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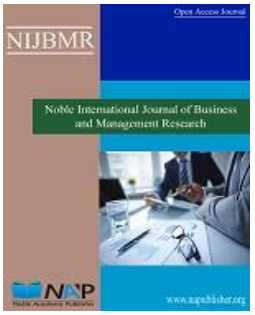

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# An Analysis of Determinants of Agricultural Growth in Kenya

**Pollyne Mbithe Mutunga[a], Evans Geoffrey Mogeni[b*], Wycliffe Mukulu Musyoka[c], David Musimbi Murunga[d]**

[a]Mount Kenya University, Department of Economics, School of Business and Economic, Machakos, Kenya
[*b]Machakos University, Department of Economics, School of Business and Economics, Machakos, Kenya
[c]University of Nairobi, School of Economics, Nairobi, Kenya
[d]Kenyatta University, School of Economics

**Abstract:** The study was an examination of the impact of structural adjustment programs on agricultural growth in Kenya. Statistics indicate that agricultural value added growth in Kenya is important as it highly influences the overall GDP growth. Despite this, the performance of the agricultural sector has shown mixed fortunes since independence. Adoption and implementation of SAPS (e.g., currency devaluation, trade liberalization, privatization, and removal of subsidies) in the 1980s and 1990s was seen as a way of reversing the widespread social and economic problems of developing nations. However, there exists a difference in opinions on how these structural adjustment programs have affected the agricultural sector performance. The study examined the short run and long run determinants of agricultural sector performance in Kenya. To achieve this, the study use time series regression modeling for data spanning from 1975 to 2010. Tests of normality, unit roots test and co integration test was applied to determine the properties of the data. Upon proof of co integration, an error correction model was estimated to link the short run and the long run relationships. Results indicate that structural adjustment program (SAPs) had a negative and significant long run effect on per capita agriculture GDP. The study concluded that Post Election Violence has a negative and significant long run effect on the per capital agriculture GDP. The study also concluded that the lagged per capital agricultural performance has a positive and significant effect on the per capita agricultural performance. The results also led to the conclusion that the long run per capita agricultural growth may be linked to the short run growth by an error correction term of -0.242583 which indicates that 0.242% of the disequilibria in short run per capita agricultural sector GDP achieved in one period are corrected in the subsequent period. The results also concludes that weather indicators (temperature and precipitation), and per capita infrastructure did not have a significant effect on the short run and long run per capita Agricultural GDP. The study recommends that some harmful policies need to be eliminated such as the removal of subsidies. Other policy recommendation are to enhance the adaptation of privatized agricultural institutions; encouragement of value addition in primary agricultural products; non price mechanisms such as Infrastructure should be encouraged especially in the rural areas; and enhancement of the political stability of the country especially during electioneering years.

**Keywords:** Human Development, Exports, Panel Data.

# 1. Introduction

## 1.1. Background of the Study

This chapter attempted to introduce the agricultural sector, its structure and policy framework. A brief discussion on structural adjustment programs was also fronted after which the problem statement was identified. The objectives and research questions were laid down in this chapter followed by significance of the study, scope and chapter summary.

## 1.2. Overview of the Agricultural Sector

Agriculture in Kenya continues to dominate Kenya's economy. However, only 15-17 percent of Kenya's total land area has sufficient fertility and rainfall to be farmed and only 7-8 percent can be classified as first-class land, that is, land which can support rain fed agricultural production year in year out. The total agricultural land in Kenya is 273,500 square kilometers. The agricultural land as a percentage of total land area currently stands at 48.05%. The agricultural irrigate land as % of total

agricultural land currently stands at 0.04%.

**Table 1.1.** Agricultural Land Area

| Column1 | Agricultural land (sq. km) | Agricultural land (% of land area) | Agricultural irrigated land (% of total agricultural land) |
|---|---|---|---|
| 2006 | 270540 | 47.53% | 0.04% |
| 2007 | 271000 | 47.62% | 0.03% |
| 2008 | 272000 | 47.79% | 0.03% |
| 2009 | 273500 | 48.05% | 0.04% |

**Source:** World Development indicators (2012)

In 2006, almost 75 percent of working Kenyans made their living by farming, compared with 80 percent in 1980. About one-half of Kenya's total agricultural output is non-marketed subsistence production. Agriculture is also the largest contributor to Kenya's gross domestic product (GDP). In 2005, agriculture, including forestry and fishing, accounted for about 24 percent of the GDP, as well as for 18 percent of wage employment and 50 percent of revenue from exports. Other reports, for instance, Ndathi *et al.* (2006) assert that agriculture accounts for about 26% of the GDP directly, while the indirect contribution to GDP stands at 27%. These figures are also confirmed by World Development Indicators (2012) which place the contribution of agriculture to GDP at 25.0% in year 2007, 25.8% in year 2008, 27.18% in year 2009, 25.18% in year 2010 and 23.13% in year 2011.

**Table 1.2.** Contribution of agriculture to GDP

| Year | Agriculture valued added% GDP |
|---|---|
| 2007 | 25.01% |
| 2008 | 25.83% |
| 2009 | 27.18% |
| 2010 | 25.18% |
| 2011 | 23.13% |

**Source:** World Development Indicators (2012)

## 1.3. Trends in Agricultural Performance (1960 to year 2010)

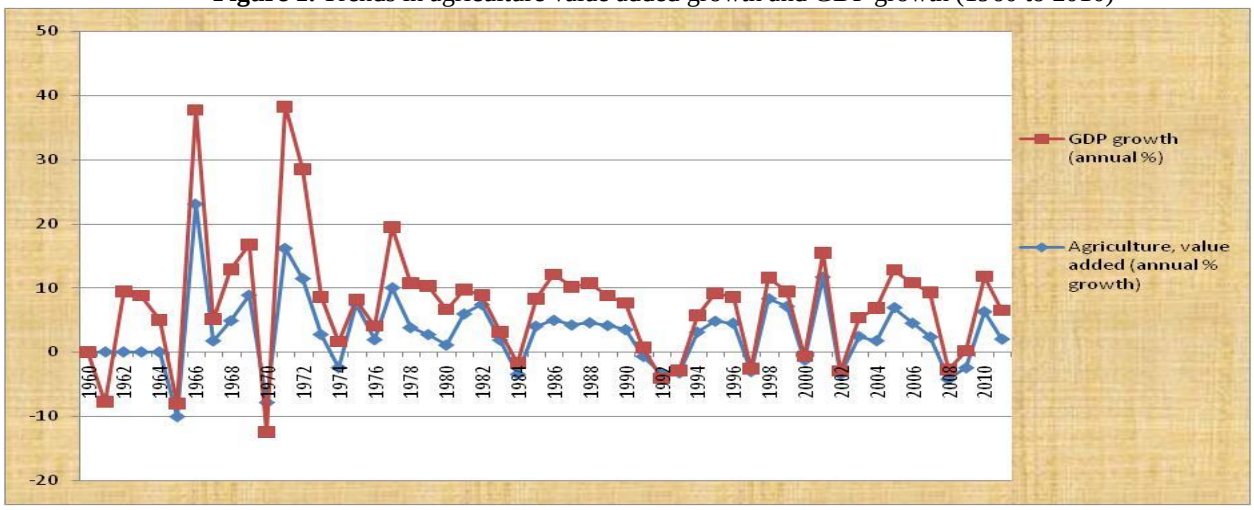
The World Development Indicators (2012) define agriculture value added as measure of agricultural productivity. Specifically, agriculture value added is measured as the output of the agricultural sector less the value of intermediate inputs.

Statistics from world development indicators (2012) indicate that agricultural value added growth in Kenya is important as it highly influences the overall GDP growth. This is evidenced in figure 1. Figure 1 indicates that agriculture value added growth moves in tandem with GDP growth. This implies that there is a close association between agriculture value added growth and economic growth. Both agriculture value added growth and GDP growth seems to have been high from the year 1965 to the year 1973. The rapid growth of both the agriculture value added and GDP growth was attributed to the introduction of a development blueprint, in which the independent government of Kenya affirmed its commitment to a free market economy where foreign investors were not only welcome but actively encouraged. The specific blue print was the Sessional Paper Number 10 "African Socialism and its Application to Planning in Kenya". This policy allayed the fears of the foreign investors and encouraged them to invest in Kenya. The sharp decline in agricultural value added and the GDP growth in 1969 was associated with the political assassination of Tom Mboya. This created ethnic animosity and did not augur well with economic development. However, the government put in measures that put the economy back on high growth trajectory and this persisted up to 1973. The first oil crisis in 1970-71, the restrictions on imports and the 1971 Ugandan coup had a lagged effect on the agriculture value added and the GDP growth. These factors led to a decline in the two indicators 1in the year 1973-1974. However, the coffee boom of 1976 led to an increase in agriculture value added growth and GDP growth. The death of the first president of Kenya In 1978 and emergence of the second oil price crisis in 1979 led to decline in the two indicators in the year 1979 and 1980. The smooth transition of power from Kenyatta regime to Moi regime positively affected the growth of agriculture and GDP growth. However, this did not last long. The attempted 1982 coup on president Moi regime led to change in focus where the Moi regime shifted its focus from national development to self-preservation. This led to a decline in the two indicators in the year 1983. This decline was emphasized by the famous 1984 drought which led to a decline in agriculture value added and as a result GDP growth declined.

The second coffee boom emerged in 1986, though it did not have dramatic effects on agriculture value added and GDP growth as the first one. It led to an increase in the two indicators. The introduction of the structural adjustment programs interventions in 1986 constituting a shift from a highly protected import substitution to stimulation of private investment was at improving efficiency, to increase foreign exchange earnings, and to diversify the economy. To achieve this, trade and tariff reforms, removal of price controls, privatization of state corporations, and promotion of exports were advocated (Bigsten and Kimuyu, 2002). It was during this period of SAPs that donors imposed aid conditions on Kenya. The disbursement of the aid was pegged on the implementation of the SAPS. The arm-twisting relationship between the donors and the government from 1987 to 1991 and the political agitation for multiparty in 1991, led to a decline of both indicators, with both indicators establishing a new low in 1992. In 1998, he political turmoil and the rigged general election led to a sharp decline in the two indicators. The worsening donor relationships, the crafting of the golden berg project, the rising political tensions, widespread corruption and HV aids scourge were major issues that led to the poor performance of both agriculture and GDP growth in the late 1990s.

Both indicators sharply declined in the year 2002 as a result of political elections which saw the entry of the NARC regime and a change of guard in the governance of the country. The implementation of policy reforms such as Economic recovery strategy for the revitalization for agriculture (SRA) amid other macro-economic reforms were responsible for the observed increasing trend in the two indicators from the year 2003 to the year 2007. However, the post-election of year 2007 led to a sharp decline in the two indicators in the year 2008 and this drop was compounded by the global financial crises of year 2009.

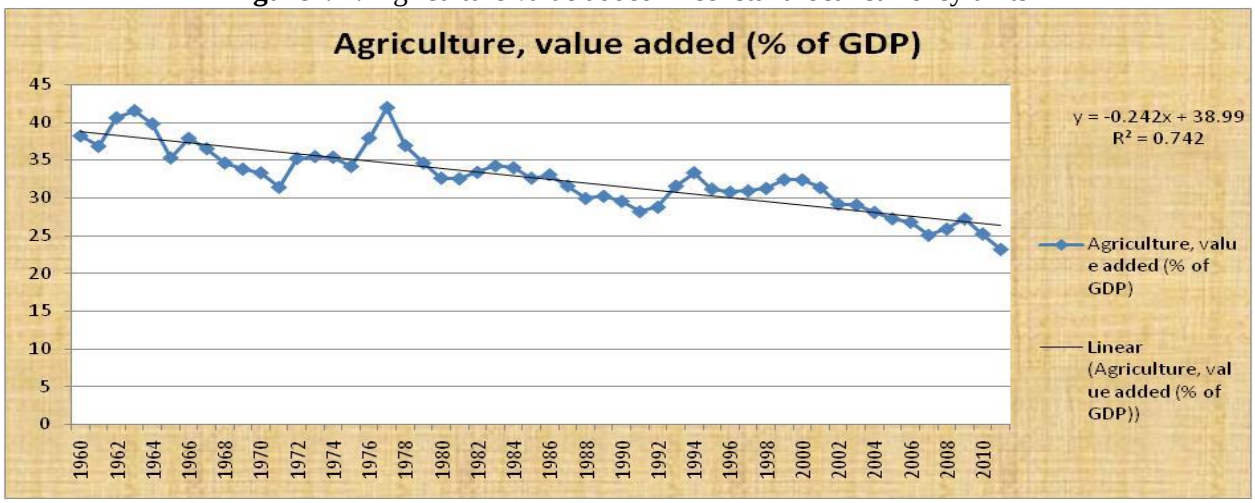
**Figure 1.** Trends in agriculture value added growth and GDP growth (1960 to 2010)




**Source:** World Development Indicators (2012)

Figure 1.2 indicates that the contribution of value added to GDP had been on a consistent decline. In two instances (1964 and in 1977), agriculture value added contribution to GDP was over 40%. However, the current contribution of agriculture value added to GDP is less than 30% as revealed by figure 2.

**Figure1. 2:** Agriculture value added in constant local currency units




**Source:** World Development Indicators (2012)

## 1.4. Statement of the Problem

The agricultural sector in Kenya is the backbone of the economy due to its numerous back and forward linkages in the economy. Policy measures aimed at revitalizing agriculture have been found to have wider distributional effects than policies aimed at any other sector. The performance of the Agricultural sector is crucial for food security. However, the agriculture sector has been performing dismally and this may have impacted negatively on food security.

There are many causes of food insecurity in Kenya. Authors such as Nyangito *et al.* (2004) have cited poor infrastructure as a possible cause of food insecurity in Kenya. Onjala (2002) cites lack of trade openness as a possible cause of food insecurity. The World Bank Pro-Poor Agriculture Report (2010) observes that inconsistent policies are partly to blame for the poor agricultural production and the resultant food insecurity. For instance, the report highlights various policies which are strewn across institutions responsible for agricultural production. Such institutions include the ministry of agriculture, ministry of livestock, ministry of fisheries and ministry of cooperative development. It is also evident that the PRSP and ERS were also biased against agriculture since they favored a model of industry led growth. However, the World Bank Pro-Poor Agriculture Report (2010) asserts that any policy that ignores the role of agriculture in economic growth is misguided. Therefore, World Bank Pro-Poor Agriculture Report (2010) advocates for a balanced growth model which included both agriculture and industry.

### 1.4.1. Objectives of the study

The study objectives are as follows:

i) To determine short run determinants of agricultural growth in Kenya
ii) To establish the long run determinants of agricultural growth in Kenya.

### 1.4.2. Research questions

The study objectives are as follows:

i) What are the short run determinants of agricultural growth in Kenya?
ii) What are the long run determinants of agricultural growth in Kenya?

## 1.5. Scope

There are two categories of Structural adjustment; economy wide SAPs (e.g., exchange rate policy) and sectoral SAPs (specific institutional changes, removal of supposed tax on agriculture, removal of protection of industry) policies. Backward and forward linkages of the sectors implies that both economy wide and sectoral specific SAPs have multiple channels of impacts. A complete evaluation of the impact of an SAP would, therefore, need an examination of the responses both the sectors within the economy but also of the aggregate economy. This study focuses on agriculture and will ensure that the analysis of the impact is restricted to agriculture. However, this study also recognizes that detaching agriculture sector from other sectors and the main economy may have its limitations, especially since indirect impacts are not considered, tradeoffs and multiple effects are also ignored.

# 2. Literature Review

## 2.1. Introduction to literature review

This section attempts to discuss the various aspects of structural adjustments programs and their intended impact on the Kenyan economy. This section also identifies the mains studies that link structural adjustment programs to agricultural growth. Studies in emerging economies are identified, followed by studies in Africa.

### 2.1.1. Theoretical Framework

This subsection attempts at identifying the various schools of thought that argue for SAPs or against and the reasons for their arguments.

### 2.1.2. Theories of Economic Growth

Economic growth is best exemplified under the models of economic growth. The models of economic growth include those advanced by classical economists and neo classical economists.

## 2.2. The Classical Theory of Economic Growth and Structural Adjustment Programs

The classical theory of economic growth was advocated by David Ricardo. He argued that the growth of a country stems from the participation in free trade resulting from the comparative advantage it has in producing goods and services. It therefore made sense to buy those goods that could not be produced at a comparative advantage and produce with an intention of selling goods which could be produced at a comparative advantage. The relevance of this theory to structural adjustment programs is obvious as structural adjustment programs advocated for liberalization of trade. Developing countries were therefore guided to open up their local economies to competition from external economies.

### 2.2.1. Empirical Review

This subsection attempts to analyze the empirical studies starting with those studies done for developed economies, followed by emerging economies, African economies and finally the Kenyan Economy. There has been considerable debate about the effects of such SAP measures. A host of researchers (Reed, 1996); (Olomola, 1994) believe that structural adjustment policies are essential prerequisites for economic recovery, adjustment to, and development in the new global market place. On the contrary, many other economists and social scientists such as Igbedioh and Aderiye (1994) and Adejumobi and Momoh (1995) argue that SAP measures have led to recessions and poor standards of living in developing countries. The empirical studies reviewed in the current study attempted to find out the different empirical results on the impact of structural adjustment programs on agricultural growth.

## 2.3. Structural Adjustment Programs and their Impact on Agriculture in Developed Economies

Qualman and Wiebe (2002) conducted a review of the impact of structural adjustment programs in Canadian Agriculture. The authors asserted that since the 1980s, the Canadian government has carefully implemented every component of an IMF program :export expansion; reduced government spending, deregulation , liberalized foreign investment , privatization , term termination of subsidies and prices supports , devaluation of currency, and a general move towards "market oriented " economic reforms. Qualman and Wiebe (2002) Identify various specific programs that were implemented in Canadian agriculture to include a federal government cut of $2.8 billion worth of programs from its annual agriculture spending. The authors argue that two decades of structural adjustment have devastated farm families and rural communities. Furthermore, statistics on declining farm incomes and farm numbers tell only half the story. Specifically, the SAPs that supported exported agricultural export expansion led to the concentration of wealth in large corporations and the marginalization of the rural farmer. This in effect widened the gap between the rich and the poor.

## 2.4. Structural Adjustment Programs and their impact on Agriculture in Emerging Economies

Yamaguchi and Sanker (1998) conducted a study to evaluate the impact of structural adjustment programs on the Sri Lankans agricultural sector with a focus on the domestic food sector. The paper used the Two Sector Equilibrium Models with Growth Accounting Approach. The two sector identified were agricultural and non-agricultural sector. In their model, agricultural production depended on factors that are fixed in the short term such as land and capital as well as variable factors such as labor and imported input fertilizer. The study concluded that although the impact of SAPs on the growth of the overall agricultural sector was positive, it was negative in relation to domestic food sector. Specifically, the changes in fertilizer prices due to SAPs had a tremendous negative effect on agricultural production and specifically domestic food production. In addition, the liberalization of food imports also negatively affected domestic agricultural food production.

Hag and M. (1997) analyzed the impact on agricultural price incentives of the main adjustment programs implemented by the Sudanese government during the period 1978-1993, notably the Economic Recovery Program (ECRP) 1978-1985 and the national economic Salvation program (NESP), 1990-93.The effects of the programs on the level and stability of price incentives were measured, both at the sectorial (direct) and economy wide (indirect) levels. In their model, real farm gate prices were a function of the nominal direct protection coefficient of products, international terms of trade for products, and rear exchange rate. The results show that both programs (ECRP and NESP) failed to improve either the level or the stability of real farm prices. The author attributed the failure to poor macroeconomic policies. The

authors also argued that with reference to the efficacy of price incentives in stimulating aggregate agricultural output, the results confirmed the leading view that increases in real farm prices have positive but limited overall effect on agriculture. Consequently, non-price factors appeared to play a greater role in determining aggregate agricultural output. The analysis implied that without the adequate provision of credit, public investments and improvement in infrastructure, the aggregate response of agriculture to price incentives would be minimal.

Merteens (2000) Undertook a study on the impact of Agricultural performance in Tanzania under structural adjustment programs. Merteens (2000) Compared the performances in the food and cash crop sectors and the availability and consumption of agricultural inputs in Tanzania during structural adjustment programs (1986–1996) with periods prior to this IMF/World Bank backed reform. The authors argued that the positive developments in the first five years of reform in South Africa appeared to be not sustainable. The authors noted that the present productivity levels per rural capita for important food and cash crops was declining. In addition, there were no further improvements in the availability and consumption of agricultural inputs. This was attributed to removal of subsidies on agricultural inputs from 1991 onwards. The removal of subsidies was crucial in explaining the decline in maize production, the main food crop in Tanzania. Structural adjustment programs had gone too far in reducing the role of the government and the involvement of government might be necessary to ensure a higher consumption of agricultural inputs and thus a better performance of the agricultural sector in Tanzania.

Baazara (2001) investigated the impact of liberalization on agriculture and food security in Uganda. The evidence available showed that liberalization had not improved real incomes of farmers, especially the small farmers. This was because prices of agricultural inputs rose in the wake of higher produce prices thus increasing production costs and undermining profit. Therefore, the author concluded that liberalization in as far as it means higher income can only benefit those who have resources to grow those crops that are attracting higher prices on the market at that moment. Specifically, rich farmers and capitalists who own adequate land and have adequate access to infrastructure stood to benefit from liberalization. The rich farmers are also able to deal with high transport costs due to high taxes on petroleum products. In this aspect, liberalization has led to inequality at the regional, social class and gender levels. Food security has further worsened due to the emphasis on marketing of non-traditional export crops such as maize and beans. Furthermore, the export crop production drive in some instances has led to a decline of food security in\some homes. In this case, poor farmers tended to increase production of cash crops at peak price moments at the expense of food crops such bananas as was the case in Masaka District, and this was on top of the limited access to land and insecurity of tenure. By reducing food production, therefore, liberalization negatively affected nutritional levels for example in places like Buganda region where malnutrition levels were high.

Bryceson *et al.* (2010) investigated structural adjustment programs in Africa. The authors examination of the structural adjustment programs in African countries suggest that African agriculture's poor performance was not necessarily due to the negative effect of internal factors such as poor governance found in African governments, but could also, in large part, be attributed to the structural adjustment policies advocated by the international financial institutions and donor countries. The author argued that the solution of the problems associated with these structural adjustment policies lay in improving the ability of African farmers to benefit from new agricultural technologies that raise staple food productivity and thereby enhance food security and national stability.

## 2.5. Structural Adjustment Programs and their impact on Agriculture in Kenya

Nyangito and Okello (1998) conducted a study on the Kenya's agricultural policy and sector performance from 1964 to 1996. The authors argue that during the era of controls, the Kenyan government dominated the production and marketing activities. This domination stifled the development of the private sector. However, government inability to continuously support the activities financially and technically, led to a decline in agricultural growth and development. In addition, government started initiative to offload the activities to the private sector and let the free markets guide production and marketing activities were also not successful. This is because there was a lack of harmony and co-ordination of the implementation for the privatization process. This resulted in stagnation of agricultural growth primarily because of the vacuum that existed as a result of a poorly developed private sector which also had poor capacity in production and marketing

Nyangito and Karugia (2000) conducted a study on the impact of recent changes in Kenyan agricultural sector and public agricultural research in Kenya. The authors used secondary data from

previous research reports and also used primary data from a questionnaire administered to management in KARI. The authors argue that the policy reforms had a negative effect on the capacity of KARI to provide research and extension services. For instance, adjustment in the government fiscal policy has meant that KARI has fewer funds to do its research. The findings imply that SAPs which advocated for the reduction in research activities had a negative effect on the productivity of the agricultural sector.

Nyangito *et al.* (2004) In Kippra discussion paper no 39 conducted a study on the Impact of Agricultural Trade and Related Policy Reforms on Food Security in Kenya. The authors analyzed the impact of specific reforms on agricultural production, performance and trade, and therefore food security. The study used secondary data from the Central Bureau of Statistics and the Ministry of Agriculture. Welfare Monitoring Surveys of 1982, 1992 and 1997 were used as sources of regional cross-sectional household data. The authors analyzed trends in production and trade, the resultant impact of policy instruments such as prices and market access, household incomes and expenditures, and food security trends using various indicators for both the pre- and post-reforms periods. The analysis indicated that agricultural prices and productivity have generally declined in the post reform period. Specifically, the authors noted that the performance of the agricultural sector in the 1990s was dismal, with annual growth in agricultural GDP averaging 2% compared with 4% in the 1980s. Agricultural export growth after the reforms had shown mixed trends due to market access limitations for Kenyan exports. Market access for imports into the Kenyan market had improved since the reforms, occasioning a tremendous import growth. However, the report argued that the capacity to import food had declined, which made Kenya more food insecure. Reforms had also negatively affected the balance of trade between Kenya and the rest of the world. After the reforms, the country moved from broad self-sufficiency in production of most food staples to a net importer, a situation that begged for a re-thinking of the policy framework on agriculture.

# 3. Research Methodology

## 3.1. Empirical Model and data

The current study used a modified form of a Cobb Douglas production function setting as follows;

$$AgricGDP = b_0 + b_1 Capital + b2Labour + b3Weather + b4Infrastructure + b5SAP + b6Postelecton\,Vioence + e \quad \ldots\ldots 3$$

The above model can be converted into per capita terms

$$KAgricGDP = b_0 + b_1 KCapital + b3Weather + b4KInfrastructure + b5SAP + b6Postelecton\,Vioence(1992,1998,2002,2007) + e \quad \ldots\ldots (4)$$

Where;
*KagricGDP*= total production in crop and livestock sector divided by labour
*KCapital* (+) = Capital divided by labour
*KInfrastructure (+)* =Government Infrastructural spending divided by labour
*Weather(+)* = Weather as represented by rainfall and temperature
*DummySAP(+)* =Dummy representing the introduction of SAPS in Kenya
*DummyPEV (1992, 1998, 2002, 2007) (-)* =Dummy for Post-election violence in the year 1992, 1998, 2002 and 2007

The expected conceptual relationships between each explanatory variable and Per capita agricultural GDP are as given in the following section;

### 3.1.1. Kagric GDP

Agricultural output in its per capita form is derived from the gross marketed production at current prices for the following agricultural subsectors, cereals, temporary crops, permanent crops, and marketed livestock production. The rationale for using marketed production is because data is easily available compared to non-marketed/ own consumption production. The data is readily available from the Kenya Agricultural Sector Data Compendium (KASDC website). The data was then be divided by labor to get the per capita agricultural output.

### 3.1.2. Dummy SAP

The variable took the form of a dummy. The variable took the value of 0 in years before the introduction of structural adjustment programs and the value of 1 during the years of SAPs. Theoretically, the introduction of SAPs is supposed to have a positive impact on Agricultural output.

### 3.1.3. Dummy PEV (1992/1993, 1997/1998, 2002/2003 and 2007/2008)

The 1992 and 1998, 2002 and 2007 post-election violence may have had a negative impact on agricultural output. Primarily, Rift Valley Province, which is Kenya's food basket, was heavily affected, with the production of maize and other food crops dropping to an all-time low. However, this effect has not been captured by any other variable in the study. It is therefore important to capture this hypothetically negative effect with the use of a dummy. A dummy variable is therefore used to capture the effect of the post-election violence.

### 3.1.3. Weather (Rainfall and Temperature)

Under the agricultural productivity framework, weather or climate variation is a crucial component in evaluating changes in output (Evenson, 2001). Good weather such as more rainfall or less occurrence of drought or flooding should raise agricultural production and productivity. Weather factors are represented by annual average rainfall measured in millimeters (*Precipitation)* and temperature in degree Celsius, using data obtained from the Kenya Agricultural Sector Data Compendium. The relevant weather stations were Kericho,Garrisa, Kajiado, Nyahururu, Meru, Mombasa , Embu and Kiambu which represent the national rainfall received in Kenya. These stations are located near agriculturally productive areas.

### 3.1.4. KInfrastructure

Consists of Government Spending on agricultural infrastructure. Infrastructure is considered a fixed factor that contributes positively to agricultural growth and productivity (Evenson and Pray, 1991),(Evenson, 2001). It is typically not included among the conventional inputs in cobb douglas production function since it is lumped together with capital (k). However, in the case of agriculture, it is important to make a distinction of the two variables; infrastructure and capital. While infrastructure mainly features rural roads and irrigation projects, telecommunication network and power network indicators, capital focuses on short to medium term outlays such as fertilizers, seeds, herbicides, machinery with a useful life of less than 5 years. Government spending on agricultural infrastructure was used as a proxy for agricultural infrastructure. A positive relation is expected between infrastructure and agricultural output .The data was obtained from various statistical abstracts.

### 3.1.5. Kcapital

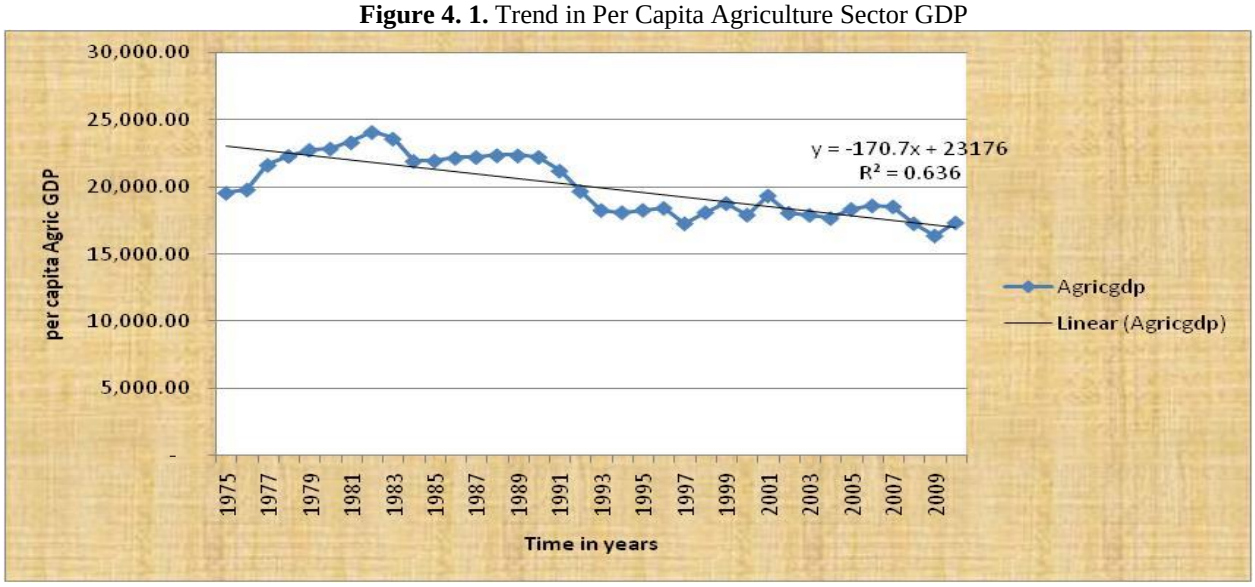
The study used both crop and livestock inputs such as seeds, fertilizers, pesticides, fuel, power, spares machinery and maintenance, bags, service inputs, livestock drugs and medicines, manufactured feeds. The data was then converted into per capita terms. A positive relation is expected between capital and agricultural output. The data was obtained from the KASDC website.

# 4. Data Analysis

## 4.1. Descriptive Statistics

Results in table 4.1 indicate that the mean per capita agricultural GDP was ksh 20,094.49 while the maximum was ksh 24,101.71 and the minimum was ksh 16,344.08. A graph representation indicated that there has been a consistent decline over time in per capita agricultural sector GDP. This is consistent with expectations as the labor force has risen at a faster rate than the agricultural value GDP.

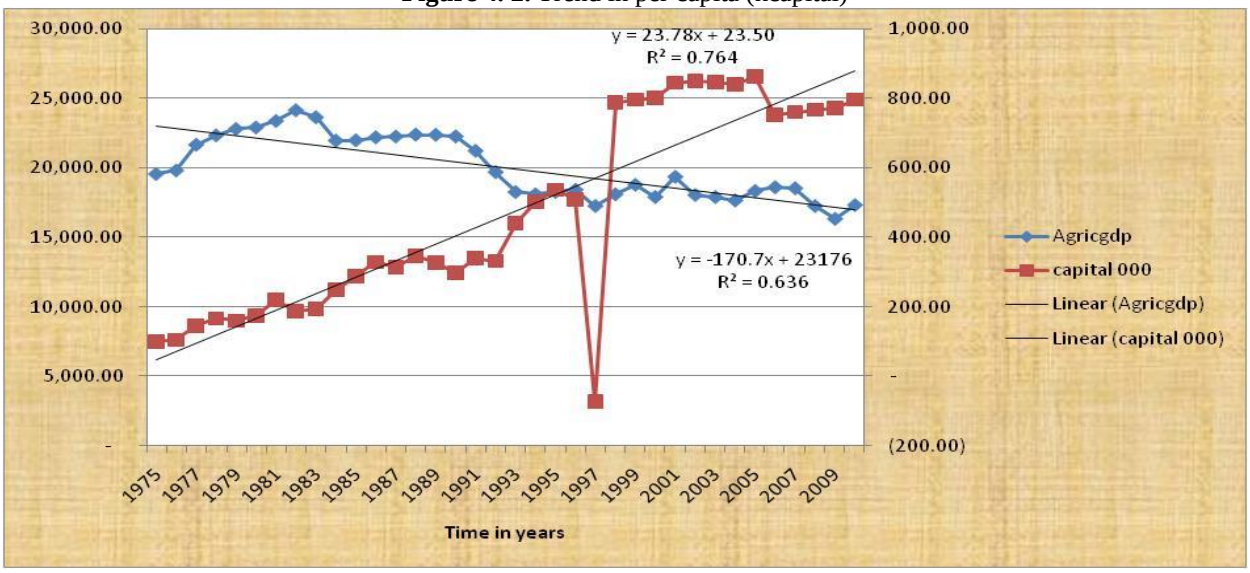
**Figure 4. 1.** Trend in Per Capita Agriculture Sector GDP




**Source:** Eviews computation

Results in table 4.1 indicate that the mean per capita (kcapital) was ksh 478.8 while the maximum was ksh 863.4 and the minimum is ksh100.4. A graphical representation of the per capita capital in figure 4.2 indicates that the per capita capital has been on the rise since 1975. This further indicates that farmers have continued to use more inputs such as fertilizers, seeds, energy despite a downward trend in the per capita agricultural sector GDP.

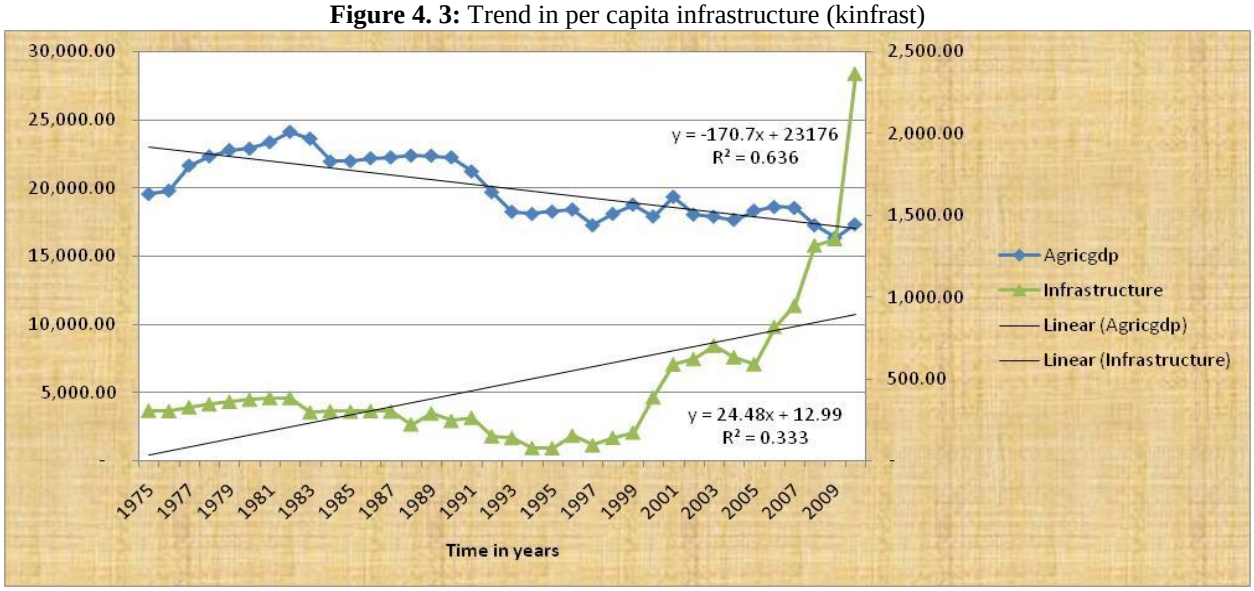
**Figure 4. 2.** Trend in per capita (kcapital)




**Source:** Eviews computation

Results in table 4.1 indicate that the mean per capita infrastructure (kinfrast) was ksh 476.3 while the maximum was ksh 2366 and the minimum is ksh80.45. A graphical representation of the per capita infrastructure in figure 4.3 indicates that the per capita infrastructure has been on the rise since 1975. This further indicates that public expenditure towards agricultural inputs such as fertilizers, seeds, energy has gradually risen despite a downward trend in the per capita agricultural sector GDP.

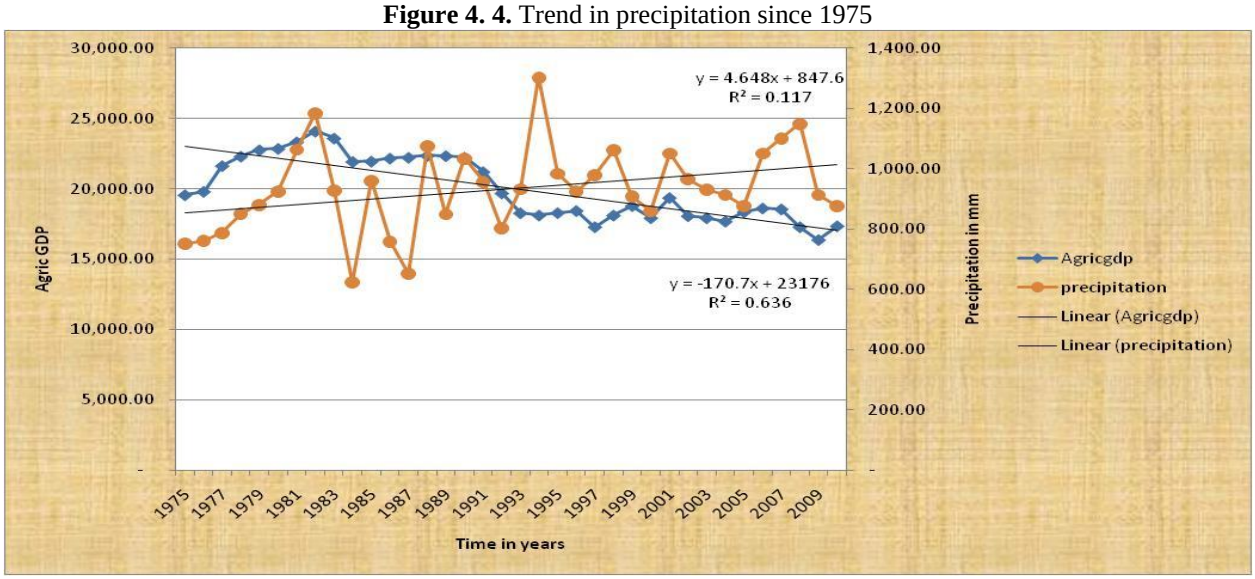
**Figure 4. 3:** Trend in per capita infrastructure (kinfrast)




**Source:** Eviews computation

Results in table 4.1 indicate that the mean precipitation was 932.3 mm while the maximum was 1304mm and the minimum is 621.9mm. A graphical representation of the precipitation in figure 4.4 indicates that the trend in precipitation has been inconsistent since 1975. This further indicates that the agricultural sector has experienced dramatic swings in rainfall with some years experiencing high rainfall while some years experienced low rainfall. The dramatic changes in precipitation may have been responsible for the decline in per capita agricultural GDP.

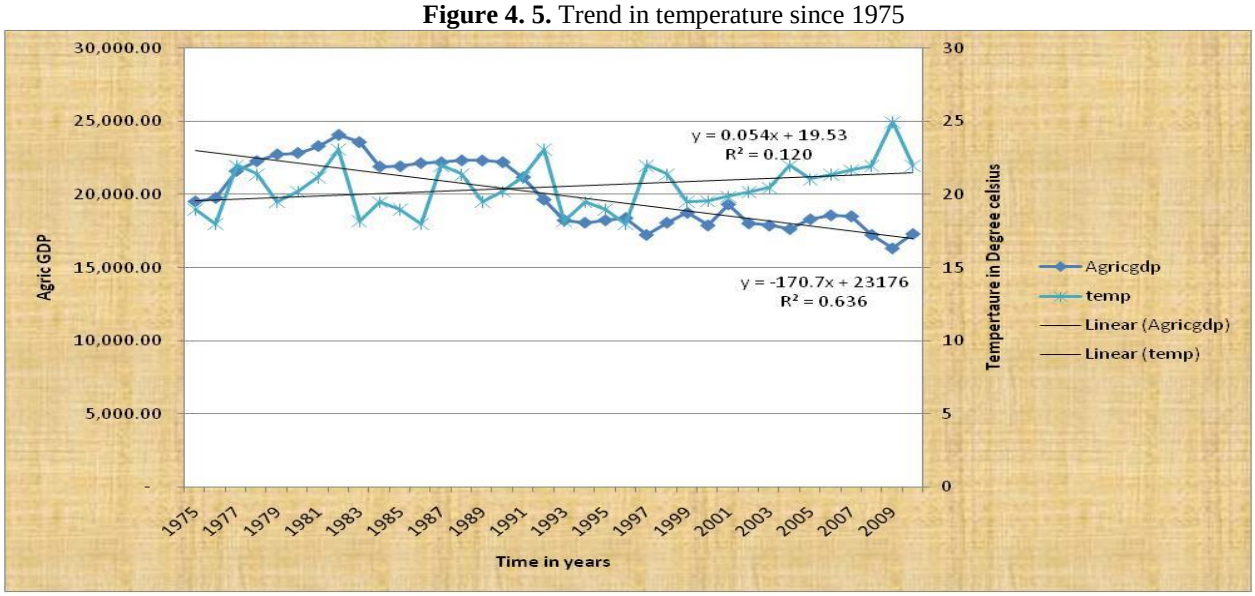
**Figure 4. 4.** Trend in precipitation since 1975




**Source:** Eviews computation

Results in table 4.1 indicate that the mean temperature was 20.5 $^{0}$c while the maximum was 24.98 $^{0}$c and the minimum is 18 $^{0}$c. A graphical representation of the temperature in figure 4.5 indicates that the trend in temperature has been inconsistent since 1975. This further indicates that the agricultural sector has gradually experienced rising temperatures since 1975. The gradual rise in temperature may have been responsible for the decline in per capita agricultural GDP.

**Figure 4. 5.** Trend in temperature since 1975




**Source:** Eviews computation

## 4.2. Unit Root Tests

Prior to testing for a causal relationship and cointegration between the time series, the first step is to check the stationarity of the variables used in the model. The aim is to verify whether the series have a stationary trend, and, if non-stationary, to establish orders of integration. The study used both Augmented Dickey-Fuller (ADF) and the Phillips-Perron (PP) tests to test for stationarity. The test results of the unit roots are presented next. Results in table 4.5 indicated that all variables are non stationary (i.e. presence of unit roots) at 1%, 5% and 10% levels of significance. This calls for first differencing of the non stationary variables.

**Table 4.1.** Unit root tests-Level

| Variable name | ADF test | PP test | 1% Level | 5% Level | 10% Level | Comment |
|---|---|---|---|---|---|---|
| **lnkAgric GDP** | -0.478368 | -0.478368 | -2.6300 | -1.9507 | -1.6208 | **Non Stationary** |
| **Laglnkagric GDP** | -0.723092 | -0.723092 | -2.6321 | -1.9510 | -1.6209 | **Non Stationary** |
| **lnkinfrast** | 1.190425 | 1.190425 | -2.6300 | -1.9507 | -1.6208 | **Non Stationary** |
| **lntemp** | 0.150516 | .150516 | -2.6300 | -1.9507 | -1.6208 | **Non Stationary** |
| **lnprecipit~n** | 0.048188 | 0.048188 | -2.6300 | -1.9507 | -1.6208 | **Non Stationary** |

**Source:** Eviews computation

Table 4.6 displays the unit root tests after first differencing. It is clear from the results in table 4.6 that all the variables become stationary (unit root disappears) on first differencing.

**Table 4.6.** Unit root tests-First Differences

| Variable name | ADF test | PP test | 1% Level | 5% Level | 10% Level | Comment |
|---|---|---|---|---|---|---|
| **DlnkAgric GDP** | -5.143689 | -5.143689 | -2.6321 | -1.9510 | -1.6209 | Stationary |
| **Dlaglnkagric GDP** | -4.777693 | -4.777693 | --2.6344 | -1.9514 | -1.6211 | Stationary |
| **Dlnkinfrast** | -5.257330 | -5.257330 | -2.6321 | -1.9510 | -1.6209 | Stationary |
| **lntemp** | -8.470068 | -8.470068 | -2.6321 | -1.9510 | -1.6209 | Stationary |
| **Dlnprecipit~n** | -8.280664 | -8.280664 | -2.6321 | -1.9510 | -1.6209 | Stationary |

**Source:** Eviews computation

## 4.2. Cointegration Tests

The two step angle granger test was conducted and results presented in table 4.8. First a long run equation was run after which the residuals were generated. The residuals were then lagged. The second step was to test for stationarity of the residuals using the ADF test. Results indicated that the lagged residuals were stationary at 5% and 10% levels. This implies that the lagged residuals were stationary. This further implies that there is cointegration among the long run variables. This also implies that the variable converge to a long run equilibrium.

**Table 4.8.** Engle Granger Cointegration Test

| | | | |
|---|---|---|---|
| ADF Test Statistic | -2.230841 | 1% Critical Value* | -2.6321 |
| | | 5% Critical Value | -1.9510 |
| | | 10% Critical Value | -1.6209 |
| *MacKinnon critical values for rejection of hypothesis of a unit root. | | | |

**Source:** Eviews computation

The Johansen Cointegration test was also conducted since it is more accurate and superior to Engle granger test of Cointegration. Johansen Results at the table 4.9 indicate that the null hypothesis of at most 1 Co integration equations for the model linking was rejected at 5% (1%) significance level. The likelihood ratio statistic for the null hypothesis of the existence of at most 1 Cointegration equations was larger than the z critical vales at 5% and a 1% level. This implies that more than 1 co integrating equation exists. This further implies that all the variables in the model 4 converge to an equilibrium in the long run ( i.e are co integrated).

**Table 4.9.** Johansen Cointergration Test

| | | | | | | |
|---|---|---|---|---|---|---|
| **Sample: 1975 2010** | | | | | | |
| **Included observations: 34** | | | | | | |
| **Test assumption: Linear deterministic trend in the data** | | | | | | |
| **Series: LNKAGRICGDP PEV SAP LNKINFRAST LNPRECIPITATION LNTEMP** | | | | | | |
| **Lags interval: 1 to 1** | | | | | | |
| | **Likelihood** | **5 Percent** | **1 Percent** | **Hypothesized** | | |
| **Eigenvalue** | **Ratio** | **Critical Value** | **Critical Value** | **No. of CE(s)** | | |
| 0.764176 | 128.7769 | 94.15 | 103.18 | None ** | | |
| 0.616676 | 79.65812 | 68.52 | 76.07 | At most 1 ** | | |
| 0.507241 | 47.05634 | 47.21 | 54.46 | At most 2 | | |
| 0.374489 | 22.99338 | 29.68 | 35.65 | At most 3 | | |
| 0.185054 | 7.041053 | 15.41 | 20.04 | At most 4 | | |
| 0.002453 | 0.083510 | 3.76 | 6.65 | At most 5 | | |
| *(**) denotes rejection of the hypothesis at 5%(1%) significance level | | | | | | |
| L.R. test indicates 2 cointegrating equation(s) at 5% significance level | | | | | | |
| | | | | | | |
| **Unnormalized Cointegrating Coefficients:** | | | | | | |
| LNKAGRICGDP | PEV | SAP | LNKINFRAST | LNPRECIPITATION | LNTEMP | |
| 1.000901 | 0.580591 | 0.013504 | -0.040255 | 0.330614 | 0.874016 | |
| 0.267514 | 0.355853 | -0.053678 | 0.017495 | -1.158341 | -1.083502 | |
| 0.607787 | 0.174368 | 0.176844 | 0.224223 | 0.780808 | -3.969485 | |
| 2.069019 | 0.012988 | 0.493667 | 0.025641 | -0.298695 | -0.078072 | |
| -1.239648 | -0.081122 | 0.220575 | 0.027154 | -0.674510 | 0.324449 | |
| -0.040733 | -0.095477 | 0.004480 | 0.248670 | -0.277404 | 0.473289 | |
| | | | | | | |
| **Normalized Cointegrating Coefficients: 1 Cointegrating Equation(s)** | | | | | | |
| LNKAGRICGDP | PEV | SAP | LNKINFRAST | LNPRECIPITATION | LNTEMP | C |
| 1.000000 | 0.580069 | 0.013492 | -0.040218 | 0.330316 | 0.873229 | -14.71039 |
| | (0.13098) | (0.05257) | (0.03511) | (0.16473) | (0.50167) | |
| | | | | | | |
| Log likelihood | 132.6563 | | | | | |
| | | | | | | |
| **Normalized Cointegrating Coefficients: 2 Cointegrating Equation(s)** | | | | | | |
| LNKAGRICGDP | PEV | SAP | LNKINFRAST | LNPRECIPITATION | LNTEMP | C |
| 1.000000 | 0.000000 | 0.179084 | -0.121889 | 3.934000 | 4.680405 | -50.34504 |
| | | (0.19328) | (0.20413) | (3.90901) | (5.33570) | |
| 0.000000 | 1.000000 | -0.285470 | 0.140794 | -6.212513 | -6.563320 | 61.43178 |
| | | (0.31127) | (0.32875) | (6.29535) | (8.59301) | |
| | | | | | | |
| Log likelihood | 148.9571 | | | | | |
| | | | | | | |
| **Normalized Cointegrating Coefficients: 3 Cointegrating Equation(s)** | | | | | | |
| LNKAGRICGDP | PEV | SAP | LNKINFRAST | LNPRECIPITATION | LNTEMP | C |

| | | | | | | |
|---|---|---|---|---|---|---|
| 1.000000 | 0.000000 | 0.000000 | -0.538150 | 4.735278 | 13.30158 | -79.31758 |
| | | | (0.78007) | (6.65596) | (18.0341) | |
| 0.000000 | 1.000000 | 0.000000 | 0.804338 | -7.489794 | -20.30594 | 107.6156 |
| | | | (1.23509) | (10.5385) | (28.5536) | |
| 0.000000 | 0.000000 | 1.000000 | 2.324388 | -4.474302 | -48.14027 | 161.7815 |
| | | | (2.12699) | (18.1486) | (49.1731) | |
| Log likelihood | 160.9886 | | | | | |
| | | | | | | |
| **Normalized Cointegrating Coefficients: 4 Cointegrating Equation(s)** | | | | | | |
| **LNKAGRICGDP** | **PEV** | **SAP** | **LNKINFRAST** | **LNPRECIPITATION** | **LNTEMP** | **C** |
| 1.000000 | 0.000000 | 0.000000 | 0.000000 | 227.2988 | 115.3069 | -1911.664 |
| | | | | (10685.7) | (5409.72) | |
| 0.000000 | 1.000000 | 0.000000 | 0.000000 | -340.1408 | -172.7665 | 2846.303 |
| | | | | (15994.7) | (8097.46) | |
| 0.000000 | 0.000000 | 1.000000 | 0.000000 | -965.7742 | -488.7231 | 8076.081 |
| | | | | (45430.5) | (22999.6) | |
| 0.000000 | 0.000000 | 0.000000 | 1.000000 | 413.5713 | 189.5479 | -3404.897 |
| | | | | (19384.8) | (9813.72) | |
| Log likelihood | 168.9648 | | | | | |
| | | | | | | |
| **Normalized Cointegrating Coefficients: 5 Cointegrating Equation(s)** | | | | | | |
| **LNKAGRICGDP** | **PEV** | **SAP** | **LNKINFRAST** | **LNPRECIPITATION** | **LNTEMP** | **C** |
| 1.000000 | 0.000000 | 0.000000 | 0.000000 | 0.000000 | -0.465771 | -8.496401 |
| | | | | | (1.11710) | |
| 0.000000 | 1.000000 | 0.000000 | 0.000000 | 0.000000 | 0.481203 | -1.688218 |
| | | | | | (1.92387) | |
| 0.000000 | 0.000000 | 1.000000 | 0.000000 | 0.000000 | 3.185440 | -10.32386 |
| | | | | | (4.78872) | |
| 0.000000 | 0.000000 | 0.000000 | 1.000000 | 0.000000 | -21.10094 | 57.92584 |
| | | | | | (5.12545) | |
| 0.000000 | 0.000000 | 0.000000 | 0.000000 | 1.000000 | 0.509341 | -8.372977 |
| | | | | | (0.58698) | |
| | | | | | | |
| Log likelihood | 172.4436 | | | | | |

**Source:** Eviews computation

# 5. Summary for Findings

Descriptive findings indicated that there has been a consistent decline over time in per capita agricultural sector GDP. This is consistent with expectations as the labor force has risen at a faster rate than the agricultural value GDP. A result also indicates that the per capita capital has been on the rise since 1975. This further indicates that farmers have continued to use more inputs such as fertilizers, seeds, energy despite a downward trend in the per capita agricultural sector GDP. The trend in precipitation has been inconsistent since 1975. This further indicates that the agricultural sector has experienced dramatic swings in rainfall with some years experiencing high rainfall while some years experienced low rainfall. The dramatic changes in precipitation may have been responsible for the decline in per capita agricultural GDP. The trend in temperature has been inconsistent since 1975. This further indicates that the agricultural sector has gradually experienced rising temperatures since 1975. The gradual rise in temperature may have been responsible for the decline in per capita agricultural GDP. The Jarque-Bera test statistic tested the null hypothesis that the distribution of the variables was not significantly different from a normal distribution. The test reveals that KAGRICGD, KCAPITAL, PRECIPITATION and TEMP were normally distributed as the reported p values were more than the critical p value of 0.05. High p values indicate that there is a very high probability that the distribution of the data is normal. The results indicate SAP, PEV and KINFRAST are not normally distributed as the reported p values are less than the critical p values. However, the natural log of KINFRAST is normally distributed.

The test results of the unit roots indicated that all variables are non-stationary (i.e. presence of unit roots) at 1%, 5% and 10% levels of significance. This calls for first differencing of the non stationary

variables. It is clear from the results that all the variables become stationary (unit root disappears) on first differencing.

The two step engle granger test results indicated that the lagged residuals were stationary at 5% and 10% levels. This implies that the lagged residuals were stationary. This further implies that there is cointegration among the long run variables. This also implies that the variable converge to a long run equilibrium. The Johansen Cointegration test indicated that the null hypothesis of at most 1 Co integration equations for the model linking was rejected at 5% (1%) significance level. The likelihood ratio statistic for the null hypothesis of the existence of at most 1 Cointegration equations was larger than the z critical vales at 5% and a 1% level. This implies that more than 1 co integrating equation exists. This further implies that all the variables in the model 4 converge to an equilibrium in the long run (i.e are co integrated).

Results in indicated that the R squared of the regression between LNKAGRICGDP and PEV had an R squared of 16.1%. The Squared improved to 44.2% once the SAP dummy was introduced. The r squared increased marginally from 44.2% to 47.2% upon the introduction of LNKINFRAST. There was no observed change in R squared when LNPRECIPITATATION and LNTEMP were introduced. The introduction of the LAGLNAGRICGDP significantly improved the R squared from 47.2% to 89.09%. In all models, the f statistic indicated that the independent variables were good joint predictors of LNKAGRICGDP.

Results in model 1 and Model 5 indicated that PEV had a negative and significant relationship with LNKAGRICGDP (-0.106, p value 0.015; -0.0321, p value= 0.0838). This implies that an increase in PEV by one unit leads to a decrease in LNKAGRICGDP by 0.106 and 0.0838 units respectively. Results in model 2, 3, 4 and 5) indicated that SAP had a negative and significant relationship with LNKAGRICGDP (-0.136, p value=0.0003; -0.135, p value=0.0002; -0.135, p value= 0.0005; -0.036, p value=0.0768). This implies that the introduction in sap by one unit leads to a decrease in LNKAGRICGDP by 0.136, 0.135, 0.135, 0.036 units respectively. Results in model 5 indicated that the lagged per capita income had a positive and significant relationship with LNKAGRICGDP (0.829, p value = 0.0000). This implies that an increase in the previous year per capita agricultural GDP by one unit leads to an increase in the current year per capital agricultural GDP by 0.829 units. Results in indicate that the other variables (LNKINFRAST; LNPRECIPITATION and LNTEMP) had insignificant causal relationships with LNKAGRICGDP.

Error correction modeling results indicated that in the short run, none of the variables except the error correction term is significant. The error correction term measures the speed of adjustment to the long run equilibrium in the dynamic model. The error correction term LAGRES_ECT has the expected sign and is significantly negative (-0.242583, p value =0.0118). This result implies that there is a negative gradual adjustment (convergence) to the long run equilibrium. The coefficient of (-0.242583) indicates that 0.242% of the disequilibria in short run per capita agricultural sector GDP achieved in one period are corrected in the subsequent period.

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