DETERMINANTS OF TECHNICAL EFFICIENCY OF SOYBEAN PRODUCTION AMONG FARMERS IN BUNGOMA COUNTY, KENYA

BY

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DECLARATIONS

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DEDICATION

This thesis is dedicated to my mom Antonina, My lovely wife Emma, My Children Fridah, Tracy, Rehema, Kris and Emmanuel, my siblings, my lecturers and my friends; for their determination to make me excel in my studies even when times were hard. I pray that the Lord may reward them abundantly for their guidance and provision.

ABSTRACT

Soybean (*Glycine max* (L.) is an important crop in the world. It has been the dominant oilseed produced since 1960's in Kenya and is used as human food, livestock feed, and for various industrial purposes. Biophysical conditions in many parts of Kenya favor the production of soybeans. Agronomic experience has shown that soybean can be successfully grown in Kenya using low agricultural input. Despite this huge potential Kenya has in soybean production and the impact of past efforts aimed at promoting soybean in the farming systems of Kenya, the results have been insignificant. Domestic production has remained constant and still stands at about 5,000 tons per annum. This leads to the question as to whether or not it is technically efficient to produce soybeans in Kenya, particularly in Bungoma County which harbors huge potential for soybeans production yet its productivity has remained low. The main objective of the study was to explore ways likely to increase productivity of soybean farmers in Bungoma County through a better use of the factors employed in soybean production, and hence increase the farmers' income. To achieve this, the following three specific objectives were pursued: (i) To analyze the socio-economic characteristics of soybean farmers in Bungoma County, (ii) To estimate the technical efficiency level of individual soybean farmers in Bungoma County and (iii) To examine socio-economic factors that influence technical inefficiencies among soybean farmers in Bungoma County. The study used primary data that were gathered from a sample of 168 soybean farmers in Bungoma County through administration of a structured questionnaire. The multi-stage random sampling technique was used. On the analysis of data, Descriptive statistics was used to analyze socio-economic characteristics while the Cobb-Douglas stochastic frontier production function was used, in order to estimate the level of technical efficiency in a way consistent with the theory of production. The technical inefficiency effects function was estimated simultaneously with the stochastic production function using a One-stage procedure in Frontier 4.1 computer program. The results show the dominance of female and old people in soybean production in Bungoma County. The results further reveal the existence of technical inefficiencies in soybean production among farmers in Bungoma County. The mean technical efficiency of soybean famers was found to be 75.25%. On the determinants of inefficiency, the study found that; gender, experience, credit access, extension services, certified seeds and membership to social group significantly reduce the technical inefficiencies among soybean farmers in Bungoma County. Increase in age of a farmer was found to significantly increase inefficiencies among Soybean farmers in Bungoma County. The study recommends: Encouragement of youths and males to participate in soybean farming, increased extension services, provision of credit services, encourage farmers to join social groups and to encourage soybean farmers in Bungoma County to use certified soybean seeds.

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LIST OF ACRONYMS AND ABBREVIATIONS

AAAE	African Association of Agricultural Economists
AERC	African Economic Research Consortium
AgDP	Agricultural Gross Domestic Product
ASARECA	Association for Strengthening Agricultural Research in Eastern and Central Africa
BIDCO	Business and Industrial Development Corporation
CRA	Commission of Revenue Allocation
CSAE	Centre for the Study of African Economies
CSSA	Crop Science Society of America
DEA	Data Envelopment Analysis
ERS	Economic Recovery Strategy
FAO	Food and Agriculture Organization
FDH	Free Disposal Hull
GDP	Gross Domestic Product
GOK	Government of Kenya
JICA	Japan International Cooperation Agency
KARI	Kenya Agricultural Research Institute
NGO	Non-Governmental Organization
SSSA	Soil Science Society of America
UCL	University College London

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CHAPTER ONE

INTRODUCTION

1.1 Background to the study

In Kenya, agriculture contributes about 25 percent of gross domestic product (GDP) and provides a livelihood to three-quarters of the population, (Government of Kenya 2012). The sector also accounts for 65 per cent of Kenya's total exports and provides more than 18 per cent of formal employment. More than 70 per cent of informal employment is in the rural areas (Government of Kenya, 2010).

According to the Agricultural Sector Development Strategy 2010- 2020, agricultural sector comprises six subsectors—industrial crops, food crops, horticulture, livestock, fisheries and forestry—and employs such factors of production as land, water and farmer institutions (cooperatives and associations). Industrial crops contribute 17 per cent of the Agricultural Gross Domestic Product (AgGDP) and 55 per cent of agricultural exports. Horticulture, which has recorded a remarkable export-driven growth in the past 5 years and is now the largest subsector, contributes 33 per cent of the AgGDP and 38 per cent of export earnings. Food crops contribute 32 per cent of the AgGDP but only 0.5 per cent of exports, while the livestock subsector contributes 17 per cent of the AgGDP and 7 per cent of exports (Government of Kenya, 2010).

The Kenya vision 2030 has identified agriculture as one of the key sectors to deliver the 10 per cent annual economic growth rate envisaged under the economic pillar and soybean has been identified as one of the crops which will contribute to the pillar for economic growth (Government of Kenya, 2007).

Soybean (*Glycine max* (L.) Merrill)) is an important crop in the world. It has been the dominant oilseed produced since the 1960s (Smith and Huyser, 1987) and is used as human food, livestock feed, and for various industrial purposes (Myaka *et al*., 2005). While most other beans contain 20% protein, soybean contains 40% (Greenberg and Hartung, 1998). Soybean products are cholesterol free and high in calcium, phosphorus, and fiber and have one of the lowest levels of saturated fat among vegetable oils, all these explain the high demand for soybean products (Greenberg and Hartung, 1998). In addition, soybean improves soil fertility by adding nitrogen from the atmosphere (Sanginga *et al.*, 2003). Some of the dual-purpose, promiscuous (it nodulates effectively with indigenous rhizobia) soybean varieties (e.g., TGx 1448-2E) are characterized by a high N-fixation capacity (>60% nitrogen derived from the atmosphere) (Sanginga *et al*. 2003). This N-fixation is an important benefit to African agriculture where the soils have become exhausted due to population pressure on land and where fertilizers are too expensive for many farmers.

According to FAO statistics, total world production of soybean increased from 136.5 million MT in 1994 to 261.6 million MT in 2010. Major global producers in order of importance include the United States of America, Brazil, Argentina, and Bolivia. The 10 largest soybean producers in the world (USA, Brazil, Argentina, China, India, Paraguay, Canada, Bolivia, Indonesia, and Uruguay) together produced about 252.9 million MT in 2010 (approximately 96% of total world production), (Chianu *et al*. 2011). Soybean growers in leading producing countries (especially Brazil, Argentina, and the U.S.A) have been using biotechnological innovations to boost soybean production. As a result, most of the soybean that is currently grown has undergone biotech modification(Jagwe and Nyapendi, 2004). Based on the 2003 production records, about 81% of the soybean produced in the United States of America has been modified using biotechnology while Argentina and Brazil have genetically modified 99% and 34% of their respective soybeans (Jagwe and Nyapendi, 2004 citing American Soybean Association, 2004). The use of biotechnology modified planting materials confers the advantages of higher crop yields and greater tolerance to soybean diseases and pests (Jagwe and Nyapendi, 2004). High crop yield increases the profits that farmers make from soybean production and marketing enterprises.

Compared to the USA, South/Latin America and Asia, Africa is a very small producer of soybean. During the last decade or so, Africa accounted for 0.4 – 1% of total world production of soybean. The main producers within the continent of Africa include Nigeria, South Africa, Uganda, and Zimbabwe. Nigeria, which contributed nearly 50% of Africa's output, accounted for a mere 0.3% of the world soybean output in 2003, (Chianu *et al*., 2008). About 19 African countries are recorded in the world soybean production statistics compiled by FAO. These countries and the proportion (%) of African soybean production that each accounts for are: Nigeria (48.9%), Uganda (16.8%), South Africa (14.9%), Zimbabwe (8.4%), Ethiopia (2.7%), Rwanda (2.0%), Egypt (1.7%), and DRC (1.4%). Others are: Cameroon (0.8%), Benin (0.7%), Cote d'Ivoire (0.3%), Liberia

(0.3%), Burkina Faso (0.3%), Zambia (0.2%), Gabon (0.2%), Tanzania (0.2%), Morocco (0.1%). Kenya is a very small soybean producer, even within the African context (Chianu *et al*., 2008). Currently, about 6000 – 7000 MT of soybean is produced in Kenya against an annual local demand of 50,000 MT. The deficit is met through imports (Mahasi *at el*, 2010). Nationally, FAO (2008) data estimates an average yield of 800 kg per ha of soybean, as shown in table 1.1.

Table 1.1: Soybean area and yield (productivity) in Kenya: 1992- 2010

Year	Area (ha)	Yield (kg/ ha)
1992	2289	968.1
1993	2365	744.2
1994	1907	825.9
1995	2177	796.1
1996	2131	1030.5
1997	2023	1055.9
1998	2103	961
1999	2012	1139.7
2000	2610	9134
2001	2876	995.5
2002	3008	860.7
2003	3316	792.8
2004	3214	1010
2005	3128	991.4
2006	2513	827
2007	2500	840
2008	2615	780.9
2009	2950	715.3
2010	1621	950

Source; FAO, 2010

Kenya consumes about 400 000 MT of vegetable oils and local production only meets a third of this demand (Jagwe and Nyapendi, 2004). Oil palms, sunflower and soybeans are vital sources of vegetable oils in Kenya. Coupled with increasing demand for soybean for animal feeds manufacturing, Kenya can easily absorb up to 150 000 MT of soybean in raw form annually (Jagwe and Nyapendi, 2004). According to Chianu et al, 2009, if human consumption of soybean in Kenya accounts for 10-15% (or 10 000 - 15 000 MT) per annum and domestic production still stands at 1 000 to 5 000 MT, it means that a part of the domestic human demand for soybean is currently being fulfilled through soybean imports.

The volume of imports of vegetable oil and fats in 2002 was estimated at approximately 390,000 MT having increased dramatically from about 250 000 MT in 2000 (Chianu *et al*. 2008, citing Central Bureau of Statistics (CBS statistical abstract 2003). The current requirements for soybean and soybean-related products (mainly soybean meal and soybean cake) are in the range of 70,000 - 100,000 MT (18-26% of the vegetable oils is obtained from soybean oil) as compared to between 1,000 and 5,000 MT produced locally by farmers in Kenya (Chianu *et al*., 2008). Overall, total soybean imports (all products) in Kenya have been more than exports as shown in table 1.2, and from 2005 to 2009, the total import value for soybean and soybean products was more than export value (Table1.3)

Table 1.2: Soybean import and export quantities (000Metric tones) in Kenya

Year	Import quantity			Export quantity			Total import	Total export
	Soya Sauce	Soybean Oil	Soybeans	Soya Sauce	Soybean Oil	Soybeans		
2001	152	14386	3137	3	3807	671	17675	4475
2002	87	9051	1528	6	6457	585	10666	7048
2003	104	22971	2645	11	7609	1296	25720	8916
2004	28	4929	4963	0	5202	788	9920	5990
2005	120	3523	5147	12	3798	916	8790	4726
2006	103	6648	8261	0	2135	6315	15012	8450
2007	269	7258	6234	59	3339	4221	13761	21380
2008	148	10194	8481	1	2206	1594	18823	3801
2009	208	100	20019	15	1222	1500	20327	2737

Source: FAO statistics 2011.

Table 1.3: Estimated Soybean Import and Export values (1000$) in Kenya

YEAR	Imports			Exports			Total import	Total Export
	Soya Sauce	Soybean Oil	Soybeans	Soya Source	Soybean Oil	Soybeans		
2005	97	1135	2743	8	3366	350	3975	3724
2006	73	4627	2753	0	1926	3344	7453	5270
2007	264	6618	1818	49	3897	2143	8700	6089
2008	142	13968	3395	4	3767	1384	17505	5155
2009	193	13800	8461	9	1677	1460	22454	3146

Source: FAO statistics 2011.

Soybean grows in all places where maize grows and to a height of 60–120 cm, maturing in 3 to 6 months (depending on variety, climate, and location) (Chianu *at el.*,2008). The pod is hairy and contains two to three seeds. Soybean grows best if planted in pure stands. It improves soil fertility by fixing nitrogen from the atmosphere (Sanginga *et al.*, 2003). Some varieties fix 44 to 103 kg N per ha annually (Sanginga *et al.*, 2003). Where rotated with other crops, the subsequent crop often benefits from the surplus nitrogen left in the soil after soybean has been harvested. In Africa, soils have become exhausted due to the population pressure on the land. Mineral fertilizers are too expensive for the generally resource-poor farmers to afford quantities sufficient for sustainable agricultural intensification. Advantage must be taken of this nitrogen fixation ability of soybean. With the right variety, soybean yields could be over 3 tons per ha, (Chianu *et al.*, 2009).

Table 3 below shows the key soybean producing districts from different provinces in Kenya

Table 1.4: Main soybean producing districts in Kenya

province	Districts
Western	Busia*, Bungoma*, Teso, Butere/Mumias, Kakamega*, Mount Elgon, Lugari, Vihiga*
Rift Valley	Nakuru*, Nandi*, Trans Nzoia*, Koibatek, Narok*, Trans Mara, Laikipia and Bomet*
Eastern	Meru*, Embu*, Mbeere, Machakos*
Nyanza	Rachuonyo, Homabay*, Gucha, Kisii*, Nyamira*, Siaya*
Central	Kirinyaga*, Murang'a*, Maragwa, Nyeri*

Note: *former districts that are now Counties

Source; Chianu at el, 2008.

Western province stands out as the leading soybean producing province in Kenya, accounting for nearly 50% of total national smallholder planted area and production in 2003 (Chianu *et al* 2008). The main soybean producing districts in Western province are Butere/Mumias, Busia, Bungoma, Teso, Kakamega, Mount Elgon, Lugari, and Vihiga. Butere/Mumias, Busia, and Bungoma districts accounted for approximately 80% of the total soybean production in the Western province of Kenya in 2003. Other major soybean producing provinces in Kenya after the Western province are Nyanza and Central provinces, which accounted for 11-12% of total smallholder soybean production in 2003 (Chianu *et al*. 2008).

Estimates of area potentially suitable for soybean production ranges from 157,000 ha (estimated by the Ministry of Agriculture in 1995) to 224,000 ha more recently (Chianu *et al.,* 2008, citing the Lake Victoria Basin Development Authority 2004) While Nyanza province accounts for 11–15% of Kenyan land area potentially suitable to soybean cultivation, the Western province accounts for 9–13%. At district level, Uasin Gishu, Trans Nzoia, Siaya, and Bungoma districts account for the largest proportion of land potentially good for soybean production in Kenya. Kenyan conditions are suitable for soybean cultivation. The main factors include congenial agro ecology, crop compatibility with existing farming systems, soybean's potential contribution in natural resource management, low cost of soybean protein, soybean's contribution to food security, its potential to contribute to bio-fuel energy, and its ability as an economic crop to create employment and generate income. Further regarding fuel production potential, soybean biodiesel produces low-carbon, and mid-carbon chains, which burn more completely with less carbon emission and metal oxide pollution risks

1.2 Problem Statement

As a legume, soybean improves soil fertility by fixing atmospheric nitrogen (one of the plant nutrients lacking in most of Kenya's soils). Soybean also presents the farmers with the much needed alternative cash income source. In the Economic Recovery Strategy (ERS) for wealth and employment creation, the Kenyan government identified agriculture as an important vehicle for the realization of its employment creation and poverty reduction objectives. According to this strategy, the government's vision is to transform Kenya's agricultural sector into a profitable economy (Government of Kenya, 2004). This transformation calls for fundamental shift to market oriented production, diversification of agriculture such as soybean and adoption of greater use of appropriate farming practices. Soybean is one such crop that has the potential to make significant contributions to healthcare (Government of Kenya, 2002; Ohiokpehai and Osborne, 2003), income and livelihood security. In Kenya Vision 2030 (Government of Kenya, 2007), soybean was identified as one of the crops which will contribute to pillar for the economic growth.

Biophysical conditions in many parts of Kenya favor the production of soybeans. Agronomic experience show that soybean, can be successfully grown in Kenya using low agricultural input. KARI released five soybean varieties in 2009 (Hill, Black Hawk, EAI 3600, Nyala and Gazelle) for specific growing areas with a yield potential of up to 2.0 tons ha-1. Estimates of area potentially suitable for soybean production ranges from 157,000 ha (estimated by the Ministry of Agriculture in 1995) to 224,000 ha (more recently estimated by the Lake Victoria Basin Development Authority, 2004 in *Chianu et al.*, 2008) While Nyanza province accounts for 11%to 15% of Kenyan land area potentially suitable to soybean cultivation, the Western province accounts for 9–13%. At district level, Uasin Gishu, Trans Nzoia, Siaya, and Bungoma districts (now Bungoma County) account for the largest proportion of land potentially good for soybean production in Kenya.

The annual average yield of Soybean range from 560 kg per ha (Western Province) to 1100 kg per ha (Eastern province) (FAO, 2008). The average yields obtained in Rift

Valley and Central Provinces ranged in between these figures. It has, however, been demonstrated that it is possible to obtain soybean yields of up to 3000 –3600 kg per ha (Mahasi *et al.,* 2010). Despite this huge potential that Bungoma County has in soybean production and most past efforts aimed at promoting soybean in the farming systems of Kenya and specifically in Bungoma County, the results has been insignificant.

Domestic production has remained constant and still stands at about 5,000 tons per annum in Kenya (Karuga and Gachanja, 2004). Productivity also remained low, particularly in Bungoma County that had productivity of 450kg per ha (Chianu *et al.,* 2009) compared to the potential 3000 -3600 kg per ha. This led to the question to whether or not it is because of technical inefficiencies that soybean productivity in Bungoma County remained low and yet the area is high potential for soybean production. This study sought to analyze the technical efficiency among Bungoma soybean farmers and its determinants.

1.3 Objectives of the study

The main objective of this study was to explore ways that would increase technical efficiency of soybean farmers in Bungoma County through a better use of the factors employed in soybean production, and hence increase the farmers' income. In order to achieve this, the following specific objectives were pursued;

I. To analyze the socio economic characteristics of Soybean farmers in Bungoma county.

II. To estimate the level of technical efficiency of individual soybean farmers in Bungoma County.

III. To examine socio-economic factors that influence technical efficiencies among these farmers.

1.4 Research Questions and Hypotheses

1.4.1 Research questions

I. How efficient are soybean farmers in Bungoma County?

II. What socio-economic factors influence soybean production and technical efficiency in Bungoma County?

III. How can efficiency of soybean farmers be improved so that they exploit the full potential in the production of the crop?

1.4.2 Hypotheses of the study

H_1; There are no technical inefficiencies among soybean farmers in Bungoma County

H_2; There are no significant relationships between technical inefficiencies and socio-economic characteristics, such as; Age, gender, experience, level of education, use of fertilizer, access to credit, type of seeds used, access to extension services and type of cropping system used among soybean farmers in Bungoma County.

1.5 Justifications of the study

Jagwe and Owuor (2004) estimated the cost of producing soybean in western Kenya to be about US$ 175 per metric ton. Data from FAO indicate that the cost of soybean production in the United States of America ranges from US$ 160 to US$ 170. This shows that soybean production in Kenya can be competitive in the global market and can further be improved upon if the cost of soybean production can be reduced through comprehensive research on ecological, edaphic, and agronomic factors (Jagwe and Owuor, 2004). Following this approach to improve productive efficiency, the crop would become more attractive to the farmers especially if linkages with the market, including the international market can be developed.

Measuring technical efficiency of soybean farmers and identifying the factors that affect it, may provide useful information for the formulation of economic policies likely to improve producer technical efficiency. In addition, from Microeconomic point of view, identifying factors that may improve farm profitability is of major significance since by using information derived from such studies, farmers may become more efficient and hence more profitable (Nchare, 2007).

Population increase has led to sub-division of land resources into small units especially in the arable regions like Bungoma County. Hence increasing production of farm products through expansion of area under farming would seem an infeasible decision. There is need to focus on improving the productivity of these farmers to enable them attain efficiency in their production process, so as to increase the production level of agriculture and thus contribute towards attaining food security in the country.

The empirical evidence of this study adds to the body of knowledge on soybean production that should assist government and non-governmental bodies to promote and improve soybean productivity. It also contributes to the applied and theoretical analysis understanding of farmers' technical performance and efficiency.

1.6 Scope and Limitations of the study

The study was limited to measuring the technical efficiency of soybean farmers. In addition, the study determined the factors influencing technical inefficiency of the above mentioned farmers. Geographically the study was carried out in Bungoma County, a region with high potential for soybean production in the country. The study collected information about socio-economic characteristics of soybean farmers and resource use on soybean production among these farmers during the long rain season of March to July 2012.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

This chapter reviews literature on agricultural efficiency. It defines the various types of efficiencies and examines the advantages and disadvantages of different models and approaches available for the estimation of a production frontier and the computation of relative efficiency scores. It looks at related past studies on efficiency using both parametric and non-parametric methods. Finally it presents the theoretical framework and the conceptual framework upon which this study is based.

Koopmans (1951), defined technical efficiency as permissible variation input/output vector in which is technically not possible to increase any output (or to reduce any input) without simultaneous reduction of other output or increasing other input**.** Technical efficiency is defined as the ability of a farm to either produce the maximum possible output from a given set of inputs and a given technology, or to yield the given level of output from the possible minimum quantum of inputs **(**Biekelile, 2011**)**. Fare and Lovell (1978) defined technical efficiency as the "degree to which the actual output of production unit approaches its maximum."

Farm efficiency is one of the important issues of production economics and production function analysis **(**Biekelile, 2011**).** Technical efficiency is a way to measure the level and extent of inefficiencies in production system. Technical efficiency describes the relationship between output and input by considering different combinations of input for output.

2.2 Theoretical framework

The study is grounded on the Microeconomic theory of the firm which is a decision making unit that is involved in production. Production is the process of transforming inputs into outputs and the objective of production is to create value through transformation. Since outputs are desirable outcomes, more is preferred and better.

The firm is faced with two inter-related optimization problems; cost minimization and or profit maximization. The firm seeks to obtain the maximum possible returns (outputs) from a given set of resources. The theory of the firm is built on the idea of rationally calculating optimizing agents using a production function. The production function is the backbone of the theory of the firm. It describes the current state of technology and how inputs can be transformed into outputs. Below is a specification of a production function;

$$Q = f\{L, S, F, \dots .\} \qquad (2.1)$$

Where Q represents a firm's output, L may represent the amount of labour, S represents the quantity of seeds used in production of Q while F represents the amount of fertilizer applied.

The objective of the producer is to maximize profit either by increasing the quantity of Q produced or by reducing the cost of producing Q. The production function shows the maximum amount of the good that can be produced using alternative combinations of labour (L), seed (S) and fertilizer (F). This production relationship can be expressed in several forms such as: Linear functional forms, Polynomial functional forms and Cobb-Douglas functional form. Technology can be simply defined as the systematic application of collective human rationality to the solution of problems through the assertion of control over nature and all kinds of human processes. It is the embodiment and result of systematic, disciplined, non-accidental and non-serendipitous research (Ellul, 1965). In this context, agricultural technology may be defined as application of technology in the promotion and development of agriculture (Ogundele, 2006).

In economic analysis, efficiency is generally defined in a number of related ways including: the use of resources in such a way as to maximize the production of goods and services; or comparison of what is actually produced or performed with what can be achieved with the same level of resources (land, capital, labour, time, etc.). In fact, the concept of efficiency is relative and differs from productivity. Productivity is the ratio of what was produced and what was spent to produce while efficiency compares what has been produced, given the resources available, with what could have been produced with the same resources (Fellipe *et al.*, 2012). If the production unit of this parameter is far away, it is considered to be inefficient.

As a component of productive efficiency, technical efficiency is derived from the production function. Productive efficiency consists of technical efficiency and allocative or factor price efficiency. Productive efficiency represents the efficient resource input mix for any given output that minimizes the cost of producing that level of output or, equivalently, the combination of inputs that for a given monetary outlay maximizes the level of production (Forsund et al., 1980). Technical efficiency reflects the ability of a firm to maximize output for a given set of resource inputs, while allocative (factor price) efficiency reflects the ability of the firm to use the inputs in optimal proportions given their respective prices and the production technology.

The level of technical efficiency of a particular farmer is characterized by the relationship between observed production and some ideal or potential production (Greene, 1980). The measurement of the firm specific technical efficiency is based upon deviations of observed output from the best production or efficient production frontier. If a farmer’s actual production point lies on the frontier, it is perfectly efficient. If it lies below the frontier, then it is technically inefficient with the ratio of actual to the potential production defining the level of efficiency of the individual farmer.

2.3 Measurement of technical efficiency

The evaluation of a firm’s technical efficiency level results from the estimation of a frontier production function. There are several approaches in literature that are used to construct efficiency frontiers. These approaches are classified into two broad groups; non-parametric and parametric frontiers (Chirwa, 2007).

2.3.1 Non-parametric approaches

The non-parametric approaches estimate the technical efficiency based on envelopment techniques. They do not impose a functional form on the production frontier and do not make any assumptions about the error term (Chirwa, 2007). These approaches require one to construct a free disposal convex hull in the input-output space from a given sample of observations of input and output. The convex hull, which is generated from a subset of the given sample, serves as an estimate of the production frontier, depicting the maximum possible output (Obwona, 2006).Technical efficiency of a firm is then measured as a ratio of the actual output to the maximum possible output on the convex hull, corresponding to the given set of inputs. Distinct among the nonparametric approaches are the free disposal hull (FDH) and Data envelopment Analysis (DEA). The FDH method was developed by Deprins et al. (1984), while DEA method was initiated by Farrel (1957) and transformed into estimation techniques by Charnes *et al*. (1978), (Nchare, 2007).

The data envelopment analysis (DEA) is a technique based on mathematical programming to analyze the relative efficiency of production units. In the literature related to DEA, a production unit is treated as a DMU (decision making unit), since these models comes from a measure to assess the relative efficiency of decision makers units (Fellipe *at el.*, 2012).

According to Charnes *et al*. (1994), to estimate and analyze the relative efficiency of DMU's, DEA uses the definition of Pareto optimality, under which any product may have increased their production without their inputs are increased or decreased production of another product. The efficiency is analyzed in relation between the units.

To incorporate the nature of multi-product and multi-input production, Charnes *et al*. (1994) proposes the DEA technique for the analysis of different units, and the relative efficiency. The distance function is used to incorporate the nature of multi-product and multi-input in the analysis of productivity and efficiency, without the need to specify behavioral objectives of decision makers.

According to Färe *et al.* (1994), the convenient way to describe the characteristic multi product production technology is defined by the set S:

$$S = \{(\boldsymbol{x}, \boldsymbol{y}) : \boldsymbol{x}\ can\ produce\ \boldsymbol{y}\} \qquad (2.2)$$

Which is defined by the set of all vectors of inputs and outputs (***x***, ***y***) such that ***x*** can produce ***y***, where ***x*** is a (k x 1) vector of non-negative inputs and***y*** is a (m x 1) vector of non-negative products.

The set of production technologies can equivalently be defined by the set of production possibilities P (x), which represents the set of all vectors ***y*** of products that can be produced by the input vector ***x***;

$$P(x) = \{\boldsymbol{y} : \boldsymbol{x} \text{ can produce } \boldsymbol{y}\} \qquad (2.2)$$

The distance function-oriented product, according to Shepard (1970) can be defined by the set of products P(x) as;

$$d_0(x, y) = \min\left\{\emptyset : \left(\frac{y}{\emptyset}\right) \in P_{(x)}\right\} (2.3)$$

$$d_0(x, y) = (\max\{\emptyset : (\emptyset y) \in P_{(x)}\})^{-1} \ (2.4)$$

Where$\emptyset$, in expression 2.3 is the minimal factor by which the product can be contracted and still be in the range of production possibilities.

The distance function $d_0(x,y)$ may have values less than or equal to 1 if the output vector y is an element of production possibility set P(x). If the output vector equals to 1, (x,y) is on the technological frontier and in this sense, the production is technically efficient.

The DEA oriented product and assumption of non-constant returns to scale seeks to maximize the proportional increase in levels of output, holding fixed the amount of inputs. According to Charnes *et al*., (1994), it can be represented algebraically by:

$$[d_0(x,y)]^{-1} = max\theta, \lambda, s^+ s^-, \phi \qquad (2.5)$$

Subject to;

$$\phi \boldsymbol{y}_i - \boldsymbol{Y\lambda} + S^+ = 0$$

$$-\boldsymbol{x}_i + \boldsymbol{X\lambda} + S^- = 0$$

$$\boldsymbol{N}1'\lambda \leq 1$$

$\lambda \geq 0$

$$S^+ \geq 0$$

$$S^- \geq 0$$

Where $\mathbf{y}_i$ is a vector (m x 1) quantities of product i-th DMU, $\mathbf{x}_i$ is a (k x 1) vector of input quantities of the i-th DMU, **Y** is a (n x m) matrix product of the n DMUs, **X** is a matrix (n x k) inputs of the n DMUs, $\boldsymbol{\lambda}$ is a (n x 1) vector weight,**N1** is a (n x 1) vector of numbers 1, $\mathbf{S}^+$ is a vector of slack on the products, $\mathbf{S}^-$ is a vector of slack relative to inputs, andϕ is a scalar quantity which equals to or greater than 1 and indicates the efficiency score of DMUs, ie, a value of 1indicates technical efficiency of the i-th DMU in relation to others, while a value less than 1 show the presence of technical inefficiency relative. The problem presented in (2.5) is solved n times - once for each DMU, and, as a result, shows the values of ϕ and λ. ϕ is the efficiency score of DMU. The performance of DMU is fully (100%) efficient if and only if ϕ=1, S^-= 0 and S^+= 0. And the performance of a DMU is weakly efficient if and only if ϕ =1, $S^- \neq 0$ and $S^+ \neq 0$.

FDH is the least restrictive nonparametric model. It does not require convexity of the underlying technology, but assumes free disposability of inputs and outputs (Walden and Tomberlin, 2010). Tulkens (1993) further refined the FDH approach and required that the frontier and evaluation of efficiency be based on observed performance. A decision making unit (DMU) is FDH efficient if it is not dominated by any other DMU. By dominance, we mean that a DMUA dominates DMUB if: (*i)* no input for DMUA exceeds the corresponding input for DMUB; (*ii)* no output in DMUA is less than the corresponding output for DMUB; and (*iii)* at least one input for DMUA is less than the corresponding one for DMUB, and at least one output for DMUA exceeds the output for DMUB (Thrall 1999). Although this seems to be a logical approach for estimating technical efficiency, FDH has been criticized as being unable to provide economic meaning for the prices of outputs and the costs of inputs (Thrall 1999). In fact, Thrall (1999) concludes that "FDH is inconsistent with all of the price theory in economics so, one or the other must be abandoned." However, when gauging performance in the public sector, where prices are usually lacking, there is less concern about this inconsistency (Walden and Tomberlin 2010, citing Briec, Kerstens, and Vanden Eeckaut 2004).

There are two approaches for constructing the FDH estimator; one is a mixed-integer programming approach, and the second is a simple sorting routine. FDH estimator can be calculated quite easily with software such as MATLAB (**mat**rix **lab**oratory), (Walden and Tomberlin, 2010). The nonparametric methods were criticized (Forsund *et al*., 1980) on the following grounds; no statistical inferences can be carried out on the estimates, they do not take into account the measurement errors and random effects; in fact they assume that every deviation from the frontier is due to the firms inefficiency and that the measures of technical efficiency using this approach are susceptible to outliers.

Simar (2003) proposed a method to improve the performance of DEA/FDH estimators in the presence of noise, while Cazals *et al.* (2002) developed a robust nonparametric estimator (Nchare 2007). Instead of estimating the full frontier, they rather proposed to estimate an expected maximal output frontier of order *m*. There are several properties of the order-m frontier that make it attractive for estimating capacity. First, by construction the estimator with a finite *m* does not envelop all the observations in the sample, and is therefore less sensitive to outliers than the DEA or FDH estimator (Simar and Wilson 2008). Secondly, as *m* increases for a fixed sample size, the order-m estimator converges to the FDH estimator. Finally, it is not subject to the "curse of dimensionality," so it is an alternative measure when there is a small data set and the DEA or FDH estimator cannot be calculated (Simar and Wilson 2008). However, it cannot reveal the optimal variable input utilization rate (Waldon and Tomberlin, 2010). Following this approach, Aragon et al. (2003) developed a new nonparametric estimator of the efficiency frontier based on the conditional quantiles of appropriate distribution associated with production processes. Unfortunately, this method is not extended to multivariate analyses (Nchare, 2007).

2.3.2 Parametric Models (Stochastic Frontier Approach)

The parametric approach is based on econometric estimation of a production frontier. Parametric frontier approaches impose a functional form on the production function and make assumptions about the data. The most common functional forms include the Cobb–Douglas, constant elasticity of substitution and translog production functions. The parametric approaches are divided into deterministic frontiers and stochastic frontiers. The deterministic frontiers assume that all the deviations from the frontier are a result of firms' inefficiency, while stochastic frontiers assume that part of the deviation from the frontier is due to random events (reflecting measurement errors and statistical noise) and partly due to firm specific inefficiency (Forsund et al., 1980; Battese, 1992; Coelli et al., 1998).

The stochastic frontier approach, unlike the other parametric frontier measures, makes allowance for stochastic errors arising from statistical noise or measurement errors. The stochastic frontier model decomposes the error term into a two-sided random error that captures the random effects outside the control of the firm (the decision making unit) and the one-sided efficiency component. The model was first proposed by Aigner *et al*. (1977)and Meeusen and van den Broeck (1977). Assuming a suitable production function, we define the stochastic production frontier as:

$$y_i = f(x_{ij}, \beta) + \varepsilon_j \qquad (2.6)$$

Where y is the level of output on the j^{th} plot, x is the value of input i used on plot j, $\varepsilon_i = v_j - u_j$the composed error term, $v_j$is the two-sided error term, and $u_j$is the one-sided error term. The components of the composed error term are governed by different assumptions about their distribution. The random (symmetric) component $v_j$is assumed to be identically and independently distributed as $NI(0,\sigma_v^2)$ and is also independent of u_j. The random error represents random variations in the economic environment facing the production units, reflecting luck, weather, machine breakdown and variable input quality; measurement errors; and omitted variables from the functional form (Aigner et al., 1977). The model collapses to a deterministic model when $\delta^2{}_v$=0 and it collapses to the stochastic production function model when $\delta^2{}_u$ =0. (Aigner et al 1977, citing Zellner, Kmenta and Draze (1966), noted that $y_i \leq f(x_i;\, \beta)+v_{i,}$ so that the frontier itself is clearly stochastic.

The economic logic behind this specification is that the production process is subject to two economically distinguishable random disturbances with different characteristics. Non-positive disturbance u_i reflects the fact that each firms output must lie on or below its frontier, $[f(x_i;\, \beta) + v_i\,]$. Any such deviation is the result of factors under the firms' control, such as technical and economic inefficiencies, the will and effort of the producer and his employees and perhaps such as defective and damaged products. But the frontier itself can vary across the firms or over time for the same firm. On this interpretation, and as already noted Aigner, (1977) also notes that the frontier is stochastic with random disturbance $v_i \geq$ or≤ 0 being the result of favorable external events such as luck, climate, topography and machine performance. Errors of measurement on y_i constitute another source of $v_i \leq$ or ≥ 0.

One interesting byproduct of the stochastic frontier approach is that we can estimate the variances of v_i and u_i so as we get the evidence on their relative sizes. Another implication of this approach is that technical efficiency should in principle be measured by the ratio;

y_i / [$f(x_i;\beta) + v_i$] (2.7)

Rather than the ratio;

y_i/ [$f(x_i; \beta)$] (2.8)

This simply distinguishes productive efficiency from other sources of disturbances that are beyond the firms' control. For example the farmer whose crop is decimated by drought or storm is unlucky on our measure (2.7), but inefficient by measure (2.8), (Aigner *et al*. 1977).

The stochastic model can be estimated by the "corrected" ordinary least squares (COLS) method or the maximum likelihood method. We follow the work of Battese and Coelli (1988, 1995) using a Battese and Corra (1977) parameterization. The maximum likelihood (ML) estimates of the production function (Equation 2.6) are obtained from the following log likelihood function;

$$\ln(L) = -\frac{N}{2}\Big[\Big(\ln\frac{\pi}{2}\Big) + \ln\delta^2\Big] + \sum_{j=1}^{N}\ln[\,1-\theta\left(\frac{\varepsilon_j\sqrt{\gamma}}{\delta\sqrt{(1-\gamma)}}\right)] - \frac{1}{2\delta^2}\sum_{j=1}^{N}\varepsilon^2$$

(2.9)

With $\varepsilon_j = y_i - f\big(x_{ij};\beta\big)$,$\varepsilon_j$ is the residual of equation 2.1, N is the number of observations, $\theta(.)$ is the standard normal distribution function and

$\sigma^2 = \sigma_v^2 + \sigma_u^2$ and $\gamma = \frac{\delta_u^2}{\delta_v^2}$ are variance parameters.

By assuming a half normal distribution of u_j, mean technical efficiency can be computed as follows;

$$E\left[\exp\left(-u_j\right)\right] = 2[\exp\left({}^{-\gamma\delta^2}/_2\right)][1 - \theta(\delta\sqrt{\gamma})] \quad (2.10)$$

Moreover the measurement of technical efficiency level of farm j requires estimating the random term u_j. Considering the assumptions made on the distribution of u_j and v_j, Jondrow *et al.* (1982) first compute the conditional mean of u_j given ε_j. Battese et al. (1988) derived the best indicator of farm j technical efficiency, written as $TE_j = \exp(-u_j)$ using the formula;

$$E\left[\frac{\exp(-u_j)}{\varepsilon_j}\right] = \left[\frac{1-\theta(\sigma_A + \gamma\varepsilon_J/\sigma_A)}{1-\theta\left({}^{\gamma\varepsilon_j}/_{\sigma_A}\right)}\right][\exp\left(\gamma\varepsilon_j + {}^{\sigma_A^2}/_2\right)] \quad (2.11)$$

Where $\sigma_A = \sqrt{\gamma(1-\gamma)\delta^2}$

The maximum likelihood estimates of the production function in Equation 2.6 are automated in a computer programme, FRONTIER Version 4.1, written by Coelli (1996). FRONTIER provides estimates of β, $\delta^2 = \sigma_U^2 + \sigma_V^2$, $\gamma = {}^{\sigma_U^2}/_{\sigma^2}$ and average technical efficiencies, as well as plot or farm level efficiencies. FRONTIER also provides the estimate for μ when the symmetric error term follows a truncated normal distribution $u \sim N(u, \sigma^2_u)$, (Chirwa, 2007).

2.4 Factors influencing technical efficiency

The literature suggests two methodological approaches for analyzing the source of technical efficiency based on stochastic production function; the two stage estimation procedure and a one stage simultaneous estimation approach (Chirwa, 2007).

Most theoretical frontier functions have not explicitly formulated a model for the inefficiency effects (Battese and Coeli 1993). According to them (Battese and Coeli), empirical papers in which issues of the explanation of the inefficiency effects has been raised include; Pitt and Lee (1981), Kalijaran (1981, 1982, 1989), Kalirajan and Flinn (1983). These papers adopted two stage approach in which the first stage involves specification and estimation of the stochastic frontier production function and prediction of either inefficiency effects or the technical efficiency of the firm involved. The second stage of the analysis involves specification of a regression model for either the predicted inefficiency effects or the level of technical efficiency of the firm in terms of various explanatory variables and additive random error. The parameters of this second stage inefficiency model have been generally estimated by using ordinary least-square (OLS) regression (Battese and Coeli 1993). Kalirajan (1981) specifies that the random errors in the second stage inefficiency model have half-normal random distribution. Battese and Coeli (1993) notes that in all these empirical studies, the methods of estimation of the parameters of the second stage inefficiency model are based on assumption which are clearly false because the effects of estimation of the stochastic frontier model were not accounted for. This approach has also been criticized on grounds that the firm's knowledge of its level of technical inefficiency affects its input choices; hence inefficiency may be dependent on the explanatory variables (Chirwa, 2007).

The single stage approach, otherwise known as the non-neutral approach was put forward by Battese and Coeli (1995). In this approach the frontier model expresses the technical effects as a function of vectors of the firm specific and the random error term. The assumption of this approach is that there are interactions between the firm specific variables and the input variables hence technical inefficiency effects are expressed in terms of the various firm specific variables. Therefore, the estimation procedure entails the estimation of the production frontier and the technical inefficiency effects simultaneously (Battese and Coeli, 1995). The one stage simultaneous approach is also implemented in frontier and in addition to the basic parameters; the program also provides coefficients for the technical inefficiency model (Chirwa, 2007).

2.5 Empirical studies on factors influencing technical efficiency

Several factors, including socio-economic and demographic factors, plot level specific characteristics, environmental factors and non-physical factors are likely to affect efficiency of the farm. Parikh *et al.* (1995), using stochastic cost frontiers in Pakistani agriculture in a two-stage estimation procedure, found that education, number of working animals, credit per acre and number of extension visits significantly increase cost efficiency, while large land holding size and subsistence significantly decrease cost efficiency (Chirwa, 2007). Coelli and Battese (1996), in a single estimation approach of the technical inefficiency model for Indian farmers, find evidence that the number of years of schooling, land size and age of farmers are positively related to technical inefficiency. Wang et al. (1996) use a shadow price profit frontier model to examine the productive efficiency of Chinese agriculture and find that a household's educational levels, family size and per capita net income are positively related to productive efficiency, but off-farm employment is negatively related to efficiency.

Tadesse and Krishnamoorthy (1997) report significant differences in technical efficiency across farm size groups, with paddy farms on small- and medium-sized holdings operating at a higher level of efficiency than large farms. They argue that because accessibility to institutional finance depends on asset position particularly land, small farms are forced to allocate their meager resources more efficiently.

Seyoum *et al*. (1998) use a one-stage model and find technical inefficiency to be a decreasing function of farmers' education and hours of extension visits to farmers participating in the modern technology project. Education does not significantly affect the efficiency of farmers using traditional farming methods.

Wadud and White (2000) apply a stochastic trans-log production frontier approach in both one-stage and two-stage technical inefficiency models. They find that inefficiency decreases with farm size and that farmers with good soils were significantly more technically efficient. Weir (1999) and Weir and Knight (2000) investigate the impact of education on technical efficiency in Ethiopia and conclude that household education positively influences the level of technical efficiency in cereal crop farms. Owens *et al*. (2001) explore the impact of agricultural extension on farm production and determine that access to agricultural extension services raises the value of crop production by 15% in Zimbabwe.

Nchare, (2007) analyzed factors affecting technical efficiency of Arabica coffee producers in Cameroon. He used translog stochastic production frontier and found that the mean technical efficiency index was 0.896% and 32% of the farmers surveyed have technical efficiency indexes of less than 0.91. The study also revealed that the educational level of farmer and credit access are the major socio-economic variables influencing the farmer's technical efficiency.

Obwona (2006) examined the determinants of technical efficiency differentials among small and medium scale farmers in Uganda, a case of Tobacco growers; he used a one-step maximum likelihood procedure by incorporating the model for technical inefficiency effects in translog production function. He found out that education, credit accessibility and extension services contributed positively towards the improvement of efficiency.

Nyagaka *et al.* (2009) analyzes economic efficiency of smallholder Irish potato producers in Kenya, a case of Nyandarua North district. They employed a dual stochastic parametric decomposition technique to disaggregate economic efficiency components and a two-stage limit Tobit mode used to derive efficiency indices as a function of vectors of socio-economic characteristics institutional factors. The empirical results show decreasing returns to scale in production, the mean economic efficiency of 0.39 with ranges of 0.12 -0.66. Education, access to credit and membership in a farmer association positively and significantly influence economic efficiency.

Mignouna *et al*. (2010) assesses the adoption of *Imazapyr*-resistant Maize (IRM) and efficiency levels of farmers in western Kenya. They use Tobit model and stochastic production frontier analysis. The results show that age, education, maize production gap, risk, contact with extension agents, lack of seeds, membership in social group, effective pathway for IRM dissemination and compatibility of the technology are the variables that were found to be significant ($P< 0.05$) in shaping the decisions of households on whether to adopt or not. The study reveals that the mean technical efficiency of maize production of sampled farmers is 70% indicating some inefficiencies of Maize production in western Kenya.

Mengist (2007), examined the efficiency of Maize and Wheat farmers in Uasin-Gishu District, Kenya, using the survey data obtained from a sample of 540 farmers. Technical, allocative and economic efficiencies were estimated using an input-oriented data envelopment analysis. The study indicates that on average wheat farmers showed better performance than maize farmers suggesting that substantial gain in output or substantial reduction of production cost within maize production. However the finding revealed that both enterprises do not achieve full efficiency levels.

Marinda et al, (2006), analyses technical efficiency in male and female managed farms of maize production in west Pokot district, Kenya. They used Cobb-Douglas stochastic production function to estimate the level of technical efficiency and single stage approach to estimate the technical efficiency effects. The empirical results shows that out of the explanatory variables identified, the main factors that tended to contribute significantly to technical efficiency are education of a farmer, access to credit, fertilizer use and distance of the farm from the main road.

It emerges from the foregoing literature review of empirical studies that farmers in general allocate their productive resources inefficiently. From 18% to as much as 64% of agricultural output is lost because of inefficiencies specific to the farms, depending on different studies (Nchare, 2007). There are many socioeconomic factors that influence the technical efficiency of farmers. Among them are farm size, age and education level of the farmer, and access to credit, modern inputs, extension services and belonging to mutual aid group. The studies show that there is possibility of increasing agricultural production significantly through improving the level of producer technical efficiency without necessarily increasing the investments in the sector.

2.6 Conceptual Framework

The conceptual framework for this study is based on the institutional analysis and development (IAD) approach of the new institutional economics (NIE). In the IAD approach by Dorward and Omamo (2005) it is assumed that an exogenous set of variables influences situations of the agents and the behavior of the agents in those situations. This leads to outcomes which provide feedback to modify the exogenous variables, the agents and their situations.

The framework is operationalized as shown in Figure 2.1 below, which represents how various factors inter-relate to influence soybean productivity and hence the welfare of the producers. The policy environment is characterized by the existing political and economic trends in the country which have an influence on the farming system and indirectly determine the soybean output. However, within the farming system various sets of factors inter-relate to determine soybean productivity.

Production factors such as seeds, fertilizers, farm size, labor, capital and agrochemicals are used as inputs into the production process. The availability and distribution of these inputs may be influenced by the policy framework in place, which in-turn determines the extent of soybean productivity. It is expected that the more inputs used by the farmer, the higher the yields per hectare of land.

Soybean productivity is affected by the farm technical efficiency. This is supported by the notion that for a production process to be effective, the manner in which available farm resources are utilized is crucial. The farm's technical efficiency is in turn influenced by the socio-economic characteristics of the farmer. Socio-economic factors are expected to influence production efficiency as follows: The group membership, credit-access and extension service are hypothesized to have a positive influence on technical efficiency. Group membership is expected to help farmers to mitigate problems associated with market imperfections and can also help in providing inputs and other crucial information to the farmers. Credit access provides funds necessary for farmers to overcome liquidity problems that hinder them from purchasing inputs on time. Then access to extension service provides farmers with information on better methods of farming and improved technologies that improve their productivity.

It is hypothesized that age of the farmer negatively affects technical efficiency. This is because older farmers are risk averse making them late adopters of better agricultural technologies. Gender of the farmer is also supposed to have a negative relationship because female farmers are faced with more challenges compared to the male farmers in terms of access to information and resources. Similarly, farmers whose main occupation is farming are expected to have lower efficiency than those engaging in employment or businesses as well. This is because the latter are more able to finance their farming activities. Off-farm employment is expected to have a positive effect on technical efficiency; since farmers with such employments have a regular source of income that they can use to acquire farm inputs. Schooling is expected to have mixed results since; on the one hand, educated farmers committed in farming may be able to take up improved technologies faster know how to implement them effectively because they understand the benefits associated with the technology, hence increasing their efficiency. On the other hand, educated farmers may be more engaged in other income generating activities and avail less attention to their farms, hence lowering their efficiency.

In addition, farmer's experience is expected to positively influence production efficiency because experienced farmers are better producers, who have learned from their past mistakes; hence they make rational decisions compared to less experienced farmers

Use of fertilizer on farm is expected to have a positive effect on the technical efficiency of the farm hence increased productivity. This is because fertilizers used rightly supplements the required nutrients in the soil thus enhancing the growth and healthy of plants hence productivity. Use of certified seeds is also hypothesized to have a positive effect on the technical efficiency. This can be explained by the notion that certified seeds have a good germination rate and are also free from diseases thus they would result in good germination and healthy plants. On the cropping system, it is expected that pure stand cropping system would have a positive effect on the technical efficiency of the farm. This is because in crops planted on a pure stand will have less competition for the available nutrients unlike in the mixed cropping system whereby the different crops will compete for the key nutrients thus resulting in the less output.

A farm that is technically efficient is expected to realize higher soybean output per hectare compared to one that is less efficient in production. Such a firm is hypothesized to incur less production costs leading to higher returns from the enterprise. This therefore has positive spillover effects on the welfare of the soybean producing households. Improved welfare of the households then provides a feedback effect in form of increased access to production inputs and relevant lessons to policy makers.

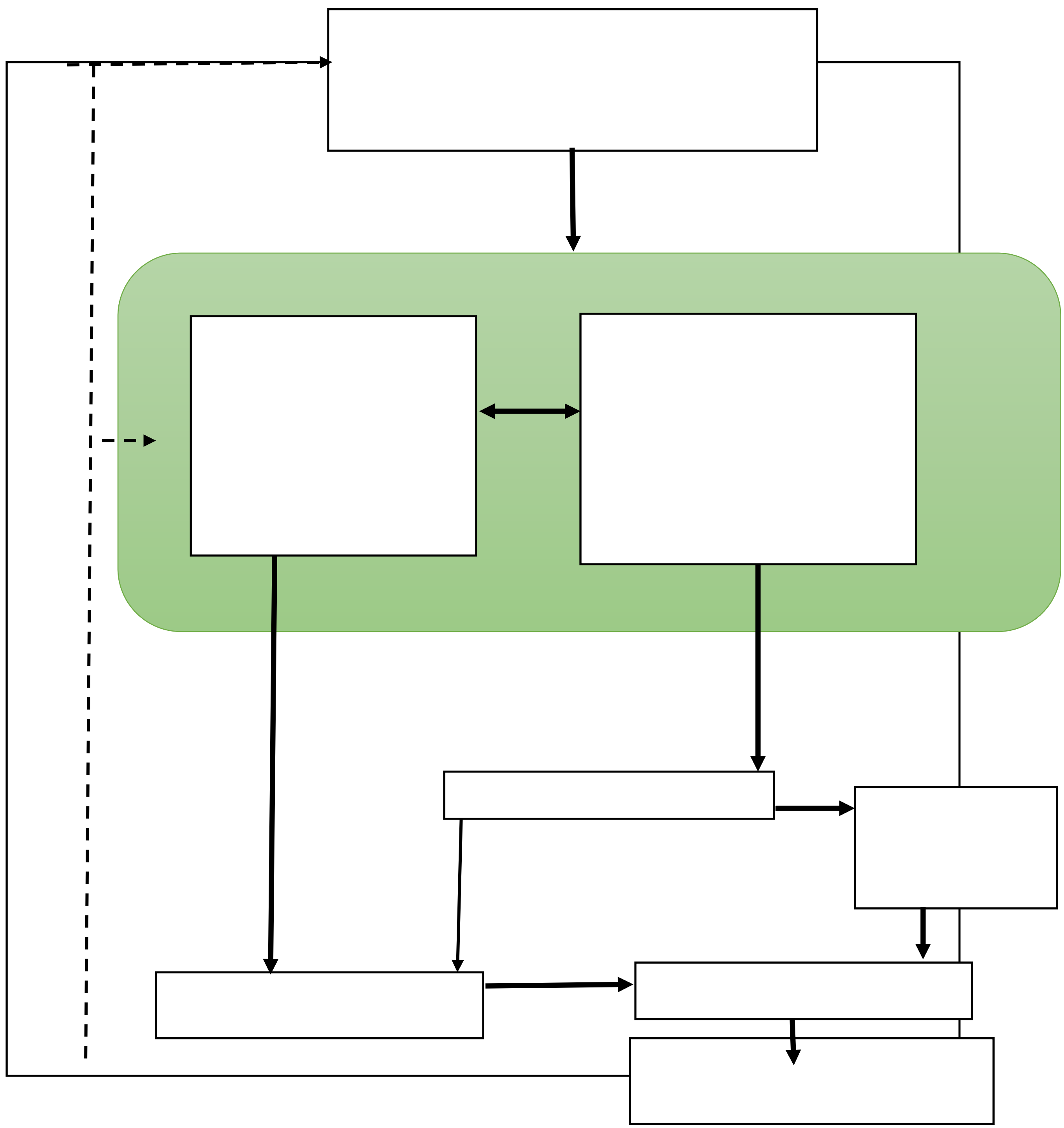


Figure 2.1: The conceptual framework of factors influencing technical efficiency

Source: Adapted from Waluse, 2012.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Study area

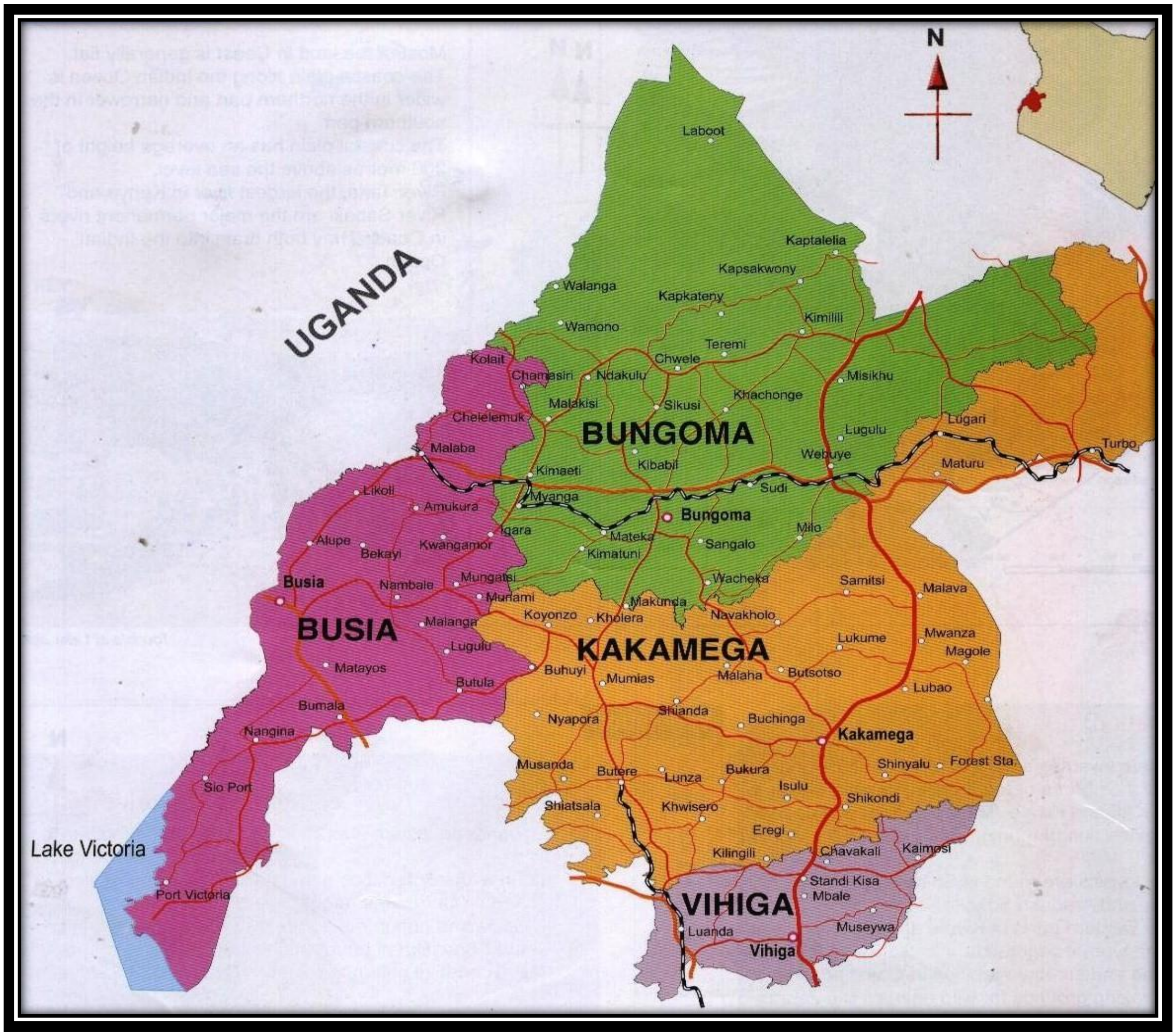
The study was based in Bungoma County located in Western Kenya along the border with Uganda, and borders Busia, Kakamega and Trans Nzoia Counties (Figure 3.1). The County is divided into eight sub-counties (formerly admistrarive districts) namely; Bumula, Bungoma South, Bungoma North, Bungoma East, Bungoma West, Bungoma Central, Cheptais and Mount Elgon sub-counties.

The County covers an area of 3,032.2 Km^2 and lies between 1200 and 1800 meters above the sea level. The region has a Temperature range from minimum of between 15 – 20 ^{0}c to a maximum of between 22 – 30 ^{0}c with a mean temperature of 23^0 c. Its latitude stands at 0.57with the longitude of 34.56. The County receives bimodal type of rainfall with the average annual rainfall ranging from 1200mm to 1800mm per annum. Most of the rain fall is experienced in the months of April-May and July August. Generally, the County is predominantly flatland that encourages agriculture and livestock keeping, (CGB, 2014).

Most land in Bungoma County is under Sugarcane and Maize/beans plantations. Horticulture farming is becoming popular in most areas in Bungoma especially in Kabuchai, Kimilili, Webuye and Kanduyi. Bananas, Irish potatoes, coffee, Cotton, Millet, sweet potatoes among others are grown to a sizable scale.

Bungoma County has a Total Population of 1,375,063 with a Population density is 453.5 people per Km^2. 53% of the population in this County live below the poverty line. Out of the total labor in the County, about 60% are engaged in agriculture and livestock activities which are dominated by small holder farmers (CGB, 2014).

Map showing Bungoma County and its border Counties of Kakamega, Busia and Uganda.



Source: CGB, (2014).

Figure 3.1 Map showing Bungoma County and its border Counties of Kakamega, Busia and Uganda.

3.2 Research Design

The study adopted explorative and correlational research design. Explorative design helped in gaining insight of characteristics of soybean farmers and correlational design perpetuated the understanding of relationships among the study variables.

3.2.1 Target population and Sampling Technique

The population of interest constituted all farmers who practice soybean farming in Bungoma County. The sampling unit was the household that planted soybeans during the long rain season of March – July 2012.

The study used multi-stage sampling technique. The first stage was the purposive selection of Bungoma County, the region that harbors higher potential for soybean production and experiences low soybean productivity. Then followed by systematic sampling of four sub-counties in Bungoma County which are: Bungoma South, Bungoma Central, Bungoma west and Cheptais. This was followed by systematic sampling of two locations from each of the selected sub-counties which are: Marakaru and Bukembe locations in Bungoma South, Nalondo and Kabuchai locations in Bungoma Central, Namwela and Sirisia Locations in Bungoma west and Chesikak and Kapkateny locations in Cheptais sub-county. Finally simple random sampling was used to draw the sampling units from the sampled locations. By assuming that Soybean farmers are evenly distributed across the sub-counties in Bungoma County, equal number of respondents were drawn from each sampled sub-county.

3.2.2 Sample Size

Because the whole population of Soybean farmers was not known with certainty and it was presumed to be large, the study followed Cochran (1963) equation (3.1) to determine the sample size.

$$n_0 = \frac{Z^2 pq}{e^2} \qquad (3.1)$$

Where; n_0 is the sample size, Z is the abscissa of the normal curve that cuts off an area at the tails, e is the desired level of precision, p is the estimated proportion of an attribute that is present in the population, and q is 1-p. Following equation (3.1), adopting a desirable confidence interval of 93%, and the maximum variability level of p= 0.5 (this was because the population of soybean farmers in Bungoma County was not certainly known, so the assumption made was that half of the population in Bungoma County practice soybean farming).The minimum sample size was;

$$n_0 = \frac{(1.81)^2(0.5)(0.5)}{(0.7)^2}$$

167 Respondents

For rationalization purpose, the study used 168 respondents, whereby 42 respondents were drawn from each of the four sampled sub-counties.

3.3 Data types and Sources

Primary data was used in this study. The data was gathered from Soybean farmers in Bungoma County who planted Soybeans during the long rain season of March- July 2012.

The data collected included farm level output of soybean beans in kilograms (kg), land size in acres, seeds used in (kg), Fertilizer used in kg, agro-chemicals (herbicides, insecticide and Fungicide) used in litres, labor used in man-days and the socio-economic and farm specific characteristics of each household which include: age of a farmer, gender, education level, access to extension services, access to Credit, belonging to social group, type of seeds used (certified or local seeds), off farm employment, cropping system used and use of fertilizer.

3.4 Data Collection Technique and Exercise

The data were collected through administering of structured questionnaires. Pretesting of the data collecting instrument (questionnaire) to ascertain its effectiveness in obtaining the required data was done in two villages from the area of study, Mukwa in Bumula sub-county and Kabusasi in Bungoma South sub-county on 29th and 30th of March 2013.

Actual data collection was done in the month of April, 2013 through administering of the structured questionnaire to sampled soybean farmers in the sampled sub-counties and locations from the study area. Collection of data was done by the author.

3.5 Data analysis

Descriptive statistics was used to analyze the socio-economic characteristics of soybean producers in Bungoma County. The descriptive statistics included the frequencies, means and standard deviations the collected data. The results were then presented in form of tables and charts from which inferences were drawn. This was done in order to achieve the first specific objective of the study. The descriptive statistics were analyzed using the SPSS (version 16.0) computer program.

To analyze the second and third objectives, the Cobb-Douglas stochastic frontier production function was estimated from which the technical efficiency score for each farmer was obtained. The technical inefficiency effects were estimated simultaneously with the stochastic production function. This was done with the aid of FRONTIER (version 4.1) statistical software developed by Coelli (1996).

3.6 Model specification and estimation

The Cobb-Douglas stochastic frontier production function was used, in order to estimate the level of Technical Efficiency in a way consistent with the theory of production function. The Cobb-Douglas specification provides an adequate representation of the production technology, if emphasis is placed on efficiency measurement and not on an analysis of the general structure of the underlying production technology (Taylor*et al.*, 1986). The Cobb-Douglas model is flexible and widely used in agricultural economics (Marinda, 2006). The following model is estimated on the basis of the Battese and Coelli (1995) procedure;

$$Y = e^{\beta_0} X_1^{\beta_1} X_2^{\beta_2} X_3^{\beta_3} X_4^{\beta_4} X_5^{\beta_5} e^{(V_j - U_j)} \quad (3.2)$$

Taking the natural log of equation (3.2) yields equation (3.3) below:

$$\ln Y = \beta_0 + \beta_1 \ln X_1 + \beta_2 \ln X_2 + \beta_3 \ln X_3 + \beta_4 \ln X_4 + \beta_5 \ln X_5 + V_j - U_j \quad (3.3)$$

Where for farm j, lnYis the natural log output, $\ln X_1$is the natural log of size of land under soybean farming, $\ln X_2$ is the natural log of labor, $\ln X_3$is the natural log of seeds, $\ln X_4$ is the natural log of fertilizer and $\ln X_5$ is the natural log of agro-chemicals. The quantity of fertilizer and agro-chemicals used by some farmers were zero, so we used the approach in Sherlund *et al*. (2002) and equated the natural logarithm of zero to the logarithm of one-tenth of the smallest non-zero values in the sample which turned out to be 2 kilogram of fertilizer and 0.25 litres of agro-chemicals. The descriptions of the variables are shown in table 3.1. β_0 is a constant, $\beta_{1\text{-}5}$ are parameters to be estimated, V_j is an independent and identically distributed random error term with zero mean and unknown variance δ^2_v, U_j is the non-negative random term $(u_j \geq 0, \forall\ j)$ representing technical inefficiency in production of farm j, it is assumed to be independently and identically distributed between observations and obtained by truncation at point zero of the normal distribution with mean u_j and variance δ^2_{u}.andthe technical inefficiency effects equation (3.4) below was estimated simultaneously with the stochastic production equation (3.3) using a One-stage procedure, following Battese and Coelli (1995).

$$u_i = Z_i\delta \qquad (3.4)$$

Where; μ_i is the technical inefficiency score of farm j, **Z** is 11×1 vectors of variables which influence efficiency of a farmer (the variables are described in table 3.2 below) and **δ** is an 1×11vector of parameters to be estimated. The technical efficiency score (TE_j) is defined according to Battese *et al*. (1988) as,

$$TE_j = \exp(-u_j) \qquad (3.5)$$

TE_j always takes the value between 0 and 1. A value of 1 indicates complete technical efficiency whereas a value close to Zero reveals the degree of inefficiency of the farm considered.The coefficients β_{0-6} and δ_{0-11} in equation 3.3 and 3.4 respectively, the variance parameters $\delta^2 = \delta^2_v + \delta^2_u$ and $\Upsilon = \delta^2_v / \delta^2_u$ and the technical efficiency scores (TEj) in equation 3.5 was simultaneously estimated by Maximum likelihood method using FRONTIER (Version 4.1) computer program developed by Coelli (1996).

Table 3.1: Variables used in stochastic frontier production function

Variable	Description	Measurement
Dependent (Y)	Quantity of soybeans harvested	Kilograms (kg)
(X_1) Land	Size of the farm/plot under Soybean	Acres
(X_2) Labor	Amount of labor used	Man-days
(X_3)Seeds	Quantity of seeds used	Kilograms (kg)
(X_4) Fertilizer	Quantity of fertilizer used	Kilograms (kg)
(X_5) Agro-chem	A total of insecticides, herbicides and fungicides used	Litres

Source; Author's tabulation, 2014

Table 3.2: Variables used in technical inefficiency effects model

Variable	Description	Measurement
Dependent (*u*)	Technical inefficiency measures	between 0 and 1
Age (Z_1)	Age of household head	years
Gender (Z_2)	Sex of the household head	"1" = Male, "0" = Female
Education (Z_3)	Number of years spend in formal schooling by the farmer	Years
Experience (Z_4)	Number of years the farmer has been producing soybeans	Years
Credit access (Z_5)	If the farmer accessed farming loan	"1" =Yes, "0" =No
Extension service(Z_6)	Access to extension service	"1" =Yes, "0"= No
Seed type (Z_7)	Types of seed used	"1"= Certified seeds, "0" = uncertified seeds
Fertilizer use(Z_8)	If the farmer used fertilizer or not	"1" =Yes, "0"= No
Socio-group(Z_9)	If the farmer belonged to any social group	"1" =Yes, "0" = No
Off-farm employment (Z_{10})	If the farmer has formal employment	"1" =Yes, "0" = No
Cropping system (Z_{11})	The type of cropping system employed by a farmer	"1" for pure stand, "0" for mixed cropping

Source: Author's tabulation, 2014

CHAPTER FOUR

RESULTS AND DISCUSSION

4.1 Introduction

This Chapter begins with a discussion on farm and farmer specific characteristics inherent among soybean farmers in Bungoma County. An analysis of technical efficiency together with the distribution of the efficiency scores across the various farm and farmer characteristics included in the study. Finally the determinants of inefficiency are discussed in detail.

4.2 Descriptive Analysis of the Characteristics of Soybean farmers

For the research, questionnaires were applied to the 168 Soybean farmers in Bungoma County. It tried to investigate the Socio-economic characteristics of the farmers who practice soybean farming in the County.

The descriptive results of socio-economic characteristics of sampled farmers are tabulated in table 4.1. The results show that 69% of the sampled farmers were female while 31% were male. This implies that soybean farming in Bungoma County is dominated by female farmers. The mean age of the sampled farmers was found to be 52.65 years with maximum age being 86 years and a minimum of 25 years. Furthermore, 45.8% of the sampled farmers were between 25 and 50 years old, and 54.2% of the farmers were found to be more than 50 years. This indicates the predominance of older soybean farmers in Bungoma County. With regard to Experience, the study found out that 76.8% of the sampled farmers had an experience of 10 years and less in soybean farming, while 23.2% were found to have more than 10 years of experience. Averagely, the mean experience of the sampled famers was found to be 6.71 years, showing dominance of less experience among soybean farmers in Bungoma County. On education, the study found that the mean number of years spend in formal learning, by sampled soybean farmers, was 10.49 years. 59.5% of these farmers were found to have more than 10 years of formal education. This shows that most of the sampled farmers had attained post primary education. On the off-farm employment, the results show that 58.3% of the sampled farmers had no off-farm formal employment. 41.7% of these farmers had formal employment.

Concerning the size of land under soybean production, the results show that the mean size of land by the sampled farmers was 0.789 acres. The largest size of land cultivated was found to be 4 acres while the smallest plot size was found to be 0.125 acres. These show that all the soybean farmers that were sampled are small-scale farmers. On the fertilizer use, the results show that 55.4% of the sampled farmers used fertilizer while 44.6% farmers did not use fertilizer. This shows that most soybean farmers used fertilizers. Regarding the type of seeds used by farmers, the result show that 61.9% of the respondents used their own local seeds (uncertified), while 38.1% used certified seeds. This indicates the dominance of use of uncertified seeds among soybean farmers in Bungoma County. It was also established that 75.6 % of the respondents used mixed crop planting system where Soybean where planted on the farm with other crops, mostly Maize. Only 24.4% of the respondents planted soybean on a pure stand. This indicates that soybeans farming enterprise is given a secondary priority by farmers in Bungoma County, especially during the long rain season.

On the access to credit, access to extension services and belonging to social group, the results show that out of the sampled farmers, 83.3% did not have access to formal loan against 16.7% who had access to formal loans. This show that most soybean farmers in Bungoma County do not have access or don’t take up agricultural loans. Access to extension services was also considered and the result show that 70.2% of the respondents did not receive extension services while 29.8% received extension services. This shows the predominance of uninformed farmers on the new farming techniques among soybean farmers in Bungoma County. On the group membership which is expected to help farmers to mitigate problems associated with market imperfections and providing inputs and other crucial information, the results show that 51.2% of the respondents belonged to social group while 48.8% did not belong to any social group.

In terms of productivity, the results show that the maximum yield obtained by soybean farmers in Bungoma County was 1440 kg per acre with the minimum of 64kg per acre. On average, the results show that soybean farmers in Bungoma County obtained the yield of 466.89 kg per acre, which is low compared to the potential level of between 3000 – 3600 kg per ha (Mahasi *et al.,* 2010). These results concur with the findings of FAO (2008) which show that Soybean productivity in western province, which Bungoma County is part of, is still low, at an average yield of 560kg per ha.

Table 4.1: Characteristics of sampled soybean farmers

		Count	%
Gender	Male	52	31
	Female	116	69
Off-farm Employment	Yes	70	41.7
	No	98	58.3
Fertilizer use	Yes	93	55.4
	No	75	44.6
Type of seed used	Certified	64	38.1
	Uncertified	104	61.9
Cropping system	Pure	41	24.4
	Mixed	127	75.6
Access to credit	Yes	28	16.7
	No	140	83.3
Access to ext services	Yes	50	29.8
	No	118	70.2
Group membership	Yes	82	48.8
	No	86	51.2

Total sample= 168

		Aggregate	%
Age	Min	25	
	Max	86	
	Mean	53.98	
	Std. Deviation	13.791	
	25-50 years old	77	45.8
	>50 years old	91	54.2
Education	Min	2	
	Max	16	
	Mean	10.49	
	Std. Deviation	3.157	
	1-10 years	68	40.5
	>10 years	100	59.5
Experience	Min	1	
	Max	20	
	Mean	6.71	
	Std. Deviation	4.588	
	1-10 years	129	76.8
	>10years	39	23.2
Farm size	Min	0.125	
	Max	4	
	Mean	0.787946	
	Std. Deviation	0.8762	
Soybean yield (kg/acre)	Min	64.00	
	Max	1440.00	
	Mean	466.89	
	Std. Deviation	305.33	

Source: Author's Field Survey Data, 2014

Table 4.2 shows how some socio-economic characteristics among soybean farmers in Bungoma County are interrelated. The results show that 92.2% of the female in the sample did not access formal credit. Only 7.8% of the female had access to formal loans. On the other hand 63.5% of the sampled male had no access to formal credit while 36.5% of the male sampled had access to credit. This shows that males are more likely to access formal credit than the female soybean farmers. The result show that 98.1% of the farmers who used uncertified seeds did not have access to formal credit while 59.4% of the farmers who used certified did not have access to formal credit. This indicates that more farmers tend to use certified seeds when they are able to access formal credit. This is also similar with the fertilizer use, where 94.7% of the sampled farmers who did not used fertilizer did not have access to formal loan while 74.2% of those who used fertilizer did not have access to credit. Only 5.3% of those who did not use fertilizer accessed formal loan. 25.5% of those who used fertilizer had access to formal loans. This can be explained by the notion that access to formal loan allow farmers to purchase the required inputs for the farming business.

Contrary to gender, type of seed used and fertilizer use, the result show that group membership are negatively correlated with access to formal credit. From the sample 17.4% of the farmers who had no group membership accessed formal credit and 15.9% of those who had group membership accessed formal credit. This can be explained by the thinking that social groups help to provide farmers with farm inputs, loans, provides for the members savings and marketing information, so a farmer who belongs to a social group will less likely apply for a formal loan because some or all of his farming needs will be given by the social group.

Table 4.2: Cross Tabulation of gender, seed type, fertilizer use and group membership against access to formal credit among soybean farmers in Bungoma County.

			Access to formal Credit		
			No	yes	**Total**
Gender of the farmer	Female	Count	107	9	116
		% within Gender	92.2%	7.8%	100%
	Male	Count	33	19	52
		% within Gender	63.5%	36.5%	100%
Total		Count	140	28	168
		%within gender	83.3%	16.7%	100%
Type of seed	uncertified	Count	102	2	104
		% within type of seed	98.1%	1.9%	100%
	certified	Count	38	26	64
		%within type of seed	59.4%	40.6%	100%
Total		Count	140	28	168
		% within type of seed	83.3%	16.7%	100%
Fertilizer use	No	Count	71	4	75
		% within fertilizer use	94.7%	5.3%	100%
	Yes	Count	69	24	93
		%within fertilizer use	74.2%	25.8%	100%
Total		Count	140	28	168
		% within fertilizer use	83.3%	16.7%	100%
Group membership	No	Count	71	15	86
		%within group membership	82.6%	17.4%	100%
	Yes	Count	68	13	82
		%within group membership	84.1%	15.9%	100%
Total		Count	140	28	168
		%within group membership	83.3%	16.7%	100%

Source: Author's Survey Data, 2014

Table 4.3 shows the results of the relationship between accessing extension service and accessing formal credit, fertilizer use, seed type and cropping system used among the sampled soybean farmers. The result shows that 71.4% of those who accessed formal credit had access to extension services while 21.1% of those who did not access formal credit had access to extension services. This indicates that more farmers who had access to extension services tend to go for formal credits. This can be supported by the notion that farmers who access extension services are more informed and would tend to invest more in agricultural projects by taking loans.

There is also a positive relationship between access to extension services and the types of seeds used, fertilizer use and cropping system. 64.1% of those who used certified seeds had access to extension services while only 8.7% of those who used uncertified seeds had access to extension services. 47.3% of farmers who used fertilizer had access to extension services while only 8% of those who did not use fertilizer had access to extension services. Concerning cropping system, 39% of those who planted soybeans on a pure stand had access to extension services while 26.8% of those who used mixed cropping system had access to extension services. The positive relationship between these characteristics can be explained by the idea that most of the farmers who access extension services are more informed hence they can make good decisions about the input use and also choose the cropping system that would help to maximize their farming objectives.

Table 4.3: Cross Tabulation of access to formal credit, type of seed, fertilizer use & cropping system against access to extension services among soybean farmers in Bungoma County

			Access to extension services		Total
			No	yes	
Access to formal credit	No	Count	110	30	140
		% within access to formal credit	78.6%	21.4%	100%
	Yes	Count	8	20	28
		% within access to formal credit	28.6%	71.4%	100%
Total		Count	118	50	168
		%within access to formal credit	70.2%	29.8%	100%
Type of seed	uncertified	Count	95	9	104
		% within type of seed	91.3%	8.7%	100%
	certified	Count	23	41	64
		%within type of seed	35.9%	64.1%	100%
Total		Count	118	50	168
		% within type of seed	70.2%%	29.8%	100%
Fertilizer use	No	Count	69	6	75
		% within fertilizer use	92.0%	8.0%	100%
	Yes	Count	49	44	93
		%within fertilizer use	52.7%	47.3%	100%
Total		Count	118	50	168
		% within fertilizer use	70.2%	29.8%	100%
Cropping system	Mixed	Count	93	34	127
		%within cropping system	73.2%	26.8%	100%
	Pure	Count	25	16	41
		%within cropping system	61.0%	39.0%	100%
Total		Count	118	50	168
		%within cropping system	70.2%	29.8%	100%

Source: Authors Field survey Data, 2014

4.3 Analysis of Technical efficiency measures

The estimation of the Cobb–Douglas stochastic production function in Equation 3.3 Simultaneously with the technical inefficiency effects in Equation 3.4 generates the results Presented in Table 4.4. The parameter $\gamma = \sigma^2_u/\sigma^2$ lies between 0 and 1; with a value equal to 0 implying that technical inefficiency is not present and the ordinary least square estimation would be an adequate representation and a value close or equal to 1 implying that the frontier model is appropriate (Piesse and Thirtle, 2000). The value of γ=0.513 is statistically significant at the 1% level, which implies that more than half of the residual variation is due to the inefficiency effect. The log likelihood ratio was found to be 219.57 and was statistically significant at 1% level.This log likelihood ratio test indicates that inefficiency exists in the data set and therefore, null hypothesis of no technical inefficiency in Soybean production in Bungoma County is rejected.

All the coefficients of the inputs in the production function are positive, with the exception of the coefficient of seed which is negative. The positive effects of inputs on the output was expected because more inputs used in rightful proportions increases production. The negative relationship between seed and output in soybean farming can be explained by the idea that most of soybean farmers in Bungoma County use uncertified seeds. Uncertified seeds are contaminated and have poor germination rate, so these farmers plant more seeds in a given size of land as compared to those who use certified seeds so as to attain the right germination rate. The coefficients of land, labour, fertilizer and agrochemicals were positive implying that increase in the use of any of these factors, all things held constant, will increase the total production of soybeans. Specifically, the coefficients of land (0.461), labour (0.844), fertilizer (0.068) and agrochemicals (0.044) were significant at 1% level. Seed coefficient (-0.110) was found to be significant at 5% level. The magnitude of coefficient of labour is higher followed by that one of land. This implies that labour and land are the most constraining factors in soybean production in Bungoma County.

Table 4.4:Results for Maximum likelihood estimation of the production frontier and inefficiency effects model

variable	parameter	coefficient	standard-error	t-ratio
Production function				
Constant	β_0	3.352***	0.252	12.9228
Land	β_1	0.461***	0.076	6.069
Labor	β_2	0.844****	0.059	14.404
Seeds	β_3	-0.110**	0.048	-2.271
Fertilizer	β_4	0.068***	0.012	5.413
Agro-chem	β_5	0.044***	0.016	2.759
Inefficiency model				
Constant	δ_0	-0.014	0.293	-0.051
Age	δ_1	0.015***	0.003	4.834
Gender	δ_2	-0.215**	0.106	-2.02
Education	δ_3	-0.007	0.015	-0.45
Experience	δ_4	-0.034***	0.010	-3.366
Crdt access	δ_5	-0.512***	0.146	-3.505
Ext services	δ_6	-0.423**	0.207	-2.04
Seed type	δ_7	-0.476**	0.181	-2.62
Fertilizer use	δ_8	0.106	0.108	0.982
Social-group	δ_9	-0.175*	0.091	-1.936
Off-farm emp	δ_{10}	-0.841	0.077	-1.089
Cropping syst	δ_{11}	-0.049	0.069	-0.705
Sigma-squared	σ^2	0.073***	0.011	6.507
Gamma	γ	0.513***	0.064	8.001

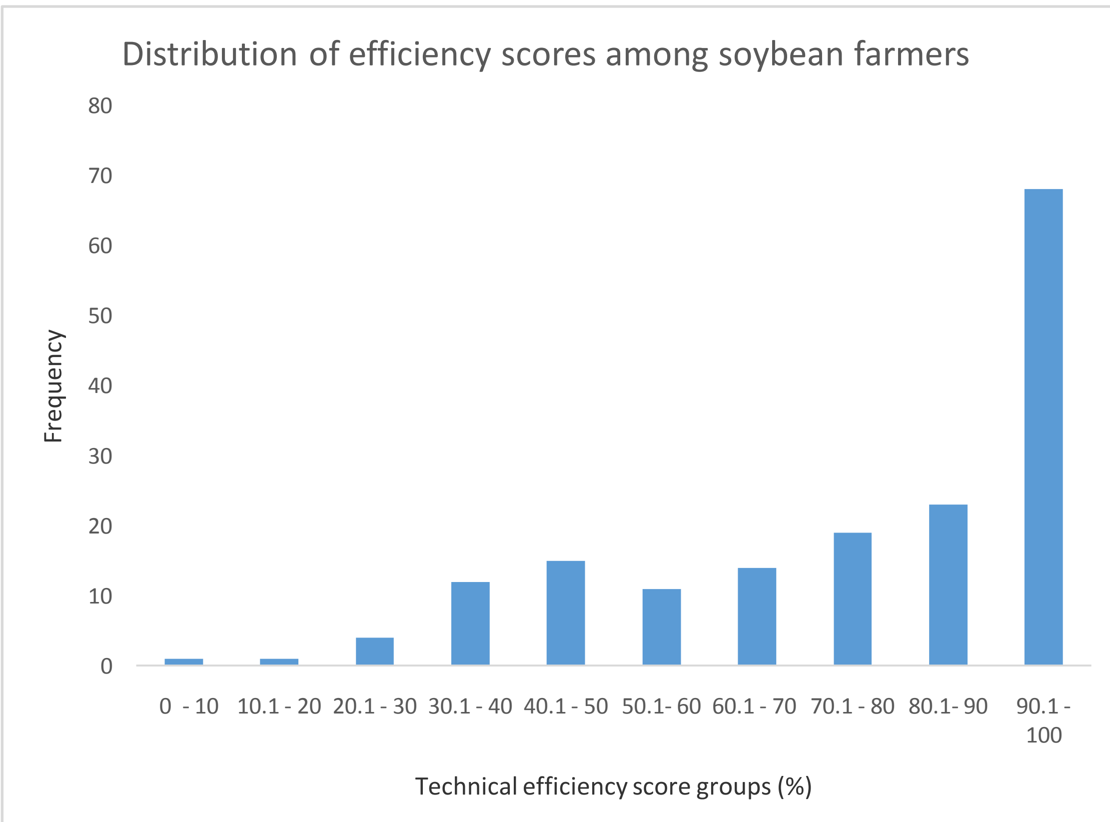
*** Statistically significant at 1% level

**Statistically significant at 5% level

*Statistically significant at 10%

Source: Author's Field Survey Data, 2014

The mean technical efficiency level among soybean farmers in Bungoma County is 75.25%, with a standard deviation of 22.4% and a range from 10 to 98.3% (Table 4.5). The distribution of technical efficiency scores is shown in figure 4.1. The distribution show that 40.47% of the farmers had technical efficiency measure of 90% and above, while 19.64% had an efficiency level of below 50%.



Source: Author's Field survey Data, 2014

Fig 4.1: Distribution of efficiency scores among Soyabean farmers

Table 4.5: Descriptive statistics for technical efficiency scores for soybean farmers in Bungoma County.

Parameter/ Variable	N	Minimum	Maximum	Mean	Std. Deviation
technical efficiency scores	168	.100	.983	.75259	.224057
Valid N (list wise)	168				

Source: Author's Field Survey Data, 2014

4.4. Analysis of Inefficiency Effects

The socioeconomic characteristics that were included in the inefficiency model were age, gender, education, experience of the farmer, access to credit, access to extension services, type of seed used, fertilizer use, membership to social group, off-farm employment and the cropping system used. The Maximum Likelihood Estimates (MLEs) of the inefficiency model are presented in table 4.4. The results indicate that, the coefficients of age of a farmer and fertilizer use were positive, but only the coefficient of age of a farmer was significant at 1% level. The coefficients of gender, education, experience, access to credit, access to extension services, type of seed used, membership to social group, off-farm employment and type of cropping system employed were found to be negative. However only coefficients for gender, experience, access to credit, access to extension services, type of seeds used and membership to social group were significant.

The coefficient for age of a farmer (0.015) was significant at 1% level. The positive effect of this coefficient implies that as the soybean farmers grow old by a year, holding other factors constant, the inefficiency in soybean production increases by 1.5%. This means that older farmers were less technically efficient in soybean production than their younger counterparts. This is consistent with findings by Waluse (2012) in Uganda, Sarfraz and Bashir (2005) and Idiong (2007). The finding is attributed to the fact that older soybean farmers in the study area are relatively more reluctant to take up better technologies, instead they prefer to hold to the traditional farming methods thus become more technically inefficient compared to their younger counterparts.

The coefficient of fertilizer use was found to be 0.106 and insignificant. This was consistent with the finding of Chirwa (2007). The positive effect of fertilizer use on the inefficiency indicates that use of fertilizer in soybean production in Bungoma County increases inefficiencies. This contradicts prior expectation that fertilizer use increases efficiency because it is expected that fertilizer used in correctly and in the right proportion supplements nutrients that are in deficient in the soil thus increasing production. This positive effect between fertilizer use and technical inefficiencies among the soybean farmers in Bungoma County can be explained by the notion that most these farmers don’t have information on the nutritional status of their soil, thus these farmers may have used wrong type of fertilizer considering their soil nutrient requirements or inappropriately used fertilizers.

The results reveal that sex of soybean farmers (gender) negatively affect the inefficiency level of these farmers, with the coefficient of (-0.215). The coefficient is statistically significant at 5% level. This shows male soybean farmers tend to be more efficient in soybean production in Bungoma County than their female counterparts. The results indicate that an increase in the number of soybean farmers by one male farmer, the technical inefficiency is reduced by 21.5%. This can be explained by the idea thatfemale farmers are faced with more challenges compared to the male farmers in terms of access to information and resources.

Education was found to negatively affect inefficiency. The coefficient of education was -0.007. However, this coefficient was insignificant. This is in consistence with Kibirike (2008) findings that, though insignificant, education influenced technical efficiency positively. The negative effect of education on inefficiency measures can be explained by the notion that more learned farmers can easily adopt and use new technologies effectively and they also tend to make rational decision concerning the farming process thus reducing inefficiencies.

Number of years in which a farmers has been practicing soybean farming (experience) was also found to have a negative influence on the technical inefficiencies. The coefficient of experience was found to be -0.034 and was statistically significant at 1% level. This implies that one extra year in soybean farming reduces technical inefficiency by 3.4%. This finding is in consistence with the prior expectations and with the findings of Idiong (2007) and Audu *et al* (2013), but contradicts the findings of Ike and Inoni

(2006) who finds a positive effect of experience on technical inefficiency. The negative effect of experience on technical inefficiency can be explained by the fact that experienced farmers are better producers, who have learned from their past mistakes; hence they make rational decisions compared to less experienced farmers.

Credit access by soybean farmers was found to have a negative effect on their technical inefficiency. This confirms our prior expectation that access to credit increases efficiency of the farmer, this concurs with the findings of Amaza *et al* (2006) and Audu *et al* (2013) which showed that access to credit had a negative influence on technical inefficiencies in farming. The coefficient of credit access was found to be -0.512 and it was significant at 1% level. This means that an increase to access to credit by a farmer reduces the technical inefficiency by 51.2%. This finding can be explained by the idea that credit empowers the farmers to buy farm inputs and improved technologies timely, which can make them produce at optimal capacity thus reducing technical inefficiency.

As expected earlier, access to extension had a negative effect on technical inefficiencies. The coefficient of extension service was found to be -0.423 and it was significant at 5% level. This indicates that increased extension services to farmers tend to increase technical efficiency in soybean production. The significance of extension in this study agrees with the findings of Seyoum *et al*. (1998) who reported positive influence of extension contact on efficiency. The positive influence of extension services can explained by the conception that farmers who access to extension services are much informed thus they make rational decisions regarding their farming business hence reducing inefficiencies.

The coefficient of the dummy representing use of certified seeds (-0.476) is statistically significant at 5% level. Soybean farmers who use certified seeds are more efficient than farmers who use uncertified seeds. These findings agrees with the findings of Chirwa (2007), which showed a negative effect of Hybrid maize seeds on the inefficiencies among smallholder maize farmers in Malawi. Despite major investments in research and development by Kenya Agricultural Research Institution and NGO's to produce certified soybean seeds, most soybean farmers in Bungoma County still prefer local uncertified soybean seeds. Certified seeds have a good germination rate and are also free from diseases thus they would result in good germination and healthy plants.

The coefficient of the dummy variable for membership in a social group (-0.175) is statistically significant at the 10% level. Social group membership is part of social capital. Binam *et al*. (2004) also use club membership to capture the role of social capital in providing incentives for efficient farm production and find similar results. Membership of the farmers' association increases farmers' interaction with fellow farmers, non-farmers and extension agents. All these improve farmers' methods of production and prevent irrational utilization of resources.

The coefficient of off-farm employment (-0.841) was negative and insignificant. As hypothesized earlier, off-farm employment was expected increase the efficiency of soybean farmers. This is explained by the notion that farmers with such employments have a regular source of income that they can use to acquire appropriate farm inputs timely.

On the type of cropping system employed, the results also reveal a negative effect of the type of cropping system used and the technical inefficiency among soybean farmers. The results show a coefficient of -0.049 which is insignificant. The negative effect of cropping system on technical inefficiencies is in consistence with prior expectations of the study. It is expected that a pure stand cropping system would have a positive effect on the technical efficiency of the farm. This is because crops planted on a pure stand will have less competition for the available nutrients unlike in the mixed cropping system whereby the different crops will compete for the key nutrients thus resulting in the less output.

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

The study was set to characterize soybean farmers in Bungoma County, estimate the level of technical efficiency and find out the factors influencing technical inefficiency among these farmers. This was based on the realization that soybean productivity in Bungoma County is very low and far away below the potential productivity level. The study was carried out in Bungoma County basing on a sample of 168 soybean farmers 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 the farmer. Descriptive statistics were used to explain the characteristics of soybean farmers while the stochastic production function approach was used to estimate technical efficiency scores and simultaneously determining the factors that are associated with inefficiencies among soybean farmers.

The descriptive statistics show that 69% of the sampled farmers were female while 31% were male, implying the dominance of female soybean farmers in Bungoma County. The mean age of the sampled farmers was found to be 52.65 years with maximum age being 86 years and a minimum of 25 years. Furthermore, the results found 45.8% of the sampled farmers were between 25 and 50 years old, and 54.2% of the farmers were found to be more than 50 years. The results also show that 76.8% of the sampled farmers had an experience of 10 years and less in soybean farming, while 23.2% were found to have more than 10 years of experience with the mean experience of the sampled famers to be 6.71 years. The study found that the mean number of years spend in formal learning, by sampled soybean farmers, was 10.49 years. 59.5% of these farmers were found to have more than 10 years of formal education. On the off-farm employment, the results show that 58.3% of the sampled farmers had no other off-farm formal employment. Concerning the size of land, the results show that the mean size of land by the sampled farmers was 0.789 acres. The largest size of land cultivated was found to be 4 acres while the smallest plot size was found to be 0.125 acres. 55.4% of the sampled farmers used fertilizer while 44.6% farmers did not use fertilizer. Regarding the type of seeds used by farmers, the result show that 61.9% of the respondents used their own local seeds (uncertified), indicating the dominance of use of uncertified seeds among the soybean farmers in Bungoma County. 70.2% of the respondents did not receive extension services while 29.8% received extension services, this indicates the dominance of uninformed soybean farmers in Bungoma County. 51.2% of the respondents belonged to social groups while 48.8% did not belong to any social group.

The estimation of the Cobb–Douglas stochastic production function reveals the existence of inefficiencies among the soybean farmers in Bungoma County. The value of γ=0.513 was statistically significant at the 1% level, implying that 51.3 of the residual variation is due to the inefficiency effect. All the coefficients of the inputs in the production function are positive, with the exception of the coefficient of seed which is negative. The positive effects of inputs on the output was expected because more inputs used in rightful proportions increases production. The negative relationship between seed and out in soybean farming can be explained by the idea that most of soybean farmers in Bungoma County use uncertified seeds. Uncertified seeds has poor germination rate, so these farmers plant more seeds in a given size of land as compared to those who use certified seeds so as to attain the right germination rate. The mean technical efficiency level among soybean farmers in Bungoma County was 75.25%, with a standard deviation of 22.4% and a range from 10% to 98.3%. The distribution show that 40.47% of the farmers had technical efficiency measure of 90% and above, while 19.64% had an efficiency level of below 50%.

The Maximum Likelihood Estimates (MLEs) of the inefficiency model indicate that, the coefficients of age of a farmer and fertilizer use were positive, but only age of a farmer was significant at 1% level. The coefficients of gender, education, experience, access to credit, access to extension services, type of seed used, membership to social group, off-farm employment and type of cropping system employed were found to be negative. However only coefficients for gender, experience, access to credit, access to extension services type of seeds used and membership to social group were significant.

5.2 Conclusions

The study concludes that Soybean farming in Bungoma County is dominated by old female farmers who are above 50 years of age. Most of these farmers have acquired post-primary education thus they can read and write. Majority of the soybean farmers in

Bungoma County have an experience of less than 10 years in the soybean farming business. Furthermore, this study finds that soybean farming business in Bungoma County is carried out on small-scale farming. On the use of resources, the study concludes that majority of these farmers use local uncertified seeds in farming process and most of them also don’t use fertilizers. Very few farmers had access to credit and extensional services indicating insufficient inputs in the soybean farming process and also lack of important information that could help improve their productivity.

The study finds that there exists technical inefficiencies among soybean farming in Bungoma County. The average technical efficiency of these famers was found to be 75.25%. Thereforein conclusion, low productivity in soybean farming in Bungoma County in partly due to technical inefficiencies, thus there is potential of improving productivity of soybeans farming in Bungoma County by efficiently using the available resources.

Old age was found to positively influence inefficiency if soybean farming. Therefore old farmers are the most inefficient producers of Soybean. Gender, experience, access to credit, extension services, certified seeds and membership to social groups significantly reduce inefficiencies, thus there exists the possibility of improving technical efficiencies if these variables are checked, hence improving soybean productivity in Bungoma County.

5.3 Recommendations

Soybean has a great potential (in terms of food, income, nutrition and human health and soil improvements through biological nitrogen fixation, etc.) in the farming systems of Kenya. High profitability has been demonstrated with improved practices and value addition. However, the realization of this potential will depend on a consistent effort addressed along the value-chain and including productivity increase, processing and value-addition at both home and cottage or community levels, and effective linkage with large-scale feed and food processors.

This study has concluded that there is exists technical inefficiencies among soybean farmer in Bungoma County. Technical inefficiencies reduces productivity which in turn reduces profitability of soybean enterprise. Given the empirical findings, the proposed recommendations are:

i. There is need for the Government, NGO's and institutions of learning to encourage youths and men to participate in soybean farming through project initiates and education. This is because the findings show that youths and men are more efficient producers of soybeans and yet soybean farming is dominated by elderly and female farmers.

ii. Access to credit has been found to reduce technical inefficiencies among Soybean farmers. Credit help farmers to acquire appropriate inputs in time thus making rational decision about the farming business. Majority of Soybean farmer have no access to credit. There is need for the government through Agricultural Financial Cooperation (AFC) and other private financial institutions to make farm credit available by designing financial portfolios that march the needs of farmers.

iii. Extension services ware also found to significantly reduce technical inefficiencies among soybean farmers. However, most of these farmers had no access to extension services. There is need to increase the extension services to these farmers by the government agents and NGO's. These farmers should also be encouraged to form and join the social group. This will help farmers' access to crucial information hence making informed decisions.

iv. Use of certified seeds also reduce, significantly, the technical inefficiencies. Majority of soybean farmers in Bungoma County uses local uncertified seeds. The study recommends that research institutions such as KARI, seed companies, Universities and NGO'sshould increase production of certified seeds and avail them to the farmers and also encourage farmers to use the certified seeds. These institutions should also intensify their research in the field of soybean to develop high yielding soybean varieties. These would help enhance soybean productivity.

5.3 Suggestions for further studies

While this study focused on measuring technical efficiency and finding the factors that influence technical inefficiency among Soybean farmers in Bungoma County, other studies can be done on allocative and economic efficiency in soybean farming not only in Bungoma County but also in other parts of the Country. This will help to understand fully why soybean productivity has remained lowover time yet there exists high potential for its production.

Moreover, the strategy for improving agricultural productivity is through market-led approach. There is need to undertake more studies on soybean marketing and value chain development in the country. This will enhance the chances of exploiting the potential opportunities that soybean farming offers to the country.

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APPENDICES

APPENDIX I: QUESTIONNAIRE

Introduction paragraph

I am Oliver Wafula, a postgraduate student at Moi University. I am doing a study on Soybean farming in Bungoma County. The information you give will be pooled together with information from other households and analysed so as to come up with conclusions and recommendations that would advise the stakeholders on what to do so as to improve Soybean production. Your responses will be treated confidentially and will never be used against you in whatsoever. I therefore request you to be honest in answering these questions.

I. Questionnaire Identification

Date:

Enumerators' Name:...

District:...

Division:...

Location:...

Sub-location:...

Village:..

II. Background information

1. Farmers Name: Age: Sex: Female ☐ Male ☐

2. Highest level of education: Other Occupation apart from farming:

3. How long have you been producing Soybean?

4. Is Soybean your main farming enterprise? Yes ☐ No ☐

(a) If no, what is your main farming enterprise?

5. What are your other farming enterprises?

III. Farm resource information

6. Do you own farming land? ☐ Yes ☐ No

(a) If yes, how many Acres do you have?

(b)If no how do you get the farming land? ☐ Hire ☐

Others, Specify ....

7. Do you usually carry out soil testing on your farm to know its nutrient contents?

(a) If yes, how often?

(b) Where do you hire such services?

(c) If no, why have never done soil testing on your farm?

8. What kind of labour do you use? ☐ Hired ☐ Family labour

9. What do you use to prepare your farm for farming?

☐ Tractor

☐ Oxen

☐ Hand preparation by use of Jembes

(a) If Tractor or Oxen, are they: ☐ Yours

☐ Hired

☐ Others, Specify ....

IV. Institutional information

10. Do you usually get extension services? ☐ Yes ☐ No

(a) If Yes, from which agent? ☐ Government extension Officers

Non-Governmental Organizations, ☐ specify:...

☐ Social groups

☐ Radio

☐ Others, Specify ....

11. Do you get loans to finance your farming operation? ☐ Yes ☐ No

(a) If No, Have you ever applied for a farming loan? ☐ Yes ☐ No

(b) If No, Why have you never applied?

(c) If you usually get loans to finance your farming operations, from where?

☐ Agricultural Finance Corporation

☐ Commercial Banks specify ....

☐ Micro Finance Institutions, Specify ....

☐ Social groups

☐ Others, specify ....

12. Do you belong to any social group? ☐ Yes ☐ No

(a) If yes, how does it help you in terms of farming operations?

☐ Give loans

☐ Provide Inputs

☐ Provide extension services

☐ Help in marketing of outputs

☐ Others, specify:......................................

13. Do you use certified seeds from seed companies? ☐ Yes ☐ No

(a) If yes, from which seed Company and do you usually get the variety you want?

(b) If No, Why?

V. Input requirement

14. What is the size of land in Acres did grow Soybean in the year 2012?

(a) Which season did you plant Soybeans ☐ March – July Season

☐ September- November season

15. How many kilograms of seed did you use?

16. What variety of Soybean did you grow?

17. Did you use fertilizer? ☐ Yes ☐ No

(a) If No, why?

(b) If yes, what type of fertilizer did you use?

(c) How many Kilograms of fertilizer did you use?

18. What did you use to prepare land for planting ☐ T☐tor ☐ Oxen Jembes

(a) And for the implement used (in above), did you hire or it was yours?

(b) If hired, how much did you pay?

19. Did you use hired labour or family labour?

20. How many people and days they took to carry out the following operations.

I. Planting Number of people ☐ Number of days ☐
II. Cultivating Number of people ☐ Number of days ☐
III. Harvesting Number of people ☐ Number of days ☐

21. Did you apply any Agrochemicals?

If yes, which?

Type of agrochemical	Quantity used in litres
Herbicide	
Fungicide	
pesticide	

22. What cropping system did you? ☐ Pure stand ☐ Intercropped with other crops

23. Did you get a loan to finance these activities? ☐ Yes ☐ No

(a) If yes, from which institution did you get the loan from?

(b) And did you get the loan in time to meet the activity requirements?

(c) If no, why?

VI. Output information

24. How many Kilograms of Soybeans did you harvest?

25. How did you use the harvested Soybeans? ☐ Sold ☐ Own consumption

Thank you very much for your cooperation and time.