ANALYSIS OF THE EFFECT OF LAND TENURE ON TECHNICAL EFFICIENCY IN SMALLHOLDER CROP PRODUCTION IN KENYA

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DECLARATION AND RECOMMENDATION

DECLARATION

This thesis is my original work and has not, wholly or in part, been presented for an award of any degree in any institution or University.

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RECOMMENDATION

This thesis was submitted for examination with our approval as University supervisors

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LIST OF ACRONYMS/ ABBREVIATIONS

AE	Allocative Efficiency
AEZ	Agro Ecological Zone
AU	African Union
DEA	Data Envelopment Analysis
EE	Economic Efficiency
HP	High Potential
HSD	Honestly Significant Difference
IFAD	International Fund for Agricultural Development
KG	Kilogram
KM	Kilometer
Ksh	Kenya Shillings
LPRC	Land Policy Research Centre
MIT	Massachusetts Institute of Technology
NEPAD	New Partnership for African Development
NLP	National Land Council
OLS	Ordinary Least Square
PRSP	Poverty Reduction Strategy Paper
SFA	Stochastic Frontier Analysis
SSA	Sub-Saharan Africa
TE	Technical Efficiency

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ABSTRACT

The agricultural sector in Kenya has been facing several challenges among them declining yields. Although agricultural production in smallholding of less than three acres is the dominant characteristic of the economy in Kenya, reasons for declining crop yield have eluded to research effort and policy. Among them it is not clear how tenure systems of holding land influence technical efficiency in conjunction with other socioeconomic factors. This study aims at examining the technical efficiency of alternative land tenure systems among smallholder farmers and identifying the determinants of inefficiency with the objective of exploring land tenure policies that would enhance efficiency in production. The study is based on the understanding that land tenure alone will not be enough to indicate the levels of efficiency of individual farms; other socio economic factors such as gender, education and farm size would also be expected to be important determinants of efficiency. A stochastic frontier function was used to estimate technical efficiency and relate it to land tenure and socio economic factors using data from 22 districts from the main agro ecological zones in Kenya.

Land owned with title was found to have the highest technical efficiency level while rented land had the lowest efficiency level. Larger parcels of land were more technically efficient in crop production than smaller sizes of land. Continued subdivision of land especially in the high potential areas of the country would have a negative effect on food production. Parcels of land owned by households headed by persons with no education had the lower technical efficiency levels than those parcels owned by households headed by persons with higher levels of education. Households headed by persons with post secondary education had the highest technical efficiency levels. Households that were accessing credit had higher

technical efficiency levels than those not accessing credit. This implied that provision of credit facilities to farmers would have a positive effect on their ability to produce more efficiently. Households participating in producer groups had a higher technical efficiency level than those not participating in group activities.

This study had several recommendations; it is important that the process of land titling be extended to all regions of the country because this may increase tenure security which would lead to increased technical efficiency. Land subdivision in high potential areas of the country should be discouraged because larger parcels of land are more technically efficient. Farmers should be provided with affordable credit either through the AFC or other institutions in order to ensure that they acquire the required farm inputs in the recommended proportions hence increasing their technical efficiency levels. Farmers should also be encouraged to participate in producer groups because is acts a forum for social networking which would allow transfer of information and skills. Higher education level was associated with higher technical efficiency. Recent government policy on free primary and secondary education is a positive move towards improving the technical efficiency levels of farming households and this policy should be upheld.

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

About 1.2 billion people, one fifth of the population in the world, live in extreme poverty manifested by chronic hunger, malnutrition and disease. According to the United Nations population growth projections (2004), the global population, which was 6.1 billion people in 2001 could rise to more than nine billion in 2050 (Kisamba-Mugerwa, 2005; Cohen, 2003). Increased population is an additional challenge in terms of food security and sustainable use of natural resources. The bulk of this population increase will be in developing countries where livelihoods, particularly for the poor, depend heavily on smallholder farming systems (Kisamba-Mugerwa, 2005).

Agriculture is the mainstay of most economies in Sub-Saharan Africa (SSA) contributing at least 70 to 80 percent of employment, 40 percent of exports earnings, 30 percent of gross domestic product (GDP) and up to 30 percent of foreign exchange earnings (Economic Commission for Africa, 2005). Two-thirds of manufacturing value-added in most African countries is based on agricultural raw materials (IFAD, 2002). However SSA stands out as the poorest region in the world (IFAD, 2002) with nearly 80 percent of the poor living in rural areas (Economic Commission for Africa, 2005). Even those who do not live in the rural areas are heavily dependent on increasing agricultural productivity to lift them out of poverty (World Bank, 2000). Agricultural productivity in Africa has declined over the years leading to progressive increase in food imports (AU/NEPAD, 2003). The total food import bill for LDCs in 1970 was US$1 billion and this has rose to estimated at US$122 billion in 2006 (FAO, 2006). Since 28 percent of the population in SSA suffers chronic food insecurity, efficiency of resources used in agricultural production will continue to be a major concern for policy and initiatives targeting improved livelihoods in the region.

Land is one of the important resources in agricultural production in Sub Saharan Africa (Economic Commission for Africa, 2005), therefore the different forms of tenure under which it is operated is a major concern not only for agricultural productivity, rural livelihood, but also for competitive market-oriented production. Land tenure has been defined as the terms and conditions under which land is held, used and transacted and the manner in which the resulting benefits and costs are distributed (Economic Commission for Africa, 2003). The draft national land policy (Kenya, 2006) also notes that land tenure definition includes the conditions under which rights to land and land-based resources are acquired, retained, used, disposed off, or transmitted.

According to the draft national land policy (Kenya, 2006), Land tenure in Kenya is generally categorized into public, communal or private land. Public land is owned by the government and is dedicated to specified public uses or can be made available for private uses at the discretion of the government. Community land is lawfully held, managed and used by a specific community. Private land is held by an individual or other entity under either freehold or leasehold tenure. Freehold land may be held under the Registration of Titles Act (Cap 281), the Land Titles Act (Cap 282) or the Government Lands Act (Cap 280). Leasehold involves the transfer of rights for a period of time in exchange for specific conditions including, but not limited to, the payment of rent (Kenya, 2006). The type of tenure under which land is held would affect the level of security. Land tenure security, according to Place *et al.*, (1994), is the perception of an individual pertaining to the rights to a piece of land on a continual basis, free from imposition or interference, as well as the ability to reap the benefits of labour or capital invested in the land, either in use or upon alienation. In this study, land tenure will be categorized into three: land owned with title, land owned without title and rented land.

Since ninety percent of all agricultural production in Africa is derived from small farms (Spencer, 2002), smallholder farming is critical to human welfare in term of employment and livelihoods, and for political stability in Sub-Saharan Africa (Delgado, 1998). Historical trends suggest that smallholder farmers will continue to dominate the agricultural industry in the developing world, especially in Africa and Asia, for at least the next two to three decades (Nagayets, 2005).

Over 87 percent of the kenyan population live in the rural areas and derive their livelihoods, directly or indirectly, from agriculture (Nyoro, 2002). Therefore the economy of Kenya, like other developing countries, is heavily dependent on agriculture which contributed 26 percent of gross domestic product (GDP) and 60 percent of export earnings in the year 2000 (Nyoro, 2002). Through linkage with manufacturing, distribution and service related sectors, agriculture contributed a further 27 percent of the GDP (Kenya, 2004) and employed 75 percent of the national labour force in the year 2000 (Nyoro, 2002). The role of smallholder farmers in the agricultural sector in Kenya cannot be over emphasized; they accounted for 75 percent of total agricultural production and 70 percent of marketed agricultural output in 2003. In addition they produced on the average, more than 70 percent of maize, 65 percent of coffee, 50 percent of tea and 90 percent of sugar (Nagayets, 2005; Kinyua, 2004). One of the main characteristics of smallholder farming in Kenya is small land sizes averaging 2-3 acres, making land one of the major constraints limiting increased agricultural production (Kinyua, 2004). Agricultural performance in developing countries depends on smallholder farms being able to produce more output (Diao *et al*, 2006). Since smallholder income is derived through the sale of surplus farm produce though frequently supplemented by non-farm income

(Nagayets, 2005), it is important to increase efficiency in smallholder farming. Land tenure systems operating in Kenya vary and in turn influence land sizes in agricultural production. However it is not clear how land tenure influences efficiency in agricultural production and in particular the technical efficiency of crop production by smallholder farmers, to inform formulation of pro-poor growth strategies.

Poverty in SSA tends to be concentrated among households operating farms of less than 2.5 acres (Kinyua, 2004). However, the area of land operated by farming household is not the only constraint in agricultural production linked to land resource. It has been observed that land tenure security is one of the requirements necessary for smallholders to take a long term view of their production system, conserve and invest in the land and its natural resources (Whiteside, 1998) which is a prerequisite for increased and sustainable agricultural productivity in most SSA countries. However, land tenure rights for smallholder farmers are unclear and sometimes overlapping. For instance, in some cases, farmers have no formal contractual arrangements on which to base decisions on land use and the role of traditional land tenure structure is not well defined (Economic Commission for Africa, 2003).

Tenure security enhances the ability of farmers to invest on land. Studies have shown that use of farm inputs such as fertilizers, herbicides, manure, improved seeds and pesticides would enable the farmers increase their yields in the short run (Byiringiro and Readon 1996, Morrison *et al.*, 2004, Ransom *et al.*, 2003; Roth *et al*, 1994). Such investment would only be undertaken if farmers are certain of benefiting from them. Long term investment such as fencing, grass stripping, mulching, removing stumps, terracing and tree crop growing would also be enhanced by secure land tenure (Roth *et al*, 1994). The government of Kenya (2006) observed that there could be a relationship between land tenure and technical efficiency. Hayami and Otsuka (1993) also observed that insecure tenure systems result in inefficient allocation of resources as well as reduced incentives to improve agricultural land. However, with the exception of few studies done to link land tenure and technical efficiency, for instance, Place, 2006; Obunde *et al.,* 2005; Waganjo and Ngugi 2001; Place *et al*., 1994; and Place, 1993, the subject has not benefited from rigorous empirical analysis in Kenya and more so, in the smallholder farming system.

Most studies examining the linkages between tenure security and efficiency found minimal relationship (for instance, Place and Hazell, 1993; Gavian and Ehui, 1999; Place and Otsuka, 2002 and 2001; Hunt, 2003). However, other studies such as Pender *et al.* (2004); Deininger *et al.* (2006); Deininger and Jin (2006); Deininger and Castagnini (2006), found significant relationship between land tenure and agricultural productivity. However, most of these studies have not been undertaken in Kenya and moreover, they are based on specific enterprises. To decipher these conflicting views on the linkages between tenure security and technical efficiency, there is need for more research on these pertinent issues especially in Kenya.

The performance of a farm can be judged using the concept of economic efficiency, which is generally assumed to be made up of two components technical efficiency and allocative efficiency (Kalirajan and Shand, 1999). Technical efficiency is defined as the capacity of a farm to produce the maximum possible output from a given bundle of inputs and technology. Allocative efficiency is the ability of an economic unit to equate its specific marginal value product with its marginal cost (Kalirajan and Shand, 1999).

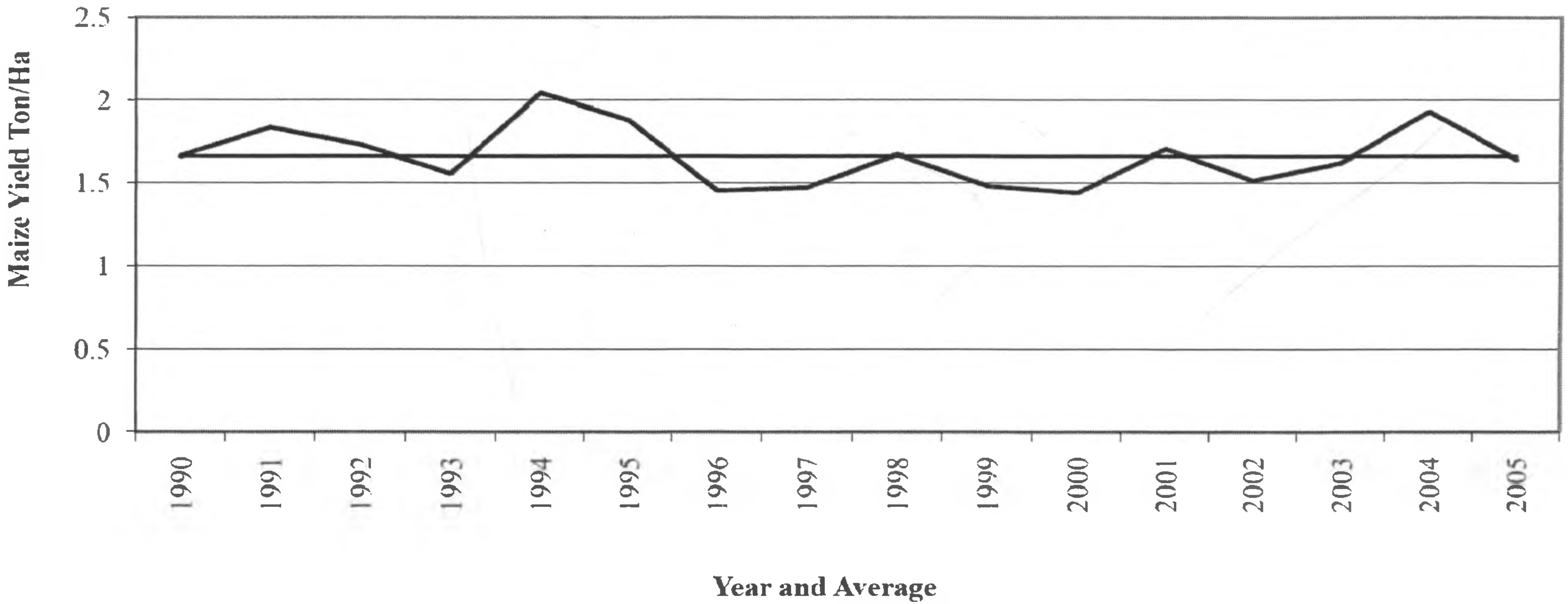
While tenure security is an important determinant of technical efficiency, it interacts with other socio economic characteristics of the farmer in ensuring efficiency in production. Holden *et al.,* (2002) observed that other socio-economic factors, for instance, the number of persons in the household, age of the head of the household, gender of the household head, owned farm size, total rented land size, value of purchased inputs and education level of household head are important aspects in increasing technical efficiency (Holden *et al,* 2002).

1.2 Problem Statement

According to the 1997 Welfare Monitoring Survey (WMS), poverty incidence in Kenya has been rising over the years from 48.8 percent in 1990 to 56 percent in 2003 (Government of Kenya, 2003). Three quarters of the poor live in rural areas where smallholder farming forms a major source of livelihood accounting for 75 percent of total agricultural production (Government of Kenya, 2006; Nagayets, 2005; Kinyua, 2004). Population increase has put pressure on the existing land (Kisamba-Mugerwa, 2005) and has further created stress on other resources therefore challenging the capacity of the country to feed itself (Clover, 2003). Over the last two decades, farmland productivity in the county has been low for most agricultural commodities. For instance, maize, which is recognized as an important cash and food crop in Kenya (Nyangito, 1997), had yields averaging 1.6 tonnes per hectare between 1990 and 2005 (see Figure 1-1). This is low compared to the potential yield of six tonnes per hectare in Kenya (FAO, 2007). Yield of other crops would follow a similar trend.

In general, the yields of maize tend to vary between 1.4 and 1.8 ton/ha and likely to remain at this level unless some measures are taken to break the low productivity trap. More often, the country faces food deficits, for instance, as shown in Table 1-1, Kenya had a maize deficit in 11 out of the 18 years presented (1990-2007), and even where the production was higher than consumption, it is not large enough to allow for sufficient reserve. The average production of maize for the 18 year period (Table 1-1) is 2,480 tonnes and only in 1994 did the production pass the 3,000 tonnes mark.

Figure 1-1: Maize Yield in Kenya 1990 – 2005(ton/ha)



Source: FAO. 2007

However, for the same period of time, the average consumption for maize was 2,650 tonnes. This indicates that Kenya has been a net importer of maize and other agricultural products. In order to reverse this trend, factors that hinder efficiency in production of maize and other important crops in Kenya need to be identified. Land is the main resource in farming and generally, is a major constraint to increasing farm production (Kinyua, 2004). It is not surprising therefore that there is a renewed interest in understanding the factors that promote or inhibit farm investment, including land tenure and land tenure security (Place, 2006).

An understanding of the influence of land tenure system on technical efficiency of smallholder farms in Kenya would provide an insight on how technical efficiency can be increased. Land tenure is likely to interact with other socio-economic factors (age, gender, education level, credit availability, land size) to influence technical efficiency. This interaction has not received rigorous empirical investigation in the context of smallholder farmers in Kenya. Even though a number of studies have focused on tenure and efficiency (Farm Africa, 2004; Diao *et al.,* 2006; Roth *et al.,* 1994), it is still not clear how the characteristics of smallholder farmers such as age of farmer, gender, education level, credit availability and land tenure systems differ across different agro ecological zones in Kenya. Technical efficiency of farmers operating under these different tenure systems among smallholder farmers in Kenya is also not well understood.

Investment on land would be determined by the socio economic status of the farmer. For example, farmers accessing credit would be in a position to invest more on the land. However, they would only be willing to make such investments if the land tenure system in which they operate assures them of recouping the benefits from such investments.

Table 1-1: Production, Consumption and Importation of Maize in Kenya between 1990 and 2006 (18 years)

Year	Production ('000 tonnes)	Consumption ('000 tonnes)	Deficit in maize production (Production-Consumption)	
1990	2,290	2,064	226	Surplus
1991	2,400	2,200	200	Surplus
1992	2,430	2,329	101	Surplus
1993	2,089	2,451	-362	Deficit
1994	3,060	2,565	495	Surplus
1995	2,699	2,654	45	Surplus
1996	2,160	2,711	-551	Deficit
1997	2,214	2,744	-530	Deficit
1998	2,464	2,764	-300	Deficit
1999	2,322	2,780	-458	Deficit
2000	2,160	2,800	-640	Deficit
2001	2,790	2,824	-34	Deficit
2002	2,409	2,852	-443	Deficit
2003	2,711	2,876	-165	Deficit
2004	2,607	2,892	-285	Deficit
2005	2,906	2,900	6	Surplus
2006	2,932	2,927	5	Surplus
2007	2,928	2,930	-2	Deficit
Mean	**2,482**	**2,650**	**-168**	**Deficit**

Source: FAO (2007)

At the same time, the age and gender of the farmer are likely to determine the kind of tenure system for which land is under and in turn, this would influence technical efficiency. More educated farmers are likely to make better investment decisions and at the same time they would be able to improve their land security status by acquiring land titles. It is therefore likely that more educated households would be more technically efficient than those with less or no formal education. Such interactions between land tenure and other social economic characteristics of smallholder farmers such as education, gender and age are not well understood. It is also not known if these interactions vary across agro ecological zones. This study aims at filling these knowledge gaps and contributing to the existing knowledge by analyzing the interaction of land tenure systems and other socio-economic factors in the determination of technical efficiency in smallholder crop production systems.

The current study differs from other studies (Place, 2006; Obunde *et al.,* 2005; Holden and Yohannes, 2002; Suyanto *et al.,* 2001; Waganjo and Ngugi 2001; Place *et al.,* 1994; Gavian and Ehui, 1999; Gavian and Fafchamps, 1996; Place, 1993; Place and Hazell, 1993) in several ways. First, it focuses on smallholder farming which remains the major source of livelihood for most of the rural poor in Kenya (Whiteside, 1998). Second, unlike most other studies, where land tenure and technical efficiency are studied separately (Kolawole and Ojo, 2006; Kibaara, 2005; Adams *et al.*, 2003; Ajibefun and Daramola, 2003; Chirwa, 2003; Haugerd, 1998; Place *et al.,* 1998; Migot-Adholla, 1991) this study investigates the relation between the two alongside other socio economic characteristics. Third, the analysis focuses on whole farm analysis where technical efficiency of all the enterprises is analyzed unlike other studies that only focus on particular crops (for instance, Kolawole and Ojo (2006); Kibaara (2005); Suyanto *et al.*, (2001), focused on cassava, maize and paddy, respectively). Such a whole farm efficiency study has been conducted by Kolawole and Ojo (2007); Brock *et al.*, (1997); Bravo-Ureta *et al.*, (1997); and Singh (1982) but did not include the aspect of land tenure.

1.3 Objectives

The general objective of this study is to analyze the effect of land tenure on technical efficiency in smallholder crop production in Kenya focusing on land owned with title, land owned without title and rented land across different agro ecological zones, with a view to identifying policy options for enhancing efficiency in land resource utilization.

The specific objectives of this study were to:

- Characterize smallholder farmers operating under different tenure systems across different agro ecological zones in Kenya, (owned with title, owned without title and rented),
- Compare technical efficiency of smallholder farms operated under different tenure systems (owned with title, owned without title, rented), across different agro ecological zones in Kenya,
- Evaluate the interaction of land tenure and other socio-economic factors (household size, age of household head, gender of household head, age of household head, credit availability, distance to motorable road and group participation) with technical efficiency of smallholder farms across different agro ecological zones in Kenya.

1.4 Hypothesis

- There is no difference in the characteristics of smallholder farmers operating under different tenure systems across different agro ecological zones in Kenya,

- There is no difference in the levels of technical efficiency among different tenure systems for smallholder farms across different agro ecological zones in Kenya,
- There is no interaction between land tenure and other socio economic factors with technical efficiency of smallholder farms across different agro ecological zones in Kenya.

1.5 Justification

Kenya faces a problem of insufficient food supply and in order to be self-sufficient in food production, maximum output from the limited resources is crucial. Efficient allocation of resources would result in increased output and in turn increasing availability of food. The land tenure systems under which farmers hold their land is likely to determine the kind of investment that they make of the land and this would have an implication on their levels of technical efficiency. Socio economic characteristics of the farmers may also influence the allocation of resources on the land and therefore would also influence technical efficiency. If the interaction between land tenure and other socio economic characteristics of the farmer was understood policy makers would develop policies that would ensure sufficient food production.

CHAPTER TWO

2.0 LITERATURE REVIEW

This chapter reviews studies that have been conducted on tenure and technical efficiency. The first section reviews the tenure property rights regimes in Kenya and other countries. The next sub-section reviews the historical aspects of land tenure followed by some discussion on the tenure security of small holder farmers. The last sub-section on looks at how efficiency has been measures and compares different approaches.

2.1 Land Tenure and Property Rights

Economic Commission for Africa (2003) defines land tenure as the terms and conditions under which land is held, used and transacted and the manner in which its benefits are distributed. Discussion on land tenure would be greatly understood from the property rights perspective. Property rights have been defined by Furubotn and Perjovich, (1972) as the claims, entitlements and related obligations among people regarding the use and disposition of a scarce resource. They are a bundle of rights that include use rights, extraction rights, transfer rights, exclusion rights and encumbrance rights (Furubotn and Perjovich, 1972). Foss and Foss (2005), Libecap (1989) view property rights as the social institutions that define or delimit the range of privileges granted to individuals of specific resources, such as parcels of land or water.

Property rights are associated with corresponding duties and responsibilities of both the right holder and also other people who would be interested in the resource (Kirsten and Karaan, 2005). This means that if one has a right, someone else has a commensurate duty to observe that right. Property rights implies the consent of others to allow one to act in particular ways meaning that the community is expected to prevent others from interfering with the rights rested in the resource owner. Property rights shape the interaction between people and resources and help in resolving conflicts relating to resources (Demsetz, 1967).

The most prevalent property rights regimes are public (rights held by state), private (rights held by individual either singly or jointly) and common property rights (rights held by organized groups). However, there is no clear boundary between these rights since the community or individuals could have some rights of access to a resource that belongs to the government and hence overlapping property rights (Komarudin *et al*, 2006; Mwangi and Meinzen-Dick, 2005). However, Knox and Gupta (2000) argue that secure rights need not be exclusive but could also be held in common or overlap with different resource users.

Property rights are important because the ability to create, appropriate, and sustain value from resources partly depends on the property rights held and how well they are protected (Foss and Foss, 2005). Property rights range from formal arrangements, including constitutional provisions, statutes, and judicial rulings, to informal conventions and customs regarding the allocations and uses of property (Libecap, 1989). They affect decision making regarding resource use and hence affect economic behavior and economic performance (Libecap, 1989). According to Mwangi and Meinzen-Dick (2005), property rights are important because the way rights are defined would determine whether people are included or excluded from the use and control of the resources that are important in their lives. Holding property rights empowers individuals or groups to take control of the resources. Property rights provide incentives to invest in resources and therefore ensuring efficiency in resource allocation. Tenure security increases the likelihood that farmers will capture their investment and also reduce the chances of resources related conflicts. Property rights also provide incentives to protect a resource from encroachment or over exploitation. Moreover, well defined property rights would prevent the degradation that often arises from free riding by users (Mwangi and Meinzen-Dick, 2005).

2.2 Historical aspects on land tenure

The process of colonization introduced an alien concept of property relations in Kenya, where the State or the protectorate as a political entity came to own land and granted subsidiary rights to property users (Kenya Government, 2006). By 1920, when Kenya was formally declared a colony, all land in the country, irrespective of whether it was occupied or unoccupied was regarded by the British government as 'Crown Land' and was available to white settlers for use as private estates (Okoth-Ogendo, 1999). This denied africans the rights to rights to hold and manage land. After 1922, attempts were made to address the issue of security of land for african cultivators. The system that was at that time was the creation of 'reservations' for each ethnic group. However, this offered no protection in the face of settler advance because the same land could be reallocated to the settlers. Land reserved for use by Africans remained 'Crown Land' (state owned) and was available for use by white farmers (Okoth-Ogendo, 1991). After several inquiries and commissions a clear separation in colonial law was made in 1938 between 'Crown Land' out of which private titles could be granted, and 'native lands' which were to be held in trust for those in actual occupation (Okoth-Ogendo, 1999). Land ownership in some parts of Kenya changed into individual private estate with titles issued by the imperial power (Okoth-Ogendo (1999). The act of taking over of customary land by the colonial government is what led to the struggle for independence in Kenya (Okoth-Ogendo (1999).

A major land reform was started in Kenya in the 1950s and was based mainly on western ideology of individual freehold tenure, but allowed the registration of group titles, especially in the dry zones of the country (Rutten, 1997). The programme began in Central Kenya under the Swynnerton Plan in the 1950s and later was been extended to other regions of the country (Haugerud, 1989). Most of the formally white owned land has been sub divided and progressively acquired by indigenous kenyans (Okoth-Ogendo (1999). One objective of land title registration was to encourage agricultural investment by reducing litigation and removing uncertainties regarding claims to land (Haugerud, 1989). The outcome has been contrary to that intended. Growing conflict over access to land and the disposition of land titles has divided communities (Haugerud, 1989). Legal battles on land ownership multiply as tenure reform is extended to other areas of Kenya, as title-holders default on commercial loans and as more land transfers go unrecorded in the registry (Haugerud, 1989). As such, land use policy is needed to guide issues such as subdivision, which have important impacts on resource management (Ritho, 2003).

Currently, in Kenya land is owned by four different kinds of entities, namely, the government, county council, individuals and groups (Kameri-Mbote, 2005; Ritho, 2003). Land tenure system existing in Kenya has been characterised as private, communal, public and open access (Kameri-Mbote, 2005; Waiganjo and Ngugi, 2001). In some cases, these systems overlap especially where the tenure reform process is incomplete, as in the case of trust land awaiting registration or where individuals have rights over land legally vested in local county councils as trustees (Kameri-Mbote, 2005). Privately owned land comprised six percent of the total land area in 1990 while Government land (formally Crown lands) was about 20 percent and included national parks, forest land, alienated and unalienated land (Kameri-Mbote, 2005). The most extensive tenure type however, is trust land (formally native areas which comprised 64 percent of total land area in 1990), awaiting smallholder registration that will effectively bring them under the private tenure systems (Kameri-Mbote, 2005).

Little effort has been made to design innovative land rights systems and not much has changed in Kenya since 1938 (Okoth-Ogendo, 1999). Land tenure system is more or less similar to other East African countries. Tanzania expanded the domain of 'public land' by abolishing all freeholds in 1962 and converting all existing government leases into 'rights of occupancy' under the 1923 Land Ordinance. However this Ordinance has remained in force since 1923 and has discouraged investment on land (Okoth-Ogendo, 1999). Similarly Uganda, has stuck to the same tenure regime categories defined by British colonialism which consists of an interaction of public and customary land holdings (Okoth-Ogendo, 1999). Ethiopia used a different approach to land reforms. In 1975, all the land was taken over by the state. Landlords lost their land rights and the land was re-allocated to individual households according to household size (Alemu, 1999). As household sizes changed over time and new households appeared, there was a need to redistribute land at later stages to improve or maintain the egalitarian distribution and to provide land to new landless households (Holden and Yohannes, 2002).

2.3 Land Tenure and Tenure Security in Crop Smallholder farming

Smallholder farms dominate farming in many developing countries. The ability of such farmers to transform from traditional to modern farming is based on their ability to operate more efficiently. If small scale farmers would increase their efficiency, they would evolve from subsistence to market led production (Farm Africa, 2004; Diao *et al*, 2006). Majority of the smallholder farmers in Kenya and in most other developing countries are resource poor (Kinyua, 2004; Nagayets, 2005; Spencer, 2002). As a result, farmers with larger farms size are likely to be more efficient in utilizing resources than farmers with smaller farms (Fabiosa *et al*, 2004). Smallholder farming has become a major driving force behind agricultural production in Kenya (Kenya Government, 2006). It is therefore important to understand how the issue of access to land is related to agricultural production and to the success of farmers.

Mwakubo, 2006 assessed land tenure and farm level soil conservations in semi arid areas of Kenya (Kitui and Machakos districts). Insecure land tenure rights and imperfect functioning of the land market were noted as the cause of reduced incentives for smallholder farmers to invest in soil conservation. When land tenure system is insecure, a farmer faces lower expected returns from soil conservation investment (terracing and gabions) because of the possibility of being evicted before realizing the benefits. Land tenure potentially affects sustainable land use by improving production incentives and increasing investment on soil conservation.

Place *et al.*, (1998) evaluated the effect of land registration on smallholder farmers in two districts in Kenya (Nyeri and Kakamega). Male household heads are more likely to hold titles than female household heads. Household heads with more education have a higher chance of possessing land title than household heads with no education.

Tenure security enhances the ability of farmers to invest on land. Studies have shown that use of farm inputs such as fertilizers, herbicides, manure, improved seeds and pesticides enable farmers to increase their yields in the short run (Byiringiro and Readon 1996, Morrison *et al.*, 2004, Ransom *et al.*, 2003; Roth *et al*, 1994). Long term investment such as fencing, grass stripping, making beds, mulching, removing stumps, terracing and tree crop growing is also enhanced by secure land tenure (Roth *et al*, 1994). Trees are important in farming because they control soil erosion. Some agro-forestry trees such as sesbania are leguminous and help in nitrogen fixing in the soil. Such interactions between investment on land and land tenure would ultimately increase farm efficiency (Aw-Hassan *et al.*, 2000, Kazianga and Masters, 2005). The way land tenure is instituted and the consequent perceptions and expectations of the land holders directly affect the way farms are managed (Sjaastad and Bromley 1997; Place and Migot-Adholla, 1998; Li *et al.*, 1998; Besley, 1995; Platteau, 1996) and this would have an effect on the level of efficiency.

In a study relating investment to farm size in Ethiopia, Alemu (1999) found that small farms invested more in land conservation than did large farm. The main reason for this is that large farms are more likely to lose land in future redistributions. In another study aimed at assessing the impact of land redistribution policy on tenure insecurity in Ethiopia, Holden *et al.*, (2002) observed that through investment in fertilizers, seeds and herbicides, farm households improved their efficiency leading to increased incomes. Farmers who felt secure would purchase more fertilizer, improved seeds and herbicides and this would have an impact on farm efficiency. The study identified household size, age of the household head, gender of the household head, total owned farm size, total rented land, share of land planted with perennial crops, distance to the market place, value of purchased inputs and education level of household head to be important determinants of efficiency. The study established that households renting land felt more insecure. Farmers would feel more secure cultivating on their own land other than in rented land.

According to Maxwell *et al.* (1999), greater tenure security increases demand for land improvements by increasing the confidence of farmers that they will benefit from such investments over the long term. Tenure security increases the supply of formal credit through the creation of tradable collateral. In much of Africa however, land titling does not appear to increase access to formal credit and even where farmers hold land titles, they are reluctant to mortgage their land (Barrow and Roth, 1990; Migot-Adholla *et al*, 1991; Shipton, 1994.

Economic Commission for Africa, 2003 investigated the factors that would strengthen women's access to land in southern Africa. The countries that were included in the study were Botswana, Lesotho, Malawi, Mozambique, South Africa and Zambia. The study observed that women were usually discriminated in accessing land. In most cases, their rights to land are secondary, derived through their membership in households and secured primarily through marriage. Women in Southern Africa do not have the resources that would enable them to meaningfully benefit from land ownership.

2.4 Efficiency Measurement

Farm performance can be measured using the concept of economic efficiency, which is assumed to be made up of two components: technical efficiency and allocative efficiency (Kalirajan and Shand, 1999; Bravo-Ureta *et al.*, 1997). Technical efficiency is the ability of a farm to obtain maximum output from a given set of inputs (Ajibefun and Daramola, 2003; Bravo-Ureta *et al.*, 1997; Banker *et al.,* 1984; Charnes *et al.,* 1978; Aigner, *et al.,* 1977; Farrell, 1957). Allocative efficiency reflects the ability of a farm to use inputs in optimal proportions given their respective prices. A production process is said to be allocatively efficient if it equates the marginal rate of substitution between each pair of inputs with the input price ratio (Ajibefun and Daramola, 2003; Bravo-Ureta *et al.*, 1997; Farrell, 1957).

Several studies have evaluated the relationship between technical efficiency and socio-economic characteristics of farming households. Older household heads are associated with higher technical efficiency (Kolawole and Ojo, 2007; Amaza and Maurice, 2005; Ahmed, *et al*, 2002; Bravo-Ureta and Pinheiro, 1997). This is because age is usually associated with experience. Education level of the household head also strongly influences technical efficiency of farms (Kolawole and Ojo, 2007; Amaza and Maurice, 2005; Bravo-Ureta and

Pinheiro, 1997). Male headed households are more efficient than female headed households (Ahmed, *et al*, 2002; Bravo-Ureta and Pinheiro, 1997). The reason for this is that male headed households have a better resource endorsement than female headed households. The size of the household unit significantly influences technical efficiency. Larger households are associated with higher efficiency than smaller households (Amaza and Maurice, 2005; Bravo-Ureta and Pinheiro, 1997). Distance from the household to the access road and to market centers also affects the level of efficiency of farms. According to Binam *et al* 2004, farmers who are nearer to motorable roads are able to purchase inputs and therefore increase their production efficiency. At the same time, they have better flow of information about emerging technologies.

Off farm income is an important determinant of efficiency. According to Rahman 2003, households who have higher opportunity to engage in off-farm work fail to pay much attention to their crops relative to other farmers and will operate at lower levels of efficiency. However Diao *et al.*, 2006 disagrees with the notion and instead argues that households with more off farm income are able to purchase farm inputs and are therefore more productive. Group membership increases the information flow into the household and also provides access to credit to farmers (Hazarika and Alwang, 2003). This would lead to increased farm efficiency. Access to extension services would enable farmers to improve on their farming systems resulting in efficiency in production (Amaza and Maurice, 2005; Battese, 1992). Karagianis and Sarris, (2005), noted that when farmers are using irrigation in crop production, they have higher chances of increasing efficiency. The main reason for this is that they are able to schedule planting and harvesting time and are therefore less vulnerable to crop loss.

Ahmed *et al.* (2002) did a study aimed at determining the sources of technical efficiency in wheat production in Ethiopia. The study used stochastic frontier model to estimate technical efficiency. Variables included in the model were tenure (whether owned or rented), age of household head, education status of the head of household (either literate or illiterate), main occupation of the household head (farming or non-farm activities), size of cultivated land and labour distribution in wheat production. The study found that tenure status significantly influences technical efficiency. More than half of the farmers cultivating wheat on their own plots operate above the average efficiency level compared to less than one quarter for those cultivating on borrowed plots. Beside land tenure systems, several other social economic and resource factors were identified to have an influence on technical efficiency. Technical efficiency was higher for older farmers which was associated with the accumulation of experience over time. Male headed households were found to be more efficient than female headed households and households with more educated heads were found to be more efficient. This study however had its emphasis on wheat production and the results would not be generalized to other enterprises.

Gavian and Fafchamps (1996) examined whether traditional land tenure systems are an impediment to allocative efficiency in Niger. Farmers who cultivate both borrowed and owned fields divert manure towards the latter. Brock *et al.,* (1997) used both stochastic frontier analysis (SFA) and Data envelopment Analysis (DEA) to evaluate technical efficiency of russian farms. The value of agricultural production (aggregating crops and livestock) was used as the dependent variable while independent variables were; the agricultural land available in hectares, number of workers engaged in agricultural activities, the value of inputs used and the value of fixed assets on the farm. The study showed that corporate farms were more efficient than smallholder farms on both the SFA and DEA scale. However, the score for DEA was much lower than that of SFA. Latruffe *et al.,* (2005) used

Data Envelopment Analysis to compare technical and scale efficiencies on crop and livestock farms in Poland. The study found that livestock farms were on average more technically efficient than crop farms. Scale inefficiency was higher in livestock farms than on crop farms and was attributed to poor management of resources.

Kolawole and Ojo, 2007 examined the overall efficiency of smallholder crop farmers in Nigeria. The study used Cobb Douglas production and cost functions to estimate technical and allocative efficiency. The dependent variable was the total value of production and total costs respectively. The study found that farmers operated under increasing returns to scale and therefore had the potential of improving their efficiency. Education level of the head of the farm (schooling years), farm size, quantity of fertilizer, age of farmer, credit availability and farming experience of the farmer were found to be significantly influencing technical efficiency.

A study conducted in the Dominican Republic by Bravo-Ureta and Pinheiro (1997) to evaluate the whole farm efficiency of smallholder farms using Cobb Douglas function showed that the average level of technical efficiency for the farms was 75 percent which indicating that the farms had the ability to improve their efficiency levels. The study evaluated the sources of inefficiencies by relating the technical inefficiencies with household characteristics. The size of land that the household possess, the gender of the household head, the number of schooling years of the household head, the age of the household head and the number of household members were identified as important aspects affecting technical efficiency. Though this study investigated sources of technical inefficiency, it did not relate it with land tenure which was the focus of the current study.

Different studies have approached land tenure, smallholder farming and efficiency in different ways. Most studies have handled the three aspects separately and only a few studies have tried to study the interactions existing between technical efficiency, land tenure and the socio economic status of the farmers. This study aimed at shading more light on the relationship between land tenure and technical efficiency for smallholder farming in Kenya. Finding from this study will augment other studies and will inform policy on approaches of improving smallholder farming both in Kenya and also in other developing countries.

CHAPTER THREE

3.0 METHODOLOGY

This chapter provides the conceptual and theoretical framework guiding this study in the first section followed by the model specification. The data collection method used and the approach used in analysis is discussed in the last subsection.

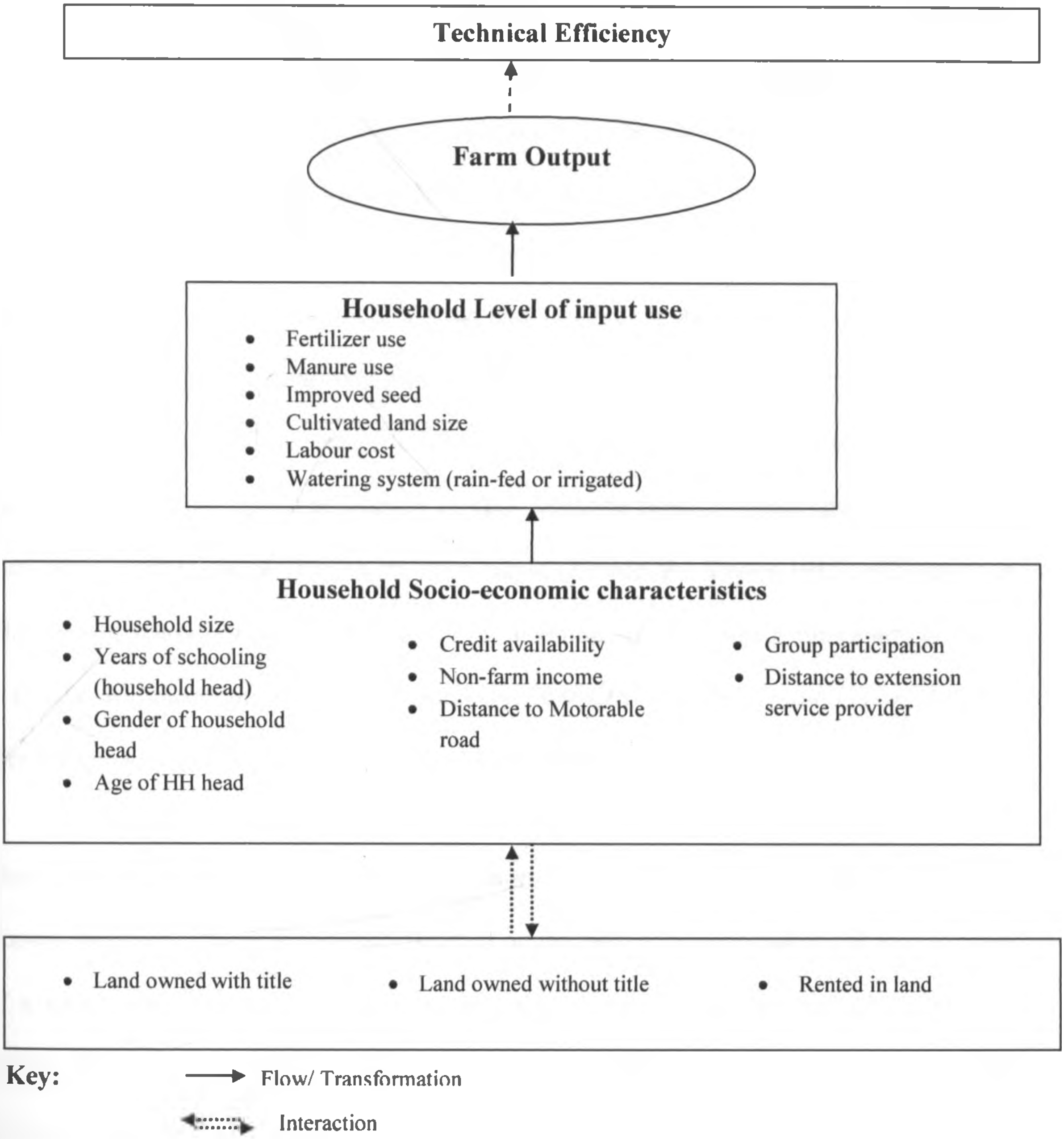
3.1 Conceptual Framework

Land tenure systems which are land owned with title, land owned without title or rented land was hypothesized to be influenced by the socio-economic characteristics of the households as shown in Figure 3-1. For instance, a household with higher income, more labour available and less land holding may rent more land or may purchase more land and acquire a title for their parcels. As noted in the literature review, households with male heads have higher probability of possessing a land title than female headed households Place *et al* (1998). At the same time, more educated household heads have higher chances of holding land title than less educated household heads (Kolawole and Ojo, 2007; Place *et al*, 1998). In the review of literature, it was also noted that older household heads have higher chances of possessing land title than younger household heads (Kolawole and Ojo, 2007; Holden *et al* 2002).

While concurring with Hayami and Otsuka (1993), the study further hypothesized that land tenure systems would be associated with some defined level of tenure security. Land tenure system would affect the level of input usage (fertilizer, manure, improved seeds) on the land holding (Maxwell *et al*, 1999). The level of input usage would also be influenced by household characteristics. Male headed households are more likely to acquire credit (Adesina and Djato 1997) and therefore would purchase more inputs. This interaction between land tenure and socio- economic characteristics of farmers will influence the level of output produced from the land parcel (Morrison *et al.*, 2004; Ransom *et al.*, 2003; Byiringiro and Readon 1996; Roth *et al*, 1994) and in turn influence technical efficiency. Large farms have higher technical efficiency than smaller farms because they enjoy economies of scale (Fabiosa *et al*, 2004). Kolawole and Ojo (2007) observed that availability of credit influences the level of technical efficiency of a farm. When credit is available to farmers, they are able to purchase inputs that would lead to higher production levels (Bravo-Ureta *et al.*, 1997; Amaza and Maurice, 2005).

Households irrigating their land are able to produce more efficiently than those relying on rain especially where the rainfall is not dependable (Rahaman and Asadullah, 2005). Land preparation cost has been used by Gavian and Fafchamps 1996 as a proxy for labour input. As indicated in subsequent sections of this chapter, the level of input usage together with outputs levels from a land holding defines the level of technical efficiency of an entity (Ajibefun and Daramola, 2003; Bravo-Ureta *et al.*, 1997; Banker *et al.*, 1984; Charnes *et al.*, 1978; Aigner, *et al.* 1977).

Figure 3-1: Conceptual Framework



Source: Author's Compilation

3.2 Theoretical Framework

The basic concept underlying the measurement of technical efficiency starts with the description of production technology (Kalirajan and Sand, 1999). Production technologies can be represented using isoquants, production functions or cost functions. Production functions and cost functions are interrelated through the duality theory of production and therefore they constitute the same basic approach (Kalirajan and Sand, 1999). Production theory presupposes the combination of fixed and variable inputs to produce a given level of output. The main inputs in farming include land, labour, capital and management. Capital is embedded in inputs such as seeds, fertilizers, herbicides and farm machinery (Beattle and Taylor 1985). Output from a production process would be used for consumption or could be used as an input in the production of other output (Beattle and Taylor 1985). Efficiency in allocation of scarce resources with the aim of obtaining optimal gains is the central problem in neoclassical theory of production (Tietenberg, 2006). Efficiency estimation is based on the economic theory of production (Ajibefun and Daramola, 2003).

There are two basic methods of measuring farm efficiency; the classical approach and the frontier approach. Classical approach is based on the ratio of quantity of output to quantities of a specific input used and is termed the 'partial productivity measure' (Ajibefun and Daramola, 2003). For example, it may be determined that 50 kilograms of DAP fertilizer produces five bags of maize. Frontier measure of efficiency implies that efficient firms are those producing along the production possibility frontier. The degree by which a firm lies below its production frontier is the measure of inefficiency (Ajibefun and Daramola, 2003). Frontier approach assumes that the efficient production function can be estimated (Ajibefun and Daramola, 2003; Coelli, 1994). Efficient production frontier is estimated from production data using various methods such as non-parametric technique which includes the

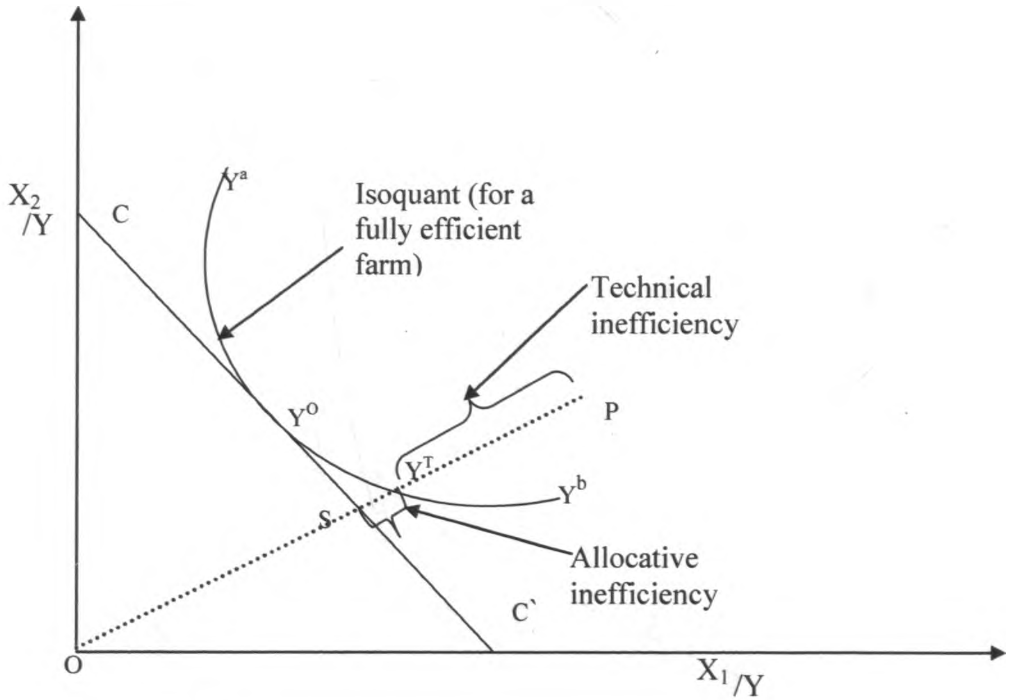
Data Envelopment Analysis (DEA) or parametric approache which includes the Cobb-Douglas and Translog functions (Asadullah, 2005; Battese, 1992).

3.2.1 Estimation of Technical Efficiency

Initial work on efficiency estimation was done by Farrell (1957). Since then, efficiency estimation has been presented in various studies, for instance, Ajibefun and Daramola, 2003; Bravo-Ureta *et al.*, 1997; Banker *et al.*, 1984; Aigner, *et al.* 1977 and Charnes *et al.*, 1978). These studies present methods of decomposing overall economic efficiency into its technical and allocative components. Productive units can be inefficient either by obtaining less than the maximum output available from a determined set of inputs (technical inefficiency) or by not purchasing the lowest priced package of inputs given their respective prices and marginal productivities (allocative efficiency). Efficiency measurement can be categorized as either input or output oriented. Input-oriented technical efficiency evaluates how much input quantities can be reduced without changing the quantities produced. Output oriented measures of efficiency estimates the extent to which output quantities can be expanded without altering the input quantities used (Coelli, 1994). Efficiency estimation can best be demonstrated by relating both allocative and technical efficiency for ease of conceptualization. This study used the input approach in estimating technical efficiency. The choice of the input oriented approach was based on the rationale that the output from a farm is exogenous while the inputs are endogenous (Murillo, 2004). A farmer can therefore determine what level of input combination to use in order to maximize output.

Figure 3-2 shows a representation of technical and allocative efficiency. The assumption is that a constant return to scale (CRS) exists and that the isoquant of a fully efficient firm (Y^aY^b) is known. The isoquant, Y^aY^b captures the minimum combination of inputs needed to produce a unit of output. Any farm producing at a point along Y^aY^b is considered technically efficient while any farm producing at a point above Y^aY^b such as point P is defined as being technically inefficient. The convex shape of the isoquant reflects a diminishing marginal rate of substitution; moving along the isoquant to the right, its slope becomes flatter. Starting from point Y^a, which uses relatively little of input X_1 and much input X_2, and moving to point Y^b which uses relatively little of input X_2 and much input X_1. Along the isoquant the production is held constant. A farm operating at point P produces the same output as a farm operating at point Y^T. However the firm at point R utilizes only a fraction (Y^TP/OP) of the inputs that the farm at point P utilizes. This indicates that the firm at point Y^T is technically efficient. The ray OP indicates a set of production alternatives with the same ratio of inputs X_1 and X_2. The distance Y^TP along the ray OP measures technical inefficiency for a farm located at point P. Y^TP represents the amount by which the two inputs can be reduced without decreasing the amount of output. Technical efficiency (TE) can be represented by the ratio Y^TP/OP. If the information on prices is known, the input price ratio can be represented by the isocost line CC.

Figure 2-2: Input oriented efficiency (Two inputs Case)



Source: Coelli, 1994

Allocative inefficiency is represented by the distance S Y^T and it represents the ability of the firm to produce a unit of output at minimum cost given the relative prices of the inputs. At point Y^T, the firm is technically efficient indicating that it is able to produce maximum output given a set of inputs. However, the firm is not allocatively efficient at that point because it is not utilizing the minimum cost combination. The ultimate aim of the firm is to operate at point Y^o which is both technically and allocatively efficient. Allocative efficiency (AE) for firm P is represented by the ratio OS/O Y^T. The measure of overall efficiency (economic efficiency) is EE=TE X AE.

3.2.2 Non Parametric Approaches to Efficiency Estimation

Economic efficiency can be estimated using two alternative approaches, the non parametric approach and the parametric approach. The most commonly used non parametric approach is the Data Envelopment Analysis (DEA) which was developed by Charnes *et al.*, (1978). DEA aims at measuring productive efficiency by defining an "envelopment surface" for all sample observations. A farm that does not lie on the surface is considered inefficient and an individual score for it can be computed. This method was used by (Latruffe *et al,* 2005; Fraser and Hone, 2001; Reinhard *et al.*, 1999) to evaluate the efficiency of farms. Fraser and Hone, (2001) used panel data to evaluate the technical efficiency of wool farmers in Australia and results indicated a gradual increase in efficiency across the years. Latruff *et al* 2005 evaluated the efficiency of both crop and livestock enterprise in Poland using DEA. Livestock farms were more technically efficient than crop farms. Reinhard *et al*, (1999) estimated the efficiency of dairy farmers in Denmark using the same approach. Efficiency levels are estimated on a scale of zero to one where the most efficient farm has a score of one while the least efficient has a score of zero.

The model by Charnes *et al.*, (1978) assumed constant returns to scale, however Banker *et al*, (1984) observes that there exists some scale inefficiencies. Banker *et al.*, (1984) extended the Data Envelopment Analysis (DEA) to handle variable returns to scale. DEA approach has several advantages that make it popular among analysts. The method does not express the relationship between inputs and outputs in a specific functional form. For this reason it is preferred by analysts who perceive that imposing any functional relationship is very restrictive. However, the DEA approach does not allow for hypothesis testing and all the deviations are attributed to inefficiency, a characteristic that leads to estimation errors. This method was therefore deemed unsuitable for the specific objectives of this study.

3.2.3 Parametric Approaches to Efficiency Estimation

Parametric approaches impose a functional form on the technical efficiency model. Both programming and econometric techniques can be applied to estimates the technical efficiency (Murillo-Zamorano, 2004). Stochastic frontier model (SFM) approach uses econometric technique to estimate the technical efficiency. This method is superior to the non parametric approach because it incorporates the efficiency term and also captures the effects of the exogenous shocks that are beyond the control of the farm such as weather fluctuation (Aigner, *et al.*, 1977).

The general mathematical form for a single output firm can be illustrated as:

$Y_i = f(X_i, \beta)\exp(V_i - U_i)$, U_i and $V_i \geq 0$ (Equation 3-1)

Where

Y_i = the output

X_i = the inputs

U_i = indicate the level of technical inefficiency which ranges between 0 and 1.

V_i = the random error which is associated with the random factors not under the control of the firm such as weather (assumed to be independently and identically distributed). The two error terms were assumed to be independent of each other and with the input variables.

Several functional forms have been used in the estimation of the stochastic frontiers. Among the commonly used forms are the translog and the Cobb Douglas forms. The translog form allows for variations of output elasticities which avoids the problems associated with constant elasticities (Miller *et al.*, 2005; Felmingham and Gang 2004. The Cobb Douglas form is preferred because it is lenders itself to interpretation in relation to the production technology (Binam *et al.*, 2004) and has been widely used in efficiency estimation studies (Amaza and Maurice, 2005; Asadullah and Rahman, 2005; Baccouche and Mokhtar, 2003; Amara *et al*, 1999). For example Amaza and Maurice 2005 estimated the technical efficiency of rice farmers in Nigeria. The study used a stochastic frontier model in a Cobb-Douglas form and the model was preferred because of its ability to separate the random error from the technical inefficiency effect.

Estimation of a stochastic frontier can be done using ordinary least square estimation (OLS), generalized least square (GLS) or Maximum likelihood (ML) estimation methods. According to Greene (1980), MLE estimates are more efficient than OLS estimates. The ML estimation method is preferred because of its desirable asymptotic properties of consistency, normality and efficiency meaning that these properties would hold as the sample size approaches infinity (Long, 1997). For these reasons, MLE was used in this study.

3.3 Model Specification

A stochastic frontier model was used to estimate technical efficiency and an input approach was used. The general form of the stochastic model was represented as;

$$Y = f(x_i, \beta)e^{v_i - u_i} \quad \text{(Equation 3-2)}$$

Where Y is the dependent variable,

β = technical coefficients,

u_i = the inefficiency effect of the firm,

v_i = the random component which is assumed to be identically and independently distributed with mean zero.

3.3.1 Valuation of Crops Produced

The dependent variable was the total value of crops produced by the farm (other than losses in the field or in store), including those used for feed and seed by the household. Following the Kolawole and Ojo (2007), the prices of individual crops were used as indices to allow for the computation of total value of all crops produced. Following Benjamin and Brandt (2002), farm output was valued at the actual market prices (p_i) that farmers received for their crops and where output was not sold village-level average prices were used (Kolawole and Ojo, 2007; Kan *et al.*, 2006).

$$\text{Crop Value } (Y) = \sum Q_i P_i \quad \text{(Equation 3-3)}$$

Where:

Y = The total value of all crops produced in the farm

Q_i = The quantity of each crop$_{(i)}$ produced in kilograms on each parcel of land for the main and short seasons in 2006

P_i = The price per kilogram of crop$_{(i)}$ derived by getting the average market price in each of the divisions that were included in this study.

3.3.2 Estimation of Technical Efficiency using Stochastic Frontier

A whole farm Technical Efficiency was estimated using the stochastic frontier model. The dependent variable in the model was the value of all crops produced by the household in the plot within the 2006/07 crop year. This approach of aggregating all value of crops has been used in other studies such as Kolawole and Ojo (2007); Brock *et al.*, (1997); Bravo-Ureta *et al.*, (1997); and Singh (1982). The rationale for using the value of crop produced as opposed to the conventional use of quantities produced was that a weighting factor is required in order to enable the aggregation of different crops. The prices of the products are used as the weights and therefore make it possible to aggregate all the crops produced (Kolawole and Ojo (2007).

The estimation equation used was as presented below and was in logarithmic form:

$$\text{vprdlln} = \beta_o + \beta_2 \ln acres + \beta_3 \ln vman + \beta_4 \ln vfert + \beta_5 \ln lpmd + \beta_6 lpsd \cos t + \beta irrigation + (V_i - U_i) \qquad \text{(Equation 3-4)}$$

Where:

vprdln = value of crop produced (dependent variable)

lnacres = land size (acres) owned by household for crop production.

lnvman = cost of farm yard and animal manure used in Kenya shillings per kilogram used on the parcel. This manure was combined for all the crops in that parcel.

lnvfert = cost of inorganic fertilizer in Kenya shillings per kilogram used on the parcel. This fertilizer was combined for all the crops in that parcel

lnlpmd = man-days used land preparation

lnsdcost = cost of seed used (Ksh per acre)

watering = Dummy variable for watering (irrigated or rain fed).

$(V_i - U_i)$ = A composite error term where. V_i: is the random error term (statistical noise) and U_i: represents the technical inefficiency

The model was run using STATA statistical package. STATA was selected because of its ability to handle stochastic frontiers analysis and has been used by other studies such as Kuosmanen *et al*. (2006) and Asadullah and Rahman (2005).

3.3.3 Interaction of Technical Efficiency and Socio-Economic Characteristics

In order to assess the interaction between technical efficiency and selected socio economic characteristics of the farm, a Tobit model was used to regress the technical efficiency scores derived in the previous model (Equation 3-5). Where dependent variable te was the estimated technical inefficiency score for each farm, the explanatory variables are a set of social economic variables, β_i is a vector of unknown parameters to be estimated, U_i are residuals that are independently and normally distributed, with mean zero and a common variance σ^2, the technical efficiency scores are censored between zero and one.

The model was run separately for each agro ecological zone to reflect the different social economic aspects influencing technical efficiency in each specific zone. The model was based on the interaction of the dummy variables on tenure system with the selected socio-economic characteristics. The rational of the interaction model is that tenure would not operate independently to influence technical efficiency. It would however interact with other factors to influence technical efficiency. For example, if land is owned with title and credit is available, there is a likelihood that this interaction would lead to a higher technical efficiency score. The same rationale can be extended to other socio economic factors. Such interaction models have been used by Tveteras and Battese, 2006; Rios and Shively, 2005; Battese and Broca, 1997 and Brambor *et al*, 2006, to relate technical efficiency with various characteristics surrounding the production environment of farmers. The technical efficiency scores were regressed with the set of socio economic characteristics. The model was tested for multicollinearity and non significant variables were dropped.

The model below was estimated:

$$\hat{te} = \beta_o + \beta_1 wotitle + \beta_2 rented + \beta_3 mem\_nu + \beta_4 edyrs + \beta_5 gender + \beta_6 credit + \beta_7 offarm + \beta_8 dmtroad + \beta_9 dextn + \beta_{10} group + \beta_{11} tacres + \beta_{12} mem\_nu * tenure + \beta_{13} edyrs * tenure + \beta_{14} gender * tenure + \beta_{15} credit * tenure + \beta_{16} offarm * tenure + \beta_{17} dmtroad * tenure + \beta_{18} dextn * tenure + \beta_{19} group * tenure + \beta_{20} tacres * tenure + U_i \quad \text{(Equation 3-5)}$$

Variable		**Description of variable**
$\hat{te}$	=	Estimated technical efficiency level (ranges from 0 to 1)
wotitle	=	Dummy variable for Land held without title, wotitle=1 if land owned without title and 0 other wise
rented	=	Dummy variable for rented land, rented=1 if land is rented and 0 otherwise
Mem_nu	=	Household family size
edyrs	=	Years of education of household head
gender	=	Gender of household head, gender=1 if household head is male, 0 otherwise

credit = Dummy variable for availability of credit, credit=1 if household got credit, zero otherwise

offarm = Whether the household has non farm income

dmtroad = Distance to motorable road in kilometers

dextn = Distance to extension service

group = Dummy variable for group membership, group=1 if any member of the household is a member of group that meets for agricultural purpose, 0 otherwise

tacres = Total land size available to the household (acres)

3.4. Data Sources and Area of Study

The study used secondary data that was provided by the Tegemeo Institute, Egerton University a research institute based in Nairobi. The data was part of a panel dataset that the institute had been compiling since 1997. The initial aim of the panel dataset was to provide information on the social economic dynamics of rural households in Kenya. Sampling for the panel survey was done in 1997 when the first phase of the survey was conducted. Since then the same households have been visited several times the latest being in 2007.

A multi-stage systematic sampling procedure was used to sample 1500 smallholder households in 22 districts in Kenya which represented five agro ecological zones (AEZ). The AEZs were jointly defined by Tegemeo Institute and ministry of agriculture. The number of households interviewed in each zone was determined based on the population density as per the 1989 population census. The Agro-Ecological zones were defined on the basis of combinations of soil, landform and climatic characteristics. The five agro ecological zones surveyed were Coastal Lowlands and Eastern Lowlands, Western Lowlands, High Potential

Maize Zone, Western Highlands and Central Highlands. Table 3-1 below shows the distribution of districts across the five agro ecological zones. This study used only the 2007 cross-section of the household level data collected. The sample comprised 1,333 smallholder farms. The survey instrument used in the 2007 survey is presented in appendix 6.

Table 3-1: Distribution of Districts across different Agro Ecological Zones (AEZ) in the Sample

Agro Ecological Zone	Districts Included
Eastern and Coastal Lowlands	Kwale, Kilifi, Taita Taveta, Kitui, Machakos, Makueni, Mwingi
High Potential Maize	Bomet, Nakuru, Narok, Trans Nzoia, Uasin Gishu, Bungoma, Kakamega
Western Lowlands	Siaya, Kisumu
Western Highlands	Vihiga, Kisii
Central Highlands	Muranga, Meru, Nyeri

3.5 Suitability and Limitations of the Secondary Data

The secondary data that were used in this study were appropriate because of several reasons. First, the sample was selected from smallholder farmers in Kenya. It is therefore representative of smallholder farming in Kenya. A structured questionnaire was used to gather information from individual households on their farming and non farming activities. The data have information on land size, cropping systems, land ownership, cost of production and incomes. Secondly, the sample size of 1,333 was large enough to allow generalization of results and had a wide coverage of zones that represent crop production in Kenya. However, those data have some limitations, which this study strived to overcome. The data were not initially structured for exclusively analyzing land tenure systems in Kenya in relation to technical efficiency; hence, they lack some variables that would have added rigor to this study. For instance the data did not have information on land conflict and resolutions, and mode of acquiring land. However the available data were sufficient to fulfill the objectives of this study.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

The objectives of the study were: to characterize smallholder farmers operating under different land tenure systems, compare technical efficiency of smallholder farms operated under different tenure systems and evaluate the interaction of land tenure and other socio-economic factors with technical efficiency of smallholder farms across different agro ecological zones in Kenya. The results for each of the three objectives are presented on a separate subsection.

4.1 Characteristics of Smallholder Farmers Operating Under Different Tenure Systems across different Agro Ecological Zones

The study analyzed a sample of 1,333 smallholder crop farmers in five agro ecological zones who had cropping activities in the 2006/07 cropping year. Within the sampled households 24 percent had several parcels of land with different tenure system and as a result the observed tenure systems in the sample were more than the number of households interviewed. In the entire sample, 44.1 percent of the households had all their land owned with title, 32.5 percent had all their on land owned without title while only 0.15 percent (two households only) did not have their own land and cultivated on rented land. However, 23.3 percent of the households had land parcels with various tenure status.

4.1.1 Land Tenure System across the Agro Ecological Zones

The percentage of land cultivated in different tenure systems across the different agro ecological zones is presented in Table 4-11. Central Highlands zone had the highest percentage of land parcels with land title deed (57 percent). Eastern and Coastal Lowlands had the lowest title holding with only 26 percent of the parcels being held with titles while 69 percent being held without title. Western Highlands had the highest percentage of rented land accounting for 23 percent of all parcels. Renting of land was least practiced in Eastern and Coastal Lowlands with only 4.5 percent occurrence. A chi square test confirmed that the land tenure status vary across the agro ecological zones (*Computed* χ^2 *=163.1, Critical value of* χ^2 *= 15.5*).

According to Okoth-Ogendo (1999) the land titling process in Kenya started in Central Kenya region before spreading to other regions of the country. This could explain why Central Highlands had the majority of households with titled land parcels. In Eastern and Coastal Lowlands, most of the households do not have titles to their parcels of land. The difference between these zones in terms of the intensity of land titling can be attributed to the cost of acquiring the certificates which is generally considered to be high and not affordable by poorer households. Central Highlands fall in the resource endowed part of the country while Eastern and Coastal Lowlands fall in one of the poorest regions of the country. As pointed in UNDP (2005), Muranga and Nyeri districts in Central Highlands recorded a poverty incidence of 30 percent while Kitui and Kilifi in Eastern and Coastal Lowlands recorded incidences of over 70 percent.

Table 4-11: Percentage of Land Parcels Cultivated Under Different Tenure Systems by Agro Ecological Zones in the 2006/07 Crop Year

Agro Ecological Zones	Total Number of land parcels	Land Owned with title deed (%)	Land Owned without title deed (%)	Rented land (%)
Eastern and Coastal Lowlands	244	26.23%	69.26%	4.51%
High Potential maize zone	696	52.51%	30.42%	17.07%
Western Lowlands	194	47.40%	38.02%	14.58%
Western Highlands	192	29.38%	46.91%	23.71%
Central Highlands	310	57.74%	27.10%	15.16%
Percent for all Zones		46.24%	38.42%	15.33%
Total number of Parcels	1636	757	629	251
Computed χ^2 *=163.09 Critical value of* χ^2 *= 15.51*				

Source: Author's Analysis

4.1.2 Size of Land Cultivated across Tenure Systems and Agro Ecological Zones

The average land cultivated by smallholder farms in the sampled households in the 2006/07 crop year was 2.76 acres (Table 4-12). This is consistent with findings of Kinyua (2004) that smallholder farms are between two and three acres per household. The average cultivated land that was held with title was found to be 3.4 acres, land with no titles averaged 2.51 acres while rented land had an average of 1.35 acres. High Potential maize zone had the largest cultivated land sizes with an average of 3.64 acres (Table 4-12). In this zone, the average land owned with title was 4.67 acres while rented land had an average of 1.92 acres. Western and Central Highlands had the lowest acreage with an average of 1.47 and 1.57 acres respectively. In the High Potential maize zones, some households had relatively larger pieces of land while other households had smaller land sizes. This can be deduced from the high coefficient of variation in land owned in the zone. Western and Central Highlands had a lower coefficient of variation in acreage cultivated (0.69 and 0.94 respectively). This finding augments the results of the 1999 Kenya household census which observed that Central Highlands and Western Highlands have the highest population density in rural areas (Kenya Government, 2006).

The difference in land sizes across the five agro ecological zones was tested using the Tukey Honestly Significant Difference (HSD) pairwise comparison test which is an extension of the one way anova and is used when there are three or more conditions and the analyst need to test for significant differences between specific pairs of means (taken just two at a time). For example, we can compare the average acreage between each two zones at a time. This test is conducted because specific contrasts are predicted by theory (Mallows and Tukey, 1982).

A pairwise comparison test showed that the size of cultivated land in Eastern and Coastal zone was not significantly different from that in High Potential maize zone (appendix 2). However the land size cultivated in Eastern and Coastal zone was significantly larger than that cultivated in Western Lowlands, Western Highlands and Central Highlands. Land cultivated in High Potential maize zone was significantly larger than land cultivated in Western Lowlands, Western Highlands and Central Highlands zones. However Land cultivated in Western Lowlands was not significantly different from that cultivated in Western Highlands and Central Highlands. There was also no significant difference in the size of land cultivated in Western Highlands and Central Highlands. This confirms that farmers in the different zones included in this survey cultivated varying sizes of land.

A pairwise comparison test was also used to establish the relationship between the sizes of land cultivated under different tenure systems in each agro ecological zone (Appendix 3). In Eastern and Coastal Lowlands there was no significant difference in the sizes of land cultivated with title, without title and rented. Among cultivated parcels of land in High Potential maize zone, the size of land cultivated that was owned with title was significantly larger than that owned without title or rented. Land cultivated in Western Lowlands zone that was owned with title was significantly larger than the land that was rented. A similar scenario is noted in Western Highlands and Central Highlands zones. This shows that there are differences in the land tenure systems in the different agro ecological zones.

Table 4-12: Average Land Size (Acres) in Different Land Tenure Systems across Agro Ecological Zones in the 2006/07 Crop year

Agro ecological zone	Land Owned with title deed	Land Owned without title deed	Rented land	Total for all tenure systems
Eastern and Coastal Lowlands	3.44	3.54	1.90	3.44 (0.95)
High Potential maize zone	4.67	2.82	1.92	3.64 (1.31)
Western Lowlands	2.12	1.96	1.00	1.89 (0.94)
Western Highlands	1.84	1.61	0.74	1.47 (0.69)
Central Highlands	2.05	1.11	0.56	1.57 (0.94)
Total for all Zones	3.43 (1.35)	2.51 (0.98)	1.35 (1.12)	2.76 (3.63)

Note: coefficients of variation are presented in parenthesis (std deviation/mean)

Source: Author's Analysis

4.1.3 Land Tenure and Gender of Household Head

The average size of land parcel cultivated by male-headed and female-headed households in the 2006/07 crop year is shown in Table 4-13. Male-headed households cultivated larger parcels of land than female-headed households. The average land cultivated for male headed households was 2.89 acres while that of female headed households was 2.27 acres. Male headed households rented more land for cultivation than female-headed households. This finding concurs with Deininger *et al.* (2003) whose results found that male-headed households are more likely to rent in land while female headed ones are more likely to rent out. A t-statistic test at 95 percent confidence level showed that there was significant difference between the total land cultivated by male and female headed households.

In order to understand the influence of gender on tenure status, a t-test was conducted separately for the three tenure system categories (land owned with title, land owned without title and rented land). For each tenure system, a t-test was conducted to compare the average size of land cultivated by male headed household against that cultivated by the female headed households. The study found there to be a significant difference in land owned with title between male headed and female headed households. The finding confirmed that male headed households cultivated more land than female headed households. There was no significant difference in land owned without title between male and female headed households. Male headed and female headed households cultivated almost the same size of land owned without title. Rented land cultivated by male headed households was significantly larger than that cultivated by female headed households as shown by the t-statistic test.

Table 4-13: Average Cultivated parcels of land Across Tenure Systems of Parcel and Gender of Household Head (Acres) in the 2006/07 Crop year

Tenure	Male-headed households	Female-headed households	Computed t value
Owned with title deed	3.78	2.37	*-3.95*
Owned without title deed	2.50	2.53	*0.10*
Rented	1.42	0.94	*-1.86*
All tenure systems	2.89	2.27	*-2.98*
Critical value of t at (0.05) ± 1.96			

Source: Author's Analysis

4.1.4 Land Tenure and Education Level of Household Head

The different categories of education attained by household head and the sizes of land cultivated by the household in the 2006/07 crop year are shown in Table 4-14. Households headed by persons with more years of formal education cultivated significantly more land than those headed by persons with less years of formal education. Household headed by persons with post secondary education cultivated significantly more land owned with title than those with less education. The average acreage for land owned with title for household headed by persons with post secondary education was 5.87 acres. The study found there to be a significant difference in the sizes of land owned in different tenure systems for households headed by person who have attained primary level of education or more. However there was no significant difference between the land sizes in the three tenure systems for households headed by persons with no formal education. Farmers with more education are more likely to have alternative sources of funds to purchase or hire more land for use in crop production. These results are in concurrence with findings of Bogale *et al.*, (2006).

Table 4-14: Average Acres Cultivated by Households headed by Persons of Different Education Level across different Tenure systems in the 2006/07 Crop Year

Education level of Head	Owned with title deed	Owned without title deed	Rented
No formal education	3.21	2.63	1.87
Primary level	2.96	2.44	1.16
Secondary level	4.18	2.63	1.33
Post secondary	5.87	2.22	1.75

Source: Author's Analysis

The study compared the sizes of land cultivated by households headed by persons of varying levels of formal education across the five agro ecological zones and the results are presented in Table 4-15. There was no significant difference in the land cultivated by households headed by persons with different education levels. In High Potential maize zone and Western Lowlands however, the differences were significant but indicated that households headed by persons with primary education had cultivated the least land in the 2006/07 crop year.

Table 4-15: Average area of land (in acres) per Household based on Years of Formal Education of Household Head and Agro Ecological Zone for 2006/07 crop year.

Agro Ecological Zones	No formal education	Primary level	Secondary level	Post secondary
Eastern and Coastal Lowlands	3.05	3.84	3.07	2.77
High Potential maize zone	3.89	3.06	4.01	4.91
Western Lowlands	1.55	1.78	3.01	1.90
Western Highlands	1.54	1.35	1.68	1.69
Central Highlands	1.44	1.60	1.41	2.00
Total	2.85	2.49	3.04	3.80

Source: Author's Analysis

4.1.5 Land tenure and Age of Household Head across the Agro Ecological Zones

Age of the household head is usually used as a proxy for experience. The age of household head and the acreage of land that was cultivated by the household in the 2006/07 year are shown in Table 4-16. The age categories were derived to enhance comparison (Young farmers aged 20 to 45 years, middle age farmers aged 45 to 65 years and older farmers aged above 65 years). Such categorization has been used by various scholars among them Unruh Jon. 2001. Households whose heads were more than 65 years of age had an average of 3.33 acres of land under cultivation.

In Eastern Lowlands and High Potential maize zones, the average cultivated land by households headed by persons above 65 years of age was 4.0 and 4.6 acres respectively. This was much higher than for the other zones in the sample. Household heads older than 65 years had significantly more land held with title than younger household heads. The average acreage cultivated that was held with title for heads aged above 65 years was 3.9 acres. Households headed by older persons rented more land than those headed by younger persons. This indicates that older farmers are more established than younger farmers. They own most of the titled land also rented more land. The average land rented by households headed by persons above 65 years was significantly higher than that of heads aged between 45 and 65 with an average of 2.0 acres and 1.1 acres respectively.

Table 4-16: Average land Cultivated across households Headed by Persons of Different Age categories in the 2006/07 crop year

Agro ecological zone	Household Head aged 20-45 years	Household Head aged 45-65 years old	Household head over 65 years old
Eastern and Coastal Lowlands	3.31	3.21	4.03
High Potential Maize Zone	3.11	3.33	4.58
Western Lowlands	1.60	1.94	1.92
Western Highlands	1.31	1.47	1.69
Central Highlands	1.29	1.40	1.96
Land Tenure Systems			
Owned with title deed	3.22	3.11	3.91
Owned without title deed	2.57	2.47	2.54
Rented	1.41	1.13	2.03
Total	**2.53**	**2.52**	**3.33**

Source: Author's Analysis

4.1.6 Membership to Farmer Groups across Land Tenure and Agro ecological zones

Membership to both producer and marketing groups was wide spread in the study area with 76 percent of households having at least one household member participating in group activities as shown on Table 4-17. In the Central Highlands, 95 percent of the households were participating in producer groups. The main purpose of these groups is to help farmers learn from each other and also synergy their resources. Most of these groups were informal taking such forms as rotating credit and saving societies (ROSCAS), women groups, youth groups and farmers groups. Formal groups included cooperative societies and savings and credit societies (SACCOS). A Chi square test confirmed that there was an association between households participating in groups and those who were not participating in group activities in all the agro ecological zones.

Table 4-17: Percentage of Households Participating in Farmer Group Activities across Land Tenure systems and Agro Ecological Zones

Agro Ecological Zone	Land tenure	Total Number of Plots	Group members	Non members
Eastern and Coastal Lowlands	Owned with title deed	64	75.0	25.0
	Owned without title deed	169	70.4	29.6
	Rented	11	63.6	36.4
High Potential Maize Zone	Owned with title deed	366	68.9	31.1
	Owned without title deed	212	56.1	43.9
	Rented	120	70.0	30.0
Western Lowlands	Owned with title deed	91	79.1	20.9
	Owned without title deed	73	79.5	20.5
	Rented	28	78.6	21.4
Western Highlands	Owned with title deed	57	91.2	8.8
	Owned without title deed	91	84.6	15.4
	Rented	46	93.5	6.5
Central Highlands	Owned with title deed	179	95.5	4.5
	Owned without title deed	84	95.2	4.8
	Rented	47	95.7	4.3
Total	Owned with title deed	757	78.6	21.4
	Owned without title deed	629	72.0	28.0
	Rented	252	79.8	20.2
	Total sample	1638	76.3	23.7

Source: Author's Analysis

4.1.7 Credit Access across Land Tenure and Agro ecological zones

Credit access for was below 50 percent in the entire sample. However, Central Highlands had the highest credit access rate for households who owned land with title, land owned without title and rented land with 73 percent, 83 percent and 79 percent respectively, as shown on Table 4-18. The high credit access rate could be associated with several factors. First the existence of various sources of credit would enable the borrower to access credit. Availability of collateral could also explain the high level of credit access. The ability of the zone to produce high value crops such as tea, horticultural crops and dairy farming would encourage lenders into the Central Highlands zone. Contrary to the situation in Central Highlands, credit was relatively less accessible in Western Lowlands.

The percentage of households accessing credit in the zone was 28 percent. The possible reason for inaccessibility of credit in this zone would include poor infrastructure which discourages investment and poor climatic conditions which make the returns to land to be low. There was an association between the numbers of households accessing credit in different agro ecological zones and also across the tenure systems. This implies that land tenure status does not increase the probability that a farmer will get credit. This finding was similar to what Barrow and Roth, 1990; Migot-Adholla *et al*, 1991; and Shipton, 1994 observed that in Africa, land titling does not appear to increase access to formal credit and even where farmers hold land titles, they are reluctant to mortgage their land.

Table 4-18: Percentage of Household Accessing Credit in the 2006/07 crop year

Agro Ecological Zone	Land Tenure	Total Number of Plots	Percent accessing credit	Percent not accessing credit
Eastern and Coastal Lowlands	Owned with title deed	64	35.9	64.1
	Owned without title deed	169	36.7	63.3
	Rented	11	45.5	54.5
High Potential Maize Zone	Owned with title deed	366	34.2	65.8
	Owned without title deed	212	35.4	64.6
	Rented	120	40.8	59.2
Western Lowlands	Owned with title deed	91	27.5	72.5
	Owned without title deed	73	31.5	68.5
	Rented	28	21.4	78.6
Western Highlands	Owned with title deed	57	56.1	43.9
	Owned without title deed	91	56.0	44.0
	Rented	46	71.7	28.3
Central Highlands	Owned with title deed	174	73.2	26.8
	Owned without title deed	84	83.3	16.7
	Rented	47	78.7	21.3
Total	Owned with title deed	757	44.4	55.6
	Owned without title deed	629	44.7	55.3
	Rented	252	51.6	48.4
	Total for entire sample	1638	45.6	54.4

Source: Author's Analysis

4.2 Technical Efficiency of Alternative Tenure Systems across different Agro Ecological Zones

This section presents the results of the technical efficiency estimation and also compares technical efficiency across tenure systems and agro ecological zones. The section also compares technical efficiency against other social economic characteristics such as gender, education and credit availability.

4.2.1 Variables used in the Stochastic Frontier Model Estimation

This section of the study further sought to establish whether there exist any differences in the levels of technical efficiency (TE) among the different tenure systems using stochastic frontier model (equation 4-4). The first step was to estimate the technical efficiency levels using a set of inputs used by smallholder farmers. After the TE levels have been estimated, the relationship between TE and land tenure was established. The estimated TE scores are presented in subsequent subsections of this section. The TE model estimated in this study was derived from several farm variables; acres of cultivated land, value of manure usage per acre, value of inorganic fertilizer usage per acre, land preparation man days per acre, cost of seeds per acre and a dummy variable for irrigation (Table 4-19).

The land cultivated in the sample was between 0.02 and 37 acres, with an average of 2.76 acres in the 2006/07 crop year. Households spent an average of Ksh. 3,186 per acre on manure. On average, Ksh 1,889 was spent on of inorganic fertilizers was used per acre. The recommended fertilizer application rate varies depending on the agro ecological zones (Delve and Ramisch, 2006). However, farmers in High Potential Maize zones such as Uasin Gishu and Trans Nzoia districts have been noted to use 50 kg per acre of basal fertilizer and 50 kg per acre of top dressing fertilizer on their maize-beans enterprise in the 2006/07 cropping season, 100 Kgs would cost, approximately, Ksh. 3,000.

Table 4-19: Variables used in the Estimation of Technical Efficiency using a Stochastic Frontier Model

Variable	description	Minimum	Maximum	Mean
lnacres	Area of land for all crops (acres)	0.02	37	2.76
lvmanure	Cost of Manure used (Ksh/ acre)	0	35,000	3,186
vfert	Cost of Inorganic fertilizer used (Ksh/ acre)	0	15,658	1,890
lpacre	Land preparation (Man days/ acre)	11	73	7
sdacre	Cost Planting seed (Ksh/ acre)	0	13,050	990
Irrigation	Percentage of Parcels that were irrigated			2.1

Source: Author's Analysis

Smallholder farmers even in the High Potential maize zone were using far much less of inorganic fertilizers than the optimum level (on average 30 kgs of fertilizer per acre). Average number of man days spent on land preparation was seven. The cost of the planting seed averaged Ksh 13,000 per acre. The average seed rate for maize in High Potential maize zone is 10 kg/acre. The price of hybrid maize in the 2006/07 crop year was averaging Ksh 140 per kg. Therefore the cost of maize seed to plant one acre was Ksh 1,400.

4.2.2 Technical Efficiency Estimation

Technical efficiency levels for each parcel of land were predicted using the model presented in Equation 4.4 and the results of the model are presented in Table 4-20. The model had good explanatory powers with a highly significant log likelihood ratio test ($\rho < 0.001$) indicating that inefficiency existed. All the independent variables except land preparation cost and seed cost were highly significant at ($\rho < 0.001$). The model had a wald χ^2 (chi square) of 2609.94, therefore the analysis rejected the hypothesis that all the covariates were jointly zero.

The coefficients of the independent variables represent the elasticities of production. For example, the positive and significant coefficient of cultivated land indicates that if land area is increased by one unit the output would increase by 0.769 *ceteris paribus* while irrigating land would increase its output by 0.427. The returns to scale (RTS) value, 1.224, obtained from the summation of the coefficients of the estimated parameters (elasticities) indicate that farms in the study area were in stage I of the production frontier. Stage I of production is characterized by increasing returns to variable inputs of production. The implication of this is that an increase in the variable inputs at the same ratio would increase the total production of the farm *ceteris paribus*. Farmers therefore have the potential of increasing their output from the current level if they would access more resources such as fertilizer and manure.

Table 4-20: Results of the Stochastic Frontier Model for Sample of Smallholder Crop Farmers in Kenya for the 2006/07 Crop Year

Variable	Variable Description	Coefficient
Dependant variable (lnvprod)	Log of the total value (Ksh.) of crop produced by the farm)	
N	Number of observations	1638
_cons	Constant	10.57***
lnacres	Natural log of total cultivated land (acres)	0.77***
lnvman	Natural log of cost of manure used (Ksh per acre)	0.01***
lnvfert	Natural log of the cost of fertilizer used (Ksh per acre)	0.02***
lnlpmd	Natural log of man days in land preparation (man days/acre)	-0.00
lnsdcost	Natural log of cost of seed used (Ksh per acre)	0.00
Irrigation	Dummy variable for irrigation	0.43***
RTS	Returns to Scale (sum of coefficients)	1.22
sigma_v	Variance from other factors	0.63
sigma_u	Variance from inefficiency	0.67
Sigma^2$(\sigma_u^2+\sigma_v^2)$		0.84
Gamma (σ_u^2/σ^2)	Source of inefficiency	1.06
Wald χ^2 (8)		2609.94

Likelihood-ratio test $\bar{\chi}^2$ =9.6***

*** significant at 1 percent

Source: Author's analysis

The Kenya vision 2030 observes that smallholder farmers utilize only 60 percent of their available land and therefore have potential of increasing their production levels (Kenya, Government, 2007). The highly significant sigma_v value of 0.63 indicates that technical inefficiency exists in crop production in the sampled areas. The gamma ratio (σ_u^2 / σ^2) indicates ratio of inefficiency to total residual variance. If the gamma ratio value is greater than one, the technical inefficiency effect dominates the random error and therefore most of the observed difference in farm performance is due to inefficiency effect. The total error variance sigma^2 ($\sigma_u^2 + \sigma_v^2$) = 0.84 which implied that 84 percent of the differences between the observed and the maximum possible production for smallholder crop production households is due to existing differences in the technical efficiency levels among the households.

The technical efficiency levels were found to range from 0.118 to 0.861 with an average of 0.632. The implication is that if an average parcel of land is to achieve the efficiency of the most efficient farmer, then the average farmer could realize up to 27 percent[1] more output from the same resources. A similar calculation of the most technically inefficient parcel of land reveals an output potential increase of up to 86 percent. This finding reveals that there is potential of increasing technical efficiency levels in the sampled areas.

Similar studies have given varying results on technical efficiency on crop farms. Amaza and Maurice (2005) found the technical efficiency of rice farms in Nigeria to be 0.8. Kolawole and Ojo (2007) found that the average technical efficiency of crop farms in Nigeria was 0.87. The study observed a higher level of technical efficiency than the current study. Bravo-Ureta

[1] $\left(1-\frac{0.632}{0.802}\right)*100$

et al, 1997) found that whole farm technical efficiency in the Dominican Republic was 0.60, a level that was similar to that observed in this study. The technical efficiency of specific crop reported by other studies were relatively low, for instance, Ali *et al.* (1994) estimated technical efficiency for rice production in Pakistan as 0.24. The differences in the technical efficiency in different countries could be attributed to different climatic conditions. Moreover, the studies have been done at different times and therefore the efficiency levels would have been varying.

4.2.3 Technical Efficiency across Tenure systems and Agro Ecological Zones

Central Highlands zone had the highest level of technical efficiency level with average of 0.694 (Table 4-21). An average land parcel in Central Highlands had the potential of producing 25 percent[2] more output given the same set of inputs if it would have to be as efficient as the most efficient farm in that zone. In the High Potential Maize zone, Western Highlands and Central Highlands there was a significant relationship between tenure and efficiency (Table 4-21). These three zones are the main food producing areas in the country and they also produce cash crops such as tea and coffee. The most inefficient region was the Eastern and Coastal Lowlands with an efficiency level of 0.604, implying that an average farm in this region would have to produce 26 percent more output if it has to be as efficient as the most efficient farm. Among land parcels that were held with own titles, Central Highlands was the most efficient with an average efficiency level of 0.709. Most farmers in this zone were smallholders producing high value crops on the titled land and this may explain the higher technical efficiency level.

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[2] $\left(1-\frac{0.631}{0.841}\right)*100$

In order to confirm whether significant difference exists across all the agro ecological zones and land tenure systems, a pairwise comparison test was used and results presented in Appendix 4. The Technical efficiency of land owned with title in Eastern and Coastal Lowlands was significantly lower than in Western Lowlands, Western Highlands and Central Highlands. The technical efficiency level of cultivated land owned without title in Eastern and Coastal Lowlands zone was significantly lower than in Central Highlands. Eastern and Coastal Lowlands zone faces the challenge of unreliable rainfall and in addition, the varieties of crops such as maize that are grown in these areas are less productive than those grown in Western Highlands and Central Highlands zones. The land sizes in these AEZ are larger than those in Western Highlands and Central Highlands zones. The intensity of use of the land in terms of seed rate, fertilizer and manure application was lower.

Table 4-21: Technical Efficiency of Land Parcels Cultivated in the 2006/07 crop year for different Agro Ecological Zones and Tenure System

Agro-Ecological zones	Land owned with title	Land owned without title	Rented land	Average for all tenure	Minimum for zone	Maximum for zone
Eastern and Coastal Lowlands	0.595	0.609	0.572	0.604	0.240	0.811
High Potential maize	0.617	0.625	0.602	0.617	0.110	0.861
Western Lowlands	0.639	0.628	0.634	0.634	0.324	0.862
Western Highlands	0.665	0.626	0.554	0.620	0.387	0.816
Central Highlands	0.709	0.702	0.625	0.694	0.116	0.841
All zones	0.653	0.632	0.600	0.631	0.110	0.862

Source: Author's Analysis

Note: Detailed pairwise comparison statistical tests are presented on Appendix 2

A comparison of High Potential maize zone with other zones showed that the technical efficiency level of land owned with title in the AEZ was significantly lower than that of the Western Highlands and Central Highlands zone. Central Highlands had a significantly higher efficiency level than High Potential maize zone for parcels of land owned without title. Though land parcel in High Potential maize zone are larger than those in Central Highlands and Western Highlands zones, the intensity of use of land in High Potential maize zone was lower than in the highlands.

Rented land in Western Lowlands is significantly more efficient than rented land in other zones. This can be associated with the growing of sugarcane in rented land in the Western Lowlands zone. Sugarcane is an important cash crop in the area and the intensity of use of the rented land is higher. Parcels of land owned with or without title in Western Lowlands are significantly less efficient than those in Central Highlands zone. Land owned with title, without title or rented Central Highlands is significantly more efficient than in Western Highlands. Higher efficiency level in Central Highlands can be explained by several factors; the high and reliable rainfall experienced in the zone, the proximity to major market centers, especially Nairobi, which encourages the farmers to grow high value crops, and the fairly well developed road network which allows easy marketing of agricultural commodities. Land that was owned with title was found to be more technically efficient than that owned without titles or rented (appendix 4). These results show that there is a variation in technical efficiency across both land tenure systems and agro ecological zones. These findings concur with those of Pender *et al*., (2004); Deininger and Jin (2006) who found a strong relationship between tenure security and technical efficiency.

4.2.4 Technical Efficiency and Size (acres) of Parcels

In order to evaluate the relationship between technical efficiency and the size of land parcels cultivated, the parcels in each agro ecological zone were grouped into quartiles. The average land size for each quartile is presented in Table 4-22. The first quartile in each zone gave the average size of lower 25 percent of the parcels while the fourth quartile represented the upper 25 percent of the parcels. Grouping the parcels into quartiles was preferred because it would give a good indication of the effect of tenure and land size on technical efficiency. Mpyisi *et al* (2003) also used land quartiles to categorize land sizes in a productivity study in Rwanda.

Technical efficiency level for land quartiles is presented in Table 4-22. A pairwise comparison test was conducted and the results presented on appendix 5. In Eastern and Coastal Lowlands, there was no significant difference in technical efficiency level in all the land quartiles. In the High Potential zone, land owned with title was found to have significantly higher technical efficiency than land owned without title for the highest land quartile. The average efficiency level for land owned with title for the highest land quartile was 0.658 while the technical efficiency of land owned without title in the zone was 0.619. Land size and land tenure do not significantly influence technical efficiency in the Western Lowlands. In most of Western Lowlands, land parcels are not titled therefore traditional systems prevail and the few parcels that have titles are not associated with higher technical efficiency. In the Western Highlands zone, the technical efficiency of land parcels owned with title in the third and forth quartile was significantly higher than that of land owned without title and land that is rented.

Table 4-22: Average Technical Efficiency of Parcels under different Tenure systems categorized by Land size Quartiles across the Agro Ecological Zones

Agro Ecological Zone	Land Tenure System	Lowest Land Quartile	2	3	Highest land Quartile
	Average cultivated land per quartile	**0.975**	**2.017**	**3.170**	**7.659**
Eastern and Coastal Lowlands	Owned with title deed	0.601	0.566	0.623	0.592
	Owned without title deed	0.637	0.608	0.610	0.581
	Rented	0.532	0.628	0.717	0.501
	Total	0.618	0.599	0.615	0.583
	Average cultivated land per quartile	**0.711**	**1.702**	**3.183**	**8.715**
High Potential Maize Zone	Owned with title deed	0.610	0.612	0.630	0.658
	Owned without title deed	0.608	0.625	0.616	0.619
	Rented	0.583	0.612	0.623	0.640
	Total	0.608	0.617	0.614	0.628
	Average cultivated land per quartile	**0.598**	**1.187**	**1.889**	**3.814**
Western Lowlands	Owned with title deed	0.628	0.630	0.640	0.652

Agro Ecological Zone	Land Tenure System	Lowest Land Quartile	2	3	Highest land Quartile
	Owned without title deed	0.653	0.632	0.625	0.612
	Rented	0.610	0.670	0.523	0.708
	Total	0.628	0.638	0.627	0.640
	Average cultivated land per quartile	**0.438**	**0.929**	**1.641**	**2.891**
Western Highlands	Owned with title deed	0.591	0.652	0.666	0.708
	Owned without title deed	0.624	0.615	0.624	0.641
	Rented	0.544	0.595	0.526	0.523
	Total	0.569	0.617	0.632	0.663
	Average cultivated land per quartile	**0.314**	**0.816**	**1.607**	**3.550**
Central Highlands	Owned with title deed	0.689	0.694	0.701	0.731
	Owned without title deed	0.683	0.691	0.732	0.710
	Rented	0.611	0.669	0.598	0.754
	Total	0.653	0.690	0.705	0.729

Source: Author's Analysis

In Central Highlands zone, land parcels owned with title in the lowest and third lowest quartile was more technically efficient than rented land. In the Central Highlands and Western Highlands zones, the larger land parcels were more efficient than small parcels. The implication is that though land title is not a very important aspect in increasing technical efficiency in some agro ecological zones, the size of land significantly influences the level of technical efficiency in the high potential zones. From the result presented on this study, it is clear that very small pieces of land are less technically efficient than larger pieces of land. Sub division of the smallholder farms would lead to technical inefficiency.

4.2.5 Technical Efficiency by Gender of Household Head

Most women headed households in the sample were as a result of the death of the spouse. This study recognizes that in some cultures, the death or migration of the man head of household does not automatically imply that the wife takes over as the head of the household. This aspect was not captured in this study. It was assumed that it the male head is absent, the wife would take over as head of the household.

The average technical efficiency for man-headed and woman-headed households was 0.636 and 0.626, respectively as shown on Table 4-23. However, the difference in TE between male-headed and female-headed was not significantly different. Other studies analyzing the relationship between farm performance and gender of household head have shown different results. Yamano and Jayne (2004), observed that the death of a working-age male household head reduces the land allocated to high value crops and results in a large reduction in per capita household crop value production. Adesina and Djato, (1996) observed that relative degree of economic efficiency of women rice farmers in Cote d' Ivoire is similar to that of men farmers. However, while women farmers are efficient in allocating resources, they lack basic resources such as capital.

Table 4-23: Average Technical Efficiency for Parcel of land Cultivated by Male and Female headed Households across different Land Tenure systems

Land tenure	Land with title deed	Land without title deed	Rented land	All tenure
Male Headed Household	0.645	0.633	0.601	0.638
Female Headed Households	0.636	0.628	0.591	0.628
Computed t statistic	-0.295	-0.673	-0.618	-0.753

Note: Critical value of t (0.05) ± 1.96

Source: Author's Analysis

4.2.6 Relationship between Technical Efficiency and level of Education of Household Head

Parcels of land owned by households headed by persons with no formal education had the lowest efficiency level, with an average technical efficiency level of 0.615 while those headed by persons with post secondary education had the highest technical efficiency level, with an average of 0.651 as shown in table 4-24.

An assessment of the relationship between education status of the household head and the land tenure status was conducted separately for each tenure systems and each pair of education categories (Appendix 5). Parcels held with title and at the same time managed by households whose heads had either primary or secondary education were significantly more technically efficient than those parcels owned with title and managed by household heads with no formal education. Rented land that was managed by persons with formal education was more technically efficient than that managed by persons with no formal education.

Table 4-24: Average Technical Efficiency for Land Parcels Cultivated by Households headed by persons of different Education Level across different Tenure categories

Education level	Land with title	Land without title	Rented land	Average for all tenure systems
No formal education	0.622	0.617	0.582	0.615
Primary level	0.646	0.633	0.600	0.634
Secondary level	0.655	0.634	0.591	0.635
Post secondary	0.653	0.640	0.668	0.651

Source: Author's Analysis

The implication is that formal education has a positive correlation with technical efficiency and should therefore be promoted. In order to compare the effect of formal education across different zones and across the three tenure systems, a pairwise comparison test was conducted. In High Potential maize zone and Central Highlands, parcels of land with titles and at the same time managed by household heads who had secondary education had a significantly higher technical efficiency than that of parcels owned by households whose head do not have formal education. Though this is not replicated in the other three zones, it gives an indication that formal education has some influence in increasing technical efficiency.

The findings of this study are consistent with those of Amaza and Maurice, (2005) who observed that farmers with more years of formal schooling tend to be more efficient in rice production, presumably due to their enhanced ability to acquire technical skills, which makes them move close to the frontier output. This finding are also in line with Battese *et al* (1996), Coelli and Battese (1996) and Seyoum *et al* (1998) who found that it is very plausible that the farmers with education respond readily to the use of improved technology, such as the application of fertilizers, use of pesticides and other inputs and thus producing more efficiently. However, Asadullah and Rahman (2005) observed that education levels beyond secondary school did not influence inefficiencies in rice production in rural Bangladesh. The main reason for this was that tertiary education had a tendency of changing the emphasis of farmers from rice production to other non-farm activities and this resulted in lower efficiency.

4.2.7 Technical Efficiency and Access to Credit

The study further evaluated the linkage between credit access and technical efficiency across the tenure systems and across the five agro ecological zones. The credit that was considered in this study was the one received either in cash or in-kind. The relationship between credit use and technical efficiency is shown in Table 4-25. Households accessing credit had a higher technical efficiency level than those not accessing credit in High Potential maize zone and Central Highlands as shown by the significant t statistic. In the Western Lowlands, parcels that have land titles and at the same time owned by households receiving credit appeared to be more inefficient than those not receiving credit. This could be associated with misuse of credit or usage of credit for the unintended purpose. The entire sample average technical efficiency for households accessing credit was 0.653 while the average efficiency for those not accessing credit was 0.615.

Households who had access to credit and at the same time had titles for their land had an average technical efficiency of 0.669. Parcels held without title by households who accessed credit were also more efficient that those parcels where credit was not accessed. Bravo-Ureta *et al*, (1997) also found that cotton and cassava farmers who had access to credit had a higher efficiency level than those not accessing credit.

Table 4-25: Average Technical Efficiency of Land Parcels Categorized by Credit Access and Land Tenure Status across the Agro Ecological Zones in the 2006/07 crop year

Agro Ecological Zone	Credit access	Land with title deed	land without title deed	Rented land	Average for all Tenure systems
Eastern and Coastal Lowlands	With Credit	0.602	0.617	0.648	0.615
	Without Credit	0.591	0.605	0.509	0.597
	t value	*-0.331*	*-0.784*	*-1.942*	*-1.228*
High Potential maize	With Credit	0.658	0.627	0.603	0.632
	Without Credit	0.611	0.608	0.601	0.609
	t value	*-1.310*	*-2.753**	*-0.110*	*-2.436**
Western Lowlands	With Credit	0.608	0.620	0.630	0.616
	Without Credit	0.650	0.631	0.635	0.641
	t value	*2.153**	*0.527*	*0.091*	*1.767*
Western Highlands	With Credit	0.671	0.639	0.555	0.624
	Without Credit	0.656	0.610	0.551	0.615
	t value	*-0.688*	*-1.827*	*-0.140*	*-0.677*
Central Highlands	With Credit	0.732	0.719	0.624	0.711
	Without Credit	0.646	0.622	0.628	0.639
	t value	*-5.958**	*-4.222**	*0.070*	*-5.549**
Total	With Credit	0.669	0.657	0.600	0.653
	Without Credit	0.622	0.611	0.599	0.615
	t value	*-5.850**	*-5.521**	*-0.037*	*-6.888**

Critical value of t (0.05) = ±1.96

Source: Author's Analysis

4.2.8 Relationship between Technical Efficiency and Membership to Producer Groups

The groups that were considered included cooperative societies, rotating savings and credit associations (ROSCA), women groups and other informal (Table 4-26). In Eastern and Coastal Lowlands, parcels that were rented and owned by households who were members of producer groups were significantly more technically efficient than those renting land but were not members of producer groups. In Western and Central Highlands, households that owned land with title and were members of producer groups were more technically efficient. Western and Central Highlands zones have active producer groups especially in tea and coffee growing regions. Farmers with titles to their land parcels and at the same time members of producer group are able to apply the skills that they learn from the group and also feel secure to apply them on their land. These skills may include, use of inputs and soil conservation which would lead to land owned with title being more efficient. An assessment of the entire sample shows that households with at least one person being a member of a producer group had higher technical efficiency score averaging 0.638. Households with no member participating in group activities had an average efficiency of 0.613. The efficiency level of households with at least one person participating in group activities was higher *(Computed $t=-3.77$, Critical value of $t=.\pm 1.96$).* Further tests of significance revealed that in both land owned with title and land owned without title, membership to producer groups had a positive effect on technical efficiency.

Idiong, (2007) also observed a positive relationship between group membership and technical efficiency. This finding is also in line with the observation of Chukwuji *et al*, 2007, who observed that members of cooperative societies were able to adopt better techniques of production than non–members because of the greater awareness created and encouragement given to their members. Binam *et al*, 2004 also found that social capital which may be in form of group participation is essential in providing incentives for efficient production, sharing of information on farming practices at group level tends to have a spillover effect to other members of the households that were not members. Furthermore, membership to groups provides farmers with secure markets for their crops as well as technical assistance which would be a source of technical efficiency.

Table 4-26: Average Technical Efficiency level categorized by Membership to Groups, Land tenure system and Agro ecological zone

Agro- ecological zone	Group membership	Land with title deed	Land without title deed	Rented	Average for all Tenure systems
Eastern and Coastal Lowlands	Group members	0.583	0.607	0.648	0.602
	Non-Group members	0.630	0.614	0.440	0.608
	t-value	*1.299*	*0.434*	***-3.852****	*0.382*
High Potential maize	Group members	0.622	0.631	0.597	0.620
	Non-Group members	0.607	0.618	0.612	0.612
	t-value	*-1.148*	*-0.769*	*0.580*	*-0.820*
Western Lowlands	Group members	0.641	0.626	0.643	0.635
	Non-Group members	0.630	0.636	0.602	0.628
	t-value	*-0.489*	*0.402*	*-0.773*	*-0.463*
Western Highlands	Group members	0.671	0.629	0.552	0.623
	Non-Group members	0.601	0.608	0.573	0.602
	t-value	***-1.975****	*-0.976*	*0.432*	*-1.051*
Central Highlands	Group members	0.712	0.705	0.622	0.697
	Non-Group members	0.634	0.641	0.681	0.643
	t-value	***-2.379****	*-1.466*	*0.630*	***-1.996****
Total	Group members	0.651	0.637	0.600	0.638
	Non-Group members	0.613	0.618	0.598	0.613
	t-value	***-3.873****	***-2.008****	*-0.122*	***-3.773****

Critical value of t at (0.05) is ±1.96

Source: Author's Analysis

4.3 Interaction of Land Tenure System and Social Characteristics in Determining Technical Efficiency across different Agro Ecological Zones

A Tobit regression model was used to evaluate the interaction between land tenure, demographic, economic, social and resource factors with technical efficiency of land parcels in each of the five agro ecological zones. The dependent variable in the model was technical efficiency scores estimated in Equation 3-5. Technical efficiency scores range between zero and therefore using a Tobit model would not have the risk of truncation bias. In order to confirm that there was no multicollinearity, a stepwise regression procedure was used and involved addition of one variable at a time to the equation and the variables that did not contribute much to the explained variance were dropped (Gujarati, 1999). Stata statistical package was used check and confirm that there was no hetroskedasticity.

The likelihood ratio test showed that all the explanatory variables in each of the five agro ecological zones taken together were significant in explaining the variation in technical efficiency in all the five agro ecological zones (Table 4-27). The base land parcel in the model was one that was owned without title, managed by a male household head, accessed credit and where at least one person was a member of a producer group. Larger parcels of land that were owned with title in Eastern Lowlands, Western Highlands and Central Highlands were more technically efficient than smaller parcels. Households with larger parcels and with land titles would be more willing to make more permanent investments on the land such as planting permanent crops or constructing soil conservation structures which would lead to a higher level of technical efficiency. Parcels of land that were owned with title by persons with higher education had a higher technical efficiency score. This indicates that possession of title would be more effective if the person managing the land is more educated.

When a parcel of land was owned with title and the household accessed credit, the technical efficiency score of the parcel increased in most of the zones. Land titling combined with access to credit would assist farmers increase their technical efficiency levels. The interaction of land owned with title with household size showed that in the High Potential maize zone, an increase in the household size increased the technical efficiency score for land owned with title. However, in the Central Highlands zone, where land was owned with title, an increase in the household size was associated with lower technical efficiency score. These differences seem to indicate that as land available per person decreases, gains in technical efficiency from land titling also decreases.

In situation where land was rented, an increase in the distance to the motorable road reduced the technical efficiency level in all the agro ecological zones. The possible reason for this is that when households rent land, they have the opportunity to identify specific sites that are well served by a motorable road. Igliori, 2005 noted that there was a significant relationship between technical efficiency and distance to motorable roads for farms in Brazil. Holden, *et al.*, (2002) also observed that proximity to both input and output markets had a positive effect on ethiopian farms.

Table 4-27: Interaction between Land Tenure and Social Characteristics in Determining Technical Efficiency using a Tobit Model

Variables included in the model	Eastern and Coastal Lowlands Zone	Western Lowlands Zone	High Potential Maize Zone	Western Highlands Zone	Central Highlands Zone
	LLR=45.5	*LLR=44.6*	*LLR=62.3*	*LLR=93.3*	*LLR[3]=95.5*
Constant	**0.57**	**0.68**	**0.58**	**0.54**	**0.59**
Non interacting characteristics					
Credit access (1=accessing credit, 0=otherwise)	0.02 [0.47]	**0.01 [1.84]***	**-0.04 [2.46]****	**0.01 [1.83]***	**0.08 [4.77]*****
Total land holdings owned in acres	0.00 [0.32]	0.00 [0.59]	**0.01 [5.01]*****	**0.01 [1.76]***	**0.02 [2.30]***
Interaction of tenure with demographic characteristics					
Land owned with title*household size	0.00 [0.86][4]	0.00 [0.52]	**0.01 [3.50]*****	-0.01 [0.60]	**-0.11 [2.75]*****
Rented land*household size	0.02 [0.95]	0.02 [0.38]	0.00 [0.48]	0.00 [0.55]	0.01 [0.73]
Land owned with title*education years of household head	**0.01 [2.27]****	0.00 [1.20]	**0.01 [1.78]***	**0.02 [2.20]****	**0.04 [1.83]***
Rented land*education years of household head	0.01 [1.39]	0.01 [1.34]	0.00 [1.30]	**0.00 [2.45]****	0.00 [0.01]
Owned with title * gender of household head	-0.03 [0.56]	0.07 [0.21]	0.02 [0.55]	-0.01 [0.62]	0.01 [0.40]
Rented land * gender of household head	**-0.11 [1.83]***	**0.04 [2.06]***	0.05 [1.44]	-0.03 [0.48]	0.02 [0.23]
Interaction of tenure with economic characteristics					
Land owned with title * credit access	0.00 [0.03]	**0.04 [1.91]***	**0.05 [2.10]****	**0.03 [1.97]***	**0.02 [2.51]****
Rented land*credit access	**0.11 [2.70]*****	-0.05 [0.67]	0.01 [0.35]	0.01 [0.32]	**-0.08 [1.94]***
Land owned with title*distance to motorable road	-0.09 [0.82]	0.01 [0.39]	0.01 [0.32]	**-0.01 [2.45]****	0.01 [1.08]
Rented land*distance to motorable road	**-0.10 [2.46]****	**-0.19 [1.78]***	**-0.03 [2.06]****	**-0.01 [2.39]***	**-0.06 [2.59]****
Land owned with title * member in producer groups	0.01 [0.17]	0.00 [0.09]	0.00 [1.24]	0.00 [0.04]	**0.01 [2.00]****
Rented land* member in producer group	**0.04 [1.85]***	0.00 [0.06]	0.00 [0.14]	-0.12 [0.74]	-0.03 [0.49]
Land owned with title*total land holding by household	**0.09 [1.78]***	-0.02 [0.29]	-0.04 [1.23]	**0.15 [1.77]***	**0.08 [1.78]***
Rented land*total land holding by household	0.01 [0.76]	0.01 [0.75]	0.00 [0.46]	0.01 [0.78]	0.00 [0.79]
Observations	244	191	687	190	309

Source: Author's Analysis

[3] Log likelihood ratios, Critical Value of Chi=42.6

[4] Figure in parenthesis is the t statistic, * Significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent

CHAPTER FIVE

5.0 SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

About 87 percent of the Kenyan population depends on agriculture which also forms 26 percent of the GDP. Smallholder farms holdings average 2.5 acres. Trends between 1990 and 2006 show a decline in food production in Kenya. The land resource has been overexploited as a result of population increase. Yields of major crops especially maize have declined. This trend necessitates an evaluation of the factors hindering technical efficiency in crop production. Land tenure and the resulting security of tenure is likely to be one of the limiting factors but empirical evidence to inform policy and practice is lacking. This study aimed at identifying the characteristics of smallholder farmers operating under different land tenure systems in Kenya, comparing their technical efficiency and evaluating how it is influenced by its interaction with important socioeconomic factors.

Technical efficiency estimation is based on the production theory. A sample of 1333 smallholder households distributed across 22 districts in five agro ecological zones collected by Tegemeo Institute of Egerton University in June 2007 was used. A stochastic frontier model was used to estimate technical efficiency. The model used the value of crops produced as the dependent variable and the independent variables were a set of inputs which included size of land cultivated, value of fertilizer use, value of manure use, cost of seed and cost of land preparation.

5.2 Conclusions and Recommendation

5.21 Characteristics of smallholder farmers operating under different tenure systems in Kenya

- Proportion of land owned with title varied across the different agro ecological zones. In Central Highlands and High Potential maize zones, a larger proportion of the land parcels had title deeds, confirming that the process of land titling had not been moving at the same pace in all regions of the country.
- Male headed households cultivated more land owned with title deed than female headed households suggesting that what it takes to own land with title deed varies by gender.
- Households headed by persons with secondary or post secondary education cultivated more land owned with title deed than households headed by persons with less education, confirming that education level has a relationship with the size of land available for cultivation.

5.22 Technical efficiency of smallholder farms operated under different tenure systems

- Land owned with title had the highest technical efficiency level while rented land had the lowest efficiency level. This confirmed that ownership of land with title had a positive effect on technical efficiency. Central Highlands zone had the highest technical efficiency level. It is therefore recommended that the process of land titling be extended to all regions of the country especially those with high agricultural potential because this would ensure tenure security and therefore lead to increased technical efficiency.

- In Central Highlands, Western Highlands and High Potential maize zones, larger parcels of land that were owned with title were more technically efficient in crop production than smaller sizes of land owned without title. Continued subdivision of land especially in the high potential areas of the country would have a negative effect on food production.

- Parcels of land owned by households headed by persons with no education had the lowest technical efficiency levels. Parcels that were owned with title by households headed by persons with post secondary education had the highest technical efficiency levels. The study recommends that the government should continue supporting education. Recent government policy on free primary and secondary education is a positive move towards improving the technical efficiency levels of farming households.

- Households accessing credit and who also had titles to their land had higher technical efficiency levels than those not accessing credit. This implied that provision of credit facilities to farmers would have a positive effect on their ability to produce more efficiently. Households participating in producer groups had a higher technical efficiency level than those not participating in group activities. The study recommends that farmers should be provided with affordable credit either through the AFC or other institutions in order to ensure that they manage to utilize farm inputs in the right proportions hence increasing their technical efficiency levels. Farmers should also be encouraged to participate in producer groups.

5.23 Interaction of Land Tenure System, Demographic, Economic and Social Characteristics of the Household with Technical Efficiency of Smallholder farms

- The interaction of land owned with title with higher levels of education was associated with higher levels of technical efficiency. This indicates that in as much as it is important to provide titles to farming households, education would still play an important role in ensuring that smallholder farms are more technically efficient.
- When parcels of land were owned with title by households that were accessing credit, the technical efficiency score was higher. This indicates that in addition to possession of land titles, households would also need credit in order to increase their technical efficiency levels. It is therefore necessary to ensure that farmers who have land titles are linked up with some institutions that can supply them with credit.
- Households who owned larger pieces of land and had titles to the land were more technically efficient than those with smaller pieces of land. Even if farmers are facilitated to own titles for their land, sub division of land would lead to reduced technical efficiency. While it would be important to ensure that land parcels have titles, land subdivision should be discouraged because it would reduce the gains from land titling.

5.24 Future studies prompted by the current study

The study prompts the following concerns for further research

- Since the study assessed the technical efficiency of small scale farms in the 2006/07 cropping year, it would be important to understand the main factors that affect technical efficiency over time. Recent years have been characterized by decreased levels of soil fertility resulting from continuous cultivation, soil erosion and sub optimal use of farm inputs. Climate change is expected to have some influence on the levels of technical efficiency. It would be important to undertake a study that would shed light on how these factors influence technical efficiency over time.

- The study assumed a household where all farming decisions are made by the household head. However, it would be important to understand whether the intra-household resource allocation has an influence on the levels technical efficiency achieved by the household.

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APPENDIXES

Appendix 1: Summary of Variables Used in the Study

Variable	Brief Description	Detailed Description
AEZ	Agro Ecological zones	The sample was divided into five agro ecological zones based on the altitude, rainfall patterns, soil type and crops grown, The zones and number of households interviewed were, Eastern Lowlands (244), High Potential maize zone (696), Western Lowlands (194), Western Highlands (192), Central Highlands (310),
Tenure	Form of land ownership	These are the tenure status that would for cultivated land. The land was either owned with title, owned without title or rented. Parcels that were owned by parents and the specific household did not hold titles to the parcel was regarded as 'without title' irrespective of whether the father had a title or not.
TE	Computed technical efficiency level	This Variable was estimated using the stochastic frontier model and was used in regressing socio-economic variables on the interaction model
Gender	Gender of household head	Binary variable for the gender of the household head. The heads were either male (1) or female (0).
Education	Highest level of school completed	Highest level of education completed. The data were collected in form of years starting from standard one to university. Form 6 level of education was taken as 14 years of schooling

Variable	Brief Description	Detailed Description
hhsize	Household size	The size of the household is the number of persons who form the household and who are involved in the day to day running of the households. Children who have been married away or moved out of the households were excluded
age	Age of household head	The age in years of the household head. The questionnaire recoded the year of birth and this was later computed into the age
acres	Acres cultivated	The size of land cultivated (acres). This was collected per parcel. Some households had more than one parcel and the mode of ownership would vary.
vprod	Value of crop production	The dependent variable was the total value of crops produced by the farm (other than losses in the field or in store), including those used for feed and seed by the household. The variable was computed using the formulae: Crop Value $(Y) = \sum Q_i P_i$ Farm output was valued at the actual market prices that farmers received for their crops and where output was not sold village-level average prices were used
lnlpmd	Land preparation man days	The total number of man days used in land preparation
sdacre	Seed cost per acre	Cost of purchasing seed for all crops was computed for each seed that was purchased. If the seed was retained, it

Variable	Brief Description	Detailed Description
		was valued using the average prices for the village. For perennials that were planted long before the 2006/07 season, the costs were equated to zero
vmanure	Value of Manure used per acre	Manure was valued using the average prices of manure in the respective areas.
vfert	Value of Fertilizer used per acre	Inorganic fertilizers were recorded for each fertilizer type and the prices were used to value the fertilizer
watering	System of watering crops	The households either relied mainly on rain water or used irrigation. If the main source of water for the specific parcel was rainwater, it was recorded as 1, if the main source was irrigation water, it was recorded as 0.
dextn	Distance in kms from household to extension advice	The distance from the homestead to the nearest extension service provider was recorded
dmtroad	Distance in kms from household to motorable road	A motorable road was regarded as one that can be accessed via motor vehicle during both wet and dry season. The distance from the homestead to the motorable road was recorded in kilometers.
mktkm	Distance in kms from household to nearest produce market	A market place was regarded as a center where buying and selling of farm and a non-farm item is undertaken. The distance from the household to the market place was recorded in kilometers.
credit	Credit access	The credit variable indicated whether the household received any credit either for agricultural or non

Variable	Brief Description	Detailed Description
		agricultural purposes. If the household received credit the variable was recorded as 1 if the household did not receive credit, the variable was recorded as 0.
group	Group participation	If there was any household member who was enrolled in a group activity (whether formal or informal), the variable was recorded as 1. If no member was enrolled in a group, the variable was recorded as 0.

Appendix 2: Summary of Pairwise Comparison Test for Land Size (Acres) Cultivated across Agro Ecological Zones in the 2006/07 Crop year

AEZ (I)	AEZ (J)	Mean Difference in acres cultivated (I-J)	Tukey HSD Probability value
Eastern and Coastal Lowlands	High Potential maize Zone	-0.14	0.97
	Western Lowlands	1.54	**0.00**
	Western Highlands	1.96	**0.00**
	Central Highlands	1.87	**0.00**
High Potential Maize Zone	Western Lowlands	1.69	**0.00**
	Western Highlands	2.11	**0.00**
	Central Highlands	2.01	**0.00**
Western Lowlands	Western Highlands	0.42	0.69
	Central Highlands	0.32	0.80
Western Highlands	Central Highlands	-0.10	0.99

* Significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent

Appendix 3: Summary of Pairwise Comparison test for Land Size (Acres) Cultivated across the different Tenure systems in the Agro Ecological Zones in the 2006/07 Crop year

Agro Ecological Zone	Form of land ownership (I)	Form of land ownership (J)	Mean Difference in Acres Cultivated (I-J)	Tukey HSD Probability value
Eastern and Coastal Lowlands	Owned with title deed	Owned without title deed	-0.09	0.97
		Rented	1.54	0.32
	Owned without title deed	Rented	1.64	0.24
High Potential maize zone	Owned with title deed	Owned without title deed	1.74	**0.00**
		Rented	2.64	**0.00**
	Owned without title deed	Rented	0.89	0.13
Western Lowlands	Owned with title deed	Owned without title deed	0.16	0.82
		Rented	1.12	**0.01**
	Owned without title deed	Rented	0.96	**0.04**
Western Highlands	Owned with title deed	Owned without title deed	0.23	0.29
		Rented	1.11	**0.00**
	Owned without title deed	Rented	0.87	**0.00**
Central Highlands	Owned with title deed	Owned without title deed	0.94	**0.00**
		Rented	1.49	**0.00**
	Owned without title deed	Rented	0.55	**0.07**

* Significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent

Appendix 4: Summary of Pairwise Comparison Test of Technical Efficiency for Land Parcels across AEZs

		Probability value (Tukey HSD) test		
Agro Ecological Zone (A)	**Agro Ecological Zone (B)**	**Land with title**	**Land without title**	**Rented land**
Eastern and Coastal Lowlands	High Potential Maize zone	0.528	0.560	0.937
	Western Lowlands	0.079*	0.708	0.593
	Western Highlands	0.003***	0.711	0.990
	Central Highlands	0.000***	0.000***	0.682
High Potential Maize Zone	Western Lowlands	0.394	1.000	0.693
	Western Highlands	0.013**	1.000	0.141
	Central Highlands	0.000***	0.000***	0.788
Western Lowlands	Western Highlands	0.592	1.000	0.042**
	Central Highlands	0.000***	0.000***	0.998
Western Highlands	Central Highlands	0.048**	0.000***	0.035**

* Significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent

Appendix 5: Summary of Pairwise Comparison Test for Parcels of land owned by Households headed by persons with different Education levels across the Land Tenure Categories.

Form of land ownership	Education level (i)	Education level (j)	Mean difference in Technical Efficiency (I-J)	Probability of value of Tukey HSD test
Owned with title deed	No formal education	Primary level	-0.02	**0.08***
		Secondary level	-0.03	**0.04****
		Post secondary	-0.03	0.36
	Primary level	Secondary level	-0.01	0.86
		Post secondary	-0.01	0.98
	Secondary level	Post secondary	0.01	0.98
Owned without title deed	No formal education	Primary level	-0.02	0.38
		Secondary level	-0.02	0.66
		Post secondary	-0.02	0.68
	Primary level	Secondary level	0.01	0.98
		Post secondary	-0.05	0.99
	Secondary level	Post secondary	-0.01	0.97
Rented	No formal education	Primary level	-0.02	0.85
		Secondary level	-0.01	0.98
		Post secondary	-0.08	**0.07***
	Primary level	Secondary level	0.01	0.96
		Post secondary	-0.07	0.13
	Secondary level	Post secondary	-0.07	**0.09***

* Significant at 10 percent; ** significant at 5 percent; *** significant at 1 percent

Identifying Variables:

Province:	__________	**PROV**	________
District:	__________	**DIST**	________
Division:	__________	**DIV**	________
Location:	__________	**LOC**	________
Sub-Location:	__________	**SUBLOC**	________
Village:	__________	**VIL**	________

LAND USE

Q1a. How many **acres in total land holdings** does the household **own**? **TACRES**________

Q1b. How many acres of land **is currently under trees?** **ATREE**________

Q1.1a. Did this household have any cropping activity during **MAIN CROP Season 2006/07?** (1= Yes No=2)
(Eastern Kenya refers to Jan-March 2007 harvest. Western, Coast Central July/October 2006; R.Valley Nov/Dec 2006) **MAINCROP**_____

Q1.1b. How many acres of land **were leased out** in the last **main season 2006/07?** **LEASE**________

Q1.1c. How many acres of land **were rented** the last **main season 2006/07?** **RENT** ________

Q1.2 Did this household have any cropping activity during **SHORT CROP Season 2006/07?** (1=Yes 2=No)
(Eastern Kenya refers to Jul-Sept 2006 harvest, Western, Central Kenya Nov 2006-Jan 2007 harvests) **SHOTCROP** ________

CROP Season 2006/07

Crop code	Field No.	Acres	Is this field 1=owned w/ deed 2=owned w/o deed 3=rented 4=owned by parent/ relative 5=government	Irrigation system	0=none 1=manual 2=oxen 3=tractor	(Ksh)	Planting Seed Type 1=Purch /N 2=Retained 3=OPV 4=local var	Quantity of seed used & cost, if purchased this season			Number of productive fruit trees	1st Fertilizer used			2nd Fertilizer used			Harvest -777=not yet harvested		Sales		**For the largest Sale**				Quantity harvested that spoiled Use harvest unit codes ***(for fruits and Veg only)***
								Qty	Unit	Cost per unit		Type	Qty	Unit	Type	Qty	Unit	Qty	Unit	Qty	Unit	Month 1= Jan. 12=Dec	Price received per unit	Buyer type	Km to point of sale	
crop	**field**	**acres**	**Tenure**	**system**	**landprep**	**lpcost**	**Sdtype**	**sqt**	**sunit**	**scost**	**ptrees**	**ft1**	**fq1**	**fu1**	**ft2**	**fq2**	**fu2**	**hvt**	**hunit**	**sold**	**slunit**	**month**	**price**	**buyer**	**km**	**spoil**

[5] Note: The survey instrument has been simplified by removing all questions that were not used for this study

CREDIT

A. CASH CREDIT

Q3a. Did any household member **try to get any cash credit during** the 2006/07 crop year? (1=Yes) (2=No **go to Q3g**) **CASHCRD** ________

Q3b. (If Yes) Did you receive the **cash credit** that **you tried to obtain**? (1= Yes) (2=No **go to Q3f**) **CASHRD** ________

Q3c. (If yes) How **much cash credit** did you receive (Ksh) **CASH** ________

Q3d. For the **two** main sources of cash credit, what was the **source** and the **amount** that you received from each? **CSRC1** ____ **CAMT1** ________

CSRC2 ____ **CAMT2** ________

(1= neighbor 2=farmer group 3=SACCO 4=commercial bank, specify _________ 5=relative/friend
6=NGO/MFI, specify________ 7=AFC 8= group (ROSCA) 9=Village bank 10=Shopkeeper 11=other, specify ________)

Q3e. How was the **cash credit** used (1=Agricultural purposes 2=Non agricultural purposes 3=Both) **MAINPUR** ________

B. IN KIND CREDIT

Q3g. Did any household member **try to get any credit in kind** during the 2006/07 crop year? (1=Yes) (2=No **go to Q3k**) **INKDCRD** ________

Q3h. (If Yes) Did you receive the **credit** in kind **that you tried to obtain**? (1= Yes) (2=No **go to Q3j**) **CRED** ________

Q3i. In what form was the credit in kind received? (1= Agricultural inputs 2=Household consumption 3=Both) **FCREDIT** ________

Q3j. If you tried to get credit in kind **but did not get** what was the reason for not getting **NCRED** ________
(1=Had outstanding loan 2= Don't Know 3= Other, specify_____)

CROP INPUTS

Q3k. What **CROP INPUTS** did you purchase/hire on **CREDIT OR IN CASH in 2006/07 cropping year? (Excluding seeds)**

Input type (Select fertilizer codes from column on the left)	Quantity bought/hired	**Unit** 1=90 kg bag 2=kg 3=litre 13=gram 20=5 kg bag 8=10 kg bag 7= 25 kg bag	**Mode of Purchase** 1=own cash 2=borrowed cash 3=in kind credit 4=own and borrowed cash	**Source of Fertilizer and other inputs** **Source type codes:** 1=small trader 2=Stockist 3=large company 4=CBO 5=KFA	**Price per unit** specified	**Kms** from point of purchase to farm	**Transport Cost per Unit** of the fertilizer (KSh) **(Instruction : fill for only fertilizers)**	**Main Crop** for which input was used	**How is/was the credit repaid?** 1=crop revenue 2=livestock revenue 3=off farm income
inptype	**qbought**	**Unit**	**mdpurch**	**inpsorce**	**punit**	**kms**	**trancost**	**mcrop**	inpaid

NON-AGRICULTURAL CREDIT

Q4a. If credit was used for non-agricultural purposes give details

Main use of the credit 1= school fees 2 =medical 3 =business 4 =household consumption	**Type of credit** received 1=Cash 2=In kind	**What was the source of credit**: 1= neighbor 2=farmer group 3=SACCO 4=commercial bank, specify ______ 5=relative/friend 6=NGO/MFI, specify ______	**Value of credit** (Kshs)	**How is/was the credit repaid?** 1=crop revenue 2=livestock revenue 3=off farm income
crduse	**ctype**	**crdsor**	**cvalue**	**repay**

Q4b. Why **didn't** the household use fertilizer **(if did not use chemical fertilizer in the cropping year)** **NOFERT** ________

1=no money 2=fertilizer not available 3=practicing organic farming 4=uses organic manure 5=lack of advice
6=no need to use 7=campaign against the use of chemical fertilizers 8 = other, specify ______

(Enumerator Instruction: check to see if household used fertilizer on **maize** from crop table. If did use then skip to Q5)

Q4c. If you **didn't use chemical fertilizer on maize**, why not? **NFERMZ** ________

0=did not plant maize 1=not profitable 2=low response rate 3=couldn't obtain credit 4=not enough cash 5=too expensive
6=maize price too low 7=no cash when needed 8= fertilizer not available 9= no need to use 10=other, specify________

LABOUR COSTS

Q5a. In total, how much did you spend on salaried farm worker(s) for cropping activities in the main and short harvests, 2006 /07? (Ksh)
(Enumerator Instruction: Remember to consider only the proportion of time spent on cropping activities on apportioning salary) SALFWRK ________

Enumerator Instruction: Ask about labour activities related to **Maize Only (Exclude fodder maize)**

Q5b. Identify the **largest monocrop maize** field *otherwise* ask for the **largest intercrop maize** field in the **main season** **FIELD**________

Q5c. What is the **slope** of this field: (1=flat 2=steep 3=steep terraced 4=moderate 5=moderate terraced) **SLOPE**________

Q5d. When did you plant maize in the **main** season? (1=Early) (2=On Time) (3=Late) **TPLANT** ________

Q5e. Did any of your salaried workers work on **the largest maize field** for the 2006/07 main season? (1=Yes) (2=No) **SALLBR** ________

Q5f. **What labour inputs** did you use for **the largest maize field** for the 2006/07 main season?

Code	**Hired Labour**				**Family Labour (adults)**						**Family Labour (children)**			**Salaried Labour (ONLY if unpaid)**		
	# hired	# of days	Kshs per person per day	Total Kshs by contract	# of males	Total # of hours each	Total Hours for all days worked	# of females	Total # of hours each	Total Hours for all days worked	# of children	Total # of hours each	Total Hours for all days worked	# Of workers	# days worked each	# hours per day each (on average)
ACTIV	**LB01**	**LB02**	**LB03**	**LB04**	**LB05**		**LB06**	**LB07**		**LB08**	**LB09**		**LB10**	**LB11**	**LB12**	**LB13**

SOIL, WATER AND ENVIRONMENTAL CONSERVATION

Q7.8a. What Soil, Water and Environmental conservation methods are you **practising?** **WEPRA1** ____**SWEPRA2** _____**SWEPRA3** _____

(0=none 1=terracing 2=mulching/cover crops 3=minimum tillage 4=wind breaks 5=contour farming 6=crop rotation 7=waterpans 8=grass strips 9=afforestation 10=re-afforestation 11=agro forestry 12=gabions 13=cut-off drains 14=fallow 15=other, specify________)

Q7.8b. Are you practising **zero-tillage**? (1=Yes) (2=No) **ZEROTIL** _______

Q7.8c. Are you **composting manure**? (1=Yes) (2=No **go to Q7.8e.**) **COMPOST** _______

Q7.8d. If **Yes**, what year did you start **composting manure?** **YRCOMP** _______

Q7.8e. How do you dispose of the **maize stover** after harvest? **MZSTOVER** _______

(1= preserve as fodder 2= feed to cattle immediately 3= burn 4= sell 5= exchange for oxen service 6= make compost 7=leave to rot in the field 8=other, specify__________)

EXTENSION and GROUP PARTICIPATION

Q13a. Did you **actively seek advice** on crop or livestock between **July06 to June07**? (1=Yes) (2=No **go to Q13c**) **SEEKADV** ________

Q13b. **If Yes**, who did you **approach** for the advice? **ADVISOR1** _________ **ADVISOR2** _________

(1=public extension agent 2=private extension agent 3=neighbour/farmer 4= ASK Shows 5=traders/input dealers 6=radio /television 7=family/friend 8=newspaper/magazines 9=farmer organizations/cooperatives 10=field days/demonstrations 11= NGO agent 12=research organizations 13= other, specify_______)

Q13c. **If No,** why didn't you seek advice? ***(Give up to 2 reasons)*** **SEEKNOT1** ________ **SEEKNOT2** ________

(1=long distance 2=Expensive 3=time consuming 4=extension agents not available 5=other , specify ___________)

Q13d. If **extension services** in general were to be availed at a fee, would you be **willing to pay**? (1=Yes **go to Q13f**) (2=No) **AVAILFEE** _________

Q13g. Is anyone in this household a **member** of any **co-operative or group or out-grower group**? (1=Yes) (2=No **go to Q14a**) **GRPMEM** _________

Q13h. If Q12a=1 (Yes), indicate **which cooperatives/groups** the household belongs to? (Specify up to 3) **GRPMEM1** _________ **GRPMEM2** _________ **GRPMEM3** _________

(1=producer cooperatives 2=multi-purpose cooperative 3=savings and credit cooperatives 4=informal/self help groups 5=out-grower company 6=others, specify________)

Q13i. What **services** do you get from the group or cooperative? (Specify up to 3) **SERV1** _________ **SERV2** _________

(0=none 1=Training 2=Marketing 3=Input acquisition 4= Financial services 5=A.I services 6= Other specify____)

Q14. DEMOGRAPHIC CHARACTERISTICS OF HOUSEHOLD MEMBERS

demog07.sav (Key variables: hhid, mem) **Reference Period: July 2006 to June 2007**

ID	Name	In which **year** was this person born?	What is the **sex** of .... ? 1=male 2=female	**Relation-ship** to **current** head ***See codes below***	Marital Status ***See codes below***	Is ..... **Currently** attending school? 1 = Yes 2 = No	What is the **highest** level of education completed? ***See codes below***	Is this person **currently** considered a **member** of this household? 1=Yes -> DA09 2=No	If this person is **not a member** of this household anymore, **why**? ***See codes below***	**How many months** in the period July 2006 to June 2007 has this person been living at home?	Did this person receive cash from **informal /business activity?** Include **farm kibarua, dividends** between July2006& June 2007? 1=Yes 2=No	Did this person receive cash or payment in kind from **salaried employment, wage activities, <u>remittances</u>, or pensions** between July 2006 and June 2007? 1=Yes 2=No	Has this person been **chronically ill** for any **3 month period** in the last 12 months and unable to perform hh duties? 1= Yes 2= No
mem	name	DA01	DA02	DA03	DA04	DA05	DA06	DA07	DA08	DA09	DA10	DA11	DA12

Q17 BUSINESS AND INFORMAL LABOUR ACTIVITIES

Person name	Person code	Activity Code	Please classify each month's net earnings as: 0=none 1=low 2=average 3=high												Low earnings month		Average earnings month		High earnings month	
			7/06	8/06	9/06	10/06	11/06	12/0	1/07	2/07	3/07	4/07	5/07	6/07						
name	mem	activity	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb		Apr	May		lgross	lcost	agross	acots	hgross	Hcost

Q18 SALARIED WAGE EMPLOYMENT/PERMANENT EMPLOYMENT ACTIVITIES

Person name	Person code	From the list below, please list all the ***salaried employment activities*** in which this person was engaged at any time during the past 12 months	What is this person's current monthly wage? Kshs	Did this person earn this same monthly wage during all of the past 12 months? 1=Yes (go to next activity) 2=No	If the person did *not* earn the same wage during all 12 months, please indicate the wage earned for each month individually (Kshs) ***Skip this section if person received the same monthly wage during the whole year***											
					7/06	8/06	9/06	10/06	11/06	12/06	1/07	2/07	3/07	4/07	5/07	6/07
Name	mem	activity	mnwage	samewage	Jul	Aug	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June

19a. What was the **main** source of the **remittances**? **REMIT** ________
(1=Son/Daughter 2=Other relative 3=friend 4=Well wisher 5=Other, specify______

19b. If the household received **remittance**, what was the **main mode** of delivery? **MREMIT** ______
(1= Hand delivery 2=Bus 3=Western union 4=Posta pay 5=Money gram 6=M-pesa 7=Sokotel 8=Telegraphic money Order 9= Postal Order 10=Courier 11=Other, specify________)

LAND OWNERSHIP AND INHERITANCE

Q21.1 In what year was this **household formed** (when you received land to farm on your own): **write the Year (e.g., 1985)?** **YRFORM** ________
Q21.2 In what year did your father's family (HH heads father) **settle in this area**? (Use 0 if father never settled there) **YRSET** ________
Q21.3 Has land been **forcefully taken away** from this Household in the last 10 years (1=Yes) (2=No) **LDTAKE** ________

INFRASTRUCTURE

Q 26. Distances from your homestead (KM)

a) What is the distance from your homestead to the nearest **fertilizer seller**? **FERTSKM** ________
b) What is the distance from your homestead to the nearest seller of **hybrid maize seed**? **CERTMAIZ** ________
c) What is the distance from your homestead to **extension advice**? **DEXTN** ________
d) What is the distance from your homestead to the nearest **market place** for **farm produce**? **MKTKM** ________
e) What is the distance from your homestead to a **motorable road**? **DMTROAD** ________
f) What is the distance from your homestead to a **tarmac road**? **DTMROAD** ________

WAGE RATES AND LAND RATES

Q27a. What is the **daily wage rate** for **general farm labour** in this area? (Ksh per day): **WAGERATE** ________

Q27b. For this wage, what is the **typical number** of hours **worked per day**? (Hours): **HOURS** ________

Q27c. What is the **land rental rate for one acre of good quality land for one year** in this area? (Ksh per acre): **LRRY** ________

Q27d. What is the **land rental rate for one acre of good quality land for one season** in this area? (Ksh per acre): **LRRS** ________