THE INTERNATIONAL JOURNAL OF BUSINESS & MANAGEMENT

An Analytical Study of the Factors Influencing Maize Production in Rwanda: A Case Study of Gatsibo District

Gaspard Ntabakirabose
Student, Department of Agricultural Science, School of Agriculture and Applied Economics,
Jomo Kenyatta University of Agriculture and Technology, Kigali Campus, Kenya
Mbabazi Mbabazize
Lecturer, Department of Agricultural Science, School of Agriculture and Applied Economics,
Jomo Kenyatta University of Agriculture and Technology, Kigali Campus, Kenya
Jaya Shukla
Lecturer, Department of Agricultural Science, School of Agriculture and Applied Economics,
Jomo Kenyatta University of Agriculture and Technology, Kigali Campus, Kenya

Abstract:
In many countries, including Rwanda, non-farm chemical inputs play a large role in agricultural production for increasing output. Pingali(2001) stated that the declining trends on quantities of maize produced has been evident at the global and regional level. This research study has been conducted in agro-ecological zone according to the importance of maize production in a given zone. The broad objective of the study was to conduct the analysis of factors influencing maize production among farmers in Gatsibo district. A sample size of 70 respondents to be employed for the identified target population was scientifically computed through the Krejcie and Morgan (1970. A cob-Douglas production function has been used to estimate a relationship between inputs and outputs. The methods of analysis used were descriptive statistics, gross margin analysis and production function analysis using the Ordinary Least Square (OLS) criterion to estimate the parameters of the production function through SPSS and STATA software. The result of the regression analysis indicated that variables include land size, labors, organic fertilizer, chemical fertilizers, improved seeds, education level, farming experience and price of produce have a positive relationship with total output. However R-squared estimated as 0.66 shows that only 66% of variations in output used in the model were explained by the explanatory variables. Based on the gross margin and net return analysis, the most profitable maize variety in the study area was DH04 followed by ZM607which gave maximum yields of 4t/ha and 3.5t/ha respectively. This is supported by the gross margin of N270960/ha and the Net profit of N225960/ha both in last cropping season. Results showed that farm operation was in stage I of the production function with RTS estimated as 1(MPP = APP) at the end of I stage. The profitability was positively influenced by improved maize variety (DH04 and ZM607), use of both chemical and organic fertilizer in combination and market price of 180Rwf/kg that are all of them significant (at 1% and 5% respectively). The local seeds, none use of any fertilizer and lower price were the main factors influencing negatively the profitability of maize output. The study indicated that the best method of fertilizer use to maximize maize output per unit area is the combination of both chemical and organic fertilizer that has positive relationship and significance at (1% level) with output. The findings from study showed that the production of maize varies with the changes of prices. This also is supported by the law of demand and total revenue, which state that when the 0<Ep<1 and the price increase, so that a lot of revenue could be gained and respectively the total revenue also increase because of somewhat inelastic.

Keywords: *Factors influencing, maize variety, market price and profitability*

1. Introduction

1.1. General Background of the Study

Rwanda is one of the Eastern African Countries that covers an area of 26338 square kilometers. Neighboring countries are Uganda to the North, Tanzania to the East, Burundi to the South, and RDC to the West. According to NIST 2012 GDP per capital was $644 and

GDP by sector is for agriculture: 33%, industry: 16%, and services: 45%. Population below poverty line is 55 %(2010) and labor force by occupation is 90% agriculture and 10% for services and industry.

Rwanda is a rural country with about 90% of the population engaged in mainly subsistence agriculture. It is the most densely populated country in Africa; is landlocked; and has few natural resources and minimal industry. Primary exports are coffee and tea. Farm size, on average, is smaller than one hectare, while population density is more than 450 persons per square kilometer of land. The Rwandan economy is based on the largely rain-fed agricultural production of small, semi-subsistence, and increasingly fragmented farms. It has few natural resources to exploit and a small, noncompetitive industrial sector stated by MINECOFIN (2013).

Most poor people live in rural areas, where subsistence agriculture is their main economic activity. The agricultural sector plays a very important role in the socio-economic development of Rwanda because most of the population, who live in rural areas, is heavily dependent on agriculture for their livelihood stated by NISR (2010). Maize (***Zea mays***) is one of the major important staple crops in Rwanda where it ranked the fifth among food crops and second among cereals after sorghum. Maize occupied about 32% of the land allocated to cereal production in 2000. Maize is currently grown in all 5province of Rwanda and is essentially intercropped with beans. Regarding to cultivated area and production maize ranks third (14%) in Rwanda production following bean (21.2%) and banana (19.6%) showed by MINAGRI (2009). Consumption of maize is increasingly becoming an important cash crop for small-scale farmers especially in the maize growing regions. Almost all agro-climatic zones of the country have great suitability in the production of maize. This study will be carried out on the analysis of the influence of multivariate factors on maize production among farmers in Gatsibo district. The multivariate factors are those which facilitate to increase maize production such as improved maize varieties, fertilizers and factors of production namely land, labor, capital and entrepreneurship.

The study will be conducted in region due to the fact that this area was chosen among others by MINAGRI as suitable area that face agro-climatic zone conditions for cereal especial maize showed by MINAGRI(2008).Maize is mainly Grown by 62% of farm households for various purposes such as to increase the population's access to food, improve nutrition, and reduce poverty in rural areas, to insure food security for all of the population, increase households' income, and avoid a future increase in poverty due to food. Generally maize plays an important role in the socio-economic life of rural households found by Terpend N. et al., (2008).

By use of recommended inputs such as improved varieties, fertilizers, pesticides and update technologies within East Africa, Tanzania is number one producer followed by Kenya and Uganda in that order. In Kenya, Nakuru district alone produces 200,000 tonnes per annum, which is about 4 times more than the whole of Rwanda produces stated by FAO (2007). Compared with major cereals crops grown in Rwanda such as wheat with 2.1 t/ha and rice with 3/ha, through the influence of multivariate factors maize presents the highest average grain yield of around 4-6 t/ha.

Maize trade flows are determined more by the theory of comparative advantage as countries in the region aim to create a free trade area. Thus, despite being major producer Kenya imports maize from Uganda and Tanzania, which are cheaper producers in the region. However, the limiting factors for the production of this crop includes high costs of inputs, poor access to agricultural credit, low prices from the maize market resulting in lower input use, and therefore, farmers are unable to purchase productivity-enhancing inputs such as improved maize varieties, fertilizers, pesticides and land preparation (FAO, 2010). On the other hand, processing units have difficulty relating to irregular and insufficient supply in maize grain and the majority of them fail to reach 50% of their industrial capacity stated by Terpend N. et al., (2007).

Maize supplies a high quantity of carbohydrates to the population. The crop has become popular especially in urban areas amongst manual laborers and is targeted by MINAGRI to contribute to the nutritional status of the population. Maize provides more than 25% of the carbohydrates and 10% of the calorie intake for approximately 70% Rwandan people in the producing regions (FAO, 1997). Maize has become a key source of revenue as they are not only traded within countries but also exported. The statues change from food to food/cash crop enhances its importance found by USAID (2010). In all districts of eastern province of Rwanda, Maize has the potential to contribute to strengthening nation food security and decreasing rural poverty through the adoption of use of recommended inputs(improved seeds, fertilizers and pesticides) in crop intensification program showed by MINAGRI (2011).

EICV3 (2012) showed that, 84.9 % of Gatsibo population both men and women basically depend on agriculture whom, at least 80% use traditional agriculture practices. Maize crop production is 49.2%; sorghum is 28.3% and Rice 2.2% while the key cash crops are coffee and pepper. Usage of inputs like fertilizers is relatively low at (49.5%EICV3) of farming households. It is important in the diet of Rwandans and in most East African countries. It is believed that Central and West Africa produces and consumes more than 60% of the world's maize production stated by (Fademi and Baiyere, 1993). One of the major problems limiting the expansion of its production in East Africa includes no use of fertilizers, climate change, high post harvest losses and low price at harvesting period.

Kaldor(1934) through the cobweb Theory indicated that based on a time lag between supply and demand decisions. Agricultural markets are a context where the cobweb model might apply, since there is a lag between planting and harvesting.It is thought that agricultural peasant farmers never learn from their past experiences, and past mistakes. They keep on copying each other and seem never to learn from their past mistakes. Apart from the problem of insufficiency, Rwandan maize also has to be sorted and graded to form uniformity and this generally causes up to 25% lost of maize production during harvesting period supported by the study of Olorunda (1996). Maize was identified as a priority crop by the Government of Rwanda and through the Crop Intensification Program, the production of maize is currently holding the detailed attention of the Rwandan Ministry of Agriculture and Animal Resources suggested by MINAGRI (2009). Maize is likely to contribute significantly to food security of Rwandans and to sustainable agricultural and rural development.

MINAGRI (2009) showed that several reasons have led the Ministry of Agriculture to target maize among its priority agricultural sectors: Increasing food production in the country, to transform agriculture from subsistence farming to market oriented modern

farming, Transformation of agriculture into a productive, high value, market oriented sector is one of the pillars of the country's long-term strategy. Hence the need to ascertain the socio-economic factors of maize production is warranted.
Due to the importance of maize production to the Rwanda people, there is the need to accentuate the role of efficient combination of inputs in maize production. Estimating the production function of maize will clearly disclose some technical weaknesses that need to address among maize producers. The main objective of this study in analyzing maize production is to raise the yield at lowest limit of cost. To that range, efficient combination of different inputs is important in profitable maize production. Input use plan is the numerical comparison of the relationship between input and output of an enterprise stated by Gezer et al., (2003). Maize production on a sustainable basis at minimum cost is very important activity to improve farmer's welfare and income status indicated by De, et al., (2001). This study was designed to provide worthily information that can improve maize production and rise up the welfare of maize farmers.
Main way to over come the constraint of low production is to access to improve inputs that has long been inhibiting the farmers from raising the productivity levels. The access was curtailed by the low demand and costs which are further amplified by the difficulties in transportation to rural areas. CIP took a supply push approach whereby the inputs are initially supplied by the government and the farmers are persuaded to use. To augment increase in productivity of these crops, CIP imported improved seeds from the neighboring countries such as Kenya and Tanzania in the region indicated by MINAGRI (2011).
Under CIP, the use of improved seeds by farmers has risen from 3% to 40%. By encouraging farmers to use improved seeds, CIP has substantially increased the local demand and the capacity for seed production. About 83% of fertilizers were used by farmers growing maize, wheat, rice and potato. Through an auction process, the CIP auctions the imported fertilizers to private distributors. Estimates suggest that as a result of these efforts, the national average fertilizer use per year has increased from 8 Kg/Ha to 23 Kg/Ha in 2010 demonstrated by MINAGRI (2011).

1.2. Problem Statement
NISR (2010) indicated that the agricultural sector plays a very important role in the socio-economic development of Rwanda because most of the population, who live in rural areas, is heavily dependent on agriculture for their livelihood. In many countries, including Rwanda, non-farm chemical inputs play a large role in agricultural production, especially because of the need to increase production. It was demonstrated by Pingali (2001) that the declining trends on quantities of maize produced has been evident at the global and regional level with a majority of the world producers of maize recording significant declines in the quantities of maize exported while Million hectare of maize, estimated on the basis of crop area surfaces) is found in Africa and Potential yields are highly variable between 5 and 10 t/ha, and typical farm yields are in the range 1-3 t/ha. In Rwanda, population in rural area 80% depend their live hood on this sector, but the maize yields remains low and maize farmers with their small production are not able to satisfy the market demand in terms of quantity compared to neighboring countries demonstrated by World Bank (2007). It was demonstrated by Devereux and Maxwell (2000) that the main problem in this situation farmers are always price taker of their crops produce. This deserves attention as crop prices are a major factor governing incomes and cropping decisions. Farmers compare what they receive and what they produce and sell at the firms.
Reported by MINAGRI (2007), generally main agricultural challenges in Rwanda are land scarcity, climatic hazards (flooding, drought in some area of country causing soil erosion), predominance of subsistence farming, weak connection to the market (limited market participation by producers) followed by lack of access to financial services, and low level of productivity mainly due to poor utilization of intensification input (1.5% for improved seeds, 8kg of fertilizers/ ha/ year compared to 150-180 kg/ha in developed countries). Estimates suggest that as a result of these efforts, the national average fertilizer use per year has increased from 8 Kg/Ha to 23 Kg/Ha in 2010(MINAGRI 2011). Maize is likely to contribute significantly to food security of Rwandans and to sustainable agricultural and rural development. This study attempted to show to the profitability of using improved inputs through the best farm management by considering factors of production. Buffer stock managers are likely to establish a price ceiling, above which intervention selling will occur, and a price floor, below which intervention buying will take place for stabilizing price in Gatsibo, Rwanda.

1.3. Objectives

1.3.1. General Objective
The broad objective of this study is to conduct the analysis of the factors influencing increased maize production among farmers in Gatsibo district.

1.3.2. The Specific Objectives
The specific objectives of this study include the following:
1. To evaluate the profitability of the improved maize varieties on maize production in Gatsibo;
2. To identify the best method of fertilizers use to maximize maize output per unit area in Gatsibo;
3. To find out the effect of market price and place on increased maize production in Gatsibo;

1.4. Research Questions
1. What is the profit level that accrues from the use of improved maize varieties in Gatsibo?
2. What is the best method of fertilizers use to maximize maize production in Gatsibo?

3. What is the effect of market price and market place on maize production in Gatsibo?

1.5. Justification of the Study

Maize is one in five priority crops that have been chosen by the Government of Rwanda in its effort to increase household incomes and the nutritional status of the Rwandan people through increased production and marketing stated by MINAGRI (2007). This depends up on the fertile soil of Gatsibo district and good understanding of the region farmers on crop intensification program. By conducting this research on the analysis of factors influencing maize production among farmers in Gatsibo district. However, the use of improved maize varieties, fertilizers and have a good price for their produce shows that farmers should optimize economic returns and minimize constraints associated with no use of fertilizers. This study tried to evaluate the profitability of improved maize varieties, best methods of fertilizer use to maximize output and finally to identify the effect of market price on maize production. This gave some advice to the agricultural Extensionists, Agricultural policy makers and many researchers to improve their program's effectiveness indicated by MINAGRI (2011). With this research the administrators will make more informed decisions on how to promote good agricultural practices in order to increase maize production in Rwanda especially in Gatsibo district. Generally this research will be very important to the studied area and well beyond the confines of the study area where for example farmers for maize crop will be more experienced in agricultural best practice like use of improved seeds, fertilizers, weeding and pests and diseases control.

1.6. Scope of the Study

The scope of this study was to analyze the factors influencing maize production in Rwanda a case study of Gatsibo district. The studied area is known as suitable agro-climatic zone among farmers of maize crop. The first objective was to evaluate the profitability of the improved maize varieties on maize production in Gatsibo; the second objective was to identify the best method of fertilizers use to maximize maize output per unit area in Gatsibo; and the third objective was to find out the effect of market price and place on increased maize production in Gatsibo. The research study was taken place from the month of January 2015 and is continuing up to date. Main and specific objectives have been formulated to get significant feature of maize production from the farmers in Gatsibo so that questionnaires, interviews and observation were used as acceptable research instruments to fulfill desired information.

1.7 .Limitation of the Study

The study was limited mainly by geographical location of zones that are generally far from the main road (tarmac road). The researcher took a long time than estimated because respondents were busy in their farm where to find respondents requested two times. The study was limited in terms of the willingness of the respondents to participate in the study. In some households the researcher therefore has been accompanied by local authorities to assure that all the information provided will be treated only for the academic purpose. Other limitation was the English language because most of are familial of the local language known as Kinyarwanda. So, here the time was mainly spent in reading, interpreted and translated questions to the participants in their local language they understood best.

2. Literature Review

2.0 Introduction

This chapter described Rwanda's economy with major emphasis on the agriculture sector and influencing factors on maize production in the country. It also examines relevant literature on the impact of factors of production including improved maize varieties, method of fertilizers application, and finally market price and place of maize production. This chapter also shows the theoretical and conceptual framework of the research study.

2.1. Conceptual Framework

The study has been based on the following model of study that identifies the independent and the dependent variable of the study. The framework conceives factors affecting maize production as independent variable while quantity of maize produced as dependent variable and then, a variable that explains a relation or provides a causal link between both dependents and independent variables as moderating variable.

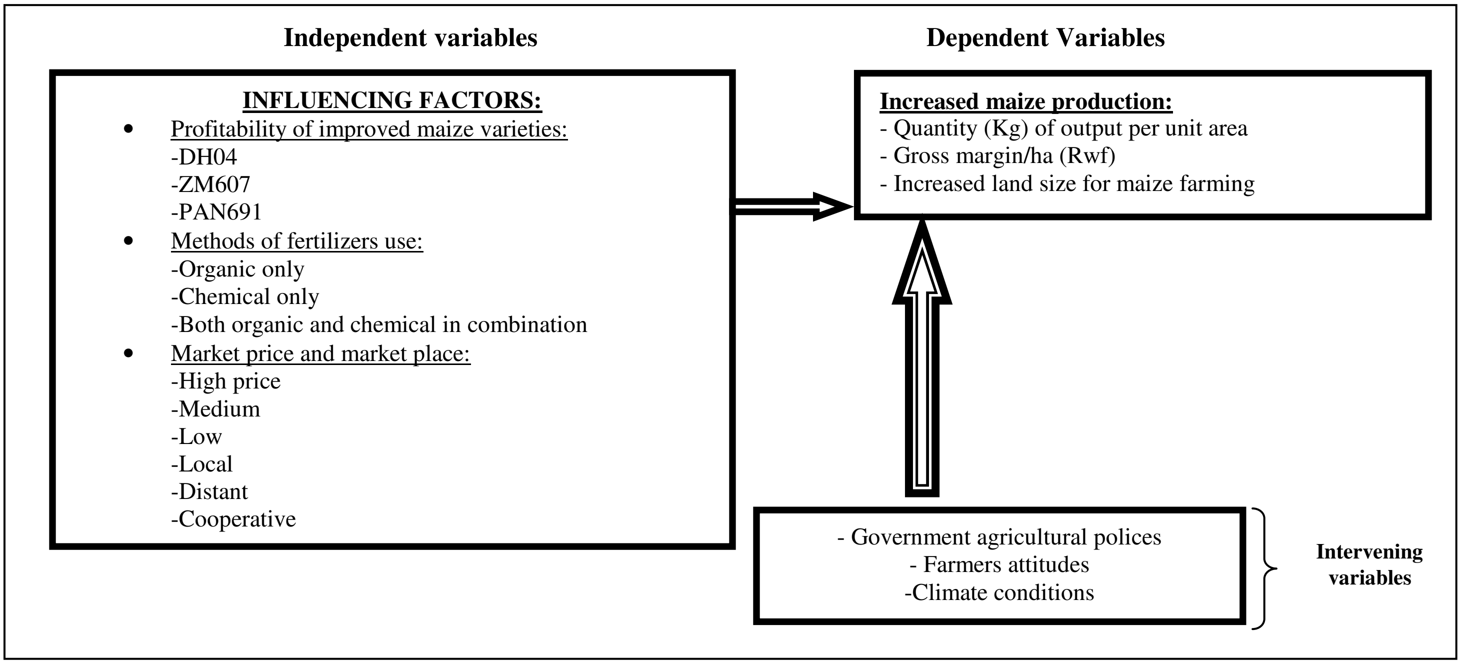


Figure 1: Conceptual Frameworks

2.2. Theoretical Framework

The study adopted the theory of farm Production and profitability. This part has outlined in considerable detail the physical or technical relationships underlying the factor-product model. A production function was developed using tabular, graphical, and mathematical tools, with illustrations from agriculture. The law of diminishing marginal returns was introduced. Marginal and average physical product concepts were developed. The rules of calculus for determining if a function is at a maximum or minimum were outlined, using a total physical product and marginal physical product concepts to illustrate the application. Finally, the concept of an elasticity of production was introduced, and the elasticity of production was linked to the marginal and average product function. Consumer surplus is the monetary gain obtained by consumers because they are able to purchase a product for a price that is less than the highest price that they would be willing to pay. Producer surplus is the amount that producers benefit by selling at a market price that is higher than the least that they would be willing to sell for; this is roughly equal to profit demonstrated by Alfred Marshall (1924).

Production theory is the study of production, or the economic process of converting inputs into outputs. The profitability of production is the share of the real process result the owner has been able to keep to himself in the income distribution process. Profit is normally measured in money terms as gross financial revenue minus total financial cost per period. Production is the processes and methods employed to transform tangible factors/resources or inputs (raw materials; semi-finished goods; or subassemblies) and intangible inputs (ideas, information, knowledge) into goods and services or output defined by Oluwatayo *et al*., (2008). These resources can be organized into a farm or producing unit whose ultimate objectives may be profit maximization, output maximization, cost minimization or utility maximization or a combination of the four stated by Oluwatayo *et al*., (2008). Certain parameters (Price taker and price maker) have to be known for one to understand how farmers make their decisions that enable them to attain their goals. This will enable a farmer to decide on what price to charge and to overcome the problems related to Food security, Profit maximization and finally Risk reduction. Although profit maximization is an important objective it is by no means the only one that motivates farmers. The basic theory of production is thus simply an application of constrained optimization. The farm-unit attempts either to minimize the cost of producing a given level of output or maximize the output attainable with a given level of costs indicated by Oluwatayo *et al*., (2008). Cobb Douglas function has been used to estimate the relationship between inputs and outputs. Factor -Product relationship guides the producer in making the decision how much to produce. This involves concept of the production function, average and marginal physical product, and various stages of production suggested by Raju *et al.* (1990) and Cobb et al., (1928). The production function represents an input-output relationship describes the rate at which resources are transformed into products supported by Olayide *et al.,* (1982). Relationships vary with crop variety, soil types, water quality, technologies; any given input-output relationship specifies the quantities and qualities of resources needed to produce a particular product. The economic model commonly used to determine the relationship between the various factors and the output in agriculture is the Cobb Douglas production function indicated by Desai, M., (1976). The production function of any farmer is determined by resource availability of the farmer. A production may be defined as a mathematical equation showing the maximum amount if output that can be realized form of the Cobb-Douglas production function is given by:

$$Y = AL^{\beta}K^{\alpha}$$

Where:

Y = total production (the monetary value of all goods produced in a year)

L= labor input

K = capital input
A = total factor productivity where α and β are the output elasticity's of labor and capital, respectively. These values are constants determined by available technology. Returns to scale refers to a technical property of production that examines changes in output subsequent to a proportional change in all inputs (where all inputs increase by a constant factor).If output increases by that same proportional change then there are constant returns to scale, sometimes referred to simply as returns to scale. If output increases by less than that proportional change, there are decreasing returns to scale. If output increases by more than that proportion, there are increasing returns to scale showed by (Cobb, 1970). Suggested by Doll, *et al.,*(1984) optimization of production is the goal of this relationship. This relationship is known as input-output relationship by farm management specialists and fertilizer responsive curve by agronomists where the Price ratio is the choice indicator. Based on the assumptions of a goal of profit maximization and making decisions in the short run, combined with our understanding of diminishing marginal productivity, the question is "what level of input should a manager use and what level of output should the manager produce to maximize profit. The answer for one business will be different than the answer for another business. Indicated by David L. Debertin (2002) the relationship between the level of variable input and level of output can be illustrated with a production function. A graph showing three stages of production may improve our understanding of the concept (figure 2*)*. The axes represent the number of physical units used (variable input or X) and the number of physical units produced (output or Y).

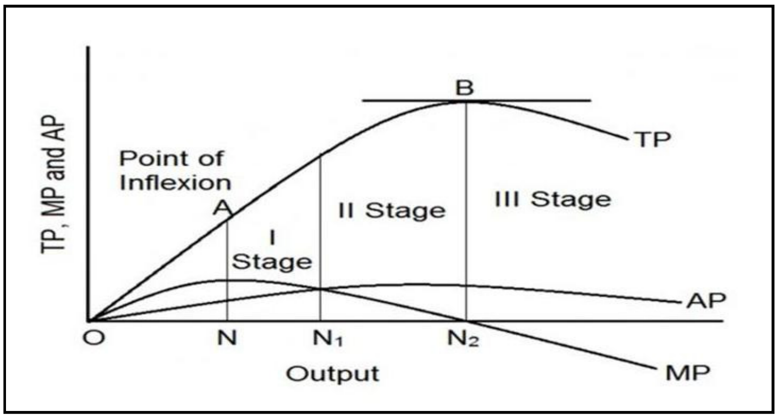


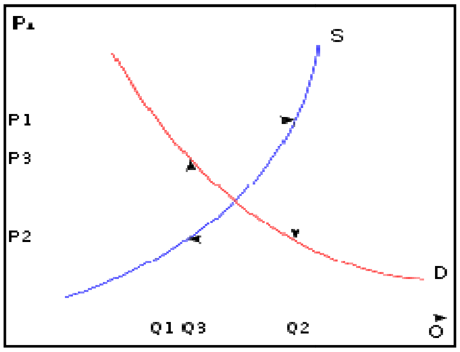
Figure 2: Three stages of production-economic decisions
Source: Source: David L. Debertin (2002)

Stage I is called irrational zone of production. Any level of resource use falling in this region is uneconomical. Therefore, it is not reasonable to stop using an input when its efficiency is increasing. In this zone, more products can be obtained from the same resource by reorganizing the combination of fixed and variable inputs. For this reason, it is called irrational zone of production. Stage II is rational zone of production. Within the boundaries of this region is the area of economic relevance. Optimum point must be somewhere in this rational zone. It can, however, be located only when input and output prices are known. Stage III is also an area of irrational production. TPP is decreasing at increasing rate and MPP is negative. Since the additional quantities of resource reduces the total output, it is not profitable zone even if the additional quantities of resources are available at free of cost. In case if a farmer operates in this zone incurs double loss. The estimation of relationship between factor-product is measured by the elasticity of production. The elasticity of production is a concept that measures the degree of responsiveness between output and input. It is independent of the units of measurement.

$$Ep = \frac{\text{\% change in outtputs}}{\text{\% change in inputs}} \text{ or } Ep = \frac{\Delta y/Y}{\Delta x/X} = \frac{\Delta y/\Delta X}{Y/X} = \frac{MPP}{APP}$$

Ep = 1, Constant Returns. Ep is one at MPP = APP (At the end of I stage)
Ep > 1, Increasing Returns (I Stage of Production)
$0 \leq Ep \leq 1$, Diminishing returns (II Stage of Production) while *Ep* is negative in stage III.
The point of diminishing returns can be defined to occur when MPP =APP that is *Ep*= 1 (lower boundary of stage II) and this is the minimum amount of variable input that will be used and it occurs when the efficiency of variable input is at its maximum. At the other end, MPP is zero, therefore Ep= 0. Thus the relevant production zone is when $O \leq Ep \leq 1$.
Profitability is the primary goal of all business ventures. Without profitability the business will not survive in the long run. So measuring current and past profitability and projecting future profitability is very important and it is measured with income and expenses. Managers constantly look for ways to change the business to improve profitability. These potential changes can be analyzed with a pro forma income statement or a Partial Budget suggested by Robert Tigner (2009). When Total Product is increasing, the Marginal Product is positive. When the Marginal Product remains constant, the Total Product increases at constant rate. When Marginal Product is equal with the Average Product, Average Product is Maximum.
The study will also use the law of demand and supply to find out the impact of price on the increased maize production in Gatsibo district. The law states that other factors being constant (cetris peribus), price and quantity demand of any good and service are

inversely related to each other. When the price of a product increases, the demand for the same product will fall. The law of demand explains consumer choice behavior when the price changes. This is the natural consumer choice behavior. This happens because a consumer hesitates to spend more for the good with the fear of going out of cash. Demonstrated by Negatu and Parikh (1999) farmer's decisions are rational and therefore are made based on utility maximization. As the price of a product increases, quantity demanded falls; likewise, as the price of a product decreases, quantity demanded increases. The cob web theory attempts to explain the reasons as to why prices of agricultural products rise and fall due to erroneous expectations of farmers. It is thought that agricultural peasant farmers never learn from their past experiences, and past mistakes. They keep on copying each other and seem never to learn from their past mistakes indicated by Kaldor(1934). The convergent case indicated that each new outcome is successively closer to the intersection of supply and demand.



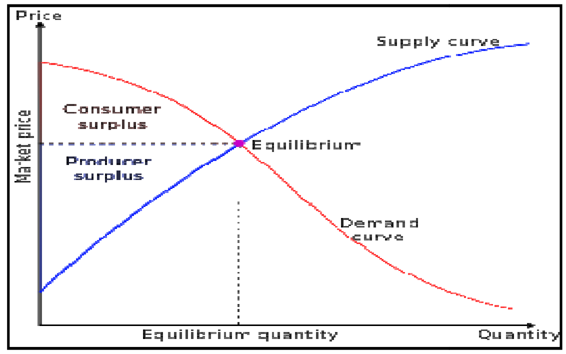


Figure 2: Cobweb convergent cases *Figure 3: Graph illustrating Economic surplus*
Source: Policy coherence in agriculture (2011) and Alfred Marshall (1924)

To evaluate the profitability of producer economists also used the theory of economic surplus. Consumer surplus is the monetary gain obtained by consumers because they are able to purchase a product for a price that is less than the highest price that they would be willing to pay. Producer surplus is the amount that producers benefit by selling at a market price that is higher than the least that they would be willing to sell for; this is roughly equal to profit demonstrated by Alfred Marshall (1924). In other word, on a standard supply and demand diagram, consumer surplus is the above the equilibrium price of the good and below the demand curve. Likewise, in the supply-demand diagram, producer surplus is the area below the equilibrium price but above the supply curve. Producer surplus = Amount received by sellers -Cost to sellers.
Because of agricultural produce that are usually perishable especially during season. Many primary markets are subject to extreme fluctuations in price. There are several methods of intervention available to governments and agencies. Buffer stocks should help stabilize prices by taking surplus output and putting it into a store, or, with a bad harvest, stock is released from storage. A target price can be achieved through intervention buying and selling. The buffer stock managers are likely to establish a price ceiling, above which intervention selling will occur, and a price floor, below which intervention buying will take place. It is supported by Morrow, Daniel T. (1980) that if prices fluctuate sufficiently, they will induce some people to store food, and thereby transfer it from times of relative abundance to times of scarcity. Yet, it must be recognized that there is an important ethical problem in relying on the market to equate the supply and demand of food.

2.3. Critical Review

2.3.1. Factors Influencing Maize Production
In Africa, maize is the most widely grown staple crop and is rapidly expanding to Asia. Maize is vital for global food security and poverty reduction. Due to the increasing demand for feed and bio-energy, the demand for maize is growing and is expected to double by 2050 indicated by Rosegrant et al., (2007). Unfortunately for many farmers in Africa, maize yields (output per acre) have fallen in the last decade, in spite of improvements in agricultural technologies stated by Saari, S. (2011). Among the major factors affecting yields are the production environment, production systems, seed varieties and other production inputs and financial outlays on research. Studies conducted to identify factors affecting the use of agricultural technologies include 22 studies done from 1996 to 1998 by CIMMYT in collaboration with national research organizations in East Africa found by Doss (2006). These studies looked into adoption of improved varieties of wheat and maize as well as chemical fertilizers in Ethiopia, Kenya, Tanzania and Uganda. They provided useful information on who is using improved seed and fertilizer and shown that farmer characteristics such as age, gender, education level and wealth are key factors to adoption decisions. In the majority of countries, open-pollinated varieties are still the most common type of seed used. They can easily be multiplied so that their seeds are cheap and readily available, and the farmer usually retains a certain portion of his harvest for future planting. Other studies that have been done on the use of technologies include Ouma *et al.,* (2002) who reviewed the socio-economic and technical factors that affect adoption of improved maize and fertilizer use in Embu District, Kenya, and the role of credit in improved maize and fertilizer use adoption. Mutune (2009) evaluated factors influencing the adoption of conservation tillage practices and their implication on profitability in maize-cowpea cropping systems in Makueni District, Kenya. Indicated by Nyagaka*et al.,* (2009) on Irish potato producers in Kenya, farmer's education positively influenced farm economic efficiency. It was argued that farmers with higher levels of education were more efficient in production and

this was attributed to the fact that educated farmers positively perceive, interpret and respond to new technologies on seeds, fertilizer, pesticides, fungicides, herbicides or markets much faster than their counterparts. On the other hand, Bravo-Ureta and Pinheiro (1997) in their analysis of economic efficiency in the Dominican Republic found that education had a negative effect on economic efficiency. This suggests that educated farmers in the Dominican Republic were less efficient economically, compared to their uneducated counterparts. Therefore, schooling can influence overall efficiency either positively or negatively. The studies like Seidu (2008) which emphasize those large households are better in providing free labor, indicating the usefulness of larger households in improving farm efficiency. In fact, 60 percent of the total maize area in the developing world, outside of Argentina, Brazil and China, is estimated to be still planted to unimproved, local varieties. Although national and international breeding programs have considerably increased the yields of open-pollinated varieties over the past, they remain below those of hybrids. Yields of hybrids, in fact, can exceed those of landraces open-pollinated varieties by 30-100 percent, with an average of perhaps 40-50 percent. Hintze *et al.,* (2003) examined the factors, including varietal characteristics, affecting the low levels of adoption of improved maize varieties in Honduras. Ransom *et al.,* (2003) demonstrated the adoption of maize varieties in the hills of Nepal. When hybrids have replaced improved open-pollinated varieties, the yield advantage of hybrids has usually been no more than 15-25 percent. Whereas almost all of the white maize produced in developed countries is from hybrid seeds, there appears to be still considerable scope in the developing countries to expand their usage indicated by Weber (1992). Fertilizer use on maize also varies widely among countries. In maize producing developing countries excluding Argentina, Brazil and China, on average two-thirds to three-quarters of total maize area receives some fertilizer in Central and South America and in Asia. In sub-Saharan Africa, only a little over one-third of all maize area is fertilized. In Egypt, all maize is fertilized at high application rates stated by Morris (2001). Poverty reduction-maize production in Gtsibo has been a source of nutrition to many households providing carbohydrates which is a vital ingredient to human health. Maize production involves so many activities and this has been source of employment among the women and youth within the society indicated by MINAGRI (2011). Farmers earn income through reaping of the output and this uplifts their living standards especially to the rural areas. Farming experience has also been found to affect farm output. Various authors have found that experience in farming enhances efficiency. Mulwa *et al., (*2009) in western Kenya observed that farming experience had a positive influence on economic efficiency. Mbanasor and Kalu (2008) also found similar results for vegetable farmers in Nigeria, which coincides with their findings for age. It is expected that experienced farmers have over the years learned from their mistakes and improved their efficiency in production. Nyagaka*et al.* (2009) further found a positive effect between extension visits and economic efficiency. This is consistent with findings indicated by Mbanasor and Kalu (2008) and implies that the more extension visits a farmer accessed from the extension workers; the more economically efficient he became. Improving the productivity of maize-based farming could significantly reduce hunger, enhance food security and alleviate poverty through increasing the purchasing power of the farmers Laborers therefore have more money to spend on food as well as other products. However, it is not only the people employed in agriculture who benefit from increases in agricultural productivity. Those employed in other sectors also enjoy lower food prices and a more stable food supply. It also supported by Jones *et al.,* 2007 found that the wages may also increase during seasonal good price. However, these studies fail to adequately answer the questions of factors such as improved seeds, fertilizer application methods and markets price affect the increased maize output. This study tries to find out gaps in determination of factors influencing maize production in Gatsibo, Rwanda.

2.3.2. Influence of the Improved Maize Varieties on the Increased Maize Production

Profitability is the primary goal of all business ventures. Without profitability the business will not survive in the long run. So measuring current and past profitability and projecting future profitability is very important. Profitability is measured with income and expenses. Income is money generated from the activities of the business. For example, if crops and livestock are produced and sold, income is generated. However, money coming into the business from activities like borrowing money does not create income. This is simply a cash transaction between the business and the lender to generate cash for operating the business or buying assets.

The study on farm productivity in Africa by Genescaet *al.,* (1992) showed that the rates of growth in yields (output/ha) and returns per labor-day were gradually low, but differed by crop, zone, technology and farm size. Yields in good agro-climatic zones were 2 to 3 times greater than those in poorer zones. Large fluctuations were also witnessed in years with good and bad rainfall levels in semi-arid zones, making farming very risky. According to Wiebe(2001) many different Factors that influence productivity of a particular producer may be classified into three main parts. Mutune, J.M. (2009) indicated that the quantity and quality of inputs used including land, labor and capital, fertilizer, seeds farm; farmer characteristics; and the external factors such as government policy Capital inputs among others include seed, fertilizer, and farm equipment are the factors influencing maize output globally. Farm and farmer characteristics on the other hand include factors such as size and topography of area cultivated, location of the farm with respect to input and output markets, age, gender, education level, household size, access to extension services, and access credit found by Michele (2001). The study also found that labor, fertilizer use, seed quality and distribution, animal traction, organic inputs or soil conservation investments and non-cropping income had a positive impact on farm productivity, which is consistent indicated by Idiong (2007). On the other hand, farm size and land tenure were found to have a negative contribution to farm productivity. However, despite the wide scope of the study covering four case studies in Bukina Faso, Senegal, Rwanda and Zimbabwe; Reardon and others failed to estimate farm-specific efficiencies and their determinants. This could have provided feedback on the contribution of the farmer's managerial ability on the farm productivity.

Bourdieu (1984) indicated that credit is necessary for improved maize farming associations running collection centers, buying products from producers and selling on in bulk. However, significant financial assets are not essential for maize farming at subsistence level. A good maize farming project will work to ensure that all available capital assets are taken into consideration, without dependence on any that are not. Olujenyo, F.O. (2008) applied the qualitative approach to evaluate the performance of improved maize varieties in Ghana, under the grains development project. They found that improved maize varieties significantly increased yields for farmers switching from local varieties. The study of Ransom et *al.,* (2003) showed that the yield increase would be even higher if the farmers applied fertilizer on the improved varieties. This indicates that the improved varieties perform better under an improved management system, although they still perform better than the local varieties even if the farmers do not use improved management approaches. The yield-enhancing effects of fertilizer and improved maize varieties are confirmed by Owino (2010), who used experimental data in the Trans Nzoia District. Owino further noted that the yields vary with different improved varieties, fertilizer types and intensity, and management practices. High labor costs may discourage extra hand cultivation and marginally lower outputs. But low agricultural wages discourage participation in the agricultural economy, where industrial or other opportunities exist stated by Heisey(1995).

The positive effect of improved maize varieties on yield has also been noted in Mexico (Becerril and Abdulai (2010); Bellon and Hellin (2010) and other countries of Africa Alene *et al.,* (2009).

In such contexts, the problem of hunger is linked to underproduction in a vicious cycle of Africans. As such, they can not realize sufficient quantities of produce to meet household needs and have a marketable surplus. The use of improved technology is the best strategy to overcome the constraint of low productivity and profitability for farmer.

2. 3.3. Influence of Best Fertilizers Application Methods on the Increased Maize Production

Meeusen, W. and Van Den Broeck, J. (1977) stated that the efficiency simply means that as resources are scarce, they have to be used in an appropriate manner. This concerns the relationship between inputs and outputs. Using inputs efficiently will mean that costs will be reduced and that output will either remain the same or it will increase. Hence, with lower costs it may be possible to keep either output the same or even increase output. The main point in efficiency is getting more from less. Factors that influence productivity may be depend on the quantity and quality of inputs used including fertilizer, seeds farm and farmer characteristics and external factors such as government policy Wiebe (2001). According to the study of De Groote *et al.,* (2005) using an econometric approach, analyzed the maize green revolution in Kenya using farm level surveys between 1992 and 2002. They found that intensity of fertilizer use had a major effect on maize yield. There are some of the activities which end up affecting maize production positively and negatively in the region for example sugar farming where the land used in maize production is being replaced thus the decline in maize production. Production theory states that under competitive conditions, a firm is said to be efficient if it equates the marginal returns of factor inputs to the market price of the input Fan (1999). Farmers are required to take their produce to a group collection centre and contact the buyer for collection. The group members are given priority than non-group members though the collection centres do not reject to collect from non-members. According to past studies and reports by Singh (2000), De Sousa (2005), Mwenda (2005), Kunkel *et al.,* (2009) and NEPAD (2009), farming under a market contract is increasingly becoming an important aspect of agricultural production and marketing that influences uptake of technologies. Kunkel *et al.,* (2009) defines a agricultural marketing contract as a contract by which a producer sometimes called a grower agrees to sell or deliver all of a designated crop raised in a manner set forth in the agreement to a contractor and is paid according to a formula established in the contract. Therefore this study defines allocative efficiency as the ability of a farm decision maker to use farm inputs up to the level where marginal value of production is equal to their factor price. Dercon and Christiaensen (2007) found that poor harvest and subsequently low consumption could lead to low fertilizer application in Ethiopia. The results are similar to those of neighboring Kenya, where adoption patterns also vary from season to season. Duflo *et al.,* (2008) sought to understand the returns to fertilizer and reasons for low fertilizer application in Western Kenya using experiments. They found dismal learning effects and a rate of return to top dressing fertilizer of between 52% and 85%. In addition, they initiated a Savings and Fertilizer Initiative (SAFI), which offered farmers subsidized fertilizer at harvest time as opposed to planting time. They reported an 11-14% increase in adoption. More recently, Duflo *et al.,* (2011) concluded that behavioral biases prevent farmers from attaining their intentions to use fertilizer. They recommended providing fertilizers immediately after harvest, when farmers have cash from crop sales, rather than later in the planting season. This study seeks to find out the best method of fertilizer use to maximize maize output per unit area in Gatsibo, Rwanda.

De Groote *et al.,* (2005), using an econometric approach, analyzed the maize green revolution in Kenya using farm level surveys between 1992 and 2002. They found that intensity of fertilizer use had a major effect on maize yield. However, the use of improved maize varieties did not have any effects on the yields, an indication that some local varieties could perform as well as the improved varieties in some areas. The yield-enhancing effects of fertilizer and improved maize varieties are confirmed by Owino (2010), who used experimental data in the Trans Nzoia District. Owino further noted that the yields vary with different improved varieties, fertilizer types and intensity, and management practices. When the right type of fertilizer for a given crop is used in recommended quantities at the right time, fertilizers do generally not harm the environment otherwise increase productivity of crops. Saari S. (2011) saw that Fertilizers also have numerous positive impacts on the environment some of them direct others indirect. Positive impacts include improvement of farming efficiency for example maize production levels in Ngoma for one season. The production are respectively without fertilizer 3tonnes 150kgs/ha, use compost 4tomes 525Kgs/ha, both organic and Inorganic 7tonnes 875kg/ha, Inorganic only DAP and UREA 5tonnes 350Kgs/ha. Morris *et al.,* (1999) found that the use of fertilizer alone increased yields significantly, even where the farmers planted local maize varieties. The main limitation of the study is that it relied on recollections by farmers who had switched from one variety to another. This may reduce the reliability of the results, especially for farmers facing multiple scenarios. It was indicated by Waithaka, *et all.,* (2007) that increased use of inorganic fertilizers will resulted in the production of healthier crops with increased crop cover and increased biomass production crop residues, which in turn reduces soil erosion and contributes to building-up soil organic matter levels, increasing water holding capacity and microbial activity, leading to prevention of soil degradation; Reduced area under cultivation because of higher yields as a result of fertilizer use and thus production of food needs that would be met with reduced cultivated areas at various levels from the household, community, regional and national levels. The study of Marenya and Barrett (2009) indicated that, in an interesting study of fertilizer interventions in Western Kenya, found that fertilizer application is beneficial to farmers with high soil organic matter. The implication is that plots with poor, degraded soils limit the marginal productivity of fertilizer. The finding showed that farmer used both combination of chemical and organic fertilizer gained more that those who do not use any type of fertilizers. However, as recommendations farmer should use fertilizer (quantity) recommended and on time as well as during planting and for top dressing.

2.3.4. The Influence of Market Price and Place on the Increased Maize Production

The marketing arrangement is not well developed leading to inadequate market outlets, high transaction costs and minimal value addition Anderson (2002). Maize farming in Africa has faced serious challenges that have led to the overall declines of the quantities of maize produced the lack of knowledge on the right practices of maize farming has led to the practice decline trends especially in the quantities of maize produced. It has been suggested by Fuglie, *et al*., (O1999) and Morrow, Daniel T. (1980) that the main important factor that should or not increase maize production is the price. Producing maize should many refer to how much of a price of a product is given at a market. As with demand the quantity supplied depends on the price of the product and on the conditions of supply. If the price of a product is high, normally more of a product will be supplied

It is also supported by the studies conducted in northern Honduras on the other hand found that the relative production and profitability of a *Mucuna pruriens* system was not solely dependent on the higher maize yields, labor costs and lower production risk but also on the seasonally high prices that favored the second season maize crop Buckles and Triomphe (1999). For example, if the price of maize is high, the farmer and his family will probably consume fewer of these products in order to make sure that more can be sent to market. The higher price would also encourage the farmer to extend the area under cultivation and provide the crop with more or better quality inputs so that a higher yield can be obtained indicated by Zeller, et *al*., (1997).

A higher price for maize would encourage other farmers and possibly the less efficient too, to go into maize production. Just as with demand, if we take single product maize we can draw up a table showing how many maize suppliers will be willing to sell at different prices. This consists of the total amounts supplied at different prices by all producers in the market at a specific period of time. If prices rise or fall there will be a movement along the supply curve. Farmers will supply less or more maize according to whether the price rises or falls. As we can see, the rise in price causes a movement along the supply curve, from the original price to final price. This causes quantity supplied to rise.

It has been indicated by (Karanja, D.D. 1996) that is important to remember, when we will be looking at market equilibrium and changes in demand and supply. At a particular price, both suppliers and consumers are willing to make an exchange; suppliers are willing and able to sell and consumers are willing and able to buy. Economists call this the equilibrium price. Prices do not change only once; they can change quite often. For example, prices vary in consequence of changes in production and demand at different times of the year. The supply of agricultural products often varies from season to season and because of weather, plant diseases and farmers' decisions; they also vary from year to year. Importantly prices also vary depending on the availability of competing products. If a wider range of competing products comes into the market, consumers have a wider choice. Although the availability of a product may remain the same, the price could go down if the consumer decides to switch to a competing product. If some factor like fertilizer is bought at prices that keep rising as the crop is produced. It is obvious that people are interested in buying products which have a low price, while farmers are interested in increasing their production to follow higher prices. This simple statement, however, may not always be true. A determining factor is how necessary is a product to the buyer. Changes in price which affect the quantities supplied and demanded are referred to in economic terms as elasticity. Farmers most often do not set their own prices. They accept the market price for what they produce. They are what are called in economics, price takers. By maintaining high prices and waiting for consumers, the farmer runs the risk of not being able to sell any produce and eventually being forced to go out of business. If there high production but low price government intervene by use of buffer stock and policy makers can put price ceiling and price floor for the benefit of society suggested by(Karanja, D.D. 1996).

2.4. Maize Production Globally

Maize or corn is a cereal crop that is grown widely throughout the world in a range of agro-ecological environments. More maize is produced annually than any other grain. About 50 species exist and consist of different colors, textures and grain shapes and sizes. White, yellow and red are the most common types. The white and yellow varieties are preferred by most people depending on the region. Maize production in the global arena can be categorized into white maize production and yellow maize production indicated by Meyer *et al.,* (2006). World production of white maize is currently estimated at around 65-70 million tons, representing 12-13 percent of the annual world output of all maize.

Over 90 percent of the white maize is produced in the developing countries, where it accounts for around one quarter of total maize output and just under two-fifths of the total maize area. According toFAO (2007) estimates, 158 million hectares of maize are harvested worldwide. Africa harvests 29 million hectares, with Nigeria, the largest producer in SSA, harvesting 3%, followed by Tanzania. Maize is an important crop for ensuring food security and increasing household income. This can only be achieved when there an increase of maize production through the use of improved maize varieties and technology. Maize as a staple crop has many social-economics important uses in developing countries like bake, brewing industries and livestock feed. According to FAO data the area which maize was planted has been increased from 3.2 million of hectares in 1961 to 8.9million of hectares in 2005 for West and Central Africa alone FAO (2005).

FAO (2007) FAOSTAT showed that in 2008, North America recorded the largest production of maize with about 38.8% of the global output. This is followed by Asia (28.5%); South America (11.2%); Europe (11.1%); Africa (6.9%); Central America (3.4%); and Oceania (0.07%). Argentina, Brazil and China account for over 60 percent of total maize output in the developing world, China alone for 45 percent. When these countries are excluded from consideration, white maize constitutes over 60 percent of the maize area in developing countries, and just under 60 percent of total maize output in those countries. By contrast, white maize is a product of much lower importance for the developed world. In the United States, for example, by far the world's largest producer of maize, white maize cultivation accounts for less than one percent of the total domestic maize output, produced to a large extent under contract farming due to the relatively limited market indicated by Martinez, (2000).

Maize is Queen of the cereals. Has highest yield/ha among the cereal crops. It is now grown in all countries except Antarctica and under a more varied range of climates than any other cereal crops. It is mainly used as a food crop in World by the rural population in the form of bread and grain; it has vast industrial potentialities as well having many as 50 different uses. Example it can be put to the manufacture of starch, alcohol, acetic acid, lactic acid, glucose, adhesives, synthetic rubber, resin, artificial leather, boot polish etc. Maize is being used as poultry and cattle feed.

2.5. Maize Production in Africa

Maize was introduced into Africa in the 1500s and has since become one of Africa's dominant food crops. Like many other regions, it is consumed as a vegetable although it is a grain crop. The grains are rich in vitamins A, C and E, carbohydrates, and essential minerals, and contain 9% protein. They are also rich in dietary fiber and calories which are a good source of energy. Maize was introduced in Africa by Portuguese traders on the Eastern and Western Africa coast and slowly moved inland through the incursion of slave traders who valued maize as a storable and easily processed grain showed by Miracle (1965). In the beginning of the independence movement (1960s), Africa was self sufficient in foods and a leading agricultural exporter. In contrast, Asia was the epicenter of the world food crisis. But by the mid 1960s, Asia had launched the green revolution, which at present adds 50 million metric tonnes of grain to the world food supply each year. Although Asia struggles with issues of household food supply, it is Africa, not Asia, which bears the brunt of the world food problem indicated by Byerlee (1997). Maize is the staple food in most parts of Eastern and Southern Africa and is produced by nearly all countries in the region. Worldwide production of maize is 785 million tons, with the largest producer, the United States, producing 42%. Africa produces 6.5% and the largest African producer is Nigeria with nearly 8 million tons, followed by South Africa. Africa imports 28% of the required maize from countries outside the continent.

Most maize production in Africa is rain fed. Irregular rainfall can trigger famines during occasional droughts. However, production is failing to keep pace with increasing demand in much of the region, making maize one of the major traded commodities across regional boundaries stated by Munyankusi (2002). In 2005, the top exporters of maize in sub-Saharan Africa were South Africa, Tanzania, Uganda, Zambia and Swaziland, with the top importers of maize Zimbabwe (a maize exporter until the late 1990s), Angola, Ghana, Kenya and Mozambique. Facing a growing population, several studies Pingali (2001) and (World Bank, (2007) note that it is critical for Kenya and other African countries to increase maize production in order to feed their people.

Most of the maize produced and consumed in Africa comes from smallholder rural farms. Production takes place under difficult conditions characterized inter alia, by poor soils; low-yielding varieties; inadequate access to yield-enhancing inputs such as fertilizers and improved seeds; inadequate access to finance by producers, suppliers and buyers; and variable climatic and environmental conditions. Domestic trade in maize has been completely liberalized and the Government's farm support price system has been abolished. Only the import and export monopoly has been retained by the National Grain Marketing Board FAO (1994). Within East Africa, Tanzania is the number one producer followed by Kenya and Uganda in that order. In Kenya, Nakuru district alone produces 200,000 tonnes per annum, which is about 4 times more than the whole of Rwanda produces. Unlike Rwanda, maize in Kenya is produced both under large and small-scale production. About 25% of production is under large-scale production (>20 ha). In Kenya the main consumers of maize are the millers of maize meal for human consumption. The second use is by the feed industry with a capacity of about 300,000 tonnes of animal feed per annum indicated by FAO (2001). For most sub Saharan African countries, the adoption of sustainable agricultural practices that enhance agricultural productivity and improve environmental outcomes remains the most concern option for achieving economic growth, food security and poverty alleviation. However, a part of research and technology development is inadequate because its adoption may be totally absent, partial or even reversed due to future. The relationship between technology adoption and agricultural productivity is, however, a complex one that is influenced and shaped by farm and farmer characteristics, access to extension and financial services, risk preferences, social capital, and farm size, among other factors found by Barrett *et al.,* (2005); Foster and Rosenzweig (1995).

Due to the increasing demand for feed and bio energy, the demand for maize is growing and is expected to double by 2050 suggested by Rosegrant *et al.,* (2007). Unfortunately for many farmers in Africa, maize yields (output per acre) still even at the lowest level compared to those of developed countries Suri (2011). This is further complicated by the threat of climate change, which will make it more difficult to meet the growing demand for maize. This is worry some for economic and social policies aimed at increasing food production and agricultural income Understanding persistently low technology adoption and its impact in the maize sector motivates our interest in this study. Field trials at agricultural stations across Kenya have developed High yielding seed varieties, optimal fertilizer application rates and increased farmer field days as demonstration projects found by Karanja (1998) and Duflo et *al.,* (2008).

Maize trade flows are determined more by the theory of comparative advantage as countries in the region aim to create a free trade area. Thus, despite being a major producer Kenya imports maize from Uganda and Tanzania, which are cheaper producers in the region. On-farm prices can be at about 55.6 US $ per tonne during harvest, while similar prices in Uganda can be as low as US $ 15.7 per tonne. On the other hand, consumer prices in Nairobi ranged between 111.1 to 138.9 US$ per tonne during the same period indicated by MINECOFIN/DS (2002). Wholesale prices in Western Uganda around first quarter of year (2003) is about US $ 70 per tonne. Data indicated that maize was moving into Rwanda from Uganda. Also, Tanzania was a major exporter of maize into Rwanda. A similar situation has been pertaining in the Southern African region where production during 1998 was estimated at about 16.24 million tonnes, representing a decline of about 5% over the previous years 'output of 17.05 million tonnes in 11 of the 14 countries. Consequently in 1998 an estimated 2 million tonnes of maize were imported by SADC countries to cover the shortage. This deficit increased to about 4 million tonnes in 2002. Given this scenario, Uganda, which has been the main exporter of maize to Rwanda, has been looking to this southern market showed by MINECOFIN (2007). This has created pressure on the demand for maize in Uganda and thereby reducing flows into Rwanda as the southern market seems to offer better prices. Ugandan traders were expecting to export up to 60,000 tonnes in 2002 to the Southern countries of Malawi, Zimbabwe and Zambia with Zambia having the strongest comparative advantage due to the good rail route.

As staple food, maize contributes to the food security of millions of people in much of developing world, and when traded in local markets they provide income and employment to rural populations. maize production may be classified as local or trade production, according to whether the flesh and untransformed dried grains are consumed locally or is sold after being transported to a more or less distant market stated by Mugisa-Mutetikka (2000). Maize being the world's most popular grains, its world trade value, estimated at more than US$ 3bn each year. World import demand is estimated at around 12millions tones representing about 14% of maize production. The rest estimated at about 65 million tones is eaten locally, implying that only a small proportion of production is being traded and the global trade is in fresh maize.

2.6. Maize Production in Rwanda

Maize is one of the important foods, green forage and industrial crops of the world. It is called In Rwanda Maize was introduced around 1957's, during the colonial period. The production had increased consistently since 1962, although the upward trends began to level off in the last decades; the decline was caused by long period of drought and population fairs to produce indicated by CMMYT (1993).

Before 1996, maize was only important in highlands where it constituted the staple crop, but from 1996, it expanded in other ecologies of Rwanda especially in moist mid-altitudes. The shift of interest from other crops such as sweet potato to maize, were multiple uses and easy conservation of maize, and its ability to grow in diverse ecologies in Rwanda. According to the encouragement to grow maize was to constitute cereal reserves to face unexpected hunger periods through the crop intensification program and. currently; maize is the leading cereal in Rwanda. However, the use of agricultural recommended inputs are very low where only 11% of farm households use improved seeds, 16% mineral fertilizers, 32% of animal manure, 16% pesticides, and 31% compost found by (NISR, 2013). Table 2 shows the evolution of use of improved seeds NISR (2012) and MINAGRI (2011). Rwanda's potential market for Maize is large with a total consumption of 550,000MT (2012) A long 5 years the area under cultivation increased 2.2 – fold: 102,000Ha (2007) to 223,414Ha (2011) with an annual growth of 11.6%. In urban areas the demand in maize consumption is increasing more than in urban areas: 17% Vs ≈ 3% (2000 to 2015).The region total domestic consumption is increasing: 7,278,000MT (2000) to 10,215,000MT (2012).The average net imports are ≈ US$ 7.5M for Maize grain per year & Consumption per capita was 145Kcal / day(2009).

Mono cropping occurs in the major production areas, which include the volcanic highlands, the Congo-Nile Crest and Umutara and where maize is a basic food for small-scale farmers. In total these areas account for about 60% of total production. According to data from MINAGRI's department of statistics, Gisenyi was the highest producer in 2000, followed by Ruhengeri and Cyangugu. Also, Gisenyi and Ruhengeri were the only provinces which registered positive growth in output over the period 1987- 90, with Gisenyi having an increase in output of about 77%.It is especially in monoculture on large farms generally held by farm cooperatives reported by MINAGRI (2011). As like other crops maize will contribute to achievement the government target of Vision 2020 through different focuses eradication of widespread poverty and assurance of equitable growth. Vision 2020 aims to average a GDP growth rate of 8.5% per annum, which will enable the country to attain Vision 2020 targets of: A GDP per capita increase to US$ 960 at the present value (currently US$ 644); Reducing population living below the poverty line to 25% (currently 65%); Increasing life expectancy to 65 years (currently 49 years); and Increasing literacy rate to 90% (currently 48%).

Crop	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Sorghum	227,972	187,380	164,406	144,418	174,553	161,229	151,754
Maize	97,251	96,662	101,659	166,853	286,946	432,404	525,679
Wheat	21,942	18,978	24,195	67,869	72,479	77,193	90,684
Rice	62,193	60,446	61,797	82,025	81,081	67,253	80,541
Sub-total	**409,358**	**363,466**	**352,057**	**461,165**	**615,059**	**738,079**	**848,658**
Beans	199,648	296,724	328,811	308,563	327,728	327,497	331,166
Groundnuts	15,105	9,020	9,921	11,122	15,353	14,369	14,756
Soybean	16,355	28,779	44,163	50,931	54,203	57,089	57,426
Peas	21,195	17,643	19,450	21,689	33,855	37,999	37,909
Su-total	**252,303**	**352,166**	**402,345**	**392,305**	**431,139**	**436,954**	**441,257**
Total	**661,661**	**715,632**	**754,402**	**853,470**	**1,046,198**	**1,175,033**	**1,289,915**

Table 1: Grain and pulse crop production (t) from 2005 to 2011
Source: NISR, 2012

Quantity marketed has been increasing, implying maize markets are assuming greater importance in the fight for food security and household incomes. Maize has multiple uses than any other cereals. It is used mainly as a food for human consumption. It is also the number-one feed grain in the country, being the main source of calories in animal feeding and feed formulation. Indicate by MINAGRI (2007) Maize production is an important means of livelihood among the people of Eastern province, Rwanda. Maize crop has been taken into consideration as a major crop in Rwanda during the starting system of crop intensification after war when government encouraged farmers to plant maize for the poverty reduction, food security and for the effort of increasing rural household incomes By providing farmers with selected seed and chemical fertilizers, the government sped the transition from other cereals like sorghum to a maize crop in the purposes of food economy. After the War, the development of export markets encouraged maize production and by 2005s, maize was established as the dominant food crop in much part of Rwanda MINAGRI (2009).
The results of this research study will serve as a key training tool for transforming maize production from a predominantly subsistence, low input and low productivity activity, to one that is predominantly market oriented. This is aimed at improving household incomes of rural farmers who form the majority of the population in Rwanda. As earlier stated maize is one the major crops in Rwanda, ranking fifth among food crops and second among cereals after sorghum. Maize is cultivated in the whole country and is essentially intercropped with beans. Maize crop has become increasingly important in Rwanda and has recently been targeted by the Ministry of Agriculture in its fight for food security, household incomes and the enhancement of nutritional standards. Maize has also become popular due to its high market potential and easy storage and its production is expected to increase MINAGRI (2011).

Evolution of maize	**Periods (averages and/or sums on the 2 seasons A and B)**						
	2005	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Importance (%)	6.95%	7.05%	8.3%	8.5%	8,7%	13.7%	19.3%
Cultivated area (ha)	109,400	113,312	141,168	144,896	231,607	306,789	322,548
Yield (kg/ha)	761	766.5	722,8	915.75	1.198.6	1,794.8	2,215
Production (tons)	97,251	96,662	102,447	166,853	277,604	550,625	714,595

Table 2: Evolution of maize importance (%), cultivated area (ha), yield (kg/ha) and production (tons) in Rwanda
Source: NISR (2012) and MINAGRI (2011).

2.7. Maize Production in Gatsibo

Gatsibo District is one of the seven Districts making the Eastern Province. It is divided into 14 Sectors into 69 cells and 603 villages. It has an area of 1585, 3 km2. The District borders with the Akagera National Park in East, to the North by Nyagatare District; to the West by Gicumbi District, to the South by Rwamagana and Kayonza Districts (**www.gatsibo.gov.rw***)*. Agriculture in terms of crop production and livestock is the principle economic activity. According to EICV3, 84.9 % of Gatsibo population both men and women basically depend on agriculture whom, at least 80% use traditional agriculture practices. The major food crops produced are beans, rice, Irish potatoes sweet potatoes, bananas, sorghum, cassava, passion fruits, peas, maize and soya. According to EICV3, Maize crop production is 49.2%, sorghum is 28.3% and Rice 2.2% while the key cash crops are coffee and pepper. Usage of inputs like fertilizers is relatively low at (49.5%EICV3) of farming households.
According to EICV3, 84.9 % of Gatsibo population both men and women basically depend on agriculture (Crop production and Livestock farming). 63.9% males and 78.7% female engage in small scale farming. There is a significant improvement in use of fertilizers both organic and mineral fertilizers, improved quality seed and land consolidation was made at (23735ha, District report) Mechanization center has been established in the District and so far (457 ha District report) of land was ploughed using tractors

2.8. Distribution of Farm Inputs

Access to improved inputs has long been inhibiting the farmers from raising the productivity levels. The access was curtailed by the low demand and costs which are further amplified by the difficulties in transportation to rural areas. To overcome these constraints, CIP took a supply push approach whereby the inputs are initially supplied by the government and the farmers are persuaded to use.

2.8.1. Improved Seeds

To augment increase in productivity of these crops, CIP imported improved seeds from the neighboring countries such as Kenya and Tanzania in the region. In 2008, 765 tons of seeds of maize and wheat were imported for cultivation in season A. The amount gradually increased from 1200 t in 2009A to 3512 t in 2011 A. In addition, improved planting materials (cuttings) of cassava and potato were also distributed to farmers (Table 1).

Crop	**2008A**	**2009A**	**2009B**	**2010A**	**Total**
Maize	520	893	179.58	1,417	3,009.58
Wheat	60	327	300.85	181	687.85
Cassava	42,932,600	95,987,000	0	0	138,919,600
Beans	0	32	28	0	60
Potatoes	400	0	0	0	400

Table 3: Distribution of improved seeds (tons) and planting materials (units) under CIP
Source: MINAGRI (2009)

Under CIP, the use of improved seeds by farmers has risen from 3% to 40%. By encouraging farmers to use improved seeds, CIP has substantially increased the local demand and the capacity for seed production. With the exception of hybrid seeds, the open pollinated varieties of maize and self pollinated varieties of wheat, rice and beans are multiplied by public (RAB) and entrepreneurial farmers in the country reported by MINAGRI (2011).

2.8.2. Distribution of fertilizers

At the beginning, MINAGRI was performing the functions of bulk purchase of fertilizer and was managing fertilizer stocks. The distribution of fertilizers was carried out by private distributors (wholesalers) and agro-input dealers (retailers). The MINAGRI was auctioning the fertilizers to private distributors. Distributors use to sell fertilizers to agro dealers who in turn were selling the fertilizers to farmers at fixed prices set by MINAGRI. The agro dealer network is well developed and each sector has at least one agro-input dealer. The voucher and fertilizer loan system was introduced to help farmers who have a low purchasing power to buy fertilizers. The voucher consists in giving 50% of the required fertilizers free (as a subsidy) and the farmer is given the portion of 50% as a loan expected to be paid after selling the yield MINAGRI (2009).

The MINAGRI together with Rwanda Agricultural Board (RAB), Districts extension workers in collaboration with private advisory service providers have the task of promoting fertilizer use and management. The promotion was done via demonstration field trials, training and the Farmer

Field School (FFS). That system has yielded some positive aspects related to awareness of farmers with regards to the importance of fertilizers in the overall crop production process and the general increase in productivity. However, one serious constraint remained unsolved: most of the farmers were not paying back the fertilizer loan contracted. Unrecovered loans have accumulated overtime and this has yielded a situation of continuous deficit. In 2012, the Government decided to introduce a new initiative in the supply chain which is the privatization of the fertilizer market.

This change is expected to bring a new incite to farmers who will continue to get the 50% subsidy for cereals and 30% for rice but will pay the remaining directly from agro-dealers cooperatives indicated by MINAGRI (2011). This new system was launched for season A 2012 (September 2011) in six pilote Districts (Nyagatare, Gatsibo, Ngoma, Kirehe, Rwamagana and Kayonza) MINAGRI (2009, 2011).

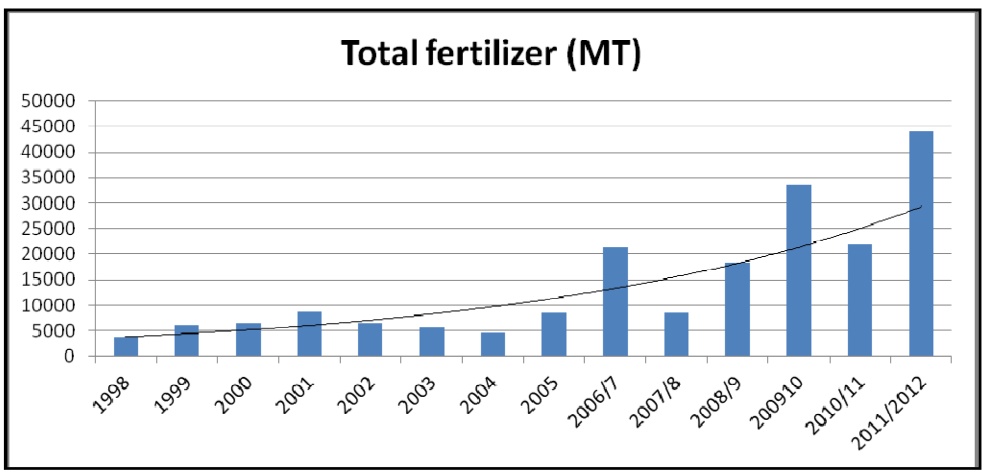


Figure 4 : Trend of fertilizer importation for the period of 1998 to 2012
Source: MINAGRI, 2011

Through bulk orders, CIP imported 6,000 tons of fertilizers and distributed to farmers for free through various service providers. About 83% of fertilizers were used by farmers growing maize, wheat, rice and potato. In 2009, CIP imported 14,427 tons and distributed to maize and wheat growers at subsidized rates (50%) covering the overhead (transportation and administrative costs) from Mombasa to rural areas were covered by the government. CIP continued to import and distribute in 2010 (33,500 t) and 2011 (22,000 t). To access these fertilizers at subsidized prices, CIP distributes vouchers to farmers through service providers.

The farmers buy fertilizers from the distributor/dealer by presenting the vouchers. The distributor transacts the vouchers at the financial bank outlets which in turn collect from MINAGRI. Estimates suggest that as a result of these efforts, the national average fertilizer use per year has increased from 8 Kg/Ha to 23 Kg/Ha in 2010 indicated by MINAGRI (2011). However, fertilizer use differs across the country with use more pronounced in some districts than others. The role of MINAGRI and its agencies is to increase fertilizer use in districts where it is still low. In seven districts, farmers used in excess of 1000MT in season 2015A.These districts are Nyabihu(2127MT),Rubavu(1689MT),Musanze(1586MT)and Burera(1560MT),Gatibo(1149MT) and Rusizi(1040) MINAGRI (2015). The rest rate is below these quantities. The pattern of fertilizer use differs across the country and is dependent on the major crops grown in specific districts. According to MINAGRI (2015) NPK 17-17-17 is the dominant fertilizer used in Nyabihu, Rubavu and Musanze, accounting for 91%, 79% and 63% of the fertilizer used in these districts, respectively. This fertilizer is used on Irish potatoes, which is the major crop grown in these districts. DAP and UREA was the dominant fertilizer used in Gatsibo district which correspond to maize that is the major crops grown. Generally, most fertilizers used on staple crop go to Irish potatoes, maize, rice and wheat. However from 2015, MINAGRI begun encouraging farmers to adopt fertilizers use on beans, soya bean, cassava, bananas, fruits and vegetables. There is a significant use in fertilizer used by vegetables. There has been an improvement in fertilizer use for especially staple crops. A seasonal agricultural survey (SAS) for season 2013A (September 2012 to February 2013) conducted by the NISR reported 17% of small scale farmers used inorganic fertilizers. The survey conducted in last corresponding season 2015 (September 2014 to February 2015) reports an increase (21.1%) of small farmers using inorganic fertilizers. It is observed that 54% of large scale farmers used inorganic fertilizer in 2015A, large scale farmers as individual or groups of farmers cultivating crops together on 10Ha or more. At the beginning of CIP in 2007 fertilizer uses in Rwanda were 4kg/Ha compared to the current 32kg/Ha. On average, farmers have increased productivity by three fold for maize, fivefold for wheat, and two fold for rice and Irish potatoes demonstrated by MINAGRI (2015). This has been instrumental in contributing to improved food security, incomes and reduced poverty. Rwanda dependents on imports for its fertilizers needs; therefore, fertilizers prices in the country are dependent on world fertilizer prices and transportation costs. There has been an increase in fertilizer and fuel prices over the years. Additionally, there has been a weakening of the Rwandan franc against the major foreign currencies.

Main season	Non subsidized(Rwf)			Subsidized(Rwf)		
	NPK/Kg	DAP/Kg	UREA/Kg	NPK/Kg	DAP/Kg	UREA/Kg
2010-2011	400	490	340	320	245	170
2011-2012	475	600	470	380	350	240
2012-2013	550	600	500	440	300	250
2013-2014	650	750	630	545	375	315
2014-2015	640	700	570	550	470	410
2015-2015	635	720	558	540	645	390

Table 3 : below shows fertilizer prices for the last 6 years.
Source: MINAGRI (2015)

The table clearly shows that there has been an increase in fertilizer market prices (None subsidized price). Further, the increase in the subsidized fertilizer price has an added element of a reduction of government subsidy. The fertilizer subsidy is an instrument used to promote fertilizer and increase in it use. MINAGRI is implementing since 2007 when CIP begin. After 6-7years of subsidies of 50% for DAP and UREA and 20% for NPK, the subsidies have now reduced to about 35% for DAP, 30% for UREA and 15% for NPK. The increase in the market fertilizer prices is a combination of the increase in market prices and reduction in subsidies stated by MINAGRI (2015).

2.8.3. Doses of fertilizer inputs (Kg/ha) for some crops

Many LDCs including Rwanda depends its live on agriculture sector production, but non recommended farm inputs play a large role in agricultural production, especially because of the need to increase production. The use of fertilizer is different from district to another some district use high quantity while other uses few one. Around 90% of farmers in Musanze district use fertilizer which has been so important and contributed greatly to the improvement of farm yields say Uwase Clemence, district fertilizer agent at the district. For Irish potatoes, the cooperative uses 300kg of NPK per hectare, 50kg of DAP for maize, 100kg of DAP for wheat and 50kg DAP beans. In some parts where farmers have not used fertilizer, there has been a great reduction in farm crop yields. Unfortunately the main limiting factors for the diminishing performance in maize production are associated with the following challenges: no use of improved maize varieties, fertilizers, pesticides, land preparation, poor access to agricultural credit and fluctuations of contract between farmer and buyer. Inputs deficiency in maize plants even at an early stage of crop growth reduced grain yield substantially.

INPUTS(KG/HA)		IRRIGATED LAND	RAIN FED LAND
Fertilizers	**NPK**	250-300	200-250
	DAP	120-150	100
	UREA	75-100	50
	ORGANIC MANURE	20000-15000	10000-15000
Improved seeds	**MAIZE**	24-30	20-25

Table 4: Recommended inputs for best farming for maize
Source: MINAGRI, 2011

Yield of maize remains the same over a wide range of pant populations. On an average 45000-
60000 plants/ha is optimum for good yields. For pure crop 20-25 kg seed/ha when intercropped with soybean 15 kg/ and for fodder maize 40-50 kg/ha. Plant populations that are higher than the optimum will lead to competition among the maize plant resulting into slender plants that will give low yield indicated by MINAGRI (2011). Lower plant population will result into low yields due to reduced number of ears per unit area. Without planting in rows, a farmer will never achieve an optimum plant population. In addition, rows ease field operations like weeding, top dressing if it is needed and will facilitate harvesting. Figure 6 shows a well mono-cropped plot of improved maize varieties (DH04) in Shikamukore and Ubuhoro zones of farming.

Figure 6: planted maize in farm and in hangar (Source: Researcher Gaspard, 2015)

For the best output from maize to be realized for a model farmer in Gatsibo, proper timing should be done coupled with the following availing the following inputs.

Inputs of activity/ha		Quantity/ha	Unit price/Rwf	Total Amount/Rwf
Seeds		24	460	11040
Chemical fertilizer	DAP	100	470	47000
	UREA	50	410	20500
Organic fertilizers		15000	15	225000
Pesticides		3	11000	33000
Organic fertilizers application		10	500	7000
First tillage		50	500	35000
Leveling of soil		5	500	3500
Sowing/planting		15	500	10500
First weeding and thinning		12	500	84000
Chemical fertilizers application(1)		10	500	7000
Earthing up		20	500	14000
Chemical fertilizers application(2)		10	500	7000
Harvesting		100	500	70000
Pests control		20	500	14000
Final weeding		12	500	8400
Grains removal		10	2500	15000
Total costs / Rwf		**-**	**-**	**546340**
Total Value of Production/ha/Kg		**3000**	**400**	**1200000**
Profit /Rwf/Ha		**2976**	**220**	**653660**

Table 5 : Farm Inputs and expected harvest 2015A cropping season
Source: MINAGRI 2007

2.8.4. Fertilizer Benefits to the Human Environment

When the right type of fertilizer for a given crop is used in recommended quantities at the right time, fertilizers do generally not harm the environment. Fertilizers also have numerous positive impacts on the environment some of them direct others indirect. Positive impacts include: Improvement of farming efficiency for example maize production levels in region: Without fertilizer = 3tonnes 150kgs/ha; with use of compost = 4tomes 525Kgs/ha; both (organic & Inorganic) = 7tonnes 875kg/ha and Inorganic only (DAP & UREA) = 5tonnes 350Kgs/ha. Economic productivity: Yields of CIP target crops showed encouraging results. Wheat yields more than doubled and maize yields increased by about 90% Morris *et al.,* (2001). Thus household incomes have increased due to increased production levels as presented in table below.

Year	Fertilizers Import (tons)	Crops Production (Mt)
2006	13942	7166567
2007	22443	7098512
2008	17533	8234188
2009	33500	9261945

Table 6: Fertilizers import vs crop production in Rwanda
Source: MINAGRI (2010)

An increased use of inorganic fertilizers will result in the production of healthier crops with increased crop cover and increased biomass production (crop residues), which in turn reduces soil erosion and contributes to building-up soil organic matter levels, increasing water holding capacity and microbial activity, leading to prevention of soil degradation. About 85% of the maize produced in Rwanda is grown by peasants whose farms are less than 2 ha. Time and method of fertilizer application in case of rain fed crop, all the fertilizers are applied in single dose as basal dressing. Place the fertilizers 10 cm away from seed rows and 5 cm below the seed. In Rwanda maize is harvested by hand immediately after it is mature and dry. Most maize is stored in gunny bags as well as the modern storage structure. Improved maize varieties mature within 90-150 days depending on agro-climatic region MINAGRI and RAB (2007). Test for maturity is that the husk cover turns pale brown and the grains are too hard to be pressed in with finger nail. The maize may be harvested at about 20% grain moisture. Enough time should be given for drying and shelling. Generally, the plants are left in the field for one or 2 days after harvesting. The grains dry up during this period. Remove the husk and maize are kept in sun for 2-3 days before shelling. After shelling, the grains may be cleaned, dried thoroughly and stored at 10 to 12% grain moisture. The optimum moisture for best popping is 12-14%. Therefore, grain is to be stored at 12% moisture in water proof bags. Yield of maize estimated to be 3.5-7 t/ha for Hybrids and 1.5-2 t/ha for locals/traditional MINAGRI (2010).

2.9. Summary

This chapter has outlined in considerable detail the physical or technical relationships underlying the factor-product model. A production function was developed using tabular, graphical, and mathematical tools, with illustrations from agriculture. The law of diminishing marginal returns was introduced. Marginal and average physical product concepts were developed. The rules of calculus for determining if a function is at a maximum or minimum were outlined, using a total physical product and marginal physical product concepts to illustrate the application. Finally, the concept of an elasticity of production was introduced, and the elasticity of production was linked to the marginal and average product function. This chapter provided a background description of the study area, an explanation of how, and what data will be obtained, and analytical methods that will be used to obtain results for the thesis. Based on this framework, the chapter highlighted the major strengths of this thesis. Factors influencing the increased maize production in Rwanda, the extensive number of explanatory variables considered to make the empirical model more reliable, and finally the use of improved maize varieties, fertilizers, and factors of production in Rwanda.

2.10. The Research Gaps

Clayton (1964) noted that it is important to know the problem facing peasant agriculture if they are related to raising agricultural productivity. Schultz (1965) says that the technological possibilities have become increasingly more favorable but the economic opportunities that are required for farmers in the low-income countries to realize their potential are far from favorable.

Hayami and Vernon (1971) hypothesized that the agricultural productivity gap among countries is based on differences in the prices of modern technical inputs in agriculture and differences in the stock of human capital capable of generating a sequence of innovations. Technological change will have an income effect and a substitution effect; the first one occurs through a real increase in efficiency so that output is increased with no increase in labor input. Technological change may have important interaction with labor input. On process, the study recognizes that there is very little comprehensive research that focusing on how in the specific manner to analyze the factors influencing maize production among farmers in Gatsibo district so, the previous studies have rarely been considered. Consequently, the farmers in region should never use even one factor of production properly while the previous studies indicated that there is no single factor has been identified as the factor affecting the quantity of increased maize production more than the other in region. The Studies also indicate that the farmers have little technical information on how to apply all inputs affecting the maize cultural practice of cause they frequently failed to explain why their maize production quantities move downward despite the efforts to adopt most farming practices to increase the production of maize in their farms. The study indicated the profitability of improved maize varieties in this study, the best method of fertilizer application to maximize output per unit area and effect of market price and place on the increased maize production in study area.

3. Research Methodology

3.0. Introduction

This chapter contains a description of: Research design, The Study area, Population and sample, Instrument and tools for the study, Conceptual framework, Estimation Data types and sampling procedures techniques, Source of data, Data processing and analysis and finally timeline and budget for research study**.** To gain answers to the research questions, this research will be planned into two main steps summarized in figure below.

The following figure shows the framework of activities in this research:

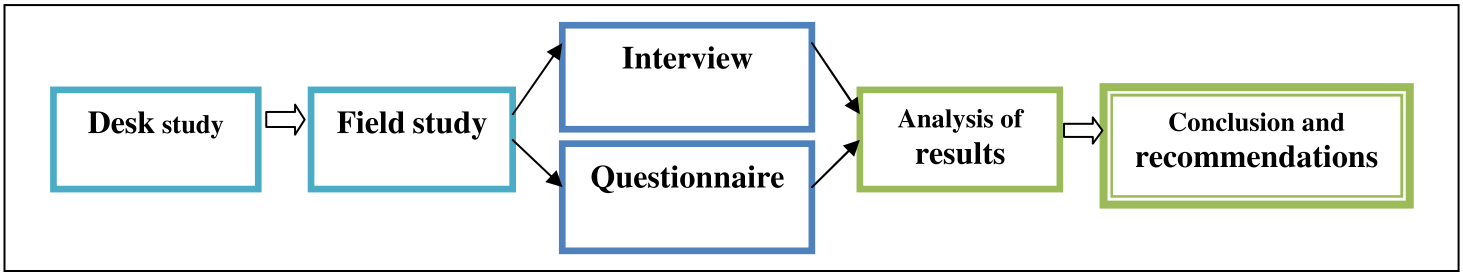


Figure 7: Frameworks of activities

3.1. The Study Area

Gatsibo District is one of the seven Districts making the Eastern Province. It is divided into 14 Sectors which are; Gasange, Gatsibo, Gitoki, Kabarore, Kageyo, Kiramuruzi, Kiziguro, Muhura, Murambi, Ngarama, Nyagihanga, Remera, Rugarama and Rwimbogo. It is also divided into 69 cells and 603 villages. The District borders with the Akagera National Park in East, to the North by Nyagatare District; to the West by Gicumbi District, to the South by Rwamagana and Kayonza Districts (DDP 2013-2018). Through CIP mono-cropping of this crop occurs in the major production areas and is also a basic food for small-scale farmers. Maize is grown for both commercial activity and subsistence by farmers of different study area.

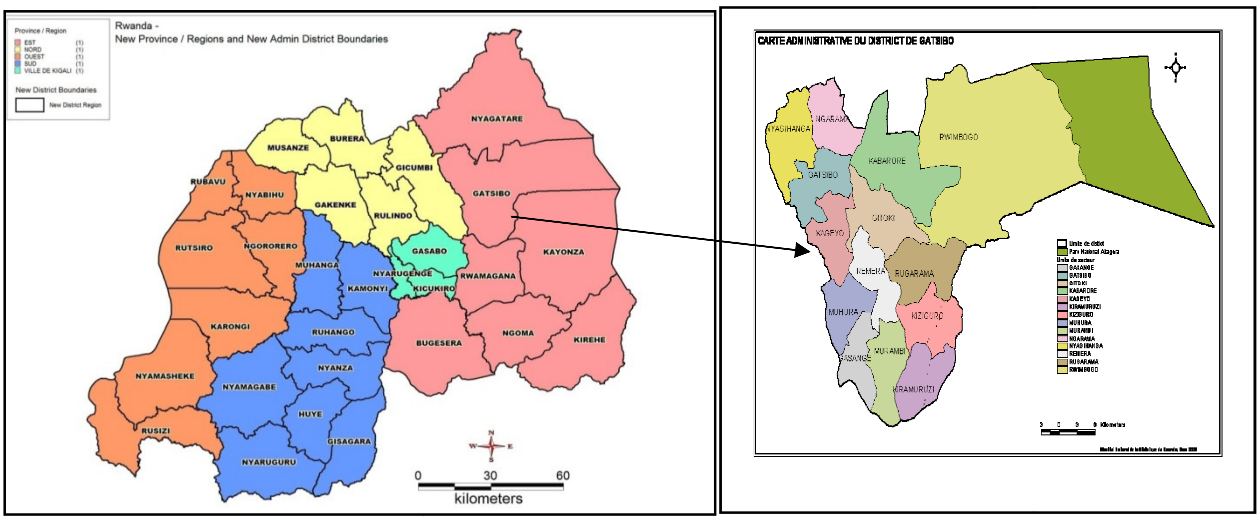


Figure 8: Gatsibo district where research was conducted and where respondents are located.
Source: Monograph of Gatsibo district (2012)

3.2. Research design

It involves describing the facts and characteristics of a given population or group by means of such instruments as interview schedules, and questionnaires. It may generally employ a structured questionnaire and the emphasis is on generating an accurate picture of relationship between and among variables. Descriptive studies typically rely heavily on cross tabulation analysis or other means of investigating the association among variables such as regression analysis. The great majority of descriptive studies were cross-sectional, although some use longitudinal information stated by Churchill (1995). Descriptive research typically describes what appears to be happening and what the important variables seem to be. According to the available resources and time allocated to the study a sample size of 70 respondents has been considered adequate for the study given the number of population study of 84. The sample size of population to be considered during the research study is a descriptive study Abbot B. (2005) and C.R Kortari (2004).

3.3. Target population and sample

Target population study is a study of a group of individuals taken from the general population who share a common characteristic, such as age, sex, or health condition Kombo and Tromp (2006).According to the 2012 National Census provisional results, the total population of Gatsibo District increased from 283,456 in 2002 to 433,997 in 2012. Gatsibo District has population density of 275 persons per square kilometer. The increase in the population represents a growth rate of 53.1% between 2002 and 2012. Males represent 48% of the population whereas females represent 52% of the population. The study population for this research was 84 respondents while70 respondents have been taken as sample size. These numbers form at least 12 farmers from each zone which is the average target number of farmers per zone engaged in maize production on a commercial. It was supported by Kothari (2004), suggested that a representative sample is one which is at least 10% of the target population. The farmers were randomly selected because they were the group of farmers who are model on the factors of production as the farming is mainly done for commercial purposes. The sample size to be employed for the identified target population was scientifically computed through Krejcie and Morgan (1970) formula.

S = X^2NP (1-P)/ d2 (N-1) + X2P (1-P)
Where:
S = required sample size
X^2 = the table value of chi-square for one degree of freedom at the desired confidence level
N = the population size
P = the population proportion (assumed to be.50 since this would provide the maximum sample size)
d = the degree of accuracy expressed as a proportion (.05)

Zone of farming	Study population	Sample size	Sampling technique
Abifatanije	12	10	Randomly
Dukanguke	12	10	Randomly
Indatezuka	12	10	Randomly
Indushabandi	12	10	Randomly
Isonga	12	10	Randomly
Shikamukore	12	10	Randomly
Ubuhoro	12	10	Randomly
TOTAL	**84**	**70**	Randomly

Table 8: Study population and sample size
Source: Researcher, (2015)

3.4. Research Instruments
The instruments used in it were mainly questionnaires, interviews and own observation

3.4.1. Questionnaire
Kothari (2004) defines a questionnaire as that consisting of a number of questions printed or typed in a definite order on a form or set of forms. The researcher constructed close-ended and open-ended questions, which was administered to the farmers of maize crop within Gatsibo district. A questionnaire was designed for the purpose of gathering information from respondents.

3.4.2. Interview
An interview is a conversation between two or more people where questions are asked by the interviewer to elicit facts and statements from the interviewee. This method is flexible, more explanatory in nature; first hand information is collected to ensure the research achieves its objectivity indicated by Weiss (1994). This verbal communication between two or more people help to gather the desired information on the research questions and other particular information related to maize production in Gatsibo district.

3.4.3. Observation
The observation technique has been used in order to verify whether what the respondents had in their respective households and field were not different from answers given through the questionnaires and interview.

3.5. Data Collection Procedures
The researcher acquired a permit from the district office to conduct the research study. The permit facilitated the researcher to administer the questionnaires to the farmers. By taking household as a basic sampling unit, the study was primary data collected on farm output of maize crop for the period of at least three years. Due to different characteristics of respondents, the sampling followed this procedure:
The cluster and systematic sampling was used to know the number of respondents to interview in each cluster. This method was most frequently used in the field. The objective of this method was to choose a limited number of smaller geographic areas in which simple or systematic random sampling can be conducted indicated by Kortari (2004). It is therefore a multi-stage sampling method very often completed in 2 stages. First stage was the random selection of clusters. The entire population of interest is divided into small distinct geographic areas. At this stage, the primary sampling unit was the village (Zone. Second stage was a random selection of households within clusters. Households were chosen randomly within each cluster using simple or systematic random sampling. Each respondent to this study area was selected according to their role in the management of maize production.

Name of Cooperative	Type of Respondents	Number of Respondents	Function	Gender of Respondents	
				Male	**Female**
KOAIGA-IMITOMA	Farmers	70	Producers	49	21
TOTAL		**70**		**49**	**21**

Table 9: Repartition of Respondents for questionnaires
Source: Primary Data (2015)

Responsible from cooperative has been selected depending on their direct contact with the farmers such as the accountant who is in charge of payment after farmers supplied their maize, the Manager who coordinates all activities related with the cooperative and the agronomist who day to day carry out all activities related with the field. Since questionnaires was administrated to the head of family and/or others members of family who participate in agricultural activities. The questionnaires in English, which is not known by the majority of the study population, the researcher read, interpreted and translated questions to the participants in their local language they understood best. The interview was a technique that aims to facilitate communication between both researcher and respondent. Observation was also another method been used by researcher in this research to see and analyze whether what the respondents had in their respective households and field are not different from information gathering through the questionnaires indicated by Churchill (1995). Ten persons with Diploma-level training in agriculture who were good at both local and English language had an intensive one-day training session on data collection techniques prior to the survey. Both qualitative and quantitative primary data were collected by way of open-ended and structured questions administered through personal interviews with the selected respondents as outlined in the previous section.

3.6. Source of Data

For primary data collection, survey (communication) methods could be used in different ways such as personal or group interviews, telephone and email surveys. In addition to that observations may also be used for primary data collection (Churchill, 1995). This study used a personal to collect data which raise a host of questions with respect to selection, training and supervision or control of the field staff questions that must be anticipated in designing research suggested by Churchill, G.A., Jr., (1995).

Pre-testing of the questionnaire was conducted in the midi date of July 2015 by interviewing the experienced farmers. It was usually take a small number of 12 respondents who are not part of the actual survey. The information obtained from the pre-test was used to revise the questionnaire to make it more focused and easier to administer. After incorporating the lessons learned from the pre-test, the questionnaire was ready for administration, and then full data collection has been conducted from 27 to 31 July 2015 in Gatsibo eastern Rwanda.

3.7. Data Processing and Analysis

The research study adopted both the qualitative and quantitative analysis in order to achieve the objective of the study. As suggested by Cooper (2003) qualitative research includes an array of interpretive techniques which seek to describe, decode, translate and otherwise come to terms with the meaning, not the frequency of certain more or less naturally occurring phenomena in the social world. The appropriate analysis for this study was descriptive analysis and regression analysis by use of SPSS and STATA software. The basic line of economics of agricultural productions at the micro level was to assist farmers to attain their objectives through efficient farm allocation of resources over a given period of time. Profit maximization could be achieved by maximizing output from a given resource or minimizing the resources required for a given output. Agricultural productivity is equivalent with resource of productivity which is the ratio of total output to the resource divided by inputs being considered indicated by Olayide, et al., (1982).

A production function is that which specifies the output of a farm, an industry, or an entire economy for all combinations of inputs. This function is an assumed technological relationship, based on current state of engineering knowledge. Almost all economic theories presuppose a production function, either on the firm level or the aggregate level Daly, (1997); Cohen and Harcourt (2003). The production function of any farmer is determined by resource availability of the farmer. In agriculture, the production inputs consist of Land and Capital as the basic factors of production. The expected relationship between output and land is that as more land is brought under production, output is increased demonstrated by Malassis (1975).

3.7.1. Analytical Study

Descriptive statistical (means, distribution frequency, and percentages) quantitative methods were used to analyze the social economic characteristics of respondents. The gross marginal analysis was used to determine the overall the gross margin and net return per hectare as well as to measure Net returns analysis was used to determine the level of profitability of improved maize varieties. According to Olorusanya and Akinyemi (2004) Gross margin of an enterprise is defined as the enterprise's financial output minus its variable costs. The use of gross margin became widespread from 1960‟s, when it was first popularized amongst farm management advisers for analysis and planning purposes Barnard and Nix (1993). Gross margin is used as the best estimator of short-run profit. The gross margin of a particular farm enterprise can then be compared with enterprises in similar farms in the area. Idris (1992) indicated that, in an economic study to access the profitability of enterprises either singly or in combination with other tools, showed the net return derivable from an enterprise after all the values of input used in such enterprises have been deducted. More studies have used gross margin for economic analysis of various enterprises. The study of Zeller *et al.,* (1997) indicated that in Malawi, used gross margin analysis to understand its implications on technology adoption and agricultural productivity. Okon and Enete (2009) used gross margin analysis to estimate the cost and return to urban vegetable production in Nigeria. Odoemenem (2011) used gross margin analysis to do economic analyses of rice in Cross River State Nigeria. In this study gross margin was used to analyze the profitability of improved maize varieties by comparing gross margin and net returns of farmers who use local maize seeds and those used improved maize seeds in the study area. Profitability is measured with income and expenses. Increasing profitability is one of the most important tasks of the business managers. Managers constantly look for ways to change the business to improve profitability. These potential changes can be analyzed with a pro forma income statement or a Partial Budget. Partial budgeting allows you to assess the impact on profitability of a small or incremental change in the business before it is implemented by Robert Tigner (2009).

There was a significant difference between two varieties towards the farmer's profit. In short run business Gross margin equal to Profit.

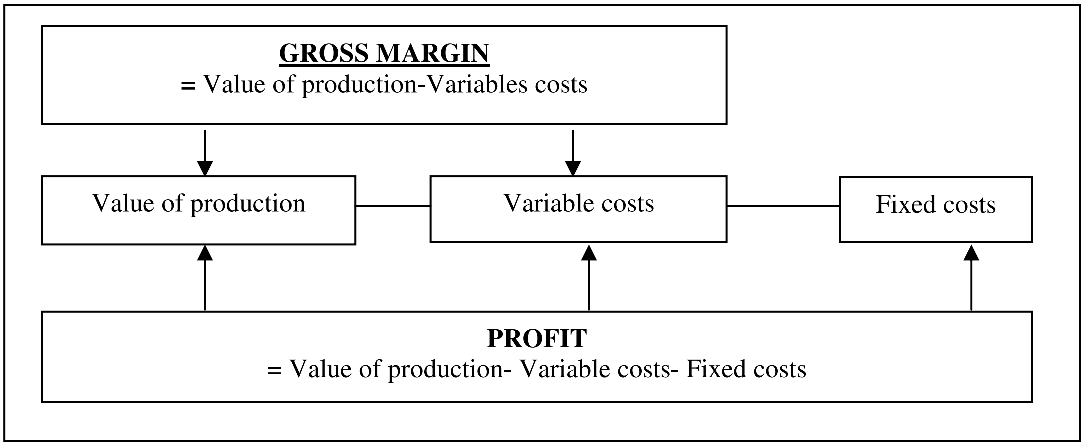


Figure 9: Gross margin and profit

Gross margin and Net returns were estimated as two equations (1) and (2):
GM = TR –TVC ……… …………………………………………. (1)
NR=NP = TR –TC …………………………………………..… (2)
Where:
TR = Total Revenue TR=Price x Quantity
TVC = Total Variable Cost TC= Total Fixed costs +Total Variable costs
TC = Total Cost

3.7.2. The Regression Model

The regression analysis has been use to estimate the level of relationship between maize outputs and explanatory variables used in this production study. According to Banaeian et al (2011) Cobb-Douglas production function was used to estimate the effect of factors influencing maize production in region. To assess the production performance of maize in area a linear regression has been taken as important.

Regression model used in this study is specified as follows:

$$Y = f(X_1, X_2, X_3, X_4, X_{5\ldots Xn}) \ldots\ldots\ldots (3)$$

Where:
Y = output or yield
X’s are different inputs that take part in the production of Y

$$LnY = \beta_0 + \beta_{1Ln\,X1} + \beta_{2\,ln\,X2} + \beta_{3\,Ln\,X3} + \beta_{4\,Ln\,X4} + \beta_{5\,Ln\,X5} + \beta_{6\,Ln\,X6} + \beta_{7\,Ln\,X7} + \beta_{8\,Ln\,X8} + \varepsilon \ldots\ldots\ldots (4)$$

Where:
Y = the quantity of maize produced (kg);
β_0=Constant
β_1-β_8= Parameters to be estimated
X_1 = land for maize (ha);
X_2 = labor used for all activities in maize production (person days);
X_3 = amount of organic fertilizer applied in kg
X_4= amount of chemical fertilizer applied in kg
X_5=Education level in term of years spent in School
X_6= Variety of seeds in kg
X_7=Farming experience in term of years
X_8= Price of maize per kg in terms of Rwf
Ln=Natural logarithm
ε= Error term

3.7.3. Output Elasticity and Returns to Scale

The determination of production elasticity becomes necessary for the estimation of responsiveness of yield to inputs. Output elasticity for each of the inputs calculated at the variable means is of great importance in this case Awudu & Eberlin (2001).The elasticity of output with respect to the Using Equation (5), output elasticity with respect to input, X1 evaluated at the sample mean can thus be computed from the following Equation:

$$eX1 = \frac{dLnY}{dLnX1} = \beta_1 + \beta_{1LnX1} + \beta_{2LnX2} + \beta_{3LnX3} + \beta_{4LnX4} + \beta_{5LnX5} + \beta_{6LnX6} + \beta_{7LnX7} + \beta_{8LnX8} \ldots (5)$$

The elasticity of output with respect to the number of input measures the responsiveness of output to a 1% change in the number input. The measure of returns to scale, RTS representing the percentage change in output due to a proportional change in use of all inputs, is

estimated as the sum of output elasticities for all inputs Brayton, G. N. (1983). If this estimate is greater than, equal to, or less than one, we have increasing, constant, or decreasing returns to scale respectively:
Ep > 1, Increasing Returns (I Stage of Production)
Ep = 1, Constant Returns. Ep is one at MPP = APP (At the end of I stage)
Ep < 1, Diminishing returns (II Stage of Production)
This relationship helps the producer in the determination of optimum input to us and optimum output to produce. Price ratio is the choice indicator. This relationship is explained by the law of diminishing returns. This law state that when increasing quantity of a variable input are used together with a fixed input eventually total product, average product and marginal products diminish.

4. Findings and Discussion

4.0. Introduction
This chapter represents two major sections. The first section represents the descriptive results of household characteristics while the second section of the chapter represents the regression results of models used. Specifically the second section represents profitability analysis of improved maize varieties on maize production, best method of fertilizer used to maximize output per unit area, and finally the effect of market price and place on the increased maize production. The methods of analysis used were descriptive statistics, gross margin analysis and production function analysis using the Ordinary Least Square (OLS) criterion to estimate the parameters of the production function through SPSS and STATA software.

4.1. Descriptive Results
The study identified the characteristic of the respondents. The findings such as frequency, percentage and mean are presented in the different tables and graphs below. The table 10 shows the gender distribution of respondents in the study area.

Gender	Frequency	Percent
Male	49	70.0
Female	21	30.0
Total	**70**	**100.0**

Table 10: Gender distributions of respondents
Source: primary data (2015)

The study indicated that 49(70 %) of the respondents were male and 21(30%) were female. This implies that most of those who participated were male and are the most likely to be participating in maize farming. This should positively impact the increase in maize production as male are main leaders of family. The table 11 shows the age distribution of respondents in the study area.

Ages	Frequency	Percent
18-25	2	2.9
26-35	14	20.0
36-45	28	40.0
46-55	21	30.0
Above 55	5	7.1
Total	**70**	**100.0**

Table 11: Ages distribution of respondents
Source: primary data (2015)

Results showed that the age of respondents ranges between 18 and 56 years. This range of age should positively impact on the increased maize production through quick adoption of new technology rather than oldest farmers above 55 years who conserve their own ideas. The reasons why majority of the respondents were ranged between18-56 years old because they are group of people who own farms hence are able to practice maize farming. The table 12 shows the family size distribution of respondents in the study area.

Family size	Frequency	Percent
1-2	4	5.7
3-4	7	10.0
5-6	44	62.9
5-8	12	17.1
Above 8	3	4.3
Total	**70**	**100.0**

Table 12: Family size distributions of respondents
Source: primary data (2015)

Results indicated that (84.3%) of the respondents are in the range of between 5-8 members of household in study area. This is a very significant impact on output through the supply of labors from same household and that minimize the costs of respondent due to low demand of labors. This was supported by the studies like Seidu (2008) which emphasize those large households are better in providing free labor, indicating the usefulness of larger households in improving farm efficiency. The table 13 shows the education level distribution of respondents in the study area.

Education level	Frequency	Percent
Illiterate	4	5.7
Primary	35	50.0
Secondary	14	20.0
Vocational	10	14.3
University	7	10.0
Total	**70**	**100.0**

Table 13: Distribution of Education level of respondents
Source: primary data (2015)

Result also indicated that majority of farmers in the study area are educated. Table 13 shows that 94.3% are educated, while 5.7 % are illiterate. This high percentage of educated farmers should have positive impact on the increased maize production through quick understanding of trainings given on the crops management like cultural best practices, pests and diseases control and the adoption of new techniques of production. The support for this study is the study of Nyagaka*et al.,* (2009) on Irish potato producers in Kenya, farmer's education positively influenced farm economic efficiency. It was argued that farmers with higher levels of education were more efficient in production and this was attributed to the fact that educated farmers positively perceive, interpret and respond to new technologies on seeds, fertilizer, pesticides, fungicides, herbicides or markets much faster than their counterparts. Table 14 shows the years of experience of respondents

Experience	Frequency	Percent
Above 6	35	50.0
4-5	28	40.0
3 and less	7	10.0
Total	**70**	**100.0**

Table 14: Distribution of experience of respondents
Source: primary data (2015)

Results demonstrated that (35)50% of the respondents are experienced in producing maize crops over than six years as commercial purpose followed by (28)40% of respondents producing maize crops between 4 and 5 years. This is supposed to have positive impact on maize output through adoption new use of inputs like improved maize varieties and fertilizers. Farming experience has also been found to affect farm output. Various authors have found that experience in farming enhances efficiency Mulwa *et al.,* (2009) in western Kenya observed that farming experience had a positive influence on economic efficiency. Mbanasor and Kalu (2008) also found similar results for vegetable farmers in Nigeria, which coincides with their findings for age. It is expected that experienced farmers have over the years learned from their mistakes and improved their efficiency in production. The farmers with high experience are also easy to be trained on cultural best practices and diseases control through farmers field school in region.

4.2. Regression Analysis of Variables

Explanatory variables	Coefficient	Standard Errors	t	P-value
Constant	-6773.125	9477.594	-0.71	0.478
ln (Land area) (ha)	1549.59	1336.881	1.16	0.251
ln (Labour) (person-days)	5.276567	2.725394	1.94	0.057
ln (organic fertilizer) (Kg hectare)	0.0915357	0.203481	0.45	0.654
Ln(Chemical fertilizer) (Kg /ha)	7.081244	3.200325	2.21	0.031
Ln(improved seeds) in term of kg	21.93655	1348.03	0.02	0.987
ln (Education of the farmer)(years)	31.49665	530.1569	0.06	0.953
ln (Farmers' experience) (years)	361.8635	394.1807	0.92	0.362
Ln(Price / kg)	38.06844	63.43582	0.60	0.551
R-squared = 0.6563 Obs = 70 **Prob > F = 0.0000 F(8,61)= 14.56**				

Table 15: Linear regression estimate of the factors influencing maize production
Source: primary data (2015)

The findings indicated that all eight independent variables(include land size, labors, organic fertilizer, chemical fertilizers, improved seeds, education level, farming experience and price of produce) were positively influenced the increase in maize production and only two independents variables such as labor and chemical fertilizers significantly influence maize production at 10% level in study area. The overall significant of the model was evaluated by the R^2 value. 66% of the variation in maize production is explained by the relationship with the independent variables. This implies that as more of this variable is employed properly, there will be an increase in total output of maize. This was also supported by Ojo (2000). The findings indicated that output from maize production is positive related to land as shown by a positive coefficient of the study. This means that 1ha increase of land for maize farming will increase maize output by 1549.59 kg. In this study, majority of households studied hired laborers in different activities of maize production (land preparation, planting, weeding, spraying, harvesting and other related crops management). The results revealed that a 1% increase in labor should increase maize output by 5kg. The results showed that a 1% increase in chemical fertilizer will increase maize output by 7kg. The findings also indicated that 1% increase in use of improved seeds should increase maize production by 21.9kg. Findings also showed that 1 year increase in education level should increase maize output by 31kg. The study indicated that 1 year more experienced in maize farming increase maize output by 362kg. The output of maize production responds positively to the changes in market price of maize as shown by a positive coefficient of the study. This implies that a 1% increase in maize produce price increase maize output by 38 kg.

Variable inputs	Elasticity	Returns-To-Scale
Improved Seeds	0.125672	Decreasing
Organic Fertilizers	0.046378	Decreasing
Chemical fertilizers	0.342102	Decreasing
Price of produce	0.512676	Decreasing
Total Return to scale	**1.0268276**	**Constant**

Table 16: Elasticity of production and Returns to Scale (RTS)
Source: primary data (2015)

The findings revealed that the sum of selected inputs (seeds, fertilizes and price) elasticities are unit inelastic. A 1% percent increase in each input results in a less than one percent increase in yield of maize output. However, the resulting returns to scale obtained by summing these input elasticities is 1.0268276.This indicates that maize production in region displayed a constant returns to scale. This was also supported by Moroney, J. R. (1967) in his study. The study shows that yield has the highest responsiveness respectively with price (0.512676), chemical fertilizer (0.342102), improved seeds (0.125672), and lastly with organic fertilizer (0.046378). Even if the price and chemical fertilizer indicated the highest elasticity of production compared with seeds and organic fertilizer but also they are still in the decreasing return one by one. The result of this should be explained by the following reasons there is a tendency by some maize farmers to use both chemical and organic fertilizer in the vegetables like tomatoes. This directly affects maize output through the reduced quantity of fertilizer expected to be applied to the maize crops. In addition to this one, use of top dressing fertilizer as a basal fertilizer may be another problem where many of farmers do not respect time of the top dressing fertilizer and method of applying it. So, this may reduce the effectiveness of the applied fertilizer. Such fertilizer applied improperly does not benefit maize plants since the nutritional requirement come at undesired stage of development. The findings indicated that yield has the lowest responsiveness to the improved seed because some maize farmers have a tendency to use local seeds and some time to do milt-cropping which reduce the density of improved maize variety and affect negatively output of maize in region. It is also indicated that yield has the lowest responsiveness to the organic fertilizer because many farmers of maize crop have a tendency of using organic fertilizer in the vegetables like tomatoes more likely selling to farmers possessed big land.

<table>
<tr><th colspan="2">Maize variety</th><th colspan="2">Frequency</th><th>Percent</th></tr>
<tr><td colspan="2">DH04</td><td colspan="2">42</td><td>60.0</td></tr>
<tr><td colspan="2">PAN53</td><td colspan="2">3</td><td>4.3</td></tr>
<tr><td colspan="2">ZM607</td><td colspan="2">7</td><td>10.0</td></tr>
<tr><td colspan="2">PAN691</td><td colspan="2">4</td><td>5.7</td></tr>
<tr><td colspan="2">LOCAL Seeds</td><td colspan="2">14</td><td>20.0</td></tr>
<tr><td colspan="2">Total</td><td colspan="2">70</td><td>100.0</td></tr>
<tr><td rowspan="2">Output(T) /ha</td><td colspan="2">Improved maize variety</td><td colspan="2">Local maize variety</td></tr>
<tr><td>Frequency</td><td>Percent</td><td>Frequency</td><td>Percent</td></tr>
<tr><td>less or equal to1</td><td>3</td><td>4.3</td><td>14</td><td>20.0</td></tr>
<tr><td>1.1-2</td><td>4</td><td>5.7</td><td>49</td><td>70.0</td></tr>
<tr><td>2.1-3</td><td>21</td><td>30.0</td><td>7</td><td>10.0</td></tr>
<tr><td>3.1-3.9</td><td>35</td><td>50.0</td><td>0</td><td>0</td></tr>
<tr><td>4 and above</td><td>7</td><td>10.0</td><td>0</td><td>0</td></tr>
<tr><td>Total</td><td>70</td><td>100.0</td><td>70</td><td>100.0</td></tr>
</table>

Table 17: Distribution of respondents to the varieties of maize used and output
Source: primary data (2015)

Result in table 17 showed that majority of farmers (80%) in the study area used improved maize varieties in last cropping season while only (20%) of respondents used local variety. The same table shows that over (80%) of respondents used improved maize varieties have production between (2-4t/ha) and above. This high percentage of farmers used improved seeds showed positive impact on the increased maize production through high yield per unit area while about only 10% of respondents used local varieties received production between (2.1-3th/ha) as maximum yield per unit area and (90%) of farmer used local varieties harvested 2t/ha and less than this quantity per unit area. This implies low net returns those farmers due even to low market demand of this produce. To assess the influence of improved maize variety on the increased maize production regression analysis has been used. The variety (DH04, PAN53, ZM607 PAN691, and LOCAL seeds) and seed rate of maize used in last cropping season of 2015 A were the independent variables of the maize production in the study area. The findings in table 17 displayed that the improved maize variety has significant impact on the increased maize production than local seeds.

Variables	Coefficient	Standard Error	t	P-Value
Constant	43.0262	1143.617	0.04	0.970
Local seeds	-4.248466	140.0906	-0.03	0.976
PAN691	108.047	85.14163	1.27	0.209
ZM607	537.0878	235.1348	2.28	0.026
PAN53	207.5285	312.7844	0.66	0.509
DH04	624.935	175.7504	3.56	0.001
Prob > F= 0.0006 F(5,64)= 5.02 R-squared = 0.2817 Obs= 70				

Table 18: Linear regression estimate of maize varieties on the influence of maize output
Source: primary data (2015)

The results in table 18 indicated that there is negative relationship between Local seeds ad maize production. This attributed that an increase in use of local seeds by a1% decrease the quantity of output by 4%. This suggests that the more local seeds a farmer used the more economically efficient reduced. The findings indicated that all improved maize varieties (DH04, PAN53, ZM607, PAN691) positively influenced maize output in both the yield and gross profit but, DH04 and ZM607 were statistically significant at 1% and 5% level. 66% of the variation in maize production is explained by the relationship with the independent variables. This means that 1% increase in use of DH04 variety increase output by 625 kg and respectively1% increase in use of ZM607 variety increase output by 537. The result revealed that 28% of the variation in maize production is explained by the relationship with the improved maize varieties as independent variables in this study. This supports the descriptive statistics in table 17, which indicated that farmers using improved inputs such as both fertilizer and improved seeds obtained high yield of around 4t/ha.

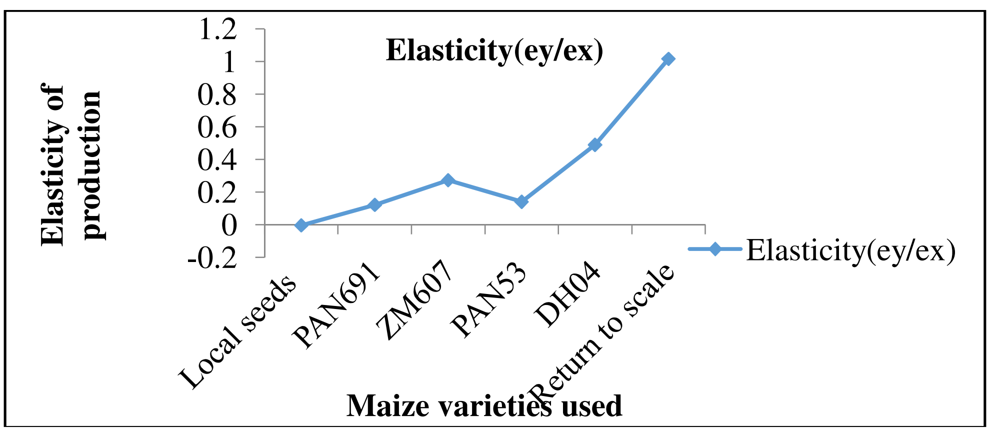


Figure 10: Elasticity of seeds to maize production and Returns to Scale (RTS)

Determination of production elasticities is necessary for the estimation of responsiveness of output to inputs. The findings indicated that all improved seeds have positive elasticity while local seeds have negative elasticity. These show a positive or negative change of output in relation with seeds used. The sum of both improved and none improved seeds have positive elasticity equal to unity which is directly indicating a constant returns to scale for these five varieties. Therefore they are efficiently utilized and hence their use is in stage II of the production function. The return to scale (RTS) estimated as 1.01614 shows that production is in stage II which is the rational stage of production. Hence, production is efficient for maize crops. Output from maize production is positively related to the improved maize varieties. Findings show that local seeds have negative sufficiency of -0.0048878. This negative elasticity of local seeds implies a negative effect on maize output in region which indicated that a higher use of local seeds will significantly reduce maize output. This means that efficient utilization of inputs through better management options will be the major key to increasing output in maize farming.

Variables	Mean	Std. Dev.	Min	Max
Output/ha	10883.57	6835.362	550	4000
Total variable costs	349520.9	82537.69	22000	449040
Total fixed costs	19428.57	9910.573	5000	45000
Total cost	368806.6	88846.74	27000	494040
Total revenue	564328.6	134571.5	99000	720000
Gross margin/ha	197270.6	80028.61	77000	270960
Net returns/ha	176062.6	57980.99	72000	225960

Table 19: Summary statistics of variables used to estimate profitability through Gross margin and Net returns
Source: primary data (2015)

Profitability is the primary goal of all business producers. Without profitability the business will not survive in the long run. So measuring current and past profitability and projecting future profitability is very important. Profitability is measured with income and expenses. In agriculture farming increasing farm profitability is one of the most important tasks of the producer. Producers constantly look for ways to change the business to improve profitability. These potential changes can be analyzed with a pro forma income statement or a Partial Budget. Partial budgeting allows you to assess the impact on profitability of a small or incremental change in the business before it is implemented indicated by Robert Tigner (2009).
In this study the profitability analysis is presented in table 19.The gross margin per hectare were estimated as N77000 and N270960 min and max respectively. While the Net profit per hectare were N72000 and N225960 minimum and maximum respectively. By considering these two both results respectively gross margin and Net profit I can say that maize farming is generally profitable in the Gatsibo district. The same table shows that total revenue is more than the total cost incurred by the respondents. So, there is a supernormal profit of farmer in study area. This also is supported by the law of demand and total revenue which state that when the Ep<1 and the price increase, so that a lot of revenue could be gained and respectively the total revenue also increase because of somewhat inelastic. Economically as the total revenue increase with the increase in price there is profit for producer.

Variables	Coefficient	Standard Error	t	P-value
Total variable costs	-10087.73	11888.74	-0.85	0.399
Total fixed costs	-1.182082	1.852033	-0.64	0.526
Total cost	-0.6786481	1.869827	-0.36	0.718
Total revenue	0.7816815	1.855104	0.42	0.675
Gross margin/ha	0.4481059	.0445899	10.05	0.000
Net returns/ha	0.5255945	.0868329	6.05	0.000
Prob > F	**= 0.0000**	**Obs**	**= 70**	
R-squared	**= 0.9525**	**F(5,64)**	**= 256.90**	

Table 20: Linear regression estimate of improved maize varieties profitability
Source: primary data (2015)

The results in table 20 revealed that there is a positive relationship between gross margin and Net returns and maize output. The two estimates of profitability such as gross margin and net profit significantly influenced maize production specifically at 1% level. It means that a 1% of increase in gross margin and net return increased maize output by 0.448% and 0.525% respectively. 95% of the variation in gross margin and net return explained the relationship of dependent variables toward maize production in study area. This suggests that the higher gross margin obtained in the short-run, the more economical profit gained.

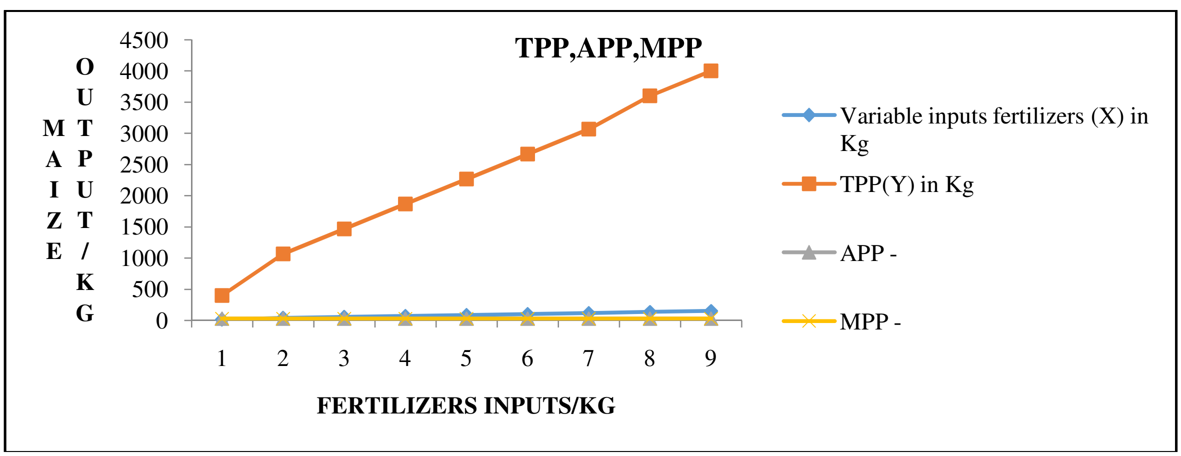


Figure 11: Graphical presentation of TPP, APP and MPP

The findings from the graph indicated that MPP = APP means that this production has a constant return to scale as MPP/APP gave a unit. Stage I of the neoclassical production function includes input levels from zero units up to the level of use where MPP= APP. Stage II includes the region from the point where MPP= APP to the point where the production function reaches its maximum and MPP is zero. Stage III includes the region where the production function is declining and MPP is negative. It is easy to understand why a rational farmer interested in maximizing profits would never choose to operate in stage III. It would never make sense to apply inputs if, on so doing, output was reduced. Even if fertilizer were free, a farmer would never apply fertilizer beyond the point of output maximum. Output could be increased and costs reduced by reducing the level of input use. The farmer would always make greater net returns by reducing the use of inputs such that he or she was operating instead in stage II. The findings indicated that 15 kg of chemical fertilizer was almost gave same output, ceteris paribus other things remaining constant. The findings shows that MPP = APP (At the end of I stage) as indicated MPP/APP gave a unit which directly classify this production in II stage of production.

Method of fertilizers application	Frequency	Percent
Chemical fertilizers only	11	15.7
Organic fertilizers only	21	30.0
Both combination of chemical and organic fertilizers	34	48.6
None	4	5.7
Total	**70**	**100.0**

Table 21: Distribution of respondents to the methods of fertilizer use
Source: primary data (2015)

Result in table 21 indicated that (48.6%) of farmers in the study area used Both Chemical and organic fertilizers in combination followed by (30%) of farmers used organic manure only and (15.7%) farmers who used Chemical fertilizers only. Finally (5.7%) respondents do not applied any fertilizer for the maize farming. To assess the best method of fertilizers application to maximize maize production per unit area regression analysis has been used. The methods of fertilizer used (Chemical fertilizers only, Organic fertilizers only, and combination of Both Chemical and organic fertilizers and none) used in last cropping season of 2015 A were the independent variables of the maize production in the study area.

Variables	Coefficient	Standard Error	t	P-Value
Constant	1368.243	1009.527	1.36	0.180
None	-188.6986	94.11464	-2.00	0.049
Both organic and chemical	547.9382	160.0839	3.42	0.001
Organic only	201.4925	287.4114	0.70	0.486
Chemical only	435.6356	198.0908	2.20	0.031
Prob > F = 0.0001	**F(4, 65) = 7.14**			
R-squared = 0.3051	**Obs = 70**			

Table 22: Linear regression Estimate of the fertilizer use to maximize maize output
Source: primary data (2015)

The results in table 22 indicated that there is negative relationship between non uses of fertilizer and maize production. All three methods of fertilizer application have a positive influence on maize production in study area. The findings indicated that a 1% increase of chemical fertilizer only or Organic only increased maize output by 436 kg and 201kg respectively. A 1% increase in use of combination of both chemical and organic fertilizer increase maize output by 548 kg. Finally 1% increase of none use of any fertilizer in maize farming reduced output by189kg. Two methods of fertilizer use were more significantly influencing maize output particularly combination of both chemical and organic fertilizer at 1% level. 30.5% of the variation in maize production is explained by the relationship with the fertilizer application method. This also was supported by Morris et al., (2007) who showed the improvement of farming efficiency for example maize production levels in region. Without fertilizer (3tonnes 150kgs/ha); with use of compost (4tomes 525Kgs/ha); both organic and Inorganic (7tonnes 875kg/ha); and Inorganic only DAP and UREA (5tonnes 350Kgs/ha). Economic productivity Yields of CIP target crops showed encouraging results where wheat yields more than doubled and maize yields increased by about (90%). Mohammadia. Omid M. (2010) support the study saying that a farmer can apply only chemical fertilizer; only compost for optimum production while combinations of the two should be encouraged to maximize profit explained by the farmers who used it and produce about 4t/ha in last cropping season of 2015 A. The task of the farmer is to apply these principles of economics so that better decisions should be taken through the objective of lowering costs and maximizing profits.

Variables	Coefficient	Standard Error	t	P-value
Constant	6206.788	511.9916	12.12	0.000
Price120	-3784.645	305.8572	-12.37	0.000
Price140	-364.8354	159.587	-2.29	0.026
Price160	701.2205	103.1267	6.80	0.000
Price180	200.2132	37.78901	5.30	0.000
Prob > F= 0.0000 F(4, 65) = 58.47				
R-squared = 0.7825 Obs = 70				

Table 23: Linear regression estimate of market price on maize output
Source: primary data (2015)

The results in table 23 indicated all independents variables were significantly influenced maize output but, lowest price influenced negatively while high and medium price influenced positively maize output. The two prices considered as good were more positive significantly influenced the output at 1% level. It implies that a 1% increase of price of 160 Rwf/kg and 180Rwf/kg should influence maize output by 701kg and 200kg respectively. The there is negative relationship between non uses of fertilizer and maize production. 78% of the variation in maize production is explained by the relationship with the marker price. This show that as the price of output raised more and more farmers should even maximize output by leaving others crops by significantly practice mono-cropping system vise versus when the price fall again and again farmers left maize crops directly by growing other crops. In the economic farming when price of produce raise the total revenue increase towards profit maximization for farmer is achieved. The figure below indicates clearly how price of market should influence maize production in study area.

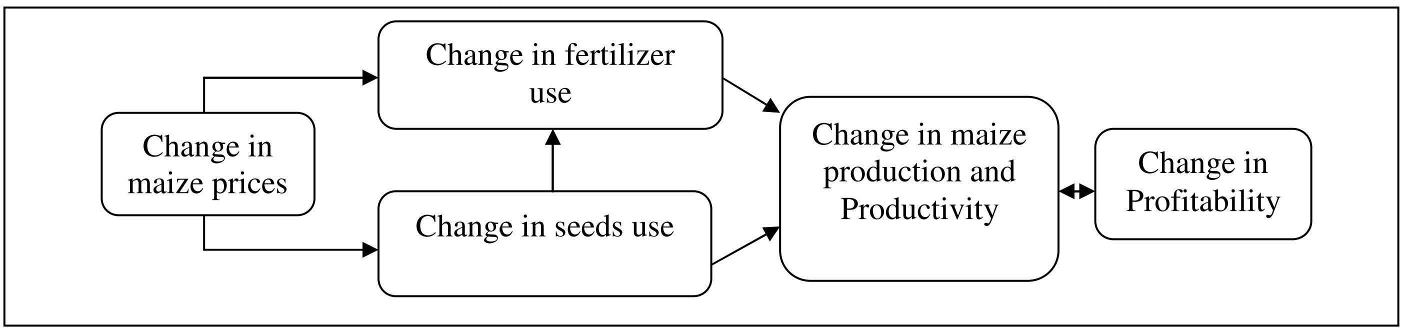


Figure 12: Effect of market price on maize production
Source: Daniel d. Karanja, et al., (1996)

The influence of market price on maize production is also supported by cob web theory which attempts to explain the reasons as to why prices of agricultural products rise and fall due to erroneous expectations of farmers. It is thought that agricultural peasant farmers never learn from their past experiences, and past mistakes. They keep on copying each other and seem never to learn from their past mistakes. This is indicated by convergent case where each new outcome is successively closer to the intersection of supply and demand

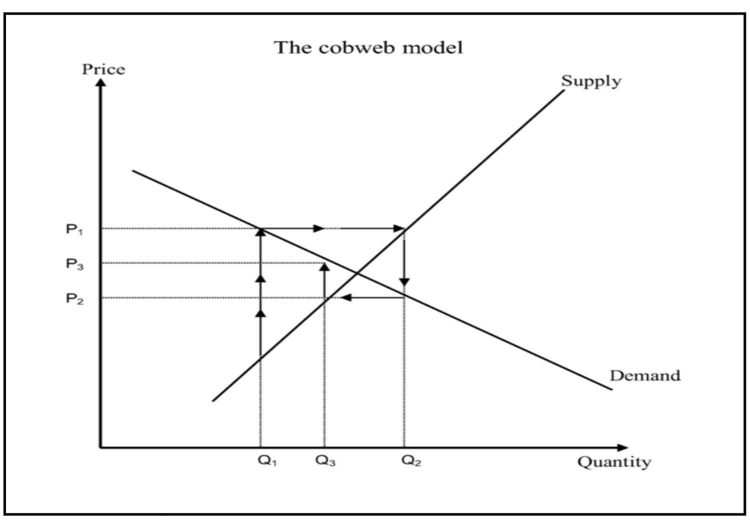


Figure 13: Cobweb convergent cases
Source: Policy coherence in agriculture 2011

If farmers expect these high price conditions to continue, then in the following year, they will raise their production of maize relative to other crops. Therefore when they go to market the supply will be high, resulting in low prices. If they then expect low prices to continue, they will decrease their production of maize for the next year, resulting in high prices again. The cobweb model or cobweb theory is an economic model that explains why prices might be subject to periodic fluctuations in certain types of markets. It describes cyclical supply and demand in a market where the amount produced must be chosen before prices are observed. Producers' expectations about prices are assumed to be based on observations of previous prices.

Variables	Coefficient	Standard Error	t	P-value
Constant	1053.964	379.253	62.78	0.007
Middlemen	33.18356	80.88991	0.41	0.683
Local market	181.0376	46.9729	3.85	0.000
Cooperative	801.772	204.4838	3.92	0.000
Distant market	-62.23927	86.66807	-0.72	0.475
Prob > F= 0.0000 F(4,65)= 15.08 R-squared = 0.4814 Obs= 70				

Table 24: Linear regression estimate of market place on maize output
Source: primary data (2015)

The results in table 24 indicated that three independents variables were positively influenced maize output and only one independent affected it negatively. Two independents variables were more positively and significantly influenced maize output at 1% level. It means that a 1% increase of cooperative and local market increased maize output by 802kg and 181kg respectively. The findings also revealed that 1kilometer increase in distant market reduced maize output by 62kg. 48% of the variation in maize production is explained by the relationship with the market place.

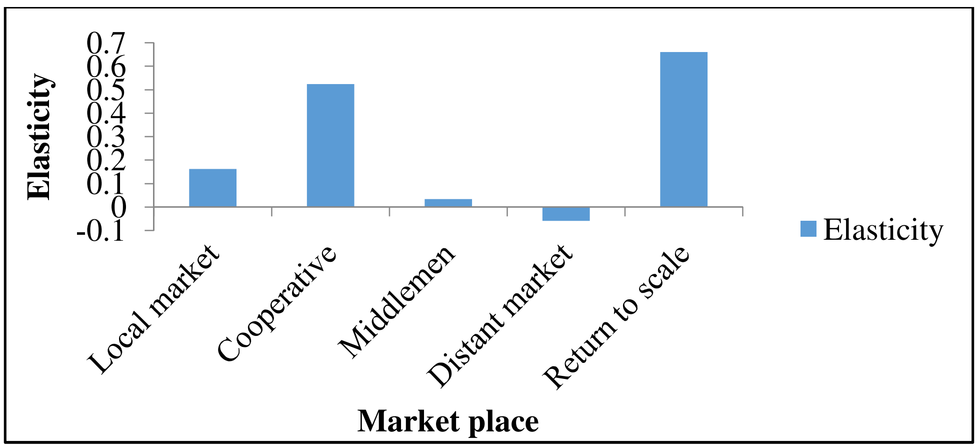


Figure 14: Elasticity of market place to maize output and Returns to Scale (RTS)

The findings indicated that the sum of all market place have positive elasticity equal to (0.660481) that is less than unity directly indicating a decrease returns to scale. Therefore they are efficiently utilized and hence their use is in stage I of the production function. Output from maize production is positively related to the improved maize varieties. Findings show that distant market has negative elasticity of -0.05929. This negative elasticity implies a negative effect on maize output in region which indicated that a higher long distance to market the higher reduction of maize output. The result is attributed to the fact that a farmer located nearest of the market gain more than a farmer who is located far from the market incurs more costs to transport farm produce to the market compared to the one closer to the market who minimized costs especially for transport. For this study the farmers in cooperative were more benefited than those far from cooperative or local market. The findings are also supported by Bagamba *et al.,* (2007) found that among smallholder banana producers in Uganda. They observed that households located nearer to the factor markets showed higher technical efficiency than those located in remote areas. According to the authors, proximity to the factor market increased farmers' ease of accessing farm inputs and extension trainings from which they could attain information and skills for better crop management hence increasing their productivity. The importance of cooperation in farmer organizations was also reported by Idiong (2007) among smallholder swamp rice producers in Nigeria; and Tchale (2009) among smallholder crop producers in Malawi. Collectively they observed that farmers who are members in producer organizations are able to benefit not only from the shared knowledge among themselves with respect to modern farming methods, but also from economies of scale in accessing input markets and produce as a group. Hence, these farmers become more technically efficient in production.

5. Summary, Conclusions and Recommendations

5.1. Introduction

This chapter provides an overview of the findings that have been conducted in this area relating to maize production with specific focus on the factors that influencing maize production in Rwanda farming including; land size, labors, fertilizers, improved seeds, experience of farmers, education level, and price of production. This chapter especially shows results from major variables that have been taken as keys of the study such as profitability of improved maize variety on maize production, Best method used to maximize maize output per unit area and effect of market price and place to the increased maize production. The chapter gives summary of the study as well as results from descriptive statistics and findings from regression analysis of explanatory variables. Finally, the chapter gives recommendations to the future researchers.

5.2. Summary

The purpose of this study was to analyze the factors influencing maize production among farmers in Rwanda. This was based on the realization that the maize productivity in the country was still too low compared to the demand. The study was conducted in Gatsibo district in seven zones of farming. Rwanda based on a sample of 70 households selected using a multi-stage sampling technique. For the data collection, a personally administered structured questionnaire was used to conduct interviews, with a focus on household head as well as man or women. A cobb-Douglas function has been used to estimate a relationship between inputs and outputs. While a descriptive analysis and linear regression analysis were key instruments to evaluate the factors influencing maize production. The study indicated that 49(70 %) of the respondents were male and 21(30%) were female. This implies that most of those who participated were male and are the most likely to be participating in maize farming. This should positively impact the increase in maize production as male are main leaders of family.

Descriptive statistics from this study indicated that the age of respondents ranges between 18 and 56 years. This range of age should passively impact on the increased maize production through quick adoption of new technology rather than oldest farmers above 55 years who conserve their own ideas. The results indicated that (59%) of the respondents are in the range of between 3-8 members of household in study area. This was a very significant impact on output through the supply of labors from same household and that minimize the costs spent to labors. The findings show that majority of farmers in the study area (94.3%) are educated, while 5.7 % are illiterate. This high percentage of educated farmers should have positive impact on the increased maize production through quick understanding of trainings given on the crops management like cultural best practices, pests and diseases control and the adoption of new techniques of production. Results indicated that (35)50% of the respondents are experienced in producing maize crops over than six years as commercial purpose followed by (28)40% of respondents producing maize crops between 4 and 5 years. This is supposed to have positive impact on maize output through adoption of new use of inputs like improved maize varieties and fertilizers. The findings indicated that majority of farmers (80%) in the study area used improved maize varieties in last cropping season while only (20%) of respondents used local variety. The same results shows that over (80%) of respondents who used improved maize varieties have production between (2-4t/ha) and above. While only 10% of respondents used local varieties received production between (2.1-3th/ha) as maximum yield per unit area and (90%) of farmer used local varieties harvested 2t/ha and less than this quantity per unit area. This implies low net returns to farmer due even to low market demand of this produce. The results also shows that (48.6%) of farmers in the study area used both Chemical and organic fertilizers followed by (30%) of farmers used organic manure only and (15.7%) farmers who used Chemical fertilizers only. Finally (5.7%) respondents do not applied any fertilizer for the maize farming. To assess the profitability of improved maize varieties, best method of fertilizers use to maximize maize output per unit area and effect of price on maize production a linear regression analysis has been used. The findings indicated that there is negative relationship between Local seeds and maize production. This attributed that an increase in use of Local seeds by a unit decrease the quantity of output by 0.976%. This suggests that the more local seeds a farmer used the more economically efficient is reduced. The coefficients for improved maize varieties (DH04, PAN53, ZM607, PAN691) in both the yield and gross profit models were all positive but, DH04 and ZM607 were statistically significant at 5% ($P<0.05$) level. This means that these two improved maize varieties explain the output of maize while PAN53 and PAN691 do not explain the maize output through its significance indicates that only increase in use of DH04 and ZM 607) varieties had respectively a significantly of ($p<0.01$) and ($p<0.05$) and positive effect on gross margin and net return of farmer. Output from maize production is positively related to the improved maize varieties. For example a 1% increases in use of DH04 variety should increase maize output by 0.48%. Findings show that Local seeds have negative sufficiency of (-0.0048878). This negative elasticity of local seeds implies a negative effect on maize output in region which indicated that a higher use of local seeds will significantly reduce maize output. According to the profitability of improved maize variety the gross margin and net return have been used to indicate it. The findings indicated that gross margin per hectare was N270960 maximum. While the Net profit per hectare was N225960 maximum both in last cropping season. By considering these two both results respectively gross margin and Net profit I can say that maize farming the primary goal of all business ventures Profitability has been achieved. With this profit the business should survive in the long run in Gatsibo district because total revenue is more than the total cost incurred by the respondents. In other word income is greater than expenses, so, there is a supernormal profit of farmer in study area and maize crops should be enhanced in region to increase the household income of the respondents.

The results of study show that Output from maize is positively related to fertilizer as shown by the findings where the coefficients are positive and only significant ($P < 0.05$) respectively for (combination of Both Chemical and organic fertilizers and chemical fertilizer only) with 0.001 and 0.031(P-value). This implies that a 1% increase in fertilizer will result in an increase of 0.001% and 0.031%% in maize output respectively. This also indicated that combination of both chemical and organic fertilizers and chemical fertilizer application are the only variables explaining maize production. The results show that farmers should use chemical only, organic only, and both Chemical and organic fertilizers to achieve optimum yield but to have maximum output farmer should use Both Chemical and organic fertilizers in combination that has a more potential than the two left.

Elasticity of price is important because it predicts what may happen to total revenue received when a market changes the price of a product. The increase in output of maize crops responds positively and significantly to the changes in market price of maize as shown by the significance ($P<0.001$) in table above. This means that an increase in price of maize by 1%, the output is expected to increase by 0.001%. This obeys the economics law state that as the price of market increase the quantity supplied should also increase proportionally. In Economic farming when price of produce raise the total revenue increase towards profit maximization for farmer is achieved.

Generally the findings shows that many respondents used improved, organic manure and chemical fertilizer at lower level compared to other country like Zimbabwe and Kenya where farmer should apply over than 150kg of DAP and over than 10tonnes of organic manure. In these countries that inputs are used at maximum of about 5-7t/ha. So the findings show that in this study area maximum chemical fertilizer both at sowing and top dressing is 150 while in other countries should even be more than 250kg/ha. The maximum organic fertilizer in study area is around 3t/ha which below the recommended quantity to be applied per hectare. According to these low inputs used the findings show that with four improved maize varieties such as DH04, PAN53, ZM607, PAN691used in last cropping season the most productive maize variety in the study area was DH04 followed by ZM607which gave maximum yields of 4t/ha and 3.5t/ha respectively. These yields have been found in two zones of farming such as Shikamukore and Abifatanize in Gatsibo district. Even if the maximum yield was 4t/ha for farmers who used the quantity given above, but the lowest yield for farmer who used fertilizer and improved seeds was 2.5t/ha while the lowest yield for local seeds had even less than 1t/ha. The findings indicated that maize output have been sold at different markets and at different prices. The results show that the maximum revenue and profitability were high to farmers who sold at 180Rwf/kg and farmers who sold their produce at 140Rwf/kg and below did not find any profit considering the cost of inputs.

5.3. Conclusion

The broad objective of the study was to conduct the analysis of factors influencing maize production among farmers in Gatsibo district. The specific objectives were to evaluate the profitability of the improved maize varieties; to identify the best method of fertilizers use to maximize maize output per unit area; and finally to find out the effect of market price and place on the increased maize production. Regression analysis were used to assess the factors influencing maize production.However, profitability of improved maize varieties, best methods of fertilizers use and effect of market price and place on maize production were the major focus of the study.

This study shows that profitability of improved maize variety is different between users and non-users of the required inputs and technology. Linear regression model estimation indicated that profitability was positively influenced by high yield value of DH04, ZM607 (at 1% level and at 5% level) respectively. Maize productivity increased was positively also influenced by fertilizer use that indicated a significance at (1% level) for farmers used both chemical and organic fertilizer in combination. The findings also showed that profitability was positively influence by maximum prices of 180Rwf/kg that is significant at (1%).The profitability was negatively influenced by local seeds through its negative coefficient. The results show that the profitability was negatively influenced by farmers who did not apply any fertilizer for their maize farming that is negatively significant at (5% level). The profitability was also negatively influenced by lower price of 120Rwf and 140Rwf respectively significant at (1% and 5%), market place was also negatively influenced the profitability. It has been found that an increase in the distance to the distant market by one kilometer; is expects to reduce maize output by 0.475%. The result is attributed to the fact that a farmer located nearest of the market gain more than a farmer who is located far from the market incurs more costs to transport farm produce to the market compared to the one closer to the market who minimized costs especially for transport. The findings are also supported by Bagamba *et al.,* (2007) found that among smallholder banana producers in Uganda. They observed that households located nearer to the factor markets showed higher technical efficiency than those located in remote areas.

The findings indicated that many causes of significant negative changes in maize production in the last cropping season include lower market prices, small land size, long distance to market, Pests and diseases, High costs of inputs, Labor is generally expensive, Climate change, and finally Public policies change. All of these constraints handicapped maize production which is still lower than the desired consumption.

5.4. Recommendations

Based on the findings of this study, the following recommendations were found out:

1. Cost of inputs should be subsidized, since high cost of fertilizer prevented farmers from using some of the improved maize varieties;
2. Efforts should be made to make credit accessible to farmers, since lack of capital was an obstacle to the adoption of the improved maize varieties that have high price per kilogram of inputs;
3. The significant relationship between maize yield and adoption of improved maize varieties indicated that an effective input supply system that would sustain the expansion of maize output by farmers in the study area should be put in place;
4. Organic fertilizers application is in any case profitable to increase nitrate and the humus content and to increase the moisture storage capacity of the soil for current and also for the next season;

5. The government should encourage private sector to invest in credit facilities like small scale banks to offer credit to farmers at affordable rates. This should be through legislation to facilitate credit creation;
6. In developing improved maize varieties, factors other than yield should be taken into consideration, including drought resistance/tolerance, resistance to storage pests, shelling quality, and taste. This requires farmer participation in the research process.
7. The formation of farmer groups should be encouraged, because lending to groups tends to reduce transactions costs and improve the rate of loan recovery;
8. 10. Buffer stocks policy and guarantee to farmers should be implemented as intervention storage attempted to use commodity storage for the purposes of stabilizing prices in an entire economy or, more commonly, an individual market;
9. Farmers should always have ability of measuring profitability as the most important measure of the success of the business to know whether he/she should improve or leave the business.
10. The agricultural policy makers should every season establish both price ceiling above which intervention selling will occur, and a price floor, below which intervention buying will take place due to the national price of inputs and losses caused by middlemen should be given up.

6. References

i. Abbot B. (2005) Research designs and Methods. Toronto, McGrawHill.
ii. Alene, A.D., A. Menkir, S.O. Ajala, A.S. Badu-Apraku, V. Olanrewaju, M. Manyong, and A. Ndiaye. (2009). "The Economic and Poverty Impacts of Maize Research in West and Central Africa,": Agricultural Economics 40: 535–550.
iii. ALMEDA, J., T. CAPISTRANO, G. SARTE, (2010), Elementary Statistics, Quezon City: UP Press.
iv. Aloyce R.M. Kaliba, Hugo Verkuijl, Wilfred Mwangi, Angello J.T. Mwilawa, Ponniah Anandajayasekeram, and Alfred J. Moshi (1998).Adoption of Maize Production Technologies in Central Tanzania. October 1998.
v. Anderson, S.& Baland, J. (2002).The economics of ROSCAs and intra household resource allocation. 117(3) 963-995: Oxford University Press
vi. Andy Mckay, Mary Strode, clare O'Brien and Geoffrey Greenwell (2007). EICV MINECOFFIN Poverty analysis for Rwanda's EDPRS, Kigali.
vii. Augustin Mutijima, Martin flower, Claver Gasirabo, and Sam Kanyarukiga(2007). Rwanda Public Expenditure Review: Kigali.
viii. Awudu, A., & Eberlin, R., (2001). Technical efficiency during economic reform in Nicaragua: evidence from farm household survey data. Economic Systems, 15(25), 113-125. http://dx.doi.org/10.1016/s0939-3625 (01)00010-3
ix. Bagamba, F., Ruerd, R., and Mariana, R. (2007).Determinants of banana productivity and technical efficiency in Uganda.
x. Smale, M., and Tushemereirwe, W.K. (Eds), An economic assessment of banana genetic improvement and innovation in the Lake Victoria Region of Uganda and Tanzania (Ch.8, pp.109-128). Accessed July 20th, 2010 from http://books.google.com/.
xi. Banaeian, N. And Zangenneh,.M.(2011) Estimating Production Function of Walnut Production in Iran using Cobb-Douglas Method; in Agricultura Tropica Et Subtropica, 44(4) 177- 189.
xii. Barnard and Nix. (1993). Farm planning and control. McGraw Hill, U.S.A.
xiii. Becerril J., and Abdulai A. (2010). The impact of improved maize varieties on poverty in Mexico: A propensity score matching approach. World Development 38(7): 1024–1035.
xiv. Bingen J., Munyankusi. (2002).Farmer associations, decentralization and development in Rwanda: challenges ahead MINAGRI.
xv. Bourdieu, Pierre. (1984). Distinction: A Social Critique of the Judgment of Taste.
xvi. Bravo-Ureta, B.E., Pinheiro, A.E. (1997). Technical, economic and allocative efficiency in peasant farming: Evidence from the Dominican Republic. Journal of Development Economics, 34: 48-67.
xvii. Buckles, D., and B. Triomphie.(1999).Adoption of Mucuna in farming systems in Northern Honduras. Agroforestry Systems, 47:67-91.
xviii. Byerlee D. and Eicher C.K. (eds.). (1997). Africa's Emerging Maize Revolution.Boulder, CO: Lynne Rienner Publishers.
xix. Churchill,G.A.,Jr.,(1995): Marketing research,Methodological foundations, The Drydeu Pres,G.Edution,New York,USA.
xx. CIMMYT Economics Program.(1993).The Adoption of Agricultural Technology: A Guide for Survey Design. Mexico, D.F.: CIMMYT.
xxi. Clayton. (1964).Agrarian Development in Peasant Economics: Pergaman Press, London.
xxii. Cobb, Charles W. and Paul H. Douglas (1928). A Theory of Production. American Economic
xxiii. Cobb-Douglas -Wikipedia. http://en.wikipedia.org/wiki/Cobb Douglas
xxiv. Commercial fertilizers increase crop yields Accessed 9 April 2012
xxv. Cooper, D., & schindler, p.s.(2003). Business Research Methods (8th ed). New delhi: tata mcgraw-hill publishing company. India
xxvi. Daly. (1997).Forum on Georgescu-Roegen versus Solow/stiglitz: Ecological Economics
xxvii. Karanja, D.D. (1996). An Institutional and Economic Analysis of Maize Research in Kenya MSU International Development Working Paper. No. 57. East Lansing: Michigan State University.
xxviii. David L., Debertin (1986): Agricultural production economics second edition: University of Kentucky

xxix. De Groote, H., G. Owuor, C. Doss, J. Ouma, L.Muhammad and K Danda (2005). The Maize Green Revolution in Kenya Revisited: Journal of Agricultural and Development Economics

xxx. Dercon, S., and L. Christiaensen.(2007). Consumption Risk, Technology Adoption, and Poverty Traps: Evidence from Ethiopia, Policy Research Working Paper No. 4257. Washington, DC: World Bank

xxxi. Devereux, S. and Maxwell, S., (2000). Food Security in Sub-Saharan Africa: University Natal press. South Africa.

xxxii. Doll, John P. and Orazem. F. (1984). Production Economics: Theory with Application, john wiley and sons, New York.

xxxiii. Dong-hae. (2006): Agricultural cooperatives amid the changing Asian Rural Landscape

xxxiv. Doss, C. R. (2006). Analyzing technology adoption using micro studies: limitations, challenges and opportunities for improvement". Yale University, Yale Center for International and Area Studies, New Haven, CT 06520-8206, USA. Agricultural Economics

xxxv. Duflo, E., M. Kremer, and J.Robinson.(2008).How High are Rates of Return to Fertilizer: Theory and Experimental Evidence from Kenya," American Economic Review

xxxvi. Duflo, E., M. Kremer, and J. Robinson.(2011).Nudging Farmers to Use Fertilizer: Theory and Experimental Evidence, Kenya American Economic Review

xxxvii. Economic Policy and Research Center. Research series No. 69. Kampala, Uganda

xxxviii. Fan, S. (1999). Technological change, technical and allocative efficiency in Chinese Agriculture: The case of rice production in Jiangsu. EPTD Discussion Paper no 39,

xxxix. FAO(2001). Food and Agriculture Organisation. Contract Farming. Washington, USA

xl. FAO (2005). Guide on fertilizers and plant nutrition. Rome, Bullitin no.9

xli. FAO (2007). Conservation Agriculture in Africa: Sustainable agriculture and rural development (SARD), Policy brief 18

xlii. Farrell, M.J. (1957). The measurement of Productive efficiency. Journal of the Royal Statistical society. ACXX part 3:253-290

xliii. Food and Agricultural Organization of the United Nations.(1994). Cereal Policies Review, 1993-94. Rome.

xliv. Food and Agricultural Organization.(2003).FAO. Food and Agricultural Monthly Bulletin of Statistics.

xlv. Foster, A., and M. Rosenzweig. (1995). Learning by Doing and Learning from Others: Human Capital and Technical Change in Agriculture, Journal of Political Economy 103(6): 1176–1209.

xlvi. Fuglie, K.O., International Potato Centre.(1999). Economics of potato storage: Case studies, Bogor, Indonesia, 1999.

xlvii. Gatsibo district, (2012). Monograph of District. Gatsibo, Eastern province, Rwanda

xlviii. Genesca, G. E. & Grifell, T. E.(1992). Profits and Total Factor Productivity: A Comparative Analysis.Omega.The International Journal of Management Science, Vol. 20, No. 5/6. p.553-568.

xlix. Giles T and M Stansfield (1990): The Farmer as Manager. CAB International Publishers, Second Edition PP 173-198.

l. Hassan, R.M. and D.D. Karanja.(1997). Increasing Maize Production in Kenya: Technology, Institutions and Policy.In Africa's Emerging Maize Revolution, eds.D. Byerlee and C.K. Eicher. Boulder: Lynne Rienner Publishers.

li. Hayami Y., Vernon W. R. (1971). Agricultural Development: an International Perspective",The Johns Hopkins Press, Baltimore and London.

lii. Heady, E.O (1952): Economics of Agricultural production and Resources use.

liii. Heisey, P.W., and Smale, M.,(1995). Maize Technology in Malawi: A Green Revolution in the Making? CIMMYT Research Report No. 4. Mexico, D.F.CIMMYT.

liv. Hintze, L. H., M. Renkow, G. Sain. (2003). "Variety characteristics and maize adoption in Honduras". Agricultural Economics, 29: 307–317.

lv. http://www.businessdictionary.com/definition/factors-of-production.html#ixzz3dAD5tsJl

lvi. http://www.globalpost.com/dispatch/news/regions/africa/120328/rwanda-economic-growth-pulling-rwandans-out-poverty

lvii. http://www.iss.co.za/AF/profiles/Rwanda/Economy.html

lviii. Idiong, I.C. (2007). Estimation of farm level technical efficiency in small-scale swamp rice production in cross river state of Nigeria: A stochastic frontier approach. World Journal of Agricultural Sciences

lix. Idris, P.O. (1992). "Economic analysis of hybrid maize V. OPV in Northern Guinea Savanna Zone in Nigeria". M.Sc. Thesis, Department of Agric. Economics, ABU Zaria, Nigeria. Liao, T. 1994.

lx. Improved Banana Varieties in East Africa", November 7-11, 2002. Kampala.

lxi. International Food Policy Research Institute. Washington, D.C: IFPRI

lxii. Interpreting Probability Models: Logit, Probit, and Other Generalized Linear Models. Thousand Oaks, CA: Sage

lxiii. Irish potato producers in Kenya (2009).A case of Nyandarua North Distric: A contributed paper prepared for presentation at the international Association of Agricultural Economists' conference, August 16-22, 2009. Beijing, China.

lxiv. ISIKLI.(1992):Agricultural Marketing research Lecture notes (Unpublished) Agricultural Faculty, Bornova-Izmir. John Wiley and Sons, New York.

lxv. Jones, M. Mukumbu, and S. Jiriyengwa. (2007). Maize Marketing and Price Policy in Eastern and Southern Africa: In D. Byerlee and C.K. Eicher (eds.),Africa's Emerging

lxvi. Karanja, D.D., Thomas S. Jayne, and Paul Strasberg. (1998). Maize Productivity and Impact of Market Liberalization in Kenya, Tegemeo Working Paper.

lxvii. Kombo and Tromp (2006). Sample determination, new analysis procedures ISBN32/32 2 Nairobi University publishers: Nairobi.
lxviii. Kortari C.R (2004). Research methodology: Methods and Techniques. College of Commerce University of Rajasthan Jaipur,India
lxix. Krejcie, R.V., & Morgan, D.W., (1970).Determining Sample Size for Research Activities: Educational and Psychological Measurement.
lxx. Kunkel, P. L., J. A. Peterson, J. A. Mitchell. (2009). Agricultural Production Contracts". Farm Legal Series: Regents of the University of Minnesota. 1-5.
lxxi. Lusty, C., Smale, M. (2002). Assessing the Social and Economic Impact of Maize Revolution. Boulder, Colorado: Lynne Rienner Publishers.
lxxii. Malassis.(1975). Agriculture and the Development Process: The Unesco Press. Paris.
lxxiii. Marenya, P.P., and C.B. Barrett. (2009). State-Conditional Fertilizer Yield Response on Western Kenyan Farms:American Journal of Agricultural Economics
lxxiv. Martinez, A.(2000). Fertilizer Use Statistics and Crop Yields: Muscle Shoals, Alabama: IFDC.
lxxv. Mbanasor, J.A., and Kalu, K.C. (2008). Economic efficiency of commercial vegetableproduction system in AkwaIbom state, Nigeria: A translog stochastic frontier cost function approach. Tropical and sub-tropical Agroecosystems
lxxvi. Mbithi, L.M.,(2000). Effects of Agricultural Policy on Maize Production in Kenya: Ph D. Thesis,University of Gent.
lxxvii. McKay, A. et al; (1997). Aggregate Export and Food crop Supply Response in Tanzania: Discussion Paper No 4 in the Credit Project on Infrastructural and institutional Constraints to Exports Promotion.
lxxviii. Meeusen, W.and Van Den Broeck, J. (1977). Efficiency Estimation from Cobb–Douglas
lxxix. Mendola, M.(2007). Farm Household Production Theories: A Review of 'Institutional' and 'Behavioral' Responses: Asian Development Review
lxxx. Meyer, F. H. (2006). Model closure and price formation under switching grain market regimes in South Africa: University of Pretoria. Pretoria: Published Phd thesis.
lxxxi. Michele. B, (2001). Linkages between FAO Agroclimatic Data Resources and the Development of GIS Models for Control of Vector-borne Diseases. Acta Tropica.
lxxxii. MINAGRI.(2008).Key achievements in agriculture, Ministries agencies 2008 final annual report, Rwanda.
lxxxiii. MINAGRI (2007). Ministry of Agriculture. Crop Intensification Program. Kigali. Rwanda
lxxxiv. MINAGRI.(2008).Strategic plan for agriculture transformation program for Rwanda(PSTA) Final report, Rwanda.
lxxxv. MINAGRI.(2008). Strategy for Rapid and sustainable Growth of fertilizers use in Rwanda ;(PASTA), Rwanda.
lxxxvi. MINAGRI.(2009). National Post Harvest Staple Crop Strategy.Kigali.
lxxxvii. MINAGRI.(2009). Strategic Plan for Transformation of agriculture in Rwanda Phase II Kigali.
lxxxviii. MINAGRI (2011). Strategies for Sustainable Crops Intensification in Rwanda, shifting focus from producing enough to producing surplus. Kigali.
lxxxix. MINAGRI.(2015). Fertilizer application improves production per unit area, live hoods. New times no.3748 Friday, July 31, 2015
xc. MINAGRI.(2007): Appui à la filière Semenciere du Rwanda
xci. MINAGRI.(2007).Ministry of Agriculture.Strategic plan of agriculture transformation. Kigali-Rwanda
xcii. MINAGRI (2009).Ministry of Agriculture: Strategic Plan for the Transformation of Agriculture in Rwanda – Phase II (PSTA-2).Final Report. Kigali- MINAGRI.
xciii. MINAGRI,(2011): Ministry of Agriculture and Animal Resources; National Post Harvest Strategy, kigali
xciv. MINAGRI (2011). Fertilizer programme privatization and role of different institutions.
xcv. MINECOFFIN/DS.(2002) National Poverty Reduction Program: A profile of poverty in Rwanda.
xcvi. MINECOFIN (2013). Economic Development and Poverty Reduction strategy Progress Report
xcvii. Miracle, M. P. (1965). The introduction and spread of maize in Africa:The Journal of African History
xcviii. Mohammed, B. T., J.J. Aduba, I. Jilasaya, and I. C. Ozumba. (2011). "Farmers Resource Use Efficiency in Sorghum Production in Nigeria". Continental Journal of Agricultural Economics.
xcix. Moroney,J. R.(1967). Cobb-Douglass production functions and returns to scale in US manufacturing industry:Western Economic Journal, vol 6, no 1, December 1967.
c. Morris, M.L., R. Tripp, and A.A. Dankyi.(1999).Adoption and Impacts of Improved Maize Production Technology: A Case Study of the Ghana Grains Development Project," Economics Program Paper. Mexico, D.F.: CIMMYT
ci. Morris,M. (2001). Assessing the benefits of international maize breeding research: An overview of the global maize impacts study. Part II of the CIMMYT 1999-2000 world maize facts and trends.
cii. Mugisa-Mutetikka, M., A.F. Opio., M.A. Ugen., P. Tukamuhabwa., B.S. Kayiwa, C.Niringiye and E. Kikoba (2000).Logistic Regression Analysis of Adoption of New Bean Varieties in Uganda. Unpublished, 2000.
ciii. Mulwa, R., Emrouznejad, A.,and Muhammed, L.(2009). Economic efficiency of smallholder maize producers in Western Kenya: A DEA meta-frontier analysis. International Journal of Operational Research.
civ. Mushunje, A. (2005). Farm efficiency and land reform in Zimbabwe. Alice: University of Fort Hare, PhD thesis.
cv. Mutune, J.M. (2009). Factors influence the adoption of conservation tillage practices and their implication on profitability in maize-cowpea cropping systems:A case of Makueni District, Kenya". MSc.Thesis, University of Nairobi, Kenya.

cvi. Negatu, W and A. Parikh.(1999).The impact of perception and other factors on the adoption of agricultural technology in the Moret and Jiru district, Ethiopia: Agricultural Economics New York: Cambridge University Press.

cvii. Niringiye and E. Kikoba(2000).Logistic Regression Analysis of Adoption of New Bean Varieties in Uganda. Unpublished, 2000.

cviii. NIRS (2010): Annual report 2011

cix. NISR (2012).The third integrated household living conditions survey (EICV-3): Agriculture, District Disaggregated Tables. Kigali: NISR.

cx. Nyagaka, D.O., Obare, G.A., and Nguyo, W. (2009). Economic efficiency of smallholder

cxi. Odoemenem, I. U., and J. A. Inakwu.(2011). Economic analysis of rice production in Cross River State, Nigeria. Journal of Development and Agricultural Economics

cxii. Ojo, S.O.(2000).Factor Productivity in Maize Production in Ondo-State, Nigeria". AppliedTropical Agriculture:School of Agriculture and Agricultural Technology, FUTA, Akure, Ondo State, Nigeria

cxiii. Okoboi, G. (2010).Improved input use and productivity in Uganda's maize sub-sector.

cxiv. Okon, U.E., and A.A. Enete. (2009). Resource Use Efficiency among Urban Vegetable Farmers in Akwa Ibom State, Nigeria. Tropicultural

cxv. Olayide, S.O. and E.O. Heady,(1982). "Introduction to Agricultural Economics", University of Ibadan Press, Ibadan, Nigeria.

cxvi. Olorusanya, E.O., and O.O.Akinyemi.(2004).Gross margin analysis of maize-based cropping systems in Oyo State, Nigeria: International Journal of Agriculture and Rural Development.

cxvii. Olson K.D (2004): Farm Management Principles and strategies by.Ames Iowa State University Press.

cxviii. Olujenyo, F.O. (2008). The determinants of agricultural production and profitability in Akako Land, Ondo-State, Nigeria. Journal of Social Sciences.

cxix. Oluwatayo, I.B.,Sekumade, A.B. and Adesoji, S.A. (2008). Resource use efficiency of maize farmers in rural Nigeria: Evidence from Ekiti State. World Journal of Agricultural Sciences

cxx. Ouma, J., M. Mureithi, and H. Groote.(2002). "Adoption of maize seed and fertilizer technologies in Embu District, Kenya". Mexico, D.F. CIMMYT. Report No. 8

cxxi. Owino, C.O. (2010). Fertilizer options for sustainable maize production in Trans Nzoia district in Kenya: African Journal of Agricultural Research.

cxxii. Pingali, P.L., (Ed.). (2001). CIMMYT 1999-2000 World maize facts and trends: Meeting world maize needs: Technological Opportunities and Priorities for the Public Sector, CIMMYT, D.F, and Mexico.

cxxiii. Policy Coherence in Agriculture by Global Donor Platform for Rural Development 2011

cxxiv. Ransom, J. K., K. Paudyal, and K. Adhikari.(2003). Adoption of improved maize varieties in the hills of Nepal. Agricultural Economics.

cxxv. Robert Tigner.(2009).Farm management field specialist. File: Economics 1-8,

cxxvi. Roger D.Norton.(2004). Agricultural Development Policy: Concept and Experiences John wiley&Sons London, 2004.

cxxvii. Rosegrant, M.W., C. Ringler, S. Msangi, T. Zhu, T. Sulser, R. Valmonte-Santos, and S. Wood.(2007). Agriculture and Food Security in Asia: The Role of Agricultural Resources Knowledge in a Changing Environment," Journal of Semi-Arid Tropical Agricultural Resources.

cxxviii. Saari, S. (2011).Production and Productivity as Sources of Well-being. MIDO OY.

cxxix. Schultz, T. W.(1965).Economic Crises in world Agriculture: The University of Michigan Press

cxxx. Seidu, A. (2008). Technical efficiency of rice farmers in Northern Ghana. Tamale, Ghana: AERC Research Paper.

cxxxi. Singh, S. (2000). "Contract farming for Agricultural Diversification in the Indian Punjab.A study of performance and problems". Indian Journal of Agricultural Economics, 56(3): 283-294.

cxxxii. Smallholder maize producers in Western Kenya: A DEA meta-frontier analysis. International Journal of Operational Research.

cxxxiii. Socio-economic factors affecting apple production Akako Land, Ondo-State, Nigeria. Journal of Social Sciences.

cxxxiv. Suri, T.(2011).Selection and Comparative Advantage in Technology Adoption: Econometrica.

cxxxv. Tchale,H.(2009).The efficiency of smallholder agriculture in Malawi. AFJARE3(2).Lilongwe, Malawi: World Bank

cxxxvi. Terpend N., Kayumba J. and Ntaganda E.(2007). Diagnostic et élaboration du plan de développement national de la filière maïs. Kigali: CODEA.

cxxxvii. Terpend, R., Tyler, B. B., Krause, D. R., & Hand field, R. B. (2008). Buyer–Supplier Relationships: Derived Value Over Two Decades.The Journal of Supply Chain Management.

cxxxviii. Turner, J and Taylor, M (1989): Applied Farm Management BSP Professional Books, Oxford.

cxxxix. USAID,(2010).Assessment of post-harvest opportunities in Rwanda. Post-Harvest Handling and Storage Project (PHHS). Kigali: USAID.

cxl. Waithaka, M. M., P. K. Thornton, K. D. Shepherd, and M. Herrero. (2007).Factors affecting the use of fertilizers and manure by smallholders: the case of Vihiga, Western Kenya. Nutrient Cycling in Agroecosystems, 78:211–224.

cxli. Weber, M., D. Tschirley, R. Varela, A.P. Santos, and H.F. De Murrule.(1992). "Reflections on Relationships between Food Aid and Maize Pricing/Marketing in Mozambique." Draft Paper. East Lansing, Michigan: Michigan State University.

cxlii. Weiss, R.S. (1994). Learning from strangers, the art and method of qualitative interview studies. New York, NY. Free Pr.

cxliii. Wiebe, K.D., Soule, M.J. and Schimmelpfennig, D., (2001).Agricultural Productivity for Sustainable Food Security in Sub-Saharan Africa. In Zepeda L (ed), Agricultural Investment and Productivity in Developing Countries, FAO, Rome.
cxliv. Wightman, J. A, International Food Policy Research Institute. (2020). Vision News and Views. November 1998.
cxlv. World Bank,(2007).Rwanda promoting pro-poor Agricultural growth in Rwanda: Challenges and opportunities. Portland. USA
cxlvi. World Food Program. (2012).Comprehensive Food Security and Vulnerability Analyisis and Nutrition Survey, Rwanda December 2012.
cxlvii. www.gatsibo.gov.rw accessed 5 February 2013
cxlviii. Zeller,M., A. Diagne, and C. Mataya. (1997). “Market Access by Smallholder Farmers in Malawi: Implications for Technology Adoption, Agricultural Productivity, and Crop Income. International Food Policy Research Institute. Discussion Paper No. 35. Washington DC.