ANALYSIS OF TECHNICAL EFFICIENCY OF IRISH POTATO PRODUCTION IN ELDORET EAST SUB COUNTY, KENYA

BY

CHEPKWONY, EZEKIEL KIPNG'ETICH

A THESIS SUBMITTED IN PARTIAL FULFILMENT FOR THE REQUIREMENTS FOR DEGREE OF MASTER OF SCIENCE IN THE DEPARTMENT OF AGRICULTURAL ECONOMICS AND RESOURCE MANAGEMENT

SCHOOL OF BUSINESS AND ECONOMICS
MOI UNIVERSITY

NOVEMBER, 2014

DECLARATION

Declaration by the Candidate

This thesis is my original work and has not been presented for a degree in any other university. No part of this thesis may be reproduced without the prior written permission of the author and / or Moi University

…………………..................……….. ………………….................

CHEPKWONY, EZEKIEL KIPNG'ETICH **DATE**
AGR/PGE/14/04

Declaration by Supervisors

This thesis has been submitted for examination with our approval as University Supervisors.

…………………..................……….. ………………….................

PROF. MARY J. KIPSAT **DATE**
DEPARTMENT OF AGRICULTURAL ECONOMICS
AND RESOURCE MANAGEMENT,
SCHOOL OF BUSINESS AND ECONOMICS,
MOI UNIVERSITY

…………………..................……….. ………………….................

DR. MARK KORIR **DATE**
DEPARTMENT OF AGRICULTURAL ECONOMICS
AND RESOURCE MANAGEMENT,
SCHOOL OF BUSINESS AND ECONOMICS,
MOI UNIVERSITY

DEDICATION

To my inspiring mother, Annah, my dear wife, Florence, son, Kevin and daughter, Sharon

ABSTRACT

The Irish potato, *Solanum tuberosum* L., has a longstanding history in human nutrition in Kenya. It holds position three relative to maize and beans as main staples, giving a high potential for the potato production and consumption in the country. However, there is low productivity due to the technical efficiency. The primary objective of this study was to estimate technical efficiency of Irish potato production. The specific objectives were: to investigate the relationship between the farm output and the inputs, given the assumption of a specific technology; to identify the socio-economic factors that affect technical efficiency. The study was done in Ainabkoi Division because it was the major Irish potato production zone in the County. A survey research design was adopted to collect the primary data. Data on socio-economic characteristics of farmers were used. The target population was the Irish potato farmers in Eldoret East Sub County. Data was obtained with the aid of questionnaires which were administered to 105 randomly selected respondents by the researcher with the help of four enumerators recruited by researcher. Stochastic frontiers method was used in this study to analyze the survey data. The first approach, called the two-step approach, first estimated the stochastic frontier production function to determine technical efficiency indicators. Next, indicators thus obtained were regressed on explanatory variables that usually represent the firms' specific characteristics, using the Ordinary Least Square method. In the stochastic frontiers model, the coefficients and the variance parameters are simultaneously estimated by maximum likelihood method, using *Frontier 4.1* software. The analysis revealed that the sum of the partial output elasticities with respect to all inputs was 1.86. This indicated an increasing return to scale in Irish potato production. It further revealed that Irish potato farmers could benefit from economies of scale linked to increasing returns to boost production. The mean technical efficiency index was estimated at 0.789. This meant that farmers have 21.1% scope of increasing the potato production by using current technology. The inefficiency parameter estimate indicated three socio economic and institutional factors (level of education; access to extension; and access to credit) as having significant effect in technical efficiency of Irish potato production. In order to improve technical efficiency, access to extension service should be enhanced by having more extension providers closer to the farmer. This would increase frequency of farmer and extension provider contact. Enabling farmers' access affordable credit facilities and Capacity building of farmers would also improve the technical efficiency of Irish potato production.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGEMENT

I wish to appreciate my supervisors; Prof. M.J. Kipsat and Dr. M. Korir. It is through their inspiring support and enlightened supervision that I was able to work on this Thesis. They were constant sources of inspiration and encouragement during analysis, and preparation. I acknowledge the constructive and valuable comments that I have used in shaping this work to what it is now. It is my pleasure to also recognize colleagues in the Ministry of Agriculture for their encouragement, especially Mrs. Grace Kirui, the Deputy Director in Rift Valley Provincial Agriculture Office (DPDA) for her motivation and facilitation while collecting data in the field. I need to also recognize my contemporaries in the Department of Economics and Agricultural Resource Management, without whom the program would have been dreary. I recognize also the services of the enumerators who worked tirelessly to ensure that I got right data on time. Last but not the least, I value the services provided by my secretary, Jerusa Atandi, towards this thesis, especially in typing and proof-reading the numerous manuscripts.

ACRONYMS AND ABREVIATIONS

PRAPACE	Eastern and Central African Irish Potato and Sweet Potato Network
CIP	International Potato Centre
DAO	District Agricultural Officer
DEA	Data Envelopment Analysis
FAO	Food and Agriculture Organization
FDH	Free Disposal Hull
FEOs	Frontline Extension Officers
GDP	Gross Domestic Product
HICs	High-Income Countries
KARI	Kenya Agricultural Research Institute
LICs	Low-Income Countries
MLE	Maximum Likelihood Estimation
NGOs	Non-Government Organizations
OLS	Ordinary Least Squares
SFA	Stochastic Frontier Approach
SSA	Sub-Saharan Africa

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Kenya's economy is heavily dependent on agriculture. This means that accelerated growth in the sector is the most important objective of the policy makers (Nyagaka *et al.*, 2010). Approximately 75 percent of Kenyans make their living from farming, producing both for local consumption and for export. On average, Agriculture accounts for 30 percent of Kenya's Gross Domestic Product (GDP) and brings in over 26 percent of foreign exchange earnings. Seventy percent of Kenya's merchandises export is agricultural and 33% manufacturing sector is based on agricultural products (Pearson, 1995). Agriculture also provides raw materials for Kenya's agro-industries. Over 50 percent of export revenue comes from tea, coffee, floriculture, and cotton. Farmers in Kenya are involved in both small and large scale farming of food and cash crops. Some of the food crops include maize; wheat; Irish potatoes, peas, beans, fruits and vegetables. Cash crops include tea, coffee, cotton and sisal. Crops produced provide self-employment to most farmers on their own farms and also creates employment for casual laborers (Lawrence, 2008).

Due to agriculture's contribution to total output and employment, now and some time to come, attempts to improve living standards must give particular attention to increased incomes and productivity in the agricultural sector. Enhancement of agricultural productivity is thus an important condition in alleviating rural poverty, increasing household food security and stimulating growth in non-farm activities.

Irish potato (*Solanum tuberosum L.*) originated from Lake Titicaca region in the highlands of South America between Peru and Bolivia, thousands of years ago. The tuber was taken by the Spanish conquistadors to Europe in the 16th Century, where it eventually became an important and popular food crop (Crissman, 1968).

During the colonial period, the potato made its way to Asia and Africa. At first, it remained a minor crop in those countries but over time it has become a more important crop. In Africa, it spread to sub Saharan region in the 19th Century (Miha and Atirib, 2007) through the activities of European missionaries, and remained an elitist food for some time. The crop is gaining popularity especially in the urban centers due the increasing demand for potato chips and crisps. The crop ranks third after maize and beans in terms of food security**.** Compared to other tuber crops, potato has the highest protein to calorie ratio, and it is the highest producer of energy per hectare per day (CIP, 1982). The crop is adapted to a cool moist climate, and grows in the high altitudinal ecosystems of Sub Saharan Africa where rainfall is well distributed for 3–4 months.

Technical efficiency is the effectiveness with which a given set of inputs are used to produce outputs. If a firm is producing the maximum output, given the resources it employs, such as labour and machinery, and the best technology available, it is said to be technically-efficient. In the theory of perfect competition, there will, in general, be no technical inefficiency because if any firm is less efficient than the others it will not make sufficient profits to stay in business in the long term. Technical efficiency looks at the outputs of potatoes that are produced with given inputs.

1.2 Statement of the Problem

The government of Kenya recognizes potatoes as one of the most important food crops in the country (GoK, 2007). Its demand has been growing steadily especially among the urban consumers (MOA, 2007). The country has high potential for the production and consumption yet production does not meet the demand because of low productivity, despite a lot of research and development efforts made on high yielding varieties (Alumira and Obara, 2008). Hybrid planting materials that are developed by Kenya Agricultural Research Institute (KARI) and have a potential of over 30 tons yield per hectare but most farmers do not achieve this yield. Farmers use different levels of production inputs and management depending on their infrastructural facility and socio economic conditions. This ultimately results in variability in the technical efficiency of Irish potato production (Hossan et al 2008). There is therefore a need to assess the technical efficiency of Irish potato production. In order to come up with proper policy measures to increase productivity, it is prudent to have adequate information on factors affecting technical efficiency in the production.

1.3 Justification for the Study

The international market for potatoes has five main segments: seed potato, ware potatoes, frozen chips, crisps / snacks and, starch / other miscellaneous products. The frozen chip and snack markets have shown the highest rates of growth in the past decade and it is most likely that frozen chips will continue to be the leading area of growth in the next decade (Ferris *et al.*, 2001). Potatoes are essentially a food security crop with steadily growing urban domestic markets. Projections for future growth are somewhat obscured by lack of sound empirical data on production and demand.

Prospects for major positive changes in the Kenyan potato market should be considered in relation to the market opportunities. Kenya has competitive advantage to enter the frozen chips market, due to good infrastructure, distance from important markets and economies of scale that are required. Prospects for production of high quality crisps and snacks to supply the domestic market are relatively good, as long as product quality can compete with imported good (Ferris *et al.,* 2001).

Expansion into the ware potato market should be analyzed against three market options: demand for 'export quality' tubers to supply fast food outlets, restaurants and the tourist trade; premium grade potatoes to supply the premium, middle class, urban market, which is being led through retail outlets such as Shoprite and; standard grade tubers to supply the bulk food security market. It may be possible to explore some limited sales of high quality tubers into the regional ware markets. Export market for seed potatoes from Kenya to neighbouring countries has a great potential. Potatoes are a very productive and nutritious food crop whose importance in managing food security in Kenya cannot be overemphasized. This study would contribute to the existing literature because it is the first comparative study of farm-level efficiency of Irish potato producers in Eldoret East Sub County.

1.4 Objectives of the Study

1.4.1 The Overall Objective

The primary objective of this study was to estimate the efficiency of Irish potato production and identify socio economic factors that affect it, in Eldoret East Sub County

1.4.2 The Specific Objectives

i. To determine the elasticities of production inputs and economies of scale of production for Irish potato in Eldoret East Sub County

ii. To estimate the technical efficiency of Irish potato production

iii. To identify the socio-economic factors that impact on technical efficiency of Irish potato production in Eldoret East Sub County

1.5 Hypotheses of the Study

- HO_1: The production inputs for Irish potato in Eldoret East Sub County have constant returns to scale.
- Ho_2: The Irish potato farmers in Eldoret East Sub County are not technically efficient.
- Ho_3: The socio-economic factors have no effect on technical efficiency among the Irish potato farmers in Eldoret East Sub County.

1.6 Scope of Study

The study focused on technical efficiency of Irish potato production in Uasin Gishu county. The effect of the market imperfection, storage, and sources of seed were not investigated though they may have effect on the technical efficiency. Focus was only on the socio economics and institutional effect on the technical efficiency of Irish production.

Uasin Gishu County and specifically the Eldoret East sub county was selected by the researcher for convenience because of limited resource available for the research, and furthermore the researcher was working as agricultural extension worker in the area, thus had prior understanding of the socio economic and demographic profile of the population.

The analysis of the data was done using Cob Douglas model. The model was commonly used by other researchers analyzing technical efficiency. It ease the understanding and fitting of the variables. The stochastic frontier model was prefered in the estimating the production frontier of Irish potato farmers. However there are other available options for hypothesis testing which the researcher would have used, such as Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH). These are non parametric and lack the statistical procedure for hypothesis testing. If estimator (Aragon et al, 2003) is used , it required conditional quantiles for appropriate distribution associated with the production. This was not applicable to multi-variable analysis. So the researcher limited himself to the use of stochastic frontier model which is parametric and thus uses econometric estimation. Furthermore the stochastic frontier could measure random effect. It was therefore appropriate in measuring the effect of socio economic on technical efficiency of Irish potato.

CHAPTER TWO

LITERATURE REVIEW

2.0 Introduction

Potato (*Solanonum tuberosum*) is the third most important food crop in Kenya after maize and beans. Its demand was increasing day by day especially among the urban dwellers (Hike et al, 2005). Three quarters of the urban population regularly consume potatoes, on average 5kilogram per adult per month (ASyieko *et al.*, 2005). Income elasticity of potato was the lowest among stable foods (Hossain *et al.*, 2005).

However, production did not satisfy the growing urban demand because of low production levels. The low production levels were due to the farmers using different level of inputs and management. Different farmers employ different levels of the inputs which ultimately result in the variability of production efficiency depending on the their infrastructural facility and socio economic conditions. In other words production performance did not depend only on the physical resources and technology but also socio economic and institutional factors. These factor included age, level of education, marital status; farming system access to credit; access to extension service; and marital status and experience of the farmer.

It was therefore prudent to analysis technical efficiency of irish production and identify the socio economic factors that influence it.

2.1 Theoretical Framework of the Study

This study was based on the production economics theory which is part of the microeconomics theory that deals with production of goods from a set of inputs. Production function is a model used to formalize the relationships between the inputs and output as defined below:

$Q = f\ (L, S, F, C, P)$……………………………………………………………… 2.1

Where: Q= output

L= labour

S= land used

F= amount of fertilizer used

C= capital

P= chemicals used

The objective of the producer is to maximize profit by either increasing the quantity produced; or reducing the cost of production (Kibaara, 2005). The production function shows the maximum amount of the goods that can be produced using the alternative combination of inputs. This alternative combination could be expressed using several forms such as polynomial functional form, linear functional forms or Cobb-douglas functional form. The theory indicates that the marginal physical product (MPP) of an input is the additional output that is produced by employing one extra input holding other factors constant. MPP of labour is thus given as $MP_L = \frac{\partial Q}{\partial L}$

This is the first derivative of the production function. However, according to Kibaara (2005), if labour is employed indefinitely while holding other factors constant, it results into diminishing marginal productivity. Hence the second derivative should be less than zero. $\frac{\partial MPL}{\partial L} = \frac{\partial^2 q}{\partial L^2} = f_{LL} < 0$ ………………………………………………………2.2

The average physical product (APP) is a measure of the efficiency (Kibaara, 2005). APP depends on the level of the other inputs employed

$AP_L = \frac{output}{labour} = \frac{Q}{L} = \frac{f(F.S.L)}{L}$ ………………………………………………………… 2.3

Concept of return to scale shows how the output responds to the increase of all inputs employed together. This would give the constant return to scale; decreasing return to scale or increasing return to scale. This was derived by computing the amount of MPP attained by each APP. i.e $\frac{mpp}{APP}$. In addition, the total Variable product (TVP) is derived by multiplying the TPP by output Price (P_y). Marginal Value product is computed as thus:

MPP × P_y =MVP………………………………………………………………… 2.4

This was economic concept from production function which was then used to generate profit function as profit (π) = TVP-TVC. When first order derivative (FOD) is applied, we get change in profit with respect to change in input e.g. labour (L); $\frac{\Delta \pi}{dL}$ = MVP_L-MVC = 0. ……………………………………………………………………………. 2.5

To determine if the inputs are used at optimal level the MVP= price of input. Therefore at profit maximization, MVP (MPP×P_y) = MVC = w (unit cost of input)

The socio economic characteristics and management are lumped together in the error term (Kibaara, 2005). However stochastic frontier production function deals with analysis of socio economics characteristics of household that are lumped in error term.

2.2 The Technical Efficiency

The concept of efficiency is derived from a particular interpretation of the notion of production frontier, which in its classical sense is the relationship between output, on the one hand, and the quantity of the inputs used in the production process to obtain that output, on the other. The efficiency of a firm is its ability to produce the greatest amount of output possible from a fixed amount of inputs. An efficient firm is one that given a state of technical know-how, can produce a given quantity of goods by using the least combination of inputs possible. In estimation methods of efficiency frontiers, the production function becomes the production frontier.

The first analyses of efficiency measures were initiated by Farrell (1957). Drawing from Debreu (1951) and Koopmans (1951), Farrell proposed a division of efficiency into two components: technical efficiency, which represents a firm's ability to produce a maximum level of output from a given level of inputs and allocative efficiency, which is the ability of a firm to use inputs in optimal proportions, given their respective prices and available technology (Nchare, 2007). The combination of these measures yields the level of economic efficiency.

The evaluation of a firm's technical efficiency level results from the estimation of a frontier production function. Two main approaches are used to construct efficiency frontiers. The first of these is the nonparametric approach. In this approach, estimation methods are based on envelopment techniques. Distinct among them are the Free Disposal Hull (FDH) and Data Envelopment Analysis (DEA) methods. The FDH method was developed by Deprins *et al.* (1984), while the DEA method was initiated by Farrell (1957) and transformed into estimation techniques by Charnes *et al.* (1978). DEA is based on linear programming and consists of estimating a production frontier through a convex envelope curve formed by line segments joining observed efficient production units. No functional form is imposed on the production frontier and no assumption is made on the error term. Nevertheless, this method is limited because it: lacks the statistical procedure for hypothesis testing; does not take measurement errors and random effects into account (it supposes that every deviation from the frontier is due to the firm's inefficiency) and; is very sensitive to extreme values and outliers.

A deterministic frontier statistical theory, which is designed to overcome some limitations of DEA is now available (Simar and Wilson, 2000). Simar (2003) has proposed a method to improve the performance of DEA/FDH estimators in the presence of noise, while

Cazals *et al.* (2002) developed a robust nonparametric estimator. Instead of estimating the full frontier, they rather propose to estimate an expected maximal output frontier of a given order.

Following this approach, Aragon *et al.* (2003) developed a new nonparametric estimator of the efficiency frontier based on the conditional quantiles of an appropriate distribution associated with production processes. Unfortunately, this method is not extended to multivariate analyses. The second approach is the parametric approach, which is based on econometric estimation of a production frontier whose functional form is specified in advance. In this approach, the stochastic frontiers method is the most popular. Also referred to as “composed error model”, the stochastic frontiers method has the advantage of taking into account measurement errors or random effects. Criticism of this method resides in the need to specify beforehand the functional form of the production function and the distributional form of the inefficiency term.

2.3 Empirical Studies on Efficiency

Chaaban *et al.* (2008) sought to identify whether production characteristics, such as technical efficiency and returns to scale, affect takeovers. Applying a two-stage procedure on original panel data on French cheese manufacturers, the authors first estimated firm-specific productive efficiency and scale economies using Data Envelopment Analysis. The researchers then used the findings of the first stage to evaluate a random effects logit model of the determinants of takeover in the French cheese industry for the period 1985-2000. The authors found that technical efficiency is not a significant determinant of takeovers, whereas the nature of scale economies is. Firms with Decreasing Returns to Scale (i.e. an over-sized production capacity) face a higher risk of takeover. The study concluded that cheese manufacturers have been seeking to expand their milk processing capacities by acquiring large firms. This proves to be an indirect consequence of the non-transferable milk quota regime affecting the scarce milk input commodity.

Iheke (2008) examined the technical effeciency of casava farmers in South Eastern Nigeria , employing the stochastic frontier production procedure. The results indicated that technical effeciency of farmers ranged between 52%-95% with mean of 77%. This indicated that there was ample opportunies for the farmers to increase their production through improvement in the technical effeciciency. Education level,experience of the farmer, household size, membership to farmers' association and access to credit, improved variety of casava and farm size were significantly related to the technical effeciency while age, and contact to the extension were not significantly related to the technical effeciency.

Fasasi (2007) used a stochastic frontier production (Maximum Likelihood Estimation, MLE) methodology to estimate the technical efficiency of 100 farmers in Oyo State, Nigeria. Efficiency analysis is an issue of interest given that the overall productivity of an economic system is directly related to the efficiency of production of the components within the system. The empirical results show that the mean level of technical efficiency was 70 percent. The estimated technical efficiencies of the farmers ranged between 18 percent and 93 percent indicating that with the present technology there is still room for a 30 percent increase in food production. Age of farmers, farming experience and level of education were factors that significantly influenced the level of technical efficiency. The researcher concluded that technical inefficiency of farmers increases with age while it decreases with years of experience and level of education.

Gauri (2006) estimated technical efficiency in production and resource use in sugar cane in India. The assessment was to find out whether farmers in India's sugar cane belt (which includes the village surveyed) were efficient producers of sugar cane, and, how the estimated inefficiency scores vary across plots used in the survey. He explored the sources of inefficiency across farmers. Using parametric approaches to production, technical inefficiency across sugar cane growing plots was estimated using an output-oriented measure. Specifically, a stochastic production function was employed and inefficiency scores for farmers at the plot level were calculated. Technical inefficiency obtained in this manner was a *relative* measure where the production frontier was defined by the farmers' plots included in its estimation. Using maximum likelihood estimation techniques and the stochastic production frontier at the plot level by ownership types of water amongst a cross section of sugar cane growing farmers using primary survey data. Inefficiency effects were modeled as a function of farmer specific explanatory variables.

Tests revealed that the null hypothesis of no inefficiency and no influence of farmer specific variables on inefficiency was rejected. Education, land area, discharge of tube well and distance of plots from the water source were the causes identified in explaining inefficiency. Estimated technical efficiency scores were highest on plots where water is sourced from a privately owned tubewell, followed by plots serviced by partnered tubewells and lowest on plots where water was bought.

Ogudarikolawle *et al.* (2007) examined the overall efficiency of small holder croppers in Nigeria with a view to examining the productive efficiency in food production in the country. They collected data from 200 farmers and analyzed using descriptive statistics, stochastic frontier production and cost function models. The return to scale (RTS), for the production function revealed that farmers operated in the irrational zone of the production surface having RTS of 1.113. However the findings were that the sampled farmers were relatively efficient in the allocative and economic efficiency with allocative efficiency appearing more significant than the technical efficiency as source of gains in economic efficiency. Their analysis indicated that presence of technical inefficiency and allocative inefficiency had effects on food crop production as depicted by the significant estimated gamma coefficient of each model, the generalized likelihoods ratio test and the predicted technical and allocative efficiency within the farmers.

Bravo-Ureta *et al.* (*2002*) undertook a meta-analysis seeking to explain the variation in average technical efficiency focusing on the agricultural sector. For this purpose, a meta-analysis of 126 technical efficiency studies on the agricultural sector of developing and developed countries was undertaken. The study contributes to cross-country productivity literature because the existing body of work in this area typically uses aggregate (national) level data to estimate total factor productivity and has ignored the technical efficiency component of productivity. The econometric results suggest that stochastic frontier models generate higher mean technical efficiency estimates than deterministic models, while parametric frontier models yield lower estimates than nonparametric.

According to Bravo-Ureta *et al.* (*2002*), the difference between parametric and non-parametric frontiers is reduced when the translog specification is used. Also, frontier models using cross-sectional data produce lower estimates than those based on panel data. The econometric results also suggest that Low-Income Countries (LICs) present a lower mean technical efficiency than High-Income Countries (HICs). A more detailed analysis reveals that Western European countries and Australia present, on average, the highest levels of mean technical efficiency among all regions after accounting for some methodological features of the studies. Eastern European countries exhibit the lowest estimate followed by Asian and African countries, while studies from Latin America and Caribbean countries and from North American countries are in an intermediate position.

Nchare (2007) conducted a study to analyze the factors affecting technical efficiency of Arabica coffee producers in Cameroon. To carry out this analysis, a translog stochastic production frontier function, in which technical inefficiency effects were specified to be functions of socio-economic variables. This was estimated using the maximum-likelihood method. The results show some increasing returns to scale in coffee production. The analysis revealed that the educational level of the farmer and access to credit were the major socioeconomic variables influencing the farmers' technical efficiency. According to the author, the findings prove that further productivity gains linked to the improvement of technical efficiency may still be realized in coffee production in Cameroon.

An analysis of the productive performance of Robusta coffee farmers in a low income area in Côte d'Ivoire, Nyemeck *et al.* (2001), used the two-step approach (Instead of adopting the parametric approach, these authors used the DEA method to calculate technical efficiency indices. Furthermore, the efficiency indices obtained were regressed on the set of socioeconomic variables with the help of double censure Tobit model. They determined that belonging to a mutual aid group and family size negatively and significantly affect the level of technical efficiency. The efficiency indices they calculated varied between 2% and 100%, with a mean of 36%.

Helfand (2003) used the same approach as Nyemeck *et al*. (2001) to explore the determinants of productive efficiency in the Brazilian Center-West. From the results of his research, it is clear that access to credit institutions and to goods supplied by the public sector such as electricity and technical assistance, the use of modern inputs like fertilizers, and the practice of irrigation, soil conservation and crop protection against pests are the factors responsible for differences in the level of inefficiency between plantations.

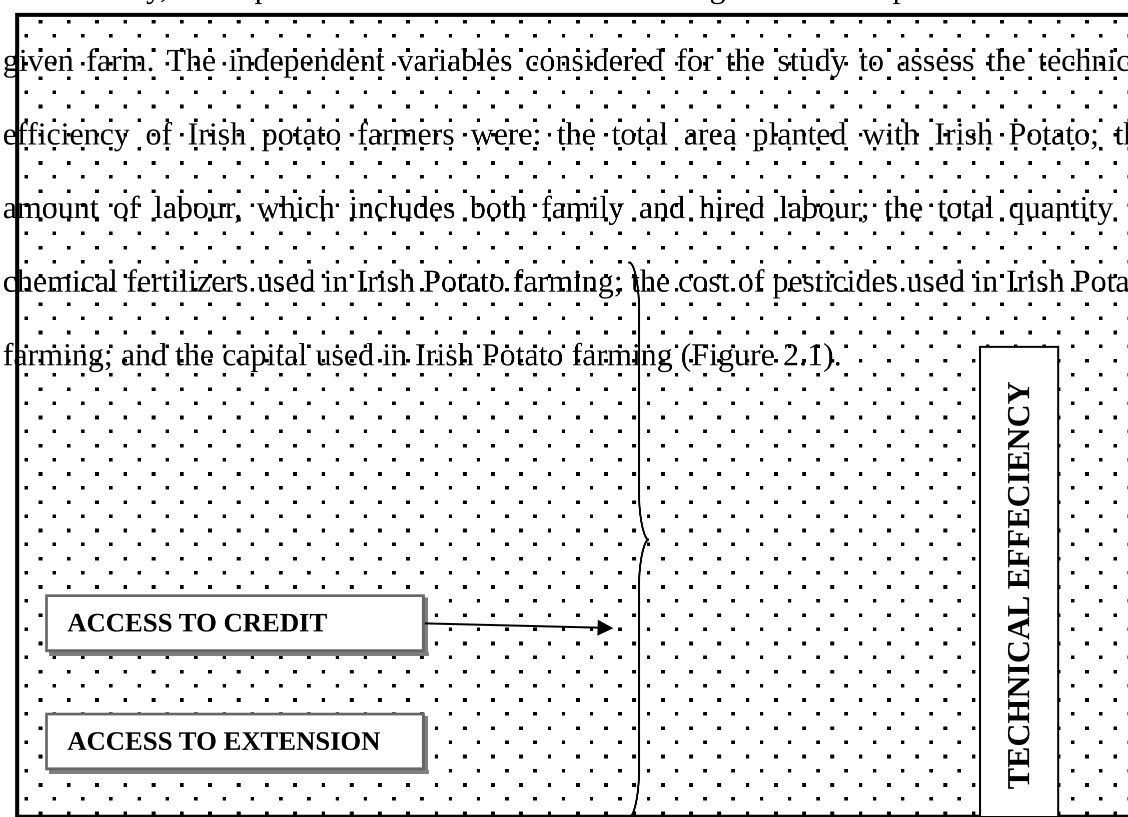
It emerges from the foregoing review of empirical studies that farmers, in general, allocate their productive resources inefficiently. From 18% to as much as 64% of agricultural output is lost because of inefficiencies specific to the farms, depending on the different studies.

Moreover, there are many socioeconomic variables that influence the technical efficiency of farmers. Personal characteristics include the farmer's age, level of education and experience. Among other immediate factors are farm size, family size, number of farm workers per hectare, distance between the farm and the nearest city, and the proportion of active household members engaged in non-farm activities. Additional influences are access to credit institutions and to goods supplied by the public sector such as electricity and technical assistance, the use of modern inputs like fertilizer, and the practice of irrigation, soil conservation and crop protection against pests. In fact, the studies reveal that it is possible to increase agricultural production significantly, simply by improving the level of producer technical efficiency without additional investments.

2.4 Conceptual Framework

Technical efficiency is a measure of how well the individual transforms inputs into a set of outputs (Aigner *et al*., 1977; Kumbhakar and Lovell, 2000). Two individuals using the same set of inputs and technology may produce considerably different levels of output. While part of the difference may just be random variations found in all aspects of life, other parts may be attributed to individual fundamental attributes and to opportunities that could be influenced through public policies.

In this study, the dependent variable was the value of agricultural output harvested on the given farm. The independent variables considered for the study to assess the technical efficiency of Irish potato farmers were: the total area planted with Irish Potato; the amount of labour, which includes both family and hired labour; the total quantity of chemical fertilizers used in Irish Potato farming; the cost of pesticides used in Irish Potato farming; and the capital used in Irish Potato farming (Figure 2.1).



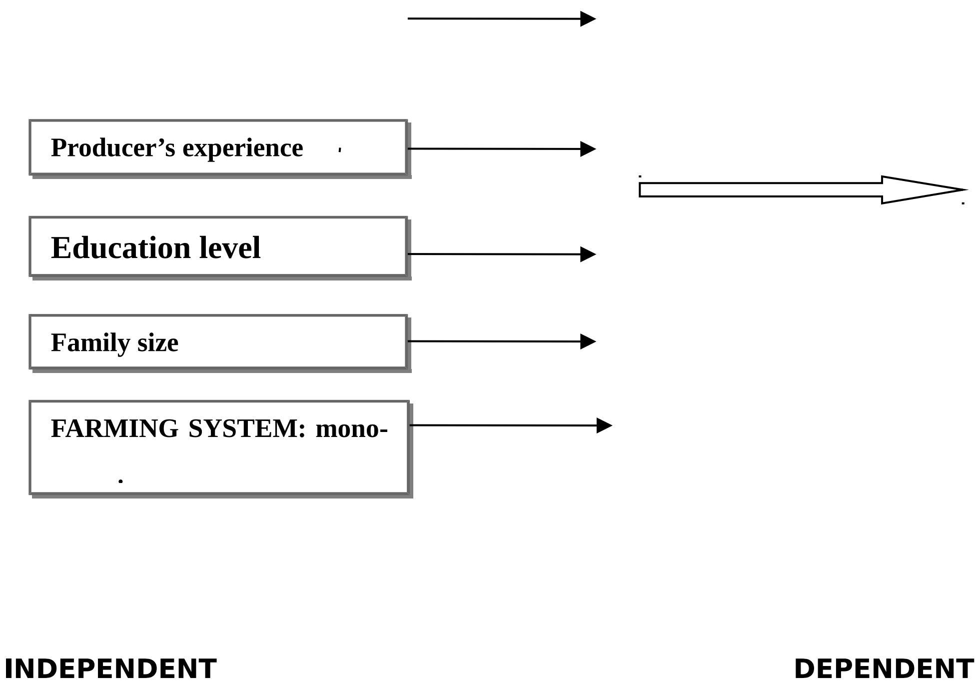


Figure 2.1: Conceptual Framework for the Study

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 introduction

This study was carried out in Uasin Gishu county and the target population was potato producers in the county. Focus was on Eldoret East Sub County which was main potato producing area in the county (GOK2008). It has two divisions namely, Ainabkoi, and Moiben. The projected population of the larger Uasin Gishu County is 777,336 (Kariuki *et al.,* 2008). It covers 3,327 sq km of which 2,995 sq km is arable land, 23.4 sq km is water mass and urban areas cover 196 sq km. The average annual rainfall in the district is 900 to 1,200 mm per year. This study concentrated within Ainabkoi Division because it is the major Irish potato production area.

The main economic activities in the area included farming, both large scale and small scale production of cereals, pulses and root crops. However majority of the farmers practice smallholder mixed farming. They also keep livestock for dairy production. To some extend a number of farmers grow horticultural crops like vegetable and passion fruit.

3.2 Research Design

An explanatory survey research design was adopted to collect the primary data for the study. The Ainabkoi Division of Eldoret East Sub County was the focus of this study because this Division is the key production area of Irish potato in the district. The target population for the study was exclusively made up of those farmers who practice Irish potato production. At the level of the Division selected, the choice of villages for the survey was done on the basis of the importance of their total Irish potato production in the division. This selection was carried out in collaboration with the Frontline Extension Officers (FEOs) of Ministry of Agriculture in the Sub County

3.3 Source and Types of Data Collected

The target population in this study involved a total of 2107 Irish potato farmers in Ainabkoi Division of Eldoret East Sub County (GoK, 2008). This study used data on the inputs–outputs of Irish potato production and socio-economic characteristics of farmers. The data include all factors of production (land, labour, fertilizers, pesticides) used in Irish potato production and their respective costs, as well as Irish potato yields, output sold, and sale prices. For socioeconomic variables, the data gathered comprised: the producer’s age, level of education, experience in Irish potato production, family size, services of agricultural extension agents, use of chemical fertilizer on Irish potato, variety grown, and the practice of mono-cropping. The data were collected during the 2008/9 crop year.

3.4 Sampling Procedure and Sample Size

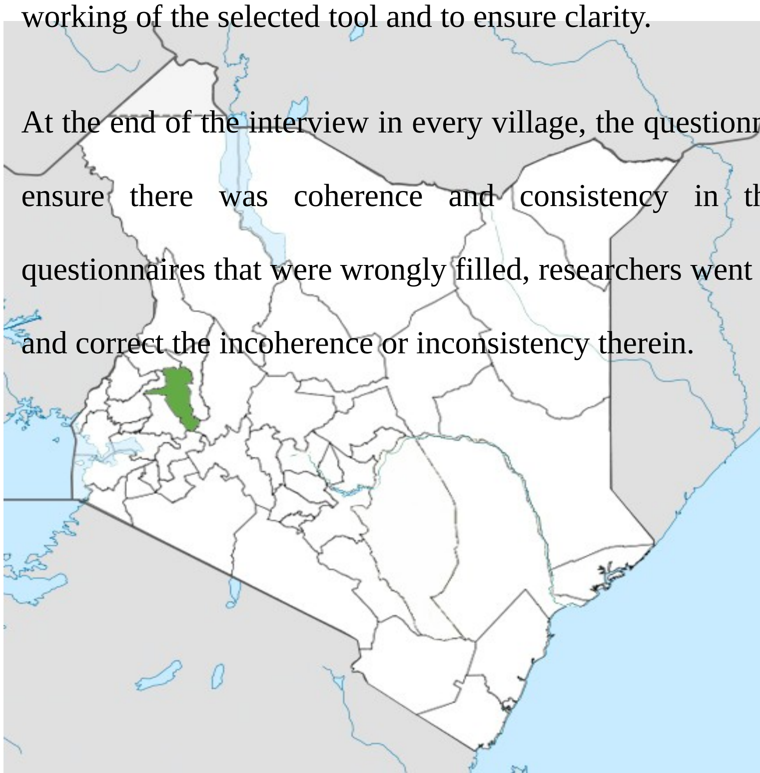
The sampling procedure adopted was multi stage random sampling to select the area of study. The selection of the location was mainly based on the consistent ability to produce high quantities of Irish potatoes based on reports from Ministry of Agriculture. All the administrative divisions in the District, with production of potatoes were identified based on 2007 district Crops annual report from Ministry of Agriculture. The sample size of 105 farmers was obtained by applying systematic sampling on the list of 2107 Irish potato farmers obtained from Ministry of Agriculture. This sample size constituted 5 per cent of the entire population and is representative of the population of study (Kothari, 1997).

3.5 Data Collection

Data collection was done vide the questionnaire developed by the researcher. The questionnaire was designed to capture socio economic variables that were used in analysis. These factors included age, family size; access to extension; access to credit; experience in farming; education level and gender. They were then administered by the researcher with the help of four enumerators recruited among Field Extension Officers (FEOs). The FEOs were chosen as enumerators because they not only had a good knowledge of rural areas, but were also well known to the farmers. Field data were collected from the statements of farmers and by direct observations. Prior to an interview, the objective and aims of the survey were clearly explained to the respondents. In every farm, the head of the household, who was considered as the farm manager, was interviewed.

Before administering the questionnaire, it was first pretested in Kapsaret Division. The area where the pre testing was done has similar condition to the selected Division and was also a potato growing area. The purpose of pre testing was to check on glitches in the working of the selected tool and to ensure clarity.

At the end of the interview in every village, the questionnaires collected were checked to ensure there was coherence and consistency in the information gathered. For questionnaires that were wrongly filled, researchers went again in the field to try to verify and correct the incoherence or inconsistency therein.



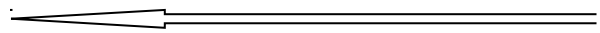


Figure 3.1: Location of Study Area in the Map of Kenya

Source: Uasin Gishu County Integrated Development Plan

3.6. Data Analysis

3.6.1 Operationalization of Variables

The value of produce harvested from the farm was used instead of the physical quantity because some farmers practiced mixed cropping in which more than one crop was grown on a piece of land at the same time. This value was obtained by multiplying the quantities of products harvested from the plot by the farm-gate price. In effect, when the farmer sold products on the market, transport and other marketing costs are subtracted from the market price to find the farm-gate price. Farm-gate prices of home consumption corresponded to the purchase price on the village market. The land size variable, it was measured by the area under Irish potato cultivation.

The calculations for labour were made by choosing the man-day as the base unit (for family and hired labour) and weighting it according to the Food and Agriculture Organization (FAO) method (Nchare, 2007).

For the fertilizer variable, the quantity registered corresponds to the one that was applied on the Irish potato in the course of the 2008 crop year. As for capital, the value of agricultural equipment was used if its economic life was less than one year. For tools whose economic life was more than one year, the depreciation charges were calculated according to the rate of straight-line depreciation recorded in the course of time. In this respect, the cost of agricultural equipment is divided by its economic life to obtain its annual use cost.

The cost of pesticides is equal to the quantity used multiplied by the purchase price, to which is added the cost of transportation to the plantation. The producer's educational level and experience are captured by the number of years spent in school and in Irish potato farming. Family size was determined by the number of people living in the household during the 2008 crop year. Agricultural extension workers' contact with the farms was calculated through the number of visits paid to farm during the 2008 crop year.

3.6.2 Parameters Estimated of the Stochastic Frontier Production Function

In choosing a model that adequately represents the data, two functional forms (Cobb–Douglas and translog) were estimated. The Cobb-Douglas production function was used for functional analysis of the data. It was a widely used model in fitting agricultural production data because of its simplicity in computation and mathematical presentation (Hossain *et al.,* 2008). Its homogeneous function provides scale factor that enables one to measure the return to scale and interpret the elasticity coefficient with ease.

3.6.3 Partial Elasticities and Returns to Scale

Considering that some individual coefficients of the variables of the translog stochastic frontier production function were not directly interpretable because of the presence of second order coefficients, partial elasticities of output with respect to inputs were estimated because they permit the evaluation of the effect of changes in the amount of an input on the output.

The objective of this study was to analyze the technical efficiency of potato production and socio economics factors that influenced efficiency of its resource use in Eldoret East Sub County. To achieve this objective, the trans-logarithmic stochastic frontier production function was estimated using the maximum likelihood method. The inefficiency effects were specified to be functions of the age, educational level and experience of the farmer, family size, contact with extension workers, access to credit, the use of various Irish potato varieties, and the pure - stand -cropping system.

3.6.4 Empirical Data Analysis for Technical Efficiency

The stochastic frontiers method was used in this study. The choice was made on the basis of the variability of agricultural production, which was attributable to natural factors such as climatic hazards, plant pathology and insect pests. Furthermore information gathered on production is usually inaccurate since small scale farmers do not have updated data on their farm operations. In fact, the stochastic frontiers method makes it possible to estimate a frontier function that simultaneously takes into account the random error and the inefficiency component specific to every farm.

The stochastic frontiers production model was proposed for the first time by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977). It had been used by many researchers in measuring technical efficiency and ineffeciciency of the production resources (Adewumi *et al.*, 2008). The preference for this model was attributed to the fact that it specified the relationships between the inputs and output and at same time inculcates the error terms.

The technical inefficiency is estimated via Maximum Likelihood Estimation method (MLE) (Adewumi *et al.*, 2008). The stochastic frontier used in this study is defined by the equation below:

$y_j = (x_{ij};\beta)+ \varepsilon_j$ ……………………………………………………………..… 3.1

Hence $\varepsilon_j = y_j - f(x_{ij};\hat{a})$,

Where:

- y_j is the output by farm j;
- x_{ij} is the vector of quantities of factors of production i used by farm j;
- β is vector parameter to be estimated.
- $\hat{a}$ is a vector of unknown parameters;
- ε_j is an error term $(u_j \geq 0, \forall_j)$ composed of two independent elements:

The error term was further defined as: $\varepsilon_j = v_j - u_j$,

Where:

- v_j is a stochastic variable with zero mean and unknown variance σ_j^2,
- u_j is the non negative stochastic term representing technical inefficiency in production of farm j; its mean is m_j and variance is σ_u^2. .its a random variable in production and is independently and identically distributed as half normal.
- By following parameterizations of Battese and Corra (1977), Battese *et al.* (1988), and Battese (1992), the likelihood function of the model defined in equation 1 can be written as:you already have other equations. Have these as 3.1, 3.2…while those in chapter 2 as 2.1, 2.2, …

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

………..… 3.2

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

$$E\left[exp(-u_j)\right] = 2[1 - \Phi(\sigma\sqrt{\gamma})] * \left[exp\left(-{}^{\gamma\sigma^2}/_2\right)\right] \qquad \ldots\ldots\ldots\ldots 3.3$$

Moreover, the measurement of technical efficiency (or inefficiency) level of farm *j* requires estimating the random term u_j. Considering the assumptions made on the distribution of u_j and *í*$_j$ Jondrow *et al*. (1982) first compute the conditional mean of u_j given *å*$_j$. Battese *et al.* (1988) derive the best indicator of farm *j* technical efficiency, written as $TE_j=exp(-u_j)$ using the formula:

$$E\left[exp(-u_j)/\varepsilon_j\right] = \left[\frac{1-\Phi\left(\sigma_A + \gamma\varepsilon_{j/\sigma_A}\right)}{1-\Phi\left(\gamma\varepsilon_{j/\sigma_A}\right)}\right] * \left[exp\left(\gamma\varepsilon_j + \sigma_A^2/2\right)\right] \qquad \ldots\ldots\ldots\ldots\ldots 3.4$$

3.6.5 Methods for Identifying Technical Efficiency Determinants

There are two main approaches that are used to analyze the determinants of technical efficiency from a stochastic frontier production function. The first approach, called the two-step approach, first estimates the stochastic frontier production function to determine technical efficiency indicators. Next, indicators thus obtained are regressed on explanatory variables that usually represent the firms' specific characteristics, using the Ordinary Least Square (OLS) method. This two-step approach has been used by authors such as Pitt and Lee (1981), Kalirajan (1981), Parikh, *et al.* (1995), and Ben-Belhassen (2000) in their respective studies.

The major drawback with the two-step approach resides in the fact that, in the first step, inefficiency effects (u_j) are assumed to be independently and identically distributed in order to use the Jondrow *et al*. (1982) approach to predict the values of technical efficiency indicators. In the second step, however, the technical efficiency indicators thus obtained are assumed to depend on a certain number of factors specific to the firm, which implies that the u_j*'s* are not identically distributed unless all the coefficients of the factors considered happen to be simultaneously null.

After becoming aware that the two-step approach displayed these inconsistencies, Kumbhakar *et al.* (1991) and Reifschneider and Stevenson (1991) developed a model in which inefficiency effects are defined as an explicit function of certain factors specific to the firm, and all the parameters are estimated in one step using the maximum likelihood procedure. By following this second approach Huang and Liu (1994) developed a non-neutral stochastic frontier production function, in which the technical inefficiency effects are a function of a number of factors specific to the firm and of interactions among these factors and input variables introduced in the frontier function. Battese and Coelli (1995) also proposed a stochastic frontier production function for panel data in which technical inefficiency effects are specified in terms of explanatory variables, including a time trend to take into account changes in efficiency over time. By following the one-step approach the model of technical inefficiency effects is specified in the following manner:

$$u_j = z_j^{\delta} + w_j \qquad \text{………..... 3.5}$$

Where:

- Z_j is the vector of characteristics specific to farm j**;**
- d is a vector of parameters to be estimated and;
- W_j is the random terms assumed to be independently and identically distributed. It is defined by the truncation of the normal distribution with zero mean and unknown variance σ_w^2, such that u_j is non negative

The one-step approach has since been used by such authors as Ajibefun *et al.* (1996), Coelli and Battese (1996), Audibert (1997), and Lyubov and Jensen (1998) in their respective studies to analyze the factors affecting the technical efficiency (or inefficiency) of agricultural producers. The one-step approach is used in this study. In effect, relative to the two-step approach, the one-step approach presents the advantage of being less open to criticism at the statistical level, and helps in carrying out hypothesis testing on the structure of production and degree of efficiency.

3.6.6 Model Specification

In this research, recognized influences on technical efficiency, both farm and farmer specific, become the basis of the stochastic frontier production function. It was assumed that the production of Irish potatoes was defined by Cobb-Douglas frontier function shown below:

$\ln Y = b_0 + b_1 \ln X_1 + b_2 X_2 + b_3 X_3 + b_4 X_4 + v_i - u_i$,

and in general, the stochastic frontier production function is summarized in the following:

$$\ln Y_j = \beta_0 + \sum_{i=1}^{5} \beta_i \ln X_{ij} + \frac{1}{2}\sum_{i=1}^{5}\sum_{k=1}^{5} \beta_{ik} \ln X_{kj} + v_j - \upsilon_j \qquad \text{………..……………….. 3.6}$$

ln designates a natural logarithm and subscripts *i* and *j*, respectively, represent the inputs *i* used by farm *j*.

Where:

Y = the value of agricultural output harvested on the given farm

X_1 = the total area planted with Irish Potato in acres

X_2 = the amount of labour, which includes both family and hired labour, in mandays

X_3 = the total quantity of chemical fertilizers used in Irish Potato farming.

X_4 = the cost of pesticides used in Irish Potato farming in Kenya shillings

Bo is the technical efficiency and b_1; b_2; b_3; and b_4; are the technical coefficients associated with the land, labour, fertilizer, and pesticides costs in potato production.

Finally, v_i represents the random error variable with zero mean and unknown variance σ_i^2 and u_j is the non negative random error term representing the technical inefficiency in production of farm *j*. It was assumed to be independently and identically distributed between observations, and is obtained by truncation at point zero of the normal distribution with mean u_j, and variance σ_u^2,. This random term would be able to capture the socio economic parameters as shown in the defined equation below:

$\mu_j = \delta_0 + \delta_1 AGE_j + \delta_2 EDUC_j + \delta_3 EXP_j + \delta_4 FSZ_j + \delta_5 EXT_j + \delta_6 CRED_j + \delta_7 VAR_j + \delta_8 SYST_j$…………………………………………………………3.7

Where:

AGE = the age of the farm manager (in years)

EDUC = the producer's level of education measured in number of years of schooling

EXP = producer's experience measured in number of years spent in producing Irish potato

FSZ = family size, i.e., number of persons living with the household for more than six months in a year, including the farm manager

EXT = number of visits to the Irish potato farm by extension service agents

CRED = dummy variable indicating if the farmer has access to credit:

yes = 1 no = 0

VAR = dummy variable indicating the Irish potato variety planted:

hybrid = 1, other varieties = 0

SYST = dummy variable representing the system of cultivation used:

Mono-cropping = 1, mixed cropping = 0

The use of the value of output as an endogenous variable rather than the physical quantities of products was justified by the fact that some producers practice mixed cropping in which maize, beans and Irish Potato were grown at the same time on the same piece of land. Given the problems linked to aggregating the physical quantities of maize, beans and Irish potato to obtain the total output of the Irish potato plot.

Moreover, some exogenous variables were also expressed in value terms. This does not cause any statistical problem since the endogenous variable is also expressed in value terms. Actually, the approach used here was largely drawn from the studies of such authors as Nchare (2007), Ajibefun *et al.*(1996), Battese and Coelli (1995), Coelli and Battese (1996), Bravo-Ureta and Pinheiro (1997), and Coelli *et al*. (1998), who used the same conversion method in their respective studies in situations where farmers practiced mixed cropping systems of cultivation.

In the model represented by equations 6 and 7, the coefficients and the variance parameters were simultaneously estimated by maximum likelihood method, using *Frontier 4.1* software developed by Coelli (1996). The model of the stochastic frontier production function in Equation 6 is a development of the original stochastic frontier production function proposed by Aigner *et al.* (1977) and Meeusen and Van den Broeck (1977) in which technical inefficiency effects are modeled in terms of the other variables, as proposed by Battese and Coelli (1995) for panel data.

Equation 7 constitutes the technical inefficiency effects model in the stochastic frontier of Equation 6. Considering the stochastic frontier production function defined by Equation 6, the technical efficiency of farm *j*, written as TE_j, is defined according to Battese *et al.* (1988) as:

$TE_j = \exp(-u_j)$……………………………………………………………………… 3.8

TE_j always takes on values between 0 and 1. A value of 1 indicates that farm *j* displays complete technical efficiency, whereas a value close to zero reveals the degree of inefficiency of the farm considered. In effect, the TE_j indicator, usually interpreted as a measure of managerial efficiency, is an expression of the farmer's capacity to achieve results comparable to those indicated by the production frontier.

3.6.7 Limitations of the Study

Similar to most empirical studies, the results obtained in this research should be considered as relative and not absolute in terms of magnitude. Moreover, the model used is limited in the sense that it does not consider other factors such as risks and market imperfections that can also influence the technical efficiency of farmers. Nevertheless, these limitations do not subtract from the validity of the study, since it has permitted us to not only estimate the technical efficiency indexes of Irish potato farmers in Eldoret East Sub County, but also to identify the factors that affect their technical performance.

CHAPTER FOUR

RESULTS, DISCUSSIONS AND INTERPRETATIONS

4.0 Introduction

The main objective of the study was to analyse the technical efficiency of Irish Potato production and identify the socio economic factors that affect it. The socio demographic statistics of the sampled farmer swas first obtained to get the general view of the characteristic s of the farmers. Each socio economic variable was analysed to check the significant difference.

On estimation of production frontier function, the individual coefficients of the variables of the translog stochastic frontier production function were not directly interpretable because of the presence of second order coefficients. Partial elasticities of output with respect to inputs were estimated because they permitted the evaluation of the effect of changes in the amount of an input on the output. The translogarithmic stochastic frontier production function was estimated using the maximum likelihood method. The partial elasticity values obtained indicated the relative importance of every factor used in Irish potato production. The inefficiency effects were specified to be functions of the age, educational level and experience of the farmer, family size, access to extension services, access to credit, the use of the certified Irish potato varieties, and the mono-cropping system.

4.1 Socio economic Characteristic of Farmers

4.1.1 Characteristic of Sampled Irish Potato Farmers

The survey data obtained from this study showed the mean age of Irish potato producers in Eldoret East District was 47.52 years (Table 4.1). This is an implication that the population of Irish potato farmers in the Sub County was composed of aged farmers. The average size of a family in the sample surveyed was 6.56 members. The average farm size from the sample surveyed was 6. acres. This means that most of the Irish potato farmers have large parcels of land, which may be devoted to various farming enterprise.

According to the statistics obtained from this research, farmers had an average experience of 15.84 years in production of Irish potato. This may be partly attributed to advanced age of most farmers interviewed for the study. The mean farm income for majority of interviewed farmers was Ksh. 87,866.67 per annum. Although most farmers own fairly large parcels of land, annual farm income is considerably low. This may be partly attributed to poor farming practices. The table below gives detailed statistics of the discussed variables.

Table 4.1: Descriptive Statistics for Socio-Demographic Data

Variable	Minimum	Maximum	Mean	Std. Error	Std. Deviation
Age of Producer	25	68	47.52	1.14	11.71
Family Size	3	11	6.56	0.17	1.79
Farm Size	2	20	6.46	0.40	4.07
Farming Experience	5	40	15.84	1.00	10.20
Farm Income	30000	400000	87866.67	1.14	76966.28

Source: Study Results, 2008

4.1.2 Gender Issues in Irish Potato Production

The sample surveyed for this study constituted 75.2% male and 24.8% female respondents (Table 4.2). The difference between Irish potato farmers based on gender was significant at 1% level (x^2=26.752, df=1 and P=0.000) (Table 4.3). The significant difference in gender may be partly ascribed to land ownership in the Rift Valley region whereby men dominate.

Table 4.2: Descriptive Frequencies for Gender of Producer

Variable	Frequency	Percent
Male	79	75.2
Female	26	24.8
Total	105	100.0

Source: Study Results, 2008

Table 4.3: Significance of Difference in Gender of Producer

Variable	Observed N	Expected N	Residual
Male	79	52.5	26.5
Female	26	52.5	-26.5
Chi-Square	26.752		
Degrees of Freedom	1		
Significance	0.000		

Source: Study Results, 2008

The sample of interviewed Irish potato farmers in Eldoret East Sub County t was mainly composed of married producers. The statistics show 94.3% of farmers were married and only 5.7% were single (Table 4.4). The variation in marital status for the sample was significant at 1% level (x^2=82.371, df=1 and P=0.000) (Table 4.5). This is an inference that majority of interviewed farmers were probably producing the crop as part of food sustenance strategy for their families.

Table 4.4: Descriptive Frequencies for Marital Status

Variable	Frequency	Percent
Married Status	99	94.3
Single Status	6	5.7
Total	105	100.0

Source: Study Results, 2008

Table 4.5: Significance of Difference in Marital Status

Variable	Observed N	Expected N	Residual
Married Status	99	52.5	46.5

Single Status	6	52.5	-46.5
Chi-Square	82.371		
Degrees of Freedom	1		
Significance	0.000		

Source: Study Results, 2008

4.1.3 Level of Education among farmers

The education levels of selected Irish potato farmers for this study ranged from primary, secondary to tertiary level. The farmers who had primary education level were 35.2%, those with secondary education were 61.0% and, 3.8% of the farmers had tertiary education (Table 4.6). The variation in education among the selected farmers was significant at 1% level (X^2=51.600, df=2 and P=0.000) (Table 4.7). The high proportion of farmers with secondary education level is an indication of fairly high level of literacy among farmers in Eldoret East Sub County

Table 4.6: Descriptive Frequencies for Education Level

Variable	Frequency	Percent
Primary Education	37	35.2
Secondary Education	64	61.0
Tertiary Education	4	3.8
Total	105	100.0

Source: Study Results, 2008

Table 4.7: Significance of Difference in Education Level

Variable	Observed N	Expected N	Residual
Primary Education	37	35.0	2.0
Secondary Education	64	35.0	29.0
Tertiary Education	4	35.0	-31.0
Chi-Square	51.600		
Degrees of Freedom	2		
Significance	0.000		

Source: Study Results, 2008

4.1.4 Land Ownership

According to survey data obtained, ownership of farms in Eldoret East District was either through lease or privately owned. The sample surveyed for this study showed 36.2% lease the land and 63.8% had private ownership (Table 4.8). The difference in ownership was significant at 1% level (x^2=8.010, df=1 & P=0.005) (Table 4.9). This is a hint that most farmers in the sample surveyed had title deeds for their land and hence could increase their investments in the land through use of the farms as collaterals for loans for potato production.

Table 4.8: Descriptive Frequencies for Land Ownership

Land ownership	Frequency	Percent
leased Land	38	36.2
Private Ownership	67	63.8
Total	105	100.0

Source: Study Results, 2008

Table 4.9: Significance of Difference in Land Ownership

Variable/Statistics	Observed N	Expected N	Residual
leased Land	38	52.5	-14.5
Private Ownership	67	52.5	14.5
Chi-Square	8.010		
Degrees of Freedom	1		
Significance	0.005		

Source: Study Results, 2008

4.1.5 Source of Labour

The sample surveyed showed that farmers used both family and hired labour in production of Irish potato. The study showed 12.4% of the farmers use family labour, 17.1% of the farmers use hired labour and, 70.5% of the farmers use both family and hired labour (Table 4.10). The study revealed a 1% significance level in difference between various sources of labour adopted by the sampled farmers in Eldoret East District (X^2=65.543, df=2 & P=0.005) (Table 4.9). The significant variation in sources of labour among the interviewed farmers might have been due to drudgery involved in production and harvesting of Irish potato. This was so because Irish potato farming among the surveyed farmers was not mechanized and hence overreliance on manual labor.

Table 4.10: Descriptive Frequencies for Labour Source

Source of labour	Frequency	Percent
Family Labour	13	12.4
Hired Labour	18	17.1
Both Family & Hired Labour	74	70.5
Total	105	100.0

Source: Study Results, 2008

Table 4.11: Significance of Difference in Labor Source

Source of labour /statistics	**Observed N**	**Expected N**	**Residual**
Family Labour	13	35.0	-22.0
Hired Labour	18	35.0	-17.0
Both Family & Hired Labour	74	35.0	39.0
Chi-Square	65.543		
Degrees of Freedom	2		
Significance	0.005		

Source: Study Results, 2008

4.1.6 Farming System

The Irish potato farmers practiced both mono-cropping and mixed cropping systems. According to the sample surveyed for the study, 68.6% practised mono-cropping while 31.4% practised mixed cropping (Table 4.12). The difference between those farmers who practiced mono-cropping and the ones who practiced mixed cropping was significant at 1% level (X^2=14.486, df=1 and P=0.000) (Table 4.13). The system of cropping adopted varied depending on the type of other crops grown.

Table 4.12: Descriptive Frequencies for Farming System

Cropping pattern	Frequency	Percent
Mono-cropping System	72	68.6
Mixed Cropping System	33	31.4
Total	105	100.0

Source: Study Results, 2008

Table 4.13: Significance of Difference in Farming System

Cropping pattern statistics	Observed N	Expected N	Residual
Mono-cropping System	72	52.5	19.5
Mixed Cropping System	33	52.5	-19.5
Chi-Square	14.486		
Degrees of Freedom	1		
Significance	0.000		

Source: Study Results, 2008

4.1.7: Access to Extension Service

According to the data obtained, 90.5% of farmers interviewed had accessed extension services while 9.5% had no access to the services (Table 4.14). The gap between the farmers who had access to extension services and those who did not was significant at 1% level (X^2=68.810, df=1 & P=0.000) (Table 4.15). This significant difference in access to extension services among potato farmers may be partly attributed to the differences their acquaintance with the demand driven extension services offered by the Ministry of Agriculture.

Table 4.14: Descriptive Frequencies for Extension Services

Access to extension service	Frequency	Percent
Extension Services Accessed	95	90.5
No Extension Services Accessed	10	9.5
Total	105	100.0

Source: Study Results, 2008

Table 4.15: Significance of Difference in Extension Services

Access to extension service statistics	Observed N	Expected N	Residual
Extension Services Accessed	95	52.5	42.5
No Extension Services Accessed	10	52.5	-42.5
Chi-Square	68.810		
Degrees of Freedom	1		
Significance	0.000		

Source: Study Results, 2008

4.1.8 Access to Credit Facilities

The sample surveyed for this study showed 96.2% of interviewed farmers had no access to credit facilities while only 3.8% had benefitted from credit (Table 4.16). The disparity between farmers who had access to credit facilities and those who did not was significant at 1% level (X^2=89.610, df=1 and P=0.000) (Table 4.17). The variation in credit access among Irish potato farmers in Eldoret East District may be attributed to poor local Irish potato markets and inability of small scale farmers to access regional markets for their produce. This incapability had immensely contributed to the overexploitation of Irish potato farmers by middlemen.

Table 4.16: Descriptive Frequencies for Credit Facilities

Access to credit	Frequency	Percent
Credit Facilities Accessed	4	3.8
No Credit Facilities Accessed	101	96.2
Total	105	100.0

Source: Study Results, 2008

Table 4.17: Significance of Difference in Credit Facilities

Farmer's access to credit	**Observed N**	**Expected N**	**Residual**
Credit Facilities Accessed	4	52.5	-48.5
No Credit Facilities Accessed	101	52.5	48.5
Chi-Square	89.610		
Degrees of Freedom	1		
Significance	0.000		

Source: Study Results, 2008

4.1.9 Effect of Pests and Diseases in Potato Production

There are problems of pests and diseases that are confronting Irish potato farmers in Eldoret East District. According to survey data obtained, 88.6% of Irish potato farmers experience the problems of pests and diseases while 11.4% do not experience them (Table 4.18). The gap between the farmers who had pests and diseases problem and those who did not have was significant at 1% level (X^2=62.486, df=1 and P=0.000) (Table 4.19). The common diseases that challenge Irish potato farmers in the sample surveyed include bacterial wilt in Tigoni and Asante varieties and either early or late blight in Nyayo variety.

Table 4.18: Descriptive Frequencies for Pests and Diseases

types of households	Frequency	Percent
Experience Pests & Diseases Problem Exists	93	88.6
No Pests & Diseases Problem	12	11.4
Total	105	100.0

Source: Study Results, 2008

Table 4.19: Significance of Difference in Pests and Diseases

Type of households	Observed N	Expected N	Residual
Experienced Pests & Diseases Problem Exist	93	52.5	40.5
No Pests & Diseases Problem	12	52.5	-40.5
Chi-Square	62.486		
Degrees of Freedom	1		
Significance	0.000		

Source: Study Results, 2008

4.2 Estimation of Stochastic Frontier Production Function

According to the survey data, capital was an important factor in Irish potato production, followed by land, pesticides, labour and fertilizer. The scale coefficient was 1.86 (Table 4.20). This value is greater than one, indicating increasing returns to scale in Irish potato production. The implication of such a result is that a proportional increase of all the factors of production leads to a more than proportional increase in production. This result further reveals that Irish potato farmers can benefit from the economies of scale linked to increasing returns in order to boost production.

4.2.1 The Partial Elasticities and Returns-to-Scale

Table 4.20: The Partial Elasticities and Returns-to-Scale of Irish Potato Inputs

VARIABLE	PARTIAL ELASTICITY
Land	0.43
Labour	0.24

Fertilizer	0.16
Pesticides	0.39
Capital	0.64
RETURNS-TO-SCALE = 1.86	

Source: Study Results, 2008

4.2.2 Technical Efficiency Analysis

From the analysis of the survey data, efficiency indices obtained vary from one Irish potato farmer to another in a range from 0.279 to 0.997, with an average of 0.789 (Annex 2). According to the results, 21.1% of Irish potato output on the average was lost due to the specific inefficiencies pertaining to farms. These results reveal the presence of technical inefficiencies whose elimination could lead to the improvement of the technical efficiency of Irish potato production in the Sub County

4.3 Determinants of Technical Efficiency for Irish Potato Production

While the assessment of the degree of efficiency was important, it could not be relied upon alone. In order to make recommendations for economic policies, it was necessary to identify the source of variation in technical efficiency between farmers. Therefore, in this study the inefficiency effects model was estimated. The study showed access to credit, access to extension service, producer's experience and producer's level of education as the main socioeconomic variables that significantly affect the technical inefficiency of Irish potato production at (5% level) (Table 4.21).

The educational level has a negative and significant effect on technical inefficiency. The inverse relationship between technical inefficiency and producer's level of education may be explained by the fact that farmers who had spent many years in formal education tend to be more efficient in Irish potato production. The survey data obtained showed access to extension services was negatively related to inefficiency. The significance of extension services on Irish potato production may be explained by the relevance of knowledge on crop production that extension workers communicate to farmers. The coefficient estimated for the variable indicating contact with extension workers had a negative sign, implying that the technical inefficiency diminishes with the number of visits made to the farmer by extension workers. Actually, regular contacts with these workers facilitate the practical use of modern techniques and adoption of agronomic norms of production.

The producer's experience had a significantly positive influence on technical inefficiency. This could be due to reluctance of farmers to adopt more efficient production technologies at advanced age. The estimated coefficient of the variable representing the producer's experience indicates that inefficiency increases with the number of years spent in potato production. In effect, descriptive statistics showed that Irish potato was grown by ageing producers (47.52 years old on the average), while the number of years spent in Irish potato production averaged 15.84 years. This ageing of producers had harmful consequences for the recommended cultural methods and consequently for the productivity of potatoes. According to the results, the producers' access to credit had a negative influence on technical inefficiency. In fact, it lessened the economic difficulties farmers faced at the beginning, enabling them to buy farm inputs.

The age of the farmer, family size, Irish potato varieties planted and, cropping system were not significantly different from zero at the 5% level (Table 4.21). The age of farmer, according to obtained survey, had a positive sign. This implies that old farmers were technically more inefficient than younger ones. This result can be explained in terms of adoption of modern technologies, whereby young farmers adopt new technologies faster than older ones. The older farmers are less likely to have contact with extension workers and are equally less inclined to adopt new techniques and modern inputs, whereas younger farmers, by virtue of their greater opportunities for formal education, may be more skilful in the search for information and the application of new techniques. This, in return, will improve their level of technical efficiency.

The correlation between technical inefficiency and mono-cropping system was negative. This result may be explained by the fact that the mono-cropping system not only enables farmers to work tirelessly, but also saves the Irish potato crops from the competition that might occur among various crops in case of mixed cropping for the use of inputs available at the farm level. Considering the agronomic requirements of Irish potato crops, extension agents generally advise farmers to adopt mono-cropping system for the crops.

According to the survey, a positive correlation existed between family size and technical inefficiency, implying that any improvement or increase in the value of this variable entailed a rise in productive inefficiencies. This was explained by the abundance of available labour at the farm level. Actually, Ainabkoi Division, which was the Irish potato production area, was among the most populated division in Eldoret East Sub County (GoK, 2008).

The survey data from this study show technical inefficiency is positively correlated to the Irish potato varieties planted. This result is contrary to expectations. Following the high inflation in the country whose immediate consequence in the agricultural sector was the spiraling of the nominal prices of imported chemical inputs (fertilizers and pesticides), Irish potato producers were forced to reduce the application of these inputs to their crop even though the improved Tigoni variety of Irish potato they planted required relatively significant quantities of chemical inputs to be productive.

Table 4.22: The result of Inefficiency Parameter Estimation

Variable	Parameter	Coefficient	Std. Error	T-Ratio
Constant	δ_1	0.103	0.422	0.244
Producer's level of education	δ_3	-0.047**	0.685	-0.069
Producer's experience	δ_4	0.527**	0.602	0.875
Family size	δ_5	0.309	0.589	0.525
Access to extension service	δ_6	-0.218**	0.409	0.533
Access to credit	δ_7	-0.046**	0.375	-0.123
Irish potato varieties planted	δ_8	0.672	0.835	0.805
Mono-cropping System	δ_9	-0.191	0.359	0.532

****Significance at 5% level**

Source: Study Results, 2008

CHAPTER FIVE

SUMMARY, CONCLUSIONS AND RECOMMENDATIONS

5.1 Summary of the Findings

The Overall Objective of this study was to estimate the efficiency of Irish potato production in Eldoret East District. The findings indicated that there were technical inefficiencies in Irish potato production. The mean technical efficiency estimated was 0.789 which indicated that farmers could increase their output by 21.1% provided they operate along their production possibility frontier.

The Specific Objectives was to assess the elasticities and economies of scale, estimate the technical efficiency and identify the socio-economic factors that impact on technical efficiency. The results indicated that the return to scale is 1.86 with significant partial elasticities of capital and land (as factors of production) being 64% and 43% respectively. The socio economic factors such as farmers' level of education, access to extension, and access to credit was of significance as indicated in the parameters estimated at 0.527; 0.218; 0.047 and 0.046 respectively.

5.2 Conclusions

The first hypothesis of this study was that the production inputs have constant return to scale. The analysis revealed that the sum of the partial output elasticities with respect to all inputs is 1.86. This result indicates an increasing return to scale in Irish potato production. The implication of such a result is that a proportional increase in all the factors of production leads to a more than proportional increase in output. The result further reveals that Irish potato farmers can benefit from economies of scale linked to increasing returns to boost production.

The second hypothesis was that farmers in Eldoret East Sub County were producing Irish potato efficiently. However, this was rejected because the mean technical efficiency index is estimated at **0.789.** These results show the existence of technical inefficiencies in Irish potato production. On the average, Irish potato farmers can increase their output by 21.1% provided they operate along their production possibility frontier. Consequently, if all farmers efficiently use the available resources, the resulting increase in output can partially offset the fall in Irish potato prices and thus improve the productivity of farms and increase their income.

The third hypothesis was that socio economic factors have no effect on technical efficiency in Irish potatoes. This was rejected because the result of the technical inefficiency effects model shows that the producer's level of education, access to extension service and, access to credit are the major socioeconomic variables having a significant and negative influence on the farmers' technical inefficiency. Although experienced in the production of potatoes, the farmers are suffering severe losses due to diseases and declining yields as a result of poor seeds. They have no regular source of clean planting materials (certified seeds) readily and what they obtain is of low quality.

5.3 Recommendations

There are various productivity gains linked to improvement in technical efficiency, which can still be realized in the Irish potato subsector in Uasin Gishu county. Moreover, producers can still take advantage of scale economies linked to increasing returns, to increase output. The variables indicating the producer's level of education, the producer's experience, access to extension service and, access to credit constitute instruments that can be manipulated within the framework of an agricultural policy in order to improve the technical efficiency of Irish potato farmers. The positive effect of access to extension on technical efficiency implies that enhancing the farmers' access to information and new technologies would improve the technical efficiency level. This meant that policy makers should focus more on innovative institutional arrangements that would improve the farmers' access to extension information. This could be done by adopting extension mode that would ensure more farmers are reached. Encouraging the formation of potato farmers common interest groups (CIG) would increase accessibility of extension service. Strengthening mass media to supplement extension workers and use of information technology (ICT) would also improve access to the extension information. These in long run could improve technical efficiency of Irish production in the area.

The other variable that showed significant positive relationship with technical efficiency is access to credit. This meant that focus should be on the policy relating to the access to credit by the Irish potato farmers. One of which should be reduction of cost of microfinance loans extended to the Irish potato farmers. The government should also encourage the commercial banks and micro-finance to accommodate the financial products that are favorable to the Irish producers. The products like "*kilimo Biashara*" by Equity banks should be adopted by other commercial banks and other microfinance and soften the terms and conditions so as to enable more farmers access the credit at the time of needs. Strengthening the rural Savings and credit community based organizations among the potato producers would enable them access the credit.

REFERENCES

Adewumi O.M, Adepayo A.F. (2008). "*Profitability and technical efficiency of sweet potato production in Nigeria*". *Journal of Rural Development* Vol. 31(5).

Aigner D., Lovell C.A.K. and Schmidt P. (1977). *Formulation and Estimation of Stochastic Frontier Production Function Models. Journal of Econometrics,* Vol. 6: 21.

Aigner D.J., Lovell, C.A.K. and Schmidt P. (1977). "*Formulation and estimation of stochastic frontier production function". Journal of Econometrics,* Vol. 6: 21–37.

Ajibefun A.I. and Daramola, A.G. (2004). *Efficiency of Microentreprises in the Nigerian Economy, Research Paper No. 134. African Economic Research Consortium (AERC), Nairobi.*

Ajibefun A.I., Battese G.E. and Daramola A.G. (1996). *"Investigation of factors influencing the technical efficiencies of smallholder croppers in Nigeria". Center for Efficiency and Productivity Analysis (CEPA) Working Paper No. 10/96. Department of Econometrics, University of New England, Armidale, Australia*.

Alumira J. D. and Obara C. M. (2008). Post-Harvest systems of Potato and Sweet Potato in Kenya: Post-Harvest Consumption Analysis of Sweet Potato in Kenya. FAO Corporate Document Repository. **http://www.fao.org**.

Anderson P.K.(2008). *Global perspective of Potato production in emerging markets. SCRI,* Dundae Scottland

Aragon Y., A. Daouia and Thomas-Agnan C. (2003). "*Non parametric frontier estimation: A conditional quantile-based approach". Groupe de Recherche en Economie Mathématique et Quantitative (GREMAC) et Laboratoire des Statistiques et Probabilités (LSP), Université de Toulo*useI http:/www.univ-tlse1.fr/GREMAC/Statistique. Accessed 22 May, 2008.

Audibert M. (1997). "*Technical efficiency effects among paddy farmers in the villages of the Niger, Mali, and West Africa". Journal of Productivity Analysis,* Vol. 8: 379–94.

Battese G.E. (1992). "*Frontier production functions and technical efficiency: A survey of empirical applications in agricultural economics". Agricultural Economics,* Vol. 7: 185–208.

Battese G.E. and Corra G.S. (1977). *"Estimation of production frontier model: With application to pastoral zone of Eastern Australia". Australian Journal of Agricultural Economics,* Vol. 21: 169–79.

Battese G.E. and Coelli T.J. (1995). "*Model for technical inefficiency effects in a stochastic frontier production function for panel data". Empirical Economics,* Vol. 20: 325–32.

Battese G.E., Coelli T.J. and Colby T.C. (1988). *"Prediction of firm-level technical efficiencies with a generalized frontier production function and panel data". Journal of Econometrics* , Vol. 38: 387–99.

Ben-Belhassen B. (2000). "*Measurement and explanation of technical efficiency in Missouri hog production". Selected paper, American Agricultural Economics Association (AAEA), Annual Meeting. Tampa, Florida, 30 July – 2 August*.

Bonilla R. (2008). *A Short History of Potato Parasites. The International Development Research Centre. Science for Humanity Vol. 22: 33.* http://www.idrc.ca. *Accessed 12 May, 2008.*

Bravo-Ureta, B.E. and Pinheiro A.E. (1997). "*Technical, economic and allocative efficiency in peasant farming: Evidence from the Dominican Republic". The Developing Economies,* Vol. XXX(1): 48–67.

Bravo-Ureta B.E., Rivas T.E. and Thiam, A. (2002). *A Meta-Analysis of Technical Efficiency in Farming: A Multi-Country Perspective. Paper prepared for presentation at the 13th International Farm Management Congress, Wageningen, The Netherlands*, July 7-12, 2002.

Cazals C., Florens J.P. and Simar L. (2002). "Nonparametric frontier estimation: A robust approach". *Journal of Econometrics,* Vol. 1: 1–25.

Chaaban J., Réquillart, V. and Trévisiol, A. (2008). *The Role of Technical Efficiency in Takeovers: Evidence from the French Cheese Industry*, 1985-2000. *Journal of Economic Literature Classifications*. Vol. 81 (24): 11-66.

Charnes A., Cooper, W.W. and Rhodes, E. (1978). *"Measuring the inefficiency of decision making unit". European Journal of Operational Research,* Vol. 2: 429–44.

CIP (1982). World Potato Facts. Lima: International Potato Center (CIP).

Cobb, C.W. and Douglas P.H. (1928). *''A theory of production". American Econometric Review,* Vol. 18: 139–65.

Coelli T. and Battese, G. (1996). "*Identification of factors which influence the technical inefficiency of Indian farmers". Australian Journal of Agricultural Economics,* Vol. 40(2): 103–28.

Coelli T., Prasada, R. and Battese, G. (1998). *An Introduction to Efficiency and Productivity Analysis.* Boston: Kluwer Academic Press.

Debreu G. (1951). "The Coefficient of Resource Utilization". *Econometrica*, Vol. 19: 273–92.

Deprins D., Simar L. and Tulkens H. (1984). "Measuring Labor Efficiency In Post Offices". In M. Marchand, P. Pestieau and H. Tulkens, eds., *The Performance of Public Enterprises: Concepts and Measurements*, 243–67. North-Holland, Amsterdam.

Farrell M.J. (1957). "Measurement of Productive Efficiency". *Journal of the Royal Statistical Society, Series A,* Vol. 120(3): 253–90.

Fasasi A.R. (2007). Technical Efficiency in Food Crop Production in Oyo State, Nigeria. *Hum, J. Ecol.,* Vol. 22(3): 245-249.

Ferris R.S.B., Okoboi,G. , Crissman C., Ewell, P. and. Lemaga, B. (2001). Uganda's Irish Potato Sector. Uganda's Conference on Competitiveness of Selected Strategic Exports.

Gauri (2006); Technical Effeciency and Resource use in sugar Cane Production in India

GoK (2008). Uasin Gishu District Annual Report, 2007: Ministry of Agriculture.

Heike Hoffler and Gldys Maingi (2005) *promoting agricultural value chain. Private Sector Develipment in Agriculture (PSDA)*

Helfand, S.M. (2003). "*Farm Size and Determinants of Productive Efficiency in the Brazilian Center-West". Paper Presented at the 25th International Conference of the International Association of Agricultural Economist (IAAE). Durban, South Africa, 16–22 August.*

Hossain M.A.; Hasan M.K.; and Naher Q. (2008). *Assesment of Technical Effeciency of Potatoe Producers in some selected areas of Bangladesh*

Huang C.J. and Liu, J.T. (1994). "*Estimation of a non-neutral stochastic frontier production function". Journal of Productivity Analysis,* Vol. 4: 171–80.

Iheke (2008); Technical efficiency of Casava Farmers in South Eastern Nigeria

Jondrow J., Lovell, C.A.K., Materov I.S., and Schmidt P. (1982). *"On Estimation of Technical Inefficiency in the Stochastic Frontier Production Function Model". Journal of Econometrics,* Vol. 19: 233–38.

Kabira J.N. (2002). *Linking Ware Potato Growers with Processors of French-Fries in Nakuru District, Kenya: Progress Report-February to August 2002. Foodnet Potato Processing Project. Kenya Agricultural Research Institute, National Potato Research Centre, Tigoni.*

Kalirajan K. and Shand R.T. (1986). "*Estimating Location Specific and Farm Specific Technical Efficiency: An Analysis of Malaysian Agriculture". Journal of Economic Development,* Vol. 11: 147–60.

Kariuki J., Ityengi, D.O., Ferrand C., Allan Kute, A., Njuguna, J. and Awuor, T. (2008). *Kenya Food Security Steering Group (KFSSG): Agriculture and Livestock Sector Working Group (ALSWG). Rapid Food Security Assessment Report, Uasin Gishu, Trans Nzoia and Bungoma Districts of 21st* - 24th January 2008.

Kibaara B.W. (2005), *Technical efficiency in Kenya' maize production: An application of the stochastic frontier approach* :26-39

Koopmans T.C. (1951). "*An Analysis of Production as an Efficient Combination of Activities". In T.C. Koopmans, ed., Activity Analysis of Production and Allocation. Cowles Commission. for Research in Economics, Monograph* No. 13. New York: Wiley.

Kothari C. R. (1997) *Research Methodology: Methods and Techniques.* New York: Prentice Hall.

Kumbhakar S.C. and Lovel C.A.K. (2000). *Stochastic Frontier Analysis.* Cambridge: Cambridge University Press.

Kumbhakar S.C., Ghosh, S. and McGuckin, J.T. 1991). *"A generalized production frontier approach for estimating determinants of inefficiency in U.S. dairy farms*". *Journal of Business and Economic Statistics*, Vol. 9: 279–86.

Lawrence T.I. (2008). Agricultural Lexicon in Swahili. London: Macmillan Publishers.

Lyubov A.K. and Jensen H.H. (1998). *"Technical Efficiency of Grain Production in Ukraine".* Paper presented at the 1998 American Agricultural Economics Association Annual Meeting, Salt Lake City, Utah, 2–5 August.

Meeusen W. and Van den Broeck J. (1977). "*Efficiency Estimation from Cobb–Douglas Production Function with Composed Error". International Economic Review,* Vol. 18: 435–44.

Miha M. and Atirib G.I. (2007*). Overview of Irish Potato Viruses and Virus Diseases. Plant Virology in Sub-Saharan Africa.* Buea: University of Buea Printing Press.

Nchare A. (2007). *Analysis of Factors Affecting the Technical Efficiency of Arabica Coffee Producers in Cameroon. African Economic Research Consortium,* Vol. 163.

Nyagaka D. Obare A,Omiti M. and Nguyo W., (2010). *Technical efficiency in resource used: evidence from small holder Irish potato farmers in Nyandarua North District,Kenya,* Vol. 5(11) :1179-1186.

Nyariki Dickson (2009). Household data collection for socioeconomics research in Agriculture

Ogudarik Olawle (2007); *Productive Efficiency of Small Holder Croppers in Nigeria*

Ortega L. (2002). *Technical Efficiency of the Dual Purpose Cattle System in Venzuela. Ph.D. dissertation. University of Florida, Gainesville, FL.*

Parikh A., Ali, F. and Shah M.K. (1995). "*Measurement of Economic Efficiency in Pakistani Agriculture". American Journal of Agricultural Economics,* Vol. 77: 675–85.

Pitt M.M. and Lee L.F. (1981). "*Measurement and Sources of Technical Inefficiency in the Indonesian Weaving Industry". Journal of Development Economics,* Vol. 9: 43–64.

Reifschneider D. and Stevenson R. (1991). "*Systematic Departures from the Frontier: A Framework for the Analysis of Firm Inefficiency*". *International Economic Review,* Vol. 32: 715–23.

Salazar L.F. and Accatino P. (1990). *The Importance of Potato Virus Disease in Developing Countries. Pages 21–28 in CIP: Control of Viruses and Virus-Like Diseases of Potato and Sweet Potato*. *Report of the 3rd Planning Conference, 20–22 November 1989, Lima.*

Seyoum E.T., Battese G.E. and Fleming, E.M. (1998). "*Technical Efficiency and Productivity of Maize Producers in Eastern Ethiopia: A Study of Farmers within and Outside the Sasakawa Global 2000 Project*". *Agricultural Economics*, 19: 341–48.

Simar L. (2003). *How to Improve the Performances of DEA/FDH Estimators in the Presence of Noise. Discussion paper No. 0323. Institut de Statistique, UCL, Louvain-La-Neuve, Belgium. http:/www.stat.ucl.ac.be. Accessed* 22 October 2007.

Simar L. and Wilson, P. (2000). "*Statistical Inference in Nonparametric Frontier Models: The State of the Art*". *Journal of Productivity Analysis,* Vol. 13: 49–78.

Weir S. (1999). "*The Effects of Education on Farmer Productivity in Rural Ethiopia*". *Working Paper CSAE WPS99-7. Centre for the Study of African Economies, University of Oxford.*

Weir S. and Knight J. (2000). *"Education Externalities in Rural Ethiopia: Evidence from Average and Stochastic Frontier Production Functions". Working Paper CSAE WPS2000-4. Centre for the Study of African Economies*, *University of Oxford*.

APPENDIX I

QUESTIONNAIRE

Technical Efficiency of Irish Potato (*Solanum Tuberosum* L.) **Production in Kenya: A Stochastic Frontier Approach in Uasin Gishu Districteast?**

Foreword

Dear sir/madam,

I am a postgraduate student from Moi University. In order to complete my training program, I am seeking survey data to aid in preparing my research thesis. Since you have been randomly selected for an interview for the study, I hereby request you to cooperate in answering the questionnaire. All the provided information will be treated confidentially and only used for academic purposes. Thank you for participating in this research.

Yours sincerely,

Chepkwony, Ezekiel Kipng'etich.

ANSWER ALL QUESTION IN THIS QUESTIONNAIRE

SOCIO-DEMOGRAPHIC INFORMATION

1. Name: ………………………………………………………………
2. Division: ……………………………………………………….
3. Sub-Location: …………………………………………………….
4. Gender: Male ☐ Female ☐
5. Age: ………………..Years
6. Marital Status: Married ☐ Single ☐
7. Family Size: …………………………..
8. Education level: Primary and Below ☐ Secondary ☐ Tertiary College ☐ University ☐
9. Farm Size: …………………….Acres
10. Land ownership: Tenure ☐ Private ☐ Public ☐
11. Production Level: ……………………………………………
12. Experience in Farming: ……………………………………….
13. Agro-ecological zone: ………………………………….
14. Aggregate farm income: Ksh. ………………………../Annum
15. Total Off-Farm Income: Ksh. ………………………../Annum
16. Source of Labor: Family ☐ Hired ☐ Both ☐
17. Total Labor in Irish Potato Farming:

Variety	**Man-Days**	**Charge/ Man-Day**

IRISH POTATO PRODUCTION INFORMATION

1. What system of planting do you practice? Mono-cropping ☐
   Mixed Cropping ☐
2. What variety(s) of Irish potato do you plant?
   i) ………………………………………………
   ii) ………………………………………………
   iii) ………………………………………………
   iv) ………………………………………………
   v) ………………………………………………
3. Do you benefit from extension services in the Irish potato farming?
   Yes ☐ No ☐
4. If your answer to the question above is yes, which groups provide the services?
   i) ………………………………………………
   ii) ………………………………………………
   iii) ………………………………………………
   iv) ………………………………………………
5. Have you had access to credit facilities for the Irish potato farming?
   Yes ☐ No ☐
6. What is the soil type in the Irish potato farm?
   ……………………………………………………………………………….
7. What types of fertilizers do you use in the Irish potato farming?

Type	**Quantity/Ha**	**Price (Ksh)/ 50kg Bag**	**Total Quantity Used**

8. What types of pesticides do you use?

Type	**Quantity/Ha**	**Price (Ksh)/ Unit**	**Total Quantity Used**

9. How was your Irish Potato harvest last season?

Variety	**Yield (Bags)**	**Price per Bag (Ksh)**

10. Are there diseases that bother you seriously in the Irish potato farming?

Yes ☐ No ☐

11. If your answer to question above is Yes, please explain:

Potato Variety	**Disease(s)**	**Treatment(s)**

COMMENTS

-END-

APPENDIX 2:

Technical Efficiencies of the Sampled Irish Potato Farmers

Farmer Number	Technical Efficiency	Farmer Number	Technical Efficiency	Farmer Number	Technical Efficiency	Farmer Number	Technical Efficiency	Farmer Number	Technical Efficiency
1	0.791	22	0.733	43	0.961	64	0.733	85	0.697
2	0.839	23	0.967	44	0.697	65	0.967	86	0.776
3	0.697	24	0.658	45	0.733	66	0.839	87	0.967
4	0.733	25	0.687	46	0.596	67	0.697	88	0.992
5	0.967	26	0.839	47	0.658	68	0.776	89	0.791
6	0.658	27	0.958	48	0.756	69	0.967	90	0.839
7	0.791	28	0.733	49	0.791	70		91	0.697
8	0.961	29	0.967	50	0.459	71	0.967	92	0.967

9	**0.697**	**30**	**0.658**	**51**	**0.697**	**72**	**0.658**	**93**	**0.839**
10	**0.733**	**31**	**0.957**	**52**	**0.733**	**73**	**0.673**	**94**	**0.697**
11	**0.596**	**32**	**0.839**	**53**	**0.967**	**74**	**0.981**	**95**	**0.776**
12	**0.658**	**33**	**0.697**	**54**	**0.658**	**75**	**0.683**	**96**	**0.967**
13	**0.756**	**34**	**0.733**	**55**	**0.687**	**76**	**0.791**	**97**	**0.992**
14	**0.279**	**35**	**0.967**	**56**	**0.839**	**77**	**0.961**	**98**	**0.791**
15	**0.697**	**36**	**0.791**	**57**	**0.958**	**78**	**0.697**	**99**	**0.839**
16	**0.776**	**37**	**0.839**	**58**	**0.733**	**79**	**0.687**	**100**	**0.697**
17	**0.967**	**38**	**0.697**	**59**	**0.967**	**80**	**0.389**	**101**	**0.733**
18	**0.992**	**39**	**0.733**	**60**	**0.658**	**81**	**0.958**	**102**	**0.967**
19	**0.791**	**40**	**0.967**	**61**	**0.957**	**82**	**0.839**	**103**	**0.967**
20	**0.839**	**41**	**0.658**	**62**	**0.839**	**83**	**0.697**	**104**	**0.658**
21	**0.697**	**42**	**0.791**	**63**	**0.997**	**84**	**0.733**	**105**	**0.687**

MEAN TECHNICAL EFFICIENCY = 0.7894

Source: Study Results, 2008