# TITLE:
# MAIZE PRICING AND STABILIZATION POLICIES: AN EVALUATION: A CASE STUDY OF BUNGOMA DISTRICT.

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# DECLARATION

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

30 JULY 2007

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This research paper has been submitted for examination with our approval as university supervisors.

30/07/2007

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## DEDICATION

*This work is specifically dedicated to my late great grand parents Agaton Makanda & Sifrose Makanda and my late grand parents Alexander Wanjala Okomba & Marsella Wanjala , whose wisdom passed down from generation to generation have contributed greatly to what I am today.*

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All errors , omissions , mistakes , views and interpretations remain my personal responsibility and should not be attributed to above acknowledged persons.

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## LIST OF ABBREVIATIONS

GOK – Government of Kenya

NCPB – The National Cereals and Produce Board.

PFP – Policy Framework Paper

ECT - Error Correction Term

ECM - Error Correction Model

DF - The Dickey-Fuller

ADF - Augmented Dickey- Fuller

M.O.A - Ministry of Agriculture

## ABSTRACT

The study was based on the maize pricing and stabilization policies. The area of study was Bungoma District. Bungoma District is located in the northern part of Western Province, Kenya .The average altitude is 1400 meters above sea level. The district covers an area approximately 2068.50 sq. km. and lies about 1 degree north of the equator. Depending on closeness to the Equator, temperatures do range from 16 degrees Celsius in the north to approximately measure 30 degrees Celsius in the southern parts of the district (GOK 1997). The area is mainly agricultural. It receives ample rainfall distributed in a bi-modal form with a working of up to 1000mm coming in the long rains season between March to July while about 500mm comes in short rain season between August to October.

The study objectives were to analyze maize price instability in Bungoma District with the view of evaluating the effectiveness of price stabilization policies overtime, to analyze the factors causing farm income instability on maize farms in the District and to find ways in which government intervention to stabilize domestic maize prices can be designed to stimulate rather than retard competitive. This was necessitated by the urge by the maize farmers is to derive good earnings on the resultant surplus maize volume over and above their subsistence levels, increase profit margins and incomes in maize farming.

The methodology of study involved both descriptive and time series analysis. Data collected covered ten years period, 1996 to 2006. The study relied mainly on secondary data sources in order to obtain the wide range of information required. The problem with primary data was that most farmers do not keep proper records and it may be difficult for them to recall information ten years ago.

The findings indicated that Input Cost per Ha has a negative and a significant relationship with the number of hectares under maize per annum. This could be attributed to the fact that when cost of input per ha increases, resources to invest become more scarce hence less production anticipated meaning less land allocated to maize production. The previous year's average farm gate maize price per 90kg bag is significant and positively related with the number of hectares under maize per annum. The previous year's last quarter average farm gate maize prices per 90kg bag are also significant and positively related to the number of hectares under maize per annum. The Previous year's yield per ha has a positive and a significant relationship with number of hectares under maize per annum.

The previous year's average farm gate maize price per 90kg bag, previous year's last quarter average farm gate maize prices per 90kg bag and Previous year's yield per ha are therefore positively related to the number of hectares under maize per annum.This could attributed to the fact that an Increase in expected price of output and expected yield increase would (holding other factors constant) lead to more investment in terms of area under maize.

The trend analysis indicates that over the years the prices of maize have varied. The month of June seems to be witnessing high prices over the years from 1996 to 2006 than any other month followed by October and then finally January. The year 2002 witnessed low maize prices in the month of October and January. The maize prices therefore tend to fluctuate over the years from 1996 to 2006. The yearly average prices are range between a minimum of Kshs 750 and maximum of Kshs 1400 over the years from 1996 to 2006. This trend means uncertainty serving as a deterrent to maize farming.

The study recommends that in order to encourage farmers to allocate more hectares to maize, the competitiveness and stability of the maize farm-gate price can be improved by more efficient use of storage, transport and market information.

In Gross Margin analysis, prices as per Ministry of Agriculture crop valuation remains constant around kshs 1000 per 90kg bag while the breakeven price average stays above Kshs 1000 per 90 Kg bag of maize. This implies that most of the years from 1996 to 2006 farmers experienced losses.

The study would therefore wish to recommend that In order to improve the number of hectares under cultivation; the agricultural policy makers should look into the cost of inputs such as fertilizers and others with a view of lowering them so that farmers can increase the number acreage under maize cultivation. This will encourage the farmers to have the morale in farming maize and therefore reduce the food insecurity.

The upgrading of Sikata–Kimilili road should be speeded. More access roads to interconnecting the interior rural in the ten divisions in Bungoma District need to be upgraded to tarmac level. More funds through the constituency roads Development Fund need to be set aside for this purpose. Good roads have potential lower the transport per unit transport cost. This incentive can encourage maize farmers to use transport to access markets that would offer competitive prices for their output.

The Ministry of Agriculture should be allocated more funds for collaboration with Non Governmental Organizations such as SACRED Africa among others. This will enhance the level of market information and organization among maize farmers. An organized and informed farmer has a better level of bargain both for his inputs and outputs.

In 2007/2008 financial year, just over 4% of National budget was allocated to agriculture which employs over 70% of the total labor force and contributes about 20% of the Gross Domestic Product.

The Constituency Development Fund committees in the five constituencies in Bungoma District should each set aside a revolving fund to give affordable credit to farmers to assist finance input costs, support storage, transportation and marketing activities of the maize commodity.

# 1.0 CHAPTER ONE: INTRODUCTION

## 1.1 General Introduction

Maize is the main staple food averaging over 80% of total cereals produced in Kenya (GOK 2006). Kenya's production has been increasing at 1% per annum while the country's consumption has been increasing at 3% per annum. (GOK 2006 estimation).Therefore by 2015, Kenya will be importing about 1 million tones of maize annually if the trend of low and declining yield continues.

According to the 2006 study carried out by the Ministry of Agriculture , the National Cereals and Produce Board is not able to make prompt purchases of maize for strategic reserve owing to delay in release of funds by the Exchequer . Secondly, the released funds are often inadequate for building the required stock of 3 million bags = 270,000 tones (GOK 2006). The mode of purchase where farmers deliver their produce to the National Cereals and Produce Board stores and wait for payment has in most cases discouraged producers because of long delays.

In Kenya losses in stored maize is estimated to be about 30-40% per annum (GOK 2006).The Ministry of Agriculture contents that maize storage has the potential of containing price fluctuations and ensure stability in its supply. The National Cereal and Produce Board has a grain storage capacity of 28 million bags which is largely underutilized (currently, only about 13% is being used) (GOK 2006). The National

Cereal and Produce Board has grain processing equipments such as driers and weigh bridges among others which are also underutilized.

Cereal self sufficiency has declined by 20% since 1991. Imports have significantly increased after introduction of market reforms. Cereals imports, which are often heavily subsidized by developed countries, have had the effect of displacing local production through depressed producer prices and reduced market share.

Paralleling the physical system for marketing maize grains is the pricing system which provides for contracts to buy and sell among business people at local, national and international levels. The pricing system has two major functions: co-ordination of production and utilization decisions of farmers, traders, processors and consumers; and helping to determine the distribution of income among these different groups (Cramer and Heid 1983).

The prices of maize determine how much land, labour, machinery, and other inputs will be used in growing, storing, processing and distributing maize and maize products. Price differences overtime help determine in each period how much maize grain is sold by farmers/traders and how much is stored for future use. Price differences between locations provide incentives to transport maize to where the need is greatest and price differences between grades provide incentives to produce the kinds of maize grains that are in greatest demand.

For the maize farmer, the price and quantity of maize produced determines how much income is available for family living. For the consumer, maize prices are a determinant of the cost of food as maize is a staple food in Kenya. For business people engaged in assembling, storing, feeding, processing and distributing maize and maize products, a few shillings difference in price per 90 kg bag can be the difference between a profit and a loss. The above global level discussion on maize pricing can be narrowed down to the local level. Maize price instability in Bungoma District not only affects farmers but also affects consumers, processors and other business people. However majority of people in Bungoma District fall in the class of maize farmers hence they are a major interest of this project. Since sales volume and turnover account for a considerable fraction of farm income in Bungoma District, the farm gate price is an important factor determining farm income.

Input prices are also an important factor that influences farm income. A change in price of farm inputs affects the cost of production which in turn affects farm income (Kohls and Uhl 1985). In Bungoma District fluctuating and generally increasing farm input prices has affected maize farmers' productivity, level of farm income as well as stability of farm income. Higher increases in input prices relative to output prices usually lead to cost-prize squeeze, lower profit margins and farm incomes.

## 1.2 Background Information

During the Colonial days maize marketing was controlled with the aim of providing direct economic support to European settlers. After independence maize marketing was still controlled by the government with the main reasons being:

- To stabilize producer and consumer prices; and
- To ensure food security in the country.

The controls were based on strict regulation of private trade in maize and direct government participation in the market through the National Cereals and Produce Board (NCPB). On the other hand input marketing and therefore pricing was not controlled. During this time there were three channels through which a farmer could market his maize: (a) The parastatal National Cereals and Produce Board (NCPB), (b) directly to consumers or (c) through market traders. The first two channels were legal, but the third channel was allowed by the law only if no inter-district trade was involved. For other transactions the sale was only lawful if a movement permit was granted by the National Cereals and Produce Board (NCPB) prior to shipment (Gsaenger and Schmidt 1977).

Since independence to 1992 (before liberalization) the board did not succeed in stabilising producer and consumer prices and also failed in creating necessary incentives for increased maize production. Further, the controls resulted in poor regional and seasonal market integration and instability in market conditions, (Nyangito and Ndirango 1997). In addition maize farmers in surplus regions such as Bungoma District did not actually receive the guaranteed farm-gate prices because of limited buying capacities of National Cereals and Produce Board shortly after harvest, (Gsaenger and Schmidt 1977). This means that maize farmers in Bungoma District sold most of their maize produce either to consumers or to market traders who may have offered prices lower than the guaranteed farm-gate prices by the National Cereals and Produce Board.

Maize marketing controls through the National Cereals and Produce Board were costly to the economy as subsidies advanced to the board amounted to approximately 20% of the Kenya's public sector budget deficit by 1992 (Kodhek 1994). The high budgetary cost of strict controls system and its stifling of private trading activity led to cereals sector reform assuming a key position in policy dialogue between the Government of Kenya (GOK) and donors as part of aid conditionality from 1985 onwards. At the end of 1993, aid was resumed as part of a package including Government of Kenya acceptance of a minimal role for the public grain marketing agency, the National Cereals and Produce Board. This was laid down in a Policy Framework Paper (PFP) signed by the government and donors (Kodhek 1994). These led to policy decisions of decontrolling the maize market. A gradual transition of maize marketing from the government controlled single channel to a multi-channel system consisting of both government and private agents was undertaken between 1986 – 1995, (Nyangito and Ndirango 1997).

Since liberalization of the maize sector in Kenya, maize pricing and marketing has been left to be determined by the free market with minimum government intervention. The role of National Cereals and Produce Board is to manage the national strategic reserve and to keep price fluctuations of maize ~~of maize~~ within given limits through its buying and selling activities. By maintaining a national strategic food reserve National Cereals and Produce Board aims at ensuring food security in the country. This helps to avoid abuse of severe deficit situations by the private sector. Price stabilization is aimed at by the National Cereals and Produce Board through its activity of defining the price structure, which is setting the ceiling price and floor price approximately. The ceiling price is usually set by the National Cereals and Produce Board in a situation, where the government feels that the market clearing prices are too low for the farmer.

The floor price is essentially set by the government when it feels that the maize market clearing prices are too high for the consumer. This system that encourages private trade and minimum government intervention has been characterized by price instability in maize which has impacted negatively to the farmers. The farm inputs such as hybrid maize seed and fertilizer have had fluctuating prices overtime with a general upward trend thus affecting net farm incomes negatively. The goals of National Cereals and Produce Board such as encouraging private trade to improve market competition hence prices has been affected by poor infrastructure and under utilization of available infrastructure.

In summary maize farmers in Bungoma District to date experience problems in the liberalization era. Price instability of maize output, high and unstable input prices, inadequacy and underutilization of available infrastructure have all led to unstable and unpredictable farm incomes that acted as deterrent to maize production in the District.

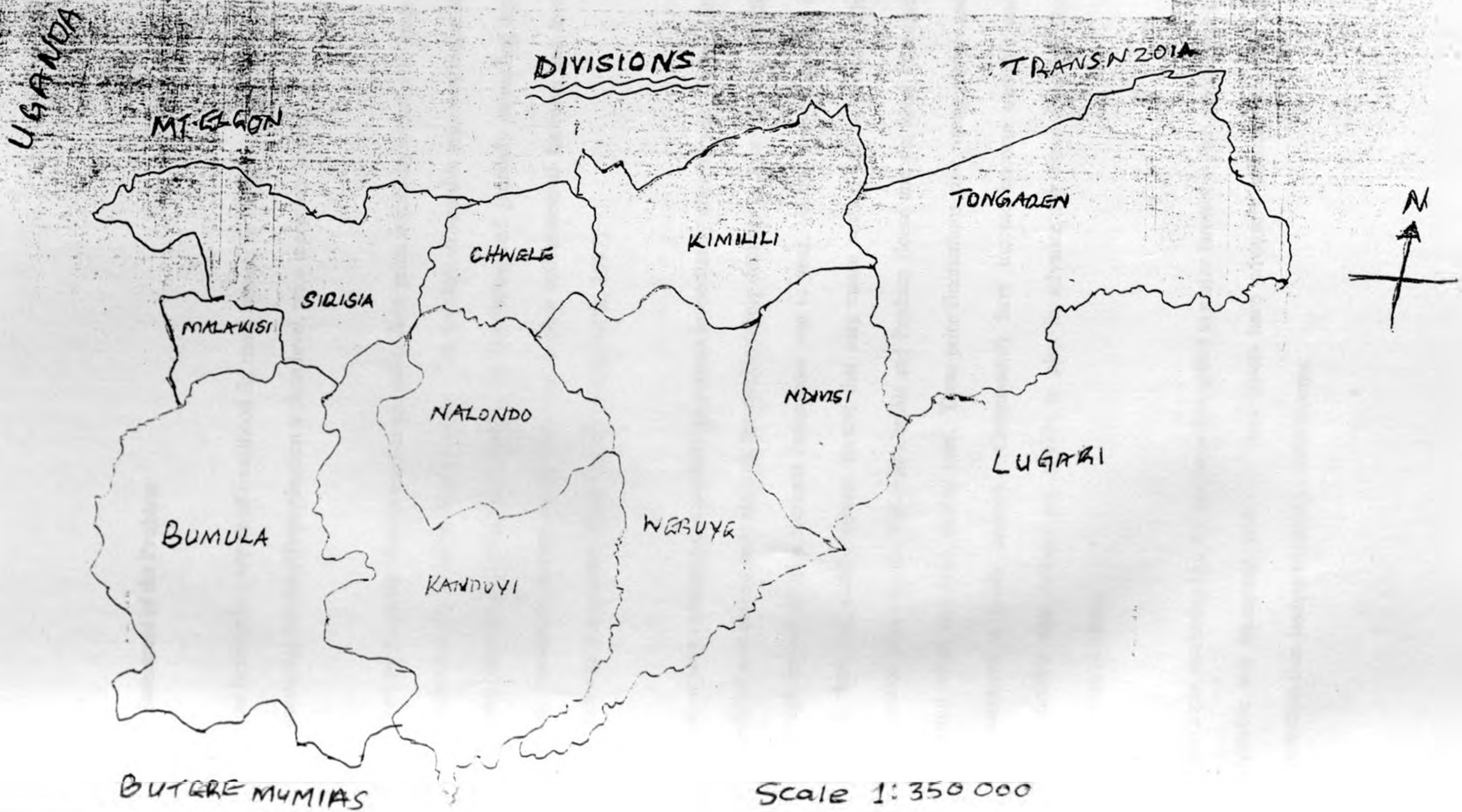
### 1.3 Area of Study

Bungoma District is located in the northern part of Western Province, Kenya ( See the map on Page 8).The average altitude is 1400 meters above sea level. The district covers an area approximately 2068.50 sq. km. and lies about 1 degree north of the equator. Depending on closeness to the Equator , temperatures do range from 16 degrees Celsius in the north to approximately measure 30 degrees Celsius in the southern parts of the district (GOK 1997). The area is mainly agricultural. It receives ample rainfall distributed in a bi-modal form with a working of up to 1000mm coming in the long rains season between March to July while about 500mm comes in short rain season between August to October.

The entire region that boarders Mt. Elgon has rich and deep volcanic soils that originated from mountain formation process. The rest of the district is composed of deep red loams, dark loams and sandy loams that have formed over the years through the weathering process of the underlying rocks. Crops grown include maize, beans, sugar cane, coffee, sweet potatoes, tobacco, millet, sorghum, cassava, cotton, tomatoes, kales, cabbages, onions, sunflower, a variety of traditional vegetables / fruits and fodder crops. Maize is grown both as a food and cash crop. Thus maize is a major crop and is grown by most farmers in Bungoma District. Maize and its pricing as a crop greatly affect the economy of the area of study hence forming the interest of this research.

MAP OF BUNGOMA DISTRICT SHOWING THE TEN DIVISONS IN THE DISTRICT WITH BORDER NEIGHBOURING DISTRICTS & UGANDA.

**Source**: Kanduyi Division Agricultural office, 2006.



### 1.4 Statement of the Problem

Maize farming is a source of livelihood for most farmers in Bungoma District. In order to encourage more maize production at farm level, price incentives is vital.

Farmers in Bungoma District experience maize farm price instability which also leads to unpredictable and unstable farm incomes. The problem of unstable prices of maize and unstable incomes is further compounded by fluctuating and generally increasing input prices, inadequate market competition due to poor infrastructural facilities and lower productivity due to cases of poor quality inputs (GOK, 1997).

Maize usually experiences low prices in periods immediately after harvest. After a few months of post harvest have elapsed, the market supply declines as prices increase rapidly although the rate of price increase varies from year to year. At this time of increase in prices, there are usually certain factors that may cause sudden fall in prices. The intervention prices by the National Cereals and Produce Board and the level of market clearing prices vary from year to year. These price fluctuations give wrong signals and disincentives to maize farmers. Consequently farm income become unstable and unpredictable thus farmers are unable to plan in advance for farm activities like acquisition of inputs.

Farm input marketing has also not been favourable to maize farmers in Bungoma District. Unstable and increasing prices of farm inputs have adversely affected the cost of production thus leading to unstable farm income.

### 1.5 Justification

One of the main objectives of maize farmers is to derive good earnings on the resultant surplus maize volume over and above their subsistence levels. Bungoma District is a net exporter of maize. To increase profit margins and incomes in maize farming, the farmers require high productivity to their resources. Increase in productivity requires advanced planning on incremental acreage and other farm inputs. The price expected to be received by the maize farmers normally determines the amount of resources committed to maize farming.

Maize farm gate price fluctuations in Bungoma District has meant that farmers in are not sure about the selling price hence the income. One of the goals of National Cereals and Produce Board is price stabilization and since this has not been achieved, this investigation is necessary. The upward and unstable trend in input prices has negatively affected productivity and enhanced the negative impact of maize farm gate price and income instability. In some cases ceiling prices set by the government have hardly covered input cost and the timing of government intervention has been too late for maize farmers.

This study seeks to determine ways of stabilizing farm gate prices so as to encourage maize production by maize farmers in the District. The results of this study will help to understand the underlying interrelationships of the maize production system so as to be able to explain disincentives in maize production and farmers' difficulties to break-even in maize production.

The major decision variables at the hand of the policy maker are the maize farm gate prices and the intervention time as the buyer of last resort.

Farmers, traders, and the National Cereals and Produce Board utilization of available infrastructure will also be evaluated with the aim of providing ways of improving utilization of infrastructure to increase competitiveness of both the maize input and output market.

## 1.6 Objectives

1. To analyze maize price instability in Bungoma District with the view of evaluating the effectiveness of price stabilization policies overtime.

2. To analyze the factors causing farm income instability on maize farms in the District.

3. To find ways in which government intervention to stabilize domestic maize prices can be designed to stimulate rather than retard competitive maize production.

## 1.7 Hypothesis

Three hypotheses are postulated in this study. These are:

1. Instability in maize farm gate prices has led to unpredictable and unstable farm incomes in Bungoma District.

2. The increasing and unstable input prices have led to unstable maize farm incomes in the study area.

3. Instability in maize farm gate prices and variability in yield per hectare has led to reduction in the rate of increase in area under maize in Bungoma District.

## 2.0 CHAPTER TWO: LITERATURE REVIEW

### 2.1 Theoretical Literature

Maize is the most commonly grown crop in Kenya, and is the staple food for over 80%of the population. Maize is grown in virtually all agro-ecological zones, ranging from the Kenyan highlands to the semi-arid zones and the humid coastal lowlands. The crop supplies 40% to 45% of the calories, and 35% to 40% of the protein consumed by an average Kenyan. It is estimated that maize accounts for 20% of all agricultural production and 25% of agricultural employment (GOK, 2003). A large portion of maize production (60%) is attributable to smallholders. However, large-scale commercial farms contribute a significant amount of total marketed maize output (Hassan and Karanja 1997; Jayne et al., 2002).

The maize sector reform began in 1987/88 and intensified in the 1990s, when under pressure from international lenders, the government eliminated movement and price controls on maize trading, deregulated maize and maize meal prices, and eliminated direct subsidies on maize sold to registered millers (Jayne and Kodhek, 1997). By the end of 1993, the market for maize was fully liberalized; maize could be distributed freely in the country by willing traders, and imported with minimal restrictions upon payment of some set tariff.

The rationale behind ensuring higher producer prices is based on the conjecture that for both microeconomic and macroeconomic reasons, no country has managed to sustain rapid economic growth without first obtaining food self-sufficiency, at least in the main staple (Timmer 1998a). At the micro-economic level, inadequate and irregular access to food limits labor productivity and reduces investment in human capital (Bliss and stern 1978; Strauss 1986; Fogel 1994). The macroeconomic impact of periodic food crises is to undermine both economic and political stability, hence reducing the levels and efficiency of investment (Timmer 1989, 1996; Dawe 1996). However, maize is the main food item in most diets. Higher maize prices would therefore erode real incomes of net buying households. In Kenya, maize expenditure accounts for over 18% of poor household's total income (GOK, 2003). This suggests that higher prices might negate efforts to ensure that the poor can afford adequate food. It is the well-known food price dilemma concept first articulated by Timmer (1986).

The importance of food price levels on the welfare of producers and consumers has over the years led governments to consider 'getting prices right' especially on key food commodities. The 'food price dilemma', articulated in Timmer (1986) embodies conflicting interests between producers and consumers of food commodities. Timmer's seminal contribution has been followed by an array of empirical work mostly in the context of developing countries. Theoretical studies on the subject include; Deaton (1989) on rice prices and income distribution in Thailand, Barrettt and Dorosh (1996) on changing rice prices and farmers welfare in Madagascar, and Budd (1993) on changing food prices and rural welfare in Cote d'I Voire.

The reforms in Kenya were expected to reduce costs in the maize marketing system by encouraging competition through the participation of more private sector participants in the market. The reform process in Kenya has nevertheless been slow and marked with a series of advances and reversals regarding the amount of freedom the private sector is permitted in maize marketing. Uncertain policy environment and frequent government interventions such as trade controls on maize imports and exports through use of tariffs and bans has also affected the extent of cereal market reform and the response by the private sector. For example, in 1994, the government introduced a variable import duty following substantial imports by private traders that had been blamed for a slump in the price of domestically produced maize. The reluctance on the part of the government to refrain from controlling prices through policy tools such as tariffs and trade bans emanated from the perception that liberalization would expose maize producers and consumers to predatory practices of private traders (Kodhek et al., 1993). Further reluctance stemmed from the concern that maize meal prices would no longer be controlled in an unregulated market that, especially in a drought year could adversely affect household food security (Pinckney, 1988). It was also feared that removal of food subsidies would hurt poor consumers by jeopardizing their access to food.

Due to the background of the self-sufficiency objectives, the Kenyan, policy makers have often acted in favor of producers by offering prices that are higher than market prices. Also, the government has imposed a levy on maize imports varying from 25 to 75 percent of the landed costs of the imported maize. Although this tax accrued to the government as income, it penalizes consumers because the taxes raise the price of maize above what they would be without the government intervention. High domestic food production costs compared to imports penalizes consumers who have to pay high food prices and is also inconsistent with international and regional agreements such as the Common Market for Southern and Eastern Africa, Eastern African Cooperation (Jayne et al 2001). The high food prices also hinder the transfer of resources from food [systems to other parts of the economy as it takes more resources from non-food sectors to purchase a unit of food. In addition, high food prices force consumers to demand higher wages, which makes industries and manufacturing less profitable and competitive internationally. Protectionist polices force consumers to bear the brunt of farmers' low productivity. With the trend toward integration of regional and international markets, protectionism will increasingly create political problems with neighbors.

## 2.2 Empirical Literature

Nyoro (1994) analyzed changes in maize prices, production cost and output levels. Method of analysis used by the author is the budget-based approach. Maize production costs for principal production regions were identified and compared. The next step was to identify how changes in maize prices affect profit. Data was collected on input prices, output quantities and prices, and quantities of inputs in their fixed labour and intermediate categories. Historical data on input and output prices for maize were used to evaluate trends in maize production costs and revenues. This analysis led the author to conclude that stable maize prices encourage production because price risk is reduced. With stable prices, constant usage of input is enhanced.

The author finally comments that whereas maize production in Kenya could increase by four million bags through area expansion, the increase from changes in fertilizers and other input could be eight million bags. A critical look at the budget-based approach used by the author is that it is more suitable for the analysis of production cost than price fluctuations. More suitable methods for analyzing price fluctuations such as time series analysis have not been utilized by the author. The author's conclusion on the other hand is in line with the objectives of the study of maize pricing in Bungoma District. This is because stable maize prices means stable farm gate income which can enable farmers to plan for and acquire inputs which in turn leads to higher production. To stress this point the author further notes that fluctuations in maize prices may reduce maize productions as risk-averse farmers produce less maize output.

Sasaki (1995) examines utilization of available infrastructure (transport and storage facilities) and harvesting patterns in relation to price changes over space and time as regard to maize in Kenya. The author's examination is carried out with reference to maize market internal liberalization era in Kenya.

Firstly Sasaki (1995) stated that in the analysis of changes in price differences and transport charges the Policy Analysis Matrix team conducted surveys of transport prices in two years (1992 and 1994/1995). The prices were those charged by 7 to 10 tonne lorries. The nominal transport charges per 90 Kg bag of maize was adjusted for inflation and real price differences between 2 years for different sets of markets compared. The author observed from the analysis that there is as increase in real prices in most routes but does not give reasons for this. The author also concludes that price differences between districts have become smaller and attributes this to liberalization as one of the significant factors. In the survey the author does not indicate the type of people involved in the transport of maize to consumer market. This information could be important in ascertaining whether maize farmers take initiatives of transporting to better markets or the entire business is left to traders and transporters. In this way the price received by farmers for the output could be known. The study can contribute to this proposal by helping to analyze the likely benefits of improving and increasing utilization of transport in Bungoma District by maize farmers and traders.

The likely benefits could be reducing price risks due to fluctuations in farm gate prices by fetching better prices in far markets through proper transport utilization by farmers. Another benefit could be increase in effectiveness and competitiveness of the market as a result of improved and increased utilization of transport facilities, and these generally leads to higher stability in maize prices.

Sasaki (1995) secondly indicates that a study was conducted by the Policy Analysis Matrix team about capacity of stores and houses to store maize on the farms. The study showed that 75% of maize farmers in Bungoma District have capacity to store maize in their stores or houses. The study also showed percentage storage capacities for other major maize producing districts in Kenya and the overall average maize storage capacity was 85%. These results were arrived at by conducting a study in which 105 farmers were able to identify the months they sold maize in 1994 for the crop harvested in 1993. This study revealed that at least 66 farmers stored some or all of their produce (maize) for at least two months. The author concludes that storage for maize is quite active contrary to the general perception that farmers do not have ability to store.

In this study the author does not consider the fact that the sample size of 105 farmers is too small hence cannot adequately represent the whole population in the country of thousands of maize farmers. The author does not take into account the quality of storage used by different farmers. Onyango (1993) concluded that less educated farmers in Trans-Nzoia District preferred bin-type storage method compared to more educated farmers whose losses are minimal because they use modern recommended stores. In addition the author's conclusion cannot easily apply to the situation in Bungoma District. This is so because majority of maize farmers in the District have children and youths still undergoing education (GOK 1997).

Thus it is unlikely that maize farmers in the District would store their maize for more than two months as they have to sell it immediately after harvest to meet the school fees demand. This problem may be compounded by scarcity of off-farm employment in the District. In fact the survey data indicates that most of maize in Bungoma is sold between November and December, which are periods immediately after a harvest.

An examination of maize harvesting patterns and seasonal prices for different months within different years for various regions in Kenya was done, (Sasaki 1995). Interviews were conducted with farmers and personnel in District Agricultural offices. In these interviews dry maize was perceived as a seasonal commodity and months of high and low prices were identified. From data collected, bar graphs for dry maize harvested and line graphs for real monthly wholesale prices of dry maize were drawn. Both graphs were drawn on same graph space for each district under examination.

The author's conclusion was that very little maize is harvested between March and June while large amounts became available in November and December. Also maize prices are expected to be lowest in November, December and January and highest in May, June and July. The author used time series analysis which can be useful in analyzing the situation of maize price instability in Bungoma District in relation to harvesting, and post harvesting seasons. The conclusions made can be useful in analyzing the likely benefits of storing maize by farmers in the District given expected variations in supply and price fluctuations overtime. The possible shortcoming in the methodology used is that some farmers conducted for interview may not have been in a position to give accurate maize farm gate prices for various months due to lack of records. This may have interfered with the required sampling size of farm gate prices. Appropriate interviewees on monthly changes in maize prices can be farmers who take active part in maize marketing throughout the year as speculators who take advantage of price fluctuations. Generally majority of farmers may be suitable interviewees to obtain information about harvesting seasons and farm gate prices at harvest time.

Sasaki (1995) further insists on calculation of percentage price changes from troughs to peaks for different years in some districts as an additional method to estimate real seasonal price changes. This methodology of percentage price changes from troughs to peaks for different periods can be used to estimate seasonal maize price changes in Bungoma District because only data on prices overtime is needed and calculations involved are simple.

An econometric study was curried out on maize and wheat acreage responses in the large farm sector in Kenya's agricultural economy (Gichuhi 1982).The author used economic and non-economic variables for the period 1954 to 1978 to measure the effects on maize and wheat planted areas in the large scale mixed farm sector. The effects of controlled guaranteed producer prices, weather and time on maize and wheat acreage were estimated using multiple regression techniques.

The estimated coefficients and acreage elasticities were found to be very stable across equations which supported the hypothesis that these variables have influenced large scale commercial maize and wheat farmers' acreage decisions.

The estimates of short run relative price elasticities were found to be greater for maize acreage than for wheat acreage; suggesting that maize producers are more responsive to other competing profitable enterprises. However, the estimated long run relative price elasticities were found to be greater for wheat acreage than maize acreage.

The above study includes the weather variable which cannot easily be precisely predicted besides involving biased estimation due to value judgment.

The multiple linear regression analysis used involves variables such as producer prices and acreage. The same variables will be used in this proposal hence the multiple linear regression model can also be applied in cause and effect relationships.

Odhiambo (1993) analyzed smallholder coffee supply response in Kenya. The study used a combination of the Fisher Lag Scheme and the Inverted V lag distribution models to derive price elasticities expressed in terms of productivity and quality of coffee for five districts in Kenya. The major determinant of productivity and quality was found to be the farmers' price expectations. Productivity response (long-run response) estimates were generally higher than those for quality response (short-run response). The author further concluded that farmers in various districts exhibited different degrees of responsiveness to both economic and non-economic variables. This was explained by variations in the development of infrastructure which determine the availability of inputs and outputs delivery, level of farmers' organization into co-operatives and the level of education and or awareness.

The foregoing study conclusions on farmers' price expectations adds weight to this proposal's focus on expected price as a major incentive in maize farming. The author's conclusion on differences in districts responsiveness emphasizes the need to study the availability and utilization of infrastructure by maize farmers in Bungoma District.

The main shortcoming in the methodology used is that it does not clearly detail the parameters that were to be used to analyze inter-district differences in infrastructural development and usage.

### 2.3 Literature Overview

Generally, the studies in the preceding discussion suffer from several identified weakness. Except for Onyango (1993) , the rest of the authors did not specifically specify differences in the sampling population in terms the level of market information the farmers have. Market information analysis can be used to gauge the level of infrastructure that is likely to be used by farmers in various aspects of farming. Most authors did not mention deliberate effort made to ensure the sampling methods generate true representation of the whole population. This is important because inferences from the sample are made to the whole population. Questions also arise on the surveys conducted by obtaining data directly from farmers in various studies in the literature review. Farmers may have short memories hence unable to provide accurate data on information older than one year. In addition record keeping by farmers could be a problem. This proposal will mainly dwell on data in Ministry of Agriculture and Non-Governmental Organizations records since these are collected and recorded on time. Only one author , Odhiambo (1993) put major effort on the aspect of coffee farmers response to expected prices. However no author discussed price stabilization issues hence this proposal comes in to fill this gap.

The studies in the literature review also exhibit a number of strengths. The studies conducted on maize would help us to confirm the facts about harvesting seasons, extend of use of infrastructure such as storage and transport, and maize farm gate general price trends. These would greatly help in evaluation of the National Cereals and Produce Board timing of intervention as the buyer of last resort with a view of regulating maize supply as well as price stabilization. The methodologies used to study maize and wheat acreage responses and smallholder coffee supply response in Kenya established several key interrelationships. The employment of the multiple linear regression analysis and the Fisher Lag models to analyze various responses could provide a starting point in modeling analyses in this proposal. The Fisher Lag Scheme in particular helped to deal with multicollinearity problems in estimating the farmers' expected price in the coffee sector.

All the studies in the literature review attempted to either include price variability or address issues of infrastructure utilization which affects market competitiveness which in turn affects maize farm gate price variability. This proposal mainly focuses on factors causing maize farm gate price instability in Bungoma District as well as an evaluation of the effects of the government's price stabilization attempts by way of issuing and implementing price stabilization policies. Analysis of the maize farm gate price changes faced by the maize farmer ranks high in this paper. This study aims at establishing the appropriate timing of government intervention needed to be employed to achieve price stabilization at farm gate.

# 3.0 CHAPTER THREE: METHODOLOGY

## 3.1. Conceptual and Theoretical Framework

Price stabilization of maize output can be achieved through a price stabilization scheme. This is done by first defining base points of intervention in the maize market. Since the operating cost of the price stabilization scheme should be minimized in order to maximize the net welfare gains, the margin between the selling and purchasing price should be sufficiently wide. Thus the upper limit (floor price) and the lower limit (ceiling price) set should be analyzed and implemented on the basis of welfare losses and gains to different target groups (Gsaenger and Schmidt 1977).

The net effects of the prices stabilization scheme depend on several factors. Firstly the source of random price fluctuations of maize in Kenya is mainly due to shifts in maize supply (Gsaenger and Schmidt 1977). Thus a price stabilization scheme will benefit producers while consumers may loose, but the net effect is positive. This holds true regardless of whether supply is based on actual prices (perfect information) or on expected prices. To offset welfare loss to consumers one might consider supplementing price stabilization scheme with subsidized consumption to certain vulnerable groups. Since such system is likely to be subverted by mismanagement and corruption, other devices for discriminating in favour of vulnerable groups should be thoroughly considered.

Second factor is the elasticity of supply and demand. When price elasticity of supply is greater than price elasticity of demand, a price stabilization scheme produces higher welfare gain than when price elasticity of demand in greater that of supply. In Bungoma District maize has price elasticity of supply being greater than price elasticity of demand thus a price stabilization scheme will lead to higher welfare gain.

Thirdly is the budgetary implication of the price stabilization scheme. The costs involved are strongly influenced by the setting of selling price in deficit regions (such as Nairobi) and purchasing prices surplus regions (such as Bungoma) in line with the long term equilibrium prices. The smaller the margin between the selling and purchasing price, the greater the number and magnitude of transactions and thus the number of changes in the stock. If the prices are not set in line with the long term trends the stocks either reach unacceptable levels causing tremendous financial burden or are exhausted quickly at the expense of the schemes effectiveness in stabilizing prices.

The fourth factor is the management of the government agency responsible for implementing the stabilization scheme. This may be a limiting factor in operating a price stabilization scheme. For instance, given poor management and political interference of the government agency responsible for implementing the stabilization scheme, open market interventions involving direct competition with the private sector may be rather difficult to perform effectively.

### 3.2 Empirical Framework

There are measurable variables that correspond to concepts used in the study. Maize pricing was measured by taking farm gate prices for different months or periods under the study. Income was measured by gross margin determination per a hectare. Infrastructure includes storage, transport, market information and handling facilities. The indicator for storage will be number and size of storage buildings available to farmers as well as the level of utilization of this facility. Transport will be measured by the number of tarmac roads accessible to farmers linking them to other markets. The level of market information will be measured by the number of information channels available in Bungoma District such as newspapers, journals, radio, or TV programs covering information pertaining to the maize market and number of reliable markets informants to farmers. Lending facilities will be measured by the number of institutions that lend money to maize farmers.

Production cost will be measured by prices and volume of various inputs used by farmers. Out put level or production will be measured by the number of 90 Kg bags of maize produced by farmers. Quality of inputs used will be determined by reliable competitors to the Kenya Seed Company who too have a reputation of high quality seed maize.

### 3.3 Sources of Data

Data collected cover ten years period, 1996 to 2006.

The study relies mainly on secondary data sources in order to obtain the wide range of information required. The problem with primary data is that most farmers do not keep proper records and it may be difficult for them to recall information ten years ago.

Secondary Data

This kind of data will be obtained from various secondary sources, which includes materials at Provincial / District / Divisional agricultural offices, District annual report, District development plans, market information centers and other relevant documentary materials and university library. Secondary data will include information about acreage of land under maize, total yield of maize and farm gate prices, availability and usage rate of infrastructure, number of market information centers on maize prices among others.

### 3.4 Tools of Analyzing Data

The following tools of analysis will be used in analyzing data:

a) The Range

This will be used to calculate the differences between the highest and the lowest price using data collected on farm gate prices. The range will be used to estimate the extent of seasonal price changes.

b) Time Series Analysis:

A graph of prices per 90 Kg bag of maize against time in months will be plotted. In addition yearly average market prices will be plotted against time in years. The graphs will be used in analyzing the trend of price fluctuations of maize over time. They will also be used to analyze and estimate seasonal price changes.

c) Gross Margin Analysis

This will be used in the analysis to find out whether maize enterprise will at least break-even or experience losses in a particular period given data on per hectare maize yield and farm gate prices, input levels and costs. See Appendix 4 on Page 79.

f) Descriptive Statistics

This will be used to analyze data relating to storage, transport, and proportion of farmer accessible to market information and available number of reliable market informants, proportion of farmers accessible to credits and number of institutions that lend to farmers.

g) General Multiple Regression Analysis

*Suitability of the model:*

In this model the level of farmers' motivation is measured by the number of hectares under maize per annum. This is used in place of actual production in the current period since the farmer does not always harvest what he desires to produce due to factors which are outside his control such as weather conditions.

Multiple regression analysis is well suited for capturing the joint and interrelated influences of several variables hypothesized to determine the farmers' response to price changes among other factors.

*The multiple regression analysis envisaged is:*

To analyze the effects of Input Cost per ha (independent variable $X_1$), Previous year's average farm gate maize prices per 90kg bag (independent variable $X_2$), Previous year's last quarter average farm gate maize prices per 90kg bag (independent variable $X_3$), & Previous year's yield per ha (independent variable $X_4$) on the number of hectares under maize per annum (dependent variable Y)

The general multiple regression model will be:

$$Y = B_0 + B_1 X_1 + B_2 X_2 + B_3 X_3 + B_4 X_4 + U_t$$

Where:

Y is number of hectares under maize per annum (dependent variable).

$B_0$ is the regression constant

$B_1$, $B_2$, $B_3$ are the slopes of the regression

$X_1, X_2, X_3, X_4$ are the independent variables explained as:

$X_1$ is the Input Cost per ha

$X_2$ is the previous year's average farm gate maize prices per 90kg bag

$X_3$, is the previous year's last quarter average farm gate maize prices per 90kg bag

$X_4$, is the Previous year's yield per ha

$U_t$ is the error or disturbance term.

Expectation:

- Inverse (negative) relationship between Y and $X_1$. When cost of input per ha increases , resources to invest become more scarce hence less production anticipated meaning less land allocated to maize production.
- Direct (positive) relationship between Y on one hand and $X_2$, $X_3$, $X_4$ on the other hand. Increase in expected price of output and expected yield increase would (holding other factors constant) lead to more investment in terms of area under maize.
- The correlation coefficient between Y and $X_3$ should be higher than the correlation coefficient between Y and $X_2$. It is assumed that farmers only take into account the price of the immediate past year (farmers are assumed to have very short memories) in determining price expectations for the current year (Gichuhi, 1982).

Assumption: For every fixed value of any X, the random disturbances or residuals, $U_t$, are independently distributed with a mean equal to zero and a common variance denoted by $S_Y$.

In order to validate the obtained linear regression equation, correlation analysis is necessary. This analysis will be done to test the goodness of fit of the regression equation for the research data.

The coefficient r, computed for all X and Y is defined by:

$$r = b_1 . S_X / S_Y$$

Where:

$$S_X = \sqrt{\Sigma (X - X)^2 / (n - 1)}$$

$$S_y = \sqrt{\Sigma (Y - Y)^2 / (n - 1)}$$

$$-1 \leq r \leq 1$$

The correlation coefficient, r, explains the strength and direction of the linear relationship between the dependent and independent variables. If r is large, there is a strong linear relationship between the variables and vice versa.

The practical significance of the regression will be measured by the squared correlation coefficient ($r^2$) which will be obtained from ANOVA table as:

$$r^2 = \Sigma (Y - Y)^2 / \Sigma (Y - Y)^2$$

This is an explanation of the total variability of Y explained by the fitted linear regression.

The F-test will be used to show whether the relationship between the dependent variable and the independent variable is significant or not.

The F-test will be tabulated from the formulae:

$$F = B_n^2/Var_{Bn}$$

Where n = 0, 1,2,3,4

The obtained F- statistic will be compared with the expected F- statistic from the tables of F-critical values at 0.5 significant level. This will form a basis of accepting or rejecting the null hypothesis.

### 3.5. Data Presentation

Use of tables and graphs will be employed where necessary.

## 4.0 CHAPTER FOUR: DATA ANALYSIS

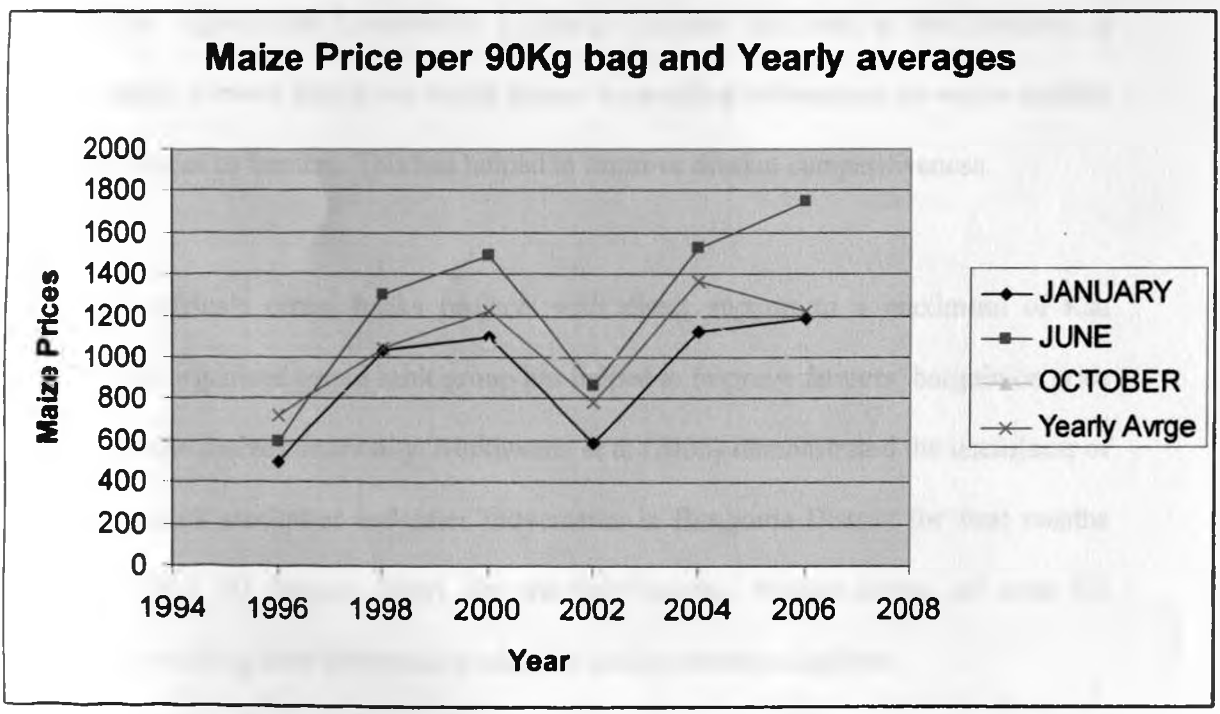
Based on the methodology the study involves the use of Trend Analysis which involves Time Series Analysis and Gross Margin Analysis and General Multiple Regression Analysis.

### 4.1 TREND ANALYSIS

#### 4.1.1 Trend in Maize Prices per 90Kg and the Yearly averages

A graph of prices per 90 Kg bag of maize against time in months was plotted. In addition yearly average market prices were also included in the same graph. The graph was then used in analyzing the trend of price fluctuations of maize over time. They will also be used to analyze and estimate seasonal price changes.

**Table 1 : Trend in Maize Prices per 90Kg and the Yearly averages**




**Source Data: 1996-1999 (Oral Interview from maize traders) & 2000-2006 (Kenya Agricultural Commodity Exchange LTD records) - See Appendix 5**

Over the years the prices of maize over different month periods tend to differ. The month of June seems to be witnessing high prices over the years from 1996 to 2006 than any other month followed by October and then finally January. It should also be noted that the year 2002 witnessed low maize prices in the month of October and January. The maize prices therefore tend to fluctuate over the years from 1996 to 2006. The yearly average prices are range between a minimum of Kshs 750 and maximum of Kshs 1400 over the years from 1996 to 2006. This trend means uncertainty hence difficulties for maize farmers to plan in advance on farm activities such as input acquisition due to variability of cash inflows from the maize output.

The Kenya Agricultural Commodity Exchange Limited has been at the forefront in linking maize farmers directly to maize buyers by availing information on maize markets and daily prices to farmers. This has helped to improve market competitiveness.

SACRED Africa's cereal banks projects with direct support to a maximum of Ksh 300,000 per organized cereal bank group has helped to improve farmers' bargain on price offered for the maize commodity. Mukhwana et al (2005) demonstrated the usefulness of the cereal bank stockpiles and sales movements in Bungoma District for four months (October 2003 TO January 2004). For the four months, farmers earned an extra US $29,204 by bulking their individual stocks and selling directly to millers.
SACRED Africa, through it's cereal bank project has sensitized farmers on the use of rail transport to access millers in Nairobi. Use of rail transport has been found to be much cheaper than road transport; One 90kg bag of maize costs Ksh200 to be transported from

Bungoma to Nairobi by road while the same costs Ksh100 by rail (Mukhwana et al 2005).

The "SOKO HEWANI" WEST FM radio station program , with potential to reach One million listeners in Western Kenya and Eastern Uganda (according to the station's broadcasters) has enabled farmers and traders alike to bid and offer different agricultural commodities , maize included. This program is only one year old (launched in 2006) hence further monitoring and research is needed to evaluate its impact on maize price stability in Bungoma District.

### 4.1.2 Gross Margin Analysis

Most roads to the vast interior rural areas remain un-tarmarked. Save for the Southern part of the district, where murram roads are maintained by Nzoia Sugar Company, the growth in the road network slow paced. This has posed a challenge to farmers who may wish to transport their maize commodity from the rural areas to better urban markets besides high fuel costs. Plans to tarmac Sikata- Kimilili road covering over 50KM will go a long way in opening up more rural farmers to better markets for their maize produce.

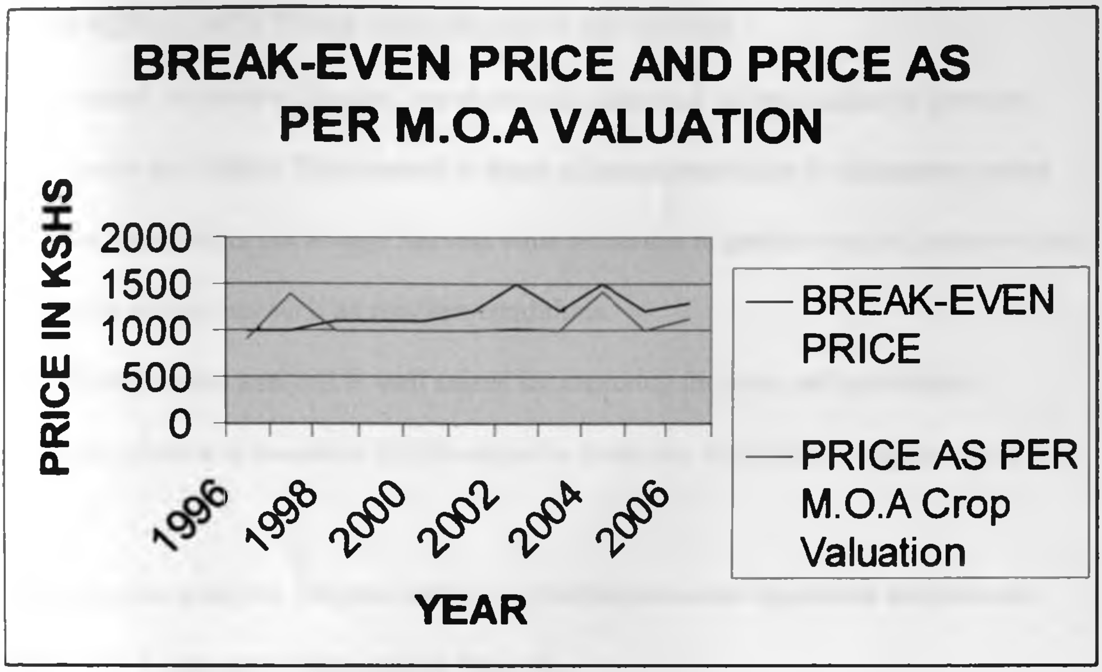
A number of new banks have been established in Bungoma District. These include: Equity Bank, Family Finance Bank and K-REP Bank. These are known to train small upcoming entrepreneurs on business skills as well offering credit. NGOs such as the SACRED Africa and the Kenya Agricultural Commodity Exchange Limited have encouraged the maize farmers to run their farms as businesses. It is envisaged that once the business culture takes root, the farm enterprises will take advantage of credit facilities and training offered by organizations such as banks.

Mukwana et al (2005) contents that any support organization such as an NGO offering assistance to farmers must have an exit strategy to encourage farmers' independence. The farmer on his own can now rationally produce and market his produce efficiently, seek credit facilities from banks among other value adding farm and off-farm activities.

Kenya has a special problem in Sub-Saharan Africa, while on average it costs Ksh 800/- to produce one 90kg bag of maize, it costs much less elsewhere, that is , Ksh. 470/- in Uganda and Ksh. 390 in South Africa (Mukwana et al ,2005).

Gross Margin analysis was used in the analysis to find out whether maize enterprise will at least break-even or experience losses in a particular period given data on per hectare maize yield and farm gate prices, input levels and costs.

**Table 2 : Break-even Analysis and valuation prices as per M.O.A**




**Source Data : Bungoma District Ministry of Agriculture Annual Reports (96-2006)**

Key: M.O.A = Ministry of Agriculture **- See Appendix 4**

The two variable break–even price and the price as per Ministry of Agriculture crop valuation was used to analyze the gross margin analysis. The break–even price as indicated in the graph breaks-even at over kshs 1000 for majority of the years whereas prices as per Ministry of Agriculture crop valuation remains at kshs 1000 for most of the years .This indicates that the maize farmers experience the losses for most of the years.

## 4.2 GENERAL MULTIPLE REGRESSION ANALYSIS

In this model the level of farmers' motivation is measured by the number of hectares under maize per annum. This is used in place of actual production in the current period since the farmer does not always harvest what he desires to produce due to factors which are outside his control such as weather conditions.

Multiple regression analysis is well suited for capturing the joint and interrelated influences of several variables hypothesized to determine the farmers' response to price change.

On Regression analysis, the tests carried out before the actual regression analyses are Stationarity Tests and Co integration Analysis.

### 4.2.1 Stationarity Test

Stationarity means that the statistical properties of the process do not change over time (Engle, 1987). If the non-stationary time series data is used, it may lead to conclusion whose validity is questionable. A convenient but weak definition of stationary regarding quantitative variables is that there is no systematic change in either mean or variance in the time series. If there were such changes, an increasing or decreasing trend in the data would be present.

Time series data regression analysis is not complete unless stationary data is used. It is therefore important to test whether the data used is stationary or not. Most time series data used is non-stationary as indicated in the Appendices 1(a) and (b). It is therefore necessary, as a first step is to correct the situation. This can be done by differencing to eliminate non-stationarity. Non-stationary series is integrated of order $\geq 1$. Stationary series on the other hand is intergraded of order I (0). If I ($\geq 1$), it can be differenced to obtain an I (0) series which is a stationary series.

Based on the graphs and Unit Root Test in Appendix 2(a) and (b), it can be seen that all the variables used are stationary after differencing. However, it is difficult to determine the order of integration. This therefore calls for a more formal test for stationary since the graphical methods is inadequate. A unit root test has therefore to be conducted.

#### 4.2.2 Unit Root Test

The unit root test indicates whether the variables are stationary or not. In carrying out a unit root test, a random walk model is used (Green, 2003). This variable assumes the same value as in the last period, modified by the current period shocks. The current period is analyzed by the past period plus ascertains unpredictable value as indicated in equation 1.

$Y_t=Y_{t-1}+\varepsilon_t$......................................................................................................1

Where, $Y_t$ is the current period, $Y_{t-1}$ is the past period and $\varepsilon_t$ are shocks to the system and assumed to be the white noise with zero mean ,constant variance and non-auto correlated. In general, the above equation can be analyzed with a modified equation (2) below for the purposes of hypothesis testing.

$Y_t=\alpha Y_{t-1}+\varepsilon_t$......................................................................................................2

Where $\alpha$ is the coefficient of the past values and is the one used to measure the stationary.

The null hypothesis: $H_0:\alpha.>0$ Non Stationary (Unit Root Presence)

Alternative hypothesis: $H_1: \alpha<1$ Stationarity (No unit root)

Rejecting the null hypothesis would mean that the series is stationary and vice versa. Accepting the null hypothesis implies that the variable has a unit root or is a random walk variable and hence is non-stationary. If $\alpha<1$, the process generating $Y_t$ is integrated of order zero and hence stationary I(0). My study uses Augmented Dickey-Fuller Test (ADF) to test for unit roots.

#### 4.2.2.1 The Dickey-Fuller (DF) and Augmented Dickey- Fuller (ADF) Test

DF is an auto-regressive model. The random walk model is a special type of AR (1) model (Non-Stationary Model) with $\alpha=1$ in equation 2. If $\alpha=1$, $Y_t$ is non-stationary and contains a stochastic trend. Thus within the AR (1) model, the hypothesis that $Y_t$ has a trend can be tested by testing: $H_0$: $\alpha=1$ vs $H_1$: $\alpha<1$ on equation 2. The null hypothesis is that of non-stationarity while the alternative hypothesis is that of stationarity.The regression software automatically prints the t –statistic testing $\alpha<1$.The t statistic is then compared with t critical. If is t-statistic is less than t-critical reject the null hypothesis of non-stationary and therefore the series is stationary (Green, 2003).

The ADF test was specified by (Granger and Engle, 1987). It follows the same procedure as the DF test. The ADF test was performed by introducing lags of the dependent variables. To avoid spurious regression, the non-stationary variables are differenced to remove any stochastic trends in the series. The ADF test takes care of the intercept as opposed to the DF. This study concentrates on the ADF test.

The test is based on the following equation $Y_t = \alpha_0 + \alpha_1 Y_{t-1} + \varepsilon_t$……………………………3

Equating equation 2 and 3 we have $Y_t = \alpha_0 + (\alpha_1 - 1)\ Yt_{-1} + \varepsilon_t$………………………………4

Now letting $\alpha_1 - 1 = \delta$.

The null hypothesis occurs when $\delta<0$ and $Y_t$ is a non-stationary series. Under alternatives hypothesis, $\delta=0$.The t-statistic is the compared with t-critical. If t- calculated is less than t-critical, then reject the null hypothesis of non-stationery and accept that the series are stationary.

**Table 3: The Unit Root Test using ADF**

| VARIABLE | ADF STATISTIC | 5% CRIRICAL VALUE | NATURE |
|---|---|---|---|
| X1 | -2.356121 | -3.9948 | NON-STATIONARY |
| X2 | -3.141044 | -3.9948 | NON-STATIONARY |
| X3 | -3.612319 | -3.9948 | NON-STATIONARY |
| X4 | -3.044669 | -3.9948 | NON-STATIONARY |
| Y | -2.951122 | -3.9948 | NON-STATIONARY |

**Source: E-Views Output**

The result in table 9 shows that the variables are non-stationary because the ADF t-statistics is greater than the ADF t-critical at 5% level of significance.

The variables are then differenced and subjected to the same tests. The results of the differenced ones are presented in the table 10. The unit root test of these non-stationary series are shown in Appendix 1.

**Table 4: Unit Root Test after Differencing (ADF)**

| VARIABLE | ADF STATISTIC | 5% CRIRICAL VALUE | NATURE |
|---|---|---|---|
| DX1 | -5.078233 | -4.1961 | STATIONARY |
| DX2 | -6.473984 | -4.1961 | TATIONARY |
| DX3 | -7.944267 | -4.1961 | STATIONARY |
| DX4 | -7.643764 | -4.1961 | STATIONARY |
| DY | -8.382216 | -4.1961 | STATIONARY |

**Source: E-Views Output**

The results from table 10 shows that the ADF t- statistics is less than the t critical and therefore we reject the null hypothesis of non-stationary and accept that the series are stationary. The first differencing of all variables is therefore stationary which implies that these variables are integrated of order one, I(1) .The the unit root test of these stationary series are shown in Appendix 2.

### 4.2.3 Co integration Analysis

This analysis combines both short-run and the long run properties and at the same time maintains stationarity in all the variables. Such an analysis tests the existence of long run relationship between a dependent variable and its explanatory variable. If two or more variables are integrated of the same order and their differences have no clear tendency to increase or decrease then this will suggest that their differences are stationary. Thus if non-stationary series have a long run relationship they will be stationary. If the linear combination of the residual from the variables is integrated of order zero I(0),then this will be a case of co integration (Green, 2003). The existence of co integration is important because failure to find co integration between variables will be a manifestation of the existence of spurious regression in which case the valid influence will not be realized. This study makes use of Engle-Granger procedure based on the Equation 1.

$Y_t = \alpha_0 + \Phi X_t + U_t$ ............................................................................................................1

Where $\Phi$ is the co integrating coefficient, which must be tested prior to testing for a unit root in the error correction model.

$H_0$: No Co integration..........Non-Stationarity

$H_1$: Co integration..............Stationarity

Test on stationarity is done on residuals. In this case, we first get the static equations of the variables in levels then we generate the residuals. If the residuals are stationary, then the two series are co integrated. The Engle-Granger co integration test results are at the

Appendix 3. From the results ADF t-statistic is less than ADF t-critical value at 5% level of significance and therefore we reject the null hypothesis of no co integration. Based on the results we can conclude that there is co integration between the variables .The These results suggest that an Error Correction Model (ECM) will provide a better fit than one without the Error Correction Variable (Green, 2003).

#### 4.2.4 Diagnostic Tests

Diagnostic Tests are necessary to indicate whether the models are consistent or not. The following diagnostic tests are carried out in the analysis.

##### 4.2.4.1 Jarque-Bera (JB) Residual Normality Test

This test is done to test for normality of the residuals. It focuses on the distribution of the first four moments (mean, standard deviation, skewness and kurtosis in addition to the minimum and the maximum values) of the series. The difference is distributed as chi-square distribution. This is then compared to the standard normal distribution. Since the error terms explain the dependent variables, the normality tests are carried out on the dependent variables, which in this study is Y.

**Table 5: Jarque Bera Test for Normality on the Residual (ResY)**

| | RESY |
|---|---|
| Mean | 3.60E-12 |
| Median | -204.0961 |
| Maximum | 2558.216 |
| Minimum | -2982.966 |
| Std. Dev. | 1603.850 |
| Skewness | 0.010874 |
| Kurtosis | 2.638965 |
| **Jarque-Bera** | **0.559959** |
| **Probability** | **0.170466** |
| Observations | 11 |

**Source: E-Views Computation**

The results in table 11 indicate that the probability values of the residual is less than the Jarque Bera chi-square statitistics and therefore the residual is normally distributed at 5% significant level (Jarque, 1980). The conclusion is that the Error Term is normally distributed and hence the regression obeys the OLS assumption of consistency and efficiency.

#### 4.2.4.2 The Autocorrelation Test

This is a test for serial correlation of the residual because the Durbin Watson TEST is not efficient when higher lagged order of the dependent variable are included as explanatory variables. This study shows that there is no serial correlation. The test uses correllogram method to test for serial correlation/autocorrelation of the residuals. The results of autocorrelation test are shown in 12. Since the stars are within the dotted bands, there is no autocorrelation in the residuals. If any of the stars would have been out of the dotted band then there would have been a serious autocorrelation in the residuals.

**Table 6: Autocorrelation Test on the Residual**

Date: 05/29/07 Time: 16:40
Sample: 1996 2006
Included observations: 11

| Autocorrelation | Partial Correlation | | AC | PAC | Q-Stat | Prob |
|---|---|---|---|---|---|---|
| . *\| . \| | . *\| . \| | 1 | -0.156 | -0.156 | 0.3479 | 0.555 |
| .***\| . \| | .***\| . \| | 2 | -0.391 | -0.425 | 2.7729 | 0.250 |
| . \|** . \| | . \|* . \| | 3 | 0.291 | 0.173 | 4.2873 | 0.232 |
| . *\| . \| | .***\| . \| | 4 | -0.185 | -0.343 | 4.9853 | 0.289 |
| . \| . \| | . \|* . \| | 5 | -0.014 | 0.167 | 4.9902 | 0.417 |
| . \| . \| | .***\| . \| | 6 | 0.017 | -0.370 | 4.9984 | 0.544 |
| . **\| . \| | . *\| . \| | 7 | -0.236 | -0.063 | 6.9819 | 0.431 |
| . \|* . \| | . **\| . \| | 8 | 0.098 | -0.292 | 7.4397 | 0.490 |
| . \|* . \| | . \|* . \| | 9 | 0.108 | 0.083 | 8.2739 | 0.507 |

**Source: E-Views Computation**

#### 4.2.4.3 The Whites Heteroscedasticity Test

This is a test for heteroskedasticity in the residuals from a least squares regression (Green, 2003). Ordinary least squares estimates are consistent in the presence heteroskedasticity, but the conventional computed standard errors are no longer valid. White's test is a test of the null hypothesis of no heteroskedasticity against heteroskedasticity.The probability value of the F-statistic is then used in the analysis. If the probability value is less than 0.05, reject the null hypothesis. The results on the heteroscedasticity test are in table 13. Since all the p-values of both the residuals are greater than 0.05, Heteroskedasticity is not a serious problem.

**Table 7: Whites Heterscedasticity Test for the Residual**

White Heteroskedasticity Test:

| | | | |
|---|---|---|---|
| F-statistic | 0.102129 | Probability | 0.985967 |
| Obs*R-squared | 4.496517 | Probability | 0.809781 |

Test Equation:
Dependent Variable: RESID^2
Method: Least Squares
Date: 05/29/07 Time: 16:48
Sample: 1996 2006
Included observations: 11

**Source: E-Views Computation**

### 4.3 REGRESSION RESULTS

The data analysis is done using the Autoregressive Distributed Lag (ADL) model. Both the dependent and additional predictors (variables) have been lagged in this a model to produce the error correction term (ECT). The study makes the use of ADL (1, 1) model in that the dependent variable and the independent variables have been lagged once (Green, 2003)

**Table 8: Modeling of number of hectares under maize per annum.**

Dependent Variable: DY
Method: Least Squares
Date: 05/29/07 Time: 17:00
Sample(adjusted): 1998 2006
Included observations: 9 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| C | 1890.187 | 39.83444 | 47.45107 | 0.0134 |
| DX1 | -0.943885 | 0.041559 | -46.77390 | 0.0136 |
| DX2 | 2.649346 | 0.335623 | -13.85289 | 0.0459 |
| DX3 | 4.626031 | 0.186565 | 24.79583 | 0.0257 |
| DX4 | 0.014380 | 0.000291 | 49.37833 | 0.0129 |
| ECT | -1.420295 | 0.013460 | -105.5212 | 0.0060 |
| R-squared | 0.799960 | Mean dependent var | | 744.3333 |
| Adjusted R-squared | 0.699677 | S.D. dependent var | | 3186.582 |
| S.E. of regression | 57.26928 | Akaike info criterion | | 10.51396 |
| Sum squared resid | 3279.771 | Schwarz criterion | | 10.68927 |
| Log likelihood | -39.31282 | F-statistic | | 3538.191 |
| Durbin-Watson stat | 1.991924 | Prob(F-statistic) | | 0.012944 |

**Source: E-Views Computation**

The number of hectares under maize per annum(Y) was modeled using the ECM. The variables were differenced and lagged to eliminate the non-stationarity problem. The residual (RESY) was generated and found to be stationary and hence cointegrated.The results show that most of the coefficients had the expected signs with the apriori expectations. The Durbin Watson statistics is 1.991924, which is closer to two signifying that there is no serial correlation among the residuals. The p-value of the constant and the original variables are all significant. The p-value is said to be significant if it is less or equal to 0.05 at 5% level of significance, otherwise not significant.

From the results, the Input Cost per ha (X1 ) has a negative relationship with the number of hectares under maize per annum.As the input cost per ha increases by 1 unit (KES 1), the number of hectares under maize per annum decreases by 0.943885 units (0.943885 Ha). This variable is also significant because the p-value which is 0.0136 is less than 0.05 at 5% level of significance.

The previous year's average farm gate maize price per 90kg bag (X2) is positively related with the number of hectares under maize per annum which is the dependent variable. As the previous year's average farm gate maize prices per 90kg bag increases by 1 unit (KES 1), the number of hectares under maize per annum increases by 2.649346 units (2.649346 Ha). This variable X2 is also significant since the value of the probability is 0.0459 which is less than 0.05 at 5% level of significance.

The previous year's last quarter average farm gate maize prices per 90kg bag(X3) is also positively related with number of hectares under maize per annum.As the previous year's last quarter average farm gate maize prices per 90kg bag increases by 1 unit (KES 1), the number of hectares under maize per annum increases by 4.626031 units (4.626031 Ha). This variable X3 is also significant since the value of the probability is 0.0257 which is less than 0.05 at 5% level of significance.

The Previous year's yield per ha (X4) has a positive relationship with number of hectares under maize per annum. As the Previous year's yield per ha increases by 1 unit (1 90kg bag of maize), the number of hectares under maize per annum increases by 0.014380 units (0.014380 Ha). The Previous year's yield per ha is also significant since the value of the probability is 0.0129 which is less than 0.05 at 5% level of significance.

The ECT (Error Correction Term) which is used to model long term relationships in the variables is also significant which is an indication that an Error Correction Model (ECM) will provide a better fit than one without the Error Correction Variable.

The $R^2$ is 0.799960 showing that the explanatory variables have a higher explanatory power of the number of hectares under maize per annum. The results can be interpreted to mean that the changes in level of the number of hectares under maize per annum depend on the explanatory variables given. It means that the explanatory variables explain about 80% of the changes in the number of hectares under maize per annum. The probability of F-statistics is 0.012944, which is clearly below .05 meaning that on average all the coefficients of the variables of the regression analysis are jointly significant at 5 % level of significance and explains the variations in the number of hectares under maize per annum. The $R^2$ is less than the Durbin Watson statistic signifying that there is no spurious regression. However if it could have been more than Durbin Watson statistic it would have signified the presence of spurious regression.

On the correlation coefficient between Y and X2 on one hand , and Y and X3 on the other hand, indicates that the coefficient of X3 is larger(4.626031) than that one on X2(2.649346).

## 4.4 DISCUSSION OF THE RESULTS

The key variables analyzed in this study are: the Input Cost per ha(X1),Previous year's average farm gate maize prices per 90kg bag(X2) , Previous year's last quarter average farm gate maize prices per 90kg bag (X3) and Previous year's yield per(X4) . The focus of the study was to analyze the importance of these variables in explaining the number of hectares under maize per annum.The coefficients was interpreted in their levels. The results indicate that an Inverse (negative) relationship between Y and X1. This could be attributed to the fact that When cost of input per ha increases, resources to invest become more scarce hence less production anticipated meaning less land allocated to maize production. Direct (positive) relationship between Y on one hand and X2, X3, X4 on the other hand. This could attributed to the fact that an Increase in expected price of output and expected yield increase would (holding other factors constant) lead to more investment in terms of area under maize. Since the On the correlation coefficient of X3 is larger than that one on X2 it indicates that It is assumed that farmers only take into account the price of the immediate past year (farmers are assumed to have very short memories) in determining price expectations for the current year .

# 5.0 CHAPTER FIVE: CONCLUSION, POLICY RECOMMENDATIONS AND AREAS OF FURTHER RESEARCH

## 5.1 Conclusions

The focus of the study was to analyze maize price instability in Bungoma District with the view of evaluating the effectiveness of price stabilization policies overtime and to find out the factors causing farm income instability on maize farms in the District. The period of study was 1996 to 2006. The results indicate that Input Cost per ha has a negative and a significant relationship with the number of hectares under maize per annum. As the input cost per ha increases, the number of hectares under maize per annum decreases. This could be attributed to the fact that when cost of input per ha increases, resources to invest become more scarce hence less production anticipated meaning less land allocated to maize production.

The previous year's average farm gate maize price per 90kg bag is significant and positively related with the number of hectares under maize per annum. As the previous year's average farm gate maize prices per 90kg bag increases, the number of hectares under maize per annum increases. The previous year's last quarter average farm gate maize prices per 90kg bag are also significant and positively related to the number of hectares under maize per annum. As the previous year's last quarter average farm gate maize prices per 90kg bag increases, the number of hectares under maize per annum increases too. The Previous year's yield per ha has a positive and a significant relationship with number of hectares under maize per annum. As the Previous year's yield per ha increases, the number of hectares under maize per annum increases.

The previous year's average farm gate maize price per 90kg bag, previous year's last quarter average farm gate maize prices per 90kg bag and Previous year's yield per ha are therefore positively related to the number of hectares under maize per annum.This could attributed to the fact that an Increase in expected price of output and expected yield increase would (holding other factors constant) lead to more investment in terms of area under maize.

The trend analysis indicates that over the years the prices of maize have varied. The month of June seems to be witnessing high prices over the years from 1996 to 2006 than any other month followed by December and then finally January. The year 2002 witnessed low maize prices in the month of December and January. The maize prices therefore tend to fluctuate over the years from 1996 to 2006. In Gross Margin analysis, prices as per Ministry of Agriculture crop valuation remains around kshs 1000 per 90kg bag while the breakeven price average stays above Kshs 1000 per 90 Kg bag of maize.

## 5.2 Policy Implications

The study has established the significance of the previous year's average farm gate maize price per 90kg bag, previous year's last quarter average farm gate maize prices per 90kg bag, Previous year's yield per ha and the Input Cost per ha in determining the number of hectares under maize per annum and therefore the overall yield per hectare in Bungoma District. This has great policy ramifications, which must be addressed by the agricultural policy makers with a view of improving the total yield of Maize in the District. The study recognizes the fact that the variables indicated in the study might not be the only variables affecting the number of hectares under maize per annum. Other factors in the background could be cultural beliefs, inadequate land, and poor farming techniques among others. The Price Trend Analysis is of great use to Policy Makers on timing of purchase of maize for strategic food reserve besides offering more competitive prices to farmers.

In order to improve the number of hectares under cultivation, the agricultural policy makers should look into the cost of inputs such as fertilizers, seed, fuel and others with a view of lowering them so that farmers can increase the number acreage under maize cultivation. This will encourage the farmers to have the morale in farming maize and therefore reduce the food insecurity. The question of Bungoma District and Kenya at large being high cost maize production region need not to be overemphasized: the talk long run of full economic integration by the East African Community and to some extend the African Union, gives more reason for much needed effort to cut down maize farmers' costs within the Kenyan economy in preparation for further anticipated competition.

The upgrading of Sikata–Kimilili road should be speeded. More access roads to interconnecting the interior rural in the ten divisions in Bungoma District need to be upgraded to tarmac level. More funds through the constituency roads Development Fund need to be set aside for this purpose. Good roads have potential lower the transport per unit transport cost. This incentive can encourage maize farmers to use transport to access markets that would offer competitive prices for their output.

The Ministry of Agriculture should be allocated more funds for collaboration with Non Governmental Organizations such as SACRED Africa among others. This will enhance the level of market information and organization among maize farmers. An organized and informed farmer has a better level of bargain both for his inputs and outputs.

In 2007/2008 financial year, just over 4% of National budget was allocated to agriculture which employs over 70% of the total labor force and contributes about 20% of the Gross Domestic Product.

The Constituency Development Fund committees in the five constituencies in Bungoma District should each set aside a revolving fund to give affordable credit to farmers to assist finance input costs, support storage, transportation and marketing activities of the maize commodity.

Collaboration between the Ministry of Agriculture and the Ministry of Culture and Social services should be strengthened with a view of creating a business culture among the farming community. This will help farmers work towards an optimal combination of inputs that would maximize their gain from the maize farming business.

**5.3 Limitations of the Study and Areas of Further Research**

Despite the efforts on ensuring the study is complete, it must be conceded that the study has some limitations. Since data collection and measurement may not have been accurate, it is likely that measurement errors were obtained in the national account data used in this study. The major reliable situation as a major limitation is availability of data. It is difficult for the study to make recommendations on this issue because Central Bureau of Statistics renews the data entry system but they never incorporate the earlier periods. The availability and the quality of data are the main constraints of the study. This is because secondary data was used.

The areas of further research should be on health status and test its effect on maize farming activities. Other factors such as nutrition, per capita income and the size of the population should be incorporated in order to find out how they affect the maize farming.

The proposed split of Bungoma District into four districts opens up new window of research. More districts it is argued would take government services closer to the people. Research is needed on the impact of such split to farmers' access to better services, more resources and more information from the Districts' Ministry of Agricultural offices that could contribute to competitiveness of the maize or agricultural sector.

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APPENDICES

## APPENDIX 1: UNIT ROOT TESTS FOR VARIABLES IN THEIR LEVELS

### (i). $X_1$ , the Input Cost per ha

| | | | |
|---|---|---|---|
| ADF Test Statistic | -2.356121 | 1% Critical Value* | -5.2735 |
| | | 5% Critical Value | -3.9948 |
| | | 10% Critical Value | -3.4455 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(X1)
Method: Least Squares
Date: 05/29/07 Time: 15:42
Sample(adjusted): 1997 2006
Included observations: 10 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| X1(-1) | -0.492563 | 0.209057 | -2.356121 | 0.0506 |
| C | 15405.23 | 5722.374 | 2.692105 | 0.0310 |
| @TREND(1996) | 336.0587 | 223.4036 | 1.504267 | 0.1762 |

| | | | |
|---|---|---|---|
| R-squared | 0.549732 | Mean dependent var | 1160.062 |
| Adjusted R-squared | 0.421085 | S.D. dependent var | 1030.644 |
| S.E. of regression | 784.1808 | Akaike info criterion | 16.41048 |
| Sum squared resid | 4304577. | Schwarz criterion | 16.50126 |
| Log likelihood | -79.05241 | F-statistic | 4.273156 |
| Durbin-Watson stat | 1.927581 | Prob(F-statistic) | 0.061256 |

**(ii) $X_2$, the previous year's average farm gate maize prices per 90kg bag**

| | | | |
|---|---|---|---|
| ADF Test Statistic | -3.612319 | 1% Critical Value* | -5.2735 |
| | | 5% Critical Value | -3.9948 |
| | | 10% Critical Value | -3.4455 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(X2)
Method: Least Squares
Date: 05/29/07 Time: 15:45
Sample(adjusted): 1997 2006
Included observations: 10 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| X2(-1) | -1.296993 | 0.359047 | -3.612319 | 0.0086 |
| C | 1242.946 | 370.3012 | 3.356580 | 0.0121 |
| @TREND(1996) | 0.230460 | 24.63115 | 0.009356 | 0.9928 |

| | | | |
|---|---|---|---|
| R-squared | 0.651087 | Mean dependent var | 8.676190 |
| Adjusted R-squared | 0.551398 | S.D. dependent var | 333.8254 |
| S.E. of regression | 223.5888 | Akaike info criterion | 13.90082 |
| Sum squared resid | 349943.6 | Schwarz criterion | 13.99159 |
| Log likelihood | -66.50410 | F-statistic | 6.531161 |
| Durbin-Watson stat | 2.198943 | Prob(F-statistic) | 0.025090 |

**(iii). $X_3$, the previous year's last quarter average farm gate maize prices per 90kg bag**

| | | | |
|---|---|---|---|
| ADF Test Statistic | -3.141044 | 1% Critical Value* | -5.2735 |
| | | 5% Critical Value | -3.9948 |
| | | 10% Critical Value | -3.4455 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(X2)
Method: Least Squares
Date: 05/29/07 Time: 16:04
Sample(adjusted): 1997 2006
Included observations: 10 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| X2(-1) | -1.035956 | 0.329813 | -3.141044 | 0.0164 |
| C | 1092.507 | 328.9344 | 3.321354 | 0.0127 |
| @TREND(1996) | 14.74695 | 23.05791 | 0.639561 | 0.5428 |

| | | | |
|---|---|---|---|
| R-squared | 0.600244 | Mean dependent var | 50.21766 |
| Adjusted R-squared | 0.486028 | S.D. dependent var | 263.1995 |
| S.E. of regression | 188.6926 | Akaike info criterion | 13.56144 |
| Sum squared resid | 249234.3 | Schwarz criterion | 13.65222 |
| Log likelihood | -64.80720 | F-statistic | 5.255341 |
| Durbin-Watson stat | 1.507258 | Prob(F-statistic) | 0.040391 |

### (iv). $X_4$, the Previous year's yield per ha

| | | | |
|---|---|---|---|
| ADF Test Statistic | -3.044669 | 1% Critical Value* | -5.2735 |
| | | 5% Critical Value | -3.9948 |
| | | 10% Critical Value | -3.4455 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(X4)
Method: Least Squares
Date: 05/29/07 Time: 16:06
Sample(adjusted): 1997 2006
Included observations: 10 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| X4(-1) | -1.050064 | 0.344886 | -3.044669 | 0.0187 |
| C | 1733551. | 549600.2 | 3.154204 | 0.0161 |
| @TREND(1996) | 18533.40 | 22397.16 | 0.827489 | 0.4353 |

| | | | |
|---|---|---|---|
| R-squared | 0.575683 | Mean dependent var | 51690.00 |
| Adjusted R-squared | 0.454449 | S.D. dependent var | 250682.6 |
| S.E. of regression | 185157.6 | Akaike info criterion | 27.33913 |
| Sum squared resid | 2.40E+11 | Schwarz criterion | 27.42990 |
| Log likelihood | -133.6956 | F-statistic | 4.748549 |
| Durbin-Watson stat | 1.920224 | Prob(F-statistic) | 0.049764 |

**(v). Y , number of hectares under maize per annum**

| | | | |
|---|---|---|---|
| ADF Test Statistic | -2.951122 | 1% Critical Value* | -5.2735 |
| | | 5% Critical Value | -3.9948 |
| | | 10% Critical Value | -3.4455 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(Y)
Method: Least Squares
Date: 05/29/07 Time: 16:06
Sample(adjusted): 1997 2006
Included observations: 10 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| Y(-1) | -1.006518 | 0.341063 | -2.951122 | 0.0214 |
| C | 54692.85 | 17512.93 | 3.122998 | 0.0168 |
| @TREND(1996) | 1034.154 | 549.9311 | 1.880516 | 0.1021 |

| | | | |
|---|---|---|---|
| R-squared | 0.590904 | Mean dependent var | 1393.000 |
| Adjusted R-squared | 0.474019 | S.D. dependent var | 3637.820 |
| S.E. of regression | 2638.313 | Akaike info criterion | 18.83699 |
| Sum squared resid | 48724871 | Schwarz criterion | 18.92777 |
| Log likelihood | -91.18496 | F-statistic | 5.055439 |
| Durbin-Watson stat | 1.678484 | Prob(F-statistic) | 0.043792 |

## APPENDIX 2: UNIT ROOT TESTS FOR DIFFERENCED VARIABLES

### (i). $X_1$, the Input Cost per ha differenced

| | | | |
|---|---|---|---|
| ADF Test Statistic | -5.078233 | 1% Critical Value* | -5.7492 |
| | | 5% Critical Value | -4.1961 |
| | | 10% Critical Value | -3.5486 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DX1,2)
Method: Least Squares
Date: 05/29/07 Time: 16:14
Sample(adjusted): 1999 2006
Included observations: 8 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(DX1(-1)) | -1.335458 | 0.327460 | -4.078233 | 0.0096 |
| C | -2142.266 | 1193.753 | -1.794564 | 0.1327 |
| @TREND(1996) | 295.1796 | 172.7548 | 1.708662 | 0.1482 |

| | | | |
|---|---|---|---|
| R-squared | 0.778546 | Mean dependent var | -106.0156 |
| Adjusted R-squared | 0.689964 | S.D. dependent var | 1976.160 |
| S.E. of regression | 1100.343 | Akaike info criterion | 17.12463 |
| Sum squared resid | 6053778. | Schwarz criterion | 17.15442 |
| Log likelihood | -65.49851 | F-statistic | 8.789009 |
| Durbin-Watson stat | 3.028886 | Prob(F-statistic) | 0.023079 |

**(ii) $X_2$ ,the previous year's average farm gate maize prices per 90kg bag differenced**

| | | | |
|---|---|---|---|
| ADF Test Statistic | -6.473984 | 1% Critical Value* | -5.7492 |
| | | 5% Critical Value | -4.1961 |
| | | 10% Critical Value | -3.5486 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DX2,2)
Method: Least Squares
Date: 05/29/07 Time: 16:17
Sample(adjusted): 1999 2006
Included observations: 8 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(DX2(-1)) | -1.199526 | 0.345288 | -3.473984 | 0.0178 |
| C | 103.0975 | 402.9763 | 0.255840 | 0.8083 |
| @TREND(1996) | -14.78076 | 57.76132 | -0.255894 | 0.8082 |

| | | | |
|---|---|---|---|
| R-squared | 0.718929 | Mean dependent var | 106.2378 |
| Adjusted R-squared | 0.606501 | S.D. dependent var | 588.3416 |
| S.E. of regression | 369.0636 | Akaike info criterion | 14.93981 |
| Sum squared resid | 681039.8 | Schwarz criterion | 14.96960 |
| Log likelihood | -56.75925 | F-statistic | 6.394564 |
| Durbin-Watson stat | 2.251103 | Prob(F-statistic) | 0.041883 |

**(iii) $X_3$, the previous year's last quarter average farm gate maize prices per 90kg bag differenced**

| | | | |
|---|---|---|---|
| ADF Test Statistic | -7.944267 | 1% Critical Value* | -5.7492 |
| | | 5% Critical Value | -4.1961 |
| | | 10% Critical Value | -3.5486 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DX3,2)
Method: Least Squares
Date: 05/29/07 Time: 16:18
Sample(adjusted): 1999 2006
Included observations: 8 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(DX3(-1)) | -1.737716 | 0.351461 | -4.944267 | 0.0043 |
| C | 153.1047 | 589.8761 | 0.259554 | 0.8056 |
| @TREND(1996) | -24.78395 | 86.09667 | -0.287862 | 0.7850 |

| | | | |
|---|---|---|---|
| R-squared | 0.831154 | Mean dependent var | 119.8036 |
| Adjusted R-squared | 0.763615 | S.D. dependent var | 1136.319 |
| S.E. of regression | 552.4718 | Akaike info criterion | 15.74668 |
| Sum squared resid | 1526126. | Schwarz criterion | 15.77647 |
| Log likelihood | -59.98671 | F-statistic | 12.30635 |
| Durbin-Watson stat | 2.397107 | Prob(F-statistic) | 0.011715 |

### (iv) $X_4$ the Previous year's yield per ha differenced

| | | | |
|---|---|---|---|
| ADF Test Statistic | -7.643764 | 1% Critical Value* | -5.7492 |
| | | 5% Critical Value | -4.1961 |
| | | 10% Critical Value | -3.5486 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DX4,2)
Method: Least Squares
Date: 05/29/07 Time: 16:20
Sample(adjusted): 1999 2006
Included observations: 8 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(DX4(-1)) | -1.946812 | 0.254693 | -7.643764 | 0.0006 |
| C | -272531.8 | 317073.4 | -0.859523 | 0.4293 |
| @TREND(1996) | 39430.53 | 46305.14 | 0.851537 | 0.4334 |

| | | | |
|---|---|---|---|
| R-squared | 0.924236 | Mean dependent var | -25530.88 |
| Adjusted R-squared | 0.893931 | S.D. dependent var | 875832.7 |
| S.E. of regression | 285243.6 | Akaike info criterion | 28.24007 |
| Sum squared resid | 4.07E+11 | Schwarz criterion | 28.26986 |
| Log likelihood | -109.9603 | F-statistic | 30.49731 |
| Durbin-Watson stat | 2.240934 | Prob(F-statistic) | 0.001580 |

**(v).Y, number of hectares under maize per annum differenced**

| | | | |
|---|---|---|---|
| ADF Test Statistic | -8.382216 | 1% Critical Value* | -5.7492 |
| | | 5% Critical Value | -4.1961 |
| | | 10% Critical Value | -3.5486 |

*MacKinnon critical values for rejection of hypothesis of a unit root.

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(DY,2)
Method: Least Squares
Date: 05/29/07 Time: 16:21
Sample(adjusted): 1999 2006
Included observations: 8 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| D(DY(-1)) | -1.238839 | 0.366280 | -3.382216 | 0.0196 |
| C | 2024.830 | 5698.720 | 0.355313 | 0.7369 |
| @TREND(1996) | -380.2778 | 819.6557 | -0.463948 | 0.6622 |

| | | | |
|---|---|---|---|
| R-squared | 0.707664 | Mean dependent var | 911.8750 |
| Adjusted R-squared | 0.590729 | S.D. dependent var | 8259.549 |
| S.E. of regression | 5283.987 | Akaike info criterion | 20.26275 |
| Sum squared resid | 1.40E+08 | Schwarz criterion | 20.29254 |
| Log likelihood | -78.05098 | F-statistic | 6.051794 |
| Durbin-Watson stat | 2.250230 | Prob(F-statistic) | 0.046207 |

## APPENDIX 3: CO INTEGRATION TEST USING UNIT ROOT TEST

| | | | |
|---|---|---|---|
| ADF Test Statistic | -8.433834 | 1% Critical Value* | -5.2735 |
| | | 5% Critical Value | -3.9948 |
| | | 10% Critical Value | -3.4455 |

*MacKinnon critical values for rejection of hypothesis of a unit root

Augmented Dickey-Fuller Test Equation
Dependent Variable: D(RESY)
Method: Least Squares
Date: 05/29/07 Time: 16:28
Sample(adjusted): 1997 2006
Included observations: 10 after adjusting endpoints

| Variable | Coefficient | Std. Error | t-Statistic | Prob. |
|---|---|---|---|---|
| RESY(-1) | -1.233544 | 0.359232 | -3.433834 | 0.0109 |
| C | -1072.659 | 1215.035 | -0.882822 | 0.4066 |
| @TREND(1996) | 178.9851 | 197.9140 | 0.904358 | 0.3959 |

| | | | |
|---|---|---|---|
| R-squared | 0.627671 | Mean dependent var | -185.3752 |
| Adjusted R-squared | 0.521291 | S.D. dependent var | 2524.774 |
| S.E. of regression | 1746.861 | Akaike info criterion | 18.01235 |
| Sum squared resid | 21360662 | Schwarz criterion | 18.10313 |
| Log likelihood | -87.06177 | F-statistic | 5.900280 |
| Durbin-Watson stat | 2.314952 | Prob(F-statistic) | 0.031495 |

## APPENDIX 4:TABLE SHOWING GROSS MARGIN ANALYSIS PER HECTARE PER ANNUM

| YEAR | 1996 (KShs) | 1997 (KShs) | 1998 (KShs) | 1999 (KShs) | 2000 (KShs) | 2001 (KShs) | 2002 (KShs) | 2003 (KShs) | 2004 (KShs) | 2005 (KShs) | 2006 (KShs | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Ploughing | 2,625 | 2,750 | 2,750 | 2,750 | 2,875 | 2,875 | 3,000 | 3,000 | 3,000 | 3,000 | 3,750 | |
| Harrowing | 1,750 | 2,000 | 2,000 | 2,000 | 2,125 | 2,125 | 2,250 | 2,250 | 2,250 | 2,250 | 2,875 | |
| Seed | 1,675 | 1,725 | 2,275 | 2,275 | 2,875 | 3,300 | 3,300 | 3,125 | 3,125 | 3,313 | 3,313 | |
| Fertilizer: DAP | 2,625 | 3,250 | 3,375 | 4,375 | 3,500 | 3,500 | 3,500 | 3,750 | 3,875 | 4,375 | 4,325 | |
| Fertilizer: CAN | 2,375 | 2,750 | 2,750 | 2,500 | 2,250 | 2,875 | 3,125 | 3,125 | 3,250 | 3,625 | 3,625 | |
| Planting and Weeding | 4,500 | 4,500 | 4,750 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | |
| Harvesting | 3,500 | 3,750 | 4,250 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | |
| Rent | 3,750 | 3,750 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | 5,000 | |
| Working capital (15% interest) | 3,420 | 3,671 | 4,073 | 4,335 | 4,294 | 4,451 | 4,526 | 4,538 | 4,575 | 4,734 | 4,933 | |
| Total Input Cost | 26,220 | 28,146 | 31,223 | 33,235 | 32,919 | 34,126 | 34,701 | 34,788 | 35,075 | 36,297 | 37,821 | |
| Yield in 90Kg Bags | 28 | 30 | 31 | 31 | 30 | 30 | 24 | 30 | 25 | 31 | 30 | |
| Price per 90Kg Bag | 913 | 1,390 | 1,000 | 1,000 | 1,000 | 1,000 | 1,013 | 1,000 | 1,421 | 1,009 | 1,120 | (As per MOA Valuation) |
| Gross Output | 25,556 | 41,700 | 30,998 | 31,000 | 30,000 | 30,000 | 24,302 | 29,995 | 35,522 | 31,273 | 33,600 | |
| GROSS MARGIN | (664) | 13,554 | (225) | (2,235) | (2,919) | (4,126) | (10,399) | (4,793) | 447 | (5,024) | (4,221) | |

Source : Bungoma District Ministry of Agriculture Annual Reports (1996-2006)

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## APPENDIX 5: MEAN MONTHLY WHOLESALE PRICES FOR BUNGOMA MARKET

MAIZE PRICE - Ksh / 90kg bag

| | 1996 | 1997 | 1998 | 1999 | 2000 | 2001 | 2002 | 2003 | 2004 | 2005 | 2006 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| JANUARY | 500.00 | 980.00 | 1040.00 | 880.00 | 1100.00 | 1240.00 | 592.00 | 912.00 | 1123.00 | 1394.29 | 1189.167 |
| FEBRUARY | 520.00 | 980.00 | 1280.00 | 880.00 | 1100.00 | 1240.00 | 612.00 | 1026.00 | 1297.00 | 1413.33 | 1212.5 |
| MARCH | 550.00 | 1000.00 | 1120.00 | 920.00 | 1200.00 | 1227.00 | 666.00 | 1097.00 | 1466.00 | 1480.00 | 1150 |
| APRIL | 550.00 | 1360.00 | 1150.00 | 1000.00 | 1300.00 | 1239.00 | 575.00 | 1167.00 | 1531.00 | 1477.50 | 1333.333 |
| MAY | 600.00 | 1500.00 | 1200.00 | 1280.00 | 1350.00 | 1221.00 | 746.00 | 1330.00 | 1562.00 | 1546.67 | 1570 |
| JUNE | 600.00 | 1700.00 | 1300.00 | 1400.00 | 1495.00 | 1136.00 | 869.00 | 1521.00 | 1531.00 | 1615.00 | 1750 |
| JULY | 900.00 | 1600.00 | 1100.00 | 1200.00 | 1600.00 | 987.00 | 997.00 | 1801.00 | 1552.00 | 1542.00 | 1502.5 |
| AUGUST | 880.00 | 1500.00 | 1000.00 | 1100.00 | 1200.00 | 653.00 | 801.00 | 1619.00 | 1412.00 | 1042.86 | 1038.333 |
| SEPTEMBER | 880.00 | 1200.00 | 900.00 | 1000.00 | 1040.00 | 544.00 | 718.00 | 1000.00 | 1189.00 | 816.00 | 1000 |
| OCTOBER | 840.00 | 1050.00 | 840.00 | 1200.00 | 1070.00 | 524.00 | 955.00 | 925.00 | 1185.00 | 760.00 | 954.2857 |
| NOVEMBER | 910.00 | 1000.00 | 840.00 | 1200.00 | 1120.00 | 545.00 | 920.00 | 1051.00 | 1270.00 | 780.00 | 1000 |
| DECEMBER | 920.00 | 990.00 | 800.00 | 1120.00 | 1110.00 | 545.00 | 1000.00 | 959.00 | 1320.00 | 840.00 | 976 |

**Source : 1996-1999 (Oral Interview from maize traders)**
**2000-2006 - Kenya Agricultural Commodity Exchange LTD**

| | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| **YEARLY AVERAGE** | 720.83 | 1238.33 | 1047.50 | 1098.33 | 1223.75 | 925.08 | 787.58 | 1200.67 | 1369.83 | 1225.64 | 1223.01 |
| **LAST QUARTER OF THE YEAR AVERAGE** | 890.00 | 1013.33 | 826.67 | 1173.33 | 1100.00 | 538.00 | 958.33 | 978.33 | 1258.33 | 793.33 | 976.76 |