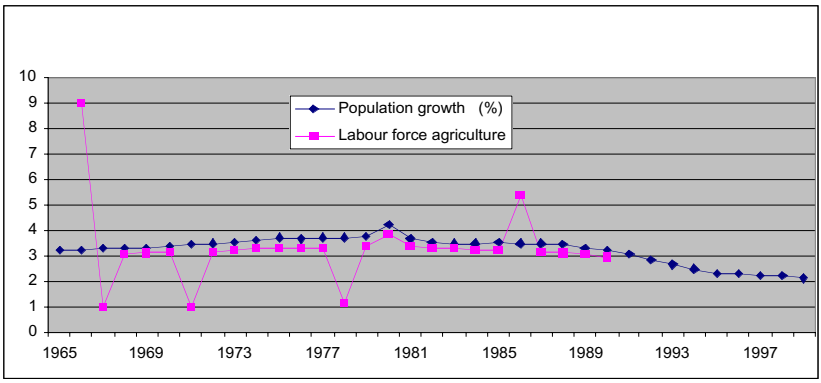
Agricultural inputs

A major factor in agricultural production in Kenya is labour. Indeed, agricultural production has been, and still remains, labour intensive. Available data indicate that over the entire period under review, agricultural labour grew at a slightly lower rate than population growth (Figure 2). In the first period, the growth of agricultural labour was higher than that of the population. This is consistent with the major expansion of the agricultural sector in the period. In the subsequent periods, population growth remained above growth in agricultural labour force pointing to both open and disguised unemployment in the sector. The difference between the two can also indicate migration of labour from agriculture to non-agricultural sectors.

Migration of labour from agriculture to the other urban-based sectors of the economy has mainly involved the young and particularly men. This has left agricultural production predominantly in the hands of women. It is currently estimated that women provide 75 per cent of the labour in small-scale agriculture. Despite their dominance, women face a number of challenges that hinder their performance. These challenges relate especially to access to productive resources including land and credit.

The traditional customary law that governs access to land in the rural setting in Kenya inhibits land ownership by women. This in turn prevents women from accessing credit that in Kenya is dependent on possession of land titles.

Figure 2: Agricultural labour force and population growth, 1965-2000



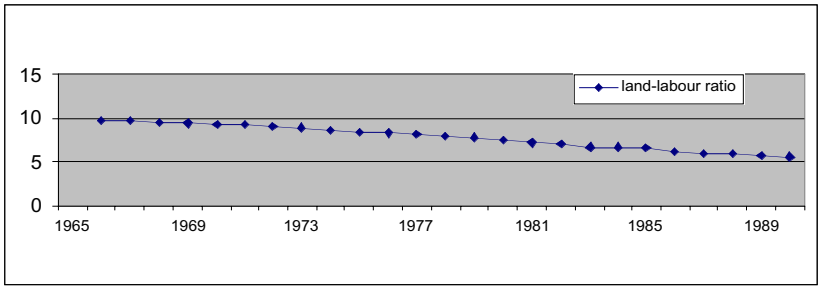
Source: World Bank Africa Database 2001

Land is the other important factor in agricultural production. This factor input has expanded very slowly relative to labour, with the result that the land-labour ratio has steadily declined (Figure 3). Arable land area has over the entire period registered a paltry growth of 0.4 per cent, with most of the increase coming from irrigation expansion. It is significant to note that most of the irrigation expansion in Kenya took place in the early years of independence when the government initiated a number of irrigation schemes. In the subsequent periods, the pace of irrigation development slowed considerably with most of the expansion coming from the smallholder sector. Overall, however, the expansion of irrigation land has been very slow (Appendix Figures 1 and 2).

Among the main inputs in agricultural production in the country are fertilisers, pesticides and other chemicals, seeds, and machinery. Fertilisers are the major purchasable non-factor inputs used by farmers in Kenya. However, the average annual consumption of fertiliser for the period 1965-2001 is about 79,000 metric tones, while its use per hectare

was 20 kilograms. These quantities are far below the estimated potential of 600,000 metric tones per year (World Bank, 1986). For the entire period under study, fertiliser usage registered a steady growth until the mid-1990s when it started falling (Figure 4). The growth rate of fertiliser use for the entire period was about 7.2 per cent, with the fastest growth being registered in the 1965-72 period. The growth in fertiliser consumption in this period reflects in part the introduction of fertiliser intensive crops such as tea and coffee.

Figure 3: Land-labour ratio, 1965-2000



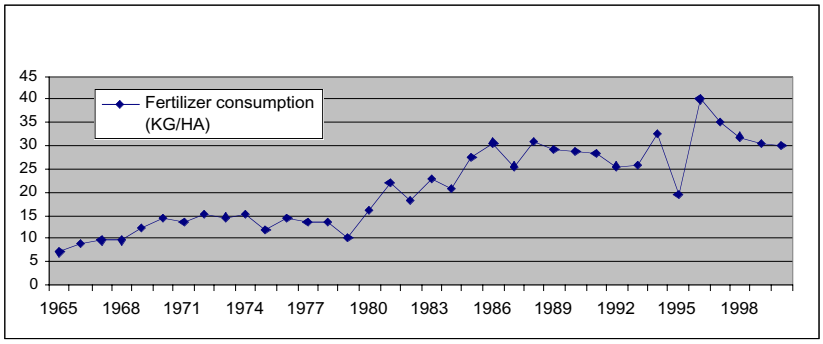
Source: World Bank Africa Database, 2001

Available statistics indicate that the national fertiliser consumption has increased in the post-liberalisation period in Kenya. Wanzala *et al* (2001) estimate that annual fertiliser consumption increased by 19 per cent between 1984/85 and 1997/98. This increase is, however, differentiated by the type of fertiliser and the enterprise on which fertiliser is being applied. Wanzala *et al* (2001) also show that consumption of maize fertiliser (DAP) declined from 70,182 tones to 67,686 tones between the period 1993 and 1992. However, the overall share of the fertiliser used increased.

Although it was widely expected that the liberalisation of the fertiliser market would increase its up-take, especially for smallholders, the result has been the contrary. The general view is that although liberalisation

increased the number of players in the fertiliser market, it did not translate into increased fertiliser use (Allgood and Kilungu, 1996; Argwings-Kodhek, 1997; Wanzala *et al*, 2001). This perhaps explains the downward trend in fertiliser consumption per acre in the second half of the 1990s (Figure 4). It is, however, evident from Figure 4 that for most of the review period, there has been an increase in fertiliser consumption rising from 5 Kg/ha in 1965 to about 40Kg/ha in 1997.

Figure 4: Fertiliser consumption per acre, 1965-2000



Source: World Bank Africa Database, 2001

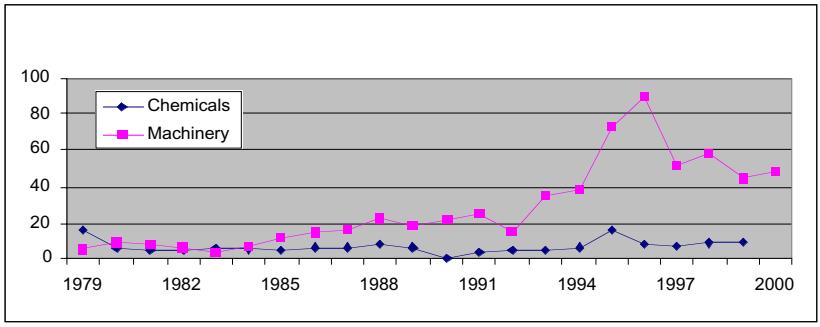
Pesticides form an important component in intensive agricultural production. The use of pesticides, however, remains very modest especially among smallholder farmers. About 90 per cent of the pesticides and chemicals used in the country is imported from abroad. Available statistics on agricultural chemicals shows a steady increase in imports (Figure 5). Importation of most of the chemicals used in agriculture is a reflection of the linkages between agriculture and industry. Among the factors that have been cited as reducing pesticide use include inappropriate technical awareness by farmers regarding returns to their use, the subsistence or near subsistence nature of production, and weak extension services (Nyangito, 1999).

As earlier indicated, use of agricultural machinery remains very low in Kenya. The majority of farmers still use simple hand tools for agricultural

production. The use of machinery is only common in the large-scale sector, and the machinery used is mostly imported. Although there have been attempts to produce machinery locally that is suitable for the small-scale sector, not much has been achieved. Some of the reasons have to do with the poor quality of the machines that are locally produced and the high cost of machinery for small-scale producers relative to those for the large-scale sector. While heavy agricultural machinery is zero-rated on customs duties and value-added tax, hand and animal drawn equipments used by the smallholders attract customs and value added taxes by virtue of the fact that they are locally manufactured.

Investment in research has over the years resulted in development of high

Figure 5: Imports of agricultural chemicals and machinery (quantity index), 1979-2000



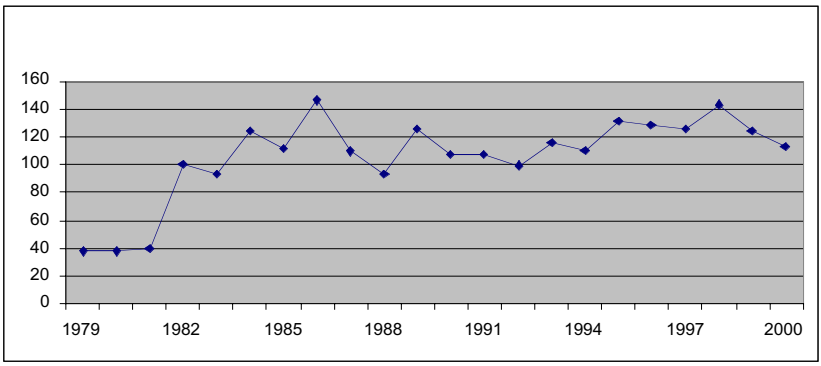
Source: Statistical Abstracts, various issues

yielding variety seeds. As a result, the country has extensive experience in production and use of certified seed. Basic seed production is mainly done by the Kenya Agricultural Research Institute (KARI) for most crops except the non-food commercial crops such as coffee and tea. Multiplication of the seeds is, however, undertaken by both public organisations such as the Kenya Seed Company and private firms. Farmers in the country have therefore the option of using purchased seeds from these outlets or using their own retained crops as seeds. The use of purchased seeds over the period has shown a remarkable increase (Figure 6).

However, the seed sector in the country still faces a number of constraints

which have affected the use of certified seed and hence productivity. These constraints include insufficient funding for basic research, inadequate resources to enforce seed quality in the country and the tendency to retain and use own seeds particularly by small-scale farmers (Nyangito, 1999). Players in the seed sub-sector have also raised concern on the seed business environment,which they contend is over-regulated. The availability of good quality seeds and planting material is critical in improving agricultural productivity in Kenya.

Figure 6: Use of certified seeds, 1979-2000 (quantum index)



Source: Statistical Abstracts, various issues

3. Production Function Analysis

We have in the foregoing section presented trends of output and input in agriculture. From the graphical trends, it is not possible to assess the contribution of inputs, individually and jointly, to the overall output. To obtain these contributions, it is necessary to estimate a production function in order to establish the relationship between the physical quantity of output of goods and specific combinations of physical quantity of inputs used in a production process. The neo-classical production function provides such a framework. It can be formulated as:

$$Y= f(X_1, X_2, X_3 \ldots\ldots X_n) \quad \ldots\ldots (1)$$

where Y is the output and X_i are the inputs.

Most analyses of productivity have typically used the constant returns to scale agricultural production relationship with two factors of production – capital and labour. It is however possible to include more factors of production (see, for example, Mundlak *et al* 2002; and Echevarria, 1998). A typical two-factor Cobb-Douglas (CD) production function can be specified as:

$$Y = AK^{\alpha}L^{\beta} \quad \ldots\ldots (2)$$

where Y, K, L indicate output level, capital and labour inputs, respectively and A, α, β are parameters determining the production technology.

In the special case that $\alpha+\beta=1$, the production technology is said to exhibit constant returns to scale, which deviates from reality.

To obtain the contribution of the various inputs to the production process, the parameters of the function are estimated and coefficients obtained. However, most production function analyses use the CD form, which imposes rather restrictive assumptions on the output elasticity of factor inputs. Moreover, it assumes constant returns to scale. It needs to be

remembered that statistical analyses lead to incorrect conclusions in general if the specified parametric model is wrongly or inappropriately specified.

To eliminate the biases in the CD formulation of the production function, economists and econometricians have sought to reformulate it to more general and flexible functional forms. Perhaps the most widely used of these forms is the transcendental logarithmic (translog) production function. The translog function is more general and flexible than either the CD or the CES as it allows for varying returns to scale and varying factor elasticity substitution. This makes it a more appropriate technique, especially where the underlying production relationship is not well understood. Taking logarithms in equation (2) above, we obtain:

$$Log\ Y = log\ A + \alpha log\ K + \beta log\ L \quad \text{..... (3)}$$

To make the equation flexible, the individual squares and the products of the factors are added to the equation to obtain the final generalised translog equation which can be specified as:

$$LogY = \beta_o + \sum_{i=1}^{k} C_i \log X_i + \sum_{i=1}^{k} \sum_{j=1}^{k} C_{i,j} \log X_i \log X_j \quad \text{..... (4)}$$

Like the CD function, the translog function is linear and can be estimated using the OLS estimation technique. An additional advantage of the translog function is that it can treat time symmetrically with other inputs. This makes it possible to examine TFP changes alongside substitution possibilities among factors.

In this paper both the CD and the translog functions were estimated for agriculture for the period 1965-2001. The former analysis is carried out primarily to demonstrate how the choice of the functional form of the production function can influence regression estimates. The dependent variable in the model is the log of agricultural output. The explanatory variables are inputs, namely land, labour and capital. Due to the

perceived importance of fertiliser in agricultural production, the input was also included in the analysis. The variables and how they have been measured are summarised in Appendix 2.

The estimations of production functions usually present a number of econometric problems and in particular multicolinearity. Strong multicolinearity decreases the precision of the OLS estimates, in which case some coefficients are not significantly different from zero, while others may have implausible negative values or have elasticity that are greater than 1. It is therefore important to carry out diagnostic analysis to ascertain the presence or otherwise of multicolinearity. The tests revealed that multicolinearity was not a serious problem in this model.

The regression results of both the CD and the translog functional forms are shown in Table 3. The results of the CD estimation are in the first column of the table while the translog estimates are in the second column. It is noted that although 4 factors of production (land, labour, capital and fertiliser) were included in both models, land and fertiliser were dropped in the CD analysis as they had negative and insignificant coefficients.

Table 3: Production function regression results

Cobb-Douglas function			Translog function		
Inputs	β	t-statistic	Inputs	β	t-statistic
Constant	2.94	4.077	Constant	3.16	2.423
K	0.46	1.932*	β_1K	0.21	1.659*
L	0.54	2.931**	β_2L	0.41	2.544**
			β_3N	0.23	1.194
			β_4K^2	-0.11	-0.132
			β_5L^2	-0.24	-2.009*
			β_6N^2	-0.06	- 1.022*
			β_7KL	0.27	1.537
			β_8KN	-0.34	-0.228
			β_9LN	2.45	2.165**
DW	1.76		DW	1.91	
Adj. R^2	0.871		Adj. R^2	0.84	
N	35		N	35	

K= Capital; L=Labour; N=Land
**= significant at 5% * = significant at 10%

Similar implausible results have been reported by Block and Timmer (1994) for the two variables. In the translog function, land had the correct coefficient although it was not significant at the 5 per cent level of signifcance.

The translog results show that the elasticity of capital as a factor of production is 0.21. The variable is positively related to output and is significant at the 10 per cent level. The elasticity of labour is 0.41 and carries an expected positive sign. The variable is also significant at the 5 per cent level. Land has an elasticity of 0.23 and is, however, not significant. It would appear from these results that capital and labour explain most of the variations in agricultural output in Kenya for the period 1965-2000. From the translog estimation, it is evident that the joint effects between capital and labour (KL) and land and labour (LN) take the expected signs although only the latter is significant at the 5 per cent level. Surprisingly, however, the joint coefficients are much smaller than the individual ones, signifying in part low levels of resource complimentarity. The joint coefficient of capital and land is not only negative but also insignificant. The squares of the factors that imply a monotonic increase in any of the factors yield negative and insignificant coefficients.

The unimportance of fertiliser in explaining variations in agricultural output in Kenya is not in any way surprising. Fertiliser use in the country, as was earlier indicated, remains very low and is highly concentrated among large-scale producers who are fewer in number. Nevertheless, the effect of fertiliser use at the farm level has been significant in many locations in the country.

3.1 Marginal productivities

Based on the elasticities derived from the regression analysis, it is possible to evaluate the marginal productivity or the shadow price of each of the various inputs used in the model. Since output was measured in value terms, the estimated elasticity can be used to obtain the marginal value products

by recalling that the marginal productivity is the product of the ratio of the inputs and outputs (taken as averages) and the elasticity. That is:

$$\frac{\partial y}{\partial x_1} = \varepsilon_j \frac{y}{x}$$

where ε_j is an estimated elasticity associated with input j, and where inputs (x) and output (y) are measured at average levels. The marginal value productivity can be interpreted as a shadow value, which under perfect conditions equals the price of the input. The estimated marginal products for labour and land are shown in Table 4. These are derived for the three periods as before. It needs to be pointed out that a constant elasticity has been assumed throughout the entire period under review. It is postulated that a different picture would have been obtained if the elasticities were allowed to vary.

Table 4: Marginal productivity of land and labour, 1965-2000

	1965-72			1973-83			1983-2000		
	Av.	Elast.	Marginal prod.	Av.	Elast.	Marginal prod.	Av.	Elast.	Marginal prod.
Labour	3,021	0.41	1,631	4,152	0.41	2,242	3,965	0.41	2,141
Land	3,245	0.23	714	5,426.2	0.23	1,194	6,468	0.23	1,423

Source: Own estimates

To gauge the efficiency in the use of resources, one would need to compare the shadow prices so generated with the actual prices. However, due to lack of information on factor prices, this comparison is not possible here. Instead, we focus on the changes in the shadow prices over time. For labour, our estimates of the marginal products show an increase from Ksh 1,631 in the 1965-72 period to Ksh 2,242 in the 1973-83 period. The figure, however, fell slightly in the 1983-2000 period to Kshs 2,141.

The fall in labour productivity is a reflection that the input has been growing faster than output. This in part suggests the existence of disguised unemployment.

A decline in labour productivity is a matter of grave concern in Kenya given the labour intensive nature of production. The marginal productivity of capital is an estimate of the shadow price of the user cost of capital. This consists of interest rates, depreciation rates and the expected capital gains. Again, due to lack of information on these key variables, it was not possible to estimate the shadow price of capital. The trajectory on returns on land displays as that of labour.

4. Sources of Agricultural Growth

This section explains the sources of agricultural growth in the period under review (1965-2001). The framework of analysis is the commonly used "growth accounting" approach. The technique is used to estimate the proportion of growth attributable to changes in labour, capital and land with the residual assumed to represent total factor productivity growth (TFPG). Assuming a three-factor production relationship with capital, labour and land, and allowing for neutral technical change, the agricultural production function can be expressed as:

$$Y_t = A_t F(K_t, L_t, N_t) \quad \text{..... (5)}$$

where Y_t is the value added in the agricultural sector in year t, K_t is capital, L_t is labour and N_t is land used in the sector in period t. The coefficient A_t denotes the level of technology, usually called the "total factor productivity" or "Solow residual". The challenge is then to obtain an estimate for A_t. Two distinct approaches can be used to estimate A_t: parametric and non parametric.[2] Parametric approaches utilise the traditional residual approach in which changes in output unexplained by the inputs are considered to be the total factor productivity growth. Differentiating equation (5), the production function with respect to time, t and dividing by Y, the growth rate of the Solow residual or total factor productivity growth can be estimated as:

$$\frac{dA}{dt}\frac{1}{A} = \frac{dY}{dt}\frac{1}{Y} - \alpha\frac{dK}{dt}\frac{1}{K} - \beta\frac{dL}{dt}\frac{1}{L} - \delta\frac{dN}{dt}\frac{1}{N} \quad \text{..... (6)}$$

where α, β and δ are the shares of value-added that remuneration of capital, labour and land represents, respectively. Therefore, given a neoclassical

2. See Odhiambo, W. and H.O. Nyangito (2003). *Measuring and analysing agricultural productivity in Kenya: A review of approaches*. KIPPRA Discussion Paper No. 26.

Cobb-Douglas production function,[3] agricultural TFPG can be estimated (in logarithms) as the difference between output and a weighted average of the inputs as:

$$\lambda_{ag} = logY_{ag} - \alpha logK_{ag} - \beta logL_{ag} - \delta logN_{ag} \quad \text{..... (7)}$$

where λ_{ag} is agricultural TFPG while the rest are as defined earlier. The weights are estimated econometrically as coefficients in the agricultural production function. Equation 7 is the basic equation used by growth economists to calculate the sources of growth.

TFPG can also be estimated using index numbers. Index number approaches entail point comparisons using discrete data. The Tornqvist index, which can either be a price or quantity, has been widely used to calculate the annual index of TFPG. It has one advantage in that it is simple and easy to compute. This is because there are no parameters to be estimated in the model. The only trouble with the index is that it does not account for measurement or sampling errors. The index takes the form (Grosskopf, 1993):

$$LnTFG = \ln y^{t+1} - \sum_{n-1}^{N} \frac{1}{2}\left[s_n(t+1) + s_n(t)\right]\left(\ln x_n^{t+1} - \ln x_n^{t}\right) \quad \text{.....8}$$

(8)

where *t* denotes time, and *Y* denotes real output. S_i represents the share of factor i, while x_i represents the inputs of factor i. It should be noted here that Tornqvist indices are non-homogeneous and assume non-constant returns to scale. As such, they provide better estimates of TFPG. Equation (8) therefore formed the basis of the analysis of the sources of growth. Onjala (2002) and Mwega (1995) have previously used this equation or variants of it to analyse total factor productivity in Kenya. The shares used here are those from the translog function with the following values: labour (0.41), capital (0.39) and land (0.23).

3. Most sources of growth studies use the Cobb-Douglas production function although any form of neoclassical production function should be compatible with the approach.

Results of the sources of growth analysis for the agricultural sector for the period 1965-2001 are shown in Table 5. Calculations for the total factor productivity growth for the whole period and the three sub-periods, 1965-72, 1972-83 and 1983-2001 are also presented. For the whole period, agricultural output grew at an average rate of 2.9 per cent. Of this total growth, about 89.7 per cent is due to the factors of production (land labour and capital). Only the remaining 10.3 per cent is attributed to total factor productivity growth (TFPG). In the first period, 1965-1972, TFPG accounted for 6.3 per cent of the total output growth in the agricultural sector. In the following period, 1972-83, the contribution of TFPG increased to 15.8 per cent then further to 13.8 per cent in the 1983-2001. These findings point to a decline in agricultural productivity, attributed to low levels of technological development in the sector.

Table 5: Sources of growth for the agricultural sector in Kenya (1965-2001)

	Growth in capital	Growth in labour	Growth in land	TFPG
1965-1972	0.9	1.5	1.1	0.3
	18.8	31.3	22.9	6.3
1972-1983	1.1	1.7	0.4	0.6
	28.9	44.7	10.5	15.8
1983-2001	0.4	1.1	0.1	0.3
	22.3	58.5	5.3	13.8
1965-2001	0.8	1.4	0.4	0.3
	27.6	48.3	13.8	10.3

Source: Own estimates

In terms of the individual inputs, it is apparent that labour has contributed the most to agricultural growth in the country. For the entire period as a whole, labour accounted for 48.3 per cent of the total growth. This is a rather large contribution, which is consistent with the fact that agricultural production in the country is largely-labour intensive. The share of labour in overall growth increased from 31.3 per cent in the 1965-1972 period to 58.5 per cent in the period 1983-2001. These results contrast strongly with similar results in Asia which show a decline in

the contribution of labour with time (Mundlak *et al*, 2002). In Thailand, for example, the contribution of labour declined from 14.3 per cent between 1971 and 1981 to only 1.2 per cent in the 1985-95 period. The difference between Kenya and the Asian countries is partly due to the green revolution in the Asian countries. The heavy use of high yielding variety seeds and fertilisers that characterised the green revolution in Asia led to a dramatic reduction in labour use. Our results however confirm those by Onjala (2002) shown in the Appendix. These results suggest that Kenyan agriculture is driven much more by the labour input. Experience in other countries and particularly in Asia shows, however, that agricultural growth is associated much more with the gradual decline in labour and an increase in other factors.

Relative to other factors of production, capital also plays an important role in agricultural growth in Kenya. It accounted for about 27 per cent of the growth in the sector in the period under review. In the first period, 1965-72, capital grew at a rate of about 0.9 per cent accounting for about 18.8 per cent of the total growth. In the third period, capital growth declined somewhat to 0.4 per cent and accounted for 22.3 per cent of the total growth. The slow growth of capital as a factor of production in Kenya is in itself a major reason for the poor performance of the sector. Capital as a factor is considered to be more productive and its growth over time is crucial for agricultural development.

Land as a factor of production accounted for the least in total agricultural growth in Kenya for the period 1965-2001. It accounted for only 13.8 per cent of the total growth for the entire period. It is instructive to note, however, that land expansion was largely responsible for growth in the early years of independence as more and more land was being brought under cultivation under the Africanisation programme. In the period, 1965-72, land as a factor of production accounted for 22.9 per cent of total agricultural growth. This declined substantially in the 1972-83 and 1983-2001 periods.

That land as a factor of production accounts for the least in agricultural growth is easy to explain. Since independence, there has been very little growth in the area of land under cultivation in the country. On the contrary, due to population pressure, arable land in the country is fast being put into settlements and other uses. There has been at the same time a very slow pace in irrigation development, which in other countries is the main source of land expansion.

TFPG is derived in this analysis as a residual factor and captures all non-input sources of agricultural growth. Included in this component is a wide range of factors including fertilisers, state variables (representing physical and human capital), policy, and other institutional variables. Ideally, fertilisers should and have in other studies been included as an input into the analysis (see for example Mundlak et al 2002). This was, however, not the case in this analysis as the variable for fertilisers was not only insignificant, but also turned a negative coefficient.

4.1 The growth sectors

We have in the foregoing section provided indications of the sources of agricultural growth in Kenya. The analysis focused on the agricultural sector as a whole. However, since agriculture is composed of different sub-sectors/activities, an understanding of the main sub-sectors in agricultural growth is important. Table 6 below shows the percentage shares of gross marketed production for Kenya's key agricultural sub-sectors. We use only marketed values because the data for un-marketed produce is hard to come by in Kenya. The information in the table should therefore be interpreted with caution, as a large proportion of produce is not sold in the market.

The data shows that permanent crops, including coffee and tea, account for most of the growth of marketed agricultural output in Kenya. These crops accounted for over 50 per cent of the total marketed output between

Table 6: Percentage shares of gross marketed production (1980-2000)

Sub-sector	1980	1984	1988	1992	1996	2000
Cereals						
- Wheat	5.0	2.6	3.6	2.0	1.8	10.7
- Maize	2.9	6.0	4.6	3.0	2.3	1.8
- Barley	1.0	0.2	0.4	8.1	0.5	0.6
- Rice	0.7	0.5	0.4	0.2	0.3	0.2
- Others	0.0	0.0	0.0	0.2	0.1	0.0
Total	*9.7*	*9.4*	*9.0*	*13.6*	*5.1*	*13.3*
Temporary Crops						
- Pineapples	0.5	0.6	0.5	0.6	0.5	0.6
- Castor and other oils	0.1	0.0	0.0	0.2	0.1	0.0
- Pyrethrum	2.3	0.4	1.0	2.1	0.8	0.7
- Sugar cane	9.3	6.2	5.8	5.4	5.6	5.4
- Cotton	1.7	0.8	0.3	0.1	0.0	0.0
- Tobacco	0.4	1.0	0.8	0.6	1.3	1.0
- Other crops	2.1	2.1	2.3	2.2	1.8	0.1
Total	16.4	11.1	10.9	11.2	10.3	7.8
Permanent Crops						
- Coffee	25.9	33.1	30.2	21.2	20.7	22.0
- Sisal	2.3	2.6	1.6	1.5	1.0	0.9
- Tea	23.9	22.6	27.8	31.5	36.0	37.0
- Wattle	0.2	0.1	0.1	0.1	0.1	0.1
- Cashew nuts	1.2	1.7	1.1	0.7	0.5	0.7
- Fruits and other crops	0.4	0.4	0.4	0.4	0.3	0.3
Total	53.8	60.5	61.2	55.4	58.6	61.0
Livestock and Products						
- Cattle and calves	12.1	11.8	10.2	13.2	18.7	13.2
- Sheep, goats and lambs	0.4	0.6	0.5	1.0	1.0	0.6
- Pigs	0.4	0.6	0.4	0.4	0.4	0.5
- Poultry and eggs	0.4	0.3	0.3	0.2	0.2	0.2
- Wool	0.2	0.1	0.1	0.1	0.2	0.2
- Hides and skins	1.1	1.0	0.7	0.8	0.7	0.8
- Dairy products	5.5	4.6	6.7	4.1	4.8	2.4
Total	20.1	19.0	19.0	19.7	26.0	17.9

Source: Economic Surveys, various issues

1980 and 2000. The next in importance is livestock, which accounts for between 17and 20 per cent of the total marketed production. The main activity under this category revolves around cattle and calves. The third sub-sector in importance comprises temporary crops. In this category, sugar cane is by far the most important, followed by pyrethrum. Cereals production account for the least in the total marketed production in

which the most important crop is wheat. Maize, which is Kenya's most important crop in terms of acreage accounts for only between 1 and 6 per cent of the marketed output in the period. These low shares are attributable to the fact that, as a staple crop, most of the maize is retained for domestic use.

5. Determinants of Agricultural TFPG

Having assessed the contribution of TFPG to agricultural growth in the foregoing section, we analyse in this section the determinants of agricultural TFPG over the period 1965-2001. The section begins by examining the theoretical linkage between TFPG and its determinants. This is then followed by an empirical analysis of the trends and determinants of agricultural TFPG in Kenya. The purpose of the analysis is to explain variations in agricultural TFP over time.

5.1 Theoretical determinants of TFPG

Total factor productivity growth(TFPG) measures the synergy and efficiency of utilisation of resources of production. To establish the link between TFP and its determinants, there are two important approaches that can be followed (Bruton, 1995). The first involves adding in the production function similar to the one described in section 3 all variables presumed to determine output. Therefore, given a typical production function, one would specify:

$$Y = F(K, L, N X^{o}) \quad \ldots\ldots (9)$$

where X^{o} refers to other factors presumed to affect output (K, L and N are already defined). By generating TFPG as a residual, it is assumed that its determinants are brought out. However, this may be misleading because any variable added into the production is assumed to affect production in the same way as the factor inputs.

A second and more robust approach is to explain TFPG with its own equation and to use correlation or econometric methods to determine the links between TFPG and its determinants (Bruton, 1995). Therefore, the TFPG equation can be written as:

$$TFPG = (X_1, X_2 X3 \ldots X_n) \quad \ldots\ldots (10)$$

where $X_i \ldots X_n$ are factors hypothesised to determine TFPG.

There has been a great deal of empirical work in the literature to assess the determinants of TFPG. These efforts have mainly been in the analysis of the sources of economic growth based on the 'growth accounting' framework. Several factors have been identified as determinants of TFPG. These are can be broadly classified into four groups:

(i) Trade policy

(ii) Activities of the government (i.e. government involvement)

(iii) Human capital, and

(iv) Climate

There are, however, other determinants of TFPG that are specific to agriculture. These include the physical environment and particularly rainfall and soils. Other factors that are likely to affect agricultural TFPG are access to markets and credit, and a number of farm-specific factors like farm management and husbandry practices. We examine the aforementioned factors in some detail below.

Trade policy

There is increasing consensus among researchers that the overall trade environment and particularly trade policies affect TFPG. It is therefore not surprising that a lot of work has been done to try and link TFPG to trade policies (e.g. Ram Rati, 1985; Tybout, 1992; Edwards, 1992; Mwega, 1995; Onjala, 2002). There are two main conceptual positions on the TFPG-trade policy nexus. The first postulation, advanced by researchers such as Ram Rati (1985) and Havrylyshyn (1990), among others, is that increased outward trade or openness contributes to economic growth through specialisation and intensification effects, greater economies of scale associated with larger markets, greater capacity utilisation and rapid technological change. It is also argued in the literature that trade encourages learning by doing and innovation, leading to productivity growth.

Trade policy can also affect growth and productivity through the foreign exchange market. There are two well-known hypotheses on the relationship between the exchange rate and productivity. The first is the so-called "exchange-rate-sheltering" hypothesis which states that a depreciating real exchange rate reduces growth in domestic productivity because it shelters domestic producers from foreign competition. This reduces their incentive to make productivity enhancing investment. The second hypothesis, the "factor-cost" hypotheses, stipulates that movements in the real exchange rate affect the absolute and relative cost of new capital and labour, therefore influencing both total factor productivity and labour productivity. Porter (1998), in his book on competition and growth, pointed out that depreciation can reduce growth, and an overvalued exchange rate can sometimes contribute to productivity growth by forcing productivity gains in the tradable sector. This contention suggests the need for assessing the precise relationship between the exchange rate and productivity in different scenarios.

Trade policies have been a dominant part of Kenya's development strategies from independence. Throughout the post-independence period, the country has used both price and quantity-oriented measures to influence the trade environment. In the early years of independence, Kenya devoted its efforts in pursuing the import substitution strategy of industrialisation. Tariffs, quantitative restrictions, import drawbacks on inputs as well as administrative controls, were variously used to effect the policy. The effects of the import substitution strategy have largely been found to be adverse and have been blamed for inefficiency and poor performance in the export sector.

Since the early 1980s, there has been a shift in policy that has seen the government increasingly pursue outward-oriented trade policies. This has been done within the context of the World Bank-sponsored structural adjustment programme. Under this programme, the government moved to remove protection on industry and other sectors. The government

(during the period) also devalued the currency and liberalised the exchange rate. In the area of trade, the government lifted quotas and administrative controls, and reduced and harmonised tariff rates. By 1995, the Kenyan economy had drastically transformed from a fairly closed economy to a more open one.[4]

As the main sector of the economy, agriculture has no doubt been affected by the changes in the trade regimes with implications on its productivity performance. The performance of the agricultural sector as Kenya's engine of growth is intricately linked to trade through exports of products (tea, coffee, pyrethrum and recently horticulture) and imports of inputs (fertilisers, chemicals and machinery). As such, changes in the overall trading environment, including exchange rates are bound to affect the performance of the sector. Productivity of the sector is also likely to be associated with macro-economic and political stability.

Government involvement

The performance of the agricultural sector is also influenced by other activities of the government in the economy in general and the agricultural sector in particular. Government intervention, particularly in terms of consumption expenditure and investments affect agricultural outcomes.

Government expenditure can have direct and indirect impact on agricultural incomes. Expenditure that does not directly affect the sector are those in general public service, defence and security, and social security. These may or may not be positively associated with TFPG. Government expenses that are complimentary to private investment and are likely to affect TFPG include expenditure on health, education, roads,

4. For a detailed characterisation of the trade policy episodes, see Little *et al* (1995). *Boom crisis and adjustment: The Macroeconomic experience of developing countries*. New York: Oxford University Press; and J.O. Onjala (2002). "Total factor productivity in Kenya: The links with trade policy." AERC Research Report 18. Nairobi: AERC.

other transport and communication infrastructure, and a wide range of economic services. More specifically expenditure on research, extension and veterinary services, rural access roads, and provision of credit are likely to directly affect agricultural performance.

In the past, the government was very active in providing subsidies on credit and inputs and in providing extension services. Since this support was not sustainable in the long run, the government was forced to reduce its expenditure on some of the services and in the process reduced overall allocation to agriculture. Services hitherto provided to agriculture (such as livestock vaccines, disease control and extension services) were therefore severely affected. Although it was widely expected that the private sector would take up some of these responsibilities, the reality has been different with the private sector only taking up some of the services.

Another state-related factor that is responsible for increased variability in agricultural growth is agricultural policy. Over the years, a number of policies have been designed and implemented in Kenya with a view to ensuring that agriculture continues to play an important role in the economy. As from the 1980s, there was a major shift in policy from reliance on government controls to liberalised markets. Many researches in Kenya so far have shown that the reforms have had significant impact on the performance of the agricultural sector and concomitantly on the entire economy. The difficulty has been to disentangle the effects of the reforms from those of the non-reform factors.

Human capital

The role of human capital in the development process in general, and particularly on productivity, has received a lot of attention in empirical literature in recent years. Growth theorists such Romer (1986), Lucas (1988, 1993) Stokey (1991) and among others, have shown that

accumulation of human capital can sustain growth. However, there is still debate on whether education and training can have an impact on farm productivity. A study by Fafchamps and Quisumbling (1997) found that education of both male and female do not systematically affect productivity. Instead, households with better-educated males with higher off-farm income divert labour resources away from farm activities towards non-farm work. It would be interesting to investigate the role of education and training in Kenya in light of these findings.

Climate

There is no dispute that agricultural performance in Kenya, and indeed in many other developing countries, relies heavily on climate. Output in the agricultural sector is to a large extent closely related to rainfall. The association of productivity to climate explains the wide regional variability in productivity. In Kenya, the climate affects not only the input uses (which directly affects productivity) but also policies. The apparent neglect of certain parts of the country in terms of agricultural development is in fact an equilibrium response to unobserved differences offered by biophysical conditions. It may, however, be worth noting that even though biophysical conditions may explain current productivity differences, they may not determine future productivity to the extent that deliberately targeted innovations (such as irrigation) can overcome location specific constraints.

5.2 Empirical estimation of determinants of TFPG

A number of factors have been hypothesised to determine agricultural TFPG. To establish the effect of each of the factors on productivity, a simple functional relationship between TFP and its determinants was formulated and estimated. TFP was hypothesised to be a function of four main factors: (a) trade policy, (b) climate, (c) government expenditure

in agriculture, and (d) physical and human capital. The assumption is that the identified factors jointly cause TFPG. The specific determinants are:

- *Rainfall (RF)*

  Rainfall is used to represent climate as a determinant of agricultural outcomes in Kenya. The variable is an index of annual rainfall in different agricultural areas in the country. A positive relationship is expected between rainfall and agricultural TFPG.

- *Trade ratio (TR)*

  This variable is meant to capture the degree of openness in the country and to reflect the changing policy episodes. The variable is defined as the ratio of imports plus exports to the country's GDP. The effect of this variable on TFPG is indeterminate, as existing theory does not provide a lead.

- *Real exchange rate (RX)*

  The real exchange rate is used in the model as a policy variable to capture the effects of the country's macro-economic and trade policies. As indicated in the previous section, the relationship between the real exchange rate and productivity is indefinite and would depend on the circumstances.

- *The import penetration index (IPI)*

  This is also a policy variable to capture the degree of openness in the country. It is used not only to capture the trade regime but also as an indicator of economic performance. The variable is the ratio of total imports to gross output plus imports minus exports. There is no a priori expectation on the relationship between IPI and TFPG.

- *Government expenditure in agriculture (GEA)*

  Expenditure in agriculture is used as a proxy of government direct involvement in agriculture. It is expected that as government involvement in agriculture increases, productivity will likewise increase.

- *Schooling (SC)*

  This is meant to capture human capital development in agriculture. Enrolment for both males and females in primary school is used to represent human capital development. A positive relationship is expected between the two variables.

- *Road length (RD)*

  This variable is used here to represent the development of infrastructure in the country. A positive relationship is also expected between this variable and TFPG.

- *Access to credit (AC)*

  This variable captures access to credit as a determinant of productivity. The variable is a dummy which takes the value 1 in the period of better access (the period after independence till 1995 when government provided subsidised credit) and 0 when otherwise (period after 1995). A positive relationship is expected between better access to credit and TFPG.

- *Total factor productivity growth (TFPG)*

  This is the dependent variable in the model. From the analysis in previous sections, there were two possibilities for obtaining TFPG: directly from the production function in Section 3 and from the sources of growth framework in Section 4. Both series were obtained and used separately. The series obtained from the

production function framework were finally used in the model as they yielded better results.

The econometric function used to estimate the effects of the variables can be summarised as:

$$Log(TFPG_{t}) = C + \beta_1 RI_t + \beta_2 TR_t \beta_3 RX_t + \beta_4 IPI_t \beta_5 GEA_t + \beta_6 SC_t + \beta_7 RD_t + \beta_8 AC_t + \varepsilon_t \quad \text{..... (11)}$$

The variables are as defined before.

As is typical with time series analysis, possibilities for multicolinearity are real. The existence of multicolinearity decreases the precision of the OLS estimates, as they will be highly unstable. If the variables are correlated, the resulting parameter estimates may take on unreasonable values and sometimes opposite signs. It is therefore very important that the existence of multicolinearity be evaluated. In the present analysis, the variance-inflated factor (VIF) was used to evaluate the presence of multicolinearity in our model. The variance inflation factor is the diagonal of $(X'X)^{-1}$ if $(X'X)$ is scaled to correlation form. VIF shows how the variance of an estimator is inflated by the presence of multicolinearity. If VIF is greater than 10, then multicolinearity is considered to be strongly present in the estimation. A value of less than 10 was obtained in our tests and so strong multicolinearity was ruled out.

A second and even more damning problem in the analysis of time series data is dealing with a series that is on a random walk. Regressing random walks on each other is very likely to produce spurious regression results. Therefore, before conducting regressions it is important to know whether the series are stationery. This is usually done by carrying out the unit root test. Both the Augmented Dickey-Fuller and the Phillips-Peron unit root tests were carried out to establish the character (stationarity) of the variables in the model. The results of the tests are in the Appendix. A number of variables were stationary, were differenced before the regression analysis, and are also shown in the Appendix. The results of

the regression analysis of the factors that determine TFP are summarised in Table 7.

Table 7: Regression results of determinants of agricultural TFPG

Variable category	Parameter	Estimates Coefficient	t-ratio
Trade policy			
Trade ratio	β_1	-0.028	-1.612*
Import penetration	β_2	-0.207	-1.412*
Real exchange rate	β^3	0.401	0.311
Climate			
Rainfall	β_4	0.632	2.319**
Government activities			
Government expenditure in agriculture	β_5	0.253	1.701**
Access to credit	β_8	0.202	0.733
Physical capital			
Roads	β_6	0.47	0.256
Human capital			
School enrolment	β_7	0.358	1.309
Adjusted-R^2	0.73		
DW	1.96		

**=significant at 5 % * =significant at 10%

Agricultural TFPG and trade policy

Trade policy was one of the main factors that were hypothesised to influence agricultural productivity. The trade ratio is negatively and strongly related to agricultural TFPG. The import penetration ratio (IPI) is also negatively related to agricultural productivity though not significantly so. These results imply that the increased 'openness' of the economy may have adversely affected agricultural productivity. There are two possible channels for this. First, greater openness characterised by the removal of tariffs and subsidies has resulted in increased costs of inputs and therefore lower levels of use. This directly affects productivity. A second possible channel could be through increased importation of

goods, including agricultural products. With the liberalisation of the economy, it became easier to import goods to compete with local production. While this is expected to enhance competition and productivity in the long run, it may have adversely affected productivity in the short run. There is certainly need to examine these possibilities in detail as the evidence remains conjectural.

The regression results show that there is a positive but insignificant relationship between agricultural TFPG and the real exchange rate in Kenya for the period 1965-2001. The negative relationship implies that an increase in the real exchange rate reduces agricultural growth and productivity. This finding conforms to the "exchange rate sheltering hypothesis" alluded to earlier which attributes the decline in production and productivity to the fact that local producers are sheltered from competition therefore reducing their incentive to make investments that are productivity enhancing. While this explanation is theoretically plausible it is hard to conceptualise in the context of Kenya where production is labour intensive and using limited external inputs. Because, the relationship is insignificant, we do not attempt to provide further insight into the nature of this relationship.

The TFPG-trade policy relationship so far discussed relates to the entire period, 1965-2000. To gain insight on the relationship between trade policy and agricultural TFPG in the sub-periods, we carried out a correlation analysis. This was necessary because the number of years in each period was inadequate for a regression. The results are summarised in Table 8 below. It is evident from the table that trade policy relates differently to TFPG in the sub-periods. It appears that trade policy had the most influence on productivity in the 1973-1983 period when, except for the export penetration ratio, all the trade indices were positively and strongly correlated to TFPG. In both the 1965-1972 and the 1984-2000 periods, the correlated coefficients show no consistent pattern besides being very low. It is notable, however, that the exchange rate returns a

fairly high coefficient, indicating that changes in the real exchange rate are closely associated with TFPG.

Table 8: Correlation matrix of agricultural TFPG and trade indices

Period	Trade ratio	Export penetration ratio	Import penetration ratio	Real exchange rate
1965-1972	0.265	-0.252	-0.269	-0.620
1973-1983	0.777	0.325	0.797	0.752
1984-2000	0.322	-0.204	-0.421	0.432
1965-2000	-0.290	-0.321	-0.240	-0.523

Source: Own estimates

The role of climate

The econometric results summarised in Table 6 show that rainfall is an important determinant of agricultural TFPG in Kenya. The variable, as a determinant of agricultural TFPG, not only carries the expected sign but is also significant. This shows that climate is an important cause of variations in agricultural performance and that it has a bearing on the overall productivity in the sector.

TFPG and human and physical capital

The empirical question here was whether human capital affects agricultural productivity in Kenya. The econometric results point to a very weak association between human capital (represented here by school enrolment) and TFPG. Therefore, although education is associated with better agricultural practices in the country it has no significant effect on productivity growth in agriculture. There is clearly no sound explanation and one could only posit, in light of these results, that households with better education in Kenya are likely to divert their

attention to off-farm activities offering higher incomes. Part of the reason for these results could also be the fact that current school attendance is unlikely to have immediate effects on agricultural outcomes. As such, more analysis perhaps using a better proxy for human development is necessary.

Also factored into the regression analysis was a variable to capture the effect of infrastructure on agricultural TFPG. For lack of a better variable, the total road length in the country was used as a proxy. As was earlier indicated, the stock of physical capital is ideally a state variable that is expected to be correlated with that component of the production function that reflects changes in the implemented technology. In other words, state variables scale production upwards. Our analysis of the relationship between the length of roads yield rather poor results. Not only is the relationship between length of roads and agricultural TFP negative, but it is also insignificant. It is worth noting here that as a variable, the total length of roads has changed only marginally over the years and is unlikely, as our analysis confirms, to be an important determinant of agricultural TFP. However, this is not to say that infrastructure is not an important driver of agricultural TFPG. Indeed, many studies have identified it as an important factor. It is probable that the quality, rather than the total length of roads, is more associated with TFPG. It was however not possible to incorporate road quality into the empirical model due to lack of data.

Effect of government involvement

Two variables were included in the model to assess the role of the government in influencing agricultural TFPG in Kenya. The variables were government expenditure in agriculture and credit. The regression results in Table 6 show that government expenditure in agriculture is positively related to agricultural TFPG. This relationship is positive at the 5 per cent level of significance. This finding would suggest therefore

that the decline in government expenditure in the last few years in Kenya could have led to a decline in agricultural productivity. The results also show a positive correlation between access to credit and productivity. The relationship is, however, not significant.

Other factors determining agricultural TFP

There are other determinants of agricultural TFP that were not included in the model largely because of lack of data. Indeed, our model was only able to explain 73 per cent of the total variations in TFPG implying that other factors account for the rest. Among the factors that we reckon could determine TFPG are research, innovation and extension, farm specific factors like the expertise of farmers, acquired through the process of learning and doing, and the role of agricultural institutions. All these factors are likely to affect the utilisation of resources and therefore productivity. Other factors include accessibility to inputs, the system of land rights, the sector's linkages with other sectors (formal and informal), and market access. Including these factors in the model would undoubtedly enhance the predictive power of the model.

6. Summary, Conclusions and Policy Implications

The overall objective of this paper was to assess the sources and determinants of agricultural growth and productivity in Kenya. The analysis began with a trend analysis of agricultural output and inputs for the period 1965-2001. This was then followed by a production function analysis to determine the contribution of each of the inputs to agricultural output. Using the growth-accounting approach, the paper examined the sources of agricultural growth in agriculture and finally attempted to investigate the possible determinants of productivity growth using econometric techniques.

6.1 Summary of key findings

The following key findings emerged from this analysis:

(i) That output from the sector has declined steadily since the early seventies. In the first decade after independence, agriculture grew at an impressive rate of 4.8 per cent per annum. From 1970s, the growth rate declined to about 3 per cent in the 1980s and further down to about 2 per cent in the 1990s. The poor performance of the sector has been attributed to, among other factors, declining productivity in the sector.

(ii) There has been a very close association between growth in agricultural output and the growth of the overall economy confirming the widely held notion that the sector is the engine of growth.

(iii) Analysis of the growth pattern of agricultural production factors shows a rapid growth in agricultural labour force largely due to a fast growing population. This has resulted in a gradual decline in the land-labour ratio, which is a manifestation of disguised or even open unemployment in

the sector. Although fertiliser use has registered the fastest growth between 1965 and 1986, its use per hectare still remains well below international standards. Similarly, the use of pesticides and chemicals, and purchased seeds have shown only marginal increases over the years.

(iv) Growth in agricultural output in Kenya is largely due to growth in the factors of production. For the whole period under review, 1965-2001, agricultural output grew at an average rate of 3.8 per cent. Of this total growth, about 89.7 per cent is due to the factors of production (land, labour and capital). Only the remaining 10.3 per cent is attributable to productivity growth or TFPG. Therefore, growth of the agricultural sector has crucially depended on factor inputs.

(v) In terms of individual inputs, the most important source of growth of the agricultural sector is labour. The input in the period under review accounted for 48.3 per cent of the total growth. In the period 1965-72, the factor accounted for 31.3 per cent of the total growth. This rose in the period 1972-83 to 44.7 per cent and further to 58.5 per cent in the 1983-2001 period. These results show the importance of labour in agricultural production in Kenya.

Next in importance in terms of contribution to overall growth in the sector is capital. Over the entire period under review, the factor accounted for 27.6 per cent of the total growth. While the contribution of the factor stood at 18.8 per cent in the first period, rose to 28.9 per cent in the 1983-2001 period before falling to 22.3 per cent in the 1983-2001 period.

Land as factor of production has accounted the least in total agricultural growth. For the period 1965-2001, the factor accounted for only 13.8 per cent of the total growth. It is

significant to note, however, that the factor accounted for about 22.9 per cent of the total growth 1965-1972 but declined in the subsequent periods to 10.5 per cent in the 1972-1983 period and 5.3 per cent in the 1983-2001 period. This is attributed to low technological development in the sector.

(vi) There has been a gradual decline in agricultural productivity in Kenya from the 1980s. In the early period, 1965-1972, TFPG accounted for 6.3 per cent of the total output growth in the agricultural sector. In the following period, 1972-83, the contribution of TFP increased to 15.8 per cent before falling to 13.8 per cent in the 1983-2001 period.

(vii) There is a close association between agricultural TFPG and trade policy. These results tend to suggest that the trade regime has had an impact on growth in the agricultural sector. Agricultural TFP is also closely associated with climate. The relationship is positive and highly significant. The results show that neither the human nor the physical capital variables has had any significant influence on agricultural productivity. Another important determinant of agricultural productivity from this analysis is government expenditure that goes to services such as research and extension.

6.2 Conclusions and policy implications

The purpose of this analysis was to understand what drives the agricultural sector in Kenya. This in itself is a necessary condition in the design and implementation of policies to improve the sector. Growth in this sector is not only crucial for poverty alleviation but also for the performance of the overall economy. The underlying fact is that the performance of the agricultural sector has declined considerably over the years. From an all time high growth rate of about 8 per cent in the

period just after independence, the sector has in recent years recorded growth rates of between 1-2 per cent, which is lower than the population growth rate. This has implications on the overall economic performance and the level of poverty in the country.

The results for this study have shown that the pace of growth of the agricultural sector is determined largely by the flow of resources. This is reflected in the weights the resources receive in accounting for the output growth. Labour in particular has accounted for the bulk of the growth in the sector. Given the poor performance of the agricultural sector in the face of massive labour expansion in the sector and also considering the disguised nature of employment in the sector, one is inclined to conclude that future growth will have to come from elsewhere. The results and experience from elsewhere show that the contribution of capital in total growth needs to be enhanced for future growth. There will therefore be need for measures to enhance the use of capital as a complimentary factor in agriculture. This will require providing incentives including rebates for capital acquisition and easing importation. A fresh look at the credit market especially for agriculture is in this regard important because it influences the use of resources such as fertilisers, machinery and chemicals.

Growth in capital is not the only determinant of future growth, but more so the growth of technology. Our results show that growth in output attributed to technological development or TPPG is low and declining. Experience in other countries, particularly Asia, shows that whereas the impact of input growth is declining, the contribution of TFPG is increasing. For Kenya, reversing the downward trend in TFPG and sustaining it is key to growth. This study has generated a number of important results that broadly indicate what needs to be done to improve TFPG. First, the results show that trade policies pursued by the government affect agricultural TFPG. Therefore, maintaining a favourable trade regime is crucial for productivity. The evidence tends

to show that liberalisation has not particularly been favourable to agricultural TFPG and vice versa. Given the 'irreversibility' of liberalisation, policy makers are left with little option but to try and improve agricultural productivity within the context of liberalisation. Improving competitiveness by reducing the costs of production is one of the available options.

The results also show a close association between TFPG and government expenditure in agriculture. Although it was not possible to discern the precise areas of expenditure, it is reasonable to assume that expenditure in research and extension would have a positive and direct impact on agricultural productivity. Studies in Asia have overwhelmingly demonstrated this fact.

The other area of government involvement is in infrastructure. Rather than including government expenditure as a determinant of productivity, analysis in this study has considered the total length of roads as a measure of infrastructure. Although the results do not show a close association between agricultural TFPG and the total length of roads, infrastructure is still crucial and should receive attention.

Appendix 1: Supplementary figures and tables

Figure 1: Expansion of area under irrigation

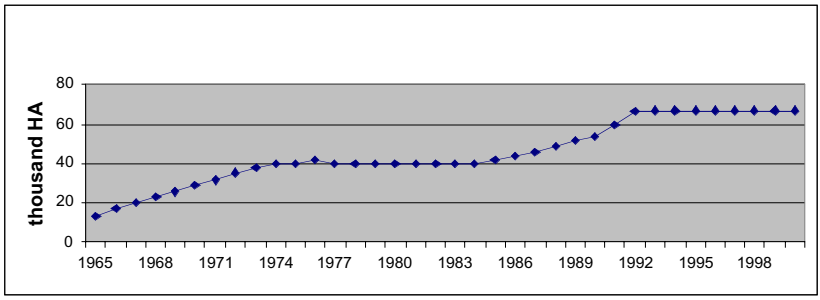


Figure 2: Ratio of irrigated land on arable land

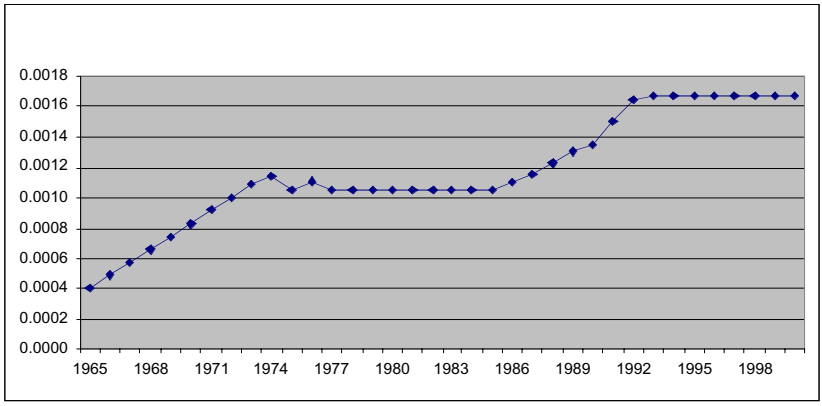


Figure 3: Road lengths in kilometres

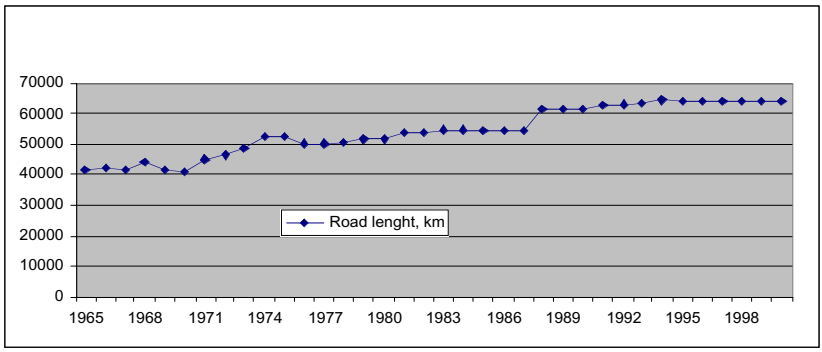


Table 1: Total factor productivity growth for the agricultural sector

Period	Capital input growth	Labour input growth	Total factor productivity
1961-1970	2.037	4.909	3.648
	19.23	46.34	34.43
1971-1975	1.864	2.818	-0.034
	40.1	60.63	0.731
1976-1979	4.268	2.949	-0.786
	66.37	45.86	12.22
1980-1985	1.311	2.754	0.732
	27.33	57.41	15.26
1986-1995	1.414	2.957	1.780
	22.99	48.07	28.94

Source: Onjala (2002)

Table 2(a): Unit root test (without differencing)

	Augmented Dickey-Fuller		Philip-Peron	
Variable	Test Statistic	Critical value (1%)	Test Statistic	Critical value (1%)
TFPG	-3.803	-3.649	-4.344	-3.803
Rainfall (RI)	-2.163	-3.645	-1.214	-3.633
Trade ratio (TR)	-1.620	-3.635	-1.520	-3.629
Exchange rate (RX)	-2.024	-3.635	-1.897	-3.629
Import penetration ratio (IPR)	-1.575	-3.635	-1.497	-3.628
Inflation (INF)	-3.053	-3.635	-2.641	-3.628
Schooling (SC)	-2.538	-3.642	-1.937	-3.635
Road length (RD)	-1.266	-3.635	-1.187	-3.628
Access to credit (AC)	-1.833	-3.635	-1.197	-3.628

Table 2(b): Unit root test (first level differencing)

	Augmented Dickey-Fuller		Philip-Peron	
Variable	Test Statistic	Critical value (1%)	Test Statistic	Critical value (1%)
Rainfall (RI)	-3.992	-3.642	-5.534	-3.941
Trade ratio (TR)	-4.397	-3.642	-6.803	-3.635
Exchange rate (RE)	-4.357	-3.642	-6.410	-3.635
Import penetration ratio (IPR)	-3.840	-3.642	-6.140	-3.635
Inflation (INF)	-5.786	-3.642	-6.231	-3.635
Schooling (SC)*	-4.511	-3.657	-10.051	-3.649
Road length (RD)	-4.768	-3.642	-5.732	-3.635
Acesss to credit(AC)	-3.882	-3.642	-4.234	-3.635

** Second level differencing*

Appendix 2: Types and sources of data

Gross Domestic Product (agriculture)

This data series includes forestry and fishing and are constant 1982 prices. The data was obtained from the World Bank Africa Database.

Capital stock (agriculture)

Although data on capital formation in agriculture is reported in the Statistical Abstracts, the analysis here required capital stocks. This kind of data is, however, not available in Kenya. Wilson, *et al* (1992) computed a series on capital stock by industry and agriculture for the period 1972-1991. The series was updated using methodologies developed by Vandemoortele (1984)

Agricultural labour (employment)

Labour force in agriculture is the proportion of the total labour force recorded as working in agriculture, hunting, forestry and fishing. This information was obtained from the World Bank Africa Database 2001.

Arable land (hectares)

This was obtained from World Bank Africa Database 2001. This is land defined by the FAO as land under temporary crops (double-cropped areas are counted once), temporary meadows for moving or pasture, land under market or kitchen gardens, and land temporarily fallow. Land abandoned as a result of shifting cultivation is excluded.

Irrigated land (hectares)

Refers to the total area under irrigation. This series was also obtained from the World Bank Africa Database.

Fertiliser consumption (Kg/Ha)

This series was obtained from World Bank Africa Database. It refers to

the total amount of fertiliser used divided by the total land. Additional information was also obtained from The KIPPRA Agricultural Data Compendium (Gitu, K. W. and J.M. Nzuma, 2003).

Fertiliser imports (in metric tons)

This refers to the total amount of fertiliser in tons imported into the country. The data was obtained from the World Bank Africa Database and the KIPPRA Data Compendium.

Length of roads (in kms)

This refers to the total length of road in kilometres of all weather roads in the country. This includes international trunk roads, national trunk roads, primary roads, secondary roads and minor roads. The information was obtained from the World Bank Africa Database.

Government expenditure (agriculture)

This is the total amount in Kenya shillings allocated by government to the agricultural sector. This was obtained from various issues of the Economic Survey.

Schooling

Economy-wide human capital is proxied by enrolment rates at primary school level. This was obtained from the statistics division of the Ministry of Education, Science and Technology.

Rainfall

This is the only weather variable used in the analysis. It was computed from rainfall totals in 19 main stations in Kenya. The stations are Kiambu, Nyeri, Nanyuki, Njoro, Kitale, Kakamega, Kisumu, Kisii, Embu, Machakos, Kilifi, Kericho, Garissa, Kajiado, Nyahururu, Meru, Mombasa, Eldoret and Nakuru. The information was obtained from the KIPPRA Agricultural

Data Compendium and various issues of Statistical Abstracts

Trade data (exports and imports)

Import and export data for Kenya was obtained in real Kenya shilling values. This was obtained from the World Bank Africa Database and complimented with data from other sources.

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