THE IMPACT OF LAND SIZE AND FARM FRAGMENTATION ON HOUSEHOLD WELFARE: THE CASE OF KILOSA DISTRICT IN MOROGORO, TANZANIA

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ABSTRACT

The study on which this thesis is based investigated the impact of land size and farm fragmentation on household welfare in Kilosa District. The specific objectives were to: determine factors affecting household land size, assess the effects of farm size on household income, determine the causes of farm fragmentation, and assess the effect of farm fragmentation on agricultural productivity. Data were collected using a structured questionnaire, which was administered to a random sample of household heads in the study area. The area was demarcated into three strata, namely improved irrigation system, traditional irrigation system and no irrigation practice at all. Statistical Package for Social Sciences (SPSS) and Microsoft Excel programmes were used to analyse the data after ensuring that there was no violation of assumptions of normality, linearity, homoscedasticity and heterogeneity. It was found that land access, size and fragmentation do negatively affect the household income which eventually affects household welfare. It was found that owned land size is a function of adult equivalent unit ($p < 0.05$), age of household head ($p < 0.05$) and household income ($p < 0.05$). Farm fragmentation was statistically described to be a function of average travel time from homestead to the farm ($p < 0.01$), total land owned per capita ($p < 0.01$), number of crops grown by household ($p < 0.05$), total arable land per capita ($p < 0.05$) and means of land acquisition ($p < 0.05$). Agricultural productivity decreased with farm fragmentation hence the Schultz's theory which asserts an inverse relationship between farm fragmentation and agricultural productivity was disproved. Land consolidation and installation of modern irrigation structures are therefore recommended for improved productivity, increased income and enhancement of welfare of farmers in the study area.

DECLARATION

I, SOPHIA FAUSTIN SWAI, do hereby declare to the Senate of Sokoine University of Agriculture that this thesis is my own original work done within the period of registration and that it has neither been submitted nor being concurrently submitted in any other institution.

24/03/2016

Sophia Faustin Swai (PhD. Candidate) — Date

The above declaration confirmed

24.03.2016

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24/3/2016

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This work is dedicated to my loving father, the late Faustin Selengia Swai, for laying the foundation of my education. I pray that the Almightily God rest his soul in peace forever. AMEN.

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LIST OF ABBREVIATION AND SYMBOLS

AEU	Adult Equivalent Units
ANOVA	Analysis of Variance
ASDP	Agricultural Sector Development Programme
ASDS	Agricultural Sector Development Strategy
CAADP	Comprehensive Africa Agriculture Development Programme
FAO	Food and Agriculture Organization
GPS	Global Positioning System
K	Januszewski index
NBS	National Bureau of Statistics
NSGRP	National Strategy for Growth and Reduction of Poverty
PHC	Population and Housing Census
PHDR	Poverty and Human Development Report
RMS	Residual Mean Square
SAGCOT	Southern Agricultural Growth Corridor of Tanzania
SI	Simpson Index
SPSS	Statistical Package for Social Sciences
TAFSIP	Tanzania Agriculture and Food Security Investment Plan
TAS	Tanzania Shilling
TDV	Tanzania Development Vision 2025
VIF	Variable Inflation Factor
ZSGRP	Zanzibar Strategy for Growth and Reduction of Poverty

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background

It is unarguable that land sustains our lives, and we all depend on it in one way or another. Be it biologically, economically or socially, the land is an imperative asset which keeps its value progressively increasing. Land is the human habitat and a resource which cannot be expanded, but keeps carrying an ever increasing human population (Furaha, 2008). Land is an important asset in agrarian societies. It is an essential natural resource needed for the survival and success of humans as well as for the maintenance of the global ecosystems (FAO, 2008). Not every human user has equal access to land all the time, but has endeavours of constant competition for it. This inequality in land access which exists among users may not only be a hindrance to development but also causes social conflicts and unrest (Deininger and Lyn, 1998). Inequality in land distribution has been found to have a strong inverse relationship with economic growth and poverty reduction. For instance, inequality in land distribution has been found to negatively affect future economic growth (Quan and Koo, 1985), and even in the process of growth, poor households appear to benefit less than wealthy households when income and assets are distributed unequally.

Land access is the process by which land users either singly or collectively gain rights and opportunities to occupy and utilize land on either a temporary or permanent basis (Jayne *et al.*, 2003). Such an access enables family labour to be productive through farming, to generate a source of food and provide livelihood (Jayne *et al.*, 2003). Land can be loaned, rented or sold in times of hardship to provide financial security. At the same time, as a heritable asset, land is a basis for wealth and livelihood security of future generations.

The rules that govern access to land and the jurisdiction regarding how land is distributed among members of a community influence how efficiently land is used, the incidence of poverty, and the level of inequality in the community (De Janvry *et al.*, 2001). A large portion of land in developing countries is underutilized and/or even misused from a sustainability point of view. Lack of access to land or unfavourable terms of access remain a fundamental cause of poverty, while unmet demands for land can be a source of political instability (De Janvry *et al.*, 2001).

Household welfare is a comprehensive and dynamic overall family situation ranging from wellbeing, through meeting interests, attaining of the happiness and living substantial level of satisfaction of its members to be considered good and vice versa Jayne *et al.* (2003). Human wants are endless, and infinity is a path to self-esteem and actualization, making it hard to affix clearly using empirical figures on a welfare scale. Household welfare is derived by several indices including household income and its allocations, agricultural productivity and produce value for those engaged in agriculture to mention a few (Jayne *et al.*, 2003). The agricultural productivity is affected by many factors including farm fragmentation in terms of both number of pieces of land and size of the pieces of land one accesses and use for production activities at exposure. Farm fragmentation bears both magnitude and direction effects on farm productivity (Kakwagh *et al.*, 2011).

Throughout this thesis, the terms land access and land acquisition are non-technically considered to be synonymous and are occasionally used interchangeably. The two terms do not mean land ownership, which might need a legal status. However, contextually, the three terms bear a sequential concept whereby land access results into land acquisition, which does eventually lead to land ownership.

The most common way of accessing a piece of land in Tanzania is through inheritance (Ngeregere, 2008), which leads to farm fragmentation, which is a situation whereby farmers operate two or more physically separated pieces of land, taking account of their sizes and distance apart at the same time (Daniel *et al.*, 2010; Wu *et al.*, 2005). Other means of land access is through government allocation, buying or renting in. Farm fragmentation is a common characteristic of many developing countries (Todorova and Lulcheva, 2005; Sabastes-Wheeler, 2002; Niroula and Thapa, 2007; Hung *et al.*, 2007 and Dijk, 2002). As used by several scholars, farm fragmentation is divided into two broad categories depending on its causes: whether supply-side or demand-side causes (Bentley, 1987; Blarel *et al.*, 1992).

The supply-side causes of farm fragmentation refer to an exogenous imposition on farmers of a pattern of land areas as a result of population pressure, inheritance laws and land scarcity (Hung and MacAulay, 2002). As the population increases, the size of holdings falls, and farm fragmentation increases leading to small plots, scattered over a wide area. The demand-side causes reflect varying degrees of farm fragmentation positively selected by farmers so as to reduce risk from natural disasters such as floods, droughts, and fire, promote crop diversification as well as to ease allocation of labour over cropping seasons (Hung and MacAulay, 2002). The empirical evidence about the effect of farm fragmentation on agricultural productivity is quite polarized. On one hand there are arguments that consider farm fragmentation as an impediment to agricultural productivity (Dirimanova, 2006; Najafi, 2003; Thomas, 2007; Thapa, 2007, Tan *et al.*, 2008) since it impairs agricultural productivity. Based on such arguments several governments such as Rwanda and Bulgaria have even sought to promote a more rational spatial allocation of land and developed policies which encourage land consolidation (Bizimana *et al.*, 2004 and Hung *et al.*, 2007). Similarly, the evolutionary Theory of Land

Rights asserts that population growth may also encourage more land consolidation (Platteau, 1996). On the other hand the demand side arguments view farm fragmentation as beneficial. According to this later viewpoint, farm fragmentation is not always defective as it has empirically been evidenced in the studies by Kadigi and Mbiha (2000) and Hung, *et al.* (2007). Farm fragmentation, can help farmers ease seasonal labour bottlenecks, reduce risks and enhance their levels of food security (Kadigi and Mbiha, 2000).

Farm fragmentation has been a common feature of smallholder farmers in Tanzania though not widely studied in the past. The empirical evidence on the causes of farm fragmentation and its impact on productivity in Tanzania are documented only for the Lake Zone based on the study by Kadigi and Mbiha (2000). This information is important as the country strives to transform her agriculture sector into not only a more commercialized sector but also a sector following an inclusive growth pathway. It is from this understanding that a study of farm fragmentation was undertaken in Kilosa District – part of the Southern Agricultural Growth Corridor of Tanzania (SAGCOT), established as part of the "Agriculture First" (commonly known as "Kilimo Kwanza" in Swahili) initiative. In addition the district has experienced many conflicts over land uses, especially between crop farmers and livestock keepers. Of most importance is perhaps to understand the nature and impact of farm fragmentation on agricultural productivity and overall issues of land tenure in the district.

1.2 Problem Statement and Justification of the Study

Tanzania has declared her desire to make abject poverty a thing of the past by the year 2025 (URT, 1999). The country's Development Vision 2025 provides the framework for achieving this goal. The vision has set targets for Tanzania to move from a less developed country (LDC) to a middle-income country by 2025. Among other things, the goal of eradicating abject poverty by the year 2025 will be achieved by ensuring sustainable development of the agricultural sector. Countries with traditional agricultural structures like Tanzania face small and fragmented plots (Khalil and Gholamhossein, 2008). Proper land access has a vital impact on agricultural productivity and the country development at large. In some cases farm fragmentation is viewed to be the main stumbling block for agricultural productivity (Sabates-Wheeler, 2002). However, the impact of farm fragmentation on welfare of the rural poor in Tanzania is neither determined nor documented compared to other countries such as Ghana, Rwanda, Nigeria and China where the phenomena is studied in depth (Kakwagh *et al.*, 2011; Blarel *et al.*, 1992). So far, only one study on farm fragmentation has been done in Tanzania: the study by Kadigi and Mbiha (2000) who evaluated the existence and impact of farm fragmentation in the Lake Zone. While Tanzania is embarking on the Kilimo Kwanza and SAGCOT initiative, as a means to transform her agriculture into a modern and commercial sector, this initiative and the overall reforms in the agricultural sector are not adequately informed by research findings, especially on existing land tenure issues and farm fragmentation. Important is the fact that land constitutes one of the ten pillars of the Kilimo Kwanza initiative that aim at transforming the agricultural sector from small scale to medium and large scales.

While there is some empirical evidence on how farm fragmentation influences farm productivity and profitability elsewhere in the world (see Blarel *et al.*, 1992; Niroula and Thapa, 2005; Tan *et al.*, 2006; Niroula and Thapa, 2007; Gajendra and Gopal, 2005; Lan 2001; Hung and MacAulay, 2002; Dirimanova, 2006; Najafi, 2003; Thomas, 2007; Thapa, 2007; Tan *et al.*, 2008), and in the Lake zone of Tanzania (Kadigi and Mbiha, 2000), the evidence provided by these studies contain contradicting results–some suggesting positive impacts on land productivity and farm income (Bentley, 1987; Kadigi and Mbiha, 2000; Tan *et al.*, 2006) while others indicate negative relationships between farm fragmentation and productivity (Lan 2001; Najafi, 2003; Gajendra and Gopal, 2005; Shushao, 2005; Dirimanova, 2006; Thomas, 2007; Thapa, 2007; Tan *et al.*, 2008). This suggests that the causes and effects of both farm fragmentation and consolidation are either not well known or situation specific, and there are no common solutions to address the impacts of the two. The nature and level of farm fragmentation are therefore an outcome of combined rather than isolated influences of supply and demand driven factors. Recognizing this, the study idea was developed to evaluate the nature of farm fragmentation and its impact on agricultural productivity in Kilosa District.

1.3 Objectives of the Study

1.3.1 Overall objective

The overall objective of this study was to investigate the impact of land size owned by household on income and the impact of level of farm fragmentation on agricultural productivity to improve household welfare and eventually contribute towards national development.

1.3.2 Specific objectives

The specific objectives of the study were:

i) To determine factors affecting household land size in the study area,

ii) To assess the impact of farm size on household income,

iii) To determine the causes of farm fragmentation in the study area, and

iv) To assess the effect of farm fragmentation on agricultural productivity.

1.4 Research Hypotheses

The study hypotheses were:

i) Household socio-economic, demographic, soil quality and agricultural factors have no effect on household land size

ii) No correlation between household land size and household income.

iii) Household socio-economic, demographic, soil quality and agricultural factors have no effect on land fragmentation

iv) Farm fragmentation has no effect on agricultural productivity (Value produce in Tanzanian Shillings/hectare).

In view of the above-highlighted research hypotheses, a number of test-hypotheses were constructed and tested using various test statistics as detailed in the methodology section.

1.5 Limitations of the Study

i) Some limitations were encountered during data collection whereby a standard or common scale to quantify both harvested and sold crops was lacking. For some crops famers were familiar with local units Probing techniques were applied to be able to convert local units into standard units. Where necessary actual measuring was done to check and confirm the local units.

ii) Moreover, the data collected relied on the farmers' ability to recall information on crop production and sales from previous seasons. The lack of record keeping in many households was a problem. In order to address this problem, respondents were encouraged to consult other family members.

iii) Price data from farmers varied greatly from one location to another for different crops. To reduce inaccuracies in estimating agricultural productivity, the district crop price records were used. This was deemed important because many farmers adopted intercropping which makes it hard to specify the area under each crop.

iv) Measuring of the farms was operationally challenging, but it was made easy by using Global Positioning System (GPS) device with area calculation capability.

1.6 Scope of the Study

This study considered only the impact of farm fragmentation on agricultural productivity, the relationship between land size and agricultural productivity and their impact on the household income. Other farm fragmentation effects such as conflicts and production efficiency were not part of the study.

1.7 Organization of the Thesis

This thesis is organized as follows: Chapter 1 is devoted for the introduction of the research. Chapter 2 covers the literature review pertinent to the study. It reviews both the theoretical (farm fragmentation is defined and its significance explained) and empirical literature on the importance of land for the economic growth or development of the African region is presented. In addition the chapter covers the review of tenure security and access to customary land in Tanzania, land ownership and poverty reduction, measures of land access, farm fragmentation externalities, measurement of farm fragmentation, the impact of farm fragmentation on agricultural productivity and farm income. Chapter 3 presents the overall methodology used by the study. Specifically the chapter presents the study design, sampling techniques, sample size, data collection procedure and data analysis. Chapter 4 presents the results of analysis and discussion of factors that determine land ownership, causes of farm fragmentation as well as the impact of farm fragmentation on agricultural productivity. Chapter 5 presents the key contribution of the study, conclusions and recommendations and area for further research.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 The Schultz's Theory

Ever since the publication of Schultz's theory (1964) which asserts the inverse relationship between land holding size and productivity, there has been a debate about it because of the general positive relationship belief (Niroula and Thapa, 2005). Despite this fact, many researchers such as Ellis (2003) and Dijk (2002) have assumed that a landholding is a single parcel and that there is no effect on accessibility to individual farmers' share of land when it is subdivided (Niroula and Thapa, 2005). But this hypothesis may not be true in the context of Tanzania (particularly in Kilosa District) or other in developing countries, where fragmentation of the land holdings leads to fragmentation of several parcels of different attributes (soil quality, size and location) even though Thapa (2007) argues that several economists put the inverse relationship as valid under traditional agriculture. The inverse relationship has been weakened due to the availability of size-neutral biotechnology such as seed and fertilizer, differences in management input and adoption of new capital intensive technologies.

2.2 Land and Development

The centre for social, political, economic well-being and life in general is land. Land and other natural resources are important possessions for economic growth and development. Most of the developing countries' economies continue to rely heavily on agriculture and natural resources for a significant share of their GDP, national food needs, employment and export revenue. At the same time agriculture, natural resource utilization and other land-based activities are the main sources of livelihoods, income and employment of the majority of their people, and land is the basis of shelter in urban and rural areas (African

Union, 2006). In rural areas of the developing world, reduced access to natural resources such as land and water leads to poverty and intensified conflicts (Madulu, 2002). In general, conflicts over natural resources are not only unique to developing countries; they are present throughout the World (Kajembe *et al.*, 2003). People everywhere in the world compete for natural resources to enhance their livelihoods. To reduce competition over the resources, there is a need to regulate means of accessing them and promote efficient use for their sustainability. Land is not an exceptional.

2.3 Land Access and Farm Size

Land access refers to land use rights (Jayne *et al.*, 2003). Land or farm size per household would, in the absence of serious barriers to access, be expected to be strongly positively correlated with household size. The improvement of land access for smallholders is achieved with difficulties even in land abundant countries (Jayne *et al.*, 2003). Access to agricultural land provides a way of food production which makes a primary contribution to food security by making food readily available to the poor (Carter, 2003). Land access reduces poverty through household income and food security, providing a buffer against external shocks and frees up resources for investment (Carter, 2003). One can own land through different ways including government land allocation, land inheritance, buying or renting. The most common way of owning the land in Tanzania is through inheritance, a process which leads to farm fragmentation through subdivision of parcels of similar quality to heirs (Ngeregere, 2008).

2.4 An Overview of Farm Fragmentation

Various factors are responsible for farm fragmentation. Among the main factors that have directly or indirectly contributed to subdivision and fragmentation is the traditional system of inheritance of land (inheritance laws), which divide a family's land amongst the sons. As the population increases, not only does the size of holdings fall, but it is also increasingly fragmented into small plots and scattered over a wide area (Gebeyehu, 1995). The most common problems of fragmentation include the fact that fragmentation makes supervision and protection of the land difficult. Farm fragmentation involves long distances from home to parcels and between the parcels, loss of working hours, the problem of transporting agricultural implements and produce and results in small and uneconomic size of operational holdings (Webster and Wilson, 1980).

Several authors have tested empirically the effects of land fragmentation on the performance of farms. For example, Jabarin and Epplin (1994) investigated the impact of land fragmentation on the production cost of wheat in Jordan. In China, Nguyen *et al.* (1996), Wan and Cheng (2001) and Tan *et al.* (2010) investigated the effect of land fragmentation on the productivity of major crops, crop output of rural households and the technical efficiency of rice producers in the South-East of the country respectively. Kawasaki (2010) evaluated both the costs and benefits of land fragmentation in the case of rice production in Japan, and Rahman and Rahman (2008) did a similar evaluation in Bangladesh. Parikh and Shah (1994) investigated the influence of land fragmentation on the technical efficiency of farms in the North- West Frontier Province of Pakistan, while Manjunatha *et al.* (2013) carried out a similar investigation in India. In Europe, Di Falco *et al.* (2010) analyzed how land fragmentation affects farm profitability in Bulgaria, and Del Corral *et al.* (2011) analyzed how land fragmentation affects the profits of Spanish dairy farms.

In most of these researches, farm fragmentation is measured by the number of plots and or their average size. These two variables are employed, either directly or indirectly, by the use of more elaborate measures, such as the Simpson index or the Januszewski index.

In this study the impact of farm fragmentation on agricultural productivity is analyzed in terms of farm fragmentation indicators (i.e. number of parcels owned per household, parcel size and Simpson Index- SI).

These variables do not account for all dimensions of farm fragmentation, however, and may not reflect all the constraints that farm fragmentation imposes on production systems. There are few exceptions to the use of these sole variables. For example, Tan *et al.* (2010) considered the average distance from the plots to the homestead, while Gonzalez *et al.* (2007) used more elaborate measures of farm fragmentation (which accounted for the size, shape and dispersion of plots) to study the productivity gains from land consolidation. However, in the latter case, these measures were not tested on a real sample of farms, but instead were applied to a hypothetical dataset of farms.

2.5 Externalities of Farm Fragmentation

When farm plots are fragmented, the development of agricultural infrastructure such as irrigation canals and farm roads becomes difficult, resulting into high costs, increased negative externalities such as reduced agricultural productivity and land conflicts, loss of land due to boundaries and a greater potential for disputes between neighbouring farmers (Lan, 2001; Hung and MacAulay, 2002). Moreover, conflicts may arise over distribution of irrigation water when canals are not properly aligned due to fragmentation of land parcels (King and Burton, 1982). Some farm plots will have direct access to irrigation water, while others have to depend on water draining out of plots with direct access to canals, eventually undermining agricultural productivity, efficiency and competitiveness of farms without direct access.

2.6 Farm Fragmentation Measures

Even though it has been a common phenomenon, farm fragmentation has no common measure since the concept means different things to different people and its degree differs among countries (Pham *et al.*, 2007). A distinction can be made between single dimension indicators (parcel size, number and distance apart) and integrated indicators such as Januszewski Index (K) and Simpson Index (SI) (Tan *et al.*, 2006), but it is still difficult to clearly determine when farms are highly fragmented or less fragmented (Pham *et al.*, 2007) because farm fragmentation is differently perceived by people. For example, the same farm acreage can be considered as less or highly fragmented under different circumstances.

The majority of authors have used two simple measures to assess farm fragmentation. These are the average number of plots per household and the average parcel size (Bentley, 1987). However, some authors have considered that farm fragmentation should be measured by six parameters: farm size (total holding), the number of plots, plot size, plot shape, spatial distribution and the size distribution of the fields (King and Burton, 1982; Bentley, 1987). The most preferred measure of farm fragmentation is the use of several single indicators into one index. The most popular integrated indicators are Januszewski index (K), Simpson index (SI) and Rembold's approach, though the first two indices fail to account for farm size, distance and parcel shape (Blarel *et al.*, 1992) and the latter fails to account for the number of plots and the spatial dispersion (distance) of the plots (Rembold, 2004).

The Januszewski index (K) is defined as, $K = \frac{\sqrt{\sum a}}{\sum \sqrt{a}}$; where 'a' represents the parcel size. The index ranges between 0 and 1. One (1) implies that the farmer holds all his land in the form of a single plot. Specifically, the Januszewski's index measures the number of plots and the size distribution of the plots.

The Simpson Index (SI) is mathematically defined as: $SI = 1 - \sum_{i=1}^{i} A_i^2 \Big/ A^2$; where, SI is the Simpson index, Ai is the area of plot i and A is the total land area. A value of zero indicates complete land consolidation (one parcel only), while the value of one is approached by holdings of numerous parcels of equal size.

Moreover, shape is an essential parameter when mechanization is required as mechanization is considered most efficient on rectangular plots. In this study the Simpson Index (SI) is chosen with other two single indicators (number of parcels and average parcel size). The drawback of SI was eliminated by measuring parcel size and distance to parcels.

2.7 Farm Fragmentation and Agricultural Productivity

Farm fragmentation, external factors, agro-ecological environment and farm characteristics have an effect on agricultural productivity (Okezie *et al.,* 2012). The effects imposed by farm fragmentation on agricultural productivity are mixed; it can either cause positive or negative effects (Rahman and Rahman, 2008). Farm fragmentation is considered to be an impediment to agricultural productivity. It can be a major obstacle to agricultural development because it hinders agricultural mechanization, causes inefficiencies in production, and involves large cost to alleviate its effects (Wan and Cheng, 2001). However, farm fragmentation is not always defective (Bentley, 1987; Kadigi and Mbiha, 2000; Tan *et al.,* 2006; Sherlund *et al.,* 2002) since it can help farmers reduce risks, ease seasonal labour bottlenecks and enhance their levels of food security.

2.8 Land Access and Gender Issues

In most of African societies, males dominate in decision making (Duze and Mohammed, 2006). Since men are influential in decision making, the type of land use will be determined by men who are also the land owner. African societies, parents bequeath part of the land to their sons while this is not common for daughters hence male headed households are likely to have more access to land than female headed households (Jayne *et al.*, 2003).

Constitutional rights for women are frequently jeopardized by some conflicting laws and long-standing African traditional practices (FAO, 2010). For example in several parts of Tanzania, there is land insecurity amongst small land holder farmers, especially women (Mugabi, 2013) while increasing women's access to land is crucial to fight hunger and poverty (Elis and Freeman, 2004). However, not only in Africa, but gender disparities in land access remain significant in most countries, regardless of their level of development.

Gender inequalities in land rights are pervasive (Jayne *et al.*, 2003). Not only do women have lower access to land than men they are also restricted to so-called secondary land rights; meaning that they hold such rights through male family members. Women thus risk losing entitlements in case of divorce, widowhood or their husband's migration. Evidence also shows that women's parcels are generally of smaller size and lower quality (Jayne *et al.*, 2003).

Agricultural census data shows that less than 20% of landholders internationally are women (FAO, 2010). The situation is particularly severe in Western and Central Africa and Near East and North Africa where less than 10% of landholders are women. The situation slightly improves in Asia, Eastern and Southern Africa and in parts of Latin

America, where women seem to have somewhat better access to land. In some countries up to 30% of land titles are held by women. Only in a few countries land is almost equally divided between women and men with Latvia and Lithuania top the list by having more than 45% of land titles being held by women (FAO, 2010).

Importantly, women smallholders who have increased tenure security may be more productive than do women who face tenure insecurity. Increased productivity often leads to higher household incomes (Elis, 2003). With increased income, women can develop a greater voice in financial decision making within households. This means that they are empowered to choose how to use any additional income they generate and they do use it to invest in their children's health and education. Less than one quarter of agricultural land holdings in developing countries is operated by women (Elis, 2003). Low female access to and control of land do significantly obstruct access to financial assets, including but not limited to credit and savings institutions (FAO, 2010).

2.9 Farm Size and Land Productivity

The debate about the relationship between farm size and land productivity started with Sen (1962) in India. Subsequently, several studies have been done to prove or reject the assertion of the inverse relationship between farm size and land productivity in South Asian and in some other developing countries. The studies using Indian data, which found inverse relationship, include that of Sen (1966); Mazumdar (1965); Saini (1971); Bharadwaj (1974); Chaddha (1978); Ghose (1979); Bhalla and Roy (1988) just to mention few. The studies which did not find inverse relationship or had inconclusive results include those of Bhattacharya and Saini (1972); Saini (1980); Bagi (1987); Deolalikar (1981) and Roy (1981). Dyer (1991) states that, the relation may hold in a relatively backward agriculture, but it breaks down with the advancement in technology.

Hossain (1977); Berry and Cline (1979) and Herdt and Mandac (1981) found the inverse relationship to hold in Indonesia, the Philippines and Bangladesh respectively. Studies using efficiency analysis in developing countries have also shown mixed results of the kind found in studies discussed above that have used the size and productivity relationship to resolve the debate. In case of Indian agriculture, Khusro (1964); Sahota (1968); Sidhu (1974); Huang and Bagi (1984) and Kalirajan (1991) concluded that productive efficiency did not differ across different farm size categories. Yotopoulos, *et al.* (1970); Yotopoulos and Lau (1973) and Bagi (1987) found negative relationship between farm size and efficiency. Bravo- Ureta and Evenson (1994) and Pinheiro (1992) found no relationship between farm size and efficiency in agriculture sectors of Paraguay and the Dominican Republic, respectively.

2.10 Measuring Farm Size

Obtaining a universally accepted definition of farm size has been one of the problems encountered in farm size and efficiency studies (Mbowa and Nieuwoudt, 1998). A review of literature, however, suggests that numerous definitions of farm size have been adopted, ranging from acreage, value of farm products sold, days worked off-farm (for small-scale farms), level of farm income, to the level of total family income (Mbowa and Nieuwoudt, 1998). Farm size has commonly been taken to be synonymous with farm acreage because it can easily be ascertained and is easy to understand (Mbowa and Nieuwoudt, 1998).

However, Britton and Hill (1975) state that when it becomes necessary to specify the criterion of size of a farm as a business, acreage is shown to be rather an unsatisfactory indicator of business size. This is because the proportions in which land and other factors (labour, capital and so forth) combine in production vary between types of farming and also between farms of the same type. Britton and Hill (1975) argue that the 'best' unit of measurement of farm size and size of enterprises within farms will depend on the purpose for which the measurement is to be used. Kay (1981) suggests that the number of acres should be used only to compare farm sizes in a limited geographical area where farm type, soil type, and climate are very similar. In this study, area operated was used as a measure of farm size as agricultural potential appears fairly homogeneous in the area. In most cases land can be measured per household or per capita. Measuring land holding per capita shows how accurately the households are either land rich or land poor (Jayne *et al.,* 2003). Huang (1973) questions whether average farm size variation is a purely random phenomenon, primarily determined by non-economic variables such as laws of inheritance, historical consequences of landlord-tenant relationships, or government policies restricting or increasing area operated.

2.11 Property Right

Variants in forms of land tenure cause a range of optimal farm size in countries at various stages of economic development (Heady, 1971). Tenancy and small-sized farms are generally related in terms of the problems that they generate (Medina, 1980). Communal land tenure creates incentive problems to invest in land improvements, and tenancy arrangements that restrict farm sizes affect farm productivity (Lyne and Nieuwoudt, 1991).

Some authors (e.g. Johnson, 1972; Barrows and Roth, 1990) state that the traditional African system of 'communal' land tenure has been empirically demonstrated by economists as inefficient when land has scarcity value. Since property rights are not broad enough, costs and rewards are not internalized, and contracts are not legal or enforceable (Barrows and Roth, 1990). Individualized freehold tenure, on the other hand, is viewed as superior because owners are given incentives to use land efficiently and leads to the maximization of agriculture's contribution to social well-being (Barrows and Roth, 1990). Johnson (1972) further argues that in situations where individuals cannot sell land, the value of investment to the farmer declines because of lost flexibility in converting a fixed-place asset into another asset form.

2.12 Land Tenure and Customary Land Rights in Tanzania

Landholding in Tanganyika before colonialism was based on customary laws and land title based on tradition and customs of the respective ethnic groups. Generally, land ownership was communal, owned by families, clans or ethnic groups whereby chiefs, headmen and elders had the powers of land allocation and confiscation, especially for the public interests (Fimbo, 2004).

These powers continued through the colonial era though they were limited by the newly introduced German and later the British land tenure system under which all lands were declared to be crown or public land respectively. To date, the customary land tenure is still in place, but since 1963 the chiefs, headmen and elders have been replaced by elected village councils. Tanzania was under German colonial rule from 1884 to 1916 and under British rule from 1917 to 1961. The country attained its independence in 1961.

Tanzania's historical experience points to the fact that land control by communities was more of concern than land ownership prior to colonialism. Since there was abundant land available for everybody's needs, the issues of having land for use and production by each homestead were given priority over ownership. Also history reveals that community leadership in whose hands land was vested guaranteed access. Land tenure security was therefore, not individualized but was provided in a collective way through clan and ethnic leadership, Ngeregere (2008).

Tanzania undertook land tenure reforms in 1990s. A Presidential Commission of Inquiry into Land Matters, established in January 1991, submitted its report in November 1992 and a National Land Policy was passed in 1995 and new land laws were enacted in 1999. The new laws reaffirmed that all land in Tanzania would continue to be public land, vested in the President as trustee for, and on behalf of, all citizens of Tanzania. Land was categorized as: general land, village land and reserved land. The law establishes a certificate for village land and designates the elected Village Council as trustee for land. Most land in Tanzania is held under customary tenure arrangement with rules and institutions specific to various ethnic groups and geographies. Statutory law and in some places Islamic law also govern land administration. Individual households' plots are registered as individual customary holdings but land is held and registered by the village (Fimbo, 2004). Land allocated by a village council "whether made under and in pursuance of a law or contrary to or in disregard of any law" is confirmed to be held under customary right of occupancy (Fimbo, 2004). These provisions have promoted the holder of customary right of occupancy from a bare licensee to a rights holder.

2.13 Measures of Farmer's Welfare

There are several approaches used to measure the welfare of farmers. These include income, asset and expenditure based measures. Income is generally considered less desirable than consumption-based measures of welfare, but in a situation where there is no record keeping and continuity of data, income is the welfare indicator that is easy to recall and its availability is consistent (Jayne *et al.*, 2003). This study adopted income as a measure of welfare. Jayne *et al.* (2003) defined household income as "the net value of income earned by resident household members from January to December. It includes retained production, agricultural sales and micro-enterprise income minus the cost of purchased agricultural inputs and non-family labour. This is the very definition employed in this study. The income from perennial crops earned in that year and livestock and their products sold in the very year as well as land rents and remittances were accounted.

2.14 Measures of Agricultural Land Productivity

Agricultural productivity has been differently defined by several scholars with reference to their own views and disciplines. The most outstanding ones are agriculturalists, agronomists, economists and geographers. For example, economists define agricultural productivity as output per unit of input or output per unit of land (Dharmasiri, 2008). Agricultural productivity may be defined as the ratio of index of agricultural output to the index of total input used (land, labor and capital) (Dharmasiri, 2008). Land productivity is a very important factor in agriculture; it is the most permanent and fixed factor among the three categories of input; land, labor and capital (Dharmasiri, 2008; Dharmasiri, 2010).

Productivity measures the ability of an input to produce a certain level of output (Harsh *et al.*, 1981). Agricultural land productivity shows how efficient a farmer is in the use of that particular input, given the range of alternative technologies at exposure. The productivity measure is given by the average physical product of the input which itself is defined as total physical product divided by the total amount of the input used in production (Ellis, 2003). Productivities are usually multiplied by the output price. Farm productivity can be calculated for one or several crops. For one crop, physical product will be preferred to value products while for multiple crops; aggregation is required using product prices and thus the preference for the value product (Ellis, 2003).

2.15 *Kilimo Kwanza* and Other Agricultural Initiatives in Tanzania

Kilimo Kwanza (Agriculture First) is a national slogan to elaborate nation's commitment to accelerate agricultural transformation. It comprises a holistic set of policy instruments and strategic interventions towards addressing the different sectoral challenges and taking advantage of the numerous opportunities to modernize and commercialize agriculture in Tanzania (Ngaiza, 2012). *Kilimo Kwanza* is comprised of ten pillars for implementation and it is the pillar number five from which this study is founded. The ten pillars are: National vision, Financing, Institutional reorganization for management, Paradigm shift to strategic framework, Land access, Incentives, Industrialization, Science and technology and human resources, Infrastructures development and Mobilization of Tanzanians. Pillar number five (Land for *Kilimo Kwanza*) mainly dealt with land access issues and Village Land Act No. 5 of 1999 was the focus of the pillar (Ngaiza, 2012).

Other initiatives implemented over the past years with the aim to improve the performance of the agriculture sector in the country include strategic frameworks such as Tanzania Development Vision 2025 (TDV 2025), National Strategy for Growth and Reduction of Poverty (NSGRP/MKUKUTA and ZSGRP/MKUZA), Agricultural Sector Development Strategy (ASDS), Agricultural Sector Development Programme (ASDP), Comprehensive Africa Agriculture Development Programme (CAADP), Tanzania Agriculture and Food Security Investment Plan (TAFSIP) and Southern Agricultural Growth Corridor of Tanzania (SAGCOT). All have been putting emphasis on agricultural transformation from subsistence to commercial one.

Tanzania adopted the ASDS in 2001, the ASDP in 2003, and the Agricultural Sector Investment Programme in 2005 – though all the cases progress in implementation was slow. *Kilimo Kwanza* was declared in 2009 as a means of accelerating the implementation of existing approaches and programmes regarding the modernization of agriculture. *Kilimo Kwanza* is a strategic programme that is focused on increasing agricultural output and strengthening food security in Tanzania. It is anchored on ten pillars among, which is land. Land distribution and allocation has been identified as Pillar No. 5 of *Kilimo Kwanza*. *Kilimo Kwanza* and ASDP have similar objective. One of the objectives of *Kilimo Kwanza* was to modernize and commercialize agriculture for peasant, small, medium and large scale producers through emphasis on productivity and tradability which is much similar to the ASDP objective of sustaining agricultural growth rate of 5% per annum primarily through the transformation from subsistence to commercial agriculture (ASDP, 2003).

CHAPTER THREE

3.0 RESEARCH METHODOLOGY

3.1 Conceptual Framework for the Study

The conceptual framework for this study consists of two main components: the independent and dependent variable identification and description. The components were used to analyze the impact of land size and farm fragmentation on agricultural productivity and household income. The independent variables represent a portfolio of livelihoods capital that farmers are endowed with. These include human capital (education, age, marital status, sex and nativity), natural capital (land), physical capital (machinery and structures), and financial capital (income). All these independent variables constitute the building blocks from which livelihood is constructed. The variables are essential for the pursuit of any livelihood strategy and can be used for analyzing land issues as key variables that explain how land is accessed and utilized.

Land rights, like any other property rights, are social conventions backed up by the power of the community at different levels from village to national level that allow individuals or households to access land. The government plays an important role of overseeing land accessibility, land tenure security and the ability to share the right to others through inheritance, borrowing, renting or purchasing. Land access causes subdivision of parcels widely scattered over long walking distances. The outcomes of land access and farm fragmentation are largely reflected through agricultural productivity and household welfare. These effects are well captured in the conceptual framework presented in Fig. 1.

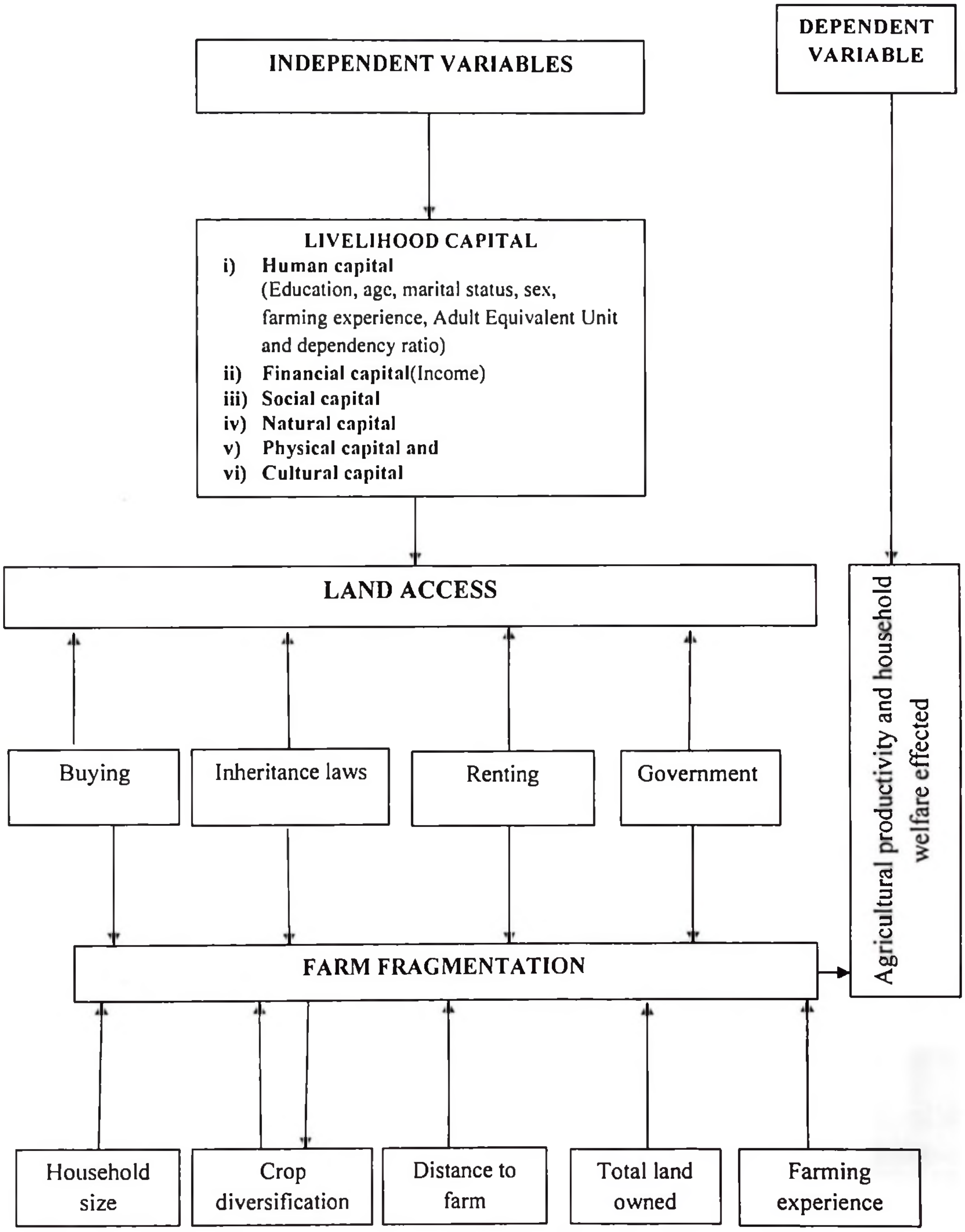

Figure 1: Conceptual framework for the study

3.2 Description of the Study Area

3.2.1 Location and size

Kilosa District (Fig. 2) is one of the six districts that constitute Morogoro Region. The district is located in East Central Tanzania, 300 km West of Dar es Salaam and is found between latitudes 5°55' and 7°53' South of the Equator and between longitudes 36°30' and 37°30 East of the Greenwich. The district borders Mvomero District to the East, Kilombero and Kilolo Districts to the South, Kiteto District (Manyara Region) and Kilindi District (Tanga Region) to the North; and Mpwapwa District (Dodoma Region) to the west.

Kilosa District covers a total area of 14 245 km^2, of which 536 590 ha (5365.9 km^2) are suitable for agriculture, 483 390 ha are under natural pasture, 323 000 ha are covered by Mikumi National Park, 80 150 ha are covered by forests and 14 420 ha are urban areas, water and swamps (Kimaro, 1989).

3.2.2 Socio economic profile of Kilosa District

Kilosa District is endowed with geographical factors that favour agricultural activities including livestock keeping. With her abundant rivers and water streams, most part of the district is green almost all year round, experiencing influx of peasants and pastoralists from various arid parts of Tanzania. Shinyanga, Dodoma, Arusha, Singida, Mwanza, and Tanga are amongst the regions that make a portion of immigrants to the area. Pastoralists from Ihefu wetland in Mbeya region who were evicted without preparations for alternative resettlements added to increased population of the district (Bernard *et al.*, 2008). The major crops grown in Kilosa District are paddy, maize, beans, cassava, sweet potatoes, ground nuts, coconut, cowpea, pigeon pea, banana, sisal, sugar cane, cotton, sunflower, sorghum, okra, onion, tomatoes, amaranth, sesame, oranges and mangoes.

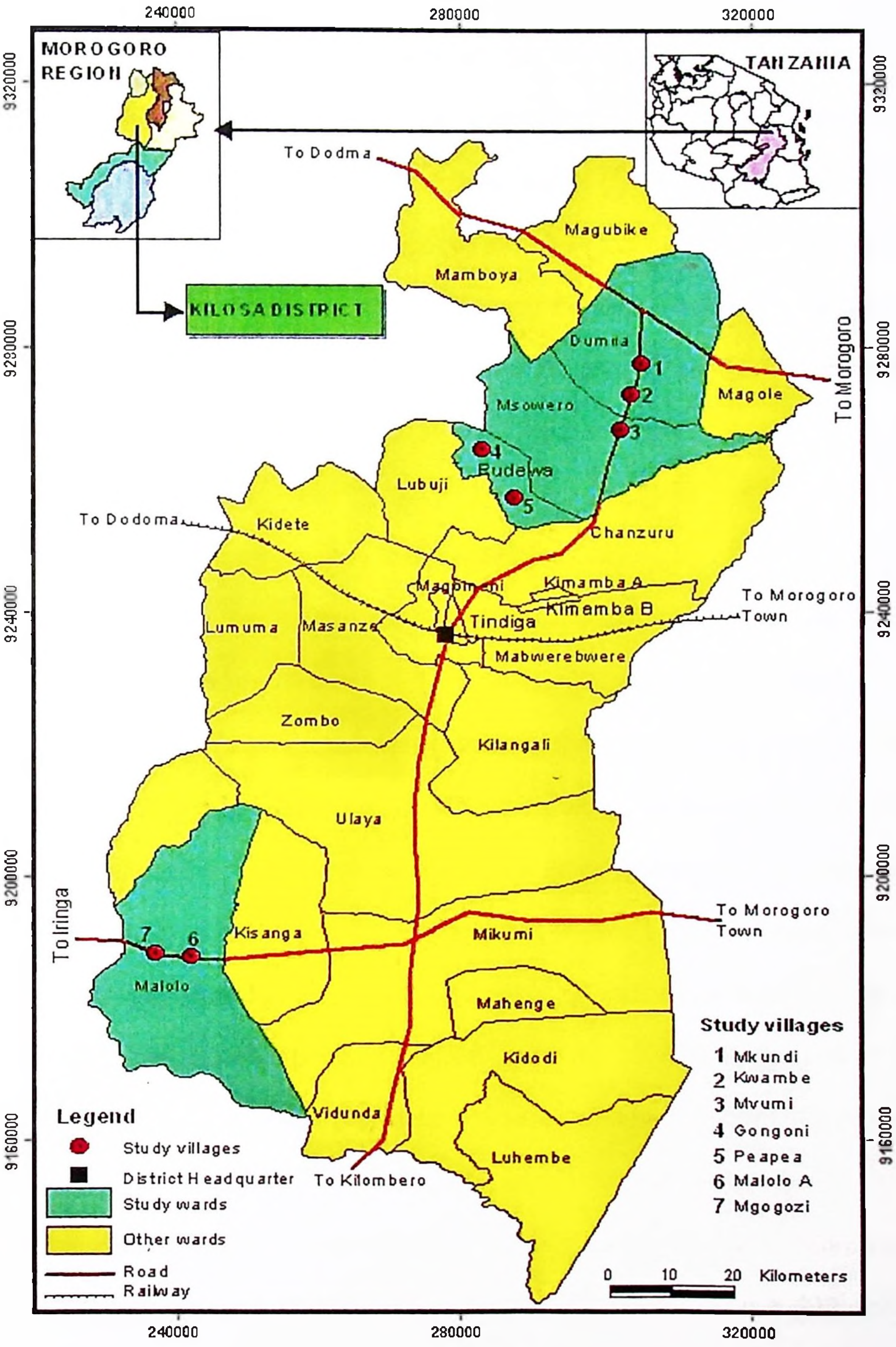

Figure 2: Map of Kilosa District showing the study area

According to the 2012 Population and Housing Census (PHC), the district's population is 438 175 persons (NBS, 2013) out of whom 218 378 were males and 219 797 were females, with an average of 4.2 persons per household. The district has a population density of 30.75 persons per km^2, which is slightly below the national average of 51 persons per km^2 and the average for Morogoro Region (31 persons per km^2). According to agriculture sample census 2007/2008, the majority (55%) of the 120 800 agricultural households in Kilosa District are engaged in crop farming. The district farming land is more populated, with a population density of 44.91 persons per km^2, compared to the overall district population density of 30.75 persons per km^2 (NBS, 2013).

3.2.3 Selection of the study area and justification

In 2009, Morogoro Region was declared a national grain basket by His Excellence President Jakaya Mrisho Kikwete (Ihucha, 2009). Kilosa being not only one of the districts found in Morogoro region but also among the districts with a great potential for economic development in Tanzania was therefore selected for this study. The district has comparatively higher income compared to many other districts in the country (PHDR, 2005). For instance in the year 2007, based on Tanzania Mainland contribution to the Gross Domestic Product of Tanzania, Kilosa ranked 6th with a contribution of 5.4 percent. Also, according to the Agriculture Sample Census of 2007/2008, the district had the highest number of agricultural households in Tanzania Mainland (120 800), of which (71 022) were crop producing households, constituting the largest number in Morogoro region compared to other districts (e.g. the agricultural households in Morogoro Rural were 88 453, Mvomero 56 520, Ulanga 35 535, Morogoro urban 6 312 and few in Kilombero). Households engaged in crop production in urban areas were few since the majority were engaged in other economic activities like wage employment and trade. The low number of the households engaged in crop production in Kilombero may be associated with presence of sugar industry and influx of farmers from town who cultivate in the area but do not reside there. The district was also selected to be among the pilot districts for implementation of the *"Kilimo Kwanza"* initiative in Tanzania.

3.3 Sampling Procedure

The study employed a cross-sectional research design which enabled the researcher to collect data at a single point in time. According to Babbie (1990), this design is the most appropriate for household surveys as it facilitates identification of the population of interest and is cost effective and less time consuming. The cross-sectional research design was adopted in order to get qualitative and quantitative information. The technique is recommended for descriptive studies and more specifically for studies that analyze the relationships between and among variables at a particular point in time (Babbie, 1990 and Bailey, 1998).

The study was conducted in three divisions (Kimamba, Magole and Mikumi) out of nine registered divisions in Kilosa District before establishment of Gairo District which dissolved the Gairo division. However, the used demographic data of Kilosa District such as population, agriculture sample census and land size of the study area included the then Gairo division. The divisions, wards and villages were purposively selected basing on the existence of irrigation infrastructure which influenced land demand. Irrigation infrastructures increase land value which leads to farm apportioning among the farmers who buy or rent it. This study consisted of three different strata of farmers, namely those who a) do not irrigate, b) irrigate by using traditional irrigation system, and c) irrigate by using the modern irrigation system. Farmers in Kimamba use traditional irrigation systems while in Mikumi farmers use improved irrigation systems. Farmers in Magole do not use irrigation, but the division was selected in order to attain representativeness of the three strata of the study. The sample wards were Rudewa, Msowero, Dumila and Malolo and the sample villages were Peapea, Gongoni, Mvumi, Kwambe, Mkundi, Mgogozi and Malolo A. Both wards and villages were selected randomly from the strata they belong.

The sampling frame constituted households undertaking agricultural activities in seven villages of Kilosa District. The list of households undertaking agricultural activities in 2011/2012 cropping season were obtained from the village leaders. From the village registers, the sample households were randomly selected. The unit of analysis was a household, which is defined by URT (2003) as a person or group of individuals who live, eat together and share common living arrangements. The heads of household were interviewed because they were considered as the ultimate and main decision makers for the land use and other farm operations.

3.4 Determination of Sample Size

The determination of sample size is an imperative aspect in research. The sample size needs to be statistically adequate. Several authors have recommended a minimum sample size of at least 5% of the study population; provided that the sample size is not less than 30 units (Bailey, 1998). The sample size for this study was at least 30 respondents per stratum resulting to a total sample size of 150 household head respondents.

3.5 Data Collection

Both primary and secondary data were collected from the study area. The secondary data such as population, crop prices and area under crop production, were obtained from key informants [District Agricultural and Livestock Development Officers (DALDOs), farmers, Village and Ward Extension Officers, village government leaders, leaders of farmers and village elders].

The primary data were collected using a structured questionnaire (Appendix 1) whereby both qualitative and quantitative data were gathered. The questionnaire contained both closed and open ended questions and was used to collect information about household characteristics, land ownership, number of parcels owned, parcel size, household income and agricultural production. To verify the accuracy of the land area household declared in their possession, the parcels were physically counted and measured using a handheld Global Positioning System (GPS) device with area calculation capability on completion of any enclosed walk.

3.6 Data Analysis

The analysis of data in this study was done based mainly on descriptive statistics including computation of means and percentages complemented by the use of Analysis of Variance (ANOVA), Pearson product-moment correlation and multiple regression models. The latter was used to evaluate the effects of farm fragmentation on agricultural productivity, identifying the main causes or factors which determine or influence land access and farm fragmentation in the study area. A T-test was conducted to ascertain if there were significant differences between some variables, and Analysis of Variance was used to identify the source of variation in land size and farm fragmentation issues.

3.6.1 Analysis of factors that determine land size

A multiple linear regression model was used to assess the factors that determine size of land used by household. Land size was measured in terms of per capita as follows:

$$\frac{Land}{N} = \frac{Area}{N} \qquad (1)$$

Where N = household size

Hypothesis 1:

H_o: household socio-economic, demographic, soil quality and agricultural factors have no effects on household land size

H_1: household socio-economic, demographic, soil quality and agricultural factors have effects on household land size. This hypothesis was tested using the following multiple regression model:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_9 X_9 + \varepsilon_i \quad (2)$$

Where $Y =$ Land size in hectare per capita used by household

The *statistical* hypotheses for the above model were:

$$H_0 : \beta_1 = \beta_2 = \beta_3 = ... = \beta_9 = 0 \quad (3)$$

$$H_1 : \text{At least one of the } \beta_s \neq 0 \quad (4)$$

For multiple regressions, the valid sample size (N) should be large enough such that (Pallant, 2005): $N \geq 50 + 8m$ .... (5)

Where m is the number of independent variables to be included in the model. The variables used in the multiple regression analyses are presented in Table 1.

Table 1: Variables used in the Multiple Regression for household land size

Variable	Definition	Measure	Expected sign
X_1	Annual household income	(TAS)	+/-
X_2	Perceived soil quality	1If good, 0 otherwise	+
X_3	Sex of household head	1 If male, 0 female	+
X_4	Years in school for household head	Number of years	+
X_5	Adult equivalent unit	Continuous	+
X_6	Age of household head	Number of years	+/-
X_7	Mode of land acquisition	1 Inheritance, 0 otherwise	-
X_8	Origin of household head	1 If native, 0 otherwise	+
X_9	Time spent to parcel	Minutes	+

3.6.2 Farm fragmentation

Hypothesis 2:

***H_0*: household socio-economic, demographic, soil quality and agricultural factors have no effects on farm fragmentation**

***H_1*: household socio-economic, demographic, soil quality and agricultural factors have effects on farm fragmentation.**

This hypothesis was tested using multiple regression models. A multiple linear regression model was used to determine the causes of farm fragmentation. Farm fragmentation in this study was measured by three fragmentation indicators (Simpson index, number of parcels owned, and average parcel size).

$$Y_{i1} = \beta_0 + \beta_1 X_1 + ...+ \beta_8 X_8 + e_i \quad (6)$$

$$Y_{i2} = \beta_0 + \beta_1 X_1 + ...+ \beta_8 X_8 + e_i \quad (7)$$

$$Y_{i3} = \beta_0 + \beta_1 X_1 + ...+ \beta_8 X_8 + e_i \quad (8)$$

Where:

Y_{i1} = Simpson Index (SI)

Y_{i2} =Number of parcel owned

Y_{i3} = Average parcel size

The *statistical* hypotheses for the above model were:

$$H_0 : \beta_1 = \beta_2 = \beta_3 = ... = \beta_8 = 0 \quad (9)$$

$$H_1 : \text{At least one of the } \beta_s \neq 0 \quad (10)$$

The variables used in the multiple regression analyses of farm fragmentation are presented in Table 2.

Table 2: Variables used in the Multiple Regression for farm fragmentation

Variable	Description	Measure	Expected sign
Y	Land fragmentation	(SI, number of parcels, average parcel size)	
X_1	Sex of household head	(1= male, 0 = female)	
X_2	Age of household head	Years	+
X_3	Agricultural training for household head	(1= trained, 0= not trained)	-
X_4	Origin of the household head	(1= native, 0 = immigrant)	+/-
X_5	Annual household income	TAS	+/ -
X_6	Number of crops planted	Number	+
X_7	Perceived soil quality	1 = good, 0 = poor	+
X_8	Mode of land acquisition	1 = inherited, 0 = otherwise	+
X_9	Adult equivalent unit	Number	+
X_{10}	Marital status of household head	1 = Married, 0 = otherwise)	
X_{11}	Education level of household head	Number of years in school	-
X_{12}	Average travel time	Minutes	+
X_{13}	Total owned land per capita	ha/capita	+
X_{14}	Whether irrigates	1 = yes, 0 = no	+
X_{15}	Total arable land per capita	ha/capita	-

3.6.3 Relationship between land size and household income

The Pearson product-moment correlation was used to explore the strength of relationship between household land size and household income. As indicated by Pallant (2005), linearity, normality, homoscedasticity and presence of outlier were checked before running correlation analysis in order to meet correlation assumptions. Pearson correlation provides both direction (positive or negative) and the strength of relationship. A positive correlation indicates that as one variable increases, so does the other. A negative correlation indicates that as one variable increases, the other one decreases. This test is applied for interval level (continuous) variables. It can also be used if one variable is continuous and the other variable is dichotomous. It is possible to compute the coefficient of determination, and also examine the effective size of the correlation.

Hypothesis 3:

***H_o*:** No correlation between household land size and household income.

***H_1*:** There is correlation between household land size and household income.

The statistical hypotheses for the above model were:

$$H_0 : r = 0 \quad \text{(11)}$$

$$H_1 : r \neq 0 \quad \text{(12)}$$

3.6.4 Relationship between farm fragmentation and agricultural productivity

The approach used was to first explore the relationship between land fragmentation indices (Simpson Index, parcel size and number of parcels) and agricultural productivity. Correlation analysis provides an indication that there is a correlation between two variables. It does not, however, indicate that one variable causes the other. This implies that correlation is not the same as causality. Many authors (e.g. Pallant, 2005) have argued convincingly that there are a number of factors to consider when interpreting a correlation coefficient: non-linearity relationship, presence of outliers, restricted range of score, and statistical versus practical significance.

The second step was to carry out a multiple regression analysis of agricultural productivity (the dependent variable) against the factors considered to influence farm fragm ıtation (the independent variables). The following standard multiple regression mode! ,vas used:

$$Y = \beta \quad + \beta_1 X_1 + \beta_2 X_2 + \ldots + \beta_k X_k + \varepsilon_i \ldots\ldots (13)$$

Wher

$Y =$ A ricultural land productivity (Tanzania shillings per hectare)

Varioı s statistical hypotheses were tested here:

$$H \quad : r = 0 \ldots\ldots (14)$$

$$H \quad : r \neq 0 \ldots\ldots (15)$$

$$H \quad : \beta_1 = \beta_2 = \beta_3 = \ldots = \beta_k = 0 \ldots\ldots (16)$$

H : At least one of the $\beta_s \neq 0$ ……(17)

3.7 Predictive Modelling

There ıre several steps used to predict models depending on the purpose of modelling (Mosl y, 2005; Oracle, 2008). The principle of parsimony in predictive model constr ction is necessary to improve prediction. In social science research, there are five basic ways of selecting variables to explain dependent variables in a regression model (Schu rman, 1983). Harrell (2008) hypothesized that, in order to avoid over-fitting, the follow ng situation should be met:

$$P < \frac{\,}{1} \ldots\ldots (18)$$

Wher p is the number of parameters in the full model or candidate parameters in the step-v se analysis, n is the sample size i.e. the valid cases included in the model. For examj e, in this study where the sample size was 150, the maximum number of the param ters (p) in the regression models should be 9. The five ways of selecting the parameters to be included in any regression model are narrated as follows: one way is to compute a separate regression equation for every possible subset of independent variables and then select the equation with relatively large R^2 and relatively few variables. Generally, this approach is very cumbersome, for example with p independent variables there are 2^p-1 possible equations. So this approach is rarely used, and was not used in this study.

Another way is to look at the ordinary correlation of each independent variable with the dependent variable (zero order correlation) and then select those with high correlation. Unfortunately, this approach fails to take into account the fact that these correlations may overlap. This approach also was not used in this study.

Another approach is the use of the stepwise method which is basically a refinement of the forward inclusion method. It is possible that a variable that entered at one step becomes insignificant at another step when other variables are entered. Hence, in the stepwise method, all the variables already in the equation are checked when a new variable enters, and if a variable becomes insignificant, it is then removed.

In adopting a forward inclusion approach, an equation is built up in a number of steps in which one variable at a time is selected to add to the equation. The first variable is the one with the highest zero order correlation. An addition of variable increases R^2 and the process continues until none of the remaining variables would add significantly to the prediction equation.

A use of backward elimination approach is considered to be relatively simple but an effective way whereby the first equation is computed with all the variables entered to check their significance levels and the least significant one is removed and a new equation is computed. This process continues until all the remaining variables are significant. Chatterjee and Price (1977) assert that the procedure is terminated when all the t-ratios are significant or all but one variable has been deleted. This approach was adopted in this study.

Chatterjee and Price (1977) recommend the backward elimination approach over the forward inclusion technique for two main reasons; firstly, the procedure calculates the equation with the full variable set; thus all variables can be inspected, even though they may not be used in the final equation. Secondly, the backward elimination approach is better because it is capable of handling multicollinearity than the forward inclusion technique.

Multicollinearity was checked through computation of tolerance and Variable Inflation Factors (VIF). According to Landau and Everrit (2004), tolerance values of not less than 0.1 and VIF values not more than 10 are appropriate to show that there is no multicollinearity. No tolerance values of less than 0.1 or VIF values greater than 10 were found; the findings hence indicated nonexistence of multicollinearity. The correlation matrix also was used to gauge the presence of multicollinearity ($r \geq 0.8$ which signifies the existence of multicollinearity) (Garson, 2007). The problem of autocorrelation was also tested through computation of a Durbin-Watson with reference value of 2 indicating either no autocorrelation or ignorable autocorrelation (Pedroso *et al.*, 2014). However, the results of analysis showed the Durbin-Watson value of approximately 2 suggesting absence of serious autocorrelation problems. The lack of autocorrelation shows that the observations in this study were independent of each other.

The testing of endogeneity problem was taken more seriously in the analysis to avoid arriving at an inconvenient truth which would eventually be misleading. Generally, a lot of constructs of interest mainly in social sciences are hardly ever perfectly observed because measurements of such constructs do inevitably include a good degree of measurement error. During this study, the measurements were carefully taken using high precision instruments such as Garmin Hx GPS for measuring the area of even the irregularly shaped farms. Moreover, during data analysis, the two Stage Least Squares (2SLS) estimates were compared to the estimates of Ordinary Least Squares (OLS) as a means to test whether endogeneity existed. This approach is one of the most effective and resourceful tools available for testing endogeneity problem (Antonakis *et al.*, 2010). By using both of these models into all equations it was found that there was no significant difference between the two sets of estimates, indicating that the estimates obtained through OLS were consistent meaning that there was no endogeniety problem which existed. The two regression models, OLS and 2SLS, were necessarily deployed together as they complement each other. Normally, OLS model is efficient but not consistent while 2SLS is not efficient but consistent (Antonakis *et al.*, 2014). Therefore, it should be noted that this much valued consistency from 2SLS estimation does come at the expense of some sort of inefficiency. All these were carried out to ensure that valid inferences are arrived at.

3.8 Determination of Adult Equivalent Units

In cognizant of the fact that if variables like income, land and dietary energy consumed are expressed in terms of the per capita they may not reflect realistic figures especially when one makes a comparison involving households with different family sizes as well as age and sex compositions. In this study land access and ownership was expressed in the per adult equivalent units. To calculate the adult equivalent units, the sex and age of every household member must be known first (Appendix 2). Then a two step procedure is followed. In the first step adult equivalent scales for East Africa (Appendix 3) by age and sex are added up for all household members to get all the household members in terms of adult equivalents Deaton (1980), cited by Collier *et al.* (1990). The second step involves adjusting the above adult equivalents for economies of scale (Appendix 4) due to the fact that larger households need fewer amounts of resources per person due to sharing some facilities Deaton (1980), cited by Collier *et al.* (1990).

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

4.1 Demographic Characteristics

The key demographic characteristics of the sample households are presented in this section. These include age of the heads of household, marital status, sex, occupation, agricultural training, as well as education and farming experience.

The ages of the household heads ranged from 21 to 80 years, with the mean age of 45.89 years and the standard deviation of 13.09. There were household heads who had not attended school at all and others who had attended up to 15 years in school, with mean years in school of 6.29 and the standard deviation of 2.9. Moreover, household heads had an average of 14.38 experiences in farming (Table 3).

Table 3: Age, years in school and farming experience of household heads

Variable	n	Minimum	Maximum	Mean	Std. Deviation
Age	150	21.00	80.00	45.8933	13.09037
Years in school	150	0	15	6.29	2.911
Years in farming	150	1.00	51.00	14.3800	12.36127

Household heads were classified into three categories basing on their age (Table 4), to represent the three common age groups, namely youth, middle group and elders. Age is an important parameter in social analysis since people of different age groups perform different sets of activities in most societies (Overholt *et al.*, 1991). Also age can be seen as a function of knowledge and experience as well as the measure of maturity of an individual. The majority 64.7% were between 20 and 50 years old. This implies that the majority of farmers were adults who actively engage in production activities with the role and responsibility to their family and society in general. Household heads with age above 30 years old and below 50 years are likely to have more access to land than those who are 30 years old or younger. As the household heads becomes older, family labour decreases as children leave home and start their own life, access to land decreases to about the same quantity as at age of 30 (Jayne *et al.*, 2003). About half of the household heads had more than 10 years of experience in farming (Table 4). Years of experience in farming were used to determine their effect on land productivity.

Table 4: Age and farming experience of household heads (n = 150)

Age categories	Percent
Young (20 – 35 years)	26.7
Middle (36 – 50 years)	38.0
Old (51 – 80 years)	35.3
Years in farming	
1 – 10	49.3
11 – 20	24.0
21 – 51	26.7

The majority of household heads (78.7%) had primary education; 13.3% were illiterates (had no formal education); 6.7% had ordinary level education and only 1.3% had college education (Table 5). The high level of education in the study area can be attributed to the deliberate effort made by government in 1978 to expand primary education in the country. It is compulsory for all children aged 7 to 14 years to attend a primary school (THDS, 1996). Education is an important parameter which enables the family to perform better in daily activities. The educated household heads are believed to perform better in agricultural activities as compared to uneducated household heads.

Table 5: Education level of household heads

Education categories (n = 150)	Percent
Illiterate	13.3
Primary	78.7
Ordinary level	6.7
Collage	1.3

Male headed households constituted the majority (88.7%) of population in the study area (Table 6). This confirms patriarchy, which exists in most of African societies and males are expected to dominate in decision making (Duze and Mohammed, 2006). Since men are influential in decision making, the type of land use will normally be determined by men who are also the land owners. In connection with this, in African culture, parents bequeath part of the land to their sons while this is not common for daughters hence male headed households are likely to have more access to land than female headed households (Jayne *et al.*, 2003).

Table 6: Sex of household heads (n = 150)

Sex	Percent
Male	88.7
Female	11.3

About 83% of heads in the study area were married (Table 7), while the rest were either widows, divorced, single or separated. In a married couple the responsibilities are likely to be high as compared to their counter parts due to increased responsibility attached to them. These include taking care of the families and the in-laws. Due to increased responsibilities, the married couples are expected to find ways of accessing more land and other natural resources in order to meet their livelihood needs (Jayne *et al.*, 2003).

Table 7: Marital status of household head (n = 150)

Marital status	Percent
Married	82.7
Widow	4.0
Divorced	1.3
Single	9.3
Separated	2.7

The results in Table 8 show that 76.3% of the households were engaged in agriculture. Not all household heads were also engaged in petty business, wage employment, casual labour, agro-pastoralist or pastoralist. Since the majority depended on farming activities, any improvement in land access could contribute to reduction of poverty at household level and national level at large.

Table 8: Main occupation of household heads (n = 150)

Occupation	Percent
Farmer	76.3
Pastoralist	0.5
Agro-pastoralist	1.0
Wage employment	7.2
Petty business	12.9
Casual labour	2.1

The average parcel size cultivated was 1.87 ha, which was smaller than the owned farm size 2.57 ha (Table 9). This implies that there was a possibility of expanding the area under cultivation. Also, the results in Table 12 show that the number of parcels owned ranged from 1 to 9 parcels with an average of 2.25 parcels per household. The average Simpson Index (SI) was 0.41, with a minimum of 0.0 and a maximum of 0.87. On average, time used from homestead to the parcels was 33.15 minutes, with a minimum time of 1 and a maximum of 180 minutes.

Table 9: Descriptive statistics for variables in farm fragmentation (n = 150)

Variable	Mean	Minimum	Maximum	Std. Deviation
Parcel size cultivated (ha)	1.87	0.15	7.44	1.407
Total land owned (ha)	2.57	0.10	16.20	2.999
Number of parcels owned by household	2.25	1	9	1.307
Simpson Index (SI)	0.41	0.0	0.87	0.271
Time from homestead to farm (minutes)	33.15	1.00	180.00	31.9765

4.2 Land Acquisition

4.2.1 Means of land acquisition

The leading mode of land acquisition in the study area was inheritance (40.6%) (Table 10), which have resulted into increased farm fragmentation. Many previous studies have also shown that inheritance is the main mode of land acquisition in developing countries (Ngeregere, 2008; Kajoba, 1994). As a general rule, women can acquire land through male connections and exercise only secondary or inferior rights which are susceptible to breakdown in relationships, divorce or disconnection. Other means of land acquisition in the study area are renting (22.6%), purchasing (19.1%), bush clearing (6.5%), government allocation (5.7%) and borrowing (5.4%).

Table 10: Mode of land acquisition (n = 150)

S/N	Mode of land acquisition	Percent
1	Inherited	40.6
2	Purchased	19.1
3	Borrowed in	5.4
4	Rented in	22.6
5	Government allocated	5.7
6	Bush clearing	6.5

4.2.2 Variation in land size

The difference in land size between and within divisions was determined using ANOVA. The results in Table 11 show low p-values, indicating that the major variation in land size

(92.75%) was due to factors within divisions whereas only 7.25% of the variation was caused by inter-divisional factors. Unequal land sizes within division is attributed to the presence of land access barriers such as inheritance laws (traditional practices of land allocation), land related conflicts, financial constraints and lack of knowledge about system and process of claiming land rights. However, based on an understanding that land in most African societies is allocated to adult males through inheritance, little variation could be expected if land were equally accessed. Several previous studies have also shown unequal land distribution in some African countries like in Zambia, Kenya, Rwanda, Mozambique and Ethiopia Jayne *et al.* (2003), unlike Lipton (1985) who reported equal land access in some developed countries. The effect of the land size and land access variation in the study area is shown in Table 12. The resulting level of variation (Eta squared) was 0.072, which, in Richardson (2011) terms, would be considered a medium effect size. Richardson classifies 0.01 as a small effect, 0.06 as a medium effect and 0.14 as a large effect.

Table 11: Analysis of Variance of land size in hectare per capita

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Between division	4.414	2	2.207	5.739	0.004
Within division	56.523	147	0.385		

Table 12: Variation of land size

Source of variation	Size of variation (%)	Eta squared	Effect size
Between division	7.25	0.072	Small
Within division	92.75		

4.2.3 Household land size

By analyzing a household's land access per capita, it is easy to verify whether or not the household has enough land. The results in Table 13 show a mean land of 0.49 hectare per capita when total land owned is considered. Table 14 shows cultivated land with a mean of 0.35 hectare per capita. However, agricultural productivity will depend on actual area cultivated or used to increase household income anyhow, including renting it out, and not merely owned land.

Table 13: Total land in hectare per capita

Village	Mean	Minimum	Maximum	Std. Deviation
Peapea	0.46	0.10	2.25	0.49
Gongoni	0.42	0.05	2.18	0.44
Mvumi	0.80	0.02	5.40	1.04
Kwambe	0.73	0.25	3.52	0.81
Mkundi	0.36	0.11	0.69	0.18
Mgogozi	0.24	0.06	0.54	0.14
Malolo A	0.19	0.02	0.51	0.15
Total	**0.49**	**0.02**	**5.40**	**0.64**

Table 14: Cultivated area capita

Village	Mean	Minimum	Maximum	Std. Deviation
Peapea	0.37	0.04	2.25	0.41
Gongoni	0.30	0.05	1.06	0.23
Mvumi	0.35	0.02	1.17	0.27
Kwambe	0.48	0.10	1.73	0.39
Mkundi	0.34	0.11	0.69	0.18
Mgogozi	0.35	0.12	0.82	0.20
Malolo A	0.34	0.05	1.21	0.32
Total	**0.35**	**0.02**	**2.25**	**0.30**

4.2.4 Determinants of land size

The correlation matrix for the candidate variables used in multiple regression analyses in determination of factors affecting household land size are presented in Table 15. In this study there was no regression coefficient (r) found to be greater or even equal to 0.8, hence indicating nonexistence of multicollinearility problem (Garson, 2007).

Table 15: Correlation matrix for multiple regression on household land size

	X1	X2	X3	X4	X5	X6	X7	X8	X9
X1		0.126	-0.121	-0.009	-0.069	-0.081	-0.031	-0.180	-0.044
X2			-0.101	-0.074	0.000	0.092	0.000	0.030	0.136
X3				0.144	0.088	-0.051	0.147	0.020	-0.176
X4					-0.101	-0.330	0.021	-0.039	-0.019
X5						0.164	0.038	0.071	-0.179
X6							-0.056	0.052	0.117
X7								0.498	-0.116
X8									-0.056
X9									

The results show that the performance of regression model was statistically significant ($p < 0.01$). Inspection of all collinearity statistics as well as examination of correlation coefficients in the correlation matrix (Table 16) suggests that there was no existence of multicollinearity. The results also show the Durbin-Watson statistic value of 1.821 which was between the recommended ranges of 1.5 to 2.5, suggesting that the observations were independent. The descriptors which were statistically significant determinants of household land size include adult equivalent units ($p < 0.01$), age of household head ($p < 0.01$) and annual household income ($p < 0.01$). It is evident from the results of analysis that the age of household head, annual household income, perceived soil quality, and sex of household heads were positively correlated with household land size while education level, mode of land acquisition, origin of household head, and average travel time) correlated negatively with household land size.

Age is an important parameter in determining the duration of settlement in a particular area hence enough time to accumulate land. Not only that, but also household heads with age between 30 and bellow 50 years of age are likely to have more access to land than younger ones because family labour is a function of age; elders have more family labour, *ceteris peribus*. As the head of household becomes older, family labour decreases as children leave home and start their own life; the access to land decreases (Jayne *et al.*, 2003). The decrease in land size at the age of 50 years and above is also due to land been given to the heirs through inheritance.

The results showed that household income increases the possibility of accessing more land as it determines the power of purchasing land or renting in land. Other studies in Eastern and Southern Africa obtained similar findings whereby income was found to have strong correlation with land size (Jayne *et al.*, 2003).

Adult Equivalent Unit analyzes the family composition by considering number, sex, different proportions of adults and children, calorific consumption and economies of scale (Jayne *et al.*, 2003). The higher the AEU, the more the land required to meet the household calorific needs. The findings of this study show negative effect of land size with AEU. The negative effect implies that the bigger the family (AEU) the less the land accessed. This causes some households to become land constrained. The mode of land acquisition (inheritance) in the study area caused the inverse relationship between land size and AEU observed because the sons inherit land from their parent irrespective of the size of the family owned or expecting to have.

Table 16: Factors affecting household land size

Predictor	Beta	T	Sign	Correlation			Collinearity statistic	
				Zero order	Partial	Part	Tolerance	VIF
X_1 (Household income)	0.219	2.744	0.007***	0.181	0.226	0.209	0.910	1.099
X_2 (Perceived soil quality)	0.039	0.497	0.620	0.076	0.042	0.038	0.949	1.054
X_3 (Sex of the household head)	0.113	1.414	0.160	0.028	0.119	0.108	0.903	1.108
X_4 (Years in school of hh head)	-0.010	-0.127	0.899	-0.063	-0.011	-0.010	0.869	1.151
X_5 (Adult equivalent units)	-0.272	-3.421	0.001***	-0.203	-0.278	-0.261	0.915	1.093
X_6 (Age of the household head)	0.275	3.310	0.001***	0.216	0.269	0.252	0.839	1.192
X_7 (Mode of land acquisition)	-0.135	-1.500	0.136	-0.166	-0.126	-0.114	0.720	1.389
X_8 (Origin of household head)	-0.037	-0.409	0.683	-0.143	-0.035	-0.031	0.710	1.408
X_9 (Average travel time)	-0.031	-0.382	0.703	0.044	-0.032	-0.029	0.900	1.111

$R^2 = 0.188$

$R^2adj = 0.135$

D-W=1.821

4.3 Variation in Household Annual Income

The variation in annual household income between and within division was analyzed using ANOVA, and the results are presented in Table 17. The size of income variation was then estimated by calculating the level of variation (Eta squared) and comparing it to the values given in Richardson (2011) to evaluate the size effect (Table 18). The low p-values observed was an indication that the major variation in annual household income (91.1%) was due to factors within divisions and only 8.9% variation was caused by the factors between divisions. This type of variation in income within divisions indicates that there are households with small parcels of farms. Other studies done elsewhere in other African countries showed unequal distribution of income within the society (Jayne *et al.*, 2003).

Table 17: Results of Analysis of Variance for annual household income (TAS)

Source of variation	Sum of Squares	df	Mean Square	F	Sig.
Between division	1.529E13	2	7.644E12	7.174	0.001
Within division	1.566E14	147	1.066E12		

Table 18: Variation of household annual income

Source of variation	Size of variation (%)	Eta squared	Effect size
Between division	8.9	0.089	Medium
Within division	91.1		

4.3.1 Relationship between land size and household income

The findings from this study showed a positive correlation between land size and household annual income ($r = 0.181$). The results of analysis showed that income was decreasing with land holding. This suggests that households with inadequate land holding were unable to improve their livelihood through alternative sources such as selling labour, petty business or through increasing productivity of the small land plots they owned. This result establishes the key role that land holdings play in household income. However, the results of this study contradict with what some authors have found in different settings of Africa. For example, Lipton (1985) argues that although the amount of land tends not to be correlated with income, access to at least some land is crucial in determining household wellbeing.

4.4 Farm Fragmentation

Farm holdings in Malolo ward are more fragmented than those in Rudewa, Msowero and Dumila (Table 19). The major causes of farm fragmentation in Malolo ward is the presence of modern irrigation infrastructures which attract farmers to invest in agriculture, leading to subdivision of the available land through allocating to heirs and/or selling of land. Moreover, the crops grown in Malolo ward are horticultural crops and in most cases they are grown in small parcels. Of the four wards, Msowero had the least fragmented farms with a median number of parcels of 1.0, average parcel size of 4.5 and mean Simpson Index of 0.1952 (Table 20). In Malolo ward, 93.3% of the households owned parcels of less than 1 hectare whereas many farmers in Rudewa, Dumila and Msowero wards (65%, 40% and 39% of the households respectively) owned parcels of less than 1 ha (Table 19).

Table 19: Farm fragmentation in the sample wards (%)

Measure of fragmentation	Rudewa	Msowero	Dumila	Malolo	Total
Number of parcels					
1	21.7	53.3	20.0	23.3	28.0
2	48.3	30.0	33.3	40.0	40.0
3	20.0	13.3	33.3	23.3	22.0
4	3.3	3.3	10.0	6.7	5.3
Over 4	6.7	0.0	3.3	6.7	4.7
Mean	2.25	1.6667	2.4333	2.3333	2.1867
Median	2.00	1.0000	2.0000	2.0000	2.2000
Average parcel size					
0.08 – 0.41	20.0	13.3	10.0	43.3	21.3
0.41 – 0.54	20.0	10.0	10.0	33.3	18.7
0.54 – 0.82	25.0	6.7	30.0	16.7	20.7
0.82 – 1.73	20.0	20.0	30.0	6.7	19.3
1.73 – 3.72	6.7	23.3	13.3	0.0	10.0
Over 3.75	8.3	26.7	6.7	0.0	10.0
Mean	2.9833	4.1000	3.4667	1.8667	3.0800
Median	3.0000	4.5000	3.5000	2.0000	3.0000
Simpson Index					
0 – 0.42	35.0	73.3	46.7	10.0	40.0
0.42 – 0.5	35.0	10.0	30.0	10.0	24.0
0.5 – 0.66	15.0	16.7	16.7	20.0	16.7
0.66 – 0.88	15.0	0.0	6.7	60.0	19.3
Mean	0.4242	0.1952	0.3683	0.6365	0.4097
Median	0.4742	0.0000	0.4307	0.6942	0.4642

When tested for significant difference using the t-test, the sample data maintained the affirmation that the mean value of Simpson Index was the largest in Malolo ward ($p < 0.01$). On average the size of parcels in Malolo ward was also the smallest ($p < 0.05$).

4.4.1 Determinants of farm fragmentation

When the variable specified in the farm fragmentation model were tested for independency, the results (Table 20) show that the observations were independent; D-W = 1.345 (Garson, 2007). Moreover, the correlation matrix (Table 21) shows the absence of multicollinearity problem among the variables used in regression analysis for farm fragmentation determination since none of the correlations was above or equal to 0.80. Garson (2007) asserts that as a rule of thumb, inter-correlation among independent variables $\geq$ 0.80 signals a multicollinearity problem.

Table 20: Variables selected by backward elimination method in farm fragmentation

Independent Variables	P	RMS	R^2	R^2_{adj}	D-W	N
$X_1 X_2 X_3 X_4 X_5 X_6 X_7 X_8 X_9 X_{10} X_{11} X_{12} X_{13} X_{14} X_{15}$	16	0.053	0.348	0.275	1.345	150
$X_1 X_2 X_4 X_5 X_6 X_7 X_8 X_9 X_{10} X_{11} X_{12} X_{13} X_{14} X_{15}$	15	0.053	0.348	0.280	1.345	150
$X_2 X_4 X_5 X_6 X_7 X_8 X_9 X_{10} X_{11} X_{12} X_{13} X_{14} X_{15}$	14	0.052	0.348	0.285	1.343	150
$X_2 X_4 X_6 X_7 X_8 X_9 X_{10} X_{11} X_{12} X_{13} X_{14} X_{15}$	13	0.052	0.347	0.289	1.357	150
$X_2 X_4 X_6 X_8 X_9 X_{10} X_{11} X_{12} X_{13} X_{14} X_{15}$	12	0.052	0.345	0.293	1.367	150
$X_2 X_4 X_6 X_8 X_9 X_{10} X_{12} X_{13} X_{14} X_{15}$	11	0.052	0.341	0.293	1.387	150
$X_2 X_4 X_6 X_8 X_9 X_{12} X_{13} X_{14} X_{15}$	10	0.052	0.332	0.289	1.393	150
$X_4 X_6 X_8 X_9 X_{12} X_{13} X_{14} X_{15}$	9	0.052	0.323	0.285	1.366	150
$X_4 X_6 X_9 X_{12} X_{13} X_{14} X_{15}$	8	0.053	0.312	0.278	1.370	150
$X_4 X_6 X_9 X_{13} X_{14} X_{15}$	7	0.054	0.277	0.268	1.372	150
$X_4 X_9 X_{13} X_{14} X_{15}$	6	0.055	0.278	0.253	1.403	150
$X_9 X_{13} X_{14} X_{15}$	5	0.058	0.235	0.214	1.358	150
$X_{13} X_{14} X_{15}$	4	0.061	0.182	0.165	1.380	150
$X_{13} X_{14}$	3	0.064	0.144	0.132	1.382	150
X_{14}	2	0.065	0.112	0.106	1.298	150

RMS = Residual Mean Square
P = Term equation (number of parameters in the equation)
R^2 = Coefficient of determination
R^2_{adj} = Adjusted coefficient of determination
D-W* = Durbin-Watson Statistic
N = Valid cases (sample size) used in the model

Table 21: Correlation matrix for farm fragmentation

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9	X_{10}	X_{11}	X_{12}	X_{13}	X_{14}
X_1		0.51	-0.038	-0.020	0.121	-0.143	0.101	-0.147	0.088	-0.781	-0.144	0.176	-0.028	-0.114
X_2			-0.052	0.052	-0.081	0.059	0.092	-0.056	0.164	-0.044	0.330	0.117	0.216	-0.096
X_3				-0.042	-0.121	0.081	-0.066	0.016	0.046	0.116	0.275	-0.113	-0.048	0.351
X_4					-0.180	-0.004	-0.030	0.498	0.071	0.057	-0.039	-0.056	-0.143	-0.060
X_5						0.166	0.126	-0.031	0.069	-0.019	-0.009	-0.044	0.181	-0.039
X_6							-0.049	0.030	0.128	0.204	0.006	-0.216	0.296	0.057
X_7								0.000	0.000	-0.114	-0.074	0.136	0.076	-0.061
X_8									0.038	0.106	0.021	-0.116	-0.166	0.014
X_9										0.199	-0.101	-0.179	-0.203	-0.049
X_{10}											0.136	-0.189	-0.002	0.059
X_{11}												-0.019	-0.063	0.176
X_{12}													0.044	-0.166
X_{13}														-0.024
X_{14}														
X_{15}														

Parcel size, number of parcels and Simpson Index (SI) were used one at a time in analysing determinants of fragmentation. Any variable which increases number of parcels and Simpson Index means that it increases farm fragmentation whereas the one which decreases parcel size increases farm fragmentation. The results showed that the model performance was statistically significant ($p < 0.01$). Inspection of all collinearity statistics as well as examination of correlation coefficients in the correlation matrixes suggests that there was no problem of multicollinearity (Table 22). The Durbin-Watson statistics confirmed that the observations were independent. Summarizing from three multiple regression models, it is reasonable to argue that the determinants of farm fragmentation were: irrigation ($p < 0.01$), average travel time from homestead to the parcel ($p < 0.01$), total land owned per capita ($p < 0.01$), adult equivalent units ($p < 0.05$), number of crops grown by households ($p < 0.05$), total arable land per capita ($p < 0.05$) and mode of land acquisition ($p < 0.05$). It is evident from the findings that, with the coefficient of determination (R^2) of 68.4%, adjusted R^2 of 66.6% and D-W statistic of 1.541, the average parcel size was the best indicator of farm fragmentation compared to the other three indicators (Simpson Index, number of parcels owned, and average parcel size) since Simpson Index. The number of parcels owned had lower values of coefficient of determination (R^2) of approximately 32% and 36% respectively (Table 23).

Farm fragmentation was increasing with the number of crops grown. This can be attributed to the fact that each crop has specific soil requirements. Due to this variation, farmers take economic advantages associated with crop diversification through spreading the risk that arise from climatic conditions and other hazards (Di Falco and Perrings, 2005; Tan *et al.*, 2006). This type of crop production is an indication of traditional agriculture which plays a significant role in farm fragmentation (Khalil and Gholamhossein, 2008). Regarding adult equivalent units (AEU), households with larger

AEU, had more mouths to feed, and they cultivated more parcels than other households in an attempt to meet their food requirements. This finding supports the assertion that the partial inheritance system or population pressure causes farm fragmentation (Khalil and Gholamhossein, 2008). Inheritance leads to farm fragmentation especially when land with similar quality is portioned and given to heirs.

Farm fragmentation was found to be increasing with time of travelling from homestead to parcels. Similarly, Kakwagh *et al.* (2011) reported travel time as amongst the factors contributing to farm fragmentation. This can be attributed to the land tenure system in the study area, which allows farmers who have moved to new locations to maintain the ownership rights over lands in their previous location.

Table 22: Regression coefficients for determinants of farm fragmentation

Predictor	Simpson Index (SI) $R^2 = 0.323$; $R^2_{adj} = 0.285$ $D-W = 1.366$			Number of parcels owned $R^2 = 0.356$; $R^2_{adj} = 0.319$ $D-W = 1.322$			Average parcel size (ha) $R^2 = 0.684$; $R^2_{adj} = 0.666$ $D-W = 1.541$		
	Beta	T	Sign	Beta	T	Sign	Beta	T	Sign
X_4 (Origin of the household head)	0.146	1.769	0.079NS	0.106	1.322	0.188NS	-0.073	-1.337	0.183NS
X_6 (Number of crops planted)	0.187	2.388	0.018*	0.214	2.801	0.006**	0.107	-1.303	0.195NS
X_8 (Mode of land acquisition)	0.121	1.493	0.138NS	0.086	1.088	0.278NS	-0.079	1.994	0.048*
X_9 (Adult equivalent unit)	0.222	2.943	0.004**	0.213	2.899	0.004**	0.239	-1.419	0.158NS
X_{12} (Average travel time)	0.142	1.920	0.057NS	0.079	1.092	0.277NS	-0.098	4.627	0.000***
X_{13} (Total land owned per-capita)	-0.390	-3.862	0.000***	-0.301	-3.052	0.003**	0.914	-1.940	0.054NS
X_{14} (Irrigation)	0.309	4.280	0.000***	0.408	5.797	0.000***	-0.065	13.224	0.000***
X_{15} (Total arable land per-capita)	0.334	3.105	0.002**	0.293	2.796	0.006**	-0.282	-1.326	0.187NS

NS = Not statistically significant at ($p < 0.1$)
* = Statistically significant at ($p < 0.1$)
** = Statistically significant at ($p < 0.05$)
*** = Statistically significant at ($p < 0.01$)

4.5 The Impact of Farm Fragmentation on Agricultural Productivity

In the analysis of farm fragmentation, all the three indicators of farm fragmentation (Simpson Index, number of parcels owned, and average parcel size) were used. The results of correlation analyses between the three measures of fragmentation and productivity are presented in Table 23. It is apparent to note that all the three measures of farm fragmentation were negatively correlated with agricultural productivity. This finding suggests that agricultural productivity increases with the size of the farm, which is contrary to the Schultz's theory which suggests an inverse relationship between farm size and farm productivity. The decrease in agricultural productivity can be associated with an increase in production cost resulting from higher cost of labour as more time is required to move from one parcel to another to carry out different farm activities in a more scattered land holding. The findings of this study are in line with those of Tan *et al.* (2008) who also reported decreasing land productivity due to farm fragmentation. Pham *et al.* (2007) and Wan and Cheng (2001) also showed negative relationships between farm fragmentation and land productivity in Vietnam and China respectively. Based on these findings, farm fragmentation is viewed as an impediment to increased agricultural productivity (Dirimanova, 2006; Najafi, 2003; Thomas, 2007; Thapa, 2007, Tan *et al.* 2008) since it impairs agricultural productivity. These findings and the results of analysis in the current study disproves the Schultz's theory which suggests an inverse relationship between the two.

Table 23: Correlation coefficients for farm fragmentation and productivity

Variables	Correlation coefficient (r)	Sign. (2-tailed)	R^2 (%)	Effective size of (r)
Land productivity vs Simpson Index	-0.102	0.213	1.04	Small
Land productivity vs Number of parcels owned	-0.080	0.331	0.64	Small
Land productivity vs Average parcels size	-0.069	0.400	0.48	Small

The impact of farm fragmentation on agricultural land productivity was furthermore analysed using a linear regression model and the results of analysis are presented in Table 24. As it can be seen from this table the observed value for statistics of Durbin-Watson was 1.806. The Simpson Index significantly decreased with agricultural land productivity ($p < 0.05$). When the degree of farm fragmentation (SI) increased by one unit the probability of having agricultural land productivity decreasing was 18.7%. The decrease in agricultural land productivity can be attributed to the increase in production costs due to higher costs for labour as more time is required to move from one parcel to another and undertake different farming activities in a unit of land. Hung and MacAulay (2002), Thomas (2007), Thapa (2007) and Tan (2008) reported decreased agricultural land productivity due to farm fragmentation. Pham *et al.* (2007) and Wan and Cheng (2001) also declared negative correlation between farm fragmentation and agricultural land productivity in Vietnam and China respectively. On the other hand Kadigi and Mbiha (2000) and Tan *et al.* (2006) indicated positive correlation between farm fragmentation and agricultural land productivity. However, when the farm is irrigated, agricultural productivity increases significantly ($p < 0.05$). The increase in household income significantly increased agricultural productivity ($p < 0.001$). The increase in income by one unit would increase the probability of increasing agricultural productivity by 81.9%. The reason for this is obvious as increase in income will also increase the affordability of farmers to purchase and apply inputs and other modern technologies which will in turn result in increased land productivity.

Table 24: The impact of farm fragmentation on agricultural land productivity

	Unstandardized Coefficients		Standardized Coefficients			Collinearity Statistics	
	B	Std. Error	Beta	t	Sig.	Tolerance	VIF
Dependent variable: Land productivity (TAS/ha)							
(Constant)	-1.316E6	897362.558		-1.466	0.145		
Age of household head	14081.922	12828.644	0.063	1.098	0.274	0.643	1.555
Years in school of household head	16691.943	51178.635	0.017	0.326	0.745	0.817	1.224
Years in farming	21526.874	14039.932	0.091	1.533	0.128	0.602	1.661
Irrigate	964636.270	330589.762	0.155	2.918	0.004	0.749	1.335
PAEU Household income (TAS)	4.651	0.280	0.819	16.595	0.000	0.873	1.145
Average parcel size (ha)	-146037.286	59277.984	-0.125	-2.464	0.015	0.822	1.216
Distance (km)	-155721.715	55249.399	-0.134	-2.819	0.006	0.936	1.069
Land ownership document	584408.381	621407.672	0.045	0.940	0.349	0.924	1.082
Sex of household head	175613.102	454151.238	0.019	0.387	0.700	0.869	1.151
Simpson Index	-2.014E6	974528.419	-0.187	-2.066	0.041	0.259	3.857
Number of parcels cultivated	213625.767	169988.338	0.111	1.257	0.211	0.271	3.694

R^2 = 70.7
Adjusted R^2 = 68.3

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

This study investigated the impacts of land access and fragmentation on the welfare of the households. From this study, the following conclusions were reached:-

Land access and farm fragmentation affect the household welfare and have an impact on the national development at large since the national development starts from household level development.

Land access in Kilosa District is mainly through inheritance and it is determined by three factors namely the adult equivalent unit, age of household head and annual income. The land size owned affects the household income; the bigger the land the higher the earnings.

Farm fragmentation in the study area is determined by the presence of irrigation infrastructure which attracts the farmers, average travel time from homestead to the farm, total land owned, adult equivalent units, number of crops grown and the way land was acquired. Farm fragmentation negatively affects agricultural productivity. High farm fragmentation leads to low agricultural productivity. Therefore, it can further be concluded from this study that the farm size directly influences agricultural productivity, contrary to the Schultz's theory (1964) which suggests an inverse relationship between the two. According to this study, farm fragmentation is detrimental.

5.2 Recommendations

Based on the findings of this study the following recommendations are drawn:

i) The Government of Tanzania and other development partners should join hands to make land consolidation possible by subsidizing the costs of consolidation such as covering for the compensation for the difference in value of the pieces of land to be swapped amongst the farmers during the process. The pieces of land that are considered fragmented do not have equal values, and this makes swapping difficulty because the owners will seldom accept exchanging their land plots simply on distance from their vicinities unless they are compensated. The consolidation of the fragmented farms will improve agricultural productivity and increase their income.

ii) Irrigation structures were found to increase fragmentation by adding value to the farms within irrigation structures coverage where farmers are likely to scramble for that land and necessitate further portioning of the land and reallocation. In order to combat this situation, the government and other development partners need to install the irrigation structures all over the arable land to accommodate the farmers who end up scrambling for the farms around and nearby irrigation structures. This will not only reduce farm fragmentation but also increase agricultural productivity, leading to more earnings and improved welfare.

5.3 Areas for Further Research

There are still other areas pertinent to this study which need to be further investigated to provide more insight into household land issues, and consequently into how to judiciously abate land-related problems.

5.4 Key Contribution of the Study

This study disproved the Schultz's theory (1964) which asserts the inverse proportional of the land size and agricultural productivity. The inverse relationship has been attributed to traditional agriculture situations. The theory seems to be currently challenged due to application of size-neutral biotechnologies such as fertilizers, improved seeds even differences in management practices.

REFERENCES

African Union (2006). On land policy in Africa: A framework of action to secure land rights, enhance productivity and secure livelihoods. *Summary of key Messages and Recommendations of the Consultative Workshop United Nations Conference Centre* Addis Ababa, Ethiopia. 27 - 29 March 2006. pp. 1 – 9.

Antonakis, J., Bendahan, S., Jacquart, P. and Lalire, R. (2010). On making causal claims. A review and recommendations. *The Leadership Quarterly* 21(6): 1086 – 1120.

ASDP (2003). *Agricultural Services Formulation Mission.* Task Force No. 3. Agricultural Sector Development Programme, Dar es Salaam, Tanzania. 7pp.

Babbie E. (1990). *Survey Research Methods.* Wads Worth Publishing Company, Belmont, California. 395pp.

Bagi, F. S. (1987). Relationship between Farm Size and Economic Efficiency: An Analysis of Farm Level Data from Haryana India. *Canadian Journal of Agricultural Economics* (29): 317–326.

Bailey, K. D. (1998). *Methods of Social Research.* Free Press Collier Macmillan Publisher, New York. 589pp.

Barrows, R. L. and Roth, M. (1990). Land tenure and investment in African agriculture: Theory and evidence. *The Journal of Modern African Studies* 28: 265 – 297.

Bentley, J. W. (1987). Economic and ecological approaches to land fragmentation: in defense of a much-maligned phenomenon: *Annual Review of Anthropology* 16: 31 – 67.

Bernard, B., Thomas, A., Stephen, A., Rodgers, L. and Baraka, C. (2008). The price of a malfunctioning Land Management System in Tanzania. *A Fact Finding Report Presented on the Dispute between Pastoralists and Peasants in Kilosa District* 2 – 7 November, 2008. pp. 1 – 29.

Berry, R. A. and Cline, W. R. (1979). Agrarian structure and productivity in developing countries. *Natural Resource Journal* 20: 417 – 418.

Bhalla, S. S. and Roy, P. (1988). Mis-specification in farm productivity analysis: The role of land quality. *Oxford Economic Papers* 40: 55 – 73.

Bharadwaj, K. (1974). Notes on Farm Size and Productivity. *Economic and Political Weekly* 9(13): 11–24.

Bhattacharya, N. and. Saini, G. R. (1972). Farm Size and Productivity: A fresh look. *Economic and Political Weekly* 7(26): 63 – 72.

Bizimana, C., Nieuwoudt, W. L. and Ferrer, S. R. D. (2004). Farm size, land fragmentation and economic efficiency in Southern Rwanda. *Agrekon Journal* 43(2): 244 – 262.

Blarel, B., Hazell, P., Place, F. and Quiggin, J. (1992). The economics of farm fragmentation: Evidence from Ghana and Rwanda. *The World Bank Economic Review* 6(2): 234 – 254.

Bravo-Ureta, B. E. and Evenson, R. E. (1994). Efficiency in Agricultural Production: The Case of Peasant Farmers in Eastern Paraguoy. *Agricultural Economics* 10: 27 – 37.

Britton, D. K. and Hill, B. (1975). *Size Efficiency in Farming.* Saxon House and Lexington Books, London. 184pp.

Carter, M. R. (2003). Designing land and property rights reform for poverty alleviation and food security. *Paper Prepared for the Informal Panel on the Impacts of Access to Land on Improving Food Security and Alleviating Poverty at the Twenty-Ninth Session of The Committee on World Food Security,* Rome, 12 – 16 May 2003. pp. 45 – 64.

Chaddha, A. N. (1978). Farm size and productivity revisited: some notes from recent experience of Punjab. *Economic and Political Weekly* 13(39): 82 – 96.

Chatterjee, S. and Price, B. (1977). *Regression by Example.* Published by John Wiley and Sons, New York. 278pp.

Collier, P., Radwan, S. and Wagner, A. (1990). *Labour and Poverty in Tanzania: Ujamaa and Rural Development in the United Republic of Tanzania.* Clarendon Press, Oxford. 346pp.

Daniel, M., Deininger, K. and Nagarajan, H. (2010). Does Land Fragmentation Reduce Efficiency: *Evidence From India. Paper Prepared For Presentation at the Agricultural and Applied Economics Association CAES and WAEA Joint Annual Meeting*, Denver, Colorado, 25 – 27 July 2010. pp. 1 – 17.

De Janvry, A., Gordillo, G., Sadoulet, E. and Platteau, J - P. (Eds) (2001). *Access to Land, Rural Poverty, and Public Action.* Oxford University Press, Oxford. 451pp.

Deininger, K. and Lyn, S. (1998). New ways of looking at old issues: Inequality and growth. *Journal of Development Economics* 57: 259 – 287.

Del Corral, J., Perez, J. A. and Roibas, D. (2011). The impact of land fragmentation on milk production. *Journal of Dairy Science* 94: 517 – 525.

Deolalikar, A. B. (1981). The inverse relationship between productivity and farm size: a test using regional data from India. *American Journal of Agricultural Economics* 63: 275 – 279.

Dharmasiri, L. M. (2008). Crop Diversification for Sustainable Agriculture: A Case Study from the Mahaweli Development Programme in Sri Lanka. *Journal of Agrarian Studies* 12(1): 35 – 41.

Dharmasiri, L. M. (2010). Measuring agricultural productivity using the average productivity index. *Sri Lanka Journal of Advanced Social Studies* 1(2): 25 – 44.

Di Falco, S. and Perrings, C. (2005). Crop biodiversity, risk management and the implications of agricultural assistance. *Ecological Economics* 55(4): 459 – 466.

Di Falco, S., Penov, I.,Aleksiev, A. and Van Rensburg, T. (2010). A grobiodiversity, farm profits and land fragmentation: Evidence from Bulgaria. *Land Use Policy* 27: 763 – 771.

Dijk, T. V. (2002). Scenarios of Central European land fragmentation. *Land Use Policy* 20(2): 149 – 158.

Dirimanova, V. (2006). Land Fragmentation in Bulgaria: An obstacle for land market development. *Annals of the Polish Association of Agricultural and Agribusiness Economists* 8(6): 37 – 42.

Duze, M. and Mohammed, Z. I. (2006). Male knowledge, attitudes and family planning practices in Northern Nigeria. *African Journal of Reproductive Health* 10(3): 53 – 65.

Dyer, G. (1991). Farm Size - Farm Productivity Re-examined: Evidence from Rural Egypt. *The Journal of Peasant Studies* 19: 59 – 92.

Ellis, F. (2003). Livelihoods and rural poverty reduction in Malawi. *World Development* 31(9): 1495 – 1510.

Ellis, F. and Freeman, H. A. (2004). Livelihoods and rural poverty reduction in Kenya. *Development Policy Review* 22: 147 – 171.

FAO (2008). Land Resources and People: Dependence and interaction. [http://www.fao.org/DOCREP/004/X3810E/x3810e04.htm#g] site visited on 20/02/2010.

FAO (2010). Gender and land rights database. [http://www.fao.org/gender/landrights] site visited on 20/02/2010.

Fimbo, G. M. (2004). *Land Law Reforms in Tanzania.* Dar es Salaam University, Dar es Salaam, Tanzania. 120pp.

Furaha, N. (2008). A century of government regulated land access in Tanzania. *Discussion Paper for the Workshop on Land Administration in Africa Searching for Alternative Approaches, Covering Tanzania*, Ghana, Malawi and South Africa. 12 – 15 May 2008. pp. 1 – 27.

Gajendra, S. N. and Gopal, B. T. (2005). Impacts and causes of land fragmentation and lessons learned from land consolidation in South Asia. *Land Use Policy* 22(4): 358 – 372.

Garson, G. D. (2007). Testing of assumptions. Quantitative research in public administration. [http://cjass.mcsi.edu/garson] site visited on 14/3/2010.

Gebeyehu, Y. (1995). Population pressure, agricultural land fragmentation and land use: A case study of Dale and Shashemene Weredas, Southern Ethiopia. *Proceedings of the fourth Annual Conference on the Ethiopian Economy*, Addis Ababa. pp. 67 – 85.

Ghose, A. K. (1979). Farm size and land productivity in Indian agriculture – a reappraisal. *Journal of Development Studies* 16(1): 27 – 49.

Gonzalez, X., Marey, M. and Álvarez, C. (2007). Evaluation of productive rural land patterns with joint regard to the size, shape and dispersion of plots. *Agricultural Systems* 92: 52–62.

Harrell, F. E. (2008). Regression Modelling Strategies. Department of Biostatistics short-course, [http:// biostat.mc. vanderbilt.edu/twiki/ pub/main/rms] site visited on 24/01/2009.

Harsh, S. B., Connor, J. J. and Schwab, G. D. (1981). Managing the Farm Business. [https://www.msu.edu] site visited on 15/5/2012.

Heady, E. O. (1971). Optimal sizes of farms under varying tenure forms, including renting, ownership, state, and collective structures. *American Journal of Agricultural Economics* 53: 17 – 25.

Herdt, R. W. and Mandac, A. M. (1981). Modern Technology and Economic Efficiency of Philippines Rice Farmers. *Economic Development and Cultural Change* 29: 375–399.

Hossain, M. (1977). Farm Size, Tenancy and Land Productivity: An analysis of farm level data in Bangladesh Agriculture. *Bangladesh Development Studies* 5: 285–348.

Huang, C. and. Bagi, F. S. (1984). Technical Efficiency on Individual Farms in Northwest India. *Southern Economic Journal* 51: 108–115.

Huang, Y. (1973). On some determinant of farm size across countries. *American Journal of Agricultural Economics* 55: 89 – 92.

Hung, P. V. and MacAulay, T. G. (2002). Land fragmentation: Effects and modelling approach. *A Paper Presented at the Workshop Vietnamese Agriculture: Policy and Issues Held* at the University of Sydney, Sydney, 14 - 15 November 2002. pp. 112 – 118.

Hung, P. V., MacAulay, T. G. and Marsh, S. (2007). The economics of land fragmentation in the north of Vietnam. *The Australian Journal of Agricultural and Resource Economics* 51(2): 195 – 211.

Ihucha, A. (2009). Morogoro geared to become country`s granary. [ipp/guardian/2009/10/131348] site visited on 23/05/2010.

Jabarin, A. S. and Epplin, F. M. (1994). Impact of land fragmentation on the cost of production wheat in the rain-fed region of northern Jordan. *Agricultural Economics* 11: 191 – 196.

Jayne, T. S., Takashi, Y., Michael, T. W., David, T., Rui, B., Antony, C. and Ballard, Z. (2003). Smallholder income and land distribution in Africa: implications for poverty reduction strategies. *Food Policy* 28(3): 253 – 275.

Johnson, O. E. G. (1972). Economic analysis, the legal framework and land tenure systems. *Journal of Law and Economics* 15: 259 – 276.

Kadigi, R. M. J. and Mbiha, E. R. (2000). Farm fragmentation in Magu District, Tanzania: Is it a Demand-or Supply-Driven Phenomenon? *Tanzania Journal of Population Studies and Development* 7(2): 47 – 61.

Kajembe G. C., Mbwilo, A. J., Kidunda, R. S. and Nduwamungu, J. (2003). Resource use conflicts in Usangu Plains, Mbarali District, Tanzania. *International Journal of Sustainable Development and World Ecology* 10: 333 – 343.

Kajoba, G. (1994). Changing perceptions on agricultural land tenure under commercialization among small-scale farmers: The Case of Chinena Village in Chibombo District Kabwe Rural, Central Zambia. *Geography* 44(1): 43 – 64.

Kakwagh, V. V., Aderonmu, J. A. and Ikwuba, A. (2011). Land fragmentation and agricultural development in Tivland of Benue State, Nigeria. *Current Research Journal of Social Sciences* 3(2): 54 – 58.

Kalirajan, K. P. (1991). The Importance of Efficient Use in the Adoption of Technology: A Micro Panel Data Analysis. *Journal of Productivity Analysis* 2: 113–26.

Kawasaki, K. (2010). The costs and benefits of land fragmentation of rice farms in Japan. *Australian Journal of Agricultural and Resource Economics* 54: 509 – 526.

Kay, R. D. (1981). *Farm Management, Planning, Control, And Implementation.* International Student Edition. McGraw-Hill Publisher, New York. 370pp.

Khalil, K. and Gholamhossein, A. (2008). Factors affecting agricultural land fragmentation in Iran: A case study of Ramjerd Sub-District in Fars Province. *American Journal of Agricultural and Biological Sciences* 3(1): 358 – 363.

Khusro, A. M. (1964). Returns to Scale in Indian Agriculture. *Indian Journal of Agricultural Economics* 19: 51–80.

Kimaro, D. N. (1989). Potentials and Constraints of Kilosa Area for rain fed agriculture with emphasis on maize. Dissertation for Award of MSc Degree at, Enschede, The Netherlands, 256pp.

King, R. L. and Burton, S. P. (1982). Land fragmentation, a fundamental rural spatial problem, *Progress in Human Geography* 6: 475 – 494.

Lan, L. M. (2001). Land fragmentation- a constraint for Vietnam's agriculture. *Vietnam's Socio-Economic Development* 26: 73 – 80.

Landau, S. and Everitt, B. S. (2004). *Statistical Analyses Using SPSS.* Chapman and Hall/CRC Press LLC, Washington DC. 339pp.

Lipton, M. (1985). *Land Assets and Rural Poverty.* Staff Working Paper No. 744. World Bank, Washington DC. 61pp.

Lyne, M. C. and Nieuwoudt, W. D. (1991). Inefficient land use in KwaZulu: Causes and remedies. *Development South Africa* 8(2): 193 – 201.

Madulu, N. F (2002). *Poverty, Conflicts and Water Resource Use in Tanzania.3rd waternet/ Symposium. Water Demand Management for Sustainable Development.* Institute of Resource Assessment, Dar es Salaam, Tanzania. 8pp.

Manjunatha, A., Anik, A. R., Speelman, S. and Nuppenau, E. (2013). Impact of land fragmentation, farm size, land ownership and crop diversity on profit and efficiency of irrigated farms in India. *Land Use Policy* 31: 397 – 405.

Mazumdar, D. (1965). Size of farm and productivity: A problem of Indian peasant agriculture. *Economics* 32: 161 – 73.

Mbowa, S. and Nieuwoudt, L. W. (1998). Economies of size in sugar cane production in Kwazulu-Natal. *Development Southern Africa* 15(3): 399 – 412.

Medina, P. E. (1980). *Prospects and Problems in the Philippine Sugarcane Industry.* Asia Productivity Organization Sugarcane Production in Asia. Tokyo, Japan. 107pp.

Mosley, R. C. (2005). The use of predictive modelling in the insurance industry. [http://www.pinnacleaactuaries.com/pages/publication] site visited on 24/01/2009.

Mugabi, C. (2013). *Challenges Facing Land Ownership in Rural Tanzania: What Needs to be Done*?. Economic and Social Research Foundation, Dar es Salaam, Tanzania. 4pp.

Najafi, M. R. (2003). Watershed Modeling of Rainfall Excess transformation into Run-off". *Journal of Hydrology* 270: 273 – 281.

National Bureau of Statistics (2013). *Population and Housing Census 2012*. National Bureau of Statistics, Ministry of Finance, Dar es Salaam, Tanzania. 264pp.

Ngaiza, R. S. (2012). *Regional Workshop on an Integrated Policy Approach to Commercializing Smallholder Maiza Production* at Norfolk Hotel in Nairobi, Kenya 6 – 7, June 2012. 30pp.

Ngeregere, F. (2008). A century of government regulated land access in Tanzania. *Discussion Paper for the Videoconferencing Workshop on Land Administration in Africa Searching for Alternative Approaches,* 12-15 May 2008 covering Tanzania, Ghana, Malawi and South Africa.

Nguyen, T., Cheng, E. and Findlay, C. (1996). Land fragmentation and farm productivity in China in the 1990s. *China Economic Review* 7: 169–180.

Niroula, G. S. and Thapa, G. B. (2005). Impacts and causes of land fragmentation, and lessons learned from land consolidation in South Asia. *Land Use Policy* 22: 358 – 372.

Niroula, G. S. and Thapa, G. B. (2007). Impacts of land fragmentation on input use, crop yield and production efficiency in the mountains of Nepal. *Land Degradation and Development* 18(3): 237 – 248.

Okezie, C. A., Ahuchuogu, C. U. and Jamalludin, S. (2012). Exploring the Link between Land Fragmentation and Agricultural Productivity. *International Journal of Agriculture and Forestry* 2(1): 30 – 34.

Oracle, C. (2008). New Horizon in predictive modelling and risk analysis. [http://www. oracle.com/ technology/products] site visited on 24/01/2009.

Overhot, C. A. Clound, K. Anderson, M. B. and Austin, J. E. (1991). Gender analysis framework. In: *Gender Analysis in Development Planning*. (Edited by Rao, A., Anderson, M. B. and Overhot, C. A.), Kumarian Press, West Hartford, USA. pp. 9 – 20.

Pallant, J. (2005). *A step by Step Guide to Data Analysis Using SPSS for Windows SPSS Survival Manual*. (2nd Edition). Allen and Unwin Publisher, Australia. 334pp.

Parikh, A. and Shah, K. (1994). Measurement of technical efficiency in the northwest frontier province of Pakistan. *Journal of Agricultural Economics* 45(1): 132– 138.

Pedroso, G. T., Silva-Mann, R., Camargo, M. E. and Russo, S. L. (2014). Applied multiple regression for autocorrelated sugarcane data. *African Journal of Agricultural Research* 9(10): 914 – 920.

Pham Van H., Gordon, T., MacAulay, and Sally, P. M. (2007). The economics of land fragmentation in the north of Vietnam. *The Australian Journal of Agricultural and Resource Economics* 51: 195 – 211.

PHDR (2005). Poverty at the district level in Mainland Tanzania. Research and analysis technical working group of the MKUKUTA monitoring system, ministry of planning, economy and empowerment. [cmsdata.iucn.org/downloads/bottlenecks. pdf] site visited on 27/10/2009.

Pinheiro, A. (1992). An Econometric Analysis of Farm Level Efficiency of Small Farms in the Dominican Republic. Dissertation for Award of MSc Degree at University of Connecticut, Storrs, USA, 190pp.

Platteau, J. P. (1996). The evolutionary theory of land rights as applied to sub-Saharan Africa: A critical assessment. *Development and Change* 27: 29 – 86.

Quan, N. and Koo, A. Y. C. (1985). Concentration of land holdings: An empirical exploration of Kuznets' conjecture. *Journal of Development Economics* 18: 101 – 117.

Rahman, S. and Rahman, M. (2008). Impact of land fragmentation and resource ownership on productivity and efficiency: The case of rice producers in Bangladesh. *Land Use Policy* 26: 95 – 103.

Rembold, F. (2004). Land fragmentation and its impact in Central and Eastern European countries and the Commonwealth of independent states. *Land Reform, Land Resettlement and Cooperatives* 2: 83 – 88.

Richardson, J. T. E. (2011). Eta squared and partial eta squared as measures of effect size in educational research. *Educational Research Review* 6(2): 135 – 147.

Roy, P. (1981). Transition in Agriculture: Empirical Indicators and Results. *Journal of Peasant Studies* 8: 212 – 241.

Sabastes-Wheeler, R. (2002). Consolidation initiatives after land reform: responses to multiple dimensions of land fragmentation in Eastern European agriculture. *Journal of International Development* 14(7): 1005 – 1018.

Sahota, G. S. (1968). Efficiency of resource allocation in Indian agriculture. *American Journal of Agricultural Economics* 50: 584 – 605.

Saini, G. R. (1971). Holding size, productivity and some related aspects of Indian agriculture. Economic and political weekly. *Review of Agriculture* 6(26): 79 – 85.

Saini, G. R. (1980) Farm size productivity and some related issues in India's agriculture: a review. *Agricultural Situation in India* 34(11): 777 – 783.

Schuerman, J. R. (1983). *Multivariate Analysis in the Human Services*. Edited by William, J. Reid. Published by Springer, Berlin. 292pp.

Sen, A. K. (1962). An Aspect of Indian Agriculture. *Economic Weekly* 14: 243 – 246.

Sen, A. K. (1966). Peasants and Dualism with or without Surplus Labour. *Journal of Political Economy* 7: 425 – 450.

Sherlund, S. M., Barrett, C. B., Adesina, A. A. (2002). Smallholder technical efficiency controlling for environmental production conditions. *Journal of Development Economics* 69: 85 – 101.

Shuhao, T. (2005). Land Fragmentation and Rice Production: A case study of small farmers. Thesis for Award of PhD Degree at Wageningen University, The Netherland, 176pp.

Sidhu, S. S. (1974). Economics of technical change in wheat production in the Indian Punjab. *American Journal of Agricultural Economic* 56: 217 – 226.

Tan, S. N., Heerink, G, Kruseman, and Qu, F. (2008). Do fragmented landholdings have higher production costs? Evidence from rice farmers in Northeastern Jiangxi province, China. *China Economic Review* 19: 347 – 358.

Tan, S. N., Heerink, G., Kruseman and Qu, F. (2006). Land fragmentation and its driving forces in China. *Land Use policy* 23(3): 272 – 285.

Tan, S., Heerink, N., Kuyvenhoven, A. and Qu, F. (2010). Impact of land fragmentation on rice producers' technical efficiency in South-East China. *NJAS - Wageningen Journal of Life Sciences* 57: 117 – 123.

Thapa, S. (2007). The Relationship between farm size and productivity: *Empirical Evidence from the Nepalese Mid-Hills. Contributed Paper Prepared for Presentation at 106th Seminar of EAAE 25* – 27 October, 2007, Montpellier, France. pp. 1 – 17.

THDS (1996). *National Bureau of Statistics.* Print Park Ltd., Dar es Salaam, Tanzania. 312pp.

Thomas, J. (2007). Property rights, land fragmentation and the emerging structure of agriculture in Central and Eastern European countries. *Electronic Journal of Agricultural and Development Economics* 3(2): 225 – 275.

Todorova, S. A. and Lulcheva, D. (2005). Economic and social effects of land fragmentation on Bulgarian agriculture. *Journal of Central European Agriculture* 6(4): 555 – 562.

URT (1999). *The Tanzania Development Vision 2025. Planning Commission,* Vice President's Office, Dar es Salaam. 31pp.

URT (2003). *Population and Housing Census 2002.* Government Printers, Dar es Salaam, Tanzania. 13pp.

Wan, G. and Cheng, E. (2001). Effects of land fragmentation and returns to scale in the Chinese farming sector. *Applied Economics* 33(2): 183 – 194.

Wan, G. and Cheng, E. (2001). Effects of land fragmentation and returns to scale in the Chinese farming sector. *Applied Economics* 33: 183 – 194.

Webster, C. C. and Wilson, P. N. (1980). *Agriculture in the Tropics.* Longmans Publishers, New York. 640pp.

Wu, Z., Liuand, M. and Davis, J. (2005). Land consolidation and productivity in Chinese household crop production. *China Economic Review* 16: 28 – 49.

Yotopoulos, P. A. and Lau, L. J. (1973). A test for relative economic efficiency- some further results. *American Economic Review* 63: 214 – 223.

Yotopoulos, P. A., Lau, L. J. and Sonel, K. (1970). Labour intensity and relative efficiency in indian agriculture. *Food Research Institute Studies in Agricultural Economics, Trade, and Development* 9: 43–55.

APPENDICES

Appendix 1: Questionnaire

IMPACT OF LAND ACCESS AND FARM FRAGMENTATION ON HOUSEHOLD WELFARE:

THE CASE OF KILOSA DISTRICT, OCTOBER 2011

HOUSEHOLD SURVEY QUESTIONNAIRE

SECTION 1: IDENTIFICATION PARTICULARS, STAFF AND SURVEY TIME DETAILS

1	District:		
2	Division:		
3	Ward:		
4	Village/hamlet		
5	Household code		
6	Head: Name:		Male
			Female
7	Respondent: Name:		Male
			Female
8	GPS location of household:	South:	
		East:	
9	GPS location of village:	South:	
		East:	
10	Village altitude masl:		
9	Wealth of household		

10	Name of interviewer			
11	Date of interview	DD	MM	YYYY
12	Name of supervisor			
13	Checking date	DD	MM	YYYY
14	Starting time	Hours	Minutes	
15	Ending time	Hours	Minutes	
16	Response code			
17	HH Phone number			

A: Household demographic

HID	Name	Native 1. YES 2. NO	Sex 1. Male 2. Female	Relation to HH (1)	Age	Marital status (2)	Education (3)	Still in school (4)	Occupation (5) more than one response	Agricultural Training 1. YES 2. NO	Months living home in the past 12 months	If < than 12 months reasons (6)
1												
2												
3												
4												
5												
6												
7												
8												
9												
10												
11												
12												

Code (1)
1. Head
2. Spouse
3. Second/third wife
4. Child
5. Parent
6. Worker
7. Grandchild
8. Other (specify)
9. Job seeker

Code (2)
1. Single
2. Monogamous
3. Polygamous
4. Widow
5. Divorced
6. Separated

Code (3)
1. Under school Age
2. Adult
3. Primary
4. O Level
5. A Level
6. Certificate
7. Diploma
8. University

Code (4)
1. Yes
2. No.

Code (5)
1. Farmer
2. Pastoralist
3. Agro-pastoralist
4. Others (specify)

Code (6)
1. None
2. Hospital
3. Work

B: Land access in dry season 2011 and wet season 2011. Note: Land access refers to cropped land, wood lots, fallow land, land under tree crops, gardens and rented land.

S/N	PID Name	Parcel size (acre)	Parcel location (Code 6)	Mode of transport to the parcel (Code 12)	Travel time (min) one way using the travel model mentioned	Distance from farm to Homestead (Km)	Acquisition (Code 7)	Year start using this plot	If rented in amount paid (dry season / wet season, 2011) in TAS		If owned land do you have ownership document? (Code 8)	Arable land (Acres)	Soil type (Code 9)	Soil quality (Code10)	Slope (Code11)
									Dry season	Wet season					
1															
2															
3															
4															
5															
6															
7															
8															
9															

Code (6)
1. Lowland rain fed
2. Lowland irrigated
3. Upland rain fed
4. Upland irrigated

Code (12) Code (7)
1. By foot
2. By bicycle
3. By public transport
4. By private vehicle
5. Other (specify)

Code (8)
1. Inherited
2. Purchased
3. Borrowed in
4. Rented in
5. Government allocated
6. Just walked in
7. Other (specify)

Code (9)
1. None
2. Title deed
3. Right of occupancy
4. Customary title deed

Code (10)
1. Sandy
2. Clay
3. Loam
4. Other (specify)

Code (11)
1. Poor
2. Medium
3. Good

1. Steep
2. Moderate
3. Level

C: **Water for irrigation**

PID	Parcel Name	Did you irrigate this parcel in the last season 2010/2011	Kind of irrigation furrow to the parcel 1. Traditional 2. Improved 3. Other (Specify)	Total cost paid (TAS) in the past 12 months		Maintenance cost (TAS) for irrigation furrow in the past 12 months	Family labour to maintain furrow (Total hrs) in the past 12 months
				Dry season	Wet season		

D: Crop income wet season 2011. Note: Land access refers to cropped land, wood lots, fallow land, land under tree crops, gardens and rented land.

Parcel ID	Plot ID	Crop name	Crop code	Area planted (acre)	Cropping pattern (Code 12)	Seed cost (TAS)	Cost of hiring labour (TAS)	Fertilizer cost (TAS)	Insecticide and herbicide cost (TAS)	Rental cost for machinery and animal (TAS)	Quantity harvested	Unit (Code 13)	Conversion factor to kg	Marketing cost (TAS)	Quantity sold	Price per unit (TAS)

Code (12)
1. Pure stand
2. Intercropped

Code (13)
1. Kg
2. Sado
3. Tin/Debe
4. Bag

E: Crop income dry season 2011. Note: Land access refers to cropped land, wood lots, fallow land, land under tree crops, gardens and rented land

Parcel ID	Plot ID	Crop name	Crop code	Area planted (acre)	Cropping pattern (Code 12)	Seed cost (TAS)	Cost of hiring labour (TAS)	Fertilizer cost (TAS)	Insecticide and herbicide cost (TAS)	Rental cost for machinery and animal (TAS)	Quantity harvested	Unit (Code 13)	Conversion factor to kg	Marketing cost (TAS)	Price per unit (TAS)

Code (12)
1. Pure stand
2. Intercropped

Code (13)
1. Kg
2. Sado
3. Tin/Debe
4. Bag

F: Rented out plot dry and wet season 2011. Note: Land access refers to cropped land, wood lots, fallow land, land under tree crops, gardens and rented land.

S/N	Parcel name	Parcel ID	Size (acre)	Parcel location (Code 6)	Rent received in (2010 dry season /2011 wet season) in TAS		Year start using this plot	Acquisition (Code 7)	If owned land title/right (Code 8)
					Dry season	Wet season			
1									
2									
3									
4									
5									
6									
7									
8									
9									

Code (6)
1. Lowland rain fed
2. Lowland irrigated
3. Upland rain fed
4. Upland irrigated

Code (7)
1. Inherited
2. Purchased
3. Borrowed in
4. Rented in
5. Government allocated
6. Just walked in 7. Other (specify)

Code (8)
1. None
2. Title deed
3. Right of occupancy
4. Customary title deed

G: Plot measurements
GPS coordinates

Parcel Name	Parcel size estimated by farmer (acre)		Total parcel size (acre)	Cultivated area (acre)	Altitude (masl)	GPS location	
	Total	Cultivated				South	East

H: Machinery and or animal use on rain season 2011

Parcel ID	Activity	Means used (Code 14)	Pairs	Number of days	Type 1.Own 2. Rented 3. Contracted	Type of contract (Code 16)	Daily rate	Piece rate cost per unit	Unit (Code 15)	Number of unit operated
1	Clearing									
	Plowing									
	Leveling									
	Other (sp)									
2	Clearing									
	Plowing									
	Leveling									
	Other (sp)									
3	Clearing									
	Plowing									
	Leveling									
	Other (sp)									
4	Clearing									
	Plowing									
	Leveling									
	Other (sp)									
5	Clearing									
	Plowing									
	Leveling									
	Other (sp)									

Code (14)
1. Animal
2. Two wheel tractor
3. Four wheel tractor

Code (15)
1. Acre
2. Kg
3. Debe/Tin
4. Bag 5. Other (specify)

Code (16)
1. Daily rate
2.Piece rate

I: Machinery and or animal use on dry season 2011

Parcel ID	Activity	Means used (Code 14)	Pairs	Number of days	Type 1.Own 2. Rented 3. Contracted	Type of contract (Code 16)	Daily rate	Piece rate cost per unit	Unit (Code 15)	Number of unit operated
1	Clearing									
	Plowing									
	Leveling									
	Other (sp)									
2	Clearing									
	Plowing									
	Leveling									
	Other (sp)									
3	Clearing									
	Plowing									
	Leveling									
	Other (sp)									
4	Clearing									
	Plowing									
	Leveling									
	Other (sp)									
5	Clearing									
	Plowing									
	Leveling									
	Other (sp)									

Code (14)
1. Animal
2. Two wheel tractor
3. Four wheel tractor

Code (15)
1. Acre
2. Kg Other (specify)
3. Debe/Tin
4. Bag 5. Other (specify)

Code (16)
1. Daily rate
2. Piece rate

J: Labor use on rain season 2011

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
1	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor

Code (16)
1. Daily rate
2. Piece rate
4. Relative (None employed)

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4. Bag 5. Other (specify)

J: Labor use on rain season 2011cont……

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
2	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor
4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4. Bag
5. Other (specify)

J: Labor use on rain season 2011cont…..

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
3																
	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4.Bag 5. Other (specify)

J: Labor use on rain season 2011cont….

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
4																
	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor
4. Relative (none employed) 5. Other (specify)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin
4. Bag

J: Labor use on rain season 2011 cont…

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
5	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4.Bag 5. Other (specify)

J: Labor use on rain season 2011cont…..

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
6	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4.Bag 5. Other (specify)

J: Labor use on rain season 2011 cont....

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
7			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4. Bag 5. Other (specify)

K: Labor use on dry season 2011

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
1			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4.Bag 5. Other (specify)

K: Labor use on dry season 2011cont…

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
2	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4. Bag 5. Other (specify)

K: Labor use on dry season 2011cont…

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
3																
	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4. Bag 5. Other (specify)

K: Labor use on dry season 2011cont…

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
4	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4.Bag 5. Other (specify)

K: Labor use on dry season 2011cont…

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
5	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4.Bag 5. Other (specify)

K: Labor use on dry season 2011cont…

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
6	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employ

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4.Bag 5. Other (specify)

K: Labor use on dry season 2011cont…

Parcel ID	Activity	Type of labor (Code 17)	Man			Woman			Child			If hired type of contract (Code 16)	Daily wage per person	Piece rate, cost per unit	Unit Code 15)	Number of units operated
			Number	Days	Hours	Number	Days	Hours	Number	Days	Hours					
7	Clearing															
	Plowing															
	Leveling															
	Planting															
	Weeding															
	Irrigation															
	Chemical application															
	Fertilizer application															
	Bird scaring															
	Troublesome animal mgt															
	Harvesting															
	Transport															

Code (17)
1. Family labor
2. Employed labor
3. Exchange labor 4. Relative (none employed)

Code (16)
1. Daily rate
2. Piece rate

Code (15)
1. Acre
2. Kg
3. Debe/Tin 4.Bag 5. Other (specify)

L: Business, salaries and wage labor activities in the past 12 months

Person ID	Actual activity name	Code	If regular monthly salary or wage, indicate how much (TAS)	Months in a year actually worked	Low gross earning months			High gross earning months		
					Number	Gross earning per month	Cost per month	Number	Gross earning per month	Cost per month

M: Transfer income and other incomes of Household: Did the household member receive credit, remittances, gifts or other transfer in cash or in kind in the past 12 months (Yes/No)?

S/N	Type	Source Code	How did you receive 1. Cash 2. In kind 3. Others (specify)	When did you receive MM/YY	What are the amounts? (TAS)	If credit			
						When did you have to pay the credit MM/YY	Total amount to be paid on the loan including interest (TAS)	Have you paid the credit? 1. Yes 2. No 3. Partially (Specify amount paid in this year)	What for did you use the credit/remittances? Code
1	Credit								
2	Remittances or assistance received from a source within this village								
3	Remittances or assistance received from a source outside this village but within Tanzania								
4	Remittances and assistance received from someone in another country								
5	Rent (Housing, shop)								
6	Pension or life insurance annuity benefits								
7	Income from the sales of assets excluding livestock								
8	Dividends (from company shares or bank)								
9	Other income (inheritance, alimony, scholarship, other unspecified income, etc)								
10	Others (specify)								

Code for uses

1. Buy land
2. Buy livestock
3. Buy farm tools and implements
4. Buy farm inputs such as seeds, fertilizer, pesticides
5. Purchase inputs/working capital for non-farm enterprise
6. Pay for building materials (buy house)
7. Buy consumption goods and services
8. Pay for education expenses
9. Pay for health expenses
10. Pay for ceremonial expenses
11. Pay for hired labour
12. Person sending money did not specify a particular intended use
13. Other (specify)

Source code

1. Formal financial institutions (banks and other government agencies subject to central monetary authority)
2. Semi formal institutions such as Micro finance institution e.g SACCOS, cooperatives, NGO, etc
3. Informal source eg local money lender, friends, relatives, rotating servings, landlord/employers, etc

N: Cash expenditure on major items (Non durable goods in the past 12 months)

Purchased products	Frequency purchased	Period 1. Day 2. Week 3. Month 4. 6 months 5. Year	Average expenditure per purchase (TAS)	Purchased products	Frequency purchased	Period 1. Day 2. Week 3. Month 4. 6 months 5. Year	Average expenditure per purchase (TAS)
STAPLES				***NON-FRESH FOOD ITEM***			
Maize grain				Sugar			
Maize meal/flour				Salt			
Millet/sorghum				Cooking oil/ghee			
Wheat flour				Coffee/Tea			
Rice				Drinks			
Cassava (fresh)				Tobacco/cigarettes			
Cassava (dry)				***NON-FOOD ITEMS***			
Sweet potatoes				School fee, textbooks, etc			
Irish potatoes				Medical fee			
Matoke				Transportation			
NON-STAPLE FRESH FOOD				Clothing/shoes			
Beans				Kerosene			
Ground nuts				Soap/washing products			
Green peas				***CONTRIBUTIONS***			
Vegetable./Fruits				SACCOS			
Chicken				Remittance to relatives			
Fish				Churches/mosques			
Meats				Mutual Support Groups			
Eggs				Cooperatives/committees			
Dairy products				Other local organization			

O: Household Assets

Asset	Number of item current owned	Total value (TAS)	Asset	Number of item current owned	Total value (TAS)
Farm equipment			*Other items*		
Tractors			Motorcycle		
Trailers			Bicycle		
Vehicles			Radio		
Carts			Car Batteries		
Donkeys			TV		
Wheelbarrows			Mobile phones		
Ploughs			Chair/sofas		
Borehole			Tables		
Hand hoe			Beds		
Chaff cutter for fodder			Mosquito nets		
Spray pumps			Solar panels		
Water tanks			Milking churns		
Grinders					
Beehives					

P: Livestock production and expenditure in the past 12 months

S/N	Type of livestock/livestock product	Code	Number owned	Total value in TAS	Feeding cost	Breeding cost	Health cost	Labor cost	Other cost	Maintenance cost	Total value sold in the past 12 months in TAS
	Exotic/cross										
1	Calves										
2	Bulls										
3	Heifers and cows										
4	Goat										
5	Sheep										
	Indigenous/Local										
6	Calves										
7	Bulls and oxen										
8	Heifers and cows										
9	Donkey										
10	Pigs										
11	Goat										
12	Sheep										
	Poultry and others										
13	Local chicken										
14	Layers (exotic)										
15	Broilers (exotic)										
16	Turkey										
17	Ducks										
18	Geese										
19	Rabbits										
20	Dogs										
21	Beehives										
22	Other (specify)										

Q: Production of livestock products

S/N	Livestock product	ID	Number of production months in the past 12 months	Average production per month during production months	Unit code	Amount sold per month	Price received per unit	How much in TAS did you earn in total in the past 12 months
1								
2								
3								
4								
5								
6								
7								
8								
9								

Code for unit
1. Numbers
2. Trays
3. Litres
4. Other (Specify)

R: Technology use in production and land improvement and or management

S/N	Type of technology	PID1			PID2			PID3			PID4			Comment
		Yes partially	Yes	No	Yes partially	Yes	No	Yes partially	Yes	No	Yes partially	Yes	No	
1	Fertilizer application													
2	Improved seed													
3	Land preparation													
4	Weeding													
5	Timely planting													
6	Herbicide application													
7	Insecticide application													
8	Bird scaring													
9	Terracing													
10	Mulching													
11	Contour farming													
12	Erosion control													
13	Tree planting													
14	Fallowing													
15	Bunds													
16	Fence													
17	Other technology (Specify)													

R: Technology use in production and land improvement and or management

S/N	Type of technology	PID5			PID6			PID7			PID8			Comment
		Yes partially	Yes	No	Yes partially	Yes	No	Yes partially	Yes	No	Yes partially	Yes	No	
1	Fertilizer application													
2	Improved seed													
3	Land preparation													
4	Weeding													
5	Timely planting													
6	Herbicide application													
7	Insecticide application													
8	Bird scaring													
9	Terracing													
10	Mulching													
11	Contour farming													
12	Erosion control													
13	Tree planting													
14	Fallowing													
15	Bunds													
16	Fence													
17	Other technology (Specify)													

THANK YOU VERY MUCH FOR YOUR COOPERATION

Appendix 2: Determination of Adult Equivalent Units

Cognizant of the fact that if variables like income, land in available and dietary energy consumed are expressed per capital they do not reflect good comparative figures in households with different sizes and composition by age and sex, land in available will be expressed per adult equivalent. In order to calculate adult equivalent units, the sex and age of every household member must be known first. Then a two step procedure is followed. In the first step adult equivalent scales for East Africa by age and sex are added up for all household members to get all the household members in terms of adult equivalents. The equivalent scales are presented in Table 25.

For example ; if a household has nine members who are : (1) Male aged 59 years; (2) Female aged 46years; (3) Male aged 70years; (4) Female aged 80 years; (5) Female aged 17 years; and (6) Female aged 14 years; (7) Female aged 12 years; (8) Male aged 20 years and (9) Male aged 6 years; they are equivalent to 1.0 $_{\text{(First Person)}}$ + 0.88 $_{\text{(Second Person)}}$ + 0.88$_{\text{(Third Person)}}$ + 0.72$_{\text{(Fourth Person)}}$ + 1.0$_{\text{(Firth Person)}}$ + 1.0$_{\text{(Sixth Person)}}$ + 0.88$_{\text{(seventh Person)}}$ + 1.0$_{\text{(eighth Person)}}$ + 0.56$_{\text{(Ninth Person)}}$ = 7.92 adults. However, the 7.92 adults are not used directly as a denominator for computing values per adult because of economies of scale. Therefore, the second step involves adjusting the above adult equivalents for economies of scale due to the fact that larger households need fewer amounts of resources per person due to sharing some facilities. In the example, economies of scale are taken into account by multiplying the adult equivalent units obtained above (7.92) by the average cost corresponding to eight people (i.e. 0.741) since 7.92 is approximately eight, correct to no decimal point, as seen in Table 26.

Therefore, since 7.92 is approximately eight, correct to no decimal point, 7.92 is multiplied by 0.741, which is the average cost (Table 26) corresponding to 8 adults living together, in order to adjust 7.92 for economies of scale. Therefore, the adjusted adult equivalent units are 5.86872, i.e. 7.92 x 0.741. This (5.86872) would be the denominator for calculating values per adult equivalent in that household. Such a procedure is followed for every household in a sample. If the nine people household had a land of 5.77 ha their land access per adult equivalent unit would be 5.77/5.86872 = 0.98 ha unlike land access per capital, which would be 5.77/9, which is 0.64 ha.

Appendix 3: Adult equivalent scales for East Africa

Age group	Sex	
	Male	Female
0 – 2	0.40	0.40
3 – 4	0.48	0.48
5 – 6	0.56	0.56
7 – 8	0.64	0.64
9 – 10	0.76	0.76
11 – 12	0.80	0.88
13 – 14	1.00	1.00
15 – 18	1.20	1.00
19 – 59	1.00	0.88
Above 60+	0.88	0.72

Appendix 4: Household economies of scale constants

Household size (Number of adults)	**Marginal costs**	**Average costs**
1	1.000	1.000
2	0.892	0.946
3	0.798	0.897
4	0.713	0.851
5	0.632	0.807
6	0.632	0.778
7	0.632	0.757
8	0.632	0.741
9	0.632	0.729
Above 10+	0.632	0.719