ANALYSIS OF TECHNICAL EFFICIENCY AND WELFARE EFFECTS OF SNOW PEAS PRODUCTION BY SMALL SCALE FARMERS IN NYANDARUA COUNTY, KENYA

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DECLARATION AND RECOMMENDATION

Declaration

I declare that this thesis is my original work and has never been submitted in this or any other university for the award of a degree.

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DEDICATION

With love and gratitude, I dedicate this work to my loving husband pastor Steve Ndegwa, my mother Ruth Mukami, my daughter Lakicia Ndegwa and my brother Steve Irungu.

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ABSTRACT

Horticultural sector is an important sector in production of food and generation of income. According to Kenya's vision 2030, crop cultivation is one of the main pillars of unlocking the potential of Kenya through increased productivity. The importance of snow peas is increasing greatly due to its high demand especially in Europe. In spite of the benefits associated with the production of snow peas, farmers in Nyandarua county have been withdrawing from its production probably due to low profitability. Profitability can be founded in technical inefficiencies. Studies on technical efficiency of snow peas are limited. This study was aimed at determining the level of efficiency of small scale farmers in Nyandarua County and categorizing them into two categories on the basis of their efficiency. The study also determined the impact of snow peas production by comparing adopters and dis-adopters in terms of their annual income, assets and expenditure. The study was conducted in Kinangop sub-County, Kenya in three wards Engineer, Gathara and Kinangop whose main economic activity is farming. The study utilized multiple stage sampling method where 267 samples were collected. A structured questionnaire was used to solicit information on socio-economic, institution, market and physical factors from small scale snow peas farmers. Stochastic frontier, and tobit regression models and propensity score matching were used to analyse the data. Stata and Statistical Package for Social Sciences (SPSS) software were used for the purpose. Results showed a wide variation between the most efficient farmer and the less efficient farmer. The efficiency scores ranged from 0.3 to 0.9 with a mean of 0.7 which means, farmers can reduce input application by 30% without affecting output. The study found that what characterized farmers in the first cluster of most efficient farmers were; high level of annual income, many years of experience in farming and fewer years in formal education. Again, the study revealed that the most efficient farmers came from Gathara and Engineer wards. It was noted that being in on-farm activities alone as compared to being in both on-farm and off-farm activities increased the level of efficiency of snow peas farming. Receiving extension services and having a higher level of annual income had a positive effect on the level of technical efficiency. In addition, more years in formal education was depicted to have a negative relationship with efficiency. Impact assessment results indicated that participating farmers had high levels of annual income, assets and expenditure compared to non-participating farmers. Due to the role played by snow peas production in improving the welfare of farmers, they should not withdraw from its cultivation but should rather enhance technical efficiency by forming snow peas farmers group and seek extension services concerning snow peas growing.

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LIST OF ACRONYMS AND ABBREVIATIONS

AEP-	Average Effect of Participation
ATE -	Average Treatment Effect
ATT-	Average Treatment on Treated
CD-	Cobb Douglas
CIA-	Condition Independence Assumption
CIDP-	County Integrated Development Plan
DEA -	Data Envelopment Analysis
DFA-	Distribution-Free Approach
DMU -	Decision Making Unit
EPZ-	Export Processing Zone
HIS-	Humane Society International
IFAS -	Institute of Agriculture Food Sciences
KNBS -	Kenya National Bureau of Statistics
MC -	Marginal Cost
PCA-	Principal Component Analysis
PSM -	Propensity Score Matching
SDG-	Sustainable Development Goals
TE-	Technical Efficiency
TFA-	Thick Frontier Approach
TTE -	Total Treatment Effect

CHAPTER ONE
INTRODUCTION

1.1 Background

For centuries, agriculture has been playing a crucial role in the development of nations. Agriculture can stimulate faster growth, reduce poverty as well as sustaining the environment if it is allowed to partner with other sectors of the economy. As an economic activity Agriculture can be a provider of investment opportunities for the private sector, a source of growth for the national economy and a main driver of agricultural related industries and the rural nonfarm economy (Awokuse and Xie 2015).

Kenya produces a wide variety of horticultural commodities. They are produced from major horticultural production areas, situated in different parts of the country. Most production is rain-fed, but irrigated products are also cultivated especially if production is for export purposes. Vegetables and fruits are grown both for household consumption and sale while cut flowers are only cultivated for commercial purposes (Kamau, 2017; Ministry of Agriculture, 2010). Majority of horticultural commodities meet domestic demand, but some are exported to overseas markets (Salami, Kamara, and Brixiova, 2010; Rutere, 2014).

The horticultural sector is therefore important as a producer of food, source of income, employment, and foreign exchange. According to the vision 2030, crop cultivation is one of the main pillars of unlocking the potential of Kenya through increased productivity of crops (Nguguna, Kamau and Owino, 2009; Ndung'u, Adam and Collier, 2011). The horticultural sub-sector has grown since to become a major pillar of economic growth. The horticulture industry is the fastest growing agricultural sub-sector and is ranked third in terms of foreign exchange earnings from exports after tourism and tea (KNBS, 2013; Kamau, 2017).

Snow peas (*Pisum sativa var. saccharatum)* is a high-value crop typically grown in temperate regions (Ferrarezi, Weiss, Geiger, and Beamer, 2016). Despite being moderate to low yielders, snow peas have been continually grown for thousands of years due to their favourable eating qualities and their ability to improve the soil. Snow peas were introduction to the Kenyan agricultural sector but their adoption by the farmers has been relatively slow due to the challenges experienced during the production and marketing processes. However, their importance has increased greatly due to their high demand especially in Europe (Weinberger and Lumpkin 2007).

Central Kenya offers favourable ecological conditions for production of peas. Production is mostly carried out by small scale farmers who are contracted by exporters (Mburu, Muriithi and Mutinda J. 2017). Most of them lack basic knowledge of producing them as well as capital for production and export opportunities (Davis, 2006). The industry is therefore characterized by brokers and middlemen who place farmers at a disadvantaged place in terms of prices and other benefits that should be associated in the entire value chain (Odero, Mburu, Ackello-Ogutu and Nderitu, *2013).* This could be possibly explained by the nature of peas. Owing to its perishable nature, brokers take advantage of the farmers by buying the products at low price on realizing they have already harvested. This could therefore be one of the major reasons why the adoption of snow peas has been slow in Kenya. Beside this dilemma, the market for snow peas has also been unstable due the consistent fluctuation in prices. This has discouraged farmers from investing in the venture (Rugenyi, 2011).

The major snow peas production areas are Nyandarua, Nyeri, Kirinyaga and Meru Counties where varieties such as dwarf grey sugar, Oregon sugar pod, mommoth melting sugar, sugar snap sweet horizon, snow wind and Toledo are grown. Picking of snow peas begins 60 to 70 days after sowing and continues for about 2 months. Snow peas produce best yields and quality in cool and moist growing conditions. The crop is sensitive to heat. Ideal growing conditions are average daily temperatures of 12-20 ºC with a maximum of 24 ºC and minimum 7 ºC. Peas can be grown on a wide range of soil types, provided the soil is well drained. Good drainage is essential for vigorous growth. They do well in well distributed rainfall of 1,555-2,200 mm per year at an altitude of 1,500-2,600 above sea level. Snow peas, as most legumes, prefer a soil pH range of 6.0 to 7.0. The minimum soil temperature for growth is 10 °C. Due to these climatic condition requirements, they are suited for the highland regions of Kenya (Kimiti, Odee, and Vanlauwe, 2012).

Being an export crop, higher quality standards are required. This has been a challenge to small scale farmers (Mburu *et al.*, 2017). This is because snow peas crop is highly susceptible to many pests like aphids and whiteflies. Furthermore, during the wet seasons, the crop is normally attacked by downy mildew and powdery mildew during the dry season. However, disease pressure is generally higher during the rainy seasons. If there is no effective disease and pest control mechanisms, quality is greatly lowered because farmers are forced to use chemicals to control the pests and diseases (Kamau, 2017). This may again translate to lower prices and great losses to farmers.

Despite the potential of peas, its productivity has remained low in the country. Peas yield 1560kg/acre against a potential of 3000kg/acre. Since production is largely rain fed, climatic change has affected productivity greatly. Cases of crop failure resulting from crop destruction by pest and diseases are reported frequently. As a result, farmers are forced to use more inputs such as fertilizers, herbicides and pesticides. Use of more inputs on the other hand increases the cost of production (MoALF, 2016).

Due to the high cost of the routine management practices such as planting, weeding, trellising, pesticide control, disease control, sorting and grading, high amount of capital is required and if these ventures do not bring back proportionate returns, farmers are discouraged to grow snow peas production in the subsequent seasons. High cost of production could also be founded on inefficiencies in the use of resources. (Riatania *et al.*, 2014). It therefore becomes essential to understand the efficiency with which these farmers combine the inputs given the state of the technology to maximize profit. Improving efficiency increases the productivity, welfare of households and the general economic growth hence it's crucial for any policy (Coelli and Rao, 2005) Much empirical evidence suggests that although producers may attempt to optimize, they do not always succeed. This is because even after the introduction of a new technology, it may take a long time before adoption and the subsequent learning of how to use it efficiently (Shumet, 2011)

1.2 Statement of the problem

Previous studies have shown that production of snow peas in Mt Kenya region does not only benefit the entire economy in terms of it being a source of foreign exchange earnings, but the crop also creates employment especially for the rural population as well as generating income for farmers. In spite of the benefits, snow peas farmers in Nyandarua county have been withdrawing from its production perhaps due to low profitability. Low profitability could be founded in technical inefficiencies. Studies on technical efficiency in pea's production are limited. The purpose of this study was therefore to bridge this knowledge gap by determining whether inefficiency in production could be one of the factors that affect snow peas production in Nyandarua County.

1.3 Objectives

1.3.1 General objective

To contribute to improved production and economic welfare of small scale snow peas' farmers in Nyandarua County, Kenya through improved efficiency in production of snow peas.

1.3.2 Specific objectives

1. To estimate technical efficiency of snow peas production and characterize snow peas farmers in Nyandarua County based on their technical efficiency.
2. To identify factors affecting technical efficiency of snow peas production in Nyandarua County.
3. To determine difference in income, assets and expenditure of adopters and non-adopters of snow peas enterprise in Nyandarua County.

1.4 Research questions

1. What is the range of technical efficiency scores of snow peas farmers in Nyandarua County?
2. What are the factors affecting technical efficiency of snow peas production in Nyandarua County?
3. Are there differences in income, assets and expenditure for the adopters and dis adopters of snow peas enterprise in Nyandarua County?

1.5 Justification

This research was motivated by the role snow peas plays in the contribution to the economic welfare of small scale farmers in Nyandarua County. It is ranked fifth after Irish potatoes, maize, cabbages and garden peas (County Agriculture office Nyandarua County, 2013) and earned 31.5 million shillings in 2012. According to Nyandarua County Government CIDP (2013), The County is predominantly reliant on agriculture. One of the objectives of Nyandarua County CIDP 2013-2017 is to address the challenges that are leading to the decline of major crops in the county.

Rugenyi (2011) recommended studies that would focus on whole smallholder snow peas value chain, identifying levels of inefficiencies in the chain. This study was therefore important as it concentrated on technical efficiency of snow peas in Nyandarua County. This also added to the body of literature on studies done on snow peas and efficiency. In addition, the study came up with policy recommendations, both short and long term, that are applicable in achieving the plans and the overall contribution towards the realization of the vision 2030. The policies will guide the extension officers on the information they need to disseminate to farmers as well as recommend to farmers how best to combine scarce resources for maximum benefit.

1.6 Scope and limitation of the study

The study focused on technical efficiency for snow peas production. Allocative and economic efficiency were not investigated because of the limited availability of resources and not due to their insignificance in snow peas production.

The study targeted small scale farmers in Nyandarua County specifically in Kinangop sub-county due to its importance in the national snow peas production. The results may be generalized to the farmers in the entire county with the same land size holdings and ecological conditions.

The study was also limited by availability of reliable data since the study relied on the honesty of farmers. Most farmers in Nyandarua County do not keep agricultural records

1.7 Operational Definition of Terms

Snow peas: A variety of pea with an edible pod, eaten when the pod is young and flat together with the peas inside them.

Small-Scale farmer: A snow pea farmer who does production activities on an area of land less than or equals to 5 acres of land either owned or leased.

Household: Social unit comprising of one or more people who live in the same dwelling and sharing meals. There should be a head to whom all other members are answerable to.

Technical efficiency: This is the ability of the farmer to maximize snow pea output from a given level of input or from a given set of resources.

Welfare Effects: The level of income, assets and expenditure of a household.

CHAPTER TWO
LITERATURE REVIEW

2.1 Small scale farming

Most farmers in Sub-Saharan Africa have limited access to land. The threshold ranges from 5 acres, mean or median land size (Mugera and Karfakis, 2013). Beside the shortage of land, use and ownership of land is another important attribute that characterizes these farmers (Jayne, Yamano, Weber,Tschirley, Benfica, Chapoto, and Zulu, 2003). Differentiating between land ownership and use becomes an issue of concern as far as small scale farming is concerned. Most small scale farmers have challenge in accessing land for farming. The challenge of land ownership calls research on how farmers can utilize the little land they have in order to remain relevant and buoyant with the changes in the market and climatic conditions. The farming system employed by farmers, either extensive or intensive also determines their classification as either large or small.

Previous studies have shown small scale farming is vital in realization of economic development in Sub-Saharan Africa. It is one of the key economic activities that could lead to decreased hunger and a way to end poverty in these countries. Due to the contribution of small scale farmers in the economy, there should be a call for greater and effective investment in small scale farming if we are to realize satisfactory results. Careful examination has revealed that, despite the contribution of small scale farmers in economic growth, there are a number of challenges facing them. This is even after the many projects, activities and support initiated by the government in the effort to enhance small scale farmers' participation in farming (Afenyo, 2012)

The world has really evolved in terms of technology and this means farming techniques and technology have to evolve in order to keep up with the pace of the ever changing circumstances. Even after great innovation in farming, small scale farmers have not been able to effectively adopt these technologies (Republic of Kenya 2007; Ogada, Nyangena and Yesuf, 2010). Attempts have been made to provide inputs, increase access to market, link them with credit market as well as provision of extension programs. These attempts have not however been able to adequately address the challenges facing small scale farmers (Ogada, Mwabu and Muchai, 2014).

According to Mugera and Karfakis (*2013*), globalization has led to changes in marketing and trading modes. This has not only affected international marketing chains but has also affected domestic markets structures. The quality standards, timing of supply and quantity of supply required in modern markets favours farmers within large operations at the expense of small scale farmers. This is because these constraints require adjustments which can only be accommodated by large firms. This does not however mean that small scale farmers cannot be integrated into global markets. However, there is need for government intervention so as to assist farmers in realizing ways to cope with challenges they face.

Amidst these challenges, smallholder farmers have also been affected by the increased concerns on environment and climatic changes. Due to lack of sufficient human, social, financial and information, farmers find it challenging to adjust to these changes (Mugera and Karfakis, 2013). Research therefore needs to be conducted in order to suggest ways that smallholder farmers can adopt so as to adjust to these threats.

2.2 Technical efficiency

Efficiency is achieved when a farmer produces the maximum possible output from inputs used, subject to existing technology (Amadou, 2007). This could be either by maximizing output from a set of resources or by minimizing the resources required to produce a given output (Rahman, Ajayi, and Gabriel, 2005). In economics, production efficiency comprises both technical and allocative efficiencies where technical efficiency reflect farmers ability to maximize output given resource constraints while allocative efficiency reflects farmer's ability to use resources optimally given their prevailing prices and production technology (Coelli, Rao, Donnel, and Battese, 2005). When a firm is both technically and allocative efficient, we can conclude that the firm is economically efficient.

In stochastic frontier production function, an efficient farmer operates on the production frontier while an inefficient farmer operates below it (Rahman, 2009). This concept is related to productive efficiency concept since production efficiency is concerned with producing at the lowest point on the short run average cost curve. Thus production efficiency requires technical efficiency. Technical efficiency is also necessary for allocative efficiency which means an output level where the price equals the marginal cost (MC) of production.

The government of Kenya, with the aid of developing partners has invested in the provision and distribution of technologies to enhance agriculture such as high-yielding varieties and inorganic farming targeting small scale farmers. Adoption of the new technologies has improved some sectors for example maize. However, studies show that general productivity has been declining or remaining stagnant (Maurice, Dianah, Germano and Mary, 2014). There is therefore need for further studies to determine the cause of the trend.

2.3 Factors affecting technical efficiency

Efficiency can be categorized into agent and structural (Van, P., Louwers and Van H. 2006). Agent factors include education level, age and social capital. Structural factors are either on-farm or off-farm. On-farm includes farm location, farm type, farm size, fertility and drainage while off-farm includes policy, infrastructure, upstream and downstream relations (Maurice *et al.,* 2014). According to Brazdik (2006), these factors are grouped into three broad categories that is, 1. Farm-specific variables: intensity of inputs such as seeds, fertilizer and labor and farm size, organizational structure such as tenure, crop varieties 2. Economic factors (prices of inputs and outputs) 3. Environmental factors, that is, wed-dry period and village.

Factors affecting technical efficiency of a farmer could also be categorized as socio-economic, demographic factors, farm level characteristics, environmental factors and non-physical factors. They are likely to affect technical efficiency of most small scale farmers either positively or negatively. Rahman and Umar (2009) and Parikh, Ali and Shah, (1995) used stochastic cost frontier to analyse efficiency in two-stage estimation and found that, education, credit per acre and number of extension visits significantly increased cost efficiency while large land holding size significantly decreased cost efficiency.

According to (Mkhabela, 2005), high number of extension services, more experience and higher diversity of cropping systems increased the efficiency level of farmers. He also found that, with increased education and off-farm income, the level of efficiency decreases. This contrasts the findings of (Sreenivasa, Sudha, Hegde and Dakshinamoorthy, 2009) who found that education is positively related to efficiency. They also found that age of the farmers was positively related to technical efficiency although it was not sufficient enough to influence the technical efficiency. Institutional factors such as cooperative societies were found not to affect technical efficiency. In small farmers, credit was found to influence technical efficiency negatively. Rahman and Umar, (2009) conducted a study on technical efficiency of crop production and realized that labour, fertilizer, age, gender, household size, marital status, other occupation and land ownership were among the important factors related to technical efficiency.

Most studies in Kenya have examined the influence of economic and farm-specific on production efficiency of crops but environmental factors are not fully explored (Kirimi and Swinton, 2004). Studies done are also general and there is therefore a need to consider specific crops. This study bridges the gap by narrowing the study down into snow peas production.

2.4 Approaches for measuring technical efficiencies

There are two major approaches used in measuring technical efficiency; parametric and non-parametric methods.

2.4.1 Non-parametric Approach

Data Envelopment Analysis (DEA) is a non-parametric or mathematical programming approach used for measuring productive efficiency of units by the consideration of multiple-inputs and outputs (Tolga, Nural, Mehmet and Bahattin, 2009). Many other researchers in agriculture have used it for example Coelli, Rahman and Thirtle, (2002). There are two major orientation of the DEA approach in measuring efficiency: input and output orientation. The approach has some drawbacks in that its recommendations for reducing input application or expanding output levels are in terms of fixed proportions.

2.4.2 Parametric Approach

Stochastic frontier approach shows the relationship between output and input levels using two error terms. One of the error terms is the normal error term where the mean is zero and the variance is constant. The second error term constitute technical inefficiency and may be expressed as a half-normal, truncated normal, exponential, or two-parameter gamma distribution (Njeru, 2010). Technical efficiency is again estimated through maximum likelihood of the production function subject to the two error terms.

Stochastic frontier production function follows either two-step approach that first specifies the stochastic frontier production function to determine the technical efficiency indicators after which the indicators are regressed on independent variables, which represent the specific characteristics of the farm using the ordinary least square (OLS) method. The major limitation of this approach is the assumption that the inefficiency impacts are independent and identically distributed. Reifschneider and Stevenson (1991) tried to come up with ways of overcoming this drawback by developing a model in which inefficiency effects are defined as an explicit function of certain factors which are specific to the farm. All the parameters are estimated in one step using the maximum likelihood procedure, and thus the one-step approach. This one step approach has been used by other researchers for example (Rahma, 2009 and Sekhon, Amrit, Manjeet and Sidhu, (2010). Another parametric approach is the Thick Frontier Approach (TFA) that specifies a functional form and it assumes that deviations from the predicted performance values from the highest and lowest performance quartiles of the observations. Finally, the Distribution-Free Approach (DFA), which also designates a functional form for the frontier, except that it assumes that the efficiency of each firm is stable over time, whereas the random error tends to average out to zero over time (Ogundele and Okoruwa, 2006).

Out of these approaches, the most preferred in agricultural economics is stochastic frontier approach because the basic assumption of non-parametric approach and deterministic frontiers: that all deviations from the frontier are due to producer’s inefficiency is highly unrealistic in the agricultural sector. In agriculture, variability in output can be attributed to climate uncertainty, plant pathology and insects, government regulations and policies, and international markets. In addition, low education level of most farmers makes information gathered on production statistics inaccurate. Moreover, the non-stochastic approaches are extremely sensitive to outliers and if the outliers are reflected in the data, they distort the frontier and the efficiency measures derived from it (Njeru, 2010)

2.5 Effects of high value crop on welfare of farmers

Production of high value crops helps the rural poor to achieve food security as most of them derive their livelihood and income from agricultural production. Even though with much challenges, this is evident especially in Sub-Saharan Africa where majority of the people experience highly valuable domestic production (Goitom, 2009).

With the reality that about half of the world's population lives in rural areas and most of them depend on agriculture for livelihoods, production of crops is likely to be a pillar to rural development and rural poverty alleviation (Hazell, Poulton, Wiggins and Dorward, (2007). Apart from this, crop cultivation creates jobs to majority of the population which account for 65% of the labour force (World Bank 2008). Income earned from wages is used to purchase other basic necessities.

For African countries to achieve Sustainable Development Goals (SDG), faster growth in agriculture should be realized (World Bank, 2007). The contribution of small scale farmers as the major drive of rural growth and development as well as livelihoods improvement depends on their level of transformation from subsistence oriented to production of high value crops for commercial purposes. In Tanzania for example, most farmers who escaped poverty were those who diversified their production to both food and cash crops (World Bank, 2007).

According to Pratt, Constantine and Murphy (2017), pea is considered a high value crop. Snow peas and French beans account greatly for Kenya's horticultural export. In 2011 for example, they accounted for 7.5% of horticultural exported earnings. Snow peas are the second most valuable vegetables after French beans. Trade of high value snow peas has provided a good market to small scale farmers thus improving their rural economic development. 80% of snow peas exports from Kenya are contributed by small scale farmers. By 2011, Kenya was the leading exporter of snow peas to the European Union. (Mburu *et al.,* 2017).

Most studies from the reviewed literature concentrated on technical efficiency of other crops other than snow peas. Additionally, none of these studies have focused specifically on technical efficiency of snow peas production in Nyandarua County. Influence of non-farm income and number of crops grown on technical efficiency has also not been captured in most studies. It was also realized that, even though many projects, activities and support have been initiated to help small scale farmers, they still face challenges especially how to combine scarce resource for maximum benefit. This therefore needs to be addressed especially in the efficiency part of production. Hence, these are empirical gaps that this study aimed to address.

2.6 Theoretical framework

The research was based on the neoclassical theory of production. Production is the process of transforming inputs into output and may take several forms: change in form or change in place. This therefore means that production increases consumer usability of goods and services (Saari, 2006).

Production concept classifies inputs into labour, land, capital, raw materials, technology and time. Entrepreneurship has also been added as an input and is measured by the managerial expertise and ability to manage the other factors of production (Shepherd, 2015). An input is anything that goes into the production process. It might be a good or a service. Inputs are classified as fixed or variable depending on how their use can be changed in the production process. From an economic point of view, a fixed input is one whose supply is inelastic in the short run but from a technical point of view, a fixed input remains fixed for a certain level of output. A variable input is one whose supply is elastic in the short run. Technically, a variable input changes with changes in output. However, all inputs are variable in the long run. Output on the other hand is the end result of the production process and could be a good or service that is derived from the production process (Fuss and McFadden, 2014; Ferguson, 2008).

The technical relationship between inputs and outputs is described by the use of a production function. Inputs and outputs are expressed in quantitative forms. Production function is therefore the maximum amount of output that can be produced from a given set of inputs. Production function also represents the technology of a firm. In this case, technical efficiency is achieved when a farmer produces the maximum possible output from inputs used, subject to existing technology (Amadou, 2007). Economic efficiency on the other hand is attained when a firm is producing a given output at the lowest total cost (Färe, Grosskopf and Lovell, 2013). Production function can be represented in a mathematical model:

$$Q = F(Ld, L, K, M, T, t) \ldots\ldots 1$$

Where: *Ld* =land and building, *L*=labour, *K*=capital, *M*=materials, *T*=technology and *t*=time. If we reduce the number of inputs used into two: labour and capital, we would have the function as:

$$Q = F(K, L) \ldots\ldots 2$$

For Q to increase, L and K must be increased ceteris paribus. Whether the firm will increase its output depends on time period whether short run or long run.

The output can be expressed in terms of either total product, marginal product or average product. The interaction of total product, marginal product and average product curves describe the three stages of production.

The production function in (2) tells us the maximum output a firm could get from a given combination of labour and capital. Inefficiency in production could reduce output from what is technologically possible (Lobo, Bettencourt, Srumsk and West, 2013).

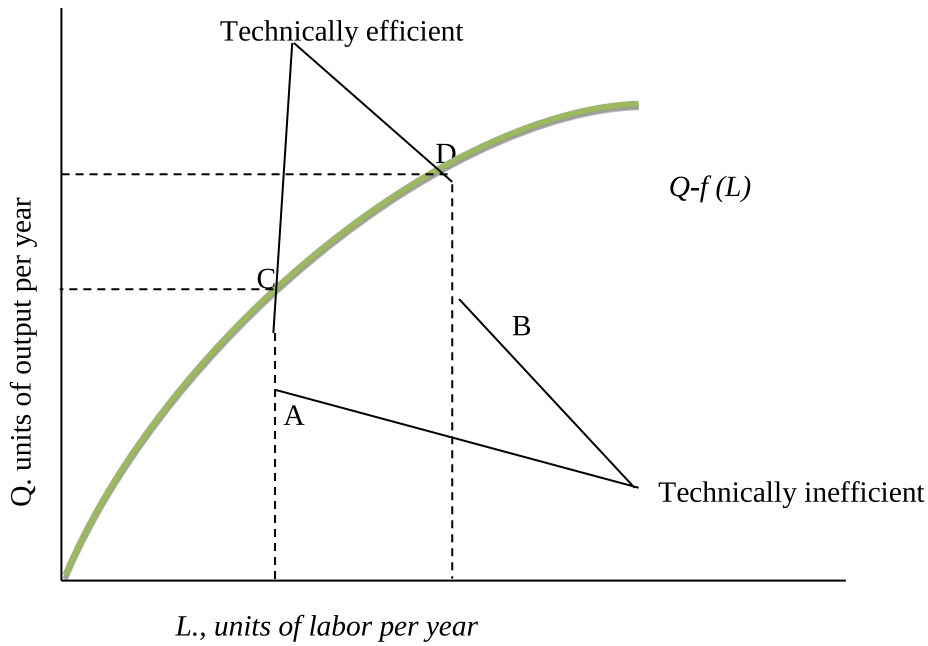

Figure 1: Output oriented decomposition function

Figure 1 depicts the possibility of a single input, labour. Point on or below the production function make the production set of the firm. At points A and B, the firm is technically inefficient: firm gets less output from employed labour than it could. Points on the boundary set, C and D are technically efficient since the firm produces maximum output from applied labour.

2.7 Conceptual framework

The conceptual framework diagram in figure 2 shows the relationship between various variables in the study. Socio-economic factors include education status measured in the number of years of formal education of a farmer, gender, size of the land, household size, marital status, age, experience, annual income and occupation. Institution factors include access to credit, access to social capital, access to extension services and group membership. Technological factors include access to inputs such as fertilizer, snow peas varieties, agrochemicals and farm machineries. Market factors on the other hand include infrastructure, and the prevailing prices of inputs and outputs.

Socio-economic, institutional and market factors affect farmer's management practices directly or through the technology the farmer will adopt. For example an experienced farmer is expected to be more efficient as compared to a less experienced farmer. If the cost of inputs is high, the farmer is likely to use less of the inputs which translate to low production. Farmer's management practices are linked to technical efficiency. Achievement of technical efficiency results to improved household income and welfare and ultimately to food secured economy. Improved income on the other hand influences snow peas farmers' management practices.

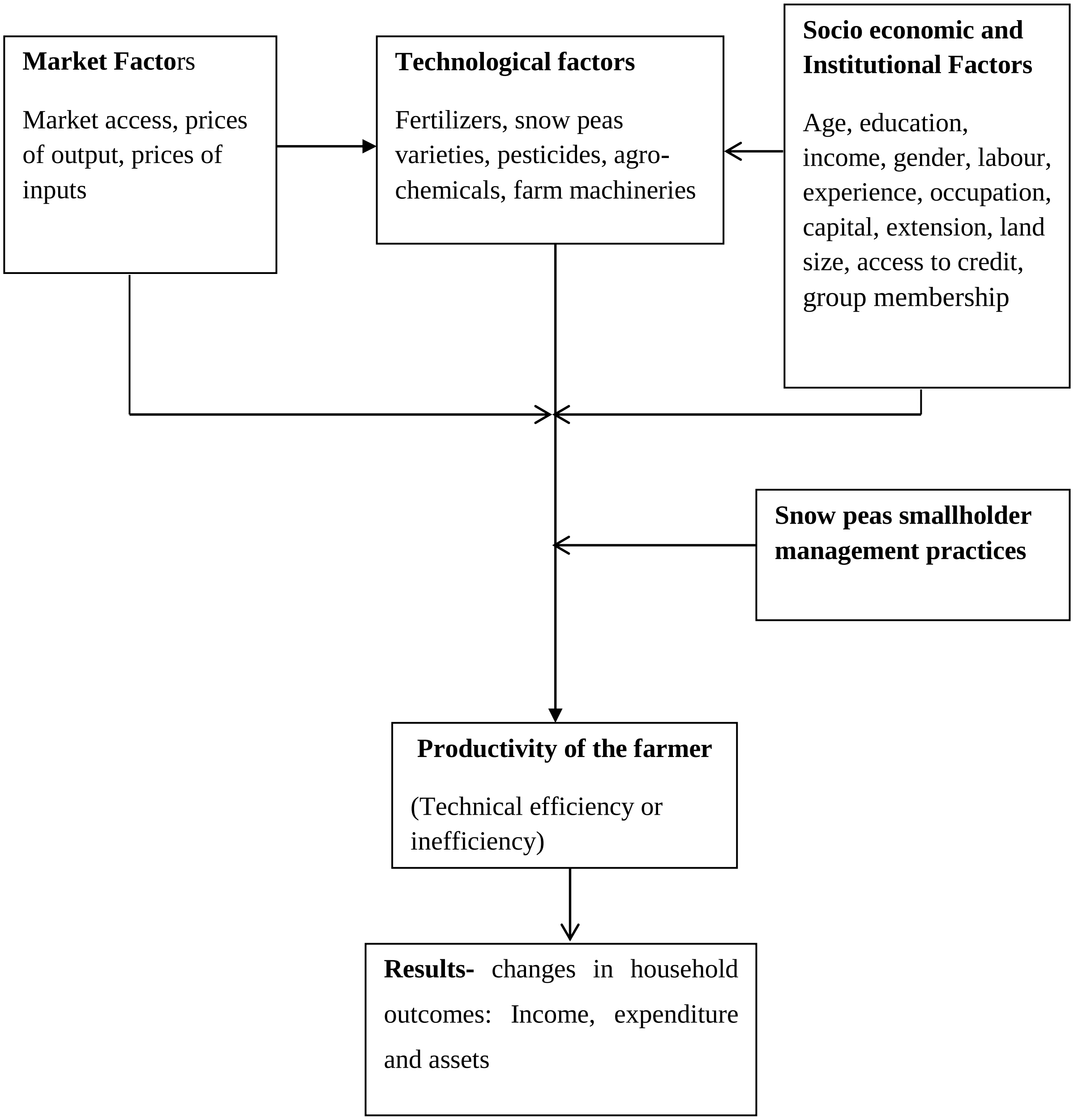

Figure 2: Conceptual framework of interaction of variables affecting technical efficiency of snow peas production

CHAPTER THREE

METHODOLOGY

3.1 Study area

This study was conducted in Nyandarua County whose capital and largest town is Ol Kalou. The altitude which is 3,500m above sea level and good climate are quite favourable for agricultural activities. The county has five constituencies: Kinangop, Kipipiri, Ol Kalou, Ol Joro Orok and Ndaragwa and 25 wards. It has a population of 596,268 and an area of 3,304 Km^2 according to the 2009 general census. Kinangop district where data was collected is the largest and has a population of 192,379 (94,331: male and 98, 048: female) (CIDP 2013). This was considered as the population for the purposes of this research. The district lies between latitude $0.50°0'$ to the North and $0°50'$ to South and between $36.20°\ 0'$ East and $36°50'$ West (Regional Center for Mapping of Resource for Development, 2016). The district's headquarter is Engineer town and covers an area of $882km^{2.}$ Administratively, the district has eight wards: Engineer, Murungaru, North Kinangop, Gathara, Githabai, Njambini/Kiburu, Nyakio and Magumu and 16 locations (CIDP, 2013). The study concentrated in Engineeer, Gathara and North Kinangop wards. Figure 3 shows the location of Kinangop district in Kenya as well as its administrative wards.

The main economic activities in the area are farming where main crops include: maize, wheat, beans, Irish potatoes, cabbages, carrots, snow peas and garden peas. A large proportion of the farming in the region is dedicated to food crops. The crops are not exclusively meant for subsistence as they also contribute to household income. The area has a high population density, the average size of land per farmer is small (5 acres) (Njarui, Gichangi, Gatheru, Nyambati, Ondiko, Njunie and Ayako, 2016) and hence smallholder farming is the most practiced method of farming. Nevertheless, a few large scale farmers also exist. Livestock production is also practiced but this is mainly on zero grazing bases for cattle due to the small sized pieces of land. Compared to other regions in central Kenya, the region produces the highest amount of milk (CIDP, 2013). The cool temperatures, high rainfall and altitude make the area a conducive place for the production of snow peas hence the selection of the area for purposes of this research. The well drained and highly fertile soils with high water retention capacity facilitate production of snow peas and also minimize the use of inputs. Snow peas are cultivated mainly for commercial purpose. Land size under snow peas farming ranges from 0.25 to 1 acre. Most farmers grow snow peas beside other crops. Mostly, farmers depend on brokers to market their produce even though there are informal arrangements with some companies through various groups.

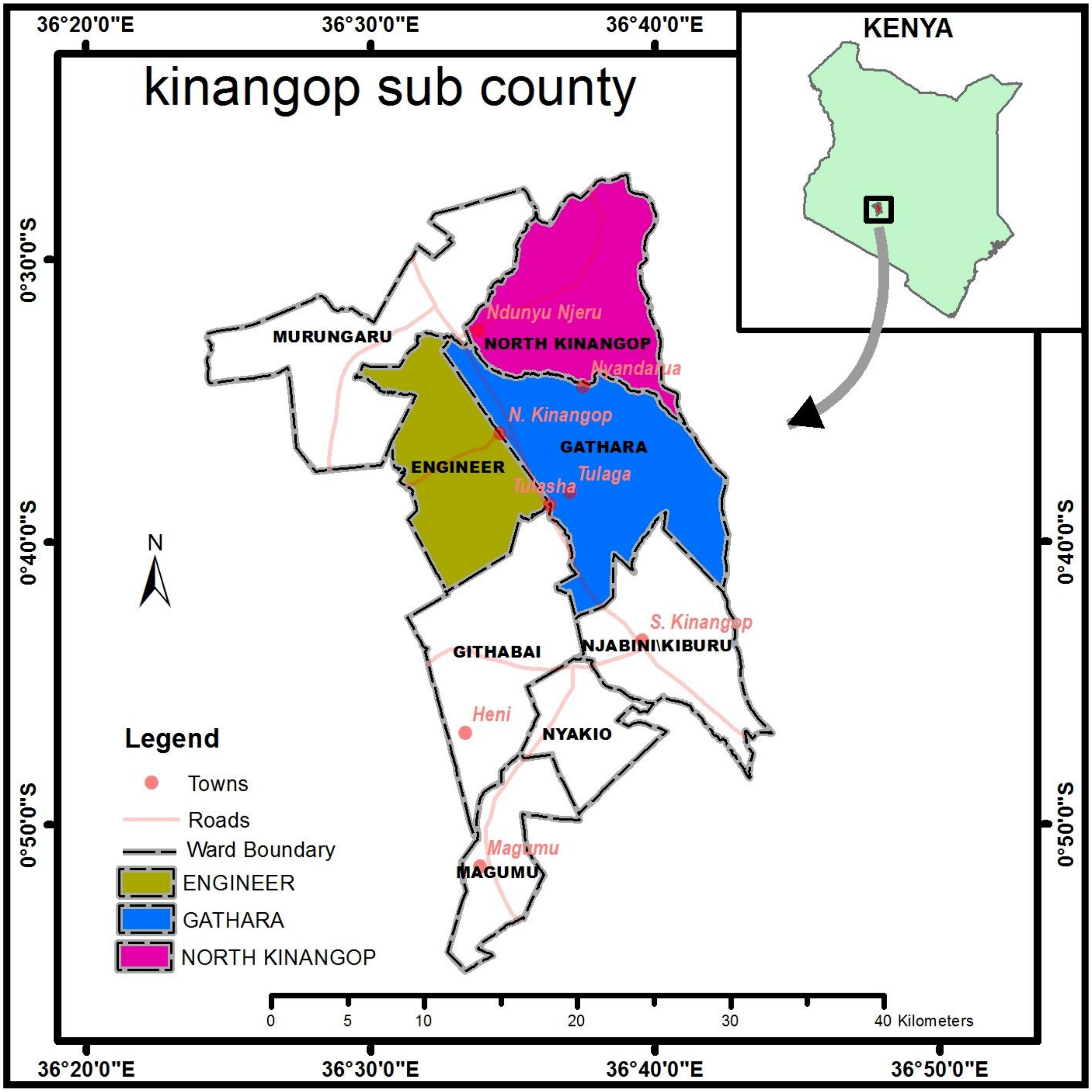

Figure 3: Map of study area

Source: Regional Center for Mapping of Resource for Development (2016)

3.2 Sampling procedure

The target population of the study was small-scale farmers. The study applied multiple-stage sampling procedure:

The first step included purposively selecting the three district wards: Engineer, Gathara and North kinangop due to their importance as the major snow peas growing area in the district followed by stratified sampling of snow peas adopters and dis-adopters. Finally proportionate random sampling to size was conducted to get the desired sample size. (Cochran formula in Mutai, 2014).

$$n = \left(\frac{z}{m}\right)^2 p(1-p) \qquad \text{.........} 3$$

$$n = \left(\frac{1.96}{0.06}\right)^2 0.5(1-0.5) = 267$$

Where: *n* = Sample size; *z* = confidence level; *p* = proportion of the population containing the major interest, and *m*= allowable error. Since the proportion of the population is not known with certainty, it is normally assumed that *p*= 0.5, and *z* = 1.96 and *m*= 0.06 (error the researcher is willing to accept). This results to a sample of 267 respondents.

To obtain impact estimates that are generalizable to the population of interest, it is necessary for the pool of comparison units to have a sufficient number of observations with characteristics corresponding to those of the treated units (Heinrich, Maffioli and Vázquez, 2010). Therefore, higher sample size for untreated (60%) than the treated were used.

Table 1: Sample strata

	POPULATION	ADOPTORS (40%)	NON-ADOPTORS (60%)	TOTAL
Gathara	26, 656	38	57	95
Engineer	26, 977	39	58	97
Kinangop	20, 898	30	45	75
Total	74, 531	107	160	267

3.3 Data collection

The study used primary data collected from small scale farmers using structured questionnaire administered to the households sampled out. The questionnaire was first pretested before the actual data collection using 15 non-sample households. This was done to enable correction of mistakes thus improving the accuracy and reliability of the data collected.

Information was collected regarding snow peas production in the year 2015. Most respondents were either household heads or any adult who is a member of the household and participated in snow peas production in the production season of the year.

The questionnaire solicited information concerning socio-economic and institution factors, marketing and physical factors, using face-to-face interviews of the 267 farmers. Specifically, the output and input information on snow peas production was gathered. The output was measured as the quantity of snow peas harvested per week which was then totalled to reflect the production quantity per year. Data on input collected included labor, fertilizer, land, seeds and agro-chemicals.

Socio-economic characteristics of the farmer included age, gender, experience in snow peas production, level of education, family size and sources of income. Institutional information included group membership, access to credit and extension services.

3.4 Data analysis

After data collection, the data was edited, coded, cleaned to enhance reliability and then entered into computer software for analysis. Regression methods were used to analyse factors affecting technical efficiency, stochastic frontier production functions was used to analyse technical efficiency while Propensity Score Matching (PSM) technique was used to analyse the difference in income, assets and expenditure for adopters and non-adopters. STATA software was utilized for regression.

3.5 Analytical method

Objective One: To determine technical efficiency of snow peas production and characterize snow peas farmers in Nyandarua County based on their technical efficiency.

Three steps were used:

(i) Estimation of the physical relationship between inputs and outputs

The stochastic frontier method requires a prior specification of most widely used functional forms like the transcendental logarithmic (translog) function and the Cobb-Douglas (CD) production functions. Unlike the translog, the Cobb-Douglas production functions are easy to estimate and interpret. The form is also preferred to other forms if there are more than two independent variables in the model (Khai and Yabe, 2011). The function had five inputs as independent variables.

On the other hand, the translog functional form is quadratic in logs and has the advantage in that it is a flexible functional form. It has less restriction on production elasticity and substitution elasticity. However, it is more difficult to interpret and requires estimation of many parameters. In addition, it can suffer from multi-collinearity among explanatory variables (Shumet Asefa, 2011). The Cobb-Douglas (CD) production function was used for estimating the physical relationship between inputs and outputs because, in addition to the already mentioned advantages, its coefficients directly represent the elasticity of production. It would be easy to determine the elasticity of the key inputs that included fertilizer, land, labour, agro-chemicals and snow peas seeds. Labour was calculated by adding total family and hired labour in man-days. Land was measured in total acreage under snow peas. Fertilizer and seeds were measured in Kilograms while agro-chemicals were measured in litres as applied. Again, the CD has been widely used in many empirical studies relating to efficiency.

Generally, the stochastic frontier production function that assumed Cobb-Douglas form is given as shown in equation 4:

$$lnQ = \beta_0 + \sum_{j=1}^{9} \beta_{ij} \; lnX_{ij} + V_i - U_i \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 4$$

Where Q is the snow peas output in kg; X_{ij} is the 5 inputs mentioned above as land area under snow peas in acre, amount of snow peas seeds used in Kilograms per acre, amount of labour applied in Man/days per acre, amount of fertilizer used in Kilograms per acre and amount of agro-chemicals applied in litres per acre; βij are parameters to be estimated by maximum likelihood estimation method (MLE). Here they depicts the elasticity of output with respect to each of the input. That is, percentage change in the quantity of snow peas due a 1% change in the respective input; V_i is the two sided random error; U_i is the one sided half normal error.

(ii) **Determination of efficiency scores of the sampled farmers**

The main methods of determining technical efficiency are DEA and stochastic frontier model. DEA has a number of drawbacks that include Lack of the statistical procedure for hypothesis testing, failure to take measurement errors and random effects into account and assumes that every deviation from the frontier is due to firm's inefficiency and its sensitivity to extreme values and outliers. On the other hand, stochastic model has only one limitation in the need to specify beforehand the functional form of the production function and the distributional form of the inefficiency term.

Due to the many limitations in DEA approach, stochastic frontier method was used because there is a lot of variability in agricultural production. This variability is not only attributed to farmers' inefficiencies but also climatic hazards, plant pathology and insect pests. In addition, information gathered on productivity is mostly inaccurate since small scale farmers do not have up-to-date records of their farm operations.

The stochastic frontiers production function was proposed for the first time by Aigner, Lovell and Schmidt, (1977) and Meeusen and Van den Broeck (1977).

$$Y = F(X\beta)exp^{(V-U)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 6$$

Measures of efficiency for the farm were calculated as:

$$\frac{F(X\beta)exp^{(V-U)}}{F(X\beta)} exp^{(V-U)} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 7$$

The empirical stochastic frontier production model was specified as follows:

$$\ln Y_i = \beta_0 + \beta_1 \ln X_{1i} + \beta_2 \ln X_{2i} + \beta_3 \ln X_{3i} + \beta_4 \ln X_{4i} + \beta_5 \ln X_{5i} + \beta_6 \ln X_{6i} + V_i - U_i \text{..........} \ 8$$

Where: subscripts i refers to the observation of i^th farmer, ln=Logarithm to base e, $\beta_0 \ldots \beta_n$= Parameters to be estimated, Y=value of snow peas output in aggregate per acre, X_1=Farm size under snow peas (acre), X_2=Labour used in snow peas production (man hours per acre), X_3= Ago-chemicals (litres per acre), X_4= Seed (kg per acre), X_5=Fertilizer (kg per acre),V_i = Random-error which have zero means associated with random factors (for example measurement errors in production not under control of a farmer), and U_i represents One-sided inefficiency component.

Cost savings were also computed to explain the implication of technical efficiency improvement as shown in equation

$$Cost\ Saving\ \% = \frac{Mean\ Technical\ Efficiency}{Technical\ Efficiency\ of\ the\ most\ Efficient\ farmer} \times 100 \ldots\ldots\ldots\ldots\ldots 9$$

iii) **Characterization of snow peas farmers**

Cluster analytical technique was utilized to cluster and characterize snow peas farmers based on their efficiency. Cluster analysis is concerned with the similarity of the subjects over the whole set of variables. The technique group subjects with similar characteristics together so that, each subject is more similar to other subjects in the group than subjects outside the group (Frank and Green, 1968), (Aldnderfer and Blashfied 1984). Cluster analysis gives groups that are meaningful and useful. In our case, the method was useful in summarization and comparison. The data used in cluster analysis can be interval, ordinal or categorical (Cornish, 2007)

The different approaches to cluster analysis include hierarchical methods and k-means. Hierarchical methods are further categorized into agglomerative methods where subjects begin in their own separate cluster. Most similar clusters are then combined repeatedly until all subjects are in one cluster. Divisive methods are then used in which all the subjects start in the same cluster and subjects are put together depending on their similarities repeatedly until every subject is in a separate cluster. The K-means clustering methods which are non-hierarchical techniques where desired number of clusters is specified in advance and the best solution chosen will be employed. It is mostly used when large data sets are involved and preferred because it allows subjects to move from one cluster to another (Cornish, 2007). Since two clusters of farmers based on technical efficiency were preferred, K-means technique was utilized in this study. The model is specified as shown below:

$$x_i \rightarrow \phi(x_i) \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 10$$

Where: x_i observed variables data matrix for subject *i* and ϕ is a constant.

This is followed by the clustering objective function as depicted in *Equation 10* and *Equation 11* (Ding and He 2004).

Minimization of K-means cluster objective function is specified in the following equation:

$$\min J_K(\phi) = \sum_i \left\| \phi(X_i) \right\|^2 - \sum_k \frac{1}{n_k} \sum_{i,j \in C_k} \phi(X_i)^T \phi(X_j), \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 11$$

Where: $\phi(.)$ is the first term which is a constant for a given mapping function and it can be ignored, $(x_1, \cdots, x_n) = X$ is the observed variables data matrix, C_k centroid of cluster, n_k is the number of points in C_k T is the desired transformation.

Maximization of distance objective function is also specified as shown in the equation below

$$J_K^W = \sum_k \frac{1}{n_k} \sum_{i,j \in C_k} w_{ij} = TrH^T WH = TrQ^T WQ. \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .12$$

Where: $W = (w_{ij})$ is the kernel matrix: $W_{ij} = \phi(X_i)^T \phi(Xj)$.

The SSE equation is as shown in below:

$$SSE = \sum_{i=1}^{K} \sum_{x \in C_i} dist(c_i, x)^2 \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots .13$$

Where: $dist$ is the standard Euclidean (L_2) distance between two objects within a Euclidean space and x is the observed factors data matrix for the selected subjects. Minimization of SSE equation gives:

$$c_i = \frac{1}{m_i} \sum_{X \in C_i} X \quad \ldots\ldots 14$$

Where: c_i is cluster i and m_i is the centroid of cluster i and x is the observed variables data matrix for subject i.

Objective Two: To determine factors affecting technical efficiency of snow peas production in Nyandarua County.

There are two main approaches of identifying determinants of technical efficiencies. The first one involves a two-step approach. First, estimate the stochastic frontier production function to determine the efficiency indicators. Secondly, the obtained indicators are regressed on explanatory variables that represent the characteristics of the firm using OLS method Nurudeen and Rasaki (2011). Many authors like Yami, Solomon, Begna, Fufa, Alemu and Alemu, (2013) and Aman and Haji, (2011) have used this approach in their respective studies.

The major limitation of the method is that in the first stage, inefficiency effects (u) are assumed to be independently and identically distributed in order to predict the values of technical efficiency indicators. However, inefficiency indicators obtained are assumed to depend on certain factors specific to the firm. Due to the inconsistencies of the two step approach, the model which was developed by Kumbhakar, Ghosh and McGuckin, (1991) and Reifschneider and Stevenson (1991) was used. The model defines inefficiency effects as explicit function of certain factors specific to the firm, and all parameters estimated in one step using maximum likelihood step. Various researchers like Leggesse (2015) have used this approach.

In this objective, censored Tobit regression function with a dependent variable of technical efficiency scores was applied to estimate the relationship between efficiency scores and their determinants that is; efficiency scores as dependent variables and nondiscretionary factors as explanatory variables to determine factors that have an effect on the technical efficiency of snow peas. There are two reasons to use a Tobit regression analysis to determine the determinants of efficiency. First, the range of technical efficiency which is the dependent variable ranges from zero to one. Therefore, there are a number of firms for which efficiency could be 1 and the bounded nature of efficiency between 0 and 1. This means that the distribution of efficiency is censored from above at a unit (Dao, 2013). Second, the independent variable in a Tobit model is not assumed to be normally distributed hence the presence of continuous and binary explanatory variables in a model are possible (Haji and Andersson 2006). According to (Gonçalves, Vieira, Lima and Gomes, 2008; Tolga, Nural, Mehmet and Bahattin, 2009) traditional methods of regression are not suitable for censored data as variables to be explained are both continuous and discrete. OLS estimator generates biased and inconsistent estimates. This is because it assumes a normal and homoskedastic distribution. The general tobit model as suggested by Greene (2003), is given by;

$y_i^* = x_i' \ \beta + u_i$ ………………………………………………………………………...15

$y_{i= y_i^*} \ if \ y_i^* < 0$ ……………………………………………………………………..……16

$y_i = 0, otherwise$

Where: $u_i \sim N(0, \sigma^2)$, x_i and β are vectors of explanatory variables and unknown parameters respectively. y_i^* Is a latent variable and y_i is a technical efficiency score and u_i is the error term.

We therefore assumed that inefficiency effects are independently distributed and U_i arises by truncation of the normal distribution with mean U_i and variance δU_2 where U_i is specified as;

$U_i = \delta_0 + \delta_1 lnZ_{1i} + \delta_2 lnZ_{2i} + \delta_3 lnZ_{3i} \dots\dots\dots\dots\dots. + \delta_7 lnZ_{7i}$ ……………………….17

Where: U_i=technical inefficiency of the ith farmer, Z_1=Farmer's age (yrs), Z_2= Gender of the ith farmer measured as dummy (if male 1, 0 otherwise), Z_3= Education of the ith farmer, as number on years of formal education, Z_4=Household size of ith farmer (number of individual), Z_5= size of the land in acre, Z6=Marital Status of the ith farmer measured as dummy (if married 1, 0 otherwise), Z_7=Major occupation of the ith farmer measured as dummy (if major is farming 1, 0 otherwise), 0 otherwise).

Objective three: To determine difference in income, assets and expenditure of adopters and non-adopters of snow peas production in Nyandarua County.

One of the main challenges in non-experimental methods is the presence of selection bias. It arises from non-random location of the project as well as the non-random selection of participants (Heckman, Ichimura and Todd, 1998). There are three potential source of bias (Bernard, Spielman, Seyoum and Gabre-Madhin, 2010). First, participating households may differ from non-participants in the community and household level due to observable characteristics such as geographic location or households' physical and human capital stock and this may have a direct impact on outcome of interest. Again, the difference may arise due to unobservable community traits such as leadership dynamics at the community level and households' entrepreneurial spirit or its relationship with other programs. This may affect households' behavior significantly. Lastly, there could be spill over effects exerted on non-participants by the project. Due to the above problems, differences between participants and non-participants may reflect the differences between the groups either totally or partially rather than the impacts of participating in the snow peas production.

The objective aimed at comparing the level of assets, expenditure and total annual income of households growing snow peas with households sharing the same social-economic characteristics but not involved in snow peas venture. Following Smith and Todd (2001), estimating the effects of household participation in snow peas production would involve various steps. Let Y_1 be the mean of the outcome conditional that a farmer participates in snow peas production and let Y_0 be the mean outcome of the control group. The impact of snow peas production on income, expenditure or assets is the change in the mean outcome caused by farmers participating in snow peas production. It's given by:

$$T_I = Y_i\,(D_i = 1) - Y_i(D_i = 0) \quad \ldots\ldots 18$$

Where: T_i is the notation for the effect of the crop for a given households, Y_I is the outcome on household, D_i is whether household i is a participant or not. Since the two outcomes cannot be observed for the same household simultaneously, the problem of missing data arises (Gebrehiwot and van der Veen, (2015) and Tolemariam, (2010). This means that the method gives biased estimates hence the need to introduce the sample average for the impacts of the treated group rather than the individual. Two treatment effects are the most common in empirical studies. The first one is the Average Treatment Effect (ATE), which is the difference of the expected outcome after participation and non-participation given by;

$\Delta Y_{ATE} = E(Y_1) - E(Y_0)$. ……………………………………………………………19

The measure shows the effect if households in the population were randomly assigned to treatment. Heckman, Ichimura and Todd (1997) noted that the measure would not be appropriate for policy makers since it includes the effects for which the intervention was not intended leading us to the second measure of treatment effects. The Average impact of the treatment on the treated (ATT) concentrates solely on participants pointing out the realized impacts of participation. It aims at determining how much the households participating benefited in the program compared to what they would have achieved without the intervention. It is given by:

$T_{ATT} = E(T|D = 1) = E(Y_1|D = 1) - E(Y_0)|D = 1$ ………………………………………20

Where: D, is a factor that indicate whether a household i received treatment or not. That $D_i = 1$ if the farmer was involved in snow peas production and 0 otherwise. Data on $E(Y_1|D = 1)$ is derived from the participants. The only problem here is to find $E(Y_0)|D = 1$. As a result, the difference between $E(Y_1|D = 1) - E(Y_0)|D = 1$ cannot be observed for the same household. This problem creates a need to use a better substitute to estimate ATT. The solution involves the use of mean outcome of the comparison individuals as a substitute control mean for the participants:

The ATT can only be identified when there is no self-section bias but if selection bias is present, the estimates are biased too (Gilligan and Hoddinott, 2007). The study area was purposively determined and this might have caused selection bias. To overcome this challenge and achieve this objective, Propensity score matching technique was applied. PSM controls for the households' observable factors by comparing the results of the program participants with those of non-participants based on similarity in the characteristics which are observed.

Where not possible to control for the characteristics, PSM technique give biased results. It is therefore important to have control households from the same population as the participants. This will help in reducing the bias. However, the main challenge of this method is removing the unobservable characteristics Tolemariam (2010). To enhance the validity of PSM, the treated and the control group were derived from similar agro-ecology and socioeconomic conditions Tolemariam (2010).

From literature, PSM is a statistical matching technique that uses propensity scores to estimate the effects of treatment by accounting for covariates that predicts receiving the treatment. It tries to reduce the bias due to confounding factors that could be found in an estimate of the treatment effect obtained from comparing outcomes amongst those that received treatment and those that did not (Garrido *et al.,* 2014).

The method involves creating a counterfactual group from a large group of non-participants, which is identical to the participating group (Caliendo and Kopeining 2008). The matching is on the basis of the propensity scores generated and the closer the scores, the better the matching. To avoid bias, both the treated and the control group should come from the same environment and should be asked similar questions (Jalan and Ravallion, 2003).

Propensity score matching method is preferred to the normal regression methods because it utilizes only comparable observations without imposing a functional form. This helps in overcoming the problems of multicollinearity and heteroscedasticity. Furthermore, the matching technique emphasizes the issue of common support thus avoiding the bias due to the extrapolation to non-data region. In addition, the results from the matching technique are easy to explain to policy makers, since the idea of comparison of similar group is intuitive. PSM depends on conditional independence and common support region assumptions. The implementation process involves five steps that include selection of variables to estimate the propensity scores, estimating the propensity scores, choosing the matching technique, assessment of overlap and common support, evaluation of the matching quality and calculation of sensitivity analysis (Caliendo and Kopeining 2008).

Selection of variables to estimate the propensity scores

The variables that were included in the probit model consisted of both continuous and discrete variables and included, occupation, age, number of years of formal education, size of the household, marital status, presence of extension visit, local group membership and the gender of the farmer. In selecting these variables to estimate propensity scores, Conditional Independence Assumption (CIA), was utilized. It was assumed potential outcomes were independent of treatment status. This assumption was supported by the fact that the covariates selected determined the selection process, there were no unobserved confounders and there were high degree of post-match balance across the covariates. From table 11, occupation, total land acreage and the presence of extension visit were statistically significant but after the post-match balance, none of the covariate was significant in influencing participation.

Estimation of the propensity scores

Estimation of propensity score was first accomplished using probit model following (Owuor, 2008) as shown:

$$pr\ ob(y_i = j) = \frac{\exp(\beta_j x_i)}{s(j=0-j)\exp(\beta_j x_i)}, j = 0,1 \ \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 21$$

Where: the left hand side represent the probability of participation in snow peas farming for j^{th} household and 'x_i' variables are characteristics of the observed household, which are the same across all outcomes. These include farmer's age in years(*Age*), education level given as the number of years of formal education(*Education*), gender of the household either male or female(*Gender*), household size in numbers(*Hhsize*), occupation of the farmer either pure farmer or non-pure farmer (*Occupation*), marital status of the farmer either married or not(*Martstatus*), extension visit to the farmer either a farmer was given extension service or not(*Extcame)* membership in any local organization as yes or no (*Localmemb*).

In linear form, equation is reduced to:

$$D(0,1) = \beta_0 + \beta_{ij} x_{ij} + \varepsilon, pscore(mypscore),[blockid(myblock), com\sup \ \ldots\ldots\ldots\ldots 22$$

Where: *D* is the indicator for participation, whereby *D*=1, if a household is a participant in snow peas production and 0 otherwise. *Xi* represents a vector of participation covariates of the household which are common across all farmers. This is then followed by options commands that generate propensity score index '*pscore'*, for the program. Specification of the outcome ***Y*** (income, expenditure or assets) is also specified in the command. The option (Y) for common support generates a dummy variable, which identifies households that meet the matching condition. The common support variable attaches numerical '1' corresponding to the subjects that meet the matching condition and '0' to those that do not meet the condition.

Estimation of average effect of participation in the programme follows commands in stata, namely '*attnd'* for nearest neighbor matching, '*attr*' for radius matching, *'attk*' for kernel matching and *'atts'* for stratified matching methods. The general formulation of the empirical model is as follows:

$command: Z = \beta_0 + \beta D + \beta_i \;\; X_i + \beta_i + \in, pscore(mypscore), comsup, logit$................23

Where command stands for either one of the matching estimation above (*attns*, *attr*, *atts*, *attk*), 'Z' is the income, expenditure or assets. X_i is a vector of participation covariates, followed by the propensity score option, then the common support option. The two options are important since they sense the average effect of participation (AEP). It is computed from propensity score index.

Choice of matching algorithm

Estimation of propensity scores is not sufficient to estimate ATT. This is because propensity score is a continuous variable and the probability of observing more than one unit with similar propensity score is zero. To overcome this problem, various matching techniques have been proposed in the literature. The matching techniques differ from one another with respect to the way control units to match with the treated group are selected and with respect to the weights attributed to the control group selected when approximating the counter factual outcome of the treated. Nevertheless, they all give consistent estimates of the ATT under CIA condition (Caliendo and Kopeinig, 2008). Commonly used matching algorithms are nearest neighbor (NN), kernel matching and caliper maching (Tolemariam, 2010)

Nearest neighbor matching method is straightest forward. An individual from the control group is chosen as matching partner for the treated household that is closest in terms of propensity score (Caliendo and Kopeinig, 2008). It can be done with and without replacement. Matching with replacement increases the quality of matches but decreases degree of precision of estimates. On the other hand matching with replacement increase precision but it's liable to biasness (Dehejia and Wahba, 2002). Caliper matching on the other hand involves getting matching partner within a given range of propensity score and the closest partner in terms of propensity score (Caliendo and Kopeinig, 2008). The main problem with the technique is that it is difficult to know the choice for the tolerance level which is reasonable (Tolemariam, 2010). In kernel matching, all the treated individuals are matched with a weighted average of all the controls with weights which are proportional to the distance between the propensity scores of treated and control (Becker and Ichino, 2002). It has a drawback of this method is that it's possible to get bad matches as estimator hence it's important to impose the common support condition for kernel matching technique. Again, it will not be obvious how to set tolerance. However, kernel matching with 0.25 band width is mostly used (Mendola, 2007). The choice of matching method depends on the data in question (Bryson, Dorsett and Purdon, 2002). When there is considerable overlap in the distribution of propensity score between the control and the treated groups, most of the matching techniques yield similar results (Dehijia and Wahba, 2002).

Assessing of region of common support and overlap

Common support is also a mandatory option to ensure matching is done only on controls that are similar to participants (Bryson, Dorsett and Purdon, 2002). The common support region is the area which contains the minimum and maximum propensity scores of the treated and control households respectively. This ensures that only the subset of the comparison group that is comparable to the treated group should be applied in the analysis (Tolemariam, 2010). The basic way of achieving this is to delete all observations whose propensity score is less than the minimum and greater than the maximum in the opposite group (Caliendo and Kopeinig, 2008). This is because there is no match that can be made to estimate the average effects on the ATT parameter when overlap exists between the treated and control groups.

Testing the matching quality

The matching procedure should be able to balance the distribution of the relevant variables in both the treated and non-treated groups. This is because the conditioning is not done on all the covariates but on the propensity score. While differences in the variables are expected before matching, it should be avoided after matching. The idea behind balancing tests is to determine whether the propensity score is balanced well or to check if at each value of propensity score, a give characteristic has equal distribution for the control and treated groups (Tolemariam, 2010). The idea is to compare the condition before and after matching to examine if there is any differences after conditioning on propensity score (Caliendo and Kopeinig, 2008).

Sensitivity analysis

Checking the sensitivity of the estimated outcomes is increasing its important in applied evaluation literatures (Caliendo and Copeining, 2008). Matching technique is based on the assumption that all variables affecting participation decision and outcome variables are tested simultaneously. It is hard to test the assumption (unconfoundedness assumption) because the data are uninformative about the distribution of the controlled outcome for the treated units (Becker and Caliendo, 2007). Where the assumption does not hold, it means there are unorbservable covariates which influence the assignment into treated and the results simultaneously. This results in a hidden bias (Rosenbaum, 2002). This translated in biased estimation of ATT. The magnitude of bias depends on the strength of the correlation between the observable covariates and the treated outcomes (Tolemariam, 2010).

Sensitivity analysis therefore involves the testing of the robustness of the outcome deviation from the assumption. The main concern is whether the treated effects may be affected by unobserved factors. This may be tested using Rosenbaum bounding approach (Rosenbaum, 2002). The approach does not test the unconfoundedness assumption rather it provides evidence on the magnitude to which any significance outcome is dependent on this untestable assumption. The approach involves calculating upper and lower bounds, using the Wilcoxon signed rank test. The rank tests the null hypothesis of control effect for various hypothesized values of unobserved selection bias. In case the results are sensitive, the researcher might have to consider about the validity of the identifying assumption and think of other estimation methods (Tolemariam, 2010).

Choice and definition of explanatory variables

When estimating the propensity score, the interest is not in the effects of covariates on the propensity score because the aim of the work is to determine the impact of snow peas growing on the outcome variables. Omitting important variables can increase the bias it the outcome (Heckman *et al.,* 1997). In this particular case, covariates that determine households' decisions to participate in snow peas production could affect the outcome variables in question. Pre-intervention characteristics, that brings differences in outcome of the interest among snow peas growers and non-growers were used. There is no general criterion for which variables to include in the model (Anderson, Auquier, Hauck, Oakes, Vandaele and Weisberg, 2009). However, the choice of variables is guided by the economic theory and empirical studies to know which observable independent variables to include in the model (Bryson, Dorsett and Purdon, 2002). The covariates used are identified in Table 2:

3.6 Definitions of explanatory variables

Table 2: Explanatory variables definition and measurements

Variable	**Types and definition**	**Measurements**
Occupation	Dummy, pure or non-pure farmer	1 if pure farmer, 0 otherwise
Age	Age of the household head	In years
Extension officer visiting farmer	Dummy, yes or no	1 if yes, 0 otherwise
Snow-peas group membership	Dummy, yes or no	1 if yes, 0 otherwise
Household size	Total family size	Number of household
Years of education	Level of formal education	in years
Land size	Total land owned	In acres
Marital status	Dummy, married or otherwise	1 if married, 0 otherwise

Choice, measurements and indicators of the outcome variables

Income

It's one of the outcome variables as a result of household's participation in snow peas production. Its measure in Kenya shillings per year and it is calculated as the total income from all the income generating sources of the farmer.

Expenditure

It's another outcome variable used to determine the welfare of individuals. It is measured in Kenya shillings and calculated by adding consumption expenditure and all other expenses incurred by a particular household per month.

Assets

It's the value of all the items a household owns. It include the value of land, furniture, tools and equipment, livestock and anything else that can be disposed to generate income. They were valued at the current market price minus the depreciation cost for the assets that depreciates.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Determination of efficiency scores and characterization of snow peas farmers based on their efficiency.

Descriptive statistics of snow peas yield and inputs used in snow peas production

Table 3 presents the descriptive statistics of the inputs applied in the production of snow peas. The average area of land under snow peas was 0.42 acres with a range of 0.25 to 1 acre, indicating a small variability of size among snow peas farmers. The results also depicts that the maximum amount of snow peas that was harvested was 2904 kg and minimum of 408 kg, giving an average of 1032.01 kg per acre in that production season. This shows that there is a high variability in yields among snow peas farmers. The results reveal that the average amount of labour throughout the production period was 85.75 with a range of 200 to 20 man-days per acre. The large variability in labour can be explained by the fact that some farmers practice mechanized agriculture while others do not. Again, some farmers depend on family labour alone while others supplement family labour with hired labour. The average seed rate used in snow peas production was found to be 11.88 kg. A farmer with the highest acreage of land under snow peas cultivation used a seed rate of 16 kg. On average, a farmer uses 31.8 kg of fertilizers, with a maximum of 68 kg and a minimum of 0 kg per acre. The study also found that the range of agro-chemicals that included, herbicides, foliar fertilizer and insecticides was 1 to 16 litres per acre. On average, the use of agro-chemicals was 8.44 litres.

Table 3: Descriptive statistics of Snow Peas Yield and inputs used in snow peas production

Variable	Unit	Mean	Standard.dev	Min	Max
Yield per acre	Kilograms	1032.01	500.89	408.00	2904.00
Land under snow peas	Acres	0.42	0.22	0.25	1.00
Labour per acre	Man-days	85.73	28.88	20.00	200.00
Seed per acre	Kilograms	11.88	1.75	10.00	16.00
Fertilizer per acre	Kilograms	31.80	19.61	0.00	68.00
Agro-chemicals per acre	Litres	8.44	3.15	1.00	16.00

The estimated coefficients for the five inputs are shown in the table 4, below. Ceteris paribus, the variables in the OLS model that are elastic are land, seed rate and agro-chemical use. The probability value of Wald chi^2 is 0.00 indicate that the model best fit the data.

The model reveals a negative relationship between yields and the area of land under snow peas production. Holding all other factors constant, an increase in acreage of land by 1% decreases the amount of yields harvested per acre by 0.206%. These findings could mean that it is easier to manage a small portion of land for maximum productivity than a relatively larger piece of land.

There is a positive relationship between the amount of yields harvested and the seed rates applied. Ceteris paribus, an increase in seed rate by 1% increases yields by 1.904%. This is related to the area of land under snow peas since the more the land the higher the seed rate. This could also be explained by the use of the correct seed rate that results in maximum yields.

Results also show that there is a positive relationship between agro-chemicals and the amount of snow peas yields. An increase in agro-chemicals application by 1% increase snow peas yield by 2.157% all other factors held constant. Snow peas production is highly affected by pests and diseases. Agro-chemicals are used to control these conditions. This means that those who applied more agro-chemicals were able to get maximum yields as opposes to those who applied insufficient amount of the same.

Fertilizer use is not related in any way to the amount of yields harvested. This shows that there is no significant difference between those who use little of this input or none and those who use much. This could imply that the zone is suitable for snow peas farming and it’s the same across the farms.

Table 4: Stochastic frontier OLS estimates of inputs used in snow peas production

ln yield per acre	**Coefficient**	**Standard error**	**P**
ln land	-0.206*	0.114	0.071
ln labour per acre	-0.024	0.088	0.782
ln Seed in kgs per acre	1.904***	0.203	0.000
ln fertilizer in kg per acre	-0.009	0.031	0.763
ln agro-chemicals per acre	0.155**	0.065	0.017
_cons	2.157***	0.610	0.000
N=107 Wald Chi^2=110.21	*Probability Chi^2= 0.000*	*Log likelihood= -22.410*	

Note:, **, *** represents significance level at 10%, 5% and 1% respectively*

Determination of technical efficiency of snow peas farmers

The range of technical efficiency scores was 0.3 to 0.9 with a mean of 0.7, which depicts that there was a significant inefficiency in snow peas production. The results show that snow peas farmers can reduce their inputs by about 30% without affecting output by improving the level of efficiency. This implies that farmers would reduce on their production costs thus increasing the gross margins of snow peas.

For the cost savings, the most efficient snow peas farmer could realize a cost saving of 22%. Therefore, it is evident from the results that technical efficiency among small-scale snow peas farmers in Nyandarau County could be improved substantially.

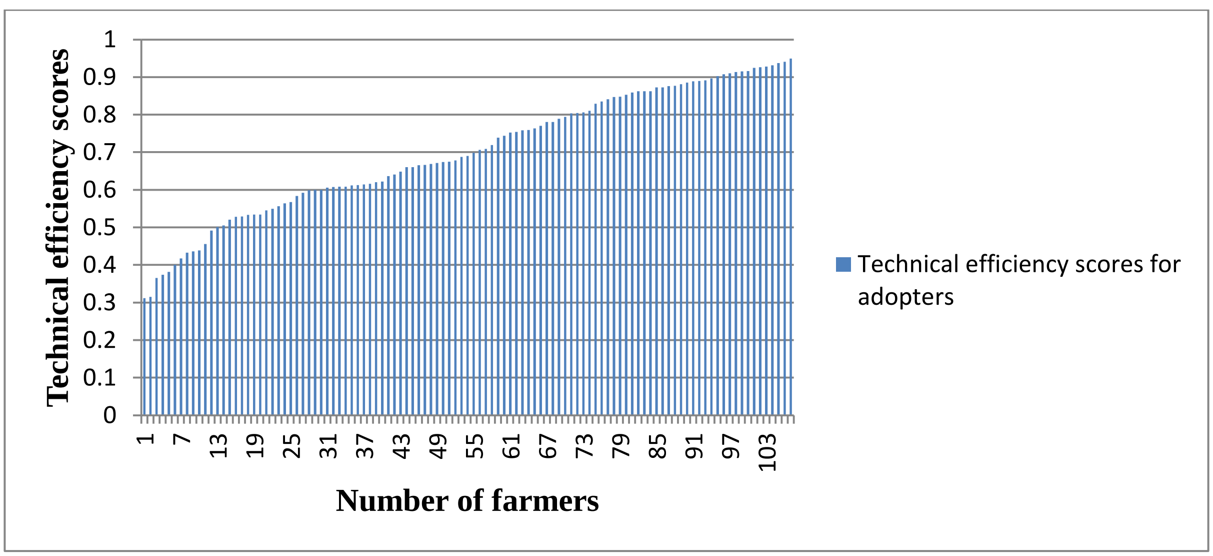

Figure 4: Technical efficiency scores for snow peas farmers

Characterization of snow peas farmers

The cluster analysis grouped the farmers into two categories of 53 and 54 farmers based on their technical efficiency scores as shown on figure 5 and 6. The first group comprised of the most efficient farmers with a mean efficiency of 0.84 and the second category of the less efficient farmers with a mean efficiency of 0.56. There is a statistically significant difference between the two means at 5%.

The results further indicate that farmers who are most efficient have a higher experience in snow peas farming compared to the less efficient farmers. The t-test confirms that the two mean experiences are statistically significant at 5%. This was expected because more experience in farming is expected to increase knowledge in various farm operations. Those farmers who have stayed long in the venture have learnt how to combine scarce resources given the level of technology well, thus increasing the level of efficiency. They could also be having knowledge on snow peace production which their counterparts lack. The knowledge ranges from pest and disease control mechanisms, new technology, market opportunities and crop varieties.

In addition, the level of annual income of farmers in the first category of more efficient farmers is higher and statistically significant from that of the inefficient farmers. The presence of high income to the farmer may provide a good basis for improved efficiency. Farmers with good income are able to afford certified seeds and other agricultural inputs like pesticides, herbicides and fertilizers. Hiring labour is also made possible by the availability of sufficient finances to pay the workers. Farmers with less annual income could be forced to depend on insufficient hired labour which is supplemented by family labour. This might affect efficiency negatively. Less income might also force farmers to forego practices that require high amount of finances like using manual weeding instead of using herbicides. They are also forced to purchase cheap and inefficient agro-chemicals that increase losses. All these factors combined can explain why high income farmers are more efficient compared to their counterparts with low income.

Contrary to what is expected, the more educated farmers are less efficient compared to their counterparts. The difference is statistically significant at 10%. The results could be supported by the fact that more educated farmers could be having more than one source of income thus not concentrating in farming. They could also be giving less concentration in agriculture as they pursue their formal careers. This might affect their level of efficiency greatly. In addition, they might have spent most of their time in acquiring formal education which might not be necessarily related to agricultural field. Their counterparts on the other hand could be involved in fully in agriculture thus gaining more experience in farming.

Even though all other continuous variables are slightly different across the clusters, they are not statistically different from one another. They include age, assets, expenditure, acreage of land under snow peas, total household size, fertilizer use, agrochemicals, seed rate applied and the amount labour used.

Table 5: Comparative analysis of selected explanatory variables by technical efficiency clusters

Variable	**Overall – 107** **Mean**	**Most efficiencent-53** **Mean**	**Less efficient-54** **Mean**	**t-test**
Technical efficiency	0.70 (0.17)	0.84 (0.07)	0.56 (0.10)	17.06***
Age in years	39.54 (7.57)	38.92 (6.48)	38.96 (6.62)	-0.03
Experience in years	5.29 (3.64)	5.96 (3.74)	4.40 (3.47)	2.06**
Income (Kes)	299755.60 (130440.10)	467142.30 (107461.30)	346210.30 (127839.40)	5.2919***
Assets (Kes)	304714.00 (193618.70)	402903.40 (132123.00)	423136.30 (187858.50)	-0.64
Expenditure (Kes)	17086.11 (19519.35)	28285.94 (28434.87)	21724.35 (24619.85)	1.28
Household size in acres	4.94 (2.93)	5.04 (2.95)	5.13 (3.12)	0.88
Education in years	9.50 (2.93)	9.02 (3.69)	9.96 (3.17)	0.16*
Total land size in acres	2.94(2.02)	2.79 (1.89)	2.62 (1.91)	0.64
Land under snow peas	0.42 (0.22)	0.41(0.15)	0.44 (0.28)	-0.69
Labour man-days per acre	85.73 (28.88)	87.05 (30.27)	84.43 (27.68)	0.47

Seed kg per acre	11.88 (1.75)	11.77 (2.03)	11.98 (1.45)	-0.61
Agro-chemicals litres per acre	8.44 (3.15)	8.72 (2.99)	8.17 (3.31)	0.90
Fertilizer kg per acre	31.80 (19.61)	30.64 (18.92)	32.94 (20.37)	-0.61

Note: **, **, *** represents significance level at 10%, 5% and 1% respectively*

Results on table 6 below indicate group membership that there is an association between efficiency and group membership. Group membership from the literature is expected to influence efficiency positively. It does so by helping farmers reduce inefficiency involved in agriculture through increase bargaining power for their products, bulky buying of inputs and benefiting from economies of scale. Dissemination of up-to-date information is also easier in a group.

In addition, results showed that there was an association between technical efficiency and the administrative ward in which a farmer is based. Majority of most efficient farmers belonged to Engineer and Gathara wards. This could mean that farmers from Gathara and Engineer wards are more informed on snow peas production than the rest. It could also mean that Gathara and Engineer zones are ecologically suitable for snow peas production.

Table 6: Comparative analysis of categorical explanatory variables by technical efficiency cluster

Variable	**Most efficiencent-53**	**%**	**Less efficient-54**	**%**	**Total**	**%**	**Chi Sq**
Time to market							
less than 30min	11	10	13	12	24	22	0.17
more than 30 min	42	39	41	38	83	78	
Farmers occupation							
On-farm and off farm activities	22	21	18	17	40	37	0.76
On-farm activities	31	29	36	34	67	63	
marital status							
Married	47	44	48	45	95	89	2.14
Never married	4	4	3	3	7	7	
Widow	1	1	0	0	1	1	
Divorced	1	1	3	3	4	4	
Farmers visiting extension officers							
No	35	33	43	40	78	73	1.51
Yes	18	17	11	10	29	27	
extension officers visiting farmers							
No	41	38	36	34	77	72	1.51
Yes	12	11	18	17	30	28	
Snow peas group membership							
No	22	21	38	36	60	56	9.05***
Yes	31	29	16	15	47	44	
membership in other groups							
No	13	12	18	17	31	29	1.01
Yes	40	37	36	34	76	71	
ward of the farmer							
Engineer	21	20	17	16	38	36	6.47**
Gathara	23	21	16	15	39	36	
North Kinangop	9	8	21	20	30	28	

Note: ***, *** represents significance level at 5% and 1% respectively*

4.2 Factors affecting technical efficiency of snow peas production

Table 7: Marginal effects of covariates on technical efficiency of the snow peas farmers

Variable	**dy/dx**	**Std.**	**P-value**
Occupation	0.0470*	0.0270	0.0800
Extension	0.1007***	0.0260	0.0000
Membership in Other Groups	0.0267	0.0250	0.2900
Gender	0.0095	0.0250	0.7100
ln_income	0.4062***	0.0420	0.0000
Age	0.0003	0.0020	0.8700
Snow peas group membership	0.0244	0.0270	0.3600
Education in Years	-0.0093***	0.0040	0.0100
Total land size in Acres	-0.0019	0.0060	0.7600
Household size in Numbers	-0.0015	0.0040	0.7000

Number of obs =107; LR chi2(13) = 96.93; Prob > chi2 = 0.0000; Pseudo R2 = -1.3899

Marginal effects after tobit=0.6974

Note: **, *** represents significance level at 10% and 1% respectively*

The Tobit estimates for identifying the relevant variables are shown in Table 7. The censoring point was the lowest technical score which was 0.3083 and as a result one participant was dropped from the analysis. The point was chosen so that any farmer above the point was considered relatively technically efficient. If you take farmer at random, their probability of being technically efficient is 69.7% as indicated by the probability of linear prediction of 0.697. Occupation, extension services, log income and education are the only statistically significant variables in the model.

Results indicate that there is a positive relationship between efficiency scores and occupation. Occupation was measured as a dummy, either pure farmer or non-pure farmer. It turned out as expected that a farmer who is not involved in off-farm activities is likely to be more efficient than a farmer who is also involved in other off-farm activities. This because he is able to give full attention to the farming business which is the only source of income, contrary to a farmer who is involved in other income generating activities which means divided attention.

As expected, there is a positive relationship between total income of the farmer and the level of efficiency. Income is expected to be a determinant of efficiency in the sense that it gives farmers a basis to secure major inputs in the right proportion throughout the production process. Farmers are able to purchase inputs with fewer struggles. It could also mean that farmers access the inputs timely thus increasing the efficiency of the farmer.

Results showed a negative relationship between formal education and technical efficiency. These results contract the findings of Khai *at al*. (2011) and Nyagaka *et al.* (2010). This could mean that education increased theoretical knowledge of the farmer. More educated farmers may feel that they have sufficient knowledge and therefore ignore the necessity to seek information from less educated farmer who could be efficient due to their experience. Again, most educated farmers could be devoting most of their time on other income generating activities hence the low efficiency in agricultural related activities.

The results further indicate that there is a positive relationship between access to extension services by snow peas farmers and technical efficiency. This implies that technical efficiency increases with the number of visits made to the household by extension agents. Similar results were reported by Nyagaka *et al.* (2010); Bozuglu and Ceyhan (2007) in their respective studies. The role of extension service in technical efficiency of a farmer is important. Extension agents provide new information and technologies to farmers. They also play a vital role in demonstrating how best agricultural practices should be done.

4.3 Differences in income, assets and expenditure of adopters and non-adopters of snow peas enterprise

The overall mean age of farmers was found to be 39.54 and the figure reflects the age of individual participants and non-participants. The mean age of participants was 38.4 while that of non-participants was 39.94 years. There is no significant difference between ages of the two categories of farmers. Age is therefore not a determinant of whether a farmer participates in snow peas production or not.

There is no significant difference between the household sizes of the farmers in the two different categories. Household size is therefore not a determinant of participation in snow peas production. The levels of education of farmers do not influence the decision to participate in snow peas production. There is no difference in education level of both snow peas farmers and the control group.

In addition, the size of land under the ownership of the farmers does not affect the participation decision of the farmer. The results show that there is no statistically significant difference between the size of the land between the treated and the control group. Result further depicts an association between participation in snow peas farming and occupation of the farmer, extension service as well as group membership.

Table 8: Descriptive statistics of selected variables to profile both participants and non-participants in snow peas production

	Overall		Participant		Non-participant		t-test
Variable	**Mean**	**Sd**	**Mean**	**Sd**	**Mean**	**Sd**	
Age (Years)	39.54	7.57	38.94	6.52	39.94	8.19	1.058
Income (Kes)	299,755.60	130,440.10	406,111.20	132,388.80	228,630.30	63,854.55	-14.61***
Assets (Kes)	304,714.00	193,618.70	413,114.40	162,210.60	232,221.30	178,825.80	-8.40***
Expenditure (Kes)	17,086.11	19,519.35	24,974.49	26,656.63	11,810.76	9,685.43	-5.71***
Household size	4.94	2.93	5.08	3.03	4.85	2.87	1.57
Years of education	9.50	2.93	9.50	3.45	9.50	2.52	0.01
Total land size (acres)	2.94	2.02	2.71	1.89	3.10	2.09	1.57

Note: **** represents significance level at 1%*

Table 9: Descriptive statistics of selected variables to profile their association with participation snow pea production

		snow peas grower **No**	**%**	**Yes**	**%**	**Total**	**%**	**chi**
Farmers occupation								6.3518**
	Off-farm and on-farm	37	14	40	15	77	29	
	On-farm	123	46	67	25	190	71	
Marital status								5.0474
	Married	144	54	95	36	239	89	
	Never married	3	1	7	3	10	4	
	Widow	4	1	1	0	5	2	
	Divorced	9	3	4	1	13	5	
Extension								4.7581**
	No	133	50	77	29	210	79	
	Yes	27	10	30	11	57	21	
Group membership								72.6473***
	No	133	50	60	22	193	72	
	Yes	0	0	47	18	47	18	

Note: ***, *** represents significance level at 5% and 1% respectively*

4.4 Estimation of propensity scores

The logistic regression model was applied to estimate the propensity score matching for participant and non-participants households. The mean average of the generated propensity scores was 0.04 with the range of 0.12 to 0.82. This means, the probability of any randomly selected farmer being a participant is 40%.

Considering the estimated coefficients (Table 10), the outcome indicates that snow peas' growing is significantly influenced by five explanatory variables. That is, occupation, total land size, extension service, marital status and gender of the farmer. From the results, Farmers who are also involved in other income generating activities or careers are likely to participate in snow peas growing. Being on on-farm activities alone decreases the likelihood of participation. Occupation was found significant at 1% significant level. This could be explained by their desires to diversify risk by trying more than one business ventures.

Farmers with large land size are less likely to participate in snow peas production in that, an increase in land size by 1 acre decreases the likelihood of participation in snow peas production by 0.0307 at 10%. The entire process of snow peas production is intensive and requires a lot capital, time and most management practices require attention. Most farmers would prefer to dedicate the production in small portions of land that are manageable. This probably explains why farmers with small pieces of land are more likely to be snow peas growers.

The positive and significant extension coefficient depicts that farmers who received extension service are likely to participate in snow peas production than their counterparts. The results were significant at 10% significance level. An extra extension visit increases the likelihood of participation in snow peas production. Extension agents play a vital role in introducing new crops and technologies to farmers. Probably, in the course of their visits to the farmers, the extension agents influenced farmers to try snow peas production. This explains why those farmers who were visited by the agents have a high possibility of participating in snow peas growing.

The results depict that being singe and never married increases the likelihood of participation in snow peas compared to being married by 1% significance level. People who are single make independent decision. This could explain why they are more likely to participate in snow peas production. Again, being a widow decreases the likelihood of participation compared to being married at 5 % significance level. Most widows are aged and lack motivation and incentives to participate in snow peas production. This could be used to support the results

Being male increases the probability of participation in snow peas production at 1% level of significance. In most African societies, male are the head of the family and consequently the decision makers. This could be the reason why in the households they are the head are likely to be snow peas growers.

Table 10: Factors influencing participation in snow peas production

Variable	**dy/dx**	**Standard Error**	**P-value**
Occupation	-0.231***	0.074	0.002
Age	0.002	0.005	0.672
Years of education	-0.018	0.012	0.117
Total land size	-0.028*	0.016	0.080
House hold size	0.002	0.011	0.861
Single never married#	0.384**	0.149	0.010
Widow#	-0.298**	0.124	0.016
Divorced#	-0.117	0.142	0.413
Visited by extension officer	0.151*	0.079	0.055
Local group membership	-0.052	0.072	0.474
Gender	0.240**	0.080	0.003

Note: **, **, *** represents significance level at 10%, 5% and 1% respectively; # dummy for marital status*

4.5 Matching participants and comparison households

Before the actual matching task, four steps are involved: predicting the propensity score, examining the common support condition, discarding observations whose predicted propensity scores lies outside the range of common support and conducting a sensitivity analysis.

The estimated propensity scores ranges between 0.12 and 0.78 with an average of 0.37 for the treated households and between 0.16 and 0.82 with an average of 0.46 for control households. From the results, the common support region would lie between 0.16 and 0.78. To satisfy the common support condition, households whose estimated propensity scores are less than 0.16 and greater than 0.78 were dropped and not considered for the matching exercise. As a result, 2 participating households were discarded from the analysis.

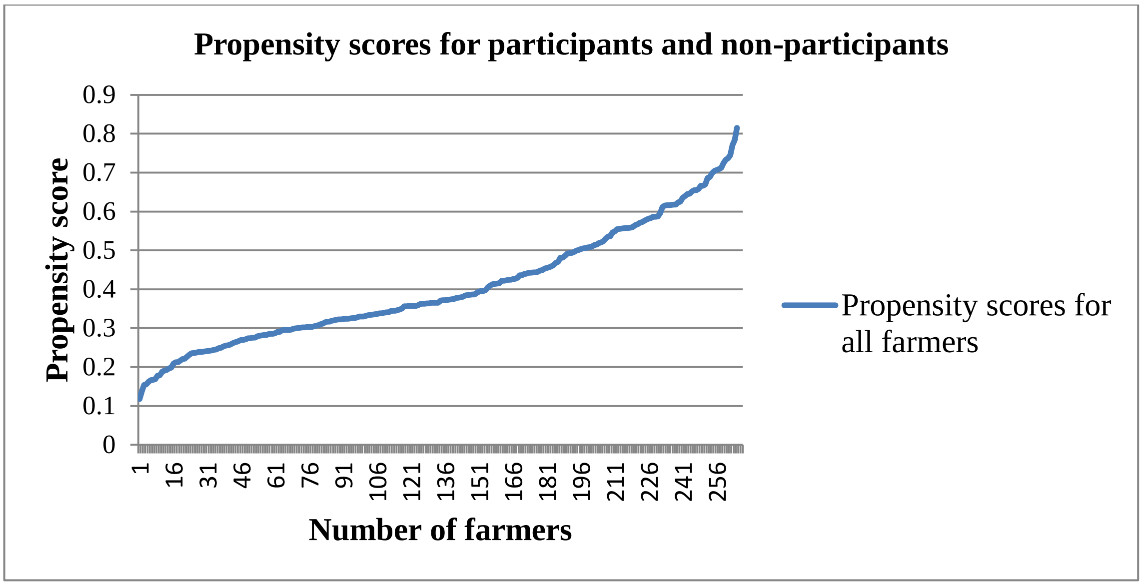

Figure 5: Propensity scores line graph for participants and non-participants

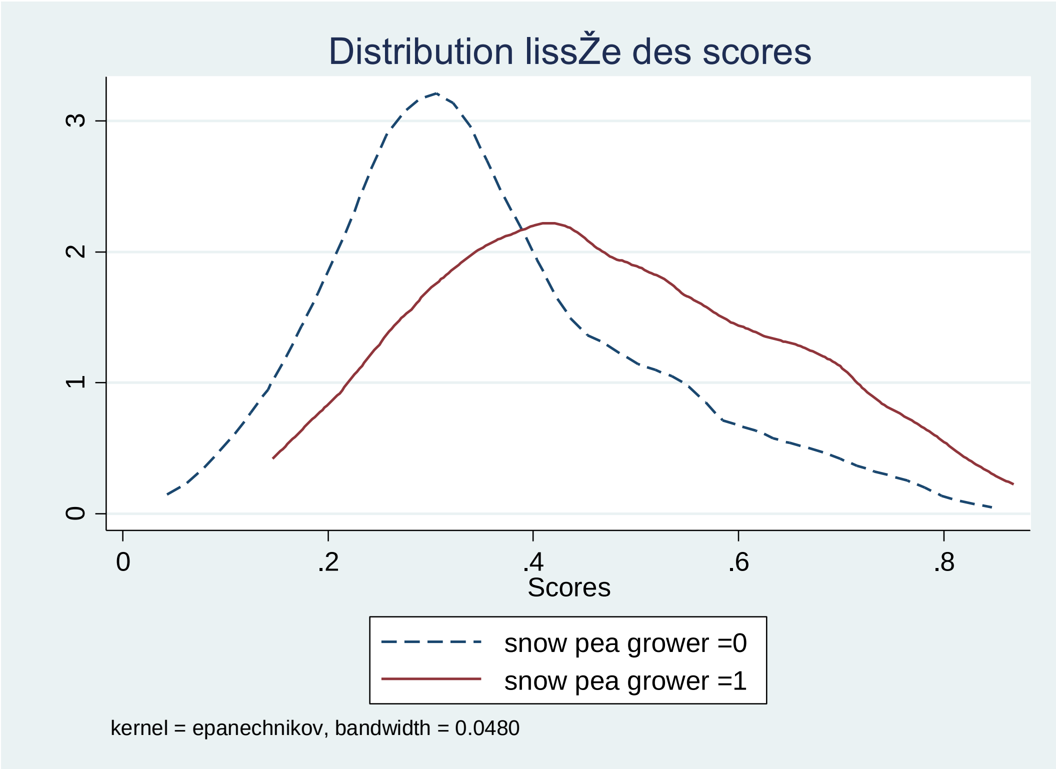

Figure 6: Propensity score graph for participants and non-participants

Choice of matching algorithm

Various matching estimators were considered in matching the treated and control group in the region of common support. The tests showed that the choice of matching algorithm chosen is suited for the data set at hand. Thus, we can progress to estimate ATT for households.

Testing the balance of propensity score and covariates

After deciding on the best matching technique, the next step is to check the balancing of propensity score and variables using different procedures by selecting matching procedure Table 11. The main purpose of estimating propensity scores is to balance the distribution of relevant covariates in to both the treated and control groups. In order to ascertain the balancing powers of the estimates, different test methods such as the reduction in the mean standardized bias between the treated and the control groups, equality of means though t-test and chi-square for joint significant tests of the covariates in question are used.

The table shows the mean standard bias before and after matching. The first column presents all the chosen variables in the model. The second and the third column indicate the mean of the treated and control before matching respectively. The t-test of the treated before matching is highlighted in the fourth column. The fifth and the sixth column indicate the mean of the treated and control after matching respectively. The last column shows the t-test after matching.

The table also shows that there are statistically significant differences between the t-tests of the chosen variables before matching. After matching, all the variables are balanced.

Table 11: Test for balance of propensity score and covariates

	Before matching mean (267)			**After matching mean (265)**		
Variable	**Treated**	**Control**	**t-test**	**Treated**	**Control**	**t-test**
Occupation	0.626	0.772	-2.60***	0.635	0.631	0.05
Age	38.944	39.937	-1.05	39.154	39.088	0.06
Years of educ	9.495	9.481	0.04	9.462	9.413	0.12
Total land size (acres)	2.706	3.097	-1.55	2.745	2.838	-0.35
Household size	5.084	4.835	0.68	4.981	4.874	0.28
SingleNM#	0.065	0.019	1.95*	0.048	0.038	0.37
Widow#	0.009	0.025	-0.94	0.010	0.011	-0.08
Divorced#	0.037	0.051	-0.51	0.038	0.045	-0.24
Extension came	0.280	0.165	2.28**	0.279	0.285	-0.09
Local member	0.710	0.741	-0.54	0.702	0.657	0.69
Gender	1.327	1.196	2.44**	1.317	1.322	-0.08

Note: ***, *** represents significance level at 5% and 1% respectively*

A low pseudo-R^2 and the insignificant likelihood ratio tests shows that both the treated and control groups have the same distribution of covariates X after matching (table 12). Kernel matching reduced bias most compared to other matching techniques (near neighbor, radius and stratified) as indicated by the least significant bias after matching (p>chi2 1.000) (Table 12).

Table 12: Chi-square test for joint significant of variable

Sample	**Mean Bias**	**Ps R2**	**LR chi2**	**p>chi2**
Unmatched	16.4***	0.086	30.740	0.001
Matched	3.0	0.004	1.070	1.000

Table 13: Impact estimate on total household net income

Matching technique	Number treated	Number control	ATT –income (Kes)	Std. Err.	T
Kernel	107	152	173,000	14806.943	11.694***
Stratified	104	155	169,000	14247.047	11.843***
Radius	100	149	174,000	14473.954	12.012***
Near neighbour	107	62	169,000	15610.159	10.825***

The results in table 13 show that there is a statistically significant difference in income between snow peas farmers and those who do not grow the crop. The estimates are significant at 1% level. Most snow peas farmers pointed out that they harvest snow peas crop two days per week. This means that they have a stream of income especially when the markets are good. As opposed to their counterparts who only depend on other types of income source, snow peas farmers have an additional source of income. This explains why they probably have more monthly net income as compared to non-snow pea's growers.

The results are contrary to the findings of Tolemariam (2010) who found that households' participation in market development intervention by coffee producers did not have statistically significant impact on their income.

Table 14: Impact estimate on expenditure

Matching technique	Number treated	Number control	ATT- Expenditure (Kes)	Std. Err.	T
Kernel	107	152	13,718	2542.316	5.396***
Stratified	104	155	13,747	2701.07	5.089***
Radius	100	149	13,743	2901.123	4.737***
Near neighbour	107	62	13,451	3091.498	4.351***

The results depict a statistically significant difference between the expenditure of participants and non-participants. Those farmers who are involved in snow peas production are depicted to spend more amount of money on various consumption expenditures. This could be explained by the fact that snow peas could be giving them more income compared to their counterparts. They are therefore able to afford all the basic commodities in satisfying amounts. They are able to afford good education for their children by taking them to good schools. They are able to afford both fresh and non-fresh staples more frequently than non-participants. They are also able to afford being members of saving societies and organizations. For the non-participants, their income comes only from other investments which participants could also be having. This makes non-participants to purchase commodities less frequently and in fewer amounts. This explains the statistically significant difference.

Table 15: Impact estimate on assets

Matching technique	Number treated	Number control	ATT	Std. Err.	T
Kernel	107	152	0.615	0.051	12.155***
Stratified	104	155	0.612	0.057	10.831***
Radius	100	149	0.585	0.063	9.28***
Near neighbor	107	62	0.504	0.094	5.344***

Assets were measured in terms of the value of all the durable commodities a farmer had ranging from livestock, furniture, electronics, land, tools and equipment. Their value was estimated using current market prices. The results depict a significant difference between the assets of participants and non-participants. Snow peas farmers are likely to use part of their income from snow peas production to purchase assets and this explains why they probably have more assets than their control counterparts.

4.6 The sensitivity of the results

Stata Mhbounds was applied to compute Mantel-Haenszel bounds to check sensitivity of estimated average treatment effects and critical hidden bias. Table 16, 17 and 18 contains the test results. $\Gamma = 1$ indicates an absence of unobserved factors. The bounds were increased slightly by 0.5 and the various levels of bounds tells us at which degree of unobserved positive or negative selection the effect would become significant. From the results the Q_mh+ and Q_mh- test statistic gave a similar result across all bound of odds assigned due to unobserved factors. The negative values of Q_mh+ therefore indicated negative selection bias where snow peas farmers tend to have low annual income, expenditure and value of assets even without participation in production of snow peas. The bias was however not significant at different bound levels in the case of overestimation and underestimation of the treated effect as indicated by P_mh + and P_mh- values. Result on the tables' further show that the study was insensitive to bias that will double or triple the odds of change in the level of income, assets and expenditure as a result of participation in snow peas production.

Table 16: Mantel-Haenszel (1959) Bounds for income

Gamma	**Q_mh+**	**Q_mh-**	**p_mh+**	**p_mh-**
1.00	.	.	.	.
1.05	-0.0818	-0.0818	0.532597	0.532597
1.10	.	-0.0818	.	0.532597
1.15	-0.0818	-0.0818	0.532597	0.532597
1.20	-0.0818	-0.0818	0.532597	0.532597
1.25	-0.0818	-0.0818	0.532597	0.532597
1.30	-0.0818	.	0.532597	.
1.35	-0.0818	-0.0818	0.532597	0.532597
1.40	-0.0818	.	0.532597	.
1.45	.	-0.0818	.	0.532597
1.50	-0.0818	-0.0818	0.532597	0.532597
1.55	-0.0818	-0.0818	0.532597	0.532597
1.60	-0.0818	-0.0818	0.532597	0.532597
1.65	-0.0818	-0.0818	0.532597	0.532597
1.70	-0.0818	-0.0818	0.532597	0.532597
1.75	-0.0818	-0.0818	0.532597	0.532597
1.80	-0.0818	-0.0818	0.532597	0.532597
1.85	-0.0818	.	0.532597	.
1.90	-0.0818	-0.0818	0.532597	0.532597
1.95	-0.0818	-0.0818	0.532597	0.532597
2.00	-0.0818	-0.0818	0.532597	0.532597

Table 17: Mantel-Haenszel (1959) Bounds for expenditure

Gamma	Q_mh+	Q_mh-	p_mh+	p_mh-
1.00	.	.	.	.
1.05	-0.0818	-0.0818	0.532597	0.532597
1.10	.	-0.0818	.	0.532597
1.15	-0.0818	-0.0818	0.532597	0.532597
1.20	-0.0818	-0.0818	0.532597	0.532597
1.25	-0.0818	-0.0818	0.532597	0.532597
1.30	-0.0818	.	0.532597	.
1.35	-0.0818	-0.0818	0.532597	0.532597
1.40	-0.0818	.	0.532597	.
1.45	.	-0.0818	.	0.532597
1.50	-0.0818	-0.0818	0.532597	0.532597
1.55	-0.0818	-0.0818	0.532597	0.532597
1.60	-0.0818	-0.0818	0.532597	0.532597
1.65	-0.0818	-0.0818	0.532597	0.532597
1.70	-0.0818	-0.0818	0.532597	0.532597
1.75	-0.0818	-0.0818	0.532597	0.532597
1.80	-0.0818	-0.0818	0.532597	0.532597
1.85	-0.0818	.	0.532597	.
1.90	-0.0818	-0.0818	0.532597	0.532597
1.95	-0.0818	-0.0818	0.532597	0.532597
2.00	-0.0818	-0.0818	0.532597	0.532597

Table 18: Mantel-Haenszel (1959) Bounds for assets

Gamma	**Q_mh+**	**Q_mh-**	**p_mh+**	**p_mh-**
1.00	.	.	.	.
1.05	-0.0818	-0.0818	0.532597	0.532597
1.10	.	-0.0818	.	0.532597
1.15	-0.0818	-0.0818	0.532597	0.532597
1.20	-0.0818	-0.0818	0.532597	0.532597
1.25	-0.0818	-0.0818	0.532597	0.532597
1.30	-0.0818	.	0.532597	.
1.35	-0.0818	-0.0818	0.532597	0.532597
1.40	-0.0818	.	0.532597	.
1.45	.	-0.0818	.	0.532597
1.50	-0.0818	-0.0818	0.532597	0.532597
1.55	-0.0818	-0.0818	0.532597	0.532597
1.60	-0.0818	-0.0818	0.532597	0.532597
1.65	-0.0818	-0.0818	0.532597	0.532597
1.70	-0.0818	-0.0818	0.532597	0.532597
1.75	-0.0818	-0.0818	0.532597	0.532597
1.80	-0.0818	-0.0818	0.532597	0.532597
1.85	-0.0818	.	0.532597	.
1.90	-0.0818	-0.0818	0.532597	0.532597
1.95	-0.0818	-0.0818	0.532597	0.532597
2.00	-0.0818	-0.0818	0.532597	0.532597

Gamma : odds of differential assignment due to unobserved factors

Q_mh+ : Mantel-Haenszel statistic (assumption: overestimation of treatment effect)

Q_mh- : Mantel-Haenszel statistic (assumption: underestimation of treatment effect)

p_mh+ : significance level (assumption: overestimation of treatment effect)

p_mh- : significance level (assumption: underestimation of treatment effect)

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusions

Results showed that the technical efficiency scores for small scale snow peas farmers in Nyandarua County ranged from 0.3 to 0.9 with a mean of 0.7. This indicates a variation between the most efficient and the less efficient farmer and a significant inefficiency in snow peas farming. Many years of experience in farming, high annual income and group membership characterized those farmers with high efficiency scores.

In analysing the factors that affect technical efficiency of farmers, results indicated that occupation, income, education and access to extension service to be the factors that influence the technical efficiency of farmers. Farmers who practice pure farming were more likely to be more efficient than farmers who are also involved in other activities of earning income. Similarly, farmers with a relatively higher level of income were depicted to have high level of efficiency. Additionally, the level of efficiency increased with increase in the number of extension visits. However, farmers who were more educated were found to be significantly less efficient compared to their counterparts who were less educated.

Finally, the study showed that the impact of snow peas farming was statistically significant different between participants and non-participants in terms of their income, assets and expenditure. The estimation of treated effect on treated showed that participating farmers had relatively higher monthly income, higher total value of assets and higher expenditure compared to non-participating farmers.

5.2 Recommendations

Basing on the empirical findings of the study, the following recommendations were made:

1. Farmers are encouraged to form groups and organizations that will improve snow peas production. This will help them in lowering the entire cost of production through bulk buying of inputs, bulk marketing of products, increased bargaining power, eliminate brokers and access to credit.
2. Provision of up to date information concerning snow peas farming by extension service providers. Farmers should be educated on snow peas varieties, correct seed rates, agro-chemicals, spacing and any other technology that can improve snow peas production.
3. Government should support and encourage snow peas production because it's a profitable venture and it was depicted to improve the welfare of small scale snow peas farmers.

5.3 Suggestions for Further Research

Future research can consider analysing and comparing snow peas marketing channels and recommend the optimal channel for small holder farmers. Secondly, while this study focused on measuring technical efficiency and welfare effects of snow peas production by small scale farmers in Nyandarua County, other studies can be done on allocative and economic efficiency in snow peas farming. This will help to understand fully why snow peas productivity has remained low over time yet there exists high potential for their production.

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APPENDICES

APPENDIX 1: Selected Stata analysis results tables

1. Tobit model

. tobit TE occupation married widow divorced extcame localcommember Gender ln_income age groupmember yearseduc totallandsize househs, ll ul

```
Tobit regression                                  Number of obs   =        107
                                                  LR chi2(13)     =      96.93
                                                  Prob > chi2     =     0.0000
Log likelihood =  83.338648                       Pseudo R2       =    -1.3899
```

TE	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
occupation	.0469956	.0267837	1.75	0.083	-.0061842	.1001753
married	.0104816	.0486161	0.22	0.830	-.0860468	.1070101
widow	.0372862	.127238	0.29	0.770	-.2153479	.2899202
divorced	-.0671458	.0725547	-0.93	0.357	-.2112049	.0769132
extcame	-.1006573	.0259936	-3.87	0.000	-.1522683	-.0490463
localcommember	.0266975	.0253825	1.05	0.296	-.0237	.0770949
Gender	.0094783	.0250596	0.38	0.706	-.0402782	.0592348
ln_income	.4062409	.0416113	9.76	0.000	.3236207	.4888611
age	.0003308	.0019503	0.17	0.866	-.0035416	.0042032
groupmember	.0243603	.0266967	0.91	0.364	-.0286467	.0773673
yearseduc	-.0092688	.0036843	-2.52	0.014	-.0165841	-.0019536
totallandsize	-.0018984	.0061334	-0.31	0.758	-.0140764	.0102797
househs	-.0014561	.0037127	-0.39	0.696	-.0088277	.0059155
_cons	-4.489839	.5405728	-8.31	0.000	-5.563159	-3.416519
/sigma	.1066733	.0074007			.091979	.1213676

```
  Obs. summary:          1  left-censored observation  at TE<=.30827895
                       105     uncensored observations
                         1 right-censored observation  at TE>=.95027018
```

2. Tobit model mfx

```
. mfx

Marginal effects after tobit
      y  = Linear prediction (predict)
         =  .69739049
```

variable	dy/dx	Std. Err.	z	P>|z|	[95% C.I.	]	X
occupa~n*	.0469956	.02678	1.75	0.079	-.0055	.099491	.626168
married*	.0104816	.04862	0.22	0.829	-.084804	.105767	.88785
widow*	.0372862	.12724	0.29	0.769	-.212096	.286668	.009346
divorced*	-.0671458	.07255	-0.93	0.355	-.20935	.075059	.037383
extcame*	-.1006573	.02599	-3.87	0.000	-.151604	-.049711	.280374
localc~r*	.0266975	.02538	1.05	0.293	-.023051	.076446	.71028
Gender	.0094783	.02506	0.38	0.705	-.039638	.058594	1.3271
ln_inc~e	.4062409	.04161	9.76	0.000	.324684	.487797	12.8601
age	.0003308	.00195	0.17	0.865	-.003492	.004153	38.9439
groupm~r*	.0243603	.0267	0.91	0.362	-.027964	.076685	.439252
yearse~c	-.0092688	.00368	-2.52	0.012	-.01649	-.002048	9.49533
totall~e	-.0018984	.00613	-0.31	0.757	-.01392	.010123	2.70561
househs	-.0014561	.00371	-0.39	0.695	-.008733	.005821	5.08411

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

APPENDIX 2: Farmers questionnaire

QUESTIONNAIRE

This study is conducted to find out the technical efficiency of small-scale snow peas farmers in Nyandarua County, Kenya. The information provided will assist in academic studies. The information needed is for the period January-December, 2015 and all information will be treated as confidential.

Questionnaire identification

Questionnaire Number ____________________ Date______________________

Constituency _____________________

Ward____

Name of enumerator____

1.0 FARMERS' BACKGROUND INFORMATION

1.1Gender of the respondent: ☐ Male ☐ Female

1.2 Are you the household head? : ☐ YES ☐ NO

1.3 If NO in 1.2, indicate your relationship with the household head

1= Wife ☐

2= Son ☐

3=Daughter ☐

4= other (specify) ____

1.2.1 Occupation ____

1.2.2Age (years) ____

1.4 Number of years in formal education of the household head

☐

1.5. Marital status. *Please tick as appropriate.*

1=Married [ ]

2=Single (Never married) [ ]

3=Divorced [ ]

4=Widowed [ ]

1.6 Have you been growing snow peas in the year 2015? 1=YES ☐ 2= NO ☐

If NO skip to 1.8

1.7 If YES, for how long have you been growing snow peas?

1.8 If NO, have you ever been involved in snow peas production? 1=YES ☐ 2= NO ☐

1.9 Are you involved in other income generating activities other than farming?

1=YES ☐ 2=NO ☐

2.0 PHYSICAL AND ECONOMIC FACTORS

2.2 What are the factors constraining the production of snow peas enterprise?

	Tick	Rank
1) High initial cost of production	☐	☐
2) Lack of capital	☐	☐
3) Lack of land	☐	☐
4) Poor soils	☐	☐
5) Lack of market	☐	☐
6) Pests and diseases	☐	☐
7) Access to credit	☐	☐
8) Weather	☐	☐
9) Price of input	☐	☐
10) Price of output	☐	☐

11) Others(specify)____

2.3 Can you say the price offered for snow peas influenced you to grow snow peas?

YES ☐ NO ☐

2.4. i. Has any diseases affected your snow peas plants? 1= YES ☐ 2= NO ☐

ii. If YES fill the following table

Disease	Effect of the disease

2.5 i. Has any pest affected your snow peas plants? 1= YES ☐ 2= NO ☐

ii. If YES, fill the following table

Pest	**Effect of the pest**

3.0: SNOW PEAS PRODUCTION

Land

	Total amount (acres)	**Amount occupied by snow peas**
Owned		
Hired in (leased)		
Communal		

Farm inputs

3.1 Did you use any inputs (fertilizers, manure, pesticides) in snow peas production last season?

1=YES ☐ 2=NO ☐

3.2 If YES which ones did you use and how much?

Fertilizer			**Agro-chemicals**		
Type of fert.	**Qty fert. (kg)**	**Price of fert. (per kg)**	**Type of Agro-chemical**	**Quantity applied (lt or kg)**	**Price per lt or Kg**
1= DAP					
2 = MAP					
3= TSP					

4=Manure					
5=Other specify					

Labour

3.3 Please fill the table below regarding the family labour input in snow peas production.

Table2: Family Labor Input.

Activity	**Male Family Labour**			**Female Family Labour**			**Child Family Labour**		
	NO of men	**Hrs /day**	**Days**	**NO of women**	**Hrs /day**	**NO. of days**	**NO of children**	**Hrs /day /child**	**Total Days**
Ploughing									
Planting									
Weeding									
Pesticide application									
Trellising									
Harvesting									
Other									

3.4 Did you hire any labor for snow peas production activities last season?

YES=1 ☐ NO=2 ☐

If YES in 3.4 please fill the table below regarding the hired labour.

Table: Hired Labor Input.

Activity	**Male Hired Labour**			**Wage rate (ksh/ day)**	**Female Hired Labour**			**Wage rate (ksh/day)**
	NO of men	**Hrs /day**	**NO of days**		**NO of women**	**Hrs /day**	**NO. of Days**	
Ploughing								
Planting								
Weeding								
Pesticide application								
Trellising								
Harvesting								
Other Specify								

4.0: SNOW PEAS YIELDS AND MARKETING

4.1 How often do you harvest your peas? ....

4.2 What is your yield per harvest? ………………………… (In kgs, crates etc.)

4.3 Was any of the harvested snow peas consumed at home?

1=YES ☐ 2=NO ☐

4.4 If YES how much:

4.5 Was any of the harvested snow peas sold in the market?

1=YES ☐ 2=NO ☐

4.6 If YES please provide the following information:

Quantity	**Average selling price**	**Total revenue**

4.7 What is the distance to the nearest market? …………. (In kilometers)

4.8 How long do you take to deliver your snow peas to the collection point.............? (Hours)

4.9 What is the state of the road to the market?

1=tarmac, 2=murrum, 3=other (specify)………… [ ]

5.0: ACCESS TO EXTENSION SERVICES

5.1 Did any extension agent visit you to talk about snow peas production last season?

1=YES [ ] NO [ ]

5.2 If YES, please fill in the table below.

Provider/extension agent **1= Government** **2= NGO** **3=Fellow farmer** **4= other (specify)**	**2015**		
	Topic **1=planting eg spacing, seed rate** **2=use of agro-chemicals** **3=marketing** **4= others specify**	**Number of visits by ext. agent**	**Avg. time for each visit (hrs)**

NB: Extension is an informal out of class exchange of information between extension agents and farmers and takes a short time per contact.

5.3 If extension agents did not visit you for advice on snow peas production did you visit any extension agent to seek for advice?

1=YES [ ] 2= NO [ ]

5.4 If YES, fill the following table

Provider/extension agent 1= Government 2= NGO 3=Fellow farmer 4= other (specify)	Topic 1=planting eg spacing, seed rate 2=use of agro-chemicals 3=marketing 4= others specify	NO. of visits to ext. agent	Avg. time for each visit made to ext. agent (hrs)

6.0: MEMBERSHIP IN AN ORGANIZATION

6.1 Are there any groups dealing with snow peas production or marketing in your area?

1=YES ☐ 2=NO ☐

6.2 If YES, did any household member belong to any of these groups last season?

1=YES ☐ 2=NO ☐

Relation with HH head	**Group** **1= snow peas producer** **2=snow peas marketing**	**Year HH member joined**	**Main activities of the organization**	**Benefits received by member**

6.3 Did any member of the household belong to a local group other than snow peas group membership in 2015?

1=YES ☐ 2=NO ☐

6.4 If YES please fill the table below. *Please complete for any household member who belongs to local group.*

Relation with the HHH	Organization 1=Farmer group 2= NGO project 3=CBO 4=Government Project 5=Other(specify)	Year HH member joined	Main activities of the organization 1= Financial services (SACCO) 2= Mutual support 3= Extension services 4= Marketing agric. products 5= other(specify)	Benefits received by member

NB: Farmers associations include women's associations, youth associations, church, mutual support group, an input supply cooperative, a marketing cooperative, savings or credit group, etc.).

7.0: ACCESS TO CREDIT

7.1 Did you have access to formal/informal credit last season?

1=YES 2= NO

7.2 If YES, fill the table:

Source	**Amount**	**Repayment period**	**Purpose**
Banks			
Cooperatives			
NGOs			
Traders			
Rotating saving and credit (table banking)			
Intermediaries			
Others, Specify			

7.3 If you did not apply, why not? ________________________________

7.4 ASSET ENDOWMENTS (NUMBERS)

Asset	Number	If would sell now, at what price Ksh
Oxen		
Dairy Cattle		
Local Cattle		
Donkeys		
Camels		
Goats		
Sheep		
Pigs		
Poultry		
Carts		
Vehicle		
Tractors		
Plough		
Wheel barrows		
Hoes/Jembes		
Pangas/Slashers		
TV		
Radio		
Bicycles		
Computer		
Furniture		
Other assets		

7.5 HOUSEHOLD INCOME SOURCES IN KSH IN 2015

Type of earning	Amount in ksh	Time period in days
Employment income		
Total Income from business		
Total Income from crop produce		
Total Income from milk sales		
Total Income from sale of livestock and other assets e.g. land, vehicle		
Transfer earnings from relatives, sons, daughters etc		
Value of gifts		
Land rented out income		
Buildings rented out income		
Other structures rented out income		
Motor vehicle rented out income		
Other income		

7.6 HOUSEHOLD EXPENDITURE ON STAPLES IN KSH IN 2015

		Frequency purchased	Period 1=day 2=week 3=month 4=6 months 5=Yearly	Quantity	Unit	Average price per unit			Frequency purchased/ contribution made	Period 1=day 2=week 3=month 4=6 months 5=yearly	Quantity	Unit	Average price Per Unit/
	Prod	**Freq**	**Period**	**Qty**	**Unit**	**Avexp**		**Prod**	**Freq**	**Period**	**Qty**	**Unit**	**Avexp**
Staples							***NOn-Fresh Food Items***						
Millet	**1**						Sugar	**23**					
Sorghum	**2**						Salt	**24**					
Wheat flour	**3**						Cooking oil	**25**					
Rice	**4**						Coffee/Tea	**26**					
Cassava (Fresh or Dry)	**5**						Drinks	**27**					
Maize (Grains)	**6**						Tobacco/ Cigarettes	**28**					
Maize meal (Posho/sifted)	**7**						Other Non-Fresh Items	**29**					
Sweet potatoes	**8**						***Non-food Items***						**Amount**
Irish potatoes	**9**						School fee, textbooks, etc	**30**					
Matoke	**10**						Medical fee	**31**					
Beans	**11**						Transportation	**32**					
Other Staples	**12**						Clothing/Shoes	**33**					

7.7 HOUSEHOLD EXPENDITURE ON NON-STAPLES IN KSH IN 2015

Non-Staple Fresh Food							Cooking/Lighting fuel	**34**				
Green Peas	**13**						Soap/washing products	**35**				
Meats	**14**						Other NOn-food items	**36**				
Eggs	**15**						***Contributions***					**Amount**
Chicken (meat)	**16**						Remittances to relatives	**37**				
Fish	**17**						Churches/Mosques					
Fish (omena)	**18**							**38**				
Vegetables	**19**						Mutual Support Groups/Funeral	**39**				
Fruits	**20**						Cooperatives/committees	**40**				
Dairy products (ghee, milk etc.)	**21**						Other local organizations	**41**				
Other NOn-staples	**22**											

Thank you for your patience and responses.