DETERMINANTS OF COMMON BEAN PRODUCTIVITYAND EFFICIENCY: A CASE OF SMALLHOLDER FARMERS IN EASTERN UGANDA

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DECLARATION AND RECOMMENDATION

DECLARATION

This thesis is my original work and it has not been presented in any university for the award of a Degree or a Diploma.

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APPROVAL

This thesis has been presented to the Graduate school for examination with our approval as university supervisors.

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DEDICATION

This thesis is dedicated to my parents Sibiko Waaluse and Josephine Alaka Sibiko, my siblings, my lecturers, my friends and relatives; 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.

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ABSTRACT

Agriculture sustains the livelihoods of about 70.8% of Ugandans, while common bean has emerged to be an important cash crop as well as a staple food for the majority of farmers and consumers. Although Uganda's bean output has more than doubled, average bean yields in the country have been between 0.6 and 0.8 Mt Ha^{-1}, even though yields higher than 1.5 Mt Ha^{-1} can be realized with improved varieties. Thusthe objective of this study was to determine the factors influencing common beanproductivityand efficiency among smallholder farmers in Eastern Uganda.The study was conducted in Busia, Mbale, Budaka and Tororo districts in Eastern Uganda based on a sample of 280 householdsselected using a multi-stage sampling technique. For the data collection, a personally administered structured questionnaire was used to conduct interviews, with a focus on household heads. In the analyses, descriptive statistics, a stochastic frontier modeland a two-limit Tobit regression model were employed. It was established that bean productivity was positively influenced by plot size, ordinary seeds, certified seeds and planting fertilizers. The mean technical efficiency among bean farms was 48.2%, mean economic efficiency was 59.94% and mean allocative efficiency was 29.37%. Finally, Tobit model estimation revealed that technical efficiency was positively influenced by value of assets at 1% level and extension service and group membership at 5% level; while age and distance to the factor market negatively influenced technical efficiency at 10% and 5% levels respectively. Economic efficiency was positively influenced by value of assets at 1% level and off-farm income and credit at 5% level. However, farmers' primary occupation negativelyinfluenced economic efficiency at 5% level. Allocative efficiency was positively influenced by value of assets at 1% level and farm size and off-farm income at 10% level; while distance to the factor market negatively influenced allocative efficiency at 5% level.Hence the study recommended on the need for increased provision of extension service and training on correct input application and improved farming technologies to increase bean productivity. It also suggested on the need for policy to discourage land fragmentation, develop road and market infrastructure in rural areas and provide affordable and easily available credit facilities to improve production efficiency of bean farms.

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LIST OF ACRONYMS AND ABBREVIATIONS

APC	Agricultural Policy Committee
CGIAR	Consultative Group on International AgriculturalResearch
CIAT	International Center for Tropical Agriculture
DEA	Data Envelopment Analysis
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
INSPIRE	Integrated Soil Productivity Initiative through Research and Education
LDC	Less Developed Countries
MAAIF	Ministry of Agriculture Animal Industry and Fisheries
NARO	National Agricultural Research Organization
SFA	Stochastic Frontier Approach
SSA	Sub Saharan Africa
UBOS	Uganda Bureau of Statistics
WB	World Bank

CHAPTER ONE:INTRODUCTION

1.1 Background information

Poor but developing, Uganda's economy is predominantly agricultural and employs about 70.8% of the population. At the rural household level, the proportion of the population directly involved in agricultural activities is even higher with crop production accounting for more than 70% of the employment within the sector itself. However, about 68.1% depend on agriculture for subsistence, while the rest practice farming for commercial purposes (FAO, 2009). In general, the sector accounts for 25% of the Gross Domestic Product (GDP), (UBOS, 2010) and serves as an important provider of inputs for the other production activities, especially the manufacturing sector. Moreover, 80% of the Ugandan population live in rural areas and depend almost entirely on Agriculture for their livelihoods;hence the sector serves as a basic source and provider of food self-sufficiency and security for majority of the population.

With respect to common bean (*Phaseolus vulgaris* L.),Mauyo*et al.* (2007) document that it is the most widely grown pulse, second only to maize as a food crop and a major source of food security in East Africa. It is readily available and a popular food to both the urban and rural populations in Uganda. In addition, according to Kara *et al.* (2009) it is consumed by people from all income levels and serves as a primary source of dietary protein for people in the lower income bracket (Wortmann *et al.,* 2004). Shelled beans are richer than green beans. They provide about 25% of the total calories and 45% of the protein intake of the diets of many Ugandans (Gepts, 1998; NARO, 2000). The crop is also a staple for more than 300 million diets worldwide.

In addition, Bean is an important source of income for many Ugandan farmers and traders, due to the increasing demand both in the domestic and export markets such as Kenya. And according FAO statistics (2009), the value of bean output was USD 244.02 (million) while the agricultural GDP was USD 4,010.75 (million) indicating that bean accounted for 6.1% of the total national agricultural GDP. The crop ranked fifth behind banana, cassava, indigenous cattle meat and cattle milk in terms of value of output. Similarly, the estimated economic value of total bean output when valued at 2009 market prices was higher than total earnings from coffee, which is Uganda's chief export commodity (FAO statistics, 2009). This implies that harnessing the bean yield potential through increased investment in bean research could lead to significant improvements in the health and wellbeing of many Ugandans (Harvest plus, 2006).

In addition, Uganda's bean consumption has been increasing since the 1980's. In 1987, Food and Agriculture Organization (FAO) estimated Uganda's bean consumption at 29.3 kg per capita (Kirkby, 1987). However, recent studies show that the country's per capita consumption has increased to over 58 kg (Soniia, 1999). This compares with Rwanda and parts of western Kenya with some of the highest consumption levels in the world at 66 kg per capita per year. Common bean is also valued by the poor because all parts of the plant can be consumed: the grain is eaten fresh or dried, the leaves are used as vegetables and the stalk is used to make soda ash (Soniia*et al.,* 2000).

In Uganda consumers prefer large seeded red-mottled bean grain types, followed by the purple and red types, while the pale and white colours are not popular. Large red-mottled varieties comprise some of the traditional types such as K20, a determinate variety developed by the national research programme in the 1960's (Rubaihayo*et al.,* 1981); and the semi climbers referred to as *Nambale*. Other important local grain types available in the country include the medium size types such as the red-medium type (*Kayinja*) and the brown-red oval types (*Kanyebwa).* The small-seeded *Lango* beans are usually black or cream coloured bush bean varieties and are popular in Northern Uganda. However, some of the new improved varieties developed by the national agricultural research organization (NARO) and other partners have also received high market reception especially K132, K131 and NABE 2 (Kalyebara, 2008). Several other bean seed types are cultivated in Uganda, with definite regional differences in preferences for production and consumption (Hildago, 1991).

1.2 An assessment of bean production in Uganda

Uganda's bean production is common in the central, eastern and western regions. It is mainly dominated by small scale farmers, who have limited resources and produce the crop under unfavourable conditions (e.g. little use of inputs, marginal lands and intercropping with competitive crops). The average plot size for these farmers ranges from 0.1 to 0.5 hectares per household (Hoogendijk and Soniia, 1997). Therefore, the greater percentage of beans is usually grown for household consumption with a small percentage sold at a market or through the other venues (Wortmann *et al.,* 2004).

Typically bush beans are intercropped with various crops like maize, cassava, cotton, banana and groundnuts. The climbing beans on the other hand are mostly intercropped with maize due to their strong agronomic compatibility, where by the maize helps in staking. However farmers prefer to grow climbers in pure stand due to the higher yield potential than when they are intercropped (Kalyebara, 2005).

Uganda's total bean output was increasing rapidlybetween 1997 and 2002 as indicated by FAO statistics (2011) in Table 1. These statistics correspond with the introduction of improved and more disease resistant varieties by NARO during the same period (Kalyebara, 2008). In fact, during this period the productivity per hectare was also increasing every year. However, subsequent years (from 2002 to 2006) saw a series of fluctuations in bean output, resulting in a general decline in domestic food supply per capita during the same period. And even as statistics for 2006 to 2011 reveal an upward trend in bean output; the country's productivity per hectare has been on the decline since 2001.

Table 1: Common bean production information in Uganda for selected years

Year	Output ('000' Mt[1])	Harvested Area ('000'Ha)	Yield (Mt/ha)	Forest area ('000' Ha)	Food supply Kg/Capita/Year
1997	221	630	0.35	4,133.60	9.20
1998	387	645	0.60	4,045.40	14.80
1999	401	669	0.60	3,957.20	14.80
2000	420	699	0.60	3,869.00	14.00
2001	511	731	0.70	3,781.00	17.70
2002	535	765	0.70	3,693.00	17.80
2003	525	780	0.67	3,605.00	16.90
2004	455	812	0.56	3,517.00	14.40
2005	478	828	0.58	3,429.00	13.80
2006	424	849	0.50	3,340.80	11.30
2007	435	870	0.50	3,252.60	11.80
2008	440	896	0.49	3,164.40	-
2009	452	925	0.49	3,076.20	-
2010	948	-	-	-	-
2011	973*	-	-	-	-

(Source: FAOSTAT, 2011) *** denotes estimated figures; - denotes missing data**

It is also evident that the area under bean cultivation has been increasing, each year since 1997, which could also explain the increase in output. However the country's forests cover is continuously being reduced as a result of agricultural expansion as is indicated in

[1]Mt denotes metric tonnes, equivalent to 1000 kgs

Table 1; and hence improving productivity inagriculture and particularly in bean farming is an inevitable step to salvage the forest resources.

According to Uganda's grain subsector report (2007), Uganda is a surplus producer of beans, with real export potentials that can be exploited by improving quality to that required by the export markets at all levels in the bean supply chains. However, data from the Agricultural policy secretariat (Table 2) on the bean balance sheet indicates that supply has been increasing at a lower rate than the demand for beans, leading to a decreasing figure of bean surpluses each year since 2001. This also reveals a productivity problem in bean cultivation in the land locked country.

Table 2: Bean supply- demand Gap (Mt): 1997- 2005 (projection)

Year	Supply (S)	Demand (D)	Surplus (S-D)
1997	346,800	320,099	26,701
1998	354,450	330,377	23,973
1999	350,200	348,446	1,754
2000	368,050	369,175	-1,125
2001	383,350	356,315	27,035
2002	412,250	396,645	15,605
2003	425,000	407,215	17,785
2004	437,750	423,302	14,448
2005	450,500	439,716	10,874

(Source: Uganda's grain subsector report, 2007)

Various policy initiatives have therefore been taken to promote sustainable agricultural development for scaling up rural incomes and food security in Uganda such as the Poverty Eradication Action Plan (PEAP) and the National Agricultural Advisory Services (NAADS) programme. The PEAP was launched in 1997, while the NAADS programme was launched in 2001 (Uganda's grain subsector report, 2007). These initiatives are spearheading agricultural development in Uganda, by providing a blue print for private sector delivery of agricultural advisory services such as extension services, input supply and regulation on agricultural inputs. However, the main policy challenge to date has been to deepen and sustain the policy reforms already implemented.Coincidentally, the current policy thrust with respect to agriculture is aimed at modernization of the sector (MAAIF, 2004). This calls for increased research, on how best to increase productivity without depleting the natural resources.

1.3 The statement of the problem

While there is evidence that Uganda has witnessed spells with upward trends in bean output since 1997; this has mainly been attributed to the increased uptake of improved bean varieties and expansion in the area under cultivation. However, the potential productivity level of the crop is yet to be achieved. The average bean yield in the country has been recorded as 0.6-0.8 Mt Ha^{-1}, although yields of 1.5-2.0 Mt Ha^{-1}can be realized with improved varieties and good crop husbandry (Kalyebara, 2008). Therefore various stakeholders such as CIAT have been promoting productivity enhancing technologies and creating an enabling environment for farmers to access markets in Eastern Uganda over the past four years through a programme called INSPIRE[2]. However, the effectiveness of this intervention in improving sustainable bean productivity has not been evaluated so as to provide policy recommendations. In addition, past studies on common bean in Uganda have also not focused on production efficiency. Therefore, this study investigated whether there are production inefficiencies resulting from sub-optimal use of available resources; as a way to explain productivity constraining factors in common bean farming.

1.4The objectives of the study

The main objective of this study was to determine the factors influencing common beanproductivityand efficiency towards achieving improved food security and household welfare among smallholder farmers in Eastern Uganda.

The specific objectives are:

1) To characterize and compare the socio-economic and institutional supportcharacteristics of smallholder common bean farmers in Eastern Uganda.
2) To assess the production factors influencing the achievement of optimal common bean productivity per hectare.
3) To evaluate the socio-economic and institutional support factors influencing technical, economic and allocative efficiency among common bean farms in Eastern Uganda.

[2] INSPIRE: Integrated Soil Productivity Initiative through Research and Education

1.5The Research question and hypotheses of the study

1.5.1 Research question

What are the socio-economic and institutional supportcharacteristics of smallholder common bean farmers in Eastern Uganda?

1.5.2 Hypotheses

1) There is no significant difference in the socio-economic and institutional support characteristics between participants and non-participants in the INSPIRE intervention.
2) The achievement of higher common bean productivity per hectare is not significantly influenced by agronomic factors prevailing in Eastern Uganda.
3) The technical, economic and allocative efficiency level of bean farms in Eastern Uganda is not significantly influenced by socio-economic and institutional support characteristics of the farmers.

1.6The justification of the study

Common bean is an important legume grown in virtually all parts of Uganda. It has generallybeen considered as low status food or the “meat of the poor” due to its low cost relative to animal products. Bean provides a rich combination of carbohydrates (60-65%), proteins (21-25%), fats (less than 2%), vitamins and minerals (Ensminger*et al.*, 1994). In fact with increasing health concerns, most people especially the urban population are reducing consumption of animal proteins, and instead they areturning to pulses such asdry bean due to its low fat content. Hence the rationale for emphasis in more bean research is self-evident.

The crop also provides farm households and traders with incomes and is therefore important from both the food security and income-generation points of view (Uganda’s grain subsector report, 2007). Hence there is need for increased bean production to enhance exports, since the local and international demand is predicted to increase due to increasing cost of living and changing food habits (Bigirwa *et al.,* 2007). For instance, the national annual demand for common bean in Kenya has been estimated at 500,000 tonnes but the actual annual production is only about 125,000 tonnes, making the country a net importer from Uganda and Tanzania. Hence Uganda can take up the opportunity strongly given that she has a competitive advantage over her neighbours.

Empirical evidence from this study aids in the achievement of the first and seventh millennium development goals of eradicating poverty and hunger and ensuring environmental sustainability respectively. It also adds to the body of knowledge on bean production, that assists government and non-governmental agencies (not only in Uganda, but also in the wider

East African Community) to improve the productivity of beans, and to find solutions to other technical problems in smallholder agriculture.

1.7The scope and limitations

The study was carried out in the Eastern region of Uganda and can be generalized to other areas with similar agro-ecological characteristics. The farmer households focused on in this study were those involved in common bean cultivation. The data collected was limited to the period January 2010 and April 2011;and soil-related and climatic factors were not considered for the study. However, the study was constrained by language barrier and the use of recall method which were deterrents in the data collection process. As such the enumerators from the study area were highly relied upon.

1.8 Operational definition of key terms

i. **Common bean:** It is used in this study as bean in some cases, and it is scientifically referred to as *Phaseolus vulgaris* L.

ii. **Smallholders**: These are defined in this study as bean farmers with at most 2hectares of total arable land whether entirely used for bean cultivation or not.

iii. **Technical efficiency**: It is the ability of a bean farm to produce the maximum possible yield (1.5-2.0 Mt Ha^{-1}) using a minimum combination of farm resources and using improved bean varieties.

iv. **Allocative efficiency:** This study borrows the definition of allocative efficiency from Tijani (2006)as the ability of a bean farmer to choose and employ the inputs inbean production to that level where their marginal returns equal their factor prices.

v. **Economic efficiency:** It is used to mean the ability of a bean farmer to employ a cost minimizing combination of farm inputs and at the same time producing the maximum possible output, given the available technology.

vi. **Participant farmers:** These are sampled farmers who were participants in the INSPIRE intervention. While non-participant farmers are sampled farmers who did not participate in the intervention.

vii. **Bean productivity:**It is a measure of the efficiency of production computed herein as a ratio of bean outputto the constraining resource (inputs) required to produce it i.e. it is the total bean output (in metric tons)per one unit of land cultivated (hectares).

CHAPTER TWO:LITERATURE REVIEW

2.0 Overview

This chapter presents a review of literature from a number of studies that are related to this study and elaborates on the theoretical basis for the study. The first section provides information about the food security situation in Sub-Saharan Africa (SSA), the need for increased bean production and the challenges faced by smallholder farmers in bean cultivation. The second section acknowledges strengths and weaknesses of selected literature on efficiency in smallholder Agriculture. Then the third and fourth sections consist of the theoretical and conceptual frameworks for the study respectively.

2.1 Food security in SSA and production constraints

According to Otsuka (2003), there is rapid population growth in Sub-Saharan Africa against a relatively slow expansion in the cultivated area, mainly because uncultivated land mass is scarce. In addition, the yield of food grain per unit of land has been constant or has even declined in some cases. And if these trends are to persist, then scientists predict a likelihood of severe food shortages. Common bean is nutrient-dense in that it provides a high amount of nutrients per calorie. Therefore, increased production will prevent populations witnessing food shortage in SSA from nutritional illnesses emanating from lack of balanced diet.

In the FASID conference for "the green revolution in Asia and its transferability to Africa", it was agreed that the situation in SSA is quite similar to the food production declinethat prevailed in Asia in 1950's and early 1960's, even though the latter had a more developed infrastructure (irrigation facilities and roads). And it became evident that to improve the food security in SSA, one strategy to adopt was to transfer the experience of the Asian "Green revolution" to SSA. This would entail transfer of institutional, social and economic systems which propelled the sustained yield growth in Asia; as opposed to mere technological transfer (Estudillo and Otsuka, 2006).

Incidentally, Baker and Herdt (1985); Cristina and Otsuka (1994); and Pingali, Mahabub and Gerpacio (1997) had earlier argued that the advent of high yielding and fertilizer- responsive crop varieties in Asia in the 1950's to 1960's, is what saved the world from a catastrophic eminent food shortage. Hence with this reality, researchers are doing a tremendous job to develop crop varieties suited for the African environment.

Over the period of at least 7000 to 8000 years, the common bean has evolved from a wild-growing vine distributed in the highlands of Middle America and the Andes into a major leguminous food crop, growing worldwide in a broad range of environments and cropping systems. It has also been produced in most parts of Africa, with production concentration in the eastern and central highlands, since its introduction from America in the 1500's and subsequent years (Hidalgo, 1991).

Specifically, Ugandan bean farmers traditionally grow varietal mixtures of variable growth habits. However, some production of single varieties is also practiced, especially for urban markets. It has been found that farmers grow the traditional varieties for the household consumption, and the improved varieties for commercial purposes (Kalyebara, 2008). There are several varieties within the country,with most of the traditional varieties having degenerated into what is commonly referred to as "local" varieties (Uganda's grain subsector report, 2007). The most common varieties grown and their key characteristics are given in Table 3.

Table 3: Common bean varieties grown in Uganda

Variety	Major characteristics				Seed source	Susceptibility
	Growth period (months)	Yield (Mt/ha)	Rainfall	% of area planted		
A: Bush type						
-K131	3	1.5-2.0	-Moderate	2	-NARO	-Very susceptible
-K132	3-5	"	-Moderate	7	"	to root rot
-NABE series	-	"	-Moderate	-	"	-Resistant
Local	3-4	0.4-0.5	Moderate	85	Local sources	-Susceptible
B: Climbing						
-Ngwinurare	4	1.5- 1.8	Moderate	6	-NARO	-More tolerant to
-Vunikingi	4	"	Moderate	"	Kisoro	root rot
-Gisenyi	4	"	Moderate	"		

(***Source: MAAIF, 2004)***

According to MAAIF (2004) there are two major bean types cultivated in Uganda, the bush bean and the climbing bean. Among the bush types there are the local varieties and the improved varieties (released between 1994 to date). The improved bush bean varieties which have been released include: K131 and K132 released in 1994; NABE 1, NABE 2 and NABE

3 released in 1995; NABE 4, NABE 5 and NABE 6 released in 1999. On the other hand, before 1999 all the available climbing bean varieties in Uganda were introduced by farmers from neighbouring countries. Climbing bean types were first released in Uganda in 1999, but as a result of limited dissemination of these varieties they have not been widely cultivated in the country (Kalyebara, 2005).

The bush bean varieties are reported to take between 3 to 5 months, while the climbing bean varieties take a constant period of 4 months. It is also clear that the bush bean is the most commonly cultivated bean type in the country, while the climbing bean has traditionally been grown only in the highland areas, constituting less than 10% of the total bean acreage. However, climbing bean varieties for low lands have also been researched in the past five years(Kalyebara, 2008). Table 3 also reveals that the only source of improved bean seeds is the National Agricultural Research Organization (NARO), which points out the seed dissemination problem in bean production.

The climbing bean is also proved to be more productive than the bush bean (Wortmann, 2001). Subsequently, the majority of research and development to date has concentrated on improving productivity and nutritional value of the climbing bean. In East Africa, the climbing bean produces yields that are almost triple those of the standard bush bean, and also has a better heat tolerance and forty percent more iron than the latter (Harvest plus, 2006). In addition, the climbing bean is less susceptible to disease and more efficient in the usage of available soil nutrients and water, hence suitable for areas with limited land availability (MAAIF, 2004). Despite its advantages, the climbing bean is not typically grown in most of Eastern Uganda and instead, the most widely cultivated seed varieties are the bush type. This is mainly because climbing types are more suited for the high altitude areas where as bush types can withstand lowland conditions (Kimani, 2006).

One study on farm productivity in Africa by Reardon *et al.* (1997) found that the rates of growth in yields (output/ha) and returns per labour-day were gradually low, but differed by crop, zone, technology and farm size. Yields in good agro-climatic zones were 2 to 3 times greater than those in poorer zones. Large fluctuations were also witnessed in years with good and bad rainfall levels in semi-arid zones, making farming very risky. The study also found that labour, fertilizer use, seed quality and distribution, animal traction, organic inputs or soil conservation investments and non-cropping income had a positive impact on farm productivity, which is consistent with Idiong (2007). On the other hand, farm size and land tenure were found to have a negative contribution to farm productivity. However, despite the wide scope of the study covering four case studies in Bukina Faso, Senegal, Rwanda and

Zimbabwe; Reardon and others failed to estimate farm-specific efficiencies and their determinants. This could have provided feedback on the contribution of the farmer's managerial ability on the farm productivity.

Kalyebara (2005) also confirmed that research efforts to increase bean yields have been increasingly curtailed by decline in soil fertility without replenishment. Incidences of diseases constraining bean production in lowlands have also been severe including common bacterial blight, web blight, bean common mosaic virus, root-rot and rust. While the most destructive pests have been bruchids, aphids, and foliage or stem beetle (Kimani, 2006).The lack of prevention and control measures also leads to further devastation of crops. Therefore for Eastern Uganda, this study evaluated the level of pesticide, fungicide and herbicide usage; as well as uptake of soil enhancing inputs among bean farmers as a way to prevent crop losses.

In addition, Uganda's grain subsector report (2007) identifies several institutional factors such as lack of information on prices, markets, input supply and stockists; failure of banks to advance credit for agricultural production; price fluctuations caused by seasonal gluts and scarcity; significant losses due to poor post harvest handling and storage facilities; and lastly changing weather patterns. This is a case of missing markets in institutional support factors and a similar scenario was found for Eastern Uganda.

In addition, some studies blame the relatively low farm yields on low input use by smallholder farmers, for instance Kijima (2008). However, this is majorly brought about by the high cost of inputs and improved technologies, which means that farmers continue to practice subsistence production, thus limiting production capacity. As such, they can not realize sufficient quantities of produce to meet household needs and have a marketable surplus. Kijima (2008) further observes that farmers instead apply crop rotation, yet due to lack of technical knowhow on which cropping pattern to adopt for the first and the second season, the yields still remain low. While these reasons may be true in explaining the relatively low bean yields, they are general for all crops in SSA; hence there was need for research to find out from the farmers' perspective, the production constraints specific to the common bean producers and for Eastern Uganda.

2.2 Empirical studies on production efficiency

This section presents a brief review of the literature on the analysis of production efficiency and the farm or household specific factors that affect technical, economic and allocative efficiency levels.

2.2.1 Empirical studies on factors influencing technical efficiency

According to Birungi *et al.* (n.d.), the key determinants of technical efficiency take two broad categories: (1) Human capital which comprises: age, sex, education, and experience in farming; and (2) socio-economic factors that comprise: credit availability, extension services, off-farm income, tenancy status, labour type, firm size among others.

The stochastic frontier approach (SFA) and the non-parametric Data Envelopment Analysis (DEA) are the most common approaches employed in efficiency analysis literature though with modifications. Among the studies that have used the SFA is Kibaara (2005) who estimated the level of technical efficiency in Kenya's maize production and determined socio-economic characteristics and management practices which influence technical efficiency in maize production. For the analysis, a recent development in stochastic frontier modelling was adopted, by using a one step process in Limdep computer software, instead of the two stage procedure usually followed for analysing technical efficiency.The results indicated that the mean technical efficiency level of Kenya's maize production was 49 percent (with variations from 8 to 98 percent). Technical efficiency was found to vary within and between maize growing regions and also by cropping system. Specifically, monocropped fields were found to have higher technical efficiency than intercropped fields. However this finding is contrary to the expectation and may have occurred because majority of the farmers who practised mono-cropping were in the high potential maize producing areas.

On the other hand, Croppenstedt (2005) employed a Cobb- Douglas stochastic production frontier approach, to measure technical efficiency of wheat farmers in Egypt. The study found that on average wheat farmers operate at 20% below the potential output. However, contrary to a study by Illukpitiya (2005) and many other authors, further analysis revealed that there was no evidence of influence of farm size and extension services on wheat producers' technical efficiency.Croppenstedt's findings reveal a weaknessespecially in terms of extension service since it is expected that the more extension contacts one receives, he/she will benefit from increased knowledge on better farming methods, hence becomes more technically efficient.

Efficiency analysis has also been applied in environmental management studies. For instance Illukpitiya (2005) studied technical efficiency in Agriculture and dependence on forest resources among rural households in Sri-lanka. The findings of the study showed that the mean technical efficiencies in agriculture in forest peripherals range between 67 and 73%. Factors such as age, education, experience, nutritional status and extension service of the household head were found to determine the level of inefficiency. This was because elderly farmers or those with experience are technically more efficient in allocating resources due to learning by doing. The author also argued that farmers who receive extension assistance tend to have more knowledge on new and improved farming practices hence became more efficient. Consistent with Kibaara (2005), the author also argued that a good nutritional status (health) of the household head reducedhis/her absence from the farm and reduced inefficiency.The nutritional status of the household head is however difficult to determine since it is based on the calories of food intake as is the case in Illukpitiya (2005).

Furthermore, Ogundele and Okoruwa (2006) also using a modified stochastic frontier model studied technical efficiency differentials in rice production technologies in Nigeria. In their approach, inefficiency effects were modelled as an explicit function of certain firm specific factors, and all the parameters were estimated in one step using a maximum likelihood procedure. The study results revealed that the traditional rice variety farmers employed more seeds, labour and herbicides, while they employed less fertilizer than their improved rice technology counterparts. And consistent with the findings in Niringiye*et al.* (2010), the most significant determinant of technical efficiency among both groups of technologies was farm size. Other determinants included hired labour, herbicides and seeds. Education and farming experience were found to influence technical efficiency in traditional technology. The study however failed to look at the allocative efficiency differentials for the two rice technologies although the findings were very relevant.

In an analysis of the technical efficiency of rice farms in Ijesha land of Osun state, Nigeria, Tijani (2006), also used a stochastic frontier production function of a Trans log form that was run in Frontier 4.1 as advised by Coelli (1994). The study revealed that technical efficiency ranged from 29.4% to 98.2% with a mean of 86.6%. In addition to the common factors that determine technical efficiency such as off-farm income, education and farm size. The study also found that traditional preparation methods were used to frighten birds off the farms. Hence use of these techniques positively influenced technical efficiency of rice farms.

Another study on rice is Hyuha*et al.* (2007) which analysed the profit inefficiency among rice producers in eastern and northern Uganda, using a Stochastic Frontier Model. They also modelled inefficiency effects as a function of firm specific factors and estimated in one step using a maximum likelihood procedure, similar to the approach byOgundele and Okoruwa (2006). The findings revealed that rice farmers in Eastern and Northern Uganda do not operate on the profit frontier. While the major causes of inefficiency in the focus areas were: level of education, limited access to extension services and credit. It was argued that educated farmers are able to gather, understand and use information from research and extension more easily than their illiterate peers. These results are also consistent with Goncalves*et al.* (2008), who using a case study of milk producing farms in Brazil, found that smallholder milk producers had difficulty to obtain credit which restricted them from investing in improved techniques and equipment, which resulted in inefficiency. However, in estimating profit efficiency,Hyuha*et al.* (2007) only covered selected districts in which lowland rice is grown; and there was need to replicate this kind of study to other districts and for other crops in the country.

One major concern for researchers has been to balance the agricultural production and soil conservation. Solis *et al.* (2007) thus evaluated technical efficiency levels for hillside farmers under different levels of adoption of soil conservation in El Salvador and Honduras. A switching regression model was implemented to examine selectivity bias for high and low level adopters and separate stochastic production frontiers corrected for selectivity bias were estimated for each group. The results revealed that households with above average adoption showed statistically higher technical efficiency than those with lower adoption. Further, households with higher adoption had smaller farms and displaced highest partial output elasticity for land.Intuitively, a farmer with a large farm land will be less pressured to conserve the soil, to guarantee good yields. The findings bySolis *et al.* (2007) also makes sense since a large farm land also serves as security for accessing more credit, which enhances affordability of production inputs that substitute soil conservation.

Bagamba*et al.* (2007) also analysed the technical efficiency of banana production among Ugandan smallholders by using the SFA approach. They examined banana productivity with specific focus on two constraints, soil fertility and labour. Contrary to many studies, the findings revealed that proximity to the market gave mixed results. Bagamba argued that proximity to the market could either increase farmers' ability to access credit which enables them to buy and apply inputs. Alternatively, it could increase farmers' access to off-farm employment with higher-return,whichimplies that they have to reallocate labour from the farm to non-farm activities. In addition, rent and remittances were found to reduce technical efficiencies, which is contrary to Feng (2008) and other authors. It is expected that payment of rent or remittances makes a farmer to be more committed to reducing wastage in resource use, hence such a farm will become more productive compared to one where such remittances are not paid.

Feng (2008) conducted a study to examine the effect of land rental market participation, land tenure contracts and off-farm employment on the technical efficiency in rice production in rural China. The findings were similar to those in Nigeria by Tijani (2006), with the mean technical efficiency of rice production being 82%, ranging from 36 to 97%. Further analysis revealed that households that rented land achieved higher technical efficiency than those with contracted or owned plots unlike what was observed by Bagamba*et al*. (2007). Furthermore, participation in migration did not have an effect on technical efficiencycontrary to the expectation. The study presented limitations by relying on various assumptions about the standard errors, such as homoscedasticity and independence of different plots managed by the same household. However, the statistical tests for the validity of these assumptions were not addressed. The study also focused on the plot as the unit of analysis and not the household, thus it ignored implicitly the heteroskedasticity between different households.

Another important factor that influences inefficiency according to Kebede (2001) is gender. The author studied rice producers' technical efficiency in Mardi watershed in Nepal using the SFA approach, and found that female headed households were more efficient. This implies that females carry out most of the farming activities in the study area, with frequent follow-ups and supervision than males. Similarly, a review of studies undertaken in the late 1980s and early 1990s found that when differences in inputs are controlled for, there were no significant differences in technical efficiency between male and female farmers (Quisumbing, 1996). However, it has often been argued that the lower level of physical and human capital among female farmers results in lower measured productivity or inability to respond to economic incentives.Kebede (2001) also incorporated a land quality variable and found that farmers with poor quality of soil were more technically efficient than their counterparts. This could either imply that higher technical efficiency was achieved through 'mining' the soil, or that these farmers provided extra effort in production activities to make the best of their land. The study however relied on the farmer demonstrations of land quality, and failed to explore the history of the plots and the plot-specific physical characteristics which makes thisfindingpartially questionable.

Another study on technical efficiency in rice production was done by Seidu (2008) in Northern Ghana. Like Tijani (2006) and other authors he adopted the transcendental logarithmic (Trans log) stochastic frontier function, and the results revealed that rice farmers were technically inefficient with no significant difference in technical efficiency between non irrigators (53%) and irrigators (51%). The results further revealed that apart from the earlier identified variables, family size also influenced inefficiency. Although this is not widely reported in literature, it is consistent with Bagamba*et al.* (2007), who argued that family size influences technical efficiency through its effect on labour endowments of households. Large families were found to be more efficient, since they can implement activities on time. However, Seidu's most unique finding was that 14% of the variations in rice output were caused by factors beyond the farmers' control, such as erratic rainfall, crop diseases, worms, bush fires, birds and grasshoppers.

According to Tchale (2009) in his analysis of Malawi's smallholder agricultural efficiency, smallholder production in developing countries is characterised by many variations, hence the use of parametric frontier approach (SFA) is more appropriate. The non-parametric approaches such as the DEA are free from mis-specification but do not account for the effect of other factors outside under the control of farmers. The findings revealed that fertilizer, land and labour (for labour intensive crops) were key factors in production of major crops grown by smallholder farmers in the maize-based farming system. The average level of technical efficiency was 53%, allocative efficiency was 46% while economic efficiency was 38%. The results imply that allocative (cost) inefficiency is worse than technical inefficiency, which reiterates the need for more research on allocative efficiency as well.

Additional findings by Tchale (2009) indicated that the size of land holding (farm size) inversely influence technical efficiency contrary to findings by Croppenstedt (2005) and Fernandez *et al.*(2009), and implies that as the land holding increases it becomes more involving to manage it; hence the efficiency level decreases. Tchale (2009) also found that purchased seed usage improves the degree of technical efficiency such that farmers who plant purchased seeds gain an average of 9% higher efficiency than those who do not. Similar to Idiong (2007), the author also found that farmers who were members in extension-related, market-related or credit-related organisations exhibited higher levels of efficiency, than non-members. It was also revealed that informal sources of learning and information sharing helped farmers in updating their farming ways, hence positively influenced their efficiency levels. Tchale also identified the fact that assets owned by the farmers improved their liquidity position thereby ensuring that they were able to respond rapidly to demand for cash to buy inputs and other factors. Furthermore, in reality individuals also invest in assets that generate more income to supplement their farm income or facilitate easy movement or ease information sharing. Hence asset ownership is a positive determinant of technical efficiency.

While the stochastic frontier approach has been widely used in the efficiency literature, the Data Envelopment Analysis (DEA) approach has also been used in some studies especially where scale efficiency is measured. According to Binam*et al.* (2003) the average level of technical efficiency among coffee farmers in Cote d'Ivoire was 36% and 47% for CCR (Charnes*et al.* 1978) and BCC (Banker *et al.* 1984) models respectively. While farm size, ethnic cohesion and membership to farmer groups and association were the most significant factors that were found to influence technical efficiency similar to findings by Tchale (2009). The study employed the DEA technique to compute farm- level technical efficiency measures of peasant farmers in Cote d'Ivoire; while the two limit Tobit regression technique was used to examine the relationship between technical efficiency and various farm or farmer characteristics. The approach is acceptable and has been applied by many other others using the DEA technique.

Another study is by Tahir*et al.* (2009) who using a non-parametric DEA approach, estimated technical and scale efficiency of Malaysian commercial banks. The results indicated that the degree of scale efficiency was lower than the degree of overall or technical efficiency. Impliedly, the portion of overall inefficiency was due to producing at inefficient scale rather than producing below the production frontier. This study thus brought out a new realization that the whole portion of inefficiency in smallholder agriculture is not often as a result of technical inefficiency, hence the need for more scale efficiency studies to be done.

Niringiye*et al.* (2010) also did a study to establish the relationship between farm-size and technical efficiency in East African manufacturing firms. The study adopted a two stage methodology to examine the relationships: in the first step, technical efficiency measures were calculated using DEA approach; and secondly, using GLS technique a technical efficiency equation was estimated to investigate whether technical efficiency is increasing with firm size. The findings were consistent with those by Edeh& Awoke (2009) and Tchale (2009), revealing a negative association between firm size and technical efficiency in both Ugandan and Tanzanian manufacturing firms.

However, Fernandez *et al*. (2009) using the same approach studied the technical efficiency in the sugarcane production in Philippines and found contradicting results. While, labour, land and power inputs were the most binding constraints, seeds and NPK fertilizer were not binding. In addition, similar to farmers' age and experience, access to credit, Nitrogen fertilizer application, and soil type, farm size also influenced overall technical efficiency positively. The results by Fernandez *et al*. (2009) regarding the influence of farm size are contrary to most studies reviewed, though it implies that larger farms could have a beneficial impact on the efficiency of the Philippines' sugar industry.

The production function approach has also been used in efficiency analysis, although there are few such cases. One case is Goni*et al.* (2007) who analysed resource use efficiency in rice production in Nigeria. In their analysis, a conventional neoclassical test of economic efficiency was derived where, the ratio of the marginal value productivity and marginal factor cost was used to determine the economic efficiency of resource use while the elasticity of production was used to compute the rate of return to scale for determining the technical efficiency levels of firms, as proposed in Farell (1957). The findings from the study revealed that rice farmers were technically inefficient in the use of farm resources (i.e. fertilizer, seeds and farmland were underutilised, while labour was over utilized). The inefficiency was attributed either directly or indirectly to the high cost of fertilizer, rent and seed. The findings in this study are still relevant though they left out some inputs like herbicides and pesticides, especially since one of the greatest challenges facing small-holder Agriculture has been found to be pests and diseases.

2.2.2 Empirical studies on factors influencing allocative efficiency

Production theory states that under competitive conditions, a firm is said to be allocatively efficient if it equates the marginal returns of factor inputs to the market price of the input (Fan, 1999). A similar definition was given by Ali and Byerlee (1991) in their review of economic efficiency of small-scale farmers in a changing world. They contend that allocative inefficiency is failure to meet the marginal conditions of profit maximization. Akinwumi and Djato (1997) in their study of the relative efficiency of women farm managers in Ivory Coast defined allocative efficiency as the extent to which farmers make efficient decisions by using inputs to the point where their marginal contribution to the production value is equal to the marginal factor costs. Therefore this study defines allocative efficiency as the ability of a farm decision maker to use farm inputs up to the level where marginal value of production is equal to their factor price.

Based on this definition, a number of studies have been conducted on the determinants of allocative efficiency. A study by Nwachukwu and Onyenweaku (2007) on allocative efficiency among pumpkin farmers in Nigeria, using a stochastic frontier approach, found that the farming experience had a positive effect on allocative efficiency. The authors observed that farmers' wealth of experience in pumpkin farming made them able to allocate their resources more efficiently. This is consistent with findings by Obare *et al.* (2010) among Irish potato producers in Kenya. In the study, a dual stochastic efficiency decomposition technique and a two-limit Tobit model were applied. Obare and others also observed a positive effect between farming experience and allocative efficiency and argued that more years of experience in farming lead to acquisition of better managerial skills over time, which made farmers able to allocate their resources more efficiently.

Another study by Ogundari and Ojo (2007) on small-scale food crop producers in Nigeria, found that age of the farmer had a negative effect on allocative efficiency. Similar findings were reported by Bravo-Ureta and Pinheiro (1997) in the Dominican Republic. This suggests that an increase in the farmer's age translated into higher inefficiencies with respect to optimal allocation of available resources. The authors applied the stochastic frontier approach, but adopted a contradicting methodology in which they used the frontier cost function to measure allocative efficiency. In addition, the authors failed to use the two-step methodology applied by most studies such as Obare et al. (2010) and Mulwa et al. (2009).

Lopez (2008) also conducted a study on Kansas farms in the USA. The study applied a DEA and Tobit methodology used by many other authors to measure technical, allocative, scale and overall efficiencies and their determinants. According to her findings, off-farm income had a positive effect on allocative efficiency. This implies that producers who had off farm sources of income showed higher allocative efficiency than those who entirely relied on farm income. The author attributed this to the fact that off-farm incomes enhanced the financial position of the farm to acquire farm inputs, especially because most of the farms in the USA carry out mechanized agriculture. The findings however contradict observations by Kibaara (2005) in Kenya, who argued that, since production is labour-intensive, off-farm activities deprive the farm of the farmer's attention as a result of labour diversion to these activities; hence leading to higher inefficiency. In any case, the type of farming in the two areas is different, making both arguments relevant depending on whether it is a developed or a developing country.

It has also been observed that regular visits of extension workers positively influenced a farmer's allocative efficiency(Obare *et al.*, 2010). This is attributed to the fact that the knowledge gained from extension visits influences producers to adopt new technologies through which they become more efficient.These findings are consistent with Illukpitiya (2005) who observed that increased extension contacts facilitate practical use of modern techniques and adoption of improved agronomic practices. In fact, the findings by Obare *et al.*(2010) also reveal that extension contacts provide information on price patterns, new varieties and available markets such as those aired through the media. This information increases farmers' ability to use farm resources optimally. Therefore extension visits or contacts enhance a farm's allocative efficiency.

Education of the household head has also been found to significantly affect allocative efficiency. According to a study by Laha and Kuri (2011) in India, farmers' years of schooling was found to have a positive effect on allocative efficiency; suggesting that the more years a farmer had spent in school the more able he was to efficiently allocate his farm resources. However, other studies have also found a negative relationship between education and allocative efficiency; for instance Nwachukwu and Onyenweaku (2007) in Nigeria and Bravo-Ureta and Pinheiro (1997) in the Dominican Republic. Thus the number of schooling years has mixed effects on the farmers' allocative efficiency level.

In terms of credit, Obare *et al.* (2010) found a positive influence on allocative efficiency. They observed that farmers with ease of access to credit exhibited higher levels of allocative efficiency. According to the authors, credit availability is expected to limit constraints hindering timely purchases of inputs and engagement of farm resources. Similar findings were established by Binam*et al.* (2003) for farmers in Ivory Coast. Nwachukwu and Onyenweaku (2007) also observed that access to credit enables farmers to overcome liquidity constraints that affect their ability to apply inputs and implement farm management decisions timely. However their findings reflected a negative effect for credit which they attributed to the fact that farmers were meeting difficulties in accessing funds for farming operations. This shows that credit has been found to influence allocative efficiency either positively or negatively.

Concerning household size, Nwachukwu and Onyenweaku (2007) found that it negatively affected allocative efficiency. They contended that larger households were faced with the challenge of attending to numerous family needs, which reduced the magnitude of resources allocated to faming activities. This is contrary to most studies like Seidu (2008) which emphasise that large households are better in providing free labour, indicating the usefulness of larger households in improving farm efficiency.

In terms of membership in farmer groups, Obare et al. (2010) argue that farmers who are affiliated to producer associations are bound to have more allocative efficiency. This finding is similar to that by Tchale (2009) on crop farmers in Malawi. According to Obare and others, producers form groups to pool resources together so as to mitigate the consequences of market imperfections. Therefore, farmers who belong to farmer associations are likely to benefit from better access to inputs and information on improved production practices (Mukhwana*et al.,* 2005). As such new users are likely to learn from the other members in the social network, hence generating significant technology spill overs and improving their allocative efficiency. Hence membership in a producer organization has a positive influence on allocative efficiency.

The area of land under a crop has also emerged as an important determinant of allocative efficiency. It is expected that the larger the cultivated area the higher the allocative efficiency level obtained. In a study on soy bean production in Vietnam, Khai and Yabe (2007) using the same approach as Obare *et al.* (2010) found that the main significant determinant of allocative efficiency was plot size. The authors however found that farmers' allocative efficiency decreased with an increase in cultivated area until 0.9 ha, after which the influence turned positive. However Ugwumba (2010) in his study on melons in Nigeria pointed out that land was underutilized in production leading to allocative inefficiencies. Ugwumba argued that in many African societies, land ownership was mainly acquired through inheritance, an issue that has increased the problem of land fragmentation and exacerbated the problem of underutilization. In this study we agree that the cultivated area has a positive influence on allocative efficiency.

Allocative efficiency is also influenced by interlinkage in the factor markets, according to findings by Laha and Kuri (2001) in their study on allocative efficiency in India. In their findings, there was a positive relationship between factor market interlinkages and allocative efficiency. The authors indicated that interlinkages among input providers, in such a way as to avail required inputs to farmers cost-effectively, is conducive for improving farmer's allocative efficiency. It also induces farmers to take up new technologies and innovations more rapidly. The findings also revealed that different forms of land tenure had varying importance in improving allocative efficiency in agriculture. Such that fixed rent tenants were more allocatively efficient than share-croppers. However, the authors applied the data envelopment approach which requires more than one crop enterprise constrained by a given set of inputs. The current study only looked at bean production; hence this approach was not applied.

Lastly, the occupation of the family head has also emerged as a critical determinant of allocative efficiency. According to findings by Mulwa *et al.* (2009) in western Kenya, farmer's main occupation was found to influence allocative efficiency negatively. This surprisingly suggests that those who did farming as their primary occupation were less allocatively efficient than those who had other sources of income. The authors argued that since allocative efficiency has to do with prices, farmers with external income sources such as employment or business may have had access to more income which improved their farming considerably. Thus this study supports findings by Mulwa *et al.* (2009) due to the fact that farmers who depend entirely on farming are disadvantaged in terms of farming capital; hence they became less allocatively efficient compared to those who also engage in non-farming activities.

2.2.3 Empirical studies on factors influencing economic efficiency

Economic efficiency is also referred to as cost efficiency in the production efficiency literature. One of the studies that have analysed economic efficiency in agricultural production is Mulwa *et al*. (2009) on smallholder maize farmers in western Kenya. The authors applied the two-step methodology where firstly, a Data Envelopment Approach was used to estimate farm efficiencies, after which selected farm and farmer attributes were regressed in a Tobit model against the estimated efficiencies. This methodology is similar to the approach by Krasachat (2007) among Thai cattle farms. Mulwa and others found that maize production in western Kenya was highly inefficient and there was room for improvement. It was further found that overall efficiency was significantly affected by the quality of seed used and household size. The authors observed a negative coefficient for household size, suggesting that the larger the household the lower the overall efficiency. The authors argued that larger households had the potential for providing cheaper farm labour, however the funds that would have been used to purchase other farm inputs is often allocated to some other necessity like household consumption, hence the negative effect on overall efficiency.

Another study that has made remarkable contribution to efficiency literature is by Krasachat (2007) on feedlot cattle farms in Thailand. This study also employed the same approach as Mulwa *et al.* (2009) on maize farms in Kenya. The results revealed that producers who used ready mixed commercial cattle feeds were more economically and allocatively efficient. But most importantly, farm size was found to have negative effect on economic efficiency, suggesting that smaller cattle farms were more economically efficient than larger farms. This finding is still relevant to the current study, even though the study was on livestock farming. This is because there is high interdependence between crop and livestock enterprises.

According to a study by Nyagaka*et al.* (2009) on Irish potato producers in Kenya, farmer's education positively influenced farm economic efficiency. It was argued that farmers with higher levels of education were more efficient in production and this was attributed to the fact that educated farmers positively perceive, interpret and respond to new technologies on seeds, fertilizer, pesticides, fungicides, herbicides or markets much faster than their counterparts. On the other hand, Bravo-Ureta and Pinheiro (1997) in their analysis of economic efficiency in the Dominican Republic found that education had a negative effect on economic efficiency. This suggests that educated farmers in the Dominican Republic were less efficient economically, compared to their uneducated counterparts. Therefore, schooling can influence overall efficiency either positively or negatively.

Bravo-Ureta and Pinheiro (1997) further found that age of the farmer had a negative effect on economic efficiency. The authors categorized age into young farmers and older farmers, with a dummy (1 for young farmers below 20 and 0 for older farmers). It was therefore observed that young farmers below the age of 20 were more efficient than older farmers in the study area. On the contrary, Mbanasor and Kalu (2008) did a study on commercial vegetable production in Nigeria using a trans-log stochastic cost frontier approach. They found that age had a positive influence on farm overall efficiency, implying that older vegetable farmers were more cost efficient than their younger counterparts. Illukpitiya (2005) also argued that elderly farmers are more efficient in allocating resources cost effectively due to the effect of the learning curve. However, the influence of age on overall efficiency varies with the crop enterprise.

Farming experience has also been found to affect farm overall efficiency. Various authors have found that experience in farming enhances efficiency. Mulwa *et al.* (2009) in western Kenya observed that farming experience had a positive influence on economic efficiency. Mbanasor and Kalu (2008) also found similar results for vegetable farmers in Nigeria, which coincides with their findings for age. It is expected that experienced farmers have over the years learned from their mistakes and improved their efficiency in production.

Nyagaka*et al.* (2009) further found a positive effect between extension visits and economic efficiency. This is consistent with findings by Mbanasor and Kalu (2008) and implies that the more extension visits a farmer accessed from the extension workers; the more economically efficient he became. The authors observed that regular provision of extension services on new seed varieties, farming technologies, and market information helped new farmers, who lack the experience, to be able to efficiently combine farm inputs just like their more experienced counterparts.

In terms of credit effect on economic efficiency, a study by Bifarin*et al.* (2010) on efficiencies in plantain production industry in Nigeria, found that economic efficiency was decreasing with an increase in credit. The authors employed a two-step approach involving a parametric stochastic frontier technique followed by a regression of selected socio-economic factors to measure the effect on efficiency indices. The negative sign on credit implied that higher access to credit rendered the farmer more economically inefficient. This finding is contrary to Ceyhan and Hazneci (2010) who analysed cattle farms in Turkey and found a positive relationship between credit and economic efficiency. It therefore reaffirms the observation by Nwachukwu and Onyenweaku (2007) in Nigeria that although credit helps solve liquidity problems in input access, difficulties in accessing such funds for farming is responsible for the negative effect, and is a common phenomenon for most of the African farmers.

Finally, with respect to membership in farmer associations Nyagaka*et al.* (2009) found that farmers who participated in such associations were less economically efficient. This is contrary to expectations since farmer associations are supposed to be instruments through which farmers can mitigate market imperfections. However, the results are similar to those found by Mbanasor and Kalu (2008) indicating that probably the farmer organizations were facing management problems that were depriving members the benefits from such groups.

The literature reviewed in this study reveals that there are very few studies on allocative and economic efficiency in Sub-Saharan Africa. In addition there are inter and intra-regional variations in production efficiency among farmers in various crop and livestock enterprises. However, we found no study on common bean production efficiency in Uganda. It has also been realised that, the extent to which efficiency measures are sensitive to the choice of methodology remains uncertain. Thereview thus revealed that, therewere mixed results with respect to the effect of: land rent and remittances, output market access, off-farm income and farm size (on technical efficiency); off-farm income, education, household size and farm size (on allocative efficiency) and education, age and credit (on economic efficiency). Hence there is need for more efficiency studies to help solve the discrepancies.

2.3 Theoretical framework for measuring efficiency

The theoretical formulation for this study is based on the theory of the firm and has been borrowed and modified from Hyuha*et al.* (2007). The theory of the firm states that firms exist and make decisions in order to maximize profits. They interact with the market to determine pricing and demand and then allocate resources according to models that ensure they maximize net profits. In measuring economic efficiency of a firm we require an understanding of the decision making behaviour of the producer. A rational producer, producing a single output from a number of inputs, $x = x_1 \ldots\ldots x_n$,that are purchased at given input prices, $w = w_1 \ldots.. w_n$ is thoughtto be efficient if operatingon a production frontier. But if the producer is using a combination of inputs in such a way that it fails to maximize output or can use less inputs to attain the same output, then the producer is not economically efficient. A given combination of input and output is therefore economically efficient if it is both technically and allocativelly efficient; that is, when the related input ratio is on both the isoquant and the isocostcurve.

Figure 1 is a diagrammatic exposition with a simple example of firms using two inputs land and labour to produce common beans. Firms producing along AB are said to be technically efficient because they are operating on the "efficiency frontier" or the isoquant, although they represent different combinations of land and labour inputs, used in producing outputQ. This is the least cost combination of inputs. In addition, DD' is an iso-cost line, which represents all combinations of inputs land and labour,such that input costs sum to the same total cost of production, given the firm's budget. However, any firm intending to maximize profits has to produce at Q', which is a point of tangency and representing the least cost combination of land and labour in production of Q metric tonnes of beans. Therefore, at point Q' the producer is economically efficient.

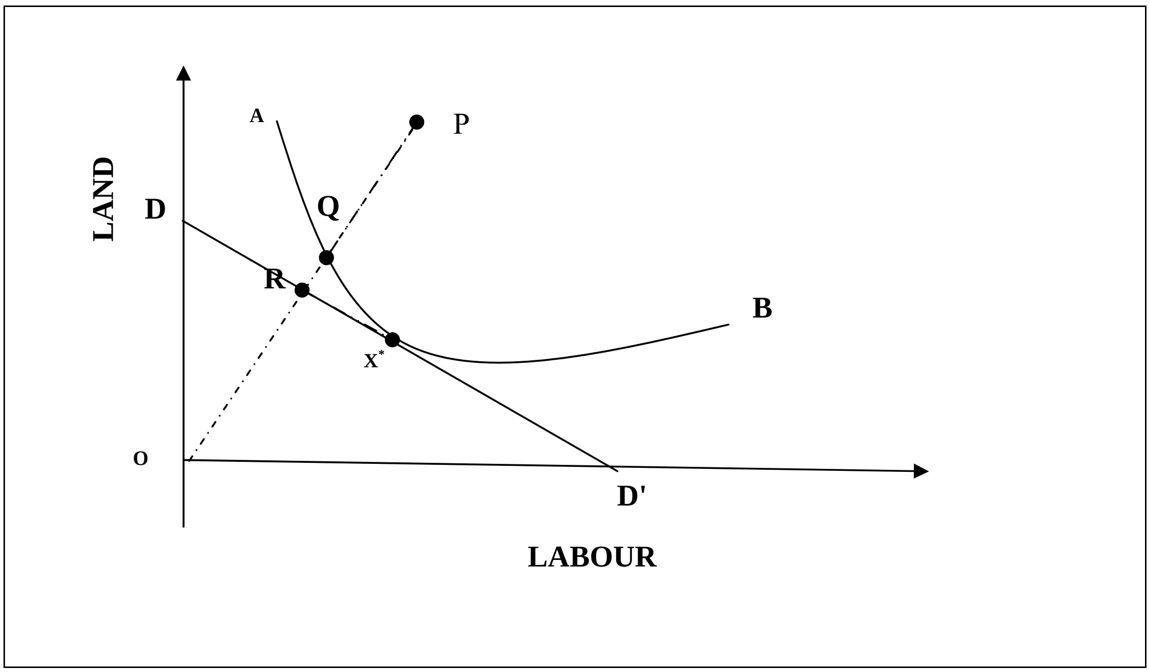

Figure 1:Technical, allocative and economic efficiency diagram

(Source: Hyuha et al., 2007)

To illustrate the measurement of technical, allocative and economic efficiency, we suppose a bean producing firmwhose output is depicted by isoquant AB, with input (land and labour) combination levels as in Figure 1. At point (P) of input combination, the production is not technically efficient because the farmer can instead produce at Q (or any point on AB) with fewer inputs. The degree of technical efficiency of such a firm is given as TE= OQ/OP.

For a fully efficient firm, TE = 1 but for all inefficient firms, a degree of TE < 1 is achieved. The difference between the estimated TE and 1 (or TE_i-1) depicts the proportion by which the firm should reduce the ratios of both inputs used to efficiently produce a metric ton of beans (Gelan & Muriithi, 2010).

However, TE does not take into account relative costs of inputs. In figure 1, DD'representinput price ratio or the iso-cost line, which gives the minimum expenditure for which a firm intending to maximize profit should adopt. The same firm using land and labour to produce beans at P would be allocatively inefficient compared to that producing at R. And its level of allocative efficiency is given by OR/OQ.

The overall (economic) efficiency is given as the product of the technical efficiency measure (OQ/OP) and the allocative efficiency measure (OR/OQ), which is OR/OP. This follows from the theoretical reduction in costs due to the shift in input combination from P to R. In this case if a technically and allocatively inefficient producer at P were to become efficient (both technically and allocatively) then she would produce at Q'.

2.4 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 behaviour 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 below, which represents how various factors inter-relate to influence common bean productivity and hence the welfare of bean 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 bean output. However, within the farming system various sets of factors inter-relate to determine bean productivity.

Production factors such as seeds, fertilizers, plot size, pesticides, herbicides and fungicides 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 bean productivity. It is expected that the more inputs used by the farmer, the higher the bean yields per hectare of land. Although, for chemical inputs, increased usage may produce negative effects on outputs if the farm has reached diminishing returns with respect to that input.

Bean productivity is also affected by the farm production 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. But the farm's production efficiency is also influenced by institutional and socio-economic characteristics of the farmer. Institutional factors are expected to influence production efficiency as follows: The nearness to the market, group membership, credit-access and extension service are hypothesised to have a positive influence on production efficiency. This is because nearness to the market increases access to inputs and credit. While group membership is expected to help farmers to mitigate problems associated with market imperfections. On the other hand, 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.

With respect to socio-economic characteristicsof the farmer, it is hypothesised that age of the farmer negatively affects production 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 income is expected to have a positive effect on production efficiency; since farmers with such incomes 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 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. Farm size is also hypothesised to have a positive influence in production efficiency, with larger farmers expected to portray economies of scale in their farming operations compared to smaller farms. Ownership of assets is expected to have a positive effect on farm efficiency. Specifically, bicycles and motor vehicles help farmers to move easily to the market, radios and televisions help farmers to access information through the media, while mobile phones assist the farmers to communicate and exchange information quickly. As such, the assets combine to make the farm more efficient.

A farm that is technically, allocatively and economically efficient is therefore expected to realize higher bean output per hectare compared to one that is less efficient in production. But on the other hand, such a firm is hypothesised to incur less production costs leading to higher returns from the enterprise. This therefore has positive spill over effects on the welfare of the bean producing households (HH).Improved welfare of the households then provides a feedback effect in form of increased access to production inputs and relevant lessons to policy makers.

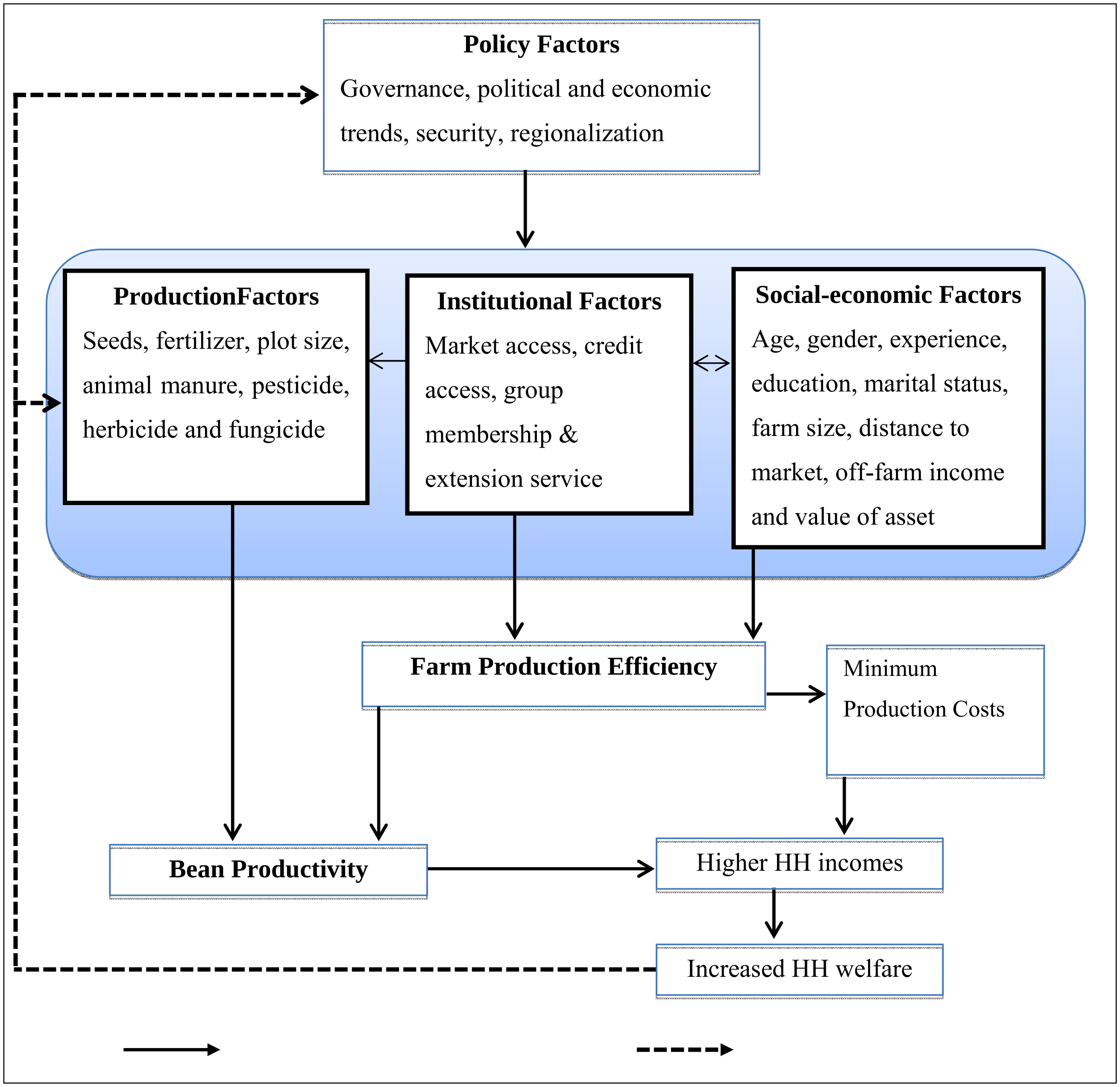

Figure 2: The conceptual framework of factors influencing production efficiency *(Adapted fromNew Institutional Economics theory)*

CHAPTER THREE:METHODOLOGY

3.1 Study area

Uganda is a land locked country, with no access to the sea. It lies astride the Equator between latitudes 4^{o}12'N and 1^{o}29'S, and longitudes 29^{o}34'W and 35^{o}0'E. The temperatures range between 15^{o}-30^{o}C with little variation throughout the year. Rainfall distribution in most of the country (70% of the land area) is fairly reliable oscillating between 1000 to 1750mm per annum; with 26% of the country receiving lower and only 4% receiving precipitation levels higher than this range (Mwebaze, 1999). Topographically, most parts of the country comprising about 84% of the land area have an altitude between 900-1500 metres. This suggests that most of Uganda's land area is in the medium altitude range, given that more than two thirds of the country is a plateau. The total land area is 241,548 Km^2 of which 75% is available for cultivation and 25% comprises lakes, swamps and protected areas. According to the CIA World Fact book (2011) estimates the country's population is reported at 34,612,250 persons, with a growth rate of about 3.6%. Therefore the capacity of this land resource to sustain the livelihoods of the rapidly increasing population largely depends on the influence of edaphic (soil related), climatic and biotic factors; and how well they can be managed to increase and sustain its productivity.

This study covered the Eastern region of Ugandawhich is generally suitable for common bean production; hence it was appropriate for this study. Specifically, the study focused on four representative districts namely: Mbale, Tororo, Busia and Budaka because bean production is high in these areas (over 80%) and also since they were incorporated in the INSPIRE project by CIAT (the basis of this study). Mbale covers an area of 2,467 Km^2 and has a population of about 410,300 persons, projected from the estimated growth rate of 2.5% in the 2002 census. The rural population in the district is 92% while the primary economic activity is agriculture (UBOS, 2010). In addition, Tororo has a population of 493,300 persons estimated from the annual growth rate of 2.7% based on the 2002 census. The district's economy also depends on agriculture. Furthermore, Busia has an estimated population of over 287,800 persons projected using a growth rate of 3% reported in the 2002 census. It is reported that 83% of the population in the district live in rural areas and largely depend on substance farming, while the town dwellers engage more in cross-border trade (UBOS, 2010). The last district selected for this study is Budaka, which has an estimated population of 293,600 persons. The district reported one of the highest growth rates of 3.5% according to the 2002 census findings. About 86% of this population practice crop agriculture and the major crops grown include bananas, cassava, millet, sorghum and cotton (UBOS, 2010).

The study area covered two agro-ecological zones. The Montane agro-ecological zone, in which Mbale falls, is found at higher elevations between 1500-1700 metres and receives high and effective rainfall. In addition, the soils in this zone are majorly volcanic with medium to high productivity. On the other hand, the Banana-millet-cotton agro-ecological zone covers Tororo, Busia and Budaka Districts and it is found at lower elevations, receiving less evenly distributed rainfall ranging between 1000-1500mm p.a. The soils in this zone are a mixture of volcanic and alluvial with low to medium productivity. The major staple crops grown in the districts include: bananas, sweet potatoes, cassava, Irish potatoes and beans. Other crops grown include coffee, wheat, barley, maize, millet, peas, *simsim*, sunflower, cotton, rice, onions, and carrots (Mwebaze, 1999).

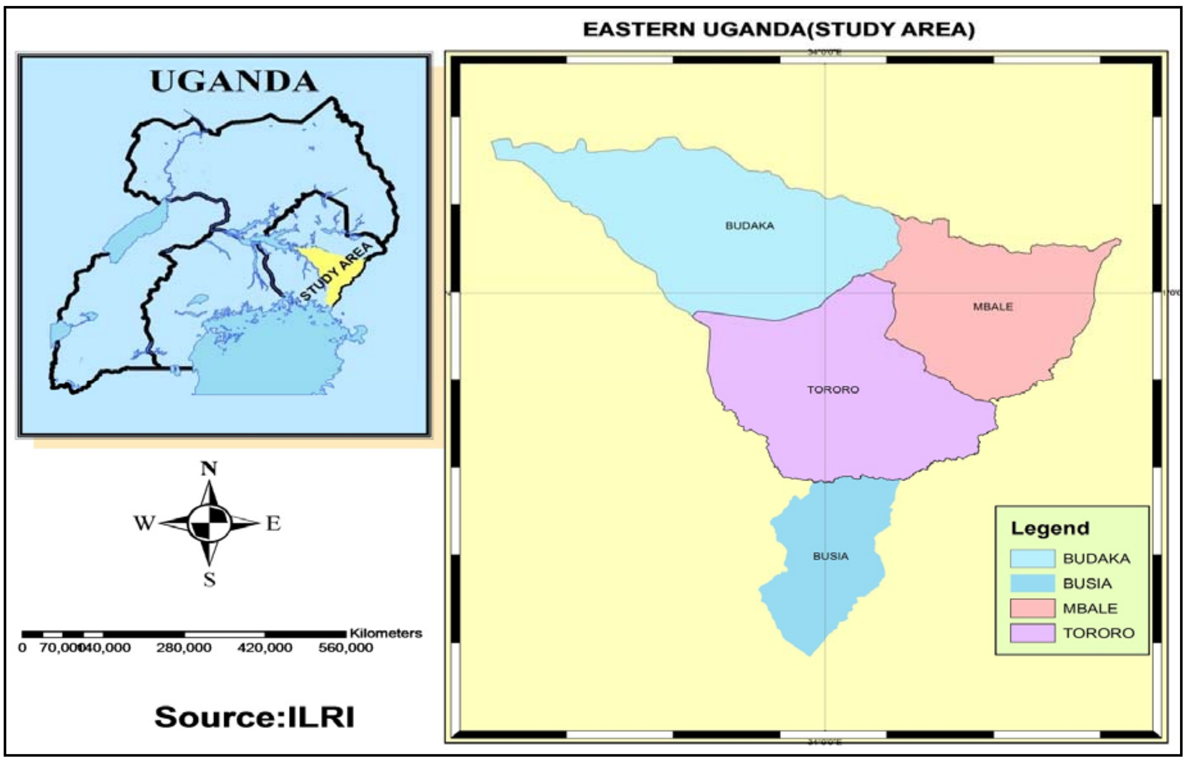

Figure 3:The map of Uganda

(Adopted from ILRI, 2002)

3.2 Sampling design

The population of interest constituted smallholder producers of common bean in Eastern Uganda, while the sampling unit was the farm household. For sampling purposes a multistage sampling technique was employed involving purposive sampling of four districts in Eastern Uganda; purposive sampling of one County in each district and purposive sampling of one sub-county in the selected County. Thena systematic random sampling procedure was used to select the sample in the villages using lists of participants and non-participants in the INSPIRE activities. The lists of participants and non-participants wereobtained from CIAT offices and MAAIF offices at the district respectively. The sample size was arrived at using a formula by Anderson*et al*. (2008) as follows:

$$n = \frac{z^2\, p\, q}{d^2} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (1)$$

Where n is the minimum sample size; Z is 1.96 at 95% confidence level; P is the population proportion i.e. the proportion of bean producers in the area that was found to be 80%. While d is the margin of error (acceptable error) which is assumed to be 0.05 and q is a weighting variable computed as (1-P).

$$n = \frac{1.96^2(0.8)(0.2)}{0.05^2} = 245.86 \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \ (2)$$

Accordingly, a minimum sample size was calculated as 246 households as shown above, but this was increased to a total sample size of 280 to simplify enumeration in the field and allow for incomplete data. The sample size was then proportionately disaggregated as follows for the four districts, based on the proportion of bean growers in each district: Busia *(165)*, Mbale *(54)*, Tororo *(41)*and Budaka *(19).*The sub-samples per district were then distributed proportionately into participants and non-participants in the INSPIRE activities.

3.3 Data collection

Primary data was collected for the 2010/2011 season using personally administered structured questionnaires and through observation method. The data included information on common bean farming operations such as: quantities of seeds, planting and topdressing fertilizer, pesticides, herbicides, fungicides, manure, land area and labour man-days. Corresponding information on average input prices was also collected from the respondents.

The land area under beans (hectares) was then used to standardize the rest of the inputs, so that each input was considered in terms of the quantity per hectare.

Additional data focused on household socio-economic and institutional characteristics such as the farmer's age, gender, years of schooling, farming experience, main occupation, household size, the income and asset profiles, distance to the market, extension contacts, group membership and credit.

3.4 Data analysis

For purposes of this study, descriptive statistics was used to characterize the socio-economic and institutionalcharacteristics of bean producers in the selected districts in Eastern Uganda. The descriptive statistics included the frequencies, means and standard deviations. The results were then presented in tables and charts from which inferences were drawn. Comparison of means was computed using an independent sample t-test, while comparison of variances was done using chi-square tests at 5% significance level. The descriptive statistics were run in SPSS (version 17) while the empirical models were run in STATA (version 9) computer soft-wares. To analyse the second objective assessing the factors influencingbean productivity; a stochastic frontier production function was estimated, from which the technical efficiency scores for each farm were also obtained. There-after, economic efficiency scores were predicted from the stochastic frontier cost function estimation. Farm-specific allocative efficiency scores were then computed using predicted technical and economic efficiency indices. Finally, the third objective onsocio-economic and institutional-support factors influencing technical, economic and allocative efficiency was achieved by estimating a two limit Tobit regression model.

3.5 Model specification: approaches for measuring efficiency

As a result of Farrell's (1957) work, there has been a series of studies in the analysis of efficiencies in all fields. But in the field of agriculture, the modeling and estimation of the stochastic function, originally proposed by Aigneir*et al.* (1977) and Meeusen and van den Broeck (1977), has proven to be instrumental. A critical narrative of the frontier literature dealing with farm level efficiency in developing countries conducted by Battese (1992), Coelli (1995) and Thiam*et al.,* (2001) indicated that there were wide-ranging theoretical issues that had to be dealt with in measuring efficiency in the context of frontiers and these included: selection of functional forms and the relevant approaches to use.

There are two approaches that can be used in measuring efficiency namely: the parametric and non-parametric models, which differ in two ways. First, they differ on assumptions of the distribution of the error term that represents inefficiency. Second, they differ in the way the functional form is imposed on the data. Parametric methods use econometric approaches to impose functional and distributional forms on the error term whereas the non-parametric methods do not (Hyuha*et al.* 2007).

Nevertheless, parametric models suffer from the same criticism as the frontier deterministic models, in the sense that they do not take into account the possible influence of measurement errors and other noises in the data as do stochastic frontier models (Thiam*et al.*, 2001). The results can also be misleading because they do not allow for random error as is the case with stochastic parametric approaches. Besides, non-parametric methods also lack statistical tests that would tell us about the confidence of the results. For this reason, this study adopts the stochastic frontier model to measure and explain inefficiencies in bean farms.

3.5.1 Stochastic Frontier Model

Afriat (1972) was the first to propose the formulation and application of a deterministic production frontier model (Taylor and Shonkwiler, 1986). The basic structure of the model is as shown below:

$$Y = f(x, \beta)e^{-\mu} \qquad (3)$$

Where f (x, ß) denotes the frontier production function and μ is a one-sided non-negative distribution term. This model imposes a constraint of $\mu \geq 0$, which implies output is less than or equal to the potential, within the given input and output prices. According to Taylor and Shonkwiler (1986), the model is in full agreement with production theory, but the main criticism against it is that all the observed variations are accounted for by the management practices as pointed out earlier. No account is taken of statistical noise such as random errors, omitted variables and shocks.

On the other hand, the history of stochastic models began withAigneir and Chu (1968) who suggested a composite error term and since their work much effort has been exerted to finding an appropriate model to measure efficiency. This resulted in the development of a stochastic frontier model. The model improved the deterministic model by introducing ‘v’ into the deterministic model to form a composite error term model (stochastic frontier).

The error term in the stochastic frontier model is assumed to have two additive components namely: a symmetric component which represents the effect of statistical noise (e.g. weather, topography, distribution of supplies, measurement error, etc.). The other error component captures systematic influences that are unexplained by the production function and are attributed to the effect of technical inefficiency (Tijani, 2006). The model is as specified below:

$$Y = f(x, \beta)e^{(\mathrm{V}-\mu)} \qquad (4)$$

Where f (x, ß) is as defined in (1) and ν-μ is error term. The V_i'sare random variables which are assumed to be iid[3] N(0,δV2) and independent of the U_i'swhich are non-negative random variables assumed to account for technical inefficiency in production and are often assumed to be iid (N (0, δu2).From equation 4 it is possible to derive the technically efficient input quantities (X_{it}) for a given level of output Y*. Assuming that equation 4 is a self-dual production frontier such as the Cobb-Douglas function, then the dual cost frontier can be expressed as:

$$C_i = g(P_i; \alpha)e^{(V+\mu)} \qquad (5)$$

Where C_i is the minimum cost incurred by the i-th farm to produce output Y; g is a suitable function (C-D); P_i represents a vector of input prices employed by the i-th farm in bean production; α is the parameter to be estimated; $V_i's$ and U_i's are as specified above.We then apply Shepherd's Lemma in partially differentiating the cost frontier with respect to each input price to obtain the system of minimum cost input demand equations as below:

$$\frac{\partial C}{\partial P_i} = X_{di} = f(P_i Y_i; \varphi) \qquad (6)$$

In equation 6,φ is a vector of parameters to be estimated. We can then obtain the economically efficient input quantities (X_{ie}) from input demand equations, by substituting the farms' input prices P and output quantity Y* into equation 6.Further, it is now possible to calculate the cost of the actual or observed input bundle as $\sum_i X_i * P_i$ while the costs of technically and economically efficient input combinations associated with the farms' observed output are given by $\sum_i X_{it} * P_i$ and $\sum_i X_{ie} * P_i$ respectively. Hence we calculate technical and economic efficiency estimates based on these cost measures as follows:

[3]iid-Independent and Identically distributed random errors

$$TE_i = \sum_i X_{it} * P_i \Big/ \sum_i X_i * P_i = \frac{cost\ of\ TE\ input\ bundle}{cost\ of\ observed\ input\ bundle} \quad \text{.................................} \quad (7)$$

And

$$EE_i = \sum_i X_{ie} * P_i \Big/ \sum_i X_i * P_i = \frac{cost\ of\ EE\ input\ bundle}{cost\ of\ observed\ input\ bundle} \quad \text{.................................} \quad (8)$$

Finally, following Farrell (1957) methodology for measuring TE, EE, and AE, it is assumed that EE is a product of TE and AE. Therefore AE can be derived from equations 7 and 8 above as the quotient of EE and TE.

$$AE_i = \sum_i X_{ie} * P_i \Big/ \sum_i X_{it} * P_i = \frac{cost\ of\ EE\ input\ bundle}{cost\ of\ TE\ input\ bundle} \quad \text{.......................................} \quad (9)$$

It is further assumed that the average level of TE or EE efficiency, measured by the mode of the non-negative half-normal, truncated, or exponential distribution (i.e. U_i) is a function of exogenous factors believed to affect inefficiency as shown below:

$$U_i = \delta_0 + \delta_i Z_i \quad \text{...} \quad (10)$$

Where: Z_i is a column vector of hypothesized efficiency determinants and δ_o and δ_i are unknown parameters to be estimated.It is clear that if U_i does not exist in equation (4) orU_i= $\delta_o^2 = 0$, the stochastic frontier production function reduces to a traditional production function. In that case, the observed units are equally efficient and residual output is solely explained by unsystematic influences. The distributional parameters, U_i and δu^2 are hence inefficiency indicators, the former indicating the average level of technical (or cost) inefficiency and the latter being the dispersion of the inefficiency level across observational units (Tijani, 2006).

Thus given functional and distributional assumptions, the values of unknown coefficients in equations 4, 5, 6 and 10 (i.e. βs, αs, δs, δu^2 and δv^2) are obtained jointly using the maximum likelihood method (ML). The estimated values of technical, economic or allocative efficiency for each observation are then calculated. While the unobservable values of V_{it} are obtained from its conditional expectation given the observable value of (V_i – U_i) in equation 4 as suggested by Yao and Liu (1998)and Tijani (2006). It is however important to mention that in this study, the factors influencing efficiency were determined using the Tobit model as explained later, other than incorporating them in the stochastic frontier model as shown in equation 10.

3.5.2 Empirical stochastic frontier model

The functional form of the stochastic frontier production (or cost) model employed forthis study is the Cobb-Douglas (C-D) functional form. This is because it is self-dual and therefore it allows for the estimation of both the production and cost functions. However, it is of essence to point out that the C-D is usually fitted and highly restrictive with respect to returns to scale and elasticities than the transcendental logarithmic form employed in many studies (Tijani, 2006;Bagamba*et al.,*2007). In any case, the impact of functional form on estimated efficiency has been reported to be very limited (Kopp and Smith, 1980). Thus the frontier production function isreduced to give:

$$InY_i = \beta_0 + \sum_{i=1}^{9} \beta_i InX_i + (V_i - U_i) \text{.. (11)}$$

In equation (11) Y_i is the bean output (90 kg bags); X_1 is the plot size (ha); X_2 is labour (man-days); X_3 is fertilizer (kgs); X_4 is chemical inputs; X_5 is seeds and X_6 is manure. $U_i$captures the level of farm-specific technical inefficiency; and V_i is the statistical disturbance term. The frontier cost function is also reduced to give:

$$InC_i = \alpha_0 + \sum_{i=1}^{9} \alpha_i InP_i + (V_i + U_i) \text{.. (12)}$$

In equation (12) $C_{i,}$ $\alpha_i V_i$ and $U_i$are as specified above; while P_i is a vector of prices of labour (wage), fertilizer, seeds, chemical inputs and manure. In this case, $U_i$captures the level of farm-specific economic inefficiency. The maximum likelihood estimates of the parameters in the stochastic frontier production & cost functions defined by equations11&12 are obtained inSTATA using the exponential form of the disturbance term.

Table 4: Variables used in the stochastic frontier production function

VARIABLE	DESCRIPTION	MEASUREMENT	EXPECTED SIGN
DEPENDENT(Y)	Total bean output for the household	90 kg bags	
PLOTSIZE	The area of land under beans	Hectares	+
SEEDS	Quantity of seeds applied per plot	Kilograms	+
FERTILIZER	Quantity of inorganic fertilizer used	Kilograms	+/-
MANURE	Quantity of animal manure used	Kilograms	+
LABOUR	Hired and family labour used in beans	Man-days	+/-
CHEMICAL INPUTS	Quantity of pesticides, fungicides and herbicides	Kilograms	+/-

Table 5: Variables used in the stochastic frontier cost function

VARIABLE	DESCRIPTION	MEASUREMENT	EXPECTED SIGN
DEPENDENT(C)	Total input cost of the i-th farm	Ush	
LABOURWAGE	Wage per man-day	Ush	+
FERTPRICE	Price per unit of chemical fertilizer	Ush	+
SEEDPRICE	Price per unit of bean seeds	Ush	+
CHEMPRICE	Price per unit of pesticides	Ush	+

3.5.3 Tobit model

The efficiency estimates obtained by the methods described above are regressed on some farm and household specific attributes by use of the Tobit model. This approach has been used widely in efficiency literature (Nyagaka*et al* 2010; Obare *et al*., 2010). The farm and household specific factors regressed here include gender, age, education, main occupation and farming experience of the farmer; as well as farm size, off-farm income, value of assets, distance to the market, group membership and credit. The choice of these variables was intuitive although they have been found to have an effect on farm efficiency among smallholder farmers. The structural equation of the Tobit model is given as:

$$y_i^* = X_i\beta + \varepsilon_i \quad \ldots\ldots (14)$$

Where y_i^* is a latent variable for the i[th] bean farm that is observed for values greater than τ and censored for values less than or equal to τ. The Tobit model can be generalized to take account of censoring both from below and from above. X is a vector of independent variables postulated to influence efficiency. The β's are parameters associated with the independent variables to be estimated. The ε is the independently distributed error term assumed to be normally distributed with a mean of zero and a constant variance. The observed y is defined by the following generic measurement equation:

$$\begin{cases} y_i = y^* \; if \; y^* > \tau \\ y_i = \tau_y \; if \; y^* \leq \tau \end{cases} \quad \text{.......} (15)$$

Typically, the Tobit model assumes that $\tau = 0$ which means that the data is censored at zero. However, farm-specific efficiency scores for the bean farms range between 0-1. Thus we substitute τ in equation 15 as follows:

$$\begin{cases} y_i = y^* \; if \; 0 < y^* < 1 \\ y_i = 0 \; if \; y^* \leq 0 \\ y_i = 1 \; if \; y^* \geq 1 \end{cases} \quad \text{.......} (16)$$

Therefore the model assumes that there is an underlying stochastic index equal to $(X_i\beta + \varepsilon_i)$ which is observed only when it is some number between 0 and 1; otherwise y_i^* qualifies as an unobserved latent (hidden) variable. The dependent variable is not normally distributed since its values range between 0 and 1. The empirical Tobit model for this study therefore takes the following form:

$$y_i^* = \beta_0 + \sum_{n=1}^{11} \beta_n X_i + \varepsilon_i \quad \text{.......} (17)$$

Where: X_1 = age (years); X_2 = farming experience (years); X_3 = education (years); X_4 = gender; X_5 = off-farm income (Ush); X_6 = distance to the input market; X_7 = Credit; X_8 = Group membership; X_9= assets; X_{10}= occupation, X_{11}= farm size and X_{12} = Extension service. It is important to mention that estimating the model using OLS would produce both inconsistent and biased estimates (Gujarati, 2004). This is because OLS underestimates the true effect of the parameters by reducing the slope (Goetz, 1995). Therefore, the maximum likelihood estimation is recommended for Tobit analysis.

Table 6: Variables used in the Tobit regression model

VARIABLE	DESCRIPTION	MEASUREMENT	EXPECTED SIGN
DEPENDENT (U)	TE, EE and AE of the i-th farm	%	
GENDER	Sex of the Household head	1=female; 0=male	-
AGE	Number of years of the bean farmer	Years since birth	-
EDUCATION	Education level of the bean farmer	Schooling years.	+/-
OCCUPATION	Farmer’s main occupation	1=farming; 0=other	-
EXPERIENCE	Experience of the bean farmer	Years	+
EXTENSION	Access to extension service	1=Yes; 0= No	+
FARMSIZE	Total size of land owned by the HH.	Hectares	+
OFFINC	Income from non-bean activities	Ush	+
ASSETS	Value of assets the HH owns	Ush	+
DISTANCE	Proximity to the nearest input market	Km	-
GRPMSHIP	Membership in farmer associations	1=Yes; 0= No	+
CREDIT	Amount of credit borrowed for farming	Ush	+

CHAPTER FOUR:RESULTS AND DISCUSSION

4.0 Overview

This chapter is divided into two major sections. The first section discusses the descriptive results comprising of household, socioeconomic and institutional characteristics. In the second section of the chapter empirical results of the stochastic frontier and Tobit models are discussed. Specifically, the farm-specific technical, economic and allocative efficiency scores of sampled bean farmsand the factors influencing efficiency in production are discussed in the section. In the discussions, comparisons are made between participants and non-participantsin the INSPIREactivities.

4.1 Descriptive results

4.1.1 Household characteristics

The selected sample consisted of 56.5% participants and 43.5% non-participants in the INSPIRE project activities. As tabulated in Table 7 below, the results show that over 69% of sampled households were male headed with female headed households comprising 31%. In addition, 92% of the sampled household heads were fulltime farmers; salaried employees comprised only 4% and business persons comprised 4.3% of the sample.

It was also found that the mean age of all the sampled farmers was 43 years, with the mean age for participant and non-participant farmers being 45 and 41 years respectively. It is thus evident that participant farmers had a higher prime age than non-participant farmers. Similarly,t-tests were significant at 5% level, which revealed that participant farmers had a significantly higher mean age than non-participant farmers. The results further showed that majority of the sampled farmers acquired only 8 years of formal education. This shows that the majority of sampled farmers had attained at least primary level of education. Participant farmers also had a higher mean schooling of 8 years compared to non-participant farmers who had a mean of 7 years. The statistical t-test was also significant at 10% level, implying that indeed participant farmers were more educated than the non-participant farmers.

It was also found that among all the farmers sampled in the study, the majority had done farming for at least 20 years. The mean farming experience for the participant farmers was also 20 years while the mean for non-participant farmers was 19 years.

Table 7: Characteristics of sampled households

		Count	%
Sex of Head	Male	192	69.1
	Female	86	30.9
Occupation	Farming	255	91.7
	Employed	11	4.0
	Business	12	4.3
Total Sample =278			

		Aggregate	Participants	Non-participants	t-ratio	Sig
Age	Mean	43.28	44.73	41.31	2.240**	0.024
	Std. deviation	12.47	12.45	12.33		
Schooling	Mean	7.69	8.08	7.21	2.009*	0.052
	Std. deviation	3.47	3.47	3.43		
Experience	Mean	19.58	20.34	18.54	1.206	0.228
	Std. deviation	12.01	12.24	11.71		
Participants = 157; Non-participants = 121						

***, ** is significant at 10% and 5% level respectively**

4.1.2 Household income and assetsprofile

The household income and assets information for the sampled respondents is presented in Table 8. The results indicate that the mean off-farm income for all the sampled households in the study area was Ush 113,227.70 (USD 44.43)[4]. It is also shown that farmers who participated in INSPIRE had a higher off-farm income of Ush 139,040.13 (USD 58.24) compared to Ush 79,735.54 (USD 33.40) obtained by their non-participant counterparts. The t-test also confirmed this and was strongly significant at 1% level. For this study, off-farm income comprised of average annual income from employment, business, as well as transfer earnings from relatives, borrowings, gifts, rent from land or buildings and motorcycles. This finding presents evidence that off-farm income was vital in influencing participation in the intervention, and is consistent with Mathenge and Tschirley (2008). The authors argued that off-farm earning is useful in spreading the risk associated with using modern farm technologies. In the sense that, it provides ready cash which smooth household consumption

[4]Exchange rate: 1USD ≡ 2,387.36 (Bank of Uganda, may 2011)

and helps farmers to use modern farming inputs and technologies, hence improving farm productivity.

The second source of farmers' income was from bean sales. The mean bean income per annum among all households was Ush 184,067.15 (USD 77.10). Thus the households in the study area depend more on bean income sources than off-farm sources of income for their livelihoods. In addition, the mean bean earning for participant farmers was Ush 181,583.48 (USD 76.06); which is lower than Ush 187,289.76(USD 78.45) for their non-participant counterparts. However, t-tests revealed that the mean difference was not significant indicating that the mean for bean earning among non-participants was not significantly greater than that obtained by the participants.

Considering the total household earnings, the mean for all the sampled households was Ush 438,905.97 (USD 183.85). These figures have significant implications on the livelihoods of smallholder farmers in Eastern Uganda. It implies that the mean amount earned by each household is about USD 183.85 per annum which still holds them below poverty line. In fact according to the Uganda bureau of statistics' poverty estimates, the region's poverty level was close to 36% between 2005 and 2006. The eastern region also ranked second after the Northern region, in terms of contribution to the national poverty levels. Thus the current findings show that this situation has not improved.

Further findings show that the mean value of assets endowment among all the respondents sampled was Ush 306,681.65 (USD 128.46). These figures indicate that the sampled households are not well endowed with adequate assets necessary to guarantee higher liquidity. The results also show that farmers in the intervention had higher asset endowment, with a mean of Ush 356,730.57 (USD 149.42) compared to the non-participants whose mean asset-worth was Ush 241,742.15 (USD 101.26). The t-test for mean difference was significant at 1% level; hence the mean value of assets owned by participant farmers is significantly greater than the mean for non-participant farmers.In this study, the total value of household assets was computed as a sum of the values of specific assets identified to have a direct use in production, or an indirect effect through improving the awareness of the farmer. These included farm equipment, bicycles, motorcycles, cars, radios, televisions, phones and computers.

Table 8: Household income and asset profile

		Aggregate	Participants	Non-participants	t	Sig.
Off- farm	Mean(Ush)	113,227.70	139,040.13	79,735.54		
Income	Std deviation	102,728.00	116,554.00	68,534.57	5.297	0.000***
Bean	Mean(Ush)	184,067.15	181,583.48	187,289.76		
Income	Std deviation	153,421.00	168,153.00	132,504.00	-0.316	0.752
Total HH	Mean(Ush)	438,905.97	525,241.66	326,883.64		
Income	Std deviation	419.495.00	475,169.00	300,474.00	4.244	0.000***
Value of	Mean(Ush)	306,681.65	356,730.57	241,742.15		
HH assets	Std deviation	292,342.00	325,892.00	227,338.00	3.461	0.001***

***** is significant at 1% level**

4.1.3 Household institutional characteristics

The results in Table 9 present findings on distance to the market, price and credit. The mean distance to the nearest input market was 4.11kmfor participants and 3.48 km for non-participants. The t-test was also significant at 10% level indicating that the mean distance to the input market for participant farmers was significantly greater than that for non-participants. It thus implies that participant farmers were more disadvantaged than the non-participants in terms of access to farm inputs. The longer the distance from a household to the nearest input market determines the transportation costs incurred in purchasing the inputs. This in turn reduces the net returns from farm produce, and deters the farmer from purchasing more inputs (Bagamba*et al.*,2007).

Another important factor considered is the selling price per kilogram of beans. The results showed that the mean price for beans sold by participant farmers was Ush 2,259.89 (USD 0.95); whereas the non-participants got a mean price of Ush 4,416.73 (USD 1.85) for every kg sold. The t-test for difference in mean prices was significant at 1% level implying that participant farmers obtained a significantly lower price for their bean produce than their non-participant counterparts. This is explained by the fact that longer distance covered by participant farmers to transport their produce to the market increased the transaction costs and forced them to opt to sell to middlemen (locally called brokers) at the farm-gate. As such they obtained relatively lower prices for their bean produce compared to the non-participant farmers who are located closer to the output markets.

Table 9: Household institutional characteristics

		Aggregate	Participants	Non-participants	t	Sig.
Distance to	Mean(Ush)	3.84	4.11	3.48		
market(Km)	Std deviation	3.10	3.26	2.87	1.725	0.086*
Price	Mean(Ush)	3,198.65	2,259.89	4,416.73		
(Ush/Kg)	Std deviation	2,663.61	1190.02	3,447.77	-6.586	0.000***
Credit (Ush)	Mean(Ush)	81,669.69	100,022.64	57,856.36		
	Std deviation	40,874.22	43,405.59	19,869.36	10.793	0.000***
Interest rate	Mean(Ush)	10.55	10.38	10.76		
(%)	Std deviation	2.77	2.57	3.00	-1.121	0.263

***, *** is significant at 10% and 1% level respectively**

In addition, farmers obtained credit mainly from relatives, friends or SACCOs and themean total borrowing among sampled farmers was Ush 81,669.69 (USD 34.21). This amount is quite low to finance farming activities successfully. Farmers attributed this low amount of credit to the 'unaffordable' interest charged (10.55%). As such they only borrowed loans when high investment or expenditure is involved, for instance to educate children or for cultivation. Among participant farmers, mean total borrowing was Ush 100,022.64 (USD 41.90) whereas the non-participants had a mean of Ush 57,856.36 (USD 24.23). The t-test for mean difference was also strongly significant at 1% level. This shows that participant farmers accessed more credit facilities than non-participants in the study area. It therefore concurs with Hyuha*et al*. (2007) who observed that small-scale producers who experienced difficulty in obtaining credit,found difficulties investing in improved farming technologies and equipment, which hindered successful technological development and adoption among them.

Table 10: Group membership, collective bean marketing and extension service

	Overall		Participants		Non-participants		Chi	Sig.
Group membership								
	Count	(%)	Count	(%)	Count	(%)		
Yes	220	79.1	149	94.9	70	58.3		
No	58	20.9	8	5.1	50	41.7	54.32	0.000***
Organized to sell beans collectively								
Yes	61	21.9	54	34.4	7	5.8		
No	217	78.1	103	65.6	114	94.2	32.66	0.000***
Accessed extension service								
Yes	101	36.3	72	45.9	29	24.0		
No	177	63.7	85	54.1	92	76.0	14.16	0.000***
Totals	278	100	157	100	121	100		

***** is significant at 1% level**

Majority of sampled bean farmers in Eastern Uganda are members of a farmer groupas is shown in Table 10 above. This is because over 79% of all the respondent households had a member in a farmer group(s). Almost all the participants (95%) were group members compared to 58% among non-participants. In fact, the chi-square test was strongly significant at 1% level, indicating that there were significantly more group participants among farmers in INSPIRE than those who were not in the intervention.

Contrary to the high rate of membership in farmer associations, only 22% of all the sampled farmers sold their bean produce in their groups. In addition, more participant farmers (34%) sold their beans collectively compared to non-participant farmers (6%). The chi-square test was also strongly significant at 1% level, implying that the proportion of participant farmers who sold beans in groups was significantly greater than that for non-participant farmers. This small proportion for joint bean sales may be explained by the fact that group marketing had been in operation for only one year and therefore it had not picked up strongly.

In terms of extension service, the findings revealed that only 36.3% of the farmers were able to access extension service. However, more participants accessed extension service (45.9%) compared to non-participants (24%). Chi-square tests also revealed that there was a significant difference at 1% level, with respect to the proportion of farmers who accessed extension service among the two farmer categories.

4.1.4Bean production characteristics

Bean production in Eastern Uganda is very low according to the findings in Table 11. The table indicates that the average bean yield per hectare among all the farmers was 0.47mtha^{-1} which is low compared to the country's productivity of between 0.6-0.8mt ha^{-1}, but is much lower than the potential productivity level in Uganda of between 1.5-1.8mt ha^{-1}. In terms of districts, Mbale had the highest mean productivity of 0.53mt ha^{-1}, followed by Busia with a mean of 0.45mt ha^{-1}, Tororo with a mean of 0.44mt ha^{-1} while Budaka had the least average productivity (0.37mt ha^{-1}). This is supported by the fact that Mbale district is located within a more productive agro-ecological zone unlike the other three districts.

Moreover, participants in the INSPIRE intervention showed higher levels of bean productivity with a mean of 0.51mt ha^{-1}, compared to non-participant farmers who showed a mean productivity of 0.36mt ha^{-1}. This shows that on average participant farmers had higher yields than non-participant farmers. In addition, the t-test result to compare the means for the two farmer categories was statistically significant at 1% level, an indication that participant farmers were significantly better bean producers than non-participants.

Table 11: Bean productivity information

Variables		Overall	Participants	Non-participants	t	Sig.
Total sample	Mean	0.47	0.52	0.40		
	S. deviation	0.32	0.35	0.27	3.434	0.001***
Busia district	Mean	0.45	0.51	0.36		
	S. deviation	0.31	0.34	0.24	3.349	0.001***
Mbale district	Mean	0.53	0.54	0.52		
	S. deviation	0.39	0.45	0.34	0.197	0.844
Budaka district	Mean	0.37	0.41	0.31		
	S. deviation	0.35	0.39	0.30	0.596	0.559
Tororo district	Mean	0.44	0.55	0.33		
	S. deviation	0.30	0.29	0.26	2.541	0.015**

****, ***is significant at 5% and 1% level respectively**

In terms of total farm size the findings in Table 12 indicate that participant farmers had a mean of 1.88 ha with a standard deviation of 1.80; while non-participant farmers had a mean of 1.45 ha with a standard deviation of 1.34. This implies that participant farmers had larger farm sizes than non-participant farmers. Similarly, t-test results showed a strongly significant difference at 5% level, meaning that there was a significantly larger mean, in terms of farm size, for participant farmers compared to non-participant farmers.

Table 12: Summary of continuous production characteristics

Variables		**Overall**	**Participants**	**Non-participants**	**t**	**Sig.**
Farm size	Mean	1.69	1.88	1.45		
(Hectares)	S. deviation	1.63	1.80	1.34	2.281	0.023**
Area planted	Mean	0.36	0.37	0.36		
(Hectares)	S. deviation	0.28	0.29	0.26	0.173	0.863
Seeds used	Mean	34.08	34.82	33.13		
($kgha^{-1}$)	S. deviation	21.91	22.55	21.10	0.640	0.523
Plant' fertilizer	Mean	89.10	90.50	87.28		
($kgha^{-1}$)	S. deviation	23.70	24.93	21.99	1.142	0.254
Topdressing	Mean	91.84	88.82	95.76		
($kgha^{-1}$)	S. deviation	15.31	15.51	14.18	-3.885	0.000***
Herbicides	Mean	27.91	4.80	57.88		
($kgha^{-1}$)	S. deviation	27.91	2.18	13.69	-42.249	0.000***
Fungicides	Mean	14.28	22.84	3.18		
($kgha^{-1}$)	S. deviation	12.28	9.91	0.71	24.770	0.000***
Pesticides	Mean	5.89	7.40	3.92		
(Litres ha^{-1})	S. deviation	3.78	4.29	1.47	9.484	0.000***
Manure	Mean	295.22	356.62	215.54		
($kgha^{-1}$)	S. deviation	194.78	226.50	97.70	7.005	0.000***
Certified seed	Mean	31.39	27.24	36.77		
($kgha^{-1}$)	S. deviation	14.91	12.27	16.29	-5.367	0.000***

****, ***is significant at 5% and 1% level respectively**

Moreover, the findings also showed that on average participant farmers had a mean area under bean production of 0.37ha, while non-participant farmers had a mean of 0.36 ha. As such, it is evident that participant farmers allocated slightly more land to bean farming than their non-participant counterparts. However, the t-test resultsrevealed that the mean difference was insignificant, implying that the mean land area under bean farming for participant farmers was not significantly larger than the mean for non-participant farmers.Therefore, despite having larger farm sizes, participant farmers allocated almost similar areas of land to bean farming as their non-participant counterparts. Which explains why participant farms have higher bean productivity per ha compared to non-participant farms.

The mean quantity of seeds used by participant farmers was 34.82 kg per ha compared to non-participant farmers who used an average of 33.13 kg per ha; thus participant farmers used slightly more seeds than the non-participant farmers. The t-test resultformean difference was however not statistically significant, implying that participant farmers did not use a significantly higher amount of planting fertilizer than non-participant farmers.Similarly, participant farmers were better in the use of planting fertilizer, with the mean amount being 90.50 kg per ha; while non-participant farmers had a mean of 87.28 kg per ha. Thet-test resultfor difference in the mean quantity of planting fertilizer used was also not statistically significant.

On the other hand, non-participant farmers applied an average of95.76 kg per ha for topdressing fertilizer compared to participant farmers who applied 88.82 kg per ha. Consequently, non-participant farmers applied more topdressing fertilizer than their participant counterparts. In fact, the t-test resultsshowed a strongly significant difference at 1% level, indicating that the mean amount of topdressing fertilizer applied by non-participant farmers was significantly greater than that for participant farmers.

The other observable difference was in the use of herbicides. The findings indicate that participant farmers had a mean of 4.80 kg per ha, whereas non-participant farmers had a mean of 57.88 kg per ha. This implies that participant farmers applied relatively less herbicides than their non-participant counterparts. Similarly, the t-test resultsin this case also showed a strong significance at 1% level, indicating that the mean amount of herbicides used by non-participant farmers was significantly greater than the mean for participant farmers. This could be attributed to the fact that there was higher adoption of safe agricultural technologies among participants in the INSPIRE intervention (as will be seen later), through which they were able to control weeds without using chemicals.

The findings further reveal that participant farmers applied more fungicides with a mean quantity of22.84kg per ha while non-participant farmers had a mean of 3.18kg per ha. Given that participant farmers had better yields, these results imply that non-participant farmers may not have been well informed on the appropriate amounts of fungicides to apply.

The subsequent t-test resultsalso turned out to be strongly significant at 1% level, indicating that indeed the mean amount of fungicides used by participant farmers was significantly greater than that for non-participant farmers.

Furthermore, findings on the quantity of pesticides used indicate that the mean for the participant farmers was 7.40 litres per ha, compared to non-participant farmerswith a mean of3.92 litres per ha. The t-test results also showed a strong significance at 1% level, which depicts that the participant farmers used significantly more pesticides than their non-participant counterparts. And lack of adequate knowledge on pesticides especially among non-participant farmersmay have been responsible for the difference, given the fact that very few of them accessed extension service.

The use of animal manure in crop farming has been highly advocated by environmental activists as a way to improve soil fertility without producing negative externalities to the environment. The results in Table 11 thus show that participant farmers used more quantities of animal manure, with a mean of356.62 kg per ha compared to non-participant farmers whose mean for animal manure was 215.54 kg per ha. The t-test resultsrevealed a strong significance at 1% level, indicating that the mean amount of animal manure used by participant farmers was significantly greater than the mean for non-participant farmers.

The same was found for the quantity of certified seed used, where by non-participant farmers showed a higher mean of 36.77 kg per ha compared to 27.24 kg per ha reported for the participant farmers. The t-test resultsalso revealed that the difference was strongly significant at 1% level. This may imply that non-participant farmers applied more certified seed because they had better access to the input market, but they failed to accompany the certified seeds with enough fertilizer and correct crop husbandry, to warrant better productivity.

4.1.5 Use of agricultural technologies and soil enhancing inputs

Farm productivity is positively affected by the use of organic inputs and investments in soil conservation practices as observed by Reardon *et al.* (1997). Therefore, Table 13 provides information about the use of several agricultural technologies and soil enhancing inputs in the study area. As observed by Kijima (2008) most farmers in the study area did not apply planting fertilizers. The findings indicate that only 18% of the farmers used planting fertilizers on their bean farms; likewise for 22.9% of participant farmers and 11.7% of non-participant farmers. These results imply that more participant farmers applied planting fertilizer than non-participants. The chi-square test also showed a strong significance at 5% level, revealing that the proportion of participant farmers who applied planting fertilizer on their bean farms was significantly larger compared to non-participant farmers.

The situation was even worse for topdressing fertilizers since, only 3.2% of all farmers; 3.8% of participant farmers and 2.5% of non-participant farmers used topdressing fertilizers on their farms. This shows that a negligible proportion of the farmers applied top-dressing fertilizers on their bean farms. Chi-square results further indicated that the proportion of farmers who applied topdressing fertilizers among the two farmer categories was not significant. The negligible proportion could however be justified by the fact that majority of the farmers applied animal manure instead; or used the other agricultural technologies mentioned above, due to the difficulty in affording chemical fertilizer. It however implies that there are minimal environmental externalities arising from agriculture in the study area.

In addition, the findings reveal that animal manure was used by 68.3% of all farmers; 77.7% of participant farmers and 56.6% of non-participant farmers. Animal manure is a viable replacement for chemical fertilizers considering their high cost. Such organic inputs are also being advocated as a way to improve productivity without depleting the environment. It is therefore promising to find that more than half of the farmers used animal manure on their farms. Furthermore, a larger proportion of participant farmers used animal manure compared to non-participants. In fact, Chi-square results also showed a significant difference at 10% level.

The findings also reveal that 54.3% of all the farmers applied weed control; likewise for 55.4% of participant farmers and 52.9% of non-participant farmers. This implies that more than half of the farmers adopted organic weed control techniques that help reduce the need for herbicides. The other implication is that participant farmers adopted weed control technology more than non-participant farmers. In fact, chi-square results revealed that the difference was strongly significant at 5% level; depicting that a significantly larger proportion of participant farmers practiced weed control compared to non-participant farmers.

Furthermore, the findings show that out of all the farmers, 65.9% had used mulching; likewise for 71.3% of participant farmers and 58.3% of non-participant farmers. As such, relatively more participant farmers had adopted and used mulching in their bean farms than the non-participant farmers; although chi-square results showed that the difference in the mulching adoption levels was not statistically significant.

Terracing was only used by 39.2% of all the farmers; 40.8% of participant farmers and 37.5% of non-participant farmers. This implies that participant farmers again adopted terracing more than non-participant farmers; although chi-square results revealed that the difference in adoption of terracing among both groups of farmers was not statistically significant. In addition, it was found that 46.8% of all farmers; 52.2% of participant farmers and 39.2% of the non-participant farmers had invested in water harvesting. This indicates that participant farmers adopted water harvesting more than the non-participant farmers; although chi- square results showed that the difference in adoption levels between the two categories of farmers was not statistically significant. Nevertheless, it is promising to find that almost half of the sampled farmers had a water harvesting technology on the farm, which helps in mitigating unreliability of rainfall as a result of climate change.

Cover cropping is a safe agricultural practice that is useful in controlling soil erosion and weeds in an environmentally friendly manner. Among all the respondents sampled, 45.7% adopted and planted cover crops; likewise for 49.7% of participant farmers and 40% of non-participant farmers. This implies that almost half of the sampled farmers had used cover crops to solve the soil erosion problem, as a way to improve their bean yields. However, the chi-square results show that there was an insignificant difference in the adoption rates of the technology between participant and non-participant farmers.

Another important agricultural technology used was conservation farming. This technology entails three principles namely: no-tillage, protection of the top soil cover and crop rotation. FAO (2007) documents that it is a form of resource-saving agricultural technique that strives to achieve acceptable profits together with high and sustained production levels while concurrently conserving the environment. The findings show that 37.8% of all the farmers, 43.3% of participant farmers and 30.8% of non-participants practiced this technology on their farms.Thus, few farmers especially non-participants were aware of the advantages of the technology, hence are less willing to take it up in their farming. The proportions of adopters among the two farmer categories were not significantly different as depicted bychi-square results.

The findings also emphasised the earlier prediction that in most cases, bean is usually intercropped. As shown in the findings, 90.3% of all the farmers, 92.4% of participant farmers and 87.5% of non-participant farmers grew beans in intercrops. Which implies that farmers prefer to intercrop beans; rather than have it in single stands.

Table 13: Use of Agricultural technologies and soil enhancing inputs

Technology	Use	Overall		Participants		Non-participants		Chi	Sig
		Count (n=278)	(%)	Count (n=157)	(%)	Count (n=121)	(%)		
Plant' fertilizer	Yes	50	18.0	36	22.9	14	11.7	6.175	0.013**
Top dressing	Yes	9	3.2	6	3.8	3	2.5	0.407	0.524
Animal manure	Yes	190	68.3	122	77.7	68	56.6	3.061	0.080*
Weed control	Yes	151	54.3	87	55.4	64	52.9	6.834	0.009**
Mulching	Yes	183	65.9	112	71.3	70	58.3	0.370	0.543
Terracing	Yes	109	39.2	64	40.8	45	37.5	0.003	0.959
Water harvesting	Yes	130	46.8	82	52.2	47	39.2	0.040	0.842
Cover Cropping	Yes	127	45.7	78	49.7	48	40	0.345	0.557
Conservation Farming	Yes	105	37.8	68	43.3	37	30.8	0.064	0.800
Inter Cropping	Yes	251	90.3	145	92.4	105	87.5	0.192	0.662

***,** is significant at 10% and 5% level respectively**

4.1.6 Bean varieties grown in Eastern Uganda

The farmers in Eastern Uganda grow a wide range of bean varieties. Table 14 shows that there are eleven different bean varieties identified among sampled farmers. Among these varieties the bush types were the majority because the study area covered mainly low-lands. However, the 'Nambale' variety was the only semi-climbing variety. The most recently released varieties among the ones identified included 'K131', 'K132' and 'Nabe 4', while the others were traditional (local) varieties. Mean yield per ha for each variety was computed to determine which variety was the most productive among the farmers. According to the findings most of the farmers making about 39.9% grew the 'Kanyebwa' variety which yielded close to 0.44Mt Ha^{-1}. This variety was prevalent in all the four districts focused in the study. The second most commonly grown variety was the 'K20' variety, which was developed and released in the 1960s by the national research programme and was found among 24.5% of the bean farmers. This variety also gave an average yield of 0.44Mt Ha^{-1} and was prevalent in all the four districts as well.

Table 14: Bean varieties

Variety		Count	(%)	Mean yield (mtha^{-1})	Std deviation	District
Kanyebwa	Local	111	39.9	0.44	0.29	1,2,3,4
K20	Local	68	24.5	0.44	0.30	1,2,3,4
K132	Improved	32	11.5	0.50	0.31	1,2,3,4
Mutike	Local	27	9.7	0.45	0.28	1,2
K131	Improved	11	4.0	0.46	0.36	1,2,3,4
Pider	Local	10	3.6	0.54	0.41	2
Kakira	Local	6	2.2	0.89	0.67	2
Wakaka	Local	3	1.1	0.07	0.07	1,2,4
Nabe 4	Improved	4	1.4	1.24	1.05	1
Tanzania	Local	2	0.7	0.39	0.21	2,4
Nambale	Local	1	0.4	0.02	0.00	4
Total		278	100.0			

District codes: 1=Busia, 2=Mbale, 3=Budaka and 4=Tororo

The third most common variety was the ‘K132’ variety found among 11.5% of the sampled farmers and it was prevalent in all the four districts. This variety is one of the recent varieties released by NARO. The mean yield obtained by farmers cultivating this variety was 0.50MtHa^{-1} which was relatively higher than the first two varieties. In addition, the ‘Mutike’ variety was prevalent in Busia and Mbale districts among 9.7% of the sampled bean farmers and gave a mean productivity of 0.45Mt Ha^{-1}. The other commonly grown varieties included ‘K131’ with a yield of 0.46Mt Ha^{-1}, ‘Pider’ with a mean yield of 0.57Mt Ha^{-1} among others.

However, the highest mean yields of 1.24Mt Ha^{-1} were achieved by bean farmers who cultivated the ‘Nabe 4’ variety.This variety was only identified in Busia.The ‘Kakira’ variety was also very productive despite being a traditional variety, with mean yields of 0.89Mt Ha^{-1} and was only found in Mbale. While it is obvious that these varieties have high productivity, they were not common among the farmers. Further probing of sampled respondents revealed that the seeds were not easily available in time, while others argued that they were not affordable.

4.2 Empirical results

4.2.1 Determinants of common bean productivity

To identify the factors affecting bean productivity, a stochastic frontier production function was estimated and the results are presented in Table 15. Four variables (plot size, seeds,planting fertilizer and certified seed) were found to significantly affect bean productivity. The log likelihood for the fitted model was -448.17 and the chi-square was 95.96 and it was strongly significant at 1% level. Thus the overall model was significant and the explanatory variables used in the model were collectively able to explain the variations in bean productivity. The model results further show that the variance of the technical inefficiency parameter γ is 0.638 [$\gamma = \sigma u^2/\sigma^2$,see Greene, (2011)] and is significantly different from zero. This implies that 63.8% of the variations in bean output were due to technical inefficiency.

The following elasticities were generated from the stochastic production frontier estimation: seeds (0.385), plot size (0.353), herbicides (0.122), certified seeds (0.116), planting fertilizer (0.110), labour (0.091), manure (0.034), pesticides (-0.004), topdressing fertilizer (-0.024) and fungicides (-0.082). Hence, the resulting returns to scale parameter obtained by summing these input elasticities is 1.101. This indicates that bean production in Eastern Uganda exhibits constant returns to scale, implying that farmers in the study area use traditional bean production techniques which have become redundant over time; although if they embraced the technological improvements they can improve their productivity. Seed had the largest elasticity, followed closely by plot size. This suggests that any interventions to increase productivity of seedand plot size would create significant achievements in bean productivity in Eastern Uganda.

The results showed a positive coefficient for seeds as was hypothesised. Seeds hada strongly significant effect on bean productivity at 1% level. The results showed that a 1% increase in the quantity of seeds used significantly increased bean yields by 38.5%. This suggests that planting more seeds improved bean productivity significantly, which is attributed to the fact that the increased number of seeds per hole helped reduce the risk of plants failing to sprout and translated into higher production from a unit piece of land. Given that seed had the largest elasticity; it might also imply that seed was the major limiting factor of production that constrained bean farmers from maximizing their output. The importance of seeds in determining productivity has also been emphasised by Reardon *et al.* (1997), although it is important to note that for seed to make its full contribution to bean productivity in Sub-Saharan Africa, the farmers need to use certified seeds which have an assurance of quality.However, the seed variety used is also important in determining the contribution of seeds to bean productivity. Better and improved seed varieties may be able to produce high yields even without planting many seeds per hole.

Table 15: Stochastic frontier production function results

Yield Ha^{-1}	Coefficient	Std- Error	z	P>|z|
Seeds ($kgHa^{-1}$)	0.385	0.079	4.88	0.000***
Plot size (Ha)	0.353	0.096	3.68	0.000***
Herbicides (kg Ha^{-1})	0.122	0.135	0.91	0.365
Certified seeds (kg Ha^{-1})	0.116	0.059	1.95	0.051*
Plant' Fertilizer (kg Ha^{-1})	0.110	0.059	1.87	0.062*
Labour (man-days Ha^{-1})	0.091	0.081	1.12	0.264
Manure (kg Ha^{-1})	0.034	0.033	1.03	0.304
Pesticides (Litres Ha^{-1})	-0.004	0.054	-0.08	0.938
Topdressing (kg Ha^{-1})	-0.024	0.067	-0.35	0.723
Fungicides (kg Ha^{-1})	-0.082	0.086	-0.96	0.339
Constant	4.395	0.361	12.18	0.000***
(σ_v)	0.706	0.056		
(σ_u)	1.123	0.101		
(σ^2)	1.760	0.214		
(γ)	0.638			
Likelihood-ratio test of $\sigma u = 0$;	Chibar^2 (01) = 64.95;		Prob> = Chibar^2 =0.000	
Log likelihood= -411.0759	Wald chi^2 (9) = 83.15		Prob> chi^2= 0.000	

***, **, *** is significant at 10%, 5% and 1% level respectively**

The findings also showed a positive coefficient for plot size as was postulated. Plot size has a strongly significant influence on common bean productivity at 1% level. According to the results, an increase in the plot size by 1% significantly increased the farmer's bean productivity by 35.3%. This suggests that the more farm land a farmer allocated to bean farming, the higher the yields obtained, which presents similar findings as those reported by Goni*et al.* (2007). The authors argued that most smallholder farmers usually fail to maximize bean yields due to underutilization of farm land. This might be due to limited availability of other production factors or due to farmers' risk averseness coupled with rainfall fluctuations brought about by climate change. However, Ugwumba (2010) in Nigeria observed that land was underutilized mainly due to land tenure problems associated with land fragmentation. Therefore based on the results it is implied that as the sizes of land holding continue to decline, it is increasingly going to become difficult to increase productivity through expansion in plot sizes.

Certified seed also showed a positive effect on bean productivityaccording to the findings. It was established that certified seed had a significant influence on bean yields at 10% level, since a 1% increase in the quantity of certified seed used increased bean productivity by 11.6%. This suggests that the more certified seeds a farmer was able to apply on the farm, the higher were the bean outputs. Despite this finding, it was observed that most farmers use recycled seed varieties for their home consumption and certified seed only for commercial bean production. This is mainly because improved seed varieties are quite costly, compared to recycled seeds. The behaviour may also be attributed to ineffectiveness in the seed distribution systemsand lack of timely availability of the seeds during the planting season (Reardon *et al.* 1997).

It was further found that planting fertilizer showed a positive coefficient as hypothesised, with a significant relationship withbean yields at 10% level. The results revealed that a 1% increase in the quantity of planting fertilizer applied, significantly improved bean productivity by 11%. This suggests that increasing the amount of planting fertilizer used would contribute to higher bean yields in the area by a factor of 10. The results are consistent as hypothesised and they reflect the findings presented by Tchale (2009) in Malawi where fertilizerwasa key factor inproduction of major crops grown by smallholder farmers. Reardon *et al.* (1997) also found a positive effect of fertilizer on productivity in case studies from Bukina Faso, Senegal, Rwanda and Zimbabwe. However, the findings contradict Kijima (2008) who observed that soils in Uganda were fertile enough and could produce relatively high yields even without adequate fertilizer use. As such, from the results it is evident that to achieve higher bean productivity, farmers in Eastern Uganda need to increase their usage of planting fertilizer.

The other variables were found to have an insignificant influence on bean productivity. For instance, herbicides, manure and labour had a positive influence on bean productivity as hypothesised; while topdressing fertilizer, fungicides and pesticides had a negative influence according to the findings. The negative sign for topdressing fertilizer, fungicides and pesticides may be attributed to the fact that there was limited knowledge among farmers about the right proportions of these inputs to apply; hence they may have over-applied it leading to negative effects on yields.

4.2.2 Farm-specific efficiency scores

Predicted farm-specific scores for technical, economic and allocative efficiency among sampled bean farms in Eastern Uganda are summarized in Table 15. The scores for technical and economic efficiency were predicted after estimating the stochastic frontier production and cost functions respectively; whereas the allocative efficiency scores were computed as the quotient between EE and TE (see section 3.5.1).

The mean technical efficiency score for all the sampled farms was 48.20%, with participant farms showing a higher mean (48.71) than the overall; while the mean for non-participant farmers was lower than the overall at 47.54%. However, subsequent t-test results revealed that the mean difference in technical efficiency was statistically insignificant. This suggests that the mean TE score for participant farmers was not significantly greater than the mean score for non-participant farmers.

The most technically efficient farm among participant farms had a score of 83.67% compared to the most efficient for non-participant farms with a score of 85.32%. The least technically efficient participant farm recorded a score of 0.51% while the least score for non-participant farms was 0.91%. These scores give evidence that there is a very huge gap between the two extreme farms in terms of technically efficiency among both categories of farmers. However, if an average bean farm were to achieve the level of technical efficiency shown by the most efficient farm, then they could realize an increase of 43.51% in terms of yields per hectare [(1-**(**48.20/ 85.32**)**) x 100].

It is also evident in Table 15 that 15.92% of the participant farms had TE levels less than 25%; which is a larger proportion than 14.88% among non-participant farms. The proportion of farmers in the highest class was 5.73% for participants and 5.79% for non-participants. In addition, about 55.41% of the participants and 53.72% of the non-participants had TE levels above the 50% limit. It is therefore implied that about half of the farms are in the upper two classes and can easily improve their technical efficiency level to that showed by the most efficient farm.

Table 16: Predicted technical, economic and allocative efficiency scores

	TE				EE				AE			
	Participants		**Non part'[5]**		**Participants**		**Non part'**		**Participants**		**Non part'**	
Class	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%	Freq	%
0-24	25	15.92	18	14.88	13	8.28	10	8.26	59	37.58	47	38.84
25-49	45	28.66	38	31.40	30	19.11	16	13.22	76	48.41	63	52.07
50-74	78	49.68	58	47.93	67	42.68	67	55.37	22	14.01	11	9.09
75-100	9	5.73	7	5.79	47	29.94	28	23.14	0	0	0	0
Total	157	100	121	100	157	100	121	100	157	100	121	100
Mean		48.71		47.54		59.82		60.09		29.95		28.61
Std dev		21.48		20.44		21.48		20.02		18.32		16.62
Max		83.67		85.32		89.17		91.10		73.81		65.80
Min		0.51		0.91		3.07		0.31		0.25		0.16
t-ratio				0.463				-0.109				0.636
Sig.				0.643				0.913				0.525
Overall mean				48.20				59.94				29.37

The findings further showed that the mean economic efficiency score among all the sampled farms was 59.94%, with non-participant farms having a higher mean (60.09%) than the overall; compared to participants who had a lower mean (59.82%) than the overall. However, t-tests revealed that the mean difference was not statistically significant, which indicates that the mean EE score for non-participants was not significantly greater than the mean for participants.

The maximum economic efficiency score was 89.17% and 91.10% for the participants and non-participants respectively. On the other hand, the minimum economic efficiency score was 3.07% and 0.31% for participants and non-participants respectively. Thus, the most economically efficient farm as well as the least economically efficient farm was found among the non-participants. This also shows that if an average bean farm were to attain the level of economic efficiency shown by the most efficient farm, then they would realize a saving of 34.20% [(1-**(**59.94/91.10**)**) x 100] in terms of total production costs while maximizing their bean productivity. The findings also reveal that there is a huge gap between the least economically efficient and the most economically efficient farm in the study area. But it is

[5]Non part': Non-participants

promising to find that 72.62% of participant farms and 78.51% of non-participant farms have economic efficiency scores above 50%.

Lastly, the results showed that the mean allocative efficiency score among the sampled farms in the study area was 29.37%. This score is too low compared to the means for technical and economic efficiency. The mean AE score for participant farms was higher than the overall at 29.95%, while the mean for non-participants was lower than the overall at 28.61%. However, t-tests revealed that the mean difference was not significant, which implies that the mean AE score for the participants was not significantly greater than the mean for non-participant farms.

The most allocatively efficient participant farm was 73.81% efficient, whereas for the non-participant farms it was 65.80% efficient. On the other hand, the least allocatively efficient farm among participant farms was 0.25% efficient; compared to 0.16% for the non-participant farms. Thus, if an average bean farm in Eastern Uganda were to achieve the level of allocative efficiency shown by the most efficient farm, then they would realize a cost saving of 60.21% [(1-**(**29.37/ 73.81**)**) x 100] holding resource availability constant. Unlike the case for technical and economic efficiency, it was further shown that only about 14.01% of participants and 9.09% of non-participants had allocative efficiency scores exceeding the 50% limit. This implies that production inefficiency among common bean farms in Eastern Uganda is contributed more by allocative rather than technical inefficiencies.

Table 17: Farm-specific efficiency scores in terms of districts

District	**TE**		**EE**		**AE**	
	Mean (%)	**S.D**	**Mean (%)**	**S.D**	**Mean (%)**	**S.D**
Busia	48.48	21.60	59.70	18.88	29.65	17.29
Mbale	51.84	19.44	54.78	27.36	28.87	19.71
Budaka	41.44	17.02	60.68	23.45	25.28	16.80
Tororo	45.39	21.79	67.54	14.55	30.81	16.46

In terms of the districts focused in the study, the results (in Table 17) revealed that Mbale had the highest average technical efficiency levels (51.84%) among bean farmers, while Budaka had the least efficient bean farms with a mean of 41.44%. This is attributed to the fact that Mbale showed the highest bean productivity per hectare, while Budaka was the least productive (see Table 11). In addition, Tororo had the highest average economic efficiency levels (67.54%) among bean farmers, whereas Mbale showed the lowest average economic efficiency of 54.78%. Finally, the most allocatively efficient bean farms were also in Tororo, with a mean score of 30.81%, while their counterparts in Budaka were the least allocatively efficient with a mean of 25.28%. Allocative and economic efficiencies are concerned with costs of production; therefore, the fact that bean farms in Tororo district were located closer to the input markets than all the other districts may be responsible for the higher levels of allocative and economic efficiencies in Tororo (see Appendix 10).

4.2.3 Determinants of technical efficiency

The results in Table 18 show the estimates from the two-limit Tobit regression of selected socio-economic and institutional-support factors against predicted technical efficiency scores.The model was correctly estimated since the model chi-square was 41.46 and it was strongly significant at 1% level. In addition, the pseudo R^2 was 55.6%, against the recommended level of 20%.Thus it is evident that the explanatory variables chosen for the model were able to explain 55.6% of the variations in technical efficiency levels. Among the selected variables, six were found to have a significant contribution on technical efficiency namely: age, farm size, asset value, distance to the input market, extension services and group membership.

Age of the household head showed a negative effect on technical efficiency of the bean farms as was hypothesised and it was significant at 10% level. The results revealed that an increase in the farmer's age by one year reduced the level of technical efficiency by 0.2%. This means that older farmers were less technically efficient in bean production than their younger counterparts consistent with findings by Kibaara (2005) in Kenya. The finding is attributed to the fact that older bean farmers in the study area are relatively more reluctant to take up better technologies, instead they prefer to hold to the traditional farming methodsthus become more technically inefficient compared to their younger counterparts. This reluctance to embrace innovative farming methods is also responsible for the constant returns to scale realized earlier. However Illukpitiya (2005) found contradicting results in Sri-lanka, where it was observed that elderly farmers had a wealth of experience and therefore were technically more efficient in production than their younger counterparts. The inconsistency may be due to differences in socio-economic characteristics of the sampled farmers, however, it is important to emphasize that being older may not always substitute being more experienced.

Farm size was found to have a positive effect on technical efficiency as hypothesised and it was significant at 10% level. According to the results, an increase in the size of the farm by a hectare increased farm technical efficiency by 1.5%. It may be argued that farmers with larger farms are more able to use the land sparingly, which reduces the loss in soil fertility level on their farm land, hence making them more productive. The opposite is true for farmers with small units of land, since the land is cultivated every year, reducing its productivity and hence increasing technical inefficiency. The resultsalso concur with those by Fernandez *et al*. (2009) among sugarcane producers in the Philippines. However, they are contrary to a number of studies that have been done in other countries or in different crops. For instance Edeh& Awoke (2009) among cassava farmers in Nigeria; Tchale (2009) among smallholder crop farmers on Malawi; andNiringiye*et al.* (2010) among East African manufacturing firms. Despite this inconsistency, the findings obtained in this study make sense since they re-emphasizes that land fragmentation commonly practiced in many rural areas has a negative effect on agricultural productivity.

Table 18: Tobit regression estimates of factors influencing technical efficiency

TE	**Coefficient**	**Std. Error**	**t**	**P>|t|**
Sex (1=F)	0.020	0.028	0.720	0.472
Age (yrs)	-0.002	0.001	-1.720	0.086*
Schooling (yrs)	0.002	0.003	0.510	0.609
Occupation	0.000	0.000	-0.070	0.947
Farming (yrs)	0.000	0.001	0.440	0.659
Farm size (ha)	0.015	0.008	1.810	0.071*
Off-farm Inc.(Ush)	0.017	0.010	1.640	0.103
Asset value (Ush)	0.024	0.008	2.910	0.004***
Distance to mkt.(km)	-0.008	0.003	-2.360	0.019**
Extension service	0.064	0.025	2.550	0.011**
Group membership	0.144	0.071	2.030	0.044**
Credit (Ush)	-0.001	0.002	-0.680	0.498
Constant	0.060	0.141	0.430	0.669
Log likelihood =	58.019	LR $chi^2(12)$ =	41.460	
Pseudo R^2 =	-0.556	Prob> chi^2 =	0.000	

***, **, *** is significant at 10%, 5% and 1% respectively**

The value of assetsowned also showed a positive effect on technical efficiency as hypothesised and was significant at 1% level. The results indicated that a unit increase in the value of assets owned by a household increased technical efficiency by 2.4%. The positive contribution of these assets can be considered with respect to their respective functions. For instance, assets like motor vehicles, motor cycles, bicycles and animal carts provide a means for farmers to move easily or ferry their produce to the market. They can also help in provision of income that enhances the available capital and improves farming investments. Furthermore, communication devices like mobile phones help farmers to easily exchange valuable information on farming. Radios and televisions also provide useful information through the media, which farmers incorporate in their farming activities, hence improving their technical efficiency. Tchale (2009) also found similar findings among smallholder crop farmers in Malawi, where he observed that assets owned by the farm household normally serve as security to guarantee access to loans by farmers, which ensures availability of funds to acquire farm inputs, hence increasing the farm'stechnical efficiency.

Further findings indicate that distance to the input market showed a negative effect on technical efficiencyas earlier expected and it was significant at 5% level. It was found that an increase in the distance to the market by one kilometre;lead to a decrease in the farm's technical efficiency by 0.8%. The result is attributed to the fact that a farm located far from the market incurs more costs to transport farm inputs from the market, compared to the one closer to the market. This in turn hinders the optimal application of farm inputs and leads to technical inefficiency. The findings are consistent with results found by Bagamba*et al.* (2007) among smallholder banana producers in Uganda. They observed that households located nearer to the factor markets showed higher technical efficiency than those located in remote areas. According to the authors, proximity (nearness) to the factor market increased farmers' ease of accessing farm inputs and extension trainings from which they could attain information and skills for better crop managementhence increasing their productivity.

Extension services also showed a positive and significant influence on technical efficiency at 5% level. According to the findings, bean farmers who accessed extension services showed a higher level of technical efficiency by 6.4%, than those who failed to access the services. This suggests that access to extension services enabled bean producers to obtain information on crop diseases or pests and their control methods; as well as insights on innovative farming techniques that guarantee higher productivity. Similar findings were reported by Illukpitiya (2005) among rural households in Sri-lanka. Illukpitiya argued that farmers who received extension service were more knowledgeable on new and improved farming practices hence they showed higher technical efficiency levels. In addition, Seidu (2008) observed that farmers who get adequate extension contacts are able to access modern agricultural technology for input mobilization, input use and disease control, which enable them to reduce technical inefficiency.

Technical efficiency was further influenced by whether a bean farmer participated in producer groups or not. According to the findings, group membership showed a positive and significant relationship at 5% level; such that farmers who were members in a producer group improved their technical efficiency levels by 14.4% compared to those who failed to join farmer groups. The importance of membership in farmer organizations was also reported by Idiong (2007) among smallholder swamp rice producers in Nigeria; and Tchale (2009) among smallholder crop producers in Malawi. Collectively they observed that farmers who are members in producer organizations are able to benefit not only from the shared knowledge among themselves with respect to modern farming methods, but also from economies of scale in accessing input markets as a group. Hence, such farmers become more technically efficient in production.

4.2.4 Determinants of economic efficiency

The results in Table 19 show estimates of the two-limit Tobit regression of selected socio-economic and institutional-support factors against farm economic efficiency indices. The model was correctly specified since its chi-square was 48.82 and it was strongly significant at 1% level. In addition, the pseudo R^2 was 72.2%, thus it implies that the independent variables chosen for the model were able to explain 72.2% of the variations in farm economic efficiency. Among the selected variables, four were found to contribute significantly to economic efficiency namely: main occupation, off-farm income, value of assets and credit.

The farmer's primary occupation showed a negative influence on farm economic efficiency as hypothesised and it was significant at 5% level. The results revealed that farmers whose main occupation was employment, business or any other income generating activity (other than farming) hadsignificantly higher farm economic efficiency by 0.1% compared to those who were full time farmers. This is attributed to the fact that in farms where the household head was involved in non-farm occupations, the farmer had more funds coming in from such external sources which were used to improve farming activities. The results are consistent with those reported by Mulwa *et al.* (2009) among maize farmers in Kenya; and also Tijani (2006) among rice farms in Nigeria. In their findings, the authors observed that farmers who entirely depended on farming were disadvantaged in that they did not have regular sources of income to finance their farming; rather, they had to wait until harvest time. In fact, in most cases the proceeds from the farm are not always reinvested back to the farm, due to other household needs or accumulated debts, so that farm productivity decreases over time.

Table 19: Tobit regression estimates of factors influencing economic efficiency

EE	Coefficient	Std. Error	t	P>|t|
Sex (1=F)	0.000	0.028	0.000	1.000
Age (yrs)	0.000	0.001	0.220	0.830
Schooling (yrs)	-0.003	0.003	-0.850	0.397
Occupation	-0.001	0.000	-2.470	0.014**
Farming (yrs)	0.000	0.001	0.130	0.900
Farm size (ha)	0.005	0.008	0.640	0.521
Off-farm Inc.(Ush)	0.021	0.010	2.020	0.044**
Asset value (Ush)	0.034	0.008	4.080	0.000***
Distance to mkt.(km)	-0.004	0.003	-1.120	0.262
Extension service	0.000	0.025	0.010	0.992
Group membership	0.001	0.071	0.010	0.994
Credit (Ush)	0.005	0.002	2.280	0.023**
Constant	1.328	0.141	9.390	0.000***
Log likelihood =	58.197	LR $chi^2(12)$ =	48.820	
Pseudo R^2 =	-0.722	Prob> chi^2 =	0.000	

***, **, *** is significant at 10%, 5% and 1% respectively**

Further findings indicate that off-farm income had a positive effect on farm economic efficiency as hypothesisedand it was significant at 5% level. The results indicate that an increase in off-farm income by a unit increased the level of farm economic efficiency by 2.1%. This suggests that the more income a farmer obtained from off-farm sources the more economically efficient he became. The positive relationship is attributed to the fact that off-farm income provides extra capital that is invested in farming in form of purchasing inputs and hiring labour; hence farmers with such earnings reflect higher farm productivity. Similar findings were reported by Lopez (2008) among selected farms in the USA. However, Kibaara

(2005) in a study of maize producers in Kenya observed that farm efficiency was reduced when farmers had higher off farm income. This may be the case if the type of off-farm activity totally deprives the farmer time to attend to his or her farm.

The other binging factor in influencing farm economic efficiency was the value of assets, which showed a positive effect on economic efficiency as was hypothesised. The coefficient was also strongly significant at 1% level. The results indicate that an increase in the value of assets owned by a unit increased the level of farm economic efficiency by 3.4%. The results are similarto those by Tchale (2009) among smallholder crop farmers in Malawi, who observed that assets (like livestock units, a radio and a bicycle) owned by the farmers improved their liquidity position thereby ensuring that they were able to purchase inputs promptly. Tchale also mentioned that radios were important for accessing production and market information thorough the media, while bicycles made it less costly for farmers to transport items to and from the market. As such, asset ownership collectively improved the level of economic efficiency of the bean farmers in the study area.

Finally, economic efficiency was also influenced by credit. The results showed that credit had a positive influence on farm economic efficiency and it was significant at 5% level. Specifically, it was found that an increase in the amount borrowed by a unit increased a farm's economic efficiency by 0.5%. The positive effect suggests that credit is a major contributor of farm economic efficiency among bean producers in the area. The findings are similar to those reported by Hyuha*et al.*(2007) among rice producers in Uganda; and also Goncalves*et al*. (2008) among milk producing farms in Brazil. In these studies, it was observed that access to credit is important in production in the sense that it improves farmers' ability to purchase the otherwise unaffordable farm inputs and consequently it significantly improves their level of efficiency. There are innovative credit facilities currently coming up that integrate credit providers, producers and traders in such a way that farmers who borrow loans are linked to a ready market for their produce; which in turn enables them to be able to repay the farming loans. On the other hand, the introduction of crop insurance has lessened uncertainties associated with agriculture, and boosted confidence among lenders to provide farming loans. Therefore credit has a great potential for improving farm economic efficiency in Uganda in coming years.

4.2.5 Determinants of allocative efficiency

The results in Table 20 show the estimates from the two-limit Tobit regression of selected socio-economic and institutional-support factors against farm allocative efficiency scores.The model is appropriately estimated since its chi-square was 61.86 and it was strongly significant at 1% level. However, the pseudo R^2 was 19.3%, which is considerably low given that a pseudo R^2 of at least 20% is normally appropriate. Thus the explanatory variables chosen for the model were able to explain 19.3% of the variations in allocative efficiency levels. Despite this, the log likelihood for the model was a relatively large negative number (-129.54) indicating that the model was correctly specified. Among the selected variables, four turned out to be significant determinants of allocative efficiency namely:farm size, off-farm income, value of assets and distance to the input market.

The findings in Table 20 show that allocative efficiency was positively and significantly influenced by farm size at 10% level. According to the results, an increase in the farm size by a hectare increased the farm allocative efficiency by 3.2%. This is consistent as hypothesised and suggests that the larger bean farmsshowed significantly higher levels of allocative efficiency. Similar results were found by Khai and Yabe (2007) among soybean producers in Vietnam. The results reflect that larger bean farmers in Eastern Uganda exhibit economies of scale in production, which makes them more efficient in allocating resources.

Furthermore, the results show that allocative efficiency was positively and significantly influenced by off-farm incomeat 5% level. According to the results, a unit increase in off-farm income increased allocative efficiency by 3.3%. This is attributed to the fact that off-farm earnings enable farmers to acquire the required farm inputs to improve their productivity. Similar findings were reported by Lopez (2008) amongfarms in the USA. In her findings, she observed that farmers with higher off-farm income also showed higher levels of allocative efficiency. However, Kibaara (2005) found a negative effect of off-farm income on farm efficiency among maize farmers in Kenya. This may be the case if the off-farm income generating activity deprives farmers' time to attend to their farms, making them incur more costs to hire labour.

The value of assets owned also showed a positive effect on farm allocative efficiency. This was consistent as hypothesisedandthe coefficient was also strongly significant at 1% level. According to the results, a unit increase in the value of assets lead to a 7.9% increase in allocative efficiency. The results are brought about by the fact that assets owned by farmers assisted them directly or indirectly in reducing costs of production and made them more allocatively efficient. These results are similar to those byTchale (2009) among smallholder farmers in Malawi, who observed that asset ownership was a tool through which the farm's liquidity position was improved; hence increasing farm productivity through higher input access.

Table 20: Tobit regression estimates of factors influencing allocative efficiency

AE	Coefficient	Std. Error	t	P>|t|
Sex (1=F)	-0.002	0.053	-0.030	0.972
Age (yrs)	-0.003	0.002	-1.570	0.118
Schooling (yrs)	0.005	0.006	0.800	0.426
Occupation	-0.001	0.001	-1.210	0.227
Farming (yrs)	0.000	0.002	-0.140	0.889
Farm size (ha)	0.032	0.017	1.890	0.060*
Off-farm Inc.(Ush)	0.033	0.020	1.660	0.099*
Asset value (Ush)	0.079	0.016	5.000	0.000***
Distance to mkt.(km)	-0.013	0.007	-2.050	0.042**
Extension service	0.075	0.048	1.560	0.120
Group membership	0.210	0.154	1.370	0.173
Credit (Ush)	0.003	0.004	0.840	0.399
Constant	-0.464	0.271	-1.720	0.088*
Log likelihood =	-129.539	LR $chi^2(12)$ =	61.860	
Pseudo R^2 =	0.193	Prob> chi^2 =	0.000	

***, **, *** is significant at 10%, 5% and 1% respectively**

Further findings indicate that distance to the input market showed a negative effect on allocative efficiencyas earlier expected and it was significant at 5% level. It was found that an increase in the distance to the market by one kilometre;lead to a decrease in the farm's allocative efficiency by 1.3%.Thus households located nearer to the factor markets showed higher allocative efficiency than those located in remote areas. This is because a farm located far from the market incurs more costs to transport farm inputs from the market all the way to the farm. As such, nearness to the market improved allocative efficiency among bean producers in the study area.Similar results were reported by Bagamba*et al.* (2007) among smallholder banana producers in Uganda. The authors attributed their findings to the fact that the nearness to the factor markets increased farmers' access to credit facilities and non farm income generating activities that enable farmers to afford and apply inputs on time. It also reduces dependence on the farm which is responsible for persistent cycle of poverty in remote areas.

CHAPTER FIVE:CONCLUSION AND RECOMMENDATIONS

5.1 Summary

The aim of this study was to explain the factors influencing common bean productivity and efficiency among smallholder farmers in Eastern Uganda. This was based on the realization that the potential bean productivity in the country was far from being achieved. The study was conducted in Busia, Mbale, Budaka and Tororo districts in Eastern Uganda based on a sample of 280 households selected using a multi-stage sampling technique. For the data collection, a personally administered structured questionnaire was used to conduct interviews, with a focus on household heads. A stochastic frontier model was then used to estimate farm efficiency levels and determinants of bean productivity, while a two-limit Tobit model was employed to evaluate the factors influencing farm technical, economic and allocative efficiency levels.

Descriptive statistics from this study indicated that the mean age of the farmers was 43years, with participant farmers having a significantly higher prime age (45years) than non-participants (41years). Majority of the sampled farmers had schooled for at least 8 years and attained primary level of education; although participant farmers had a significantly higher level of schooling years than the non-participant farmers. The results also indicated that the mean for off-farm income was significantly higher for participants than non-participant farmers. Households in the study area depended more on bean earnings with a mean equivalent of USD 77.10, compared to off-farm earnings equivalent toUSD 44.43. However, the mean total income p.a. was Ush 438,905.97 or USD183.85 which still holds farm households below poverty line.

The findings further showed that the mean distance to the nearest input market for all farmers was 3.84km. The distance to participant farms was significantly greater (4.11km) compared to the mean distance for non-participant farms (3.98km). This had implications on the input access and use among the two categories of farmers. In fact due to the distance, participant farmers obtained a significantly lower price per kg of beans (Ush 2,259.89) compared to non-participant farmers (Ush 4,416.73). In addition, participants accessed more credit with a mean total borrowing of Ush 100,022.64 (USD 41.90), compared to non-participants who borrowed an average of Ush 57,856.36 (USD 24.23). Farmers attributed the low credit access to the 'unaffordable' interest rates (10.55%) charged on the loans as well as lack of sufficient collateral. It was also found that majority of the farmers (79.1%) were members in producer groups, with participants showing a significantly higher level of membership (94.9%) than non-participants (58.3%). Out of the group participants, only

21.9% of all farmers, 34.4% of participants and 5.8% of non-participants practiced collective bean marketing. But participants were significantly more involved in collective bean marketing than non-participants.

An assessment of bean production in the study area showed that productivity was very low ($0.47mtha^{-1}$), with participant farmers yielding significantly higher ($0.52mtha^{-1}$) compared to $0.39mtha^{-1}$ for non-participants. These results were also backed up by the fact that participants were relatively better in the application of planting fertilizers, animal manure, fungicides and pesticides; compared to their non-participant counterparts. However, it was ironic that non-participants applied significantly higher amounts of top-dressing fertilizer, herbicides and certified seeds. This was attributed to the fact that fewer non-participant farmers (24%) accessed extension service compared to participants (45.86%); hence they lacked knowledge on the correct usage of these inputs.Furthermore, the most common technologies adopted to reduce soil degradation were mulching, intercropping and animal manure use. Among the farmers, 65.9% had used mulching, 90.3% had intercropped their bean crop, and 68.3% had applied animal manure. Further analysis revealed that a significantly larger proportion of participant farmers applied animal manure, weed control and planting fertilizers compared to their non-participant counterparts.

In total eleven varieties were identified among the farmers in Eastern Uganda namely K131, K132 and NABE 4 which are improved varieties, whereas the 'K20', 'Kanyebwa', 'Mutike', 'Pider', 'Kakira', 'Wakaka', 'Tanzania' and 'Nambale' varieties are the local varieties.The most productive bean variety in the study area was 'NABE 4' which gave yields of 1.24Mt ha^{-1} and was prevalent in Busia district. It was followed by the 'Kakira variety which yielded 0.89Mt ha^{-1} and was prevalent in Mbale district. These two varieties were however not very common among sampled farmers since they have not yet been widely disseminated. The most common variety was the 'Kanyebwa' variety which yielded 0.44Mt ha^{-1} and was prevalent in all the four districts.

5.2 Conclusion

The main objective dealt with in this study was to determine the factors influencing common bean productivity and efficiency among smallholder farmers in Eastern Uganda. It was established that bean productivity was significantly influenced by plot size, ordinary seeds, certified seeds and planting fertilizer; all of which had a positive effect as hypothesised.

The mean technical efficiency among bean farms was 48.2%, mean economic efficiency was 59.94% and mean allocative efficiency was 29.37%. However, there were large discrepancies between the most efficient and the least efficient farmers. It was also encouraging that at least half of the farmers had technical and economic efficiency scores exceeding the 50% limit and could easily improve to the level of the most efficient farmers. But it was worrying that only 14% of participants and 9% of non-participants had allocative efficiency scores exceeding the 50% limit. With respect to the districts, it was found that the most technically efficient farms were in Mbale; while the most economically and allocatively efficient farms were in Tororo.

Finally, the Tobit regression model estimation revealed that technical efficiency was positively influenced by value of assets (at 1% level),extension service and group membership (at 5% level); andnegatively influenced by ageand distance to the factor market at 10% and 5% levelsrespectively. On the other hand, economic efficiency was positively influenced by value of assets (at 1% level),off-farm income and credit (at 5% level); andnegativelyinfluenced by farmers' primary occupation at 5% level. Lastly, allocative efficiency was positively influenced by value of assets (at 1% level), farm size and off-farm income (at 10% level); andnegatively influenced by distance to the factor market at 5% level.

5.3 Recommendations

In the context of bean production, there is need for the Ministry of Agriculture Animal Industry and Fisheries (MAAIF) to sensitize farmers on the importance of adopting soil enhancing technologies to enhance retention of soil fertility. MAAIF is also obliged to provide more extension service and training to farmers about correct input application and also concerning improved seed varieties that have disease resistant and high productivity traits. On the other hand, the National Beans Programme concerned with carrying out research in the country needs to have proper mechanisms of disseminating new seed varieties to farmers all over the country. It is further necessary for farmers to allocate more of the available farm land to bean production or apply relay cropping and increase application of fertilizers so as to increase bean productivity to the potential level.

With respect to production efficiency, the government of Uganda needs to introduce policies discouraging land fragmentation since this would help reduce technical inefficiency. There is also need for farmers to be trained on entrepreneurial skills so that they can invest their farm profits into more income generating assets so as to harness more farming capital. This initiative will also reduce over-dependence on farm produce and provide alternative employment to the young people in the area. Government should also develop better roads and market infrastructure in the rural areas to attract private investors, as a way to reduce the distance farmers have to cover to the market. In so doing, bean farmers in Eastern Uganda will become more efficient in production.

In addition, there is also need for the MAAIF and other stakeholders to come up with more initiatives through which farmers can access adequate credit facilitiesat affordable interest rates and without the need for collateral, so that smallholder farmers can invest more in farming to increase their economic efficiency. Smallholder farmers should also be encouraged to form effective producer groups, associations and networks which will help improve their bargaining power when purchasing inputs, accessing extension services as well as borrowing farming loans and marketing their produce.

5.4 Areas of further research

While this study only covered areas growing bush bean varieties, it may also be important for future research to evaluate production efficiency among climbing bean producers. The study also failed to look at marketing challenges faced by bean producers, yet the current strategy for improving agricultural productivity is through a market-led production approach. Therefore future research can venture into this area not only in Uganda but also in other bean producing countries.

Moreover, it was observed that the literature available on efficiency analysis in Africa is majorly on technical efficiency, with countable ones on allocative and economic efficiency. Findings derived from this study show that while one variable might influence technical efficiency positively; it may actually be reducing allocative and/or economic efficiency. Secondly, it has been found that farmers are more allocatively inefficient than they are technically inefficient. Therefore, future research should consider measuring not only technical efficiency, but also allocative and economic efficiency so as to give accurate policy recommendations.

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APPENDICES

ANNEX 1: STRUCTURED HOUSEHOLD SURVEY QUESTIONNAIRE

AN ANALYSIS OF DETERMINANTS OF COMMON BEAN PRODUCTIVITY AND EFFICIENCY: CASE OF SMALLHOLDER FARMERS IN EASTERN UGANDA

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Introduction:

Agriculture sustains the livelihood of about 70.8% of Ugandans, while Common bean is an important staple food as well as a cash crop for both the rural and urban areas. Although Uganda is a net Common bean exporter there is a great potential for improving its productivity, to transform livelihoods of poor smallholder farmers and to improve food security in the country. This research is strictly academic, with a purpose of providing knowledge on the yield constraining factors in bean production.

NB: The information provided herein will remain strictly confidential.

SECTION A. GENERAL INFORMATION

Questionnaire number……………………………..

Respondent's name:…………………………………. . Sex: 1=female 0=male

District ………………………………………………………………

Sub-county:………………………………………………………………..

Village ________________________________

Location village 1=Urban; 2=Per-urban; 3=Rural 4=others (specify)

Name of network or group…………

GPS Location: E………………………….
N……………………………………..Altitude………………………………....

NB: i) Do not leave any blank spaces. Use code 0 if the answer is No; and code -99 if not applicable and -88 if no response is given. Circle the appropriate responses.
ii) Get the conversion factor for each unit of measure e.g. 1 tin of beans is equivalent to 18kgs of beans.

SECTION B: FARMERS' HOUSEHOLD CHARACTERISTICS

Questions	**Codes**	
1. Sex of household head	***1=Female; 0=Male***	
2. Age in years or year born (a) household head; (b) spouse	Actual number of years	
3. Marital status	***1=Married; 2=single; 3=Divorced; 4=Widowed5=others (specify)***	
4. Number of years of schooling		
5. Number of rooms in the house	***Actual number of rooms***	
6. How many people are currently living with you?	***Adult (F+M) aged 60+***	
	Adult females (18-59)	
	Adult males (18-59)	
	Children (7-17)	
	Young children below 6 years	
7. Where does your spouse (husband or wife) reside?	***1=within village; 2=other village; 3=town/city; 99=not applicable***	
8. What is your current occupation?	***1=farming; 2=teacher; 3=Agric. officer; 4=others (specify); 99=not applicable***	
a) Primary occupation		
b) Secondary occupation		
9. What was your previous occupation?	1=farming; 2=teacher; 3=Agric. officer; 4=others (specify); 99=not applicable	
10. How many years have you been farming beans since your previous occupation?	***Number of years***	

SECTION C STRUCTURE OF LAND OWNERSHIP AND USE
C1: Land Ownership

Total size		Tenure system (in ha)			
		Owned	Rented in	Rented out	Communal
Acres					

SECTION D. INSPIRE AND OTHER AGRICULTURAL TECHNOLOGIES

For each of the following technologies, please indicate the usage of the technologies

Agricultural Technology / Mgt Practice	(a) Do you know this technology? 1=Yes 0=No	(b)Source of tech? (see codes)	(c)) Did you seek information on tech? 1=Yes 2=No	(d) Have you ever used this technology in your bean fields 1=Yes 0=No	(e)Year you first used this technology	(g) If you did not use this technology during the 2010/11 season why?
Soil fertility and Water Management						
Mulching						
Terracing						
Water harvesting						
Cover cropping						
Conservation farming						
Animal Manure						
Crop rotation						
Intercropping						
Chemical fertilizer						
Plant Spacing						
Pesticide						
Planting in lines						
Weed control						
Other1, specify						
Other2, specify						
Which bean varieties did you cultivate last season						
1=Bush bean						
2=Climbing						

Codes for source of information on technologies: *1=Government Extension workers, 3=Farmer Group members, 4=NGO (specify), 5=Other farmers, 6=Radio, 7=Demonstration/research sites, 8=Village Information Centers (VIC); 9=INSPIRE 10=A2N 11=AT (U); 12=NAADS; 99=Other (specify)*

SECTION E: BEAN PRODUCTIVITY IN THE LAST CROPPING SEASON

Bean variety	Area planted (Acres)	Seeds (kg)	Source of seeds	Fertilizer applied 0=no 1=yes	Planting (Kg) & Type 0=no 1=yes	Top dressing (Kg) & type 0=no 1=yes	Yield or Production in /kg	Price/ unit

SECTION F: ACCESS TO INPUTS

1. How did you access and use the following inputs?

Type of inputs	(a) [1]Common source	(b) Distance from house to source (km)	(c) Time to source (min)	(d) Average cost per unit	(e) Unit	(f) Area applied	Quantity used	(g) [2]Main constraints to use of input	(h) [3]Was this usage better or similar to 2007?
Planting Fertilizer									
Top dress fertilizer									
Other fertilizer									
Herbicides									
Fungicides									
Pesticides									
Animal Manure									
Certified seed									
Seed dressing									

[1]***Common source of inputs:*** *1=purchased from market; 2=purchased from stockists; 3=purchased from other farmers; 4=received from government; 5=received from NGOs; 99=others (specify)…*

[2] ***Main constraints to access****: 1=Too far from household, 2=Unsuitable packaging (large) 3=No knowledge of how to use 4=No transport, 99= others (specify)*

[3]*0=worse off 1=similar 2=better*

SECTION G: AVERAGE ANNUAL HOUSEHOLD INCOME SOURCES

	Current Income 2011		**Was income more same or less compared to 2007? =less 1=same 2=more**
Type of earning or income	**Amount**	**Frequency**	
Employment income			
Income from business			
Income from farm produce sales (bean produce)			
Income from sale of livestock and movable asset value			
Transfer earnings from relatives, sons, daughters etc			
Borrowing from friends, neighbors			
Loans from credit inst. /associations			

Value of gifts			
Land rented out income			
Buildings rented out income			
Other structures rented out income			
Motor/bike/cycle rented out income			
Other income			

SECTION H: HOUSEHOLD ASSET ENDOWMENTS

Asset	2011				Before 2007
	No. of assets	Value, USHs	Ownership 1= Husband 2= wife 3= joint ownership	Who has access to these assets? 1=husband; 2=wife; 3=children; 4=all family members; 5=other spec.	When was asset acquired?
Non-Agricultural Assets					
Bicycles					
Motor cycle					
Personal car					
Radios					
Beds and mattresses					
Chairs/sofas					
Mats					
Mobile phone					
Computer					
Commercial Vehicle					
Others					
Agricultural Assets					
Oxen					
Wheel barrows					
Spraying pump					
Dairy cattle					
Other cattle					
Donkeys					
Goats					
Sheep					
Pigs					
tractor					
Others (specify)					
Cribs					
Granaries with food					
spade, hoe					

Machetes/slasher					
Plough					
Others, specify					

SECTION I: BEAN PRODUCTION ISSUES

I1a). Did you have land which you did not use in the last growing season? 1=Yes; 0=No. What of 2007? 1=Yes, 0= No

I2). If yes, what was the size of the unused land: 2010? ………..2007………

I3. If you did not cultivate all of the land you had access to in the previous season, give reasons

Reason for non use	Rank/prioritize them	Score the ranks between 1 lowest and 5 highest
1=not enough seed		
2=not enough other input		
3=not enough labour		
4=Left fallow land		
5=lack of funds		
6=others (specify)		

I4). Gender and labour distribution households

Ploughing	Planting	Weeding	Fertilizing	Spraying	Harvesting	Post harvest handling	Marketing produce	[1]Was the gender labor the same before 2007? 0=no 1=yes

Codes 1=Husband only; 2=Wife only; 3=Husband mostly; 4=Wife mostly; 5=Husband and wife equally; 6=Children; 7=Hired labour; 8=Other (specify)……

I5). Have you experienced any bean yield reduction in the last 1-2 years? 1=Yes; 2=No If yes, give reasons.

I6). Have you experienced any bean yield reduction in the last 4-5 years ago? 1=Yes; 2=No If yes, give reasons.

____

____

I7) Do you know any factors/ practices that cause soil depletion? 1=Yes; 0=No If yes, list them.

____

____

I8). What factors affect your bean yields? Rank them in terms of significance

(1)
(2)
(3)

SECTION J1: ACCESS TO MARKET

		Distance in Km		[1]Means of travel		Time in minutes	
		Current period	Before 2007	Current period	Before 2007	Currently 2011	Before 2007
Input market	Nearest market						
	Most important (urban) market						
Output market	Nearest market						
	Most important (urban) market						
Distance/time to Main road							

[1]1=private car 2=public vehicle 3=motorbike 4=bicycle 5=walking 6=other, specify

J2a. How did you utilize the outputs from your bean farm in the last season? *(NB: for quantities specify unit of measure and get the conversion factor)*

[1]Purpose	Total quantity produced	Quantity consumed and gifted or donated	Qty sold	Qty spoilt/wasted	Price per unit	Proportion sold through group/net-work	[2]How marketed ?	[3]Who keeps the money	Months when sold

[1]Purpose: 1= food only; 2=food but sell in case of emergency; 3=food but sell when has plenty; 4=for both food and sale; 5=for sale only; 6=others (specify)…

[2]Who/how marketed: 1=self/individually 2=collectively through network/group 3=both self and group

[3]Codes for who keeps the money: 1=husband 2=wife 3=boy child 4=girl child 5=laborer 6=others (specify)

J3a.Please provide information about bean sales in the last season

Qty sold	[1]Who do you mostly sell to	[2]Where do you usually sell	Mode of selling 1=cash 2=credit 3=both	Distance to market	[3]Transport means to the market?	How often do you sell?	Time of the year when prices are very high?	Time when prices are very low?

[1]Codes for buyer: 1= local trader; 2=long distance trader; other farmers, others (specify)…

[2]Codes for place of sale: 1=on farm; 2=Roadside near village; 3=local market; 4=district town; 5=distant market; 7=others (specify)…

[3]Codes for transport means: 1=private car 2=public vehicle 3=motorbike 4=bicycle 5=walking 6=other, specify

J4b. Please provide information about bean sales in 2007 or earlier

Qty sold	[1]Who do you mostly sell to	[2]Where do you usually sell	Mode of selling 1=cash 2=credit 3=both	Distance to market or selling point	How often do you sell bean produce?	[3]How do you transport beans to the market?	Time of the year when prices are very high? *Specify*	Time when prices are very low? *Specify*

[1]*Codes for buyer: 1= local trader; 2=long distance trader; other farmers, others (specify)…*

[2]*Codes for place of sale: 1=on farm; 2=Roadside near village; 3=local market; 4=district town; 5=distant market; 7=others (specify)…*

[3]*Code for transport means1=private car 2=public vehicle 3=motorbike 4=bicycle 5=walking 6=other, (specify)…*

K6. How do you access information on bean farming? What kind of information do you get from the following sources? How useful is each source of information?

	2011		How does the information access compare to 2007
Source	Frequency of access to information	Rank the usefulness of source from 1 least useful to 10 very useful	0=poorer 1=same 2=better
1=Radio			
2=extension office			
3=Fellow farmers			
4=Neighbour			
5=Group members			
6=News papers			
7. Phone SMS			
8. Market boards			
9.Village information centres			
10. =Others specify			

J7a). Have you ever organized yourself with other farmers to sell beans in-groups?

(In 2010) 1=Yes 0=No, _________________

b) When did you join the collective activity ______________________

J8). If yes, with whom, how many times, what markets/where and what was the difference in selling as a group?

With whom	Proportion collectively sold	How many times	[1]What markets?	What was the difference in price received? 0=lower 1=same 2=better	Distance to market/selling point	[2]Means of transport

[1]*Codes for place of sale: 1=on farm; 2=Roadside near village; 3=local market; 4=district town; 5=distant market; 7=others (specify)…*

[2]*Codes for transport means 1=private car 2=public vehicle 3=motorbike 4=bicycle 5=walking 6=other, specify*

SECTION K. COLLECTIVE ACTION

K1a. Are you **currently (2010)** a member of any farmers' group or local association in this village? If yes, give the name.

Name of group or association (include local institution)	Please rank the Primary objectives of association: rank them 1=savings 2=agriculture 3= marketing 4=welfare 5=other	Your position in the group 1=committee member 2=ordinary member	How long have you been a member of this group?	Does your wife or husband belong to the same group with you 1=Yes, 0=No	Was your participation different before 2007? 0=No 1= yes	If different, please indicate the differences

K2). How often have you or members of your household joined with other farmers in this village to work collectively?

In 2011				**Before 2007**			
Type of activity or occasion	Frequency (How often?)	Estimate number of people who participated		Were you engaging in the same activities before 2007 0=No 1=yes	If no, is the variation up or down (frequency and numbers/ gender		
		Male	Female		Frequency	Male	Female

SECTION L: SAVINGS AND CREDIT

L1a). Do you have individual savings? In 2011(1=Yes; 0 =No) _________. If yes, when did you begin saving? ________.

L1b). If yes, how often do you currently save money? ....: (*0=Never; 1=occasionally; 2=regularly; 3=Always).*

Is current savings different from 2007*? ………:* 0=no 1=yes.

If yes, how different? ………*:1=more 2=less*

L2a). In which months do you save most? Specify months in the season and reason

____

L2b). How do you use the savings you achieve each year?

____

L2c). In which months did you save least last year?

____

L2d. In which months did you save least in 2007?

____

L3a. Where are your individual savings kept? …….

1=at home; 2=with another person; 3=bank; 4=group account; 5=in post offices; 6=others specify.

L3b.Where did you save before 2007?…… :*1=at home; 2=with another person; 3=bank; 4=group account; 5=in post offices; 6=others specify*

L4. What do you use the money for? If more than one use, rank them in order of importance.

1=education; 2=health; 3=loan payment; 4=agricultural input purchase; 5=housing; 6=consumption 7=celebrations; 8=others (specify) in 2007? 1=education; 2=health; 3=loan payment; 4=agricultural input purchase; 5=housing; 6=consumption 7=celebrations; 8=others (specify)

L5a. Have you ever borrowed money from any of the following sources in the last year or over the last three years?

Source of borrowed money	Ever borrowed 1=Yes 0=No	Amount borrowed last year	No. of times in a year	Interest rate charged per month or year, specify	[1]Purpose of borrowing	Actual use of borrowed money	Amount paid back	[2]How does current borrowing compare to three years ago?
Relative								
Friend								
Informal savings and credit group								
Money lender								

Government								
NGO/Church								
Bank or micro-finance institution								
Others (specify)…								

[1]*Codes for purpose and use of money: 1=food; 2=non-food household necessities (soap, paraffin); 3=scholastic materials e.g. school fees, uniform, books; 4=medical care; 5=burial; 6=bride price; 7=others (specify)…*
[2] *0=lower 1= same 2=higher*

L6). If your household income were to double, what would you do with the extra money?

Investment decision	Rank the 5 most important decisions **(1 first priority) current period 2010**	Rank the 5 most important decisions **(1 first priority) in 2007**

M). Would you like to make any comments or ask questions? 1=Yes 0=No, if yes, what are the comments or questions?

Webalennyo. Thank you very much

****

Interviewed by:
Date:
Time:
Observations:

Checked by:
Date:
Time:
Comments:

ANNEX 2: STOCHASTIC FRONTIER PRODUCTION RESULTS

```
Stoc.frontier normal/exponential model          Number of obs   =        277
                                                 Wald chi2(10)   =      95.96
Log likelihood = -448.17332                      Prob> chi2     =     0.0000
------------------------------------------------------------------------------
Lneydbe |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
LnArea |   .3534072   .0960175     3.68   0.000     .1652164     .541598
Lnesdbekg |    .384536   .0787361     4.88   0.000      .2302161    .5388559
Lngqplfet |   .1095965   .0586298     1.87   0.062    -.0053158    .2245087
Lngqtopdre|  -.0238868   .0674953    -0.35   0.723    -.1561751    .1084015
Lngqherb |   .1224712   .1350683     0.91   0.365    -.1422578    .3872001
Lngqfungi|  -.0820294   .0858424    -0.96   0.339    -.2502774    .0862186
Lngqpest|  -.0041723   .0540131    -0.08   0.938    -.1100361    .1016915
Lngqmanure |   .0339914   .0330899     1.03   0.304    -.0308637    .0988464
Lngqcseed |   .1156513   .0592909     1.95   0.051    -.0005567    .2318593
LnTotalLr |   .0906627   .0811719     1.12   0.264    -.0684313    .2497567
       _cons |   4.394758   .3607693    12.18   0.000     3.687664    5.101853
-------------+----------------------------------------------------------------
    /lnsig2v |  -.6962179   .1596783    -4.36   0.000    -1.009182   -.3832543
    /lnsig2u |   .2323296   .1791545     1.30   0.195    -.1188068    .5834659
-------------+----------------------------------------------------------------
sigma_v |    .706022   .0563682                      .6037526    .8256147
sigma_u |   1.123181   .1006115                      .9423266    1.338745
      sigma2 |   1.760002   .2138283                      1.340907    2.179098
lambda |   1.590858    .130332                     1.335412    1.846304
------------------------------------------------------------------------------
Likelihood-ratio test of sigma_u=0: chibar2(01) = 64.95  Prob>=chibar2 = 0.000
```

ANNEX 3: STOCHASTIC FRONTIER COST RESULTS

```
Stoc.frontier normal/exponential model          Number of obs   =        278
                                                 Wald chi2(10)   =     435.31
Log likelihood = -258.18013                      Prob> chi2     =     0.0000
------------------------------------------------------------------------------
LnTTInputc~t |      Coef.   Std. Err.      z    P>|z|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
Lnesdbecost |   .4326732   .0593486     7.29   0.000      .316352    .5489943
Lneydbe |   .1176595   .0210407     5.59   0.000     .0764204    .1588985
Lngdplfert |   .0171393   .0133193     1.29   0.198    -.0089661    .0432447
Lngdtopdre |   .0755169   .0169411     4.46   0.000     .0423129     .108721
Lngdherb |   .0400515    .016278     2.46   0.014     .0081472    .0719558
Lngdfungi|  -.0010647   .0130962    -0.08   0.935    -.0267327    .0246033
Lngdpest |    .013695   .0099789     1.37   0.170    -.0058633    .0332532
Lngdmanure |   .0348791   .0149089     2.34   0.019     .0056581    .0641001
Lngdcseed |   .0244938   .0087097     2.81   0.005     .0074232    .0415644
LnCostperM~y |   .2164573   .0247201     8.76   0.000     .1680068    .2649079
       _cons |   5.511967   .5028296    10.96   0.000      4.52644    6.497495
-------------+----------------------------------------------------------------
    /lnsig2v |   -2.24053   .2045587   -10.95   0.000    -2.641458   -1.839603
    /lnsig2u |  -1.020406   .1864764    -5.47   0.000    -1.385893   -.6549185
-------------+----------------------------------------------------------------
sigma_v |   .3261933   .0333628                      .2669406    .3985982
sigma_u |   .6003738   .0559778                      .5001004    .7207527
      sigma2 |   .4668508   .0601746                      .3489108    .5847908
lambda |   1.840546   .0774358                     1.688775    1.992318
------------------------------------------------------------------------------
Likelihood-ratio test of sigma_u=0: chibar2(01) = 80.77  Prob>=chibar2 = 0.000
```

ANNEX 4: TOBIT MODEL TECHNICAL EFFICIENCY RESULTS

Tobit regression	Number of obs = 266
LR chi2(12) = 41.46
Prob> chi2 = 0.0000
Log likelihood = 58.018507	Pseudo R2 = -0.5559

te	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
q1sxhd10	.0202079	.0280402	0.72	0.472	-.0350129	.0754287
q2aghd10	-.0019556	.0011363	-1.72	0.086	-.0041934	.0002822
q4scy10	.00165	.0032253	0.51	0.609	-.0047018	.0080018
q9pocc10	-.0000312	.0004689	-0.07	0.947	-.0009546	.0008922
q11yfm10	.0004966	.0011257	0.44	0.659	-.0017204	.0027136
Landha	.0151024	.0083314	1.81	0.071	-.001305	.0315097
LnOtherInc	.0170428	.0104104	1.64	0.103	-.0034589	.0375445
LnOtherAss~s	.0239644	.0082352	2.91	0.004	.0077464	.0401823
K1IDNK10	-.0079354	.0033622	-2.36	0.019	-.0145567	-.0013141
K6SEXT10	.0644592	.0252844	2.55	0.011	.0146654	.114253
K8PSCBN	.1442404	.071148	2.03	0.044	.0041253	.2843555
LnTotalCre~t	-.0014819	.0021856	-0.68	0.498	-.0057862	.0028223
_cons	.0604137	.141369	0.43	0.669	-.2179911	.3388185
/sigma	.1945525	.0084349			.1779412	.2111638

Obs. summary: 0 left-censored observations
266 uncensored observations
0 right-censored observations

ANNEX 5: MARGINAL EFFECTS FOR TE AFTER TOBIT

Marginal effects after tobit
y = Fitted values (predict)
= .51924901

variable	dy/dx	Std. Err.	z	P>|z|	[95%	C.I.]	X
q1sxhd10*	.0202079	.02804	0.72	0.471	-.03475	.075166	.308271
q2aghd10	-.0019556	.00114	-1.72	0.085	-.004183	.000272	43.1015
q4scy10	.00165	.00323	0.51	0.609	-.004672	.007972	6.67293
q9pocc10	-.0000312	.00047	-0.07	0.947	-.00095	.000888	-7.22932
q11yfm10	.0004966	.00113	0.44	0.659	-.00171	.002703	18.5263
Landha	.0151024	.00833	1.81	0.070	-.001227	.031432	1.704
LnOthe~c	.0170428	.01041	1.64	0.102	-.003361	.037447	12.3942
LnOthe~s	.0239644	.00824	2.91	0.004	.007824	.040105	12.0858
K1IDNK10	-.0079354	.00336	-2.36	0.018	-.014525	-.001346	3.77237
K6SEXT10*	.0644592	.02528	2.55	0.011	.014903	.114016	.379699
K8PSCBN*	.1442404	.07115	2.03	0.043	.004793	.283688	.030075
LnTota~t	-.0014819	.00219	-0.68	0.498	-.005766	.002802	6.08247

(*) dy/dx is for discrete change of dummy variable from 0 to 1

ANNEX 6: TOBIT MODEL ECONOMIC EFFICIENCYRESULTS

Tobit regression　　　　Number of obs = 267
LR chi2(12) = 48.82
Prob> chi2 = 0.0000
Log likelihood = 58.196534　　　　Pseudo R2 = -0.7224

ee	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
q1sxhd10	-1.65e-06	.0279326	-0.00	1.000	-.0550096	.0550063
q2aghd10	.0002443	.0011358	0.22	0.830	-.0019925	.002481
q4scy10	-.0027336	.0032234	-0.85	0.397	-.0090815	.0036144
q9pocc10	-.0011576	.0004689	-2.47	0.014	-.002081	-.0002342
q11yfm10	.0001412	.0011217	0.13	0.900	-.0020678	.0023503
Landha	.0053578	.0083326	0.64	0.521	-.0110516	.0217672
LnOtherInc	.0210641	.0104091	2.02	0.044	-.0415628	-.0005653
LnOtherAss~s	.033622	.0082359	4.08	0.000	-.0498409	-.017403
K1IDNK10	-.0037822	.0033626	-1.12	0.262	-.0104042	.0028399
K6SEXT10	.0002436	.025255	0.01	0.992	-.0494913	.0499785
K8PSCBN	.0005179	.0711514	0.01	0.994	-.1396013	.1406371
LnTotalCre~t	.0049759	.0021825	2.28	0.023	-.0092741	-.0006778
_cons	1.327792	.1413869	9.39	0.000	1.049357	1.606227
/sigma	.1945817	.0084204			.1779994	.211164

Obs. summary: 0 left-censored observations
267 uncensored observations
0 right-censored observations

ANNEX 7: MARGINAL EFFECTS FOR EE AFTER TOBIT

Marginal effects after tobit
y = Fitted values (predict)
= .62822305

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
q1sxhd10*	-1.65e-06	.02793	-0.00	1.000	-.054749	.054745	.310861
q2aghd10	.0002443	.00114	0.22	0.830	-.001982	.00247	43.0899
q4scy10	-.0027336	.00322	-0.85	0.396	-.009051	.003584	6.68165
q9pocc10	-.0011576	.00047	-2.47	0.014	-.002077	-.000239	-7.20225
q11yfm10	.0001412	.00112	0.13	0.900	-.002057	.00234	18.4682
Landha	.0053578	.00833	0.64	0.520	-.010974	.021689	1.7052
LnOthe~c	.0210641	.01041	2.02	0.043	-.041465	-.000663	12.3929
LnOthe~s	.033622	.00824	4.08	0.000	-.049764	-.01748	12.0857
K1IDNK10	-.0037822	.00336	-1.12	0.261	-.010373	.002808	3.76948
K6SEXT10*	.0002436	.02525	0.01	0.992	-.049255	.049742	.378277
K8PSCBN*	.0005179	.07115	0.01	0.994	-.138936	.139972	.029963
LnTota~t	.0049759	.00218	2.28	0.023	-.009254	-.000698	6.1038

(*) dy/dx is for discrete change of dummy variable from 0 to 1

ANNEX 8: TOBIT MODEL ALLOCATIVE EFFICIENCYRESULTS

```
Tobit regression                                  Number of obs   =        266
                                                  LR chi2(12)     =      61.86
Prob> chi2     =     0.0000
Log likelihood = -129.53948                       Pseudo R2       =     0.1928
------------------------------------------------------------------------------
AE |      Coef.   Std. Err.      t    P>|t|     [95% Conf. Interval]
-------------+----------------------------------------------------------------
    q1sxhd10 |  -.0018392   .0529504    -0.03   0.972    -.1061169    .1024384
    q2aghd10 |  -.0033161   .0021166    -1.57   0.118    -.0074844    .0008523
     q4scy10 |   .0049122   .0061603     0.80   0.426    -.0072196    .0170441
    q9pocc10 |  -.0010439   .0008615    -1.21   0.227    -.0006527    .0027406
    q11yfm10 |  -.0002974   .0021267    -0.14   0.889    -.0044855    .0038908
Landha |    .031637    .016722     1.89   0.060    -.0012944    .0645683
LnOtherInc |   .0332421   .0200527     1.66   0.099    -.0062486    .0727328
LnOtherAss~s |    .078784   .0157412     5.00   0.000     .0477841    .1097839
    K1IDNK10 |  -.0133497    .006518    -2.05   0.042    -.0261859   -.0005135
    K6SEXT10 |    .074791   .0479215     1.56   0.120    -.0195832    .1691652
     K8PSCBN |   .2097635   .1536606     1.37   0.173    -.0928477    .5123747
LnTotalCre~t |    .003484   .0041264     0.84   0.399    -.0046424    .0116104
       _cons |  -.4643297   .2707219    -1.72   0.088    -.9974751    .0688157
-------------+----------------------------------------------------------------
      /sigma |   .3460318   .0193219                      .3079803    .3840834
------------------------------------------------------------------------------
  Obs. summary:          0  left-censored observations
                       180     uncensored observations
                        86 right-censored observations at AE>=1
```

ANNEX 9: MARGINAL EFFECTS FOR AE AFTER TOBIT

Marginal effects after tobit
y = Fitted values (predict)
= .83552078

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
q1sxhd10*	-.0018392	.05295	-0.03	0.972	-.10562	.101942	.308271
q2aghd10	-.0033161	.00212	-1.57	0.117	-.007465	.000832	43.1015
q4scy10	.0049122	.00616	0.80	0.425	-.007162	.016986	6.67293
q9pocc10	-.0010439	.00086	-1.21	0.226	-.000645	.002733	-7.22932
q11yfm10	-.0002974	.00213	-0.14	0.889	-.004466	.003871	18.5263
Landha	.031637	.01672	1.89	0.058	-.001137	.064411	1.704
LnOthe~c	.0332421	.02005	1.66	0.097	-.00606	.072545	12.3942
LnOthe~s	.078784	.01574	5.00	0.000	.047932	.109636	12.0858
K1IDNK10	-.0133497	.00652	-2.05	0.041	-.026125	-.000575	3.77237
K6SEXT10*	.074791	.04792	1.56	0.119	-.019133	.168715	.379699
K8PSCBN*	.2097635	.15366	1.37	0.172	-.091406	.510933	.030075
LnTota~t	.003484	.00413	0.84	0.398	-.004604	.011572	6.08247

(*) dy/dx is for discrete change of dummy variable from 0 to 1

ANNEX 10: HOUSEHOLD CHARACTERISTICS BY DISTRICT

Variables	Busia		Mbale		Budaka		Tororo	
	Mean	S. deviation	Mean	S. deviation	Mean	S. deviation	Mean	S. deviation
Age	43.42	12.75	42.5	11.47	42.37	11.39	44.18	13.46
Schooling	8	3.78	7.29	2.71	7.73	2.34	7.08	3.55
Farming years	19.99	11.71	21.02	13.25	19.41	9.59	16	12.16
Farm size	1.98	1.85	0.93	0.68	1.43	1.16	1.64	1.37
Total income	511,069.50	836,968.53	449,527.80	626,421.30	237,579.00	503,722.07	605,238.00	673,408.93
On-farm income	300,868.20	482,636.09	354,018.50	478,191.10	193,526.30	459,604.46	374,363.00	517,639.59
Off-farm income	92,281.82	167,813.07	57,546.30	122,571.60	37,736.84	526,15.84	118,625.00	203,279.23
Value of assets	535,044.90	1,061,745.00	408,805.60	604,878.70	878,263.20	1,461,348.70	475,188.00	742,618.40
Distance to the input market	4.19	3.29	3.27	3.17	3.84	3.35	3.16	1.63
Price per kg of beans sold	3,025.54	2,906.98	3,124.89	2,370.50	4,271.78	1,872.78	3,502.59	2,193.28
Credit	85,697.74	42,656.53	77,288.00	39,742.30	71,360.20	42,344.84	75,866.30	32,544.41