ADOPTION STATUS AND MANAGEMENT OF AGROFORESTRY SYSTEMS AND TECHNOLOGIES BY COMMUNITIES: A CASE STUDY OF KASULU DISTRICT, KIGOMA, TANZANIA

MARY NDENGAHE CHIJA

A DISSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN MANAGEMENT OF NATURAL RESOURCES FOR SUSTAINABLE AGRICULTURE OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA

2013

ABSTRACT

This study was done to assess and document the adoption status of Agroforestry systems and technologies in Kasulu District, Kigoma Region, Tanzania. Specifically, the study determined the current status of Agroforestry adoption by the communities in the district, identified agroforestry systems and technologies practiced, determined the factors influencing the adoption of agroforestry and the measures that would be required to improve its adoption in the district. Data collection methods involved reconnaissance, household and field surveys. Data collected were summarized and analysed using the SPSS and SAS Computer software. The findings show that by 2011, the adoption status of Agroforestry in Kasulu District was 91%. Three Agroforestry systems namely Agrosilviculture, Agrosilvopasture and Silvopasture are currently in use in the district with the Agrosilvicultural system (42%) being the most adopted system. Eight Agroforestry technologies were found to be adopted by the farmers of which the Homegardens (26%), Mixed intercropping (25%) and Integrated tree/pasture management (17%) technologies were the most adopted technologies. *Brachystegia spiciforms* and *Pericopsis angolensis* were the most preferred indigenous tree species whereas *Senna siamea*, *Eucalyptus maidenii* and *Elais guinensis* were the most preferred exotic species. *Mangifera indica*, *Citrus sinensis* and *Persea americana* were currently the most preferred fruit trees. Income generation, farmer’s awareness and access to extension services were some of the most critical factors that enhance farmers adoption of agroforestry, whereas lack of knowledge, land shortage and lack of monetary capital were the most limiting factors. Based on the results and discussion it was concluded that the extent of agroforestry adoption in the study area

was high. It was then recommended to encourage farmers to maintain the existing agroforestry adoption reached, provide germplasm of the improved tree species, educate and sensitizing farmers to have individual or community tree nurseries that can be accessed easily by farmers.

DECLARATION

I, MARY NDENGAHE CHIJA, do hereby declare to the Senate of Sokoine University of Agriculture that this dissertation 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.

……………………………. …………………………

Mary Ndengahe Chija **Date**

(MSc. Candidate)

The above declaration is confirmed

……………………………… …………………………

Prof. L.L.L. Lulandala **Date**

(Supervisor)

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ACKNOWLEDGEMENTS

First of all, I would like to thank the Almighty God for helping and keeping me healthy throughout my studies to this moment. My deepest appreciation and hearty thanks go to my supervisor, Professor L.L.L Lulandala, from the Department of Forest Biology, Faculty of Forestry and Nature Conservation, whose valuable guidance and constructive criticisms as well as tireless efforts in advising me throughout this study, have made the completion of this work possible.

My special thanks go to my employer, the Ministry of Agriculture, Food Security and Cooperatives for the financial support and releasing me to pursue further studies at Sokoine University of Agriculture without which my studies couldn't have been possible.

I would also like to extend my special thanks to the DALDO of Kasulu District for his supportive assistance during my field work. I also like to express my thanks to the various staff of the Natural Resources Department (Forestry) in Kasulu District who assisted me in translating the local names of indigenous trees identified in the study area. I appreciate also the role done by Mr. Albert Chombe who assisted me to collect data during the household surveys. I also like to extend my special thanks to all Ward/Village Agricultural Extension Officers who responded positively and provided me with good support during the time of data collection. My special thanks also go to all smallholder farmers, Village and Ward leaders as well as various other individuals, whom I consulted during data collection for their cooperation. I am glad also to express my gratitude to all members of the Faculty of Forestry and Nature

Conservation and all other people who in one way or another have contributed to the success of this study. Special thanks also go to my fellow students for their encouragement and moral support during the whole period of my study.

Special thanks also go to my sisters Esteria, Bertha, Imelda and Gertrude and my brother in law Mr K. M. Buhahilo for their prayers and encouragement throughout my study. Lastly but not least, I give special thanks to my husband Mr. Philip .S. Humbiye and our beloved children Mkiza, Serekwa, Ntibagiligwa and Nikobhali, for their patience and encouragement during the whole period of my study.

DEDICATION

This dissertation is dedicated to my beloved parents, my mother, Pudensiana Goye and my father the late Chija Bacha. May the Almighty God rest his soul in eternal peace.

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LIST OF ABBREVIATIONS

AF	-	Agroforestry
AFs	-	Agroforestry systems
AFTs	-	Agroforestry technologies
ASARECA	-	Association for Strengthening of Agricultural Research in Eastern and Central Africa
DALDO	-	District Agricultural and Livestock Development Officer
DRC	-	Democratic Republic of Congo
FAO	-	Food and Agriculture Organization of the United Nations
HHs	-	Households
HIMA	-	Hifadhi ya Mazingira
ICRAF	-	International Centre for Research in Agroforestry
KDC	-	Kasulu District Council
LSD	-	Least Significance Difference
MAFC	-	Ministry of Agriculture, Food Security and Cooperatives
NARO	-	National Agricultural Research Organization
NASCO	-	National Agroforestry Steering Committee
NGO' s	-	Non Governmental Organizations
SAS	-	Statistical Analysis Systems
SPSS	-	Statistical Package for Social Sciences
SFR	-	Soil Fertility Replenishment
SUA	-	Sokoine University of Agriculture
URT	-	United Republic of Tanzania
WAC	-	World Agroforestry Centre

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Agroforestry (AF) comprises of land use systems and technologies in which the woody perennials are deliberately integrated on the same land management unit with herbaceous crops and or animals in either some forms of spatial arrangement or temporal sequence (Nair, 1989). In AF systems there are both ecological and economical interactions between the different components (Nair, 1993; Lulandala, 2009).

Agroforestry is a system in which different components are benefiting from each other in several different ways. The trees can give fodder to animals and fix nitrogen for the crops and providing different biological pesticides and an improved micro-climate (Kiriba, 2011). Agroforestry also ranges from very simple and sparse to very complex and dense systems and it holds a wide range of practices. The aim of Agroforestry lies in optimizing production based on interactions between various systems` components and their physical environments leading to higher sum total and a more diversified and sustainable production (Abdelkadir *et al.*, 2003).

The most common Agroforestry systems (AFs) in the tropics and subtropics include; Agrosilviculture, Silvopasture and Agrosilvopasture (Nair, 1989). Others are Aquosilvicultural and Aposilvicultural systems (Trongkongsin, 1987). Agroforestry technologies (AFTs) on the other hand, refer to the various way of arrangement of the components in an Agroforestry system (Lulandala, 2009). Examples of AFTs are like Homegardens, Mixed intercropping, Integrated tree/pasture management, Alley farming, Windbreak, etc. (Odoul e*t al.,* 2006).

The productive, service and protective functions are the three fundamental features of all AFs, For example, the productive roles include the production of food, fodder and fuel wood (Young, 1990), whereas services are like soil fertility maintenance and microclimate amelioration (Parwada *et al.,* 2010; Kiriba, 2011). Protective functions are like soil erosion control through vegetation cover and mulching and also their role as live fences, shelterbelts and windbreaks.

According to Rogers (2003), adoption is defined as a decision of full use of an innovation as the best course of action available for addressing a need. An innovation may be an idea, practice and object accepted and practiced by an individual, group or community. According to Ajayi (2007) a farmer who has adopted Agroforestry follows such attributes as good management of the farm, density of planting and mix of species planted, number of years the farmers continuously practices AF and the size of the farm. However the essence of the current research in Kasulu District considered a farmer having adopted Agroforestry system and technology when he/she has integrated woody perennial(s) in his/her farm regardless of tree density, management and size of the farm.

In Tanzania, adoption of Agroforestry ranges from various traditional to modern systems and technologies that have been in practice for hundreds of years, e.g. the Chagga Homegardens (Fernandes *et al.,* 1984), the related Mara Region

Homegarden known as *Obohochere,* the traditional Wasukuma Silvopastoral technologies called *Ngitili* (Kamwenda, 2002) and those of the Haya practices known as *Kibanja* (Maruo, 2002). Modern AFs and Technologies are like contour ridges, rotational woodlots and alley farming. Modern Agroforestry reflects the use of exotic trees within the farm with regular arrangement and differs from traditional Agroforestry in that in the traditional practices useful indigenous trees are left in cropland during cultivation where as in modern practices both exotic and indigenous trees are planted. Traditional practices have been developed and tested by farmers, are flexible and able to acclimatize to the changing needs of the household without involvement of research and extension service (Kefleketema, 2006). AF practices help to enhance poverty reduction and transition to permanent cultivation regardless of whether it is traditional or modern (Rahman *et al.,* 2008).

1.2 Problem Statement and Justification

About 1.2 billion people of the world's population depend on Agroforestry practices and services for their livelihoods (Garrity, 2006). Agroforestry has the potential to enhance food and nutritional security, human health and environmental sustainability especially among subsistence farmers (NASCO, 2006). Since 1970s, there has been a significant amount of experimental research done on AF with much of this having been conducted in Africa, indicating a significant potential for AF to increase resource income and meet household needs (Garrity, 2006). In Tanzania since the 1980s there have been also various researches done on AF with priority areas being the Lake, Northern, Southern Highlands and the Western zones (NASCO, 2006).

Most of the inhabitants in Kasulu District are subsistence farmers and they had been practicing traditional Agroforestry systems for decades (KDC, 2007). Agroforestry systems are practices that may be influenced by a number of factors such as socio economic characteristics of farmers access to resources, provision of extension services, preference and attitude of a farmer and market availability (Ramji *et al*., 2001). These may result into different levels of adoption among individuals, groups and different communities, thus leading to different adoption status (Ghimmire and Pimbert, 1997). Although the people in Kasulu District for years have been practicing Agroforestry, the level of adoption of various Agroforestry systems and technologies by the communities has not been determined and documented. The rationale of the current study was therefore to assess and document the adoption status or extent of adoption of Agroforestry by the local communities in Kasulu District. The information gathered can make a significant contribution to Agroforestry promotion and provide useful feedback to researchers, policy makers and other stakeholders in terms of developing and providing strategies related to Agroforestry scaling up interventions and associated local development with regard to community needs.

1.3 Objectives of the Study

1.3.1 General objective

The main objective of this study was to assess and document the status of Agroforestry systems and technologies in Kasulu District, Kigoma Region, Tanzania.

1.3.2 Specific objectives

i. To determine the current status of adoption of Agroforestry by the communities in the district.

ii. To identify the Agroforestry systems and technologies that are preferred and used by the people in the study area.

iii. To determine actors influencing the adoption of Agroforestry by the community.

iv. To identify measures that would be required to improve the adoption of Agroforestry systems and technologies by the community in the study area.

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Adoption of Agroforestry

The acceptability and adoption of Agroforestry technologies involves not only its biophysical and economic profitability but also requires adequate knowledge of a number of factors including how farmers perceive the underlying problems, their attitudes, beliefs and practices related to the intervening solutions offered to them. Motivation factors in the diffusion process of the Agroforestry practices as innovations may include their profitability, compatibility, complexity, trialability and observability (Rogers, 2003). It is believed that a particular technology is adopted when the expected utility exceeds that of non-adoption (Douthwaite *et al*., 2001). Example is how Agroforestry systems adopted in Mara Region where about 19 916 (72%) out of 35 640 people implemented one or more agroforestry activity (ies) through Vi Agroforestry programme (Odhiambo and Garret, 2008). These were regarded to be the degree to which an innovation was perceived as being consistent with the existing values, past experiences, and needs of adopters.

Zeleke (2009) reported that about 91% of the community adopted and practiced Agroforestry in their land whereas only 9% of them had not adopted Agroforestry in Oromia, Ethiopia. It was reported that farmers in Oromia, Ethiopia, had been accumulating diversified products and services from the trees which were retained and planted in their farms. Among the uses and services they accrued included: fuelwood, construction materials, fruits, traditional medicines, farm implements, shade, bee products, soil fertility improvement and timber.

Kyamani (2009) reported that by the year 2006, 10% of the population in Uyui District, Tabora Region, adopted Agroforestry. This implied that the adoption was low although there were strategies for dissemination of Agroforestry. Mgeni (2008) also reported that about 65% of the populations were reported to have adopted Agroforestry through the dissemination agents that were available in Mufindi District such as CONCERN, HIMA and various government extension agents. In Lushoto District, Tanzania, 90% of the surveyed farmers had adopted Agroforestry and were merely depending on Agroforestry as the main source of income (Bonifasi, 2004). Shilabu (2008) reported that only 22% of the farmer's households had adopted Agroforestry in Maswa District. The adoption was influenced by the climatic conditions, attitude and preference whereas lack of land, fear of components competition caused by lack of knowledge on components arrangement and management were the main constraining factors.

According to Shilabu (2008) adoption of AFs was affected by age and gender. It was observed that elders were the ones having family resource rights and therefore being in a better position of adopting new technologies whereas young farmers were likely to adopt new AFs and technologies if they fetched more quick market responses. The report by Odhiambo and Garret (2008) in Mwanza and Mara (Musoma) showed that about 27 632 (72%) and 35 640 (56%) farmer households respectively were registered in Agroforestry data bases and had been practicing one or more of Agroforestry systems. Agroforestry practices in these two regions were initiated by the Vi Agroforestry programme which intended to develop appropriate Agroforestry technologies that would be beneficial to the intended communities specifically local farmers (Odhiambo and Garret, 2008). Orisakwe and Agomuo (2011) observed that the average rate of adoption of AFTs was 34.12% whereas about 50% of the respondents had farm sizes of 1-3 ha in Imo State Nigeria. In Tabora District, Tanzania, about 1 000 tobacco farmers had planted *Acacia crassicarpa* woodlots to produce fuelwood for tobacco curing. Growing wood on farms prevents felling of trees from the natural forest, thus reducing forest degradation (Ramadhani *et al.*, 2002).

2.2 Preferences and Types of Agroforestry Systems and Technologies

2.2.1 Preference for Agroforestry systems and technologies

The most decisive factor for the success of Agroforestry is the choice of suitable and usable tree species (Lulandala, 2009). The proposed technology should aim to achieve the highest output possible per unit of resource base while disallowing any depreciation in the basic agricultural land (Swaminathan, 1987). Msuya *et al.* (2006) reported that about 40% of the respondent farmers were practicing boundary planting because it was the most preferred AF technology in the surveyed areas of Shinyanga Region, Tanzania. Ajayi (2007) also reported that farmers preferred plant species that re-sprout after being cut because this character eliminates labour and cost that would otherwise be required to re-establish. The performance of tree species in relation to environment and their effects on the soil, propagation, management requirements and the direct economic and nutritional benefits may lead farmers to prefer some of species (Kyamani, 2009).

Farmers give preference also, to species that have shorter payback period, most probably to ensure that farmers recover their investment cost at the earliest possible period. Farmers, also, prefer species which are less prone to attack by pests, livestock and fire e.g *Eucalyptus* and *Sesbania spp* (Simmons and Leakey, 2004; Oduol *et al.,* 2006). Farmers preferred woody perennials which basically improve soil fertility and which indirectly raised crop yields and increased family income (Haggblade *et al.*, 2004). Farmers prefer woody perennials which decay rapidly and release nutrients easily and rapidly (Nyadzi *et al*., 2003). According to Zeleke (2009) farmers maintained trees on their farms for different socio-economic purposes including medicinal products, provision of shade and shelter, fodder and fuelwood in Ethiopia while Kebebew *et al.* (2011) and Sebyuku and Mosango (2012) in Uganda reported that woody perennials are known to restore and sustain soil fertility through nutrient cycling, provide fodder for livestock and reduce soil erosion hence reduces pressure on land by minimizing demand for arable land.

Ekue *et al.* (2010) reported that *Blighia sapida* tree emerged as the high priority tree species for domestication in Benin Germany. It was also observed that the Otamari ethnic group in the same region showed the highest preference of tree species for medicinal (73.3%) and marketing (36.7%) purposes, whereas the Natemba ethnic group in the same study area was the second group using *Blighia sapida* for its marketing (40%) value. Oke and Odebiyi (2007) reported that farmers preferred *Citrus sinenses, Mangifera indica*, *Persea americana*, *Psidium guajava* as the most important exotic tree species cultivated to provide edible fruits in addition to shade for cocoa crop in Ondo State Nigeria.

According to Kefleketema (2006); Lulandala (2009) and Lulandala (2011), the felt needs of the people for which the Agroforestry technology is intended (e.g wood, nutritional etc), adaptability, compatibility of various components in the system, are some criteria interests which one or group of people have to consider during the selection of woody perennials. Farmers in Sidama, Ethiopia, for example were motivated to plant *Eucalyptus* tree species because of their high cash returns. They planted them in a way that it didn't compete directly with the agricultural crops because they were aware of their side effects to crops when integrated together in the same land unit (Tesfaye, 2003). Zeleke (2009) reported that *Croton macrostachyus* was the most dominant tree species that was maintained followed by *Warburgia ugandensis, Syzygium guineense, Cordia africana, Pygeum africanum, Ficus vasta* and the like respectively in Burkitu Ethiopia. The fruit trees like *Mangifera indica, Persea americana, Psidium guajava* and *Annona muricata* were the major exotic trees preferred for fruits provision.

Sebukyu and Mosango (2012) also revealed that the most common indigenous tree species that farmers were used to integrate with other Agroforestry components in their farm land in Masaka District in Uganda included: *Ficus natalensis* and *Markhamia lutea* whereas the common exotic species highly preferred were *Grevillea robusta* and *Calliandra calothyrsus* from Central America. Many exotic tree species were woody legumes used to fix nitrogen. It is reported that woody leguminous species were the most important group because of their economic uses and ecological adaptability (Nair, 1993). Woody leguminous species had added advantage of their capability for nitrogen fixation. Therefore, replacing the less productive woody species with fast growing nitrogen fixing species such as *Leucaena leucocephala, Sesbania sesban, Gliricidia sepium* and *Mimosa scabrella* will increase crop yields, provide farmers with more fuel, fodder and green manure hence improving farmer's livelihoods. In Eastern Zambia, *Gliricidia sepium* leaf mulches were used in combination with nitrogen fertilizers implying that it was the most preferred tree species for soil fertility improvement in the country (Ajayi *et al.*, 2006). According to Akinnifesi *et al.* (2004; 2006), the Miombo indigenous fruit trees were also important for food and nutritional security, as well as being a source of income for rural communities in Southern Africa, with women and children being the main beneficiaries. Ajayi *et al.* (2006) reported also that wild fruit trees represented about 20% of total woodland resource use by rural households in Zimbabwe because it were preferred.

Buyinza *et al.* (2008) also reported that most farmers preferred planting fruit trees than planting non-fruit bearing trees in Uganda. These indigenous trees served a number of functions in the daily life of the people such as: Food, medicine, fuel wood, building poles, shade, windbreaks and source of income through the sale of firewood/charcoal and soil fertility improvement. Other trees commonly integrated included: *Melia azedarach, Markhamia lutea*, *Vitellaria paradoxa, Senna spectabilis, Tamarindus indica, Eucalyptus* spp, *Citrus* spp, and *Mangifera indica. Ficus* and *Euphorbia* species were planted as boundary markers and fences. Dowiya *et al.* (2009) reported that farmers practiced Agroforestry in North and South Kivu in the Democratic Republic of Congo and they grew *Eucalyptus* spp. for fuelwood and *Carica papaya*, *Mangifera indica*, *Persea americana* and *Psidium guajava* as multi-purpose trees.

2.2.2 Types of Agroforestry systems and technologies

In AFs there are three basic sets of components that are managed by the land user namely, trees or woody perennials, herbaceous crops and pastures or animals (Nair, 1993). Other components include insects and waterborn lifeforms/aguatic lifeforms both integrated with woody perennial(s) (Young, 1990; Lulandala, 2009). Based on composition, there are currently five major categories of Agroforestry systems most widely referred to: Agrosilvopastoral, Agrosilvicultural, Silvopastoral, Aquosilvocultural and Aposilvicultural systems. There are many more Agroforestry systems with potential for wider application in the future (Lulandala, 2011).

- **Agrosilvicultural system**

It involves integration of woody perennials with agricultural crops only in the same land unit (Nair, 1993; Lulandala, 2009; Lulandala, 2011). Trees may be grown on farmer's fields while crops are grown in the understorey. The trees may also be dispersed widely either spaced systematically in a grid or scattered at random. The system is common where agricultural crop production is the dominant economic activity (Nair, 1989; Lulandala, 2009). Annual crops are grown simultaneously with trees to provide better sustained production of crops, fodder and wood (Abdelkadir *et al.*, 2003).

The system may have varying benefits depending on the type of components that exit within the same land management unit. It provides benefits such as environmental benefits e.g. increment in soil nutrients through addition and decomposition of litter, economic benefits such as increase in level of farm income due to improved and sustained productivity (Lulandala, 2009; Lulandala, 2011). Zeleke (2009) reported that about 2.7% farmers in Burkitu Ethiopia were practicing Agrosilvicultural system. The adoption of the system was low as compared to other systems adopted such as Agrosilvopastoral which rates to 86% of the Agroforestry adopters.

Mgeni (2008) reported that farmers had been practicing Agrosilviculture and this was the most widely disseminated and adopted system in Mufindi District, Iringa Region. The high adoption of the system in Mufindi was due to the influence of agricultural crop production being the major social activity of the community in the District (URT, 1997). The lower adoption of Agrosilvipastoral system was attributed to limited tradition in animal production (Mgeni, 2008). Taungya (33%), Mixed intercropping (26%), Windbreak (17%), shifting cultivation (6%), Contour bands (4%), Alley cropping (3%), Live fences(4%) and Homegarderns (8%) were the common technologies adopted in Mufindi District with the Taungya technology being highly practiced than the rest followed by Mixed intercropping which was common in the lower zones and comprised mainly of the retained and naturally occurring woody perennials in agricultural fields (Mgeni, 2008).

Kyamani (2009) reported that four technologies were identified to be commonly practiced in Agrosilvicultural system in Uyui District, Tabora Region. These included: The Improved fallow (43%), Rotational woodlots (30%), Boundary planting (17%) and Fodder bank technologies (10%). Improved fallow and Rotational woodlots were the most widely adopted AFTs due to the fact that the two were reported to have several benefits within a short time such as improving soil fertility, providing fuel wood and other valuable products (Gama *et al*., 2002; Ajayi *et al*., 2006b). Alavalapati *et al*. (1995) also reported that technologies that take a long time period for their benefits to be realized may not be affordable to subsistence farmers.

It had been observed in Kordafan and Darfur Southern Sudan that preference across technologies adoption are much influenced by what the farmers see as incentive or dicentive (Rahim *et al.*, 2005). The biggest incentive is the income that is obtained from the sale of the products, increased yield, the medicinal value derived from such technologies and the improvement of welfare due to raised farm income (Nyadzi *et al.*, 2003; Simons and Leakey, 2004; Ajayi, 2006). Buyinza *et al*. (2008) reported that most farmers practiced Agroforestry Homegardens and Mixed intercropping. The *Citrus* species had been found to be the most favoured plant and had been planted in most Homegardens and were used mainly as source of fruits as well as sources of income through the sale of fruits in Hoima District, Uganda.

Sood (2006) reported that farmers were practicing Agroforestry but with more traditional Agroforestry systems in Western Himalayas, India. The traditional Agroforestry systems that were practiced by farmers in Mandi were Agrosilvicultural and Silvipastoral systems, with the Agrosilvicultural system being highly preferred. Irshad *et al.* (2011) also reported that Agrosilviculture was most preferred in Swat, Pakistan. Common technologies in Agrosilviculture include Homegardens, Alley farming, Taungya, Rotational cropping, Windbreak, Live fences, Mixed intercropping etc (Young, 1997; Mbwambo, 2004).

- **Silvopastoral system**

It is the system which combines pasture/animals and trees on the same land management unit (Abdelkadir *et al.,* 2003; Lulandala, 2009). This combination can be arranged as a pure stand with fodder trees/shrubs planted as a protein bank (with cut and carry fodder production) and/or mixed in different patterns. The objective of the system varies according to the components and farmers needs. It may be designed to produce a high value tree component, while continuing producing of the forage component indefinitely or for a significant time (Lulandala, 2009; Lulandala, 2011). The system can be practiced on both range and forest lands for the production of both fodder and woody materials. The system could also be practiced on sloping ground by growing grasses and trees/shrubs together for soil conservation purposes (Abderkadir *et al.*, 2003). According to Kaale *et al.* (2002), Silvopastoral system enhanced the availability of fodder, woody products, and environmental conservation.

Trees integrated in silvopastoral land may be used for timber, fibre, fuelwood, fruits or any other valuable products. Nitrogen-fixing trees can be useful to supply nitrogen for the forage crops. Trees may also be maintained to provide shade, shelter and fodder for animals. Zeleke (2009) reported that about 1.3% of the community adopted and practiced Silvopastoral system in Burkitu Ethiopia. Pye-smith (2010) reported also that there were approximately 600 ha of documented *ngitili* silvopastoral technology in Shinyanga. According to Kamwenda (2002), *Ngitili* is a traditional land management system among the Wasukuma Agropastoralists which alleviate dry season fodder shortages, prevents environmental degradation such as soil erosion and helps conserve biodiversity. Shilabu (2008) reported that Integrated tree pasture *Ngitili* (15%) and Mixed intercropping (5.8%), were the common Agroforestry technologies being adopted whereas the *Ngitili* traditional technology was mostly preferred in Maswa District, Shinyanga. It was reported that Agrosilvipastoral system was not common in Maswa District due to available free grazing land in the crop fields following crop harvest. Other technologies of the Silvopastoral systems which have been reported included: Integrated tree-pasture management, Intensive foliage production practices, Integrated poultry production and Plantation crops with pastures and protein banks (Lulandala, 2009).

- **Agrosilvopastoral system**

It is an Agroforestry practice in which agricultural crops, pasture/animals and trees are combined on the same unit of land (Abdelkadir *et al.*, 2003). Since the crops and animals can’t occupy the same land management unit at the same time, the question of sequencing the components becomes important. Thus during the cropping season, the animals such as cattle and goats can continue benefiting from the system through a cut and carry mechanism of the fodder materials from the land management unit to the stall-fed housed livestock or supplementing the pastures external to the system (Lulandala, 2009). This system is practiced when the farmer needs all the benefits that would be obtained from Silvopastoral and Agrosilvicultural systems from the same unit of land. It is also practiced when the cropland is constrained by erosion like in the Ethiopian highlands which have soil erosion as one of the land use problems (Abdelkadir *et al.*, 2003).

In Tanzania Agrosilvipastoral land management system is highly practiced by the Chagga, Nyakyusa, Haya, Sambaa and various high population rural communities and also spreading fast among the urban and especially peri-urban households throughout the country (Lulandala, 2009). According to Fernandes *et al.* (1984), farmers in Kilimanjaro in northern highland Tanzania knew the functions/uses of the plant species on their farms. The large plant species diversity provided both subsistence and cash crops which enabled farmers to keep their management options open and provided insurance against drought, pest and economic risks. Zeleke (2009) reported that 86% of the community adopted and practiced the Agrosilvopastoral system and farmers obtained diverse types of benefits. Income generation and minimization of the impacts of natural hazards were among the objectives of this system, since the Agroforestry practice holds more components, so that if one of the components fails, there is a possibility to be secured by the other components unlike monocropping systems.

Other benefits of the Agrosilvipastoral include diversification of income, household consumption, traditional medicine and employment opportunity. It was observed that more than 90% of the community in Oromia, Ethiopia declared that cash income was the most important benefit that had been gathered from Agroforestry practices (Sood, 2006; Zeleke, 2009). Sebyuku and Mosango (2012) reported that farmers adopted five types of Agroforestry systems, namely: Agrosilvipasture (45.5%), Agrosilviculture (32.9%), Silvopasture (16%), Aposilviculture (4.5%) and Agroaguosilviculture (1.1%) in Masaka District Uganda. Agrosilvopastoral system was the most widely adopted by farmers because the system had the potential in

Masaka District particularly for improvement of food security and farmers livelihood. Zeleke (2009) also reported that Agrosilvopastoral (86%), Silvopastoral and Agrosilvicultural systems (2.7%) were practiced in Oromia Ethiopia.

Agrosilvopastoral technologies practiced include: Homegardens e.g Chagga Homegarden (Fernandes *et al.*, 1984) and those reported by Maruo (2002) in Kagera Tanzania. Bonifasi (2004) also reported that Agroforestry Homegardens comprised a mixture of Agricultural crops, various tree species and shrubs and different types of livestock like cows, goats, sheep, chicken and ducks hence farmers had the opportunity for continuous production of different crops and tree products throughout the year in Lushoto Tanzania. Okia *et al.* (2009) reported that environmental sustainability, social acceptability, adoptability, economic feasibility and gender equality, were the five factors which made possible for technologies to be adopted. The top five technologies which were highly preferred and practiced under Agrosilvopastoral system in Uganda included; Homegardens, Mixed intercropping, Improved fallowing, Relay and Rotational cropping and Fodder banks. One of the key motivations for farmers to practice Agroforestry was that the technologies should be able to generate benefits in addition to economic/financial benefits accruing from such technologies (Zeleke, 2009).

Mukome (1998) reported that most respondents declared that Alley farming technology needed more manpower and proper management which requires skilled personnel in Dodoma. Proper weeding at the right time, early planting, spacing of the crop and selection of better species of both crops and trees were among the management skills farmers had to consider. The technology needed regular contact with extension agents so as to motivate and expose the farmers to the innovations and give them information on how to use the technologies.

- **Aquosilvicultural system**

It is a system of resources use where trees are integrated into one land unit area in combination with some aquatic organisms like fish, snails and other aquatic food resources (Amin, 1993; Lulandala, 2009; Lulandala, 2011). Technologies in this system included: Tree-fish, Tree-frog, Tree-crocodiles, Tree-shrimp and Tree-crab management.

- **Aposilvicultural system**

It is a type of Agroforestry system which involves the production of various species of insects. The Aposilvicultural system in Thailand ranges from traditional honey hunting to large scale commercial beekeeping (Trongkongsin, 1987). Aposilvicultural technologies include: The tree bee interaction, tree-grasshopper management, tree-butterfly caterpillar management practiced in Zambia, Zimbabwe and South Africa and the tree-locust management practiced in Asia and Northern Africa (Trongkongsin, 1987; Lulandala, 2009; Lulandala, 2011).

2.3 Factors Influencing the Adoption of Agroforestry Systems and Technologies

Although the overall objective of AFs and technologies is to provide benefits such as environmental, economic and social benefits, its adoption is still influenced by several other factors such as socioeconomic, biophysical characteristics and persons attitude. Persons attitude are governed by a set of intervening variables such as individual needs, knowledge about the technology and individual perceptions about methods used to achieve the needs etc (Kabwe, 2010). These factors may result into adoption or non-adoption but it may also result into different levels of adoption for those who will adopt the innovations. Some of the specific factors which influence AFs adoption include: Government policies, land tenure, farmers preference and awareness, farmers income, technology characteristics, gender and age, farmers education, extension services and cultural norms.

Sebukyu and Mosango (2012) reported that the adoption of AFs was influenced by several factors including high demand for land due to increasing population, soil fertility decline, erosion problems and demand for tree products such as fuelwood, fodder and increased crop yields in Masaka District Uganda. Personal land ownership has also facilitated the adoption of Agroforestry systems in Masaka District since the majority of farmers hold personal land.

Thangata *et al*. (2008) also reported that the potential adoption of Agroforestry by farmers in Malawi, Zimbabwe and Zambia depended on household composition, farm size, availability of draft power animals, and a seed selling incentive. Nkamleu and Manyong (2005) reported that the gender of a farmer, household family size, level of education, farmer's experience, membership within farmers associations, contact with research and extension agents, security of land tenure, agro-ecological zone, distance of the village from nearest town, village accessibility and income from livestock, all facilitated the adoption of Agroforestry systems in Cameroon.

According to Muneer (2008), age of the farmer, gender, education level, social participation of the farmer and area owned were the factors that had greater influence on the adoption of Agroforestry practices in Northern Kordofan Sudan.

Buyinza *et al.* (2008), reported that factors that significantly influenced the decision to adopt rotational woodlot technology included; gender, tree tenure security, seed supply, contact with extension and research agencies, soil erosion index, size of landholding, fuelwood scarcity and main source of family income in Hoima District, Uganda. Farmers adoption behavior, especially in low income countries is influenced by a complex set of socioeconomic, demographic, technical, institutional and bio-physical factors (Masangano, 1996).

2.3.1 Factors that enhance adoption of Agroforestry systems and technologies

- **Government policies**

It has become increasingly apparent that AF systems and technologies in many countries are hindered by the lack of appropriate policies to support their promotion (Ajayi *et al*., 2006). Public policies such as land and agriculture policies have a great impact on land use system. According to NASCO (2006), Agroforestry has a strong interconnectedness with land, agriculture and forestry. Therefore support for Agroforestry is reflected in the agricultural and forestry national policies as well as land policy. There must be specific policies, institutional and incentive structures that are needed to speed up the Agroforestry adoption process (Kabwe, 2010). Msuya and Kidegesho (2012) reported that Agroforestry has been overlooked in terms of policy and that its association with both agricultural and forestry policies has often affected Agroforestry negatively. Forestry policies for example, are well known to be protective of the forestry resources but in the process of protection, they provide a disincentive for farmers to grow the trees. On the other hand the agricultural policy focuses on increasing productivity without much emphasis on the tree components on farm. Such policy constraints have affected the performance of smallholder farming (ICRAF, 2007). NASCO (2006) also reported that sector policies and regulations need to be harmonized in order to address issues related to land tenure e.g. access to land, particularly for smallholder farmers and women. In addition, Village and District authorities are encouraged to formulate and enforce by-laws pertaining to Agroforestry adoption.

Nyariki *et al.* (2010) reported that policies and institutions of governance influence how people use and manage natural resources. Place *et al.* (2012) reported however that while some countries have found tree growing to be extremely profitable others do not even consider it as a potential livelihood. The justification for why adoption of agroforestry is a policy issue is that it generates significant public environmental services such as watershed protection, biodiversity, and carbon sequestration. Land tenure is the body of rights and duties which regulates the use and control of land. The customary property systems also often distinguish between trees and land on which they grow and may vary between regions and countries (Kang and Akinnifesi, 2000). Lack of land tenure is a discouragement to the adoption of Agroforestry technologies (Fahlen, 2002).

Nair (1989) reported that farmers with less secure land had least incentive for adoption of tree-based systems and technologies. Example in Costa- Rica and Haiti, farmers tended to prefer secured lands for Agroforestry and therefore grow short-term crops on less secure lands. According to Kofi *et al.* (2003), land tenure has placed constraints on the long term investment in land that would be fundamental for increasing the farm productivity. Parwada *et al.* (2010) reported that use of land rights were the requirement for farmers to adopt better land use management like agroforestry practices in Zimbabwe. Zeleke (2009) on other hand reported that shortage of land could also be the major constraint in adopting agroforestry practices. In his study he revealed that about 68% of the community had problem of land shortage which resulted in hindering the development of agroforestry practices in Oromia Ethiopia.

Nyadzi *et al*. (2003) reported that farmers in villages facing high land pressure may lack enough land for experimentation with Agroforestry technologies. World Forests (2005) also reported that farmers with insecure land rights were unwilling to plant trees. It had been, however reported that, formal land registration is not always necessary, as some traditional forms of tenure provide for the security to plant trees. Buyinza *et al*. (2008) reported that the majority of the farmers (81%) preferred the free hold type of land tenure system to practice Agroforestry whereas only 19% preferred the lease hold tenure system in Uganda. This was preferred because under this system farmers have full continuous ownership of land and free decision making, thereby allowing them to practice any Agroforestry technology even those that may be long term such as tree planting.

Suyanto *et al.* (2002) reported that securing land tenure is a key determinant in improving sustainable land management in Sumatra, Indonesia. The study observed that the main motivation for local communities to better management of land was to secure land rights that would enable farmers to carry out more sustainable and protective practices. Even where forests are degraded, local communities with secure tenure rights can rehabilitate unproductive lands into more productive and sustainable systems. Land tenure can be an attractive incentive for farmers to be engaged in sustainable management of protected forest land and reduced social conflict and expenses for forest protection. However, Glenn *et al.* (2002) reported that there were no relationship between tenure status and willingness to adopt agricultural technology in Haiti.

- **Farmers awareness**

Rogers *et al*. (2005) and Wambungu *et al.* (2006) reported that most farmers preferred plants which they were familiar with and have short term return. Ajayi (2006) and Oduol *et al.* (2006) also reported that farmers preferred plant species that coppice after being cut because this eliminates labour that would otherwise be required to re-establish fallows continually in Malawi Southern Africa. These together are influenced by the farmer's awareness of AF technologies components. Parwada *et al.* (2010) reported that increased likelihood in adopting the Agroforestry technologies was influenced by awareness suggesting that since Agroforestry was still a new phenomenon among farmers, awareness of the technologies was therefore very important before adoption. This means that the initial stage for adoption of Agroforestry practices was awareness. There is a need of effective communication to farmers to create awareness about Agroforestry in order for adoption of Agroforestry to take place. With the level of awareness of Agroforestry technologies, there are likely high adoption rate since farmers are aware of a given technology before adoption.

Mutonyi and Fungo (2011) revealed that farmer's exposure to a technology was the most important determinant of adoption among all Agroforestry systems in the Lake Victoria Zone, Uganda. This was supported by Kiptot *et al*. (2007) who reported that farmers in western Kenya who had a long history of exposure to Agroforestry research had higher adoption level than those with recent history. Munner (2008) reported that farmer's level of awareness was influenced positively by educational level and/or degree of contact with the agricultural extension services and therefore the reason to the causative of the people innovativeness to be positive towards Agroforestry adoption in Northern Kordan Sudan. However Thangata and Alavalapati (2003) reported that non-adopters of Agroforestry practices had higher awareness than adopters. This could imply that farmers had little preference and little attitude towards Agroforestry practices although the practices were not new technologies in Malawi. It can also imply that non adopters might have other activities which are beneficial to them.

According to Smith (2010), primary barrier to wider adoption of agroforestry was the inadequate awareness among farmers and landowners of Agroforestry practices in Hamstead Marshall. For Agroforestry to be adopted on a wider scale, economic viability and practical management skills need to be demonstrated to farmers and landowners. Raising awareness of the potential of AF is essential for promoting Agroforestry as a mainstream land-use system. Thangata and Alavalapati (2003) reported that household level of awareness about Agroforestry practices depended on contact with extension agents, neighbours and participation in field days.

- **Farmers income and income generation**

Sood (2006) reported that income is a proxy for wealth status. Farmer's income is positively related to adoption of Agroforestry systems and technologies implying that the rich farmers adopt AFs and technologies more than the poor farmers. This could be caused by the power the individual has to purchase new inputs such as improved seeds, fertilizes etc and or implements and extend facilities for improved and higher productivity which is dictated by individual financial capability. Casey (2001) and Parwada *et al.* (2010) reported that farmers with high income were more likely to be adopters of new innovation than farmers with low income in South-eastern Mexico and Zimbabwe respectively. Lambert and Ozioma (2011) reported that 48.9% of the community were rich and had adopted Agroforestry due to the higher economic status they had. Indeed, there was increased Agroforestry adoption among households with higher off-farm, agricultural and total incomes. Rogers (2003) reported also that adopters of new technologies had good income but also had positive attitudes towards the technology and had high level of social participation.

However, Thangata and Alavalapati (2003) concluded that it was not necessarily that the adopters of Agroforestry technologies were wealthier than non adopters in Malawi. This could be for the reason that the objective behind the promotion of the technology at hand was to alleviate the problems associated with the use of high cost fertilizers. Since better-off households could afford to use high cost chemical fertilizers, it was likely that there was less necessity for them to adopt the Agroforestry technology at hand therefore those poor farmers were the one who adopted the innovation.

World Forest (2005), reported that most farmers adopted Agroforestry because they were influenced by income generation. They realized that through Agroforestry, farmers can generate cash income through sale of Agroforestry components including tree products. Agroforestry provides products that farmers would otherwise have to purchase. Place *et al.* (2004) reported that Agroforestry enhanced diversity both in terms of plant biodiversity and enterprise diversity. The latter decrease risk and allow farmers to reduce seasonal labour peaks, earn income throughout the year and accrue benefits at different times depending on the Agroforestry components.

Buyinza *et al.* (2008) reported that farmers who adopted Woodlot technology intended to have domestic requirements such as firewood, construction materials (68%) as well as household income generation (54%) in Hoima, Uganda. In addition to that, farmers (42%) reported that they had established Woodlots so as to have financial security during declining revenues of their current marketable food crops. Irshed *et al.* (2011) also reported that the aim of Agroforestry systems was to optimize the positive outcomes in order to obtain diversified and more sustainable production systems from the limited resources in Swat Pakistan. According to Zeleke (2009) more than 90% of the community reported that generating income was the most important socio-economic benefit that was accumulated from Agroforestry practices despite of many benefits obtained from AFs in Ethiopia.

ASARECA (2004) reported that by increasing the income while maintaining land productivity with minimal external farm inputs, were the main objectives of practicing Agroforestry in the targeted areas. Farmers should benefit from diversification and intensification of multipurpose tree and shrub species that provided a range of high value products to generate income and poverty alleviation. Odoul *et al.* (2006) also reported that indigenous fruits provided income generation to farming households. Efforts by WAC and partners in western Tanzania have raised the value of several species of indigenous *Miombo* fruits for example *Parinari curatellifolia and Syzygium guineense*. More than 2 500 women from 50 women's groups in Tabora were employed in indigenous fruit processing enterprises. Indigenous tree fruits provided income and opportunities in processing and enterprise development for rural women.

Ruheza *et al*. (2012) reported that most people were interested in planting trees on their farms for economic benefits by producing timber (48%) rather than for environmental conservation in Uluguru Mountains Tanzania. This implied that more efforts were directed to planting tree species that have economic benefits to farmers in order to speed up the rate of Agroforestry adoption to increase family income. Ruheza *et al.* (2012) also reported that farmers with a relatively high level of income planted more trees than those with small level of income. Probably this was because farmers with relatively high levels of income can invest more in long term economic activities as they are able to buffer for any risk that might be involved in the practice. Chirwa and Quinion (2008) reported that Agroforestry and specifically integrated with soil fertility replenishment (SFR) tree species had the ability to increase crop production and provided additional income to farmers. The uses of SFR technologies promoted the diversification of income generating activities in Central and Southern Malawi.

- **Technology characteristics**

Agroforestry technologies are known to be more sophisticated than those of annual crops practices because of the multi-components, multi-ages testing and management nature (Scherr and Miller, 1991; Mercer, 2004). Farmers always decide to adopt technologies upon benefits consideration especially when benefits from technologies being promoted exceed those obtained from the old ones (Ajayi, 2006). Also farmers adopt easily understandable innovations (Muneer, 2008). It has been proved that the multifunctional nature of Agroforestry offers a range of opportunities sustaining ecosystem functions which include the use of live fences to protect farms, woodlots to produce fuel wood, and nitrogen fixing trees to improve soil fertility, soil organic matter and physical conditions (Ajayi, 2007).

- **Farmers education**

Farmer's education background is an important factor that determines the readiness to accept and apply a new technology. It is also believed that higher level of education increases a farmer's ability to obtain and use information (Buyinza *et al.,* 2008). Therefore education is expected to have a positive effect on the decision to adopt agroforestry. To have effective adoption a farmer must understand the problem and this requires formal education that exposes information regarding the benefits of the innovations (Matata *et al.,* 2010). Buyinza *et al.* (2008) reported that

Agroforestry was a knowledgeable and management intensive practice which required ability to manage the tree-crop combinations so as to achieve the optimal results. Lack of proper management can lead to poor performance of both components.

Lambert and Ozioma (2011) reported that 36.67% of the community had secondary education, 34.44% had primary education while 22.22% had tertiary education and about 6.67% had no formal education, hence constituting the illiterate class of the community. This literate proportion of the community implied that adoption of innovations like Agroforestry was favoured by education level. Ruheza (2003) reported that knowledge on tree planting and ages of adopters were some of the personal factors influencing the adoption of innovation in the Uluguru Mountains, Tanzania. However, Muneer (2008) reported that about two thirds (66.0%) of the community did not attend any formal education but they adopted Agroforestry. This high rate adoption of the farmers with no formal education is expected to represent a major constraint to the efforts exerted to disseminate the Agroforestry practices and convince farmers to adopt them.

- **Extension services**

It is believed that the success of any Agroforestry program in terms of adoption rest partly on the reliability of the extension agents and their ability to communicate with farmers. Lambert and Ozioma (2011) observed that farmer's contact with extension agents were positively related to the adoption rate of Agroforestry technologies Imo State Nigeria. Visits of extension agents to farmers created and increased awareness about the AF knowledge but also developed a favorable attitude among farmers towards the technology. Lambert and Ozioma (2011) also reported that 38.9% of the community who adopted Agroforestry technologies had contact with extension agents twice a month, while 21.11% had no contact with extension agents.

Regular contact with extension agents motivates and exposes the farmers to innovations and also gives them information on how to use the technologies. Mgeni (2008) reported that the increase in an awareness on the importance of adopting Agroforestry technologies by the households increased food availability in Mufindi District, Iringa, Tanzania. Buyinza *et al.* (2008) also reported that Agroforestry was a knowledgeable and management intensive practice which required ability to manage the tree crop combinations so as to achieve the optimal results in Kabale District, Uganda. Sezgin *et al.* (2011) observed that in order to improve the adoption of innovations significantly it was necessary to hold extension studies constantly in Turkey. Kabwe (2010) reported that various extension methods like field visit and demonstration plots were used to attract farmers to invest in Agroforestry systems and technologies in Zambia.

Mutonyi and Fungo (2011) reported that of the factors known to affect the adoption of Homegardens technologies, training and exposure to demonstration sites of Agroforestry were mostly stated. Others were land size, level of income derived from Agroforestry and land tenure (Kiptot *et al*., 2007). Nkonya (2002) and Fungo *et al.* (2011) reported that contact with extension agents and other sources of agricultural knowledge increased adoption of soil fertility technologies, hence leading to nutrients balances and enhancement of nutrients inflow at farm level in

Southwestern and Eastern Uganda. Sebyuku and Mosango (2012) revealed that of the factors which influenced AF adoption, contact with Vi-Tree Agroforestry Project extension services, demand for land, soil fertility decline, erosion problems, demand for woody products and fodder were the most important factors.

2.3.2 Factors that limit adoption of Agroforestry systems and technologies

Although it is known that AF provides several benefits there are still factors which limit some farmers from adopting and practicing AF. Some examples which are known to limit farmers to adopt the practice include: lack of income, farmers unawareness, shortage of land, lack of land tenure, lack of extension services, lack of improved seeds and cultural norms.

- **Lack of monetary income**

It is believed that farmers with high income are likely to adopt new technologies than farmers with low income, because income increases farmer's ability to hire labour and meet cost associated with technologies (Casey, 2001). Kabwe (2010) reported that wealth among other factors like labour availability and farm size affected farmer's decisions to initially establish improved fallows and practicing the technology in Zambia. Use of fertilizers and oxen ownership positively influenced farmer's decision to establish a fallow in Zambia. However, Parwada *et al.* (2010) demonstrated that there was an increased likelihood of unemployed farmers to adopt improved fallows and fodder bank technologies in Zimbabwe.

- **Lack of farmers knowledge**

Smallholder farmers are the major recipients of AFTs, but unfortunately few farmers and other stakeholders involved in agriculture and natural resources management have been exposed to Agroforestry technologies (NASCO, 2006). Lambert and Ozioma (2011) reported that with high level of awareness of Agroforestry systems, there was likely to be high adoption, since farmers were aware of a given system adoption. The study also revealed that the technologies adopted by the community were Tree-snail rearing 83.3% and Mixed intercropping 82.2%. AFs adopted were such as Aposilviculture and Silvopastoral system such as Vertivar Grass production 17.8%. The majority of the community had knowledge and hence awareness on Tree-snail rearing and Mixed intercropping technologies. Parwada *et al.* (2010) reported that awareness to Agroforestry technologies among farmers was low. Ineffective communication about the long term benefits of Agroforestry technologies between the change agents and other farmers was the reason for low adoption of some AFTs in Zimbabwe. It was also reported that due to lack of awareness and knowledge about 64% of the community didn't adopt live fence, 65.3% didn't integrate tree for soil fertility improvement and 88.3% didn't adopt fodder bank technologies (Parwada *et al.*, 2010). Mashinini *et al*. (2011) reported also that lack of adequate knowledge pertaining the type and amount of inputs to be used by farmers hindered farmers to produce more food in Swaziland.

- **Lack of land tenure**

Land tenure is the name given in common law systems to the legal regime in which land is owned by an individual who is said to hold the land. Security of tenure is the certainty that a person's right to land will be recognized by others and protected in case of specific challenges. NASCO (2006) reported that some of the government policies have implications on agroforestry activities. These include policies related to land tenure, e.g. most women don't have ownership of land hence they are discouraged from tree planting. Parwada *et al.* (2010) reported that adoption of live fence technology was significantly predicted by possessing permanent land ownership simply because Agroforestry requires big investments on land and the benefits normally come after a long time lapse. Farmers needed to be assured that they will enjoy the benefits once they have embarked on such technologies. Without secure land, households are significantly impaired in their ability to secure sufficient food and enjoy sustainable rural livelihoods. Bakengesa *et al.* (2002) reported that insecurity on land tenure has resulted in low adoption of AFTs by farmers in Shinyanga, Tanzania. Msuya *et al.* (2006) also noted that a fundamental challenge in dissemination and adoption of AF was lack of permanent land ownership. Generally, farmers fear to invest on the land which does not belong to them.

- **Shortage of land**

It has long been recognized that conservation practices such as terraces and contour strips as well as Agroforestry practices reduced land from crop production (Adjaye, 2008). From farmer's perspective, reduction in land area for growing crops may be seen as a sacrifice. It implies that farmers with small plots of land cannot afford to take land out of food production and put it under conservations purposes (Kaliba *et al.*, 2000; Adjaye, 2008). Zeleke (2009) reported that about 68% of the community proved that shortage of land was a factor that inhibited the uptake of agroforestry practices. Kyamani (2009) reported that farm size was often hypothesized as a determinant of adoption of Agroforestry in Uyui District, Tabora, Tanzania.

Ajayi *et al*. (2003) also reported that establishment of fertilizer tree fallow plots was positively associated with availability of land and size of land holding in Zambia. Lambert and Ozioma (2011) reported that farm size was positively related to adoption rate of AFTs implying that as the farmers farm sizes increased they adopt more of agroforestry technologies in Imo state Nigeria. Kabwe (2010) reported that when the farm size was large, it encouraged AF adoption in Zimbabwe.

- **Lack of extension services**

Extension services are a series of set in communicative interventions that are meant among others to develop and induce innovations which supposedly help to resolve problematic situations (Rutatola and Matee, 2001). Extension services increase farmer's awareness of specific technical advice and increases rate of technical adoption. Extension workers, are not only for informing farmers to improve their lands and prepare a cropping pattern, but also motivate them to adopt modern agricultural practices according to their socioeconomic status (Ahmad *et al.*, 2007).

It is against this condition that Lambert and Ozioma (2011) reported that ineffective linkage between extension workers and farmers was responsible for low adoption of technology including AFTs. Zeleke (2009) reported that about 36.5% of the community complained to have had low extension services hence was slow in adopting AF in Oromia, Ethiopia. According to Orisakwe *et al.* (2011) poor extension delivery was the factor that limited adoption of AF in Imo state, Nigeria.

- **Lack of quality tree seeds**

Tree planting activities are often constrained by limited access to planting materials, poor nursery skills and inappropriate technical information of tree planting (Gunasena and Rushetko, 2000). Kabwe (2010) reported that lack of seeds emerged as one of the important reasons for farmers not testing and adopting both improved fallows and biomass transfer technologies in Zambia. However, although lack of seed appeared to be a limiting factor for testing and adopting of improved fallows, it affected less than 40 % of the community who wanted to adopt Agroforestry. Farmers in Zambia were discouraged by the late delivery of seeds for establishment of nurseries. Zeleke (2009) also reported that 42.7% of the community had shortage of planting materials, a factor which limits them to adopt Agroforestry practices.

Ajayi (2007) reported also that insufficient amounts of good quality seeds, constrained the widespread uptake of improved fallows. Ajayi (2006) reported that one of the greatest constraints of some Agroforestry technologies was lack of access to quality seeds in Lusaka, Zambia. Unlike the seeds of annual crops in which established institutions exist to promote them and also private sector organizations have been engaged in their multiplication and distribution, there is little or no institutional structure to make the seeds of AF tree species available. Kyamani (2009) suggested that for AFTs to be widely disseminated and adopted there should be sustainable supply of Agroforestry tree seeds that can meet the needs and priority of small-scale farmers in Tabora Region.

2.4 Corrective Measures Required for Improving Adoption of Agroforestry

Several approaches can be suggested to enhance the use and improve the adoption rate of Agroforestry by farmers in Tanzania. Some of the measures which if well implemented can improve the uptake and the use of Agroforestry practices include: improvement of extension services, development of policies which advocate Agroforestry, introduction of improved tree species, formulation and enforcement of village by laws, promote traditional rules, provide agricultural inputs, harmonisation of land tenure policy and improve institutional linkages.

2.4.1 Improvement of extension services

There are several extension methods that extension representatives commonly use to help farmers create attitudes and make decisions to adopt new technologies. However, the methods to be used depend on the specific goals and situation in which one works. Kabwe (2010) reported that extension worker used different extension methods to disseminate and create awareness so that farmers motivated to adopt the innovation in Zambia. These included field visits to individual farmers, meeting with farmer groups, experimentation in a demonstration plot, field or classroom training, field days and tours, seminars and exhibitions etc. It is expected that with increased awareness, many farmers would adopt AFTs as a means not only to improve soil fertility but also rural livelihoods.

Zeleke (2009) recommended that district agricultural workers, rural development officers and other stakeholders should provide suitable extension services so that existing traditional practices and traditional knowledge that farmers have been using in managing Agroforestry practices show beneficial advantages in Ethiopia.

NASCO (2006) reported that in order to scale up Agroforestry and make impact up to the national level, capacity building at all levels should be advocated. Efforts should be directed towards field extension staff, district councils, policy makers, researchers and Agroforestry teams such as agriculture, forest, livestock and community development. Ajayi (2006) observed that there must be an opportunity to improve farmer's knowledge on fertilizer tree fallows.

According to Fungo *et al*. (2011) a lot of efforts were required to sensitize farmers on the need to seek extension advice where they needed it, because about 85% of the households had not been visited by an agricultural extension worker for the previous 2 years. Orisakwe and Agomuo (2011) reported that poor delivery of services was the factor that restricted adoption of AF. It implied that presence of extension officers in the farmer fields could encourage the adoption of Agroforestry. Kaliba *et al.* (2000) reported that availability of extension services and on farm field trials were the most important factors that influenced the extent of adopting improved maize and the use of inorganic fertilizers for maize production in the intermediate and lowland zones in Tanzania.

2.4.2 Formulation of policy which advocate agroforestry

According to NASCO (2006), sustainability of Agroforestry practices will depend on farmer's acceptance and adoption, favourable policy support, market and information accessibility and good weather that sustain plant growth. Nyariki *et al.* (2010) defined Policy as a typical course of action adopted for the sake of practicality and followed by Government, private sector organizations and groups or individuals according to the social and economic objectives that it is desired to achieve. It is the way in which the Government uses its institutional and legal means to carry out its programmes of activities aimed at achieving its chosen objectives. Policies provide rules by which individuals or groups in a society are expected to wisely use the physical environment within society's beliefs, values and ideas.

Matata *et al*. (2010) reported that about 5% of the respondents emphasized to formulate policy regarding Agroforestry practices as the way forward to create awareness and to enhance the use of improved fallows in Tabora, Tanzania. Parwada *et al.* (2010) also reported that policy makers should consider Agroforestry practices when formulating policies by granting permanent land ownership to farmers and privatization of livestock during summer and winter seasons to reduce complications to farmers when adopting the technologies. NASCO (2006) reported that Tanzanian Government supported agriculture in some ways, but Agroforestry is not often included as an agricultural enterprise for support.

In India, for example credit at low rates was available for agriculture, but Agroforestry falls under forestry and gets a much higher interest rate. Also many Governments have now improved market information systems for agricultural commodities but again, tree products are usually neglected (Place *et al.,* 2012).
Place *et al.* (2012) also reported that there were challenges that faced AF in management of landscapes that occurred from ambiguity and conflict between capacities for Government at national and local level. This was because the boundaries of authorities over natural resources management were not always clear.

For example it happened that funding for local level planning and implementation on AF management was usually given low priority compared to sectors such as education, health and water. NASCO (2006) reported that appropriate land tenure and Government policy support were basic conditions that were required to facilitate the development of a wide range of AFTs on the smallholder land management systems. For Agroforestry to be adopted there must be a conducive policy at both local and national level (Haggblade *et al.,* 2004; Ajayi *et al.,* 2006).

2.4.3 Introduction of improved tree species

NASCO (2006) reported that shortage of quality tree seeds, seedlings and other propagation materials was one of the most important constraints in dissemination and adoption of AFTs in Tanzania. This was due to limited capacity to produce and supply seeds to meet the demand. Efforts must be embarked in conducting studies on quality germplasm of appropriate species which are important for effective innovation and intervention, particularly for smallholder farmers because tree seeds are key input for promoting Agroforestry practices (Simons and Leakey, 2004).

Ajayi *et al*. (2006) reported that successful scaling up of Agroforestry was based on sustainable supply of germplasm of high physiological and genetic quality for a wide range of species that could meet the needs and priorities of small scale farmers. ICRAF and other organizations that support Agroforestry activities have been supplying large quantities of free seeds to farmers (Ajayi *et al.,* 2006). Ajayi *et al.* (2003) reported however that although it was appreciated that free seeds should be part of the dissemination process in the initial stages of the project for smallholder farmers in Zambia, it was noted that continued supply of free tree seeds made difficult to determine the effective demand for Agroforestry seeds.

This situation destabilized the establishment of a sustainable seeds supply in the study area and therefore poor adoption of Agroforestry. Mutonyi and Fungo (2011) reported that germplasm of tree species were developed and available to farmers through local nursery operators that were periodically supervised by NARO and other NGOs in the Western zones of Uganda. Ruheza (2003) reported that 64% of the community in the Uluguru Mountains, Tanzania, suggested that seedlings should be supplied freely to farmers to make the adoption of Agroforestry successfully.

2.4.4 Enforcement of village by laws and promote traditional rules

According to Parwada *et al.* (2010), Agroforestry is financially profitable and that there has been an increasing trend in the uptake of the technologies by farmers. However wide spread adoption of Agroforestry by many smallholder farmers is yet constrained by several challenges one of them being the presence of local customs. Kamwenda (2002) reported that traditional rules were informal and neither documented nor enacted by a defined legal body but they had the advantage of using them since most people in the community adhere to them in Shinyanga.

It is because customary institutions provide a strong social structure for implementing improvements and changes among the society. For example *ngitili* is a traditional practice (Silvopastoral system) in Sukumaland which involves retaining an area of standing vegetation such as grasses, trees, shrubs and forbs from the onset to the end of the rainy season. It remains closed to livestock at the beginning of the wet season and is opened up for grazing at the peak of dry season due to traditional rules (Kamwenda, 2002).

Matata *et al.* (2010) also reported that problems of bush fire and free grazing were discouraged by establishing village by-laws which were used to control free grazing and browsing livestock in Agroforestry land system. In addition to that, farmers in Western Tanzania recommended that by-laws should be documented such that they could be used as a tool to safeguard all stakeholders including livestock and other non-agroforestry farmers. Kamwenda (2002) also reported that the advantage of using by laws was that most people strictly adhered to them because village by-laws were formal legal instruments. However Kamwenda (2002) concluded that those traditional rules and village bylaws were complementary and that the choice of whether to use customary or statutory regulations depended on the problem or issues that need to be addressed, the village leadership and the social set-up of the village.
Sanginga *et al.* (2006) and Shilabu (2008) reported that the management of natural resources for sustainable agricultural production was sustained principally through the use of indigenous knowledge systems developed over generations to manage environmental resources. For interventions to be sustainable there must be active involvement of the people for collective action, by-laws implementation and linking with local Government structures to increase the ability of communities to manage and transform opportunities. Wezel and Lykke (2006) pointed out that empowering local institution was an effective and sustainable way of managing resources in Sahelian West Africa.

2.4.5 Harmonization of land tenure policy

Sectoral policies and regulations such as agriculture policy, environment policy, land policy, forestry policy and livestock policy need to be harmonized in order to address issues related to land tenure (NASCO, 2006). This strategy is likely to support successes if villages and districts authorities are encouraged to formulate and enforce by-laws pertaining to AF adoption (Otsuka *et al.*, 2003). Rules of land and tree tenure affect preservation, protection and planting of trees. Buyinza *et al.* (2008) reported that about 60% of the respondents were greatly influenced by the type of land tenure system in their decisions to adopt AF, although 40% practiced AF regardless of the land tenure they hold in Uganda.

The question of land tenure should be immediately resolved so as to enhance formulation of a good land use policy so that farmers can acquire land titles to guarantee security of their land. According to Kiptot and Franzel (2011), women in Africa have limited rights to land although there are exceptional cases. It is because land tenure systems in many parts of Africa grant rights to own and dispose of land to adult males. Therefore harmonization of policies and regulations are required since it will grant women access to land. Suyanto *et al*. (2002) reported that with less government involvement, but more secured land rights as perceived by communities had successfully rehabilitated degraded land located in state forestland in Sumatra.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Description of the Study Area

3.1.1 Location of the study area

Kasulu District is among the four District Local Authorities of Kigoma Region. It covers an area of 9 315km^2, of which 9 128 km^2 is land and 187km^2 under water (URT, 2008). It lies between latitudes 4º 00' and 4º 50' S and longitudes 29º 50' and 30º 30' E. It is bordered to the North by Burundi, to the East by Kibondo District and to the South by Kigoma Rural and Kigoma Urban Districts. The District comprises seven Divisions namely Makere, Buhoro, Buyonga, Manyovu, Muyama, Heru Juu and Heru Chini. It has 30 Wards and 90 Villages. It is 60 kilometers from Kigoma town, the capital of Kigoma Region.

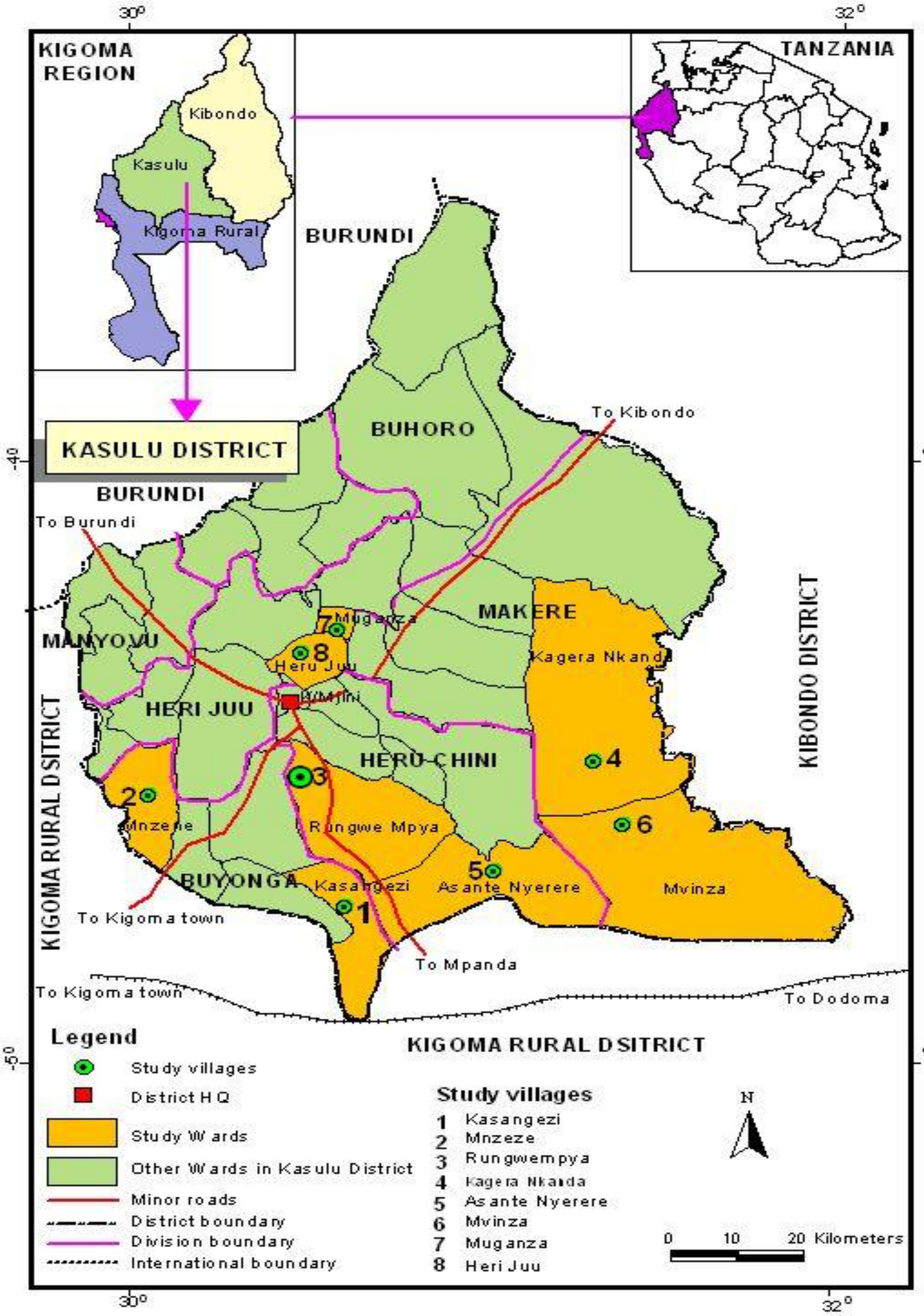

Figure 1: Map of Kasulu District showing the location of the study areas

3.1.2 Population

According to the 2002 Tanzania National Census, the population of the Kasulu District was 628 677 (KDC, 2007; URT, 2008). Based on the annual population growth rate of 4.8% in the district, the current population is estimated to be 1 016 000. It has a higher population density than the other districts in the region due to high influx of refugees from neighboring countries namely Burundi and DRC. The predominant ethnic group in Kasulu District is the Ha tribe. Other tribes are Nyamwezi, Haya, Sukuma, Jita, Kurya, Nyakyusa, Tutsi, Hutu and others who are employed in the public and private sectors (KDC, 2007).

3.1.3 Climate and soils

The annual rainfall ranges between 800mm to 1500mm. The pattern of the rainfall is uni-modal with the rainy season lasting from October to May, followed by a prolonged dry season. Precipitation is reliable and allows a wide range of crops to be grown with some double planting of short season crops (URT, 2008). Temperatures range between 15ºC and 22ºC with the highest temperature experienced in September. The soil is mostly loam, clay, red soils and sand.

3.1.4 Physical features and topography

The land surface of Kasulu District is hilly ranging between 1200m to 1700m above sea level. A great part of the district is covered with *Miombo* woodlands and swamps (URT, 2008). Other vegetation types include bush grasslands and bamboo thickets vegetation. The forests and woodlands support most communities by providing fuelwood, food, shelter, medicine, fruits and income to many people. The swampy vegetation is dominated by mat forming species such as *Cyperus* spp. which together with other plant species cover the area of Malagarasi. The study area also is crossed by many rivers and tributaries which pour their water into the major rivers like Maragarasi then to Lake Tanganyika.

3.1.5 Infrastructure

Kasulu District has a better developed communication network compared to the other two rural Districts of Kigoma Region (URT, 2008). However, accessibility to and within the district is mainly by land of which road transport is the most common (KDC, 2007). Railway and air transport are also used from outside the district especially from Dar es Salaam city and other regions like Mwanza and Tabora to Kigoma town where one has to travel by motor car via Kigoma-Kasulu-Kibondo-Nyakanazi road. The road covers about 335 kilometers to Nyakanazi and has earth surface partly engineered gravel or medium to fair standard and partly earth. The district is also connected by Rukwa Region through Kasulu-Rukwa road, a road which is mainly of earth and is in a very poor condition. It connects Rukwa Region at Uvinza and it facilitates transportation of salt from Nyanza Salt Mines at Uvinza, timber and other crops cultivated in this area. Within the district, different divisions, wards and villages can be reached through all weather and seasonal roads.

3.1.6 Land use and economic activities

About 85% of the districts income is generated from agriculture (crop and animal production). The type of agriculture practiced in the district is peasant agriculture whereby smallholders who employ very limited capital in their production process are the most involved (KDC, 2007; URT, 2008). Food crops include maize, beans, cassava, sweet potatoes, bananas, groundnuts, pigeon peas and cow peas. Other food crops grown are sorghum, millet and Irish potatoes. Nowadays small scale farmers also grow rice but it is widely grown in river valleys. The main cash crops are coffee, tobacco, groundnuts, cotton, palm oil and ginger (KDC, 2007).

Livestock keeping practiced by the local farmers in the district is traditional in nature since large proportion is dominated by indigenous animals except in town where the improved types are found. However livestock keeping is the second most important economic activity in the district. Livestock kept are cattle, goats, sheep and poultry. There are also pigs of mixed variety. The total estimated grazing land is 181 800 ha while land currently used for grazing is 60 600 ha. Other economic activities include beekeeping and petty business (KDC, 2007; URT, 2008).

3.2 Sampling Procedure and Sample Size

The sampling procedure used in the current study was a multistage random sampling. Four divisions were randomly selected among the divisions of Kasulu District. From each of the selected division, two wards were randomly selected while from each of the sample ward one village was randomly selected making a total random sample of eight villages. Then from each of the eight sample villages, 20 households were randomly selected for the study to form a total sample of 160 households. A random sampling technique was used to avoid researcher bias and to provide an equal opportunity for each division, ward, village and household to be selected as a sample to provide essential information. This is in accordance with

Kothari (2004). The divisions which were randomly selected were: Makere, Heru Chini, Buyonga and Heru Juu. Sampling frames for this study were the village registers containing the list of households. Key informants involved were village leaders, Ward Executive Officers, DALDO, Agriculture Extension Officers and Natural Resources Officers. No focus discussion group was done because intentionally the study focused on the household members and not special groups like gender, elders and youths.

3.3 Data Collection

3.3.1 Reconnaissance survey

Data collection was preceded by a pilot study, which aimed at providing a general picture of the study area to the researcher. During this time, the researcher was able to introduce herself and introduce the intention of the study to the leaders. The researcher was able to select sample divisions, wards and villages. Through this survey, identification of various people of interest and or groups available in various areas of the study such as DALDO, extension workers, Ward and Village Executive Officers were done. Pilot study assisted also in discovering the nature of relationships between variables and some problems which could have emerged during the main investigation. Two villages were used to test the questionnaires.

3.3.2 Social survey

- **Primary data**

Primary data were collected through formal survey by interviewing 20 selected households representative in each village using household questionnaires (Appendix

1). Structured questionnaires which contained both closed and open ended questions were employed to collect primary data for this study. Data collected through this method included general information, demographic information, land use and land size, adopters and non adopters of Agroforestry systems and technologies, Agroforestry systems, technologies and tree species preferred by the communities and their uses, factors which influenced adoption of Agroforestry (i.e. enhancing and limiting factors) and finally data on measures to consider for encouraging the adoption of AFs and technologies in the study area. Key Informant interviews using checklists of probe questions (Appendix 2) were also used to enrich the information from the questionnaire survey.

- **Secondary data**

Secondary data were obtained from DALDO Office, Natural Resources Offices of Kasulu District Council, Kasulu District Council profile and reviewing online databases and documents. Some more secondary data were obtained from Village, Ward and Division Offices and from Libraries.

3.3.3 Field survey

The survey was carried out in the study areas in some of the villages to assess the existing situation of Agroforestry systems and technologies adopted but also to observe various tree species integrated by farmers in their farmland, grazing land and/or around their homes. Observations were done so as to verify and supplement the information collected during household's survey and Key informants' interview. Documentation involved photographing of some of the systems and technologies.

3.4 Data Analysis

Data collected from the primary sources using structured questionnaires and checklist of probe questions were compiled, summarized and coded to facilitate data entry into statistical software ready for analysis. The statistical analysis was carried out using the Completely Randomized Block Design (CRBD) statistical model using the SPSS and SAS softwares. Means of the variables under study were then compared using the Analysis of Variance (ANOVA) to check for existence of significant differences between them. The Least Significant Difference (LSD) was used to separate the differing treatment means. The compiled results were then presented in the form of tables.

CHAPTER FOUR

4.0 RESULTS

4.1 Extent and Trend of Agroforestry Adoption in Kasulu District by the Year 2011

4.1.1 Extent of Agroforestry adoption in various parts of the district

The results on the status of Agroforestry adoption by the local communities of Kasulu District are presented in Table 1 and the raw data and ANOVA tables as Appendices 3 and 4. On average, ninety one (91%) of the communities of Kasulu District has adopted Agroforestry with Buyonga Division having the highest adoption rate followed by Heru Juu Division. However, statistically the adoption rate of the divisions was not significant.

Table 1: Extent of adoption status of Agroforestry systems in Kasulu District

Division	Adoption (%)
Buyonga	100[a]
Heru Juu	90[a]
Heru Chini	88[a]
Makere	88[a]

The values within the same column with the same following letter do not differ significantly ($p < 0.05$)

4.1.2 The trends of Agroforestry adoption by the communities in Kasulu District

The results in Tables 2 and 3 present the adoption trends of Agroforestry practices in Kasulu District. The raw data are presented in appendices 5 and 7 respectively while the ANOVA tables are presented in Appendices 6 and 8 respectively. Kasulu District communities have long been practicing Agroforestry and by 2007 already

89% had adopted Agroforestry. This probably indicates that farmers in the study area have long been aware of the practices and their associated benefits. From year 2007 to 2011 the increase of adopters was very minimal implying that already most of the farmers had adopted Agroforestry (Table 3).

Table 2: Periodic trends of Agroforestry adoption by the communities in Kasulu District

Time	Frequency	Percentage
2007	130	89.0[a]
2008	7	4.0[b]
2009	4	3.0[b]
2010	4	3.0[b]
2011	1	1.0[b]
Total	**146**	**100.0**

The values within the same column with the same following letter do not differ significantly ($p < 0.05$)

Table 3: Cumulative trend of Agroforestry adoption by the communities in Kasulu District

Time	Cumulative Frequency	Cumulative Percentage
2007	130	89[c]
2008	137	93[c]
2009	141	96[cb]
2010	145	99[b]
2011	146	100[a]
Total	**146**	**100.0**

The values within the same column with the same following letter do not differ significantly ($p < 0.05$)

4.2 Agroforestry Systems, Technologies and Woody Perennials Preferred by Local Communities in Kasulu District

4.2.1 Agroforestry systems adopted by communities in Kasulu District

The results on the Agroforestry systems that are adopted by the communities in the district are presented in Table 4 and the detailed data and ANOVA tables presented in Appendices 9 and 10 respectively. Agrosilvicultural system was the most widely adopted system by the community in the study area probably because agriculture (growing crops) was the mainstay of most of the farmers in Kasulu District. Agrosilvipastoral system ranked the second followed by Silvopastoral system.

Table 4: Agroforestry systems adopted in Kasulu District

System	Frequency	Percentage
Agrosilvicultural system	133	42[a]
Agrosilvipastoral system	100	32[b]
Silvipastoral system	84	26[c]
Total	**317***	**100.0**

The values within the same column with the same following letter do not differ significantly ($p < 0.05$)
***Total frequencies are higher than total sample size indicating that some farmers adopted more than one system

4.2.2 Agroforestry systems adopted in each division in Kasulu District

The results in Table 5 present the various Agroforestry systems adopted by the communities in different divisions in Kasulu District. Their data details and ANOVA tables are provided in Appendices 11 to 18. Buyonga Division ranked higher in adoption of the systems. It was also found that Agrosilviculture was the most widely adopted system where as Silvipastoral system was the least adopted. However the extent of adoption of different Agroforestry systems within four different divisions did not differ statistically.

Table 5: Agroforestry systems adopted in divisions of Kasulu District

Division	System	Frequency	Percentage
Buyonga			**100**
	Agrosilvicultural system	38	43[a]
	Agrosilvipastoral system**	26	29[a]
	Silvopastoral system	25	28[a]
		89	
Heru Juu			**90**
	Agrosilvicultural system	30	38[a]
	Agrosilvipastoral system**	24	30[a]
	Silvopastoral system	17	22[a]
	Total	**71**	
Heru Chini			**88**
	Agrosilvicultural system	32	36[a]
	Agrosilvipastoral system**	27	31[a]
	Silvopastoral system	19	21[a]
	Total	**78**	
Makere			**88**
	Agrosilvicultural system	33	37[a]
	Agrosilvipastoral system**	23	26[a]
	Silvopastoral system	23	26[a]
	Total	**79**	

***Total frequencies are higher than sample size indicating that some farmers adopted more than one system
**Animal components in Agrosilvipastoral system consists mainly of chicken, ducks, and pigs
Values in the same column that are followed by the same letter do not differ significantly ($p < 0.05$)

4.2.3 Technologies adopted by the local communities in Kasulu District

The results on various Agroforestry technologies which have been adopted and practiced in Kasulu District are presented in Table 6 and their data details and ANOVA in Appendices 19 and 20 respectively. Agroforestry Homegardens and Mixed intercropping technologies were highly preferred and most widely practiced by the farmers. Other widely used technologies included Integrated tree/pasture management, Windbreak and Shifting cultivation.

Table 6: Technologies adopted by communities in Kasulu District

Technology	Frequency	Percentage
Homegardens	119	26[a]
Mixed intercropping	115	25[a]
Integrated tree/pasture management	78	17[b]
Windbreaks/boundary	64	14[b]
Shifting cultivation	59	13[b]
Live fences	14	3[c]
Alley farming/Hedgerow	7	2[c]
Taungya	3	1[c]
Total	**459***	**100.0**

*****Total frequencies are higher than total sample size indicating that some farmers adopted more than one technology Values in the same column that followed by the same letter do not differ significantly ($p < 0.05$)

4.2.4 Agroforestry technologies adopted by the local communities in the various divisions of Kasulu District

The results on the adoption status of Agroforestry technologies in the different divisions of Kasulu District are presented in Table 7 and their details data and ANOVA indicated in Appendices 21 to 28 respectively. Homegardens and Mixed intercropping were the most widely adopted technologies in the district. Integrated/pasture management and Windbreak technologies also featured clearly in Heru Juu Divisions probably indicating that farmers wanted to optimize pasture and livestock production levels and support the cropping program but also to reduce and modify the speed of wind and its potentially damaging effects.

Table 7: Technologies adopted by communities in various divisions in Kasulu District

Division	Technology	Frequency	Percentage
Makere			**88**
	Homegardens	29	22^{a}
	Mixed intercropping	26	20^{a}
	Integrated tree/pasture management	23	18^{ab}
	Windbreaks/boundary	22	17^{ab}
	Shifting cultivation	12	9^{ab}
	Live fences	2	2^{b}
	Total	**114***	
Heru Chini			**88**
	Mixed intercropping	32	26^{a}
	Homegardens	28	23^{ab}
	Shifting cultivation	18	15^{bc}
	Integrated tree/pasture management	17	14^{c}
	Windbreaks/boundary	12	10^{c}
	Alley farming/Hedgerow cropping	1	1^{d}
	Total	**108***	
Buyonga			**100**
	Homegardens	35	26^{a}
	Mixed intercropping	34	25^{a}
	Integrated tree/pasture management	25	18^{b}
	Shifting cultivation	20	15^{cb}
	Windbreaks/boundary	14	10^{cd}
	Live fences	7	5^{ed}
	Alley farming/Hedgerow cropping	1	1^{e}
	Total	**136***	
Heru Juu			**90**
	Homegardens	27	24^{a}
	Mixed intercropping	23	20^{ab}
	Windbreaks/boundary	16	14^{abc}
	Integrated tree/pasture management	13	12^{abc}
	Shifting cultivation	9	8^{abc}
	Alley farming/Hedgerow cropping	5	4^{bc}
	Live fences	5	4^{bc}
	Taungya	3	3^{c}
	Total	**101**	

*****Total frequencies are higher than total sample size indicating that some farmers adopted more than one technology Values in the same column that followed by the same letter do not differ significantly ($p < 0.05$)

4.2.5 Technologies practiced in different Agroforestry systems in Kasulu District

The results on the Agroforestry technologies that are practiced in different Agroforestry systems in the district are presented in Table 8 while the data details and ANOVA tables in Appendices 29 to 34 respectively. Homegardens and Mixed intercropping of both Agrosilvicultural and Agrosilvipastoral systems were the most preferred technologies, probably due to the continuous production throughout the year resulting in a relatively uninterrupted food supply and less need for laborious work of systematically arranged trees respectively.

Table 8: The technologies adopted in different Agroforestry systems in Kasulu District

Agroforestry system	Technology	Frequency	Percentage
Agrosilvicultural			**42**
	Homegardens	109	13[a]
	Mixed intercropping	109	13[a]
	Windbreaks/boundary	57	7[b]
	Shifting cultivation	54	6[b]
	Live fences	13	1[c]
	Alley farming/Hedgerow cropping	6	1[c]
	Taungya	3	1[c]
	Total	**351***	
Agrosilvipastoral**			**32**
	Homegardens	91	10[a]
	Mixed intercropping	83	9[a]
	Windbreaks/boundary	47	5[b]
	Shifting cultivation	46	5[b]
	Live fences	8	1[c]
	Alley farming /Hedgerow cropping	6	1[c]
	Taungya	2	1[c]
	Total	**283***	
Silvopastoral			**26**
	Integrated tree/pasture management	75	12[a]
	Shifting cultivation	38	6[b]
	Windbreaks/boundary	35	6[b]
	Live fences	6	1[c]
	Alley farming /Hedgerow cropping	4	1[c]
	Total	**158***	**100**

*****Total frequencies are higher than total sample size indicating that some farmers adopted more than one technology
**Animal components in Agrosilvipastoral system consists mainly of chicken, ducks, and pigs
Values in the same column that are followed by the same letter do not differ significantly ($p < 0.05$)

4.2.6 The woody perennials integrated in various Agroforestry system and technologies in Kasulu District

Table 9 provides a list of various tree species which were commonly integrated with other Agroforestry components in the study area. Appendices 35 to 36 represent the raw data and ANOVA tables. *Mangifera indica* was the most preferred tree species among the local communities in Kasulu District followed by *Citrus sinensis* and *Persea americana* for the reasons of providing fruits to the society. Among the most common naturally occurring indigenous trees deliberately retained in farms included *Brachystegia spiciformis and Pericopsis angolensis.* Other exotic tree species included S*enna siamea, Eucalyptus maidenii* and *Elais guinensis* a kind of tree which is used in the production of cooking oil.

Table 9: Tree species adopted by the local communities in Kasulu District

Local name	**Scientific name**	**Frequency**	**Percentage**
Miembe	*Mangifera indica*	98	67^{a}
Mitundu	*Brachystegia spiciformis*	66	45^{b}
Mmbanga	*Pericopsis angolensis*	58	40^{c}
Mjohoro	*Senna siamea*	52	36^{d}
Mchungwa	*Citrus sinensis*	33	23^{e}
Mparachichi	*Persea Americana*	29	20^{f}
Mkaratusi	*Eucalyptus maidenii*	29	20^{f}
Mlembela	*Isoberlinia tomentosa*	27	19^{fg}
Mchikichi	*Elais guinensis*	25	17^{g}
Mninga	*Pterocarpus angolensis*	22	15^{h}
Mshindwi	*Anisophyllea boehmii*	21	14^{hi}
Umumoli	*Dalbergia melanoxylon*	19	13^{ij}
Mpera	*Psidium guajava*	18	12^{j}
Umkoyoyo	*Combretum zeyheri*	18	12^{j}
Mgrivellia	*Grevillea robusta*	17	12^{jk}
Mlimao	*Citrus limon*	17	12^{jkl}
Msonobali	*Pinus pitula*	16	11^{jklm}
Mlumba	*Ficus spp*	14	10^{km}
Mkurungu	Pterocarpus tinctorius	14	10^{km}
Umvyilu	*Vitex keniensis*	10	7^{n}
Umkanda	*Annona senegalensis*	10	7^{n}
Mpapai	*Carica papaya*	9	6^{no}
Kahawa	*Coffea canephora*	8	5^{nop}
Umsiloti	*Pterocarpus spp*	7	5^{nop}
Umuhongolo	*Sclerocarya birrea*	7	5^{nop}
Umukuyu	*Ficus glumosa*	6	4^{op}
Mibhombo	*Brachystegia spp*	5	3^{pq}
Umulalangwe	Not found	3	2^{q}
Mchenza	*Citrus reticulate*	3	2^{q}
Umusilasi	*Garcinia buchananii*	2	1^{q}
Mibono	*Ricinus communis*	2	1^{q}
Umuyama	Not found	2	1^{q}
Iminyale	*Euphorbia tirucalli*	2	1^{q}
Umsasa	*Cordia monoica*	2	1^{q}
Umulama	*Syzygium guinneense*	2	1^{q}
Umgunga	*Acacia nilotica*	2	1^{q}

Values in the same column that followed by the same letter don’t differ significantly ($p < 0.05$

4.2.7 Different uses/services of woody perennials in Kasulu District

Results on different uses of woody perennials are presented in Table 10 and its raw data and ANOVA tables in Appendices 38 and 39. Along with fruits, woody perennials provided fuel woody and timber which both ranked high in Kasulu District. Other uses and services include soil fertility improvement, shade, windbreak/boundary, building poles, environmental services, cooking oil (palm oil), traditional medicine and fodder. Beverage and carving uses were unpopular probably because the woody producing these uses/services might not grow well in some of divisions in the district. It could probably also meant that unavailability of market information of the woody perennials producing these types of services hindered farmers to adopt them.

Table 10: Uses/services of tree species in various divisions in Kasulu District

Use	Frequency	Percentage
Fruits	121	18^{a}
Fuel wood	112	17^{a}
Timber	111	17^{a}
Manure (soil fertility improvement)	73	11^{b}
Shade/shelter	51	8^{bc}
Windbreak/boundary	43	6^{c}
Environmental conservation	32	5^{cd}
Poles	31	5^{cd}
Cooking oil	25	4^{cd}
Fodder for livestock	23	3^{cd}
Traditional medicines	23	3^{cd}
Beverage	9	1^{d}
Carving	8	1^{d}
Total	**662**	**100**

Total frequencies are higher than total sample size indicating that some trees have more than one tree use.
Value in the same column that are followed by the same letter do not differ significantly ($p < 0.05$)]

4.3 Factors Influencing Adoption of Agroforestry Systems and Technologies in Kasulu District

4.3.1 Factors enhancing adoption of Agroforestry systems and technologies

Results on Table 11 show factors enhancing the adoption of AFs and technologies in the study area with the respective raw data details and ANOVA presented in Appendices 40 and 41 respectively. Income was the main factor which enhanced the uptake of Agroforestry services ($p<0.05$) followed by awareness and access to extension services**.**

Table 11: Factors enhancing adoption of Agroforestry systems and technologies in Kasulu District

Factor	**Frequency**	**Percentage**
Income generation	125	17[a]
Farmers awareness	114	15[a]
Access to extension services	91	12[b]
Cultural norms	70	9[c]
Source of manure	65	9[c]
Environmental conservation	64	9[c]
Shade purposes	47	6[d]
Availability of land	41	5[d]
Soil conservation purposes	39	5[d]
Fuel need	36	5[de]
Food need	26	3[def]
Windbreak/boundary	17	2[ef]
Medicinal purposes (for health)	9	1[f]
Provision of building materials	7	1[f]
Total	**751***	**100**

*Total frequencies are higher than total sample size indicating that some farmers were enhanced by more than one factor. Values in the same column that are followed by the same letter do not differ significantly ($p < 0.05$)

4.3.2 Factors limiting the adoption of Agroforestry systems and technologies

The results on Table 12 present the factors which limit the adoption of Agroforestry systems and technologies in the study area. The raw data details and ANOVA Tables are presented in Appendices 42 and 43 respectively. The major limiting factor was lack of knowledge of farmers followed by land shortage and income (monetary income).

Table 12: Factors limiting adoption of Agroforestry systems and technologies

Factor	Frequency	Percentage
Lack of knowledge	13	38[a]
Land shortage	8	24[b]
Lack of monetary income	6	18[b]
Lack of extension services	4	12[bc]
Cultural norms	2	6[cd]
Lack of tree seeds/seedlings	1	3[d]
Total	**34**	**100**

Values in the same column that are followed by the same letter do not differ significantly ($p < 0.05$)

4.4 Measures Required for Improvement of Agroforestry Adoption in Kasulu District

Results on the measures required for improving the adoption of AFs and technologies are presented on Table 13 and raw data details and ANOVA in Appendices 44 and 45 respectively. The majority of farmers suggested that extension services and development of policies which advocate Agroforestry could be the best strategy which will enforce Agroforestry adoption among the farmers. Other significant measures included introduction of improved species, formulation of village bylaws, promotion of traditional rules and provision of agricultural inputs.

Table 13: Measures suggested by farmers to improve adoption of Agroforestry systems and technologies in Kasulu District

Measure	Frequency	Percentage
Improve extension services	152	20[a]
Develop policy which advocates Agroforestry	151	20[a]
Introduction of improved species	143	19[ab]
Formulate and enforce village bylaws	119	16[b]
Promote traditional rules	75	10[c]
Provide agricultural inputs	66	8[c]
Harmonise land tenure policy	37	5[d]
Improve institutional linkages	4	1[e]
Total	**747***	**100.0**

*Total frequencies are higher than total sample size indicating that some farmers suggested more than one measure.
Values in the same column that are followed by the same letter do not differ significant ($p < 0.05$).

CHAPTER FIVE

5.0 DISCUSSION

5.1 The Current Adoption Status of Agroforestry System(s) and Technologies in Kasulu District

The results on the status of adoption of agroforestry by the local communities of Kasulu District including the trends of adoption are presented in Tables 1 to 3 with the respective raw data and ANOVA tables in Appendices 3 to 4 and 5 to 8 respectively.

The findings of the district high agroforestry adoption by the local communities compares well with the findings reported for Lushoto District (Bonifasi, 2004), in Mwanza (Odhiambo and Garret, 2008), Mufindi, Iringa (Mgeni, 2008) and Burkitu, Ethiopia (Zeleke, 2009) where the farmer communities were reported to depend on Agroforestry as their main source of food and income. 91% of Agroforestry adoption status observed in the district was however higher than those reported by Shilabu (2008) for Maswa District, Shinyanga and Kyamani (2009) for Uyui Tabora in Western Tanzania where the adoption rate of 22% and 10% respectively had been recorded. They were also higher than those recorded in Imo state, Nigeria (Orisakwe and Agomuo, 2011). The high adoption rates of Agroforestry reported for the present study probably indicated increased awareness of the communities on Agroforestry in contributing to poverty alleviation as the majority of the population in the study area depended entirely on farming for their livelihood. Just as in some areas in Tanzania, most farmers in the study area practiced a mixture of traditional and improved Agroforestry. They own trees through retention of naturally regenerating indigenous species and or deliberately plant both indigenous and exotic trees. The fact that 89% of the community in the present study had already adopted Agroforestry by 2007 indicates that they have long experience in the practice and its contribution towards improving resources productivity among resource poor smallholder farmers.

5.2 Agroforestry Systems, Technologies and Various Tree Species Preferred and Used by the People in Kasulu District

The results on the various Agroforestry systems, technologies and various tree species that are preferred and practised by the farmers in Kasulu District are presented in Tables 4 to 10 and their detailed raw data and ANOVA tables in Appendices 9 to 39 respectively.

The indication of higher adoption of Agrosilvicultural system (Table 4) could be attributed to the fact that agricultural crop production is the major socio-economic activity of the local communities in the district (URT, 2008). These results compare well with the findings reported for Mufindi, Iringa in Tanzania (Mgeni, 2008), Mandi District, Western Himalayas, India (Sood, 2006) and those reported by Irshad *et al.* (2011) for Swat in Pakistan, but with more diverse Agroforestry systems being adopted. However the findings reported for Burkita, Ethiopia (Zeleke, 2009), Masaka District, Uganda (Sebyuku and Mosango, 2012) and various highlands in Tanzania (Fernandes *et al.,* 1984; Maruo, 2002; Bonifasi, 2004) indicated higher adoption of Agrosilvopastoral systems and more highly diversified systems that most farmers needed for diversification of outputs to ensure household food sufficiency, sustainability and reducing the risk of crop failure. The reason that

Silvopastoral system was least adopted practice in the current study area could be attributed to restrictive factors such as infestation of tsetse flies ((URT, 2008; KDC, 2007) which limit some of the farmers to keep animals such as cattle. This also compared well with the findings reported by Zeleke (2009) in Ethiopia.

The high adoption rate of Agroforestry Homegardens technology in Kasulu District probably implied that farmers preferred practices which ensured continuous production with a relatively uninterrupted supply of food products throughout the year. Similar motivating factors were reported to have influenced the adoption of Agroforestry by the communities of Kordafan and Darfur Southern, Sudan (Rahim *et al.,* 2005), Burkitu, Ethiopia (Zeleke, 2009) and various other places (Nair, 1993; Okia *et al.,* 2009). It also indicated that most farmers preferred Agroforestry Homegardens for ease of management since they enabled farmers to protect their farms against raids by wildlife and theft, and also, the labour required can be easily combined with home and childcare responsibilities. Another important encouraging factor was the fact that the practices offer several benefits within short time after trees establishment. It was also well supported by Alavalapati *et al.* (1995) that technologies that take long time for their benefits to be realized may not be affordable to subsistence farmers.

Plate 1: One of the Homegardens technologies practiced by Hamenya John in Muganza Village

Other Agroforestry technologies such as Alley farming were less practiced by farmers because their unique roles in soil erosion control were not needed as the land was more or less flat. Alley farming practice requires more knowledge and skills in their management as observed earlier by Mukome (1998); Scherr and Miller (1991); Mercer (2004) and Muneer (2008).

Mixed intercropping Agroforestry technology was the most dominant widely used in Kasulu District in which trees were irregularly scattered among herbaceous crop(s) and doesn’t require systematic arrangement which is a laborious work to farmers.

Plate 2: Mixed intercropping Agroforestry technology practiced by Buhahilo Kagoma in Kasangezi Village

During field as well as social survey it was observed that there was diversity of different woody perennials involved in different Agroforestry systems in Kasulu District. Since there were both indigenous and exotic species, farmers obtained diversified types of products and services (Table 10) from different woody perennial components. Similar findings were reported elsewhere by Haggblade *et al.* (2004); Kyamani (2009); Zeleke (2009) and Sebukyu and Mosango (2012).

Exotic fruit tree species were also reported as species which were preferred by most farmers in Kasulu District (Table 9). This implied that farmers opted to grow exotic trees for providing fruits to the society to improve nutrition status but also for income generation after selling the fruits. Similar findings were reported elsewhere by Oke and Odebiyi (2007); Buyinza *et al.* (2008); Dowiya *et al.*(2009) and Zeleke (2009) who revealed that *Citrus sinenses*, *Mangifera indica*, *Persea Americana*, *Psidium guajava* and other exotic fruits species were preferred by farmers because they provided edible and nutritious fruits in additional to other important services to community. *Mangifera indica* was the most preferred species by the communities in the study area probably due to its climatic adaptability, fruits provision, shelter and medicinal use. This agrees also with the report by Kefleketema (2006); Ajayi (2007) and Lulandala (2009) who reported that trees selected must be preferred and acceptable by the people who are going to use them but also be able to establish and grow well in the local environmental conditions.

5.3 Factors Influencing the Adoption of Agroforestry Systems and Technologies in Kasulu District

The results on factors influencing the adoption of Agroforestry systems and technologies as mentioned by the respondents are presented on Tables 11 and 12 and their respective raw data and ANOVA table in Appendices 40 to 43.

Adoption of Agroforestry by the local communities in Kasulu was enhanced by several factors (Table 11) and this compares well with the findings reported by Buyinza *et al.* (2008); Sebyuku and Mosango (2012) where Agroforestry adoption was possible due to several factors. An almost similar finding was reported in Cameroon by Nkamleu and Manyong (2005) where factors such as gender, household family size, level of education, farmer’s experience, agro ecological zones and distance of the village from nearest town were reported to influence adoption of Agroforestry. Findings reported by Thangata *et al.* (2007); Thangata *et al*.(2008) and Lambert and Ozioma (2011) disagree with the current findings that household composition, farm size, availability of draft power and seed selling incentive were the most common factors that influenced AFTs adoption.

The observation that intention of income generation was the most factor that enhanced adoption of Agroforestry by 17% of the community (Table 11) probably implied that already farmers understanding the benefits obtained from Agroforestry practices and that generation of income was one of those benefits through the sale of AF components. This agrees well with World forests (2005) that Agroforestry practices hold more components which results into diversification of income such that if one of the components failed there is a possibility to be secured by other components. The findings were also supported elsewhere by Thangata and Alavalapati (2003); Place *et al.* (2004); Buyinza *et al.* (2008); Zeleke (2009); Irshed *et al.* (2011); Chirwa and Quinion (2012) and Ruheza *et al.* (2012) in that farmers were interested in planting trees on their farms for economic benefits.

Awareness has positive influence on the adoption of technologies including Agroforestry practices. The findings reported by Munner (2008) and Parwada *et al.* (2010) agreed with current findings. Contrary to the current findings were reported by Thangata and Alavalapati (2003) that non adopters of Agroforestry practices had higher awareness than adopters. This implied that farmers in the study area had little preference and little attitude towards Agroforestry practices.

The observation that extension services was the factor that enhanced farmers to adopt Agroforestry by 12% implied that extension worker can generate and raise awareness about the Agroforestry but also develop a favorable attitude among farmers towards the technology. Farmers get sensitized and encouraged when trained and get exposure to some demonstration of any new innovation(s). Similar findings were reported elsewhere by Thangata and Alavalapati (2003). It agree also by the findings reported by Nkonya (2002); Kiptot *et al.* (2007); Buyinza *et al.* (2008); Lambert and Ozioma (2011); Mutonyi and Fungo (2011) and Sebyuku and Mosango (2012).

The current study also observed factors which limit Agroforestry adoption in the study area. It was revealed that some smallholder farmers are resource poor in terms of fund, land and knowledge. Lacks of these resources made them fail to adopt some of the Agroforestry innovations. Similar findings were reported by Ajayi *et al*. (2003) and Kalaba *et al.* (2010) that the adoption of Agroforestry was not direct relationship based on the technological advantages of an Agroforestry practice alone, but was influenced by several other factors.

The fact that lack of knowledge limits the adoption of AF practices is well supported by Parwada *et al.* (2010); Lambert and Ozioma (2011) and Mashinini *et al*. (2011). Ineffective communication about benefits and characteristics of Agroforestry technologies between the change agents and farmers resulted into poor knowledge of the practices thus failing to adopt the Agroforestry technologies. Farmers lack the information and or training on plantation diversification and the technical or financial resources required so as to diversify and rearrange the Agroforestry components in the same land unit. Training and communication creates awareness of a given technology before farmers adopt Agroforestry. It is also well supported by Ruheza 2003; Buyinza *et al.* (2008) and Matata *et al.* 2010 that to have effective adoption farmer requires education and knowledge that exposes information regarding the technology.

Land shortage was another factor which limited the adoption of Agroforestry systems and technologies in the study area. This compares well with the findings reported by Ajayi (2003); Kyamani (2008); Adjaye (2008); Zeleke (2009); Kabwe (2010) and Lambert and Ozioma (2011) who reported that farmers with small plots of land struggle to produce sufficient food and can not to take land out of food production and put it under conservations purposes.

Lack of monetary income was a factor which limited some of the farmers to adopt the Agroforestry systems, an implication that smallholder farmers are resource poor particularly in terms of financial situation. The findings were reported elsewhere by Kabwe (2010) and Parwada *et al*. (2010).

Poor extension services hindered some of the farmers to adopt Agroforestry practices. These findings compares well with findings reported by Ahmed *et al.* (2007); Zeleke (2009) and Orisakwe *et al.* (2011) that ineffective linkage between extension workers and farmers is responsible for low adoption of technology including AFTs. Key informants also revealed that lack of extension facilities such as transport and financial constraints caused extension services not reaching all places in the study area to advice farmers on Agroforestry matters.

5.4 Suggestion on Measures for Improvement of Agroforestry Adoption

The results on Table 13 and its raw data and analysis of variance (ANOVA) in Appendices 44 and 45 respectively show the suggested measures on how the adoption of Agroforestry in Kasulu District can be improved. Observation that improvement of extension services by 20% of the community declared that it enhanced the adoption of Agroforestry in Kasulu District compares well with the findings reported by Zeleke (2009); Kabwe (2010); Lambert and Ozioma (2010) and Sezgin *et al*. (2011) that in order to improve the adoption of innovations significantly, it was necessary to hold extension studies constantly and intensively. The findings were also reported by Rutatora and Matee (2001); Ruheza (2003); Mgeni (2008); Fungo *et al.* (2011) and Sebyuku and Mosango (2012). Most farmers in Kasulu District responded to this approach probably indicating that they understand the role played by agricultural extension officers and that how well or poorly conducted extension education is, can result into both testing and adopting the technology (ies) or abandon it.

The observation that development of policies which advocate Agroforestry as 20% of the community claimed could be the best measure to improve the adoption of agroforestry in the district agrees well with the findings reported by NASCO (2006); Kabwe (2010); Matata *et al*. (2010); Nyariki *et al*. (2010) and Parwada *et al*. (2010). For Agroforestry to be adopted there must be conducive policies and institutional framework at both local and national levels since policies provide rules and regulations by which individuals and groups in a society are expected to follow and adopt to address and reach a given goals (Ajayi *et al.*, 2006; Place *et al.*, 2012). Harmonization of different natural resources policy is needed because AF practices incorporate trees on agricultural land to contribute to livelihood and environmental sustainability. All contradictions and conflicting interests in different sector policies which touch Agroforestry need to be harmonized to create environment such that Agroforestry practices can be adopted easily.

Improved tree species as 19% of the community claimed were needed by farmers in Kasulu District. This probably implied that improved tree species were not readily available to farmers but also most farmers needed tree species that have extra benefits. The findings agree well with the findings reported by Mutonyi and Fungo (2011) who reported that germplasm of tree species were developed and available to farmers. It also agree with the findings reported by Simons and Leakey (2004); Ajayi (2006) and Kiptot *et al.* (2006) that if Agroforestry practices have to be part of the farming systems tree germplasms need to available either through seed nursery or seed markets. The findings reported by Ruheza (2003) agree well with the current findings that seedlings should be supplied to farmers to make them adopt Agroforestry practices.

The observation that formulation and enforcement of village bylaws as 16% of the community claimed can enhance adoption of Agroforestry in the district agrees well with the findings reported by Kamwenda (2002); NASCO (2006); Sanginga *et al.*

(2006); Wezel and Lykke (2006); Shilabu (2008) and Matata *et al.* (2010). Although traditional rules are informal and neither documented nor enacted by a defined legal body, still the communities adhere to them for natural resources management. This implied that customary bodies provide a strong social structure for changes among the society. If legislative changes concerning property rights will engage customary forms, then there will be full motivation for communities to adopt other new innovations specifically Agroforestry.

The current findings also observed that it was important to harmonize land tenure system as reported by 5% of the community. This probably indicated that some farmers in Kasulu District lack land ownership resulting to some farmers to dislike adopt Agroforestry technologies. This implied that possession of land was necessary for adoption of Agroforestry by farmers. The findings by Parwada *et al.* (2010) and Place *et al.* (2012) support well the current findings. Use of land rights was the requirement for farmers to adopt better land use management because where property rights are missing, tree planting and management becomes limited. It was also well supported by Suyanto *et al.* (2002); Otsuka *et al*. (2003); NASCO (2006); Buyinza *et al.* (2008) and Kiptot and Franzel (2011) that more secure land rights policies was required to encourage farmers to adopt and manage land resources sustainably.

CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

Based on the findings obtained and the proceeding discussion the following conclusions have been drawn:

(i) Currently the adoption status of agroforestry by the communities in Kasulu District is 91%. They have been using Agroforestry practices for a long time and by 2007 already 89% of the households had adopted the technologies implying that the farmers were aware about the benefits of Agroforestry.

(ii) Only three types of Agroforestry systems namely Agrosilviculture 42%, Agrosilvipasture 32% and Silvopasture 26% with the Homegardens 26%, Mixed intercropping 25% and Integrated tree/pasture management 17% were the main technologies used in the district.

(iii) *Brachstegia spiciforms* and *Pericopisis angolensis* which are indigenous species and *Senna siamea* and *Eucalyptus maidenii* (exotic) are the most commonly used timber tree species. *Mangifera indica, Citrus sinensis*, *Persea americana* and *Elais guinensis* are fruit trees widely preferred for use in Agroforestry in Kasulu District.

(iv) The main uses and services provided by woody perennials for the local communities are fruits 18% for home consumption and sell, fuel wood 17%, timber 17%, soil fertility improvement 11%, shade/shelter 8%, fodder and traditional medicines.

(v) Income generation 17%, farmer’s awareness of AF benefits 15%, access to extension services 12% and source of manure (9%) were the most enhancing factors of Agroforestry adoption in Kasulu District.

(vi) Lack of Agroforestry knowledge, land shortage, lack of monetary capital and unavailability of improved tree germplasm were the most significant factors that limit the adoption of AF systems and technologies.

(vii) Improvement of extension services 20%, development of policies which advocate Agroforestry 20% and introduction of improved tree species 19% were the appropriate required measures to improve the adoption and usage of Agroforestry systems and technologies.

6.2 Recommendations

(i) The extent of adoption reached by the communities in practicing Agroforestry is significantly high (91%), however more sensitization is required to maintain the existing adoption status reached to ensure its sustainability.

(ii) Agroforestry systems and their respective technologies that are mostly preferred by the communities should be emphasized and farmers be advised to diversify Agroforestry components to provide a range of products and services so as to increase their ability of sustaining food supply and income generation to the entire community.

(iii) Promotion of more exotic timber tree species is important rather than relying on only two species.

(iv) Training of both agricultural extension officers and farmers is needed so as to solve the problem of agroforestry knowledge. Land shortage can be solved by Agroforestry intensification.

(v) Lack of monetary capital and improved tree germplasm can be solved by the Government to provide credits through farmer groups, but also educate farmers to have their own tree nurseries such that the seedlings can be accessed easily by farmers.

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APPENDICES

Appendix 1: Questionnaire for communities households heads

A: General information

- Date of interview……………………………….
- Name of enumerator……………………………
- Name of Division………………………………
- Name of Ward………………………………….
- Name of Village………………………………..
- Name of respondent ……………………………
- Position of respondent in household....................

B: Household demographic information

1. Gender of respondent

a) Male [ ]

b) Female [ ]

2. Age of the respondents in years

a) 18-35 [ ]

b) 36-45 [ ]

c) 46- 60 [ ]

d) 60 or over [ ]

3. Marital status of respondent

a) Married [ ]

b) Not married [ ]

c) Widowed [ ]

d) Divorced [ ]

e) Separated [ ]

4. What is your educational level?

a) Never attended school [ ]

b) Primary school education [ ]

c) Secondary education [ ]

d) College [ ]

e) University [ ]

C. Livestock ownership

5. Do you own animals?

a) Yes [ ]

b) No [ ]

6. What type of animals do you own? ....

7. What is the tenure of grazing land?

a) Communal [ ]

b) Private land [ ]

c) Hire [ ]

d) Others......................... ....

8. What are the purposes of keeping livestock?

a) For sale [ ]

b) Home consumption [ ]

c) Manure [ ]

d) Social (Ceremonies, prestige) [ ]

e) a, b, c, and d [ ]

f) Others (specify)...

D. Land ownership

9. How many farm plots do you have? (In acres)

a) < 2 plots [ ]

b) 3-5 plots [ ]

c) More than 5 plots [ ]

10. How did you acquire (ownership) the land for the plots above?

a) Given by village leaders [ ]

b) Bought [ ]

c) Inherited from family members [ ]

d) Hiring [ ]

11. Which are the most types of crops grown in your field?............................

E. Current status of adoption of Agroforestry and technologies and preferences

12. Do you have wood perennial(s) planted in your farmland?

a) Yes [ ]

b) No [ ]

13. If yes what wood perennial(s) species do you have in your farm land?

Number	Specie type	Reason for integrating tree(s)
1		
2		
3		
4		
Others (specify)		

14. What year did you start practicing Agroforestry?

....

F. Types of Agroforestry systems and technologies

15. From the following mentioned types of AFs which one do you practice?

a) Agrosilvicultural system [ ]

b) Agrosilvipastoral system [ ]

c) Silvipastoral system [ ]

d) Aposilvipastoral system [ ]

e) Aquasilvipastoral system [ ]

f) Others (specify .... [ ]

16. From the following mentioned types of AFTs which one do you practice?

a) Homegarden [ ]

b) Windbreaks [ ]

c) Alley cropping / Hedgerow [ ]

d) Shifting cultivation [ ]

e) Mixed intercropping [ ]

f) Live fences [ ]

e) Others (Mention if any)……………………………

G. Factors influencing the adoption of Agroforestry system and technologies

17. What has influenced you to adopt AF system (s)?

Enhancing factors	Limiting factors

H. Measures to improve Agroforestry systems and technologies adoption

19. What do you think can improve Agroforestry practices in your area?

i) Develop policy which advocates Agroforestry. [ ]

ii) Improve extension services [ ]

iii) Formulate and enforce Village bylaws [ ]

iv) Harmonize land tenure policy [ ]

v) Introduction of improved species [ ]

vi) To promote traditional rules [ ]

vii) Improve institutional linkage [ ]

vii) Others (mention)..

End of interview-Thank you for your time and valuable information!.

Appendix 2: Checklist of probe questions for district/ward/village forestry& Agricultural Extension Officers

1. Does district/ward/ village practice Agroforestry?

2. What are your views on the current status of Agroforestry practices in your village?

3. What are the current Agroforestry extensions approaches used in the area?

3. What extension approaches do you think would be appropriate to assist promotion of

   Agroforestry and technologies in the area?

4. What constraints do you face in implementing extension services?

5. What limitations do farmers face in adopting the AF practices?

6. What are your suggestions for success of AFs practices in this area?

Appendix 3: Extent of adoption of Agroforestry systems and technologies in Kasulu District

Division	Percentage of Ward adopters		Means
Makere	84.7	89.8	87.2
Heru Chini	89.8	84.7	87.2
Buyonga	100.0	100	100
Heru Juu	94.9	84.7	89.8

Least Significant Difference (LSD) 14.816

Appendix 4: ANOVA for the extent of adoption of Agroforestry systems and technologies in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P –value
Rows	3	221.0850000	73.6950000	3.40	0.1708
Columns	1	13.0050000	13.0050000	0.60	0.4950
Error	3	65.0250000	21.6750000		
Total	7	299.1150000			

Appendix 5: Percentages for the trend of Agroforestry adoption by the communities in Kasulu District

	Divisions				
Years	**Makere**	**Heru chini**	**Buyonga**	**Heru juu**	**Means**
2011	0.0	0.7	0.0	0.0	0.2
2010	0.0	1.4	0.0	1.4	0.7
2009	0.0	0.7	1.4	0.7	0.7
2008	2.1	1.4	0.7	0.7	1.2
2007	21.9	19.9	25.3	21.9	22.3

Least Significant Difference (LSD) 1.8971

Appendix 6: ANOVA for the trend of Agroforestry adoption by the communities in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P –value
Rows	4	1488.293000	372.073250	245.39	<.0001
Columns	3	1.530000	0.510000	0.34	0.7994
Error	12	18.195000	1.516250		
Total	19	1508.018000			

Appendix 7: Percentages for the cumulative trend of Agroforestry adoption by the communities in Kasulu District

	Divisions				
Years	**Makere**	**Heru Chini**	**Buyonga**	**Heru Juu**	**Means**
2011	0.0	0.7	0.0	0.0	0.2
2010	0.0	2.1	0.0	1.4	0.9
2009	0.0	2.7	1.4	2.1	1.5
2008	2.1	4.1	2.1	2.7	2.7
2007	24.0	24.0	27.4	24.7	25.0

Least Significant Difference (LSD) 1.2207

Appendix 8: ANOVA for the cumulative trend of Agroforestry adoption by the communities in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	4	1887.363000	471.840750	751.64	<.0001
Columns	3	3.222000	1.074000	1.71	0.2177
Error	12	7.533000			
Total	19	1898.118000			

Appendix 9: Percentages of Agroforestry systems adopted by the local communities in Kasulu District

System	Division				
	Makere	**Heru Chini**	**Buyonga**	**Heru Juu**	**Means**
Agrosilvicultural system	22.6	21.9	26.0	20.5	22.8
Agrosilvipastoral system	15.8	18.5	17.8	16.4	17.1
Silvipastoral system	15.8	13.0	17.1	11.6	14.4

Values in the same column that followed by the same letter do not differ significant ($p<0.05$)

Least Significant Difference (LSD) 2.6469

Appendix 10: ANOVA for the Agroforestry systems adopted by the local communities in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	2	145.7916667	72.8958333	31.15	0.0007
Columns	3	26.0033333	8.6677778	3.70	0.0809
Error	6	14.0416667	2.3402778		
Total	11	185.8366667			

Appendix 11: Percentages for the Agroforestry systems adopted in Makere Division

System	**Kagera Nkanda**	**Mvinza**	**Means**
Agrosilvicultural system	42.9	51.4	47.1
Agrosilvipastoral system	37.1	28.6	32.9
Silvipastoral system	25.7	40.0	32.9

Least Significant Difference (LSD) 36.052

Appendix 12: ANOVA for the Agroforestry systems adopted in Makere Division

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	2	272.6533333	136.3266667	1.94	0.3399
Columns	1	34.0816667	34.0816667	0.49	0.5581
Error	2	140.4133333	70.2066667		
Total	5	447.1483333			

Appendix 13: Percentages for the Agroforestry systems adopted in Heru Chini Division

System	Rungwe Mpya	Asante Nyerere	Means
Agrosilvicultural system	45.7	45.7	45.7
Agrosilvipastoral system	31.4	45.7	38.6
Silvipastoral system	25.7	28.6	27.1

Least Significant Difference (LSD) 22.999

Appendix 14: ANOVA for the Agroforestry systems adopted in Heru Chini Division

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	2	350.1233333	175.0616667	6.13	0.1403
Columns	1	49.3066667	49.3066667	1.73	0.3194
Error	2	57.1433333	28.5716667		
Total	5	456.5733333			

Appendix 15: Percentages of the Agroforestry systems adopted in Buyonga Division

System	Munzese	Kigembe	Means
Agrosilvicultural system	50.0	45.0	47.5
Agrosilvipastoral system	30.0	35.0	32.5
Silvipastoral system	27.5	35.0	31.3

Least Significant Difference (LSD) 20.124

Appendix 16: ANOVA for the Agroforestry systems adopted in Buyonga Division

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	2	327.0833333	163.5416667	7.48	0.1180
Columns	1	9.3750000	9.3750000	0.43	0.5799
Error	2	43.7500000			
Total	5	380.2083333			

Appendix 17: Percentages of the Agroforestry systems adopted in Heru Juu Division

System	Muganza	Heru Juu	Means
Agrosilvicultural system	44.4	38.9	41.7
Agrosilvipastoral system	44.4	22.2	33.3
Silvipastoral system	22.2	25.0	23.6

Least Significant Difference (LSD) 38.739

Appendix 18: ANOVA for the Agroforestry systems adopted in Heru Juu Division

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	2	326.4100000	163.2050000	2.01	0.3319
Columns	1	103.3350000	103.3350000	1.27	0.3761
Error	2	162.1300000	81.0650000		
Total	5	591.8750000			

Appendix 19: Percentages for the Agroforestry technologies adopted in Kasulu District

Technology	Makere	Heru Chini	Buyonga	Heru Juu	Mean
Home garden	19.9	19.2	24.0	18.5	20.4
Windbreaks/Boundary	15.1	8.2	9.6	11.0	11.0
Alley cropping/Hedgerow	0.0	0.7	0.7	3.4	1.2
Shifting cultivation	8.2	12.3	13.7	6.2	10.1
Mixed intercropping	17.8	21.9	23.3	15.8	19.7
Live fences	1.4	0.0	4.8	3.4	2.4
Taungya	0.0	0.0	0.0	2.1	0.5
Integrated tree/pasture management	15.8	11.6	17.1	8.9	13.4

Least Significant Difference (LSD) 3.8562

Appendix 20: ANOVA for the Agroforestry technologies adopted in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	7	1756.723750	250.960536	36.49	<.0001
Columns	3	40.236250	13.412083	1.95	0.1524
Error	21	144.408750			
Total	31	1941.368750			

Appendix 21: Percentages for the Agroforestry technologies adopted in Makere Division

Technology	Kagera Nkanda	Mvinza	Means
Homegarden	40.0	42.9	41.4
Windbreaks/boundary	45.7	17.1	31.4
Shifting cultivation	5.7	28.6	17.1
Mixed intercropping	31.4	42.9	37.1
Live fences	0.0	5.7	2.9
Integrated tree/pasture management	28.6	37.1	32.9

Least Significant Difference (LSD) 31.487

Appendix 22: ANOVA for the Agroforestry technologies adopted in Makere Division

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	5	2091.064167	418.212833	2.79	0.1425
Columns	1	43.700833	43.700833	0.29	0.6126
Error	5	750.184167			
Total	11	2884.949167			

Appendix 23: Percentages for the Agroforestry technologies adopted in Heru Chini

Technology	Rungwe Mpya	Asante Nyerere	Means
Homegarden	31.4	48.6	40.0
Windbreaks/Boundary	11.4	22.9	17.1
Alley cropping/Hedgerow	2.9	0.0	1.4
Shifting cultivation	25.7	25.7	25.7
Mixed intercropping	45.7	45.7	45.7
Integrated tree/pasture management	25.7	22.9	24.3

Least Significant Difference (LSD) 15.341

Appendix 24:ANOVA for the Agroforestry technologies adopted in Heru Chini

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	5	2535.226667	507.045333	14.24	0.0056
Columns	1	44.083333	44.083333	1.24	0.3165
Error	5	178.086667	35.617333		
Total	11	2757.396667			

Appendix 25: Percentages for the Agroforestry technologies adopted in Buyonga Division

Technology	**Munzese**	**Kigembe**	**Means**
Homegarden	45.0	42.5	43.8
Windbreaks/boundary	17.5	17.5	17.5
Alley cropping/Hedgerow	0.0	2.5	1.3
Shifting cultivation	22.5	27.5	25.0
Mixed intercropping	45.0	40.0	42.5
Live fences	12.5	5.0	8.8
Integrated tree/pasture management	27.5	35.0	31.3

Least Significant Difference (LSD) 9.3443

Appendix 26: ANOVA for the Agroforestry technologies adopted in Buyonga Division

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	6	3155.357143	525.892857	36.06	0.0002
Columns	1	0.000000	0.000000	0.00	1.0000
Error	6	87.500000			
Total	13	3242.857143			

Appendix 27: Percentages for the Agroforestry technologies adopted in Heru Juu Division

Technology	Muganza	Heru Juu	Means
Homegarden	52.8	22.2	37.5
Windbreaks	33.3	11.1	22.2
Alley cropping/Hedgerow	13.9	0.0	6.9
Shifting cultivation	5.6	19.4	12.5
Mixed intercropping	33.3	30.6	31.9
Live fences	2.8	11.1	6.9
Taungya	0.0	8.3	4.2
Integrated tree/pasture management	16.7	19.4	18.1

Least Significant Difference (LSD) 26.816

Appendix 28: ANOVA for the Agroforestry technologies adopted in Heru Juu Division

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	7	2114.029375	302.004196	2.35	0.1413
Columns	1	82.355625	82.355625	0.64	0.4499
Error	7	900.249375			
Total	15	3096.634375			

Appendix 29: Percentages for the technologies adopted on Agrosilvicultural system in Kasulu District

Technology	Division				
	Makere	Heru Chini	Buyonga	Heru Juu	Means
Homegarden	21.1	19.5	24.8	16.5	20.5
Windbreaks/boundary	15.8	7.5	9.8	9.8	10.7
Alley cropping/Hedgerow	0.0	0.8	0.8	3.0	1.1
Shifting cultivation	9.0	12.0	13.5	6.0	10.2
Mixed intercropping	18.8	22.6	24.1	16.5	20.5
Live fences	1.5	0.0	5.3	3.0	2.4
Taungya	0.0	0.0	0.0	2.3	0.6

Least Significant Difference (LSD) 4.0331

Appendix 30: ANOVA for the technologies adopted on Agrosilvicultural system in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	6	1769.547143	294.924524	40.02	<.0001
Columns	3	34.785714	11.595238	1.57	0.2305
Error	18	132.664286			
Total	27	1936.997143			

Appendix 31: Percentages of the technologies adopted on Agrosilvipastoral system in Kasulu District

Technology	**Division**				
	Makere	**Heru Chini**	**Buyonga**	**Heru Juu**	**Means**
Homegarden	22	24	24	21	23
Windbreaks	15	10	8	14	12
Alley cropping/Hedgerow	0	1	0	5	2
Shifting cultivation	9	16	15	6	12
Mixed intercropping	18	25	25	15	21
Live fences	1	0	5	2	2
Taungya	0	0	0	2	1

Least Significant Difference (LSD) 4.9555

Appendix 32: ANOVA for the technologies adopted on Agrosilvipastoral system in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	6	2039.428571	339.904762	30.55	<.0001
Columns	3	18.964286	6.321429	0.57	0.6431
Error	18	200.285714			
Total	27	2258.678571			

Appendix 33: Percentages for the technologies adopted on Silvopastoral system in Kasulu District

Technology	Division				
	Makere	Heru Chini	Buyonga	Heru Juu	Means
Windbreaks	15.3	7.1	8.2	10.6	10.3
Alley cropping/Hedgerow	0.0	0.0	1.2	3.5	1.2
Shifting cultivation	10.6	12.9	12.9	8.2	11.2
Live fences	1.2	0.0	4.7	1.2	1.8
Integrated tree/pasture management	25.9	18.8	28.2	15.3	22.1

Least Significant Difference 5.2032

Appendix 34: ANOVA for the technologies adopted on Silvopastoral system in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	4	1158.503000	289.625750	25.39	<.0001
Columns	3	47.302000	15.767333	1.38	0.2955
Error	12	136.873000	11.406083		
Total	19	1342.678000			

Appendix 35: Percentages of the tree species adopted in various divisions Kasulu District

Local name	Division				
	Makere	Heru chini	Buyonga	Heru juu	Means
Mchikichi	0	7	18	0	6.3
Mchungwa	7	10	8	8	8.3
Mibhombo	0	1	3	1	1.3
Mmbanga	21	18	19	0	14.5
Miembe	30	25	28	15	24.5
Mikoyoyo	3	4	11	0	4.5

Mlama	0	0	2	0	0.5
Msonobali	1	4	6	5	4.0
Mitundu	31	22	13	0	16.5
Mjoholo	24	18	10	0	13.0
Mikanda	0	5	5	0	2.5
Mvyilu	2	0	6	2	2.5
Mlembela	9	7	11	0	6.8
Mshindwi	4	5	12	0	5.3
Mparachichi	2	5	4	18	7.3
Mumoli	10	4	5	0	4.8
Mlumba	6	0	1	7	3.5
Mpapai	4	4	1	0	2.3
Mlalangwe	3	0	0	0	0.8
Mkurungu	0	11	3	0	3.5
Mgunga	0	2	0	0	0.5
Mgrivellia	3	1	1	12	4.3
Kahawa	0	0	0	8	2.0
Mkaratusi	1	3	2	23	7.3
Msasa	0	0	0	2	0.5
Mkuyu	0	1	4	1	1.5
Mchenza	0	1	1	1	0.8
Mlimao	4	6	3	4	4.3
Mpera	3	4	6	5	4.5
Msiloti	0	2	5	0	1.8
Mninga	7	10	5	0	5.5
Muhongolo	2	0	5	0	1.8
Msilasi	1	0	1	0	0.5
Mibono	2	0	0	0	0.5
Muyama	0	0	2	0	0.5
Minyaa	2	0	0	0	0.5

Values in the same row that are followed by the same letter do not differ significantly ($p<0.05$)

Least Significant Difference 6.9345

Appendix 36: ANOVA for the tree species adopted by communities in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	35	3801.687500	108.619643	4.44	<.0001
Columns	3	126.743056	42.247685	1.73	0.1659
Error	105	2568.506944	24.461971		
Total	143	6496.937500			

Appendix 37: Uses and services of the various tree species in Kasulu District

Local name	Scientific name	Use/service
Miembe	*Mangifera indica*	Fruits,firewood,shade,windbreak,fodder
Mitundu	*Brachystegia spiciformis*	Fuelwood,timber,ropes,medicine,fodder
Mmbanga	*Pericopsis angolensis*	Fuelwood,timber,poles,carving,fodder
Mjohoro	*Senna siamea*	Fuelwood,timber,poles,beeforage,windbreak
Mchungwa	*Citrus sinensis*	Fruits,fuelwood,shade
Mparachichi	*Persea americana*	Fruits,shade,
Mkaratusi	*Eucalyptus maidenii*	Poles,fuelwood,timber,carving,medicine,windbreak
Mlembela	*Isoberlinia tomentosa*	Fuelwood,timber,beehives,beeforage,shade
Mchikichi	*Elais guinensis*	Cookingoil,fruits,poles,soap,brooms,animalfeeds
Mninga	*Pterocarpus angolensis*	Timber,poles,fuelwood,carving/utensils
Mshindwi	*Anisophyllea boehmii*	Fruits,fuelwood,charcoal,beeforage
Umumoli	*Dalbergia melanoxylon*	Fuelwood,timber,carving/utensils,fodder
Mpera	*Psidium guajava*	Fruits,medicines,poles,fuelwood,shade
Umkoyoyo	*Combretum zeyheri*	Manure, fuelwood, carving
Mgrivellia	*Grevillea robusta*	Ornamental,shade,fodder,timber,firewood,poles
Mlimao	*Citrus limon*	Fruits,fuelwood,shade
Msonobali	*Pinus pitula*	Ornamental,shade,timber,poles,fuelwood,
Mlumba	*Ficus spp*	Fibre/weaving,ropes,shade,ornamental,ceremonial
Mkurungu	*Pterocarpus tinctorius*	Timber,poles,fuelwood,carving
Umvyilu	*Vitex keniensis*	Fruits,fuelwood,mulch
Umkanda	*Annona senegalensis*	Medicines,fodder,tannin
Mpapai	*Carica papaya*	Fruits,medicine
Kahawa	*Coffea canephora*	Beverage, shade
Umsiloti	*Pterocarpus spp*	Fuelwood, fodder,shade
Umuhongolo	*Sclerocarya birrea*	Medicines

Umukuyu	*Ficus glumosa*	Shade,fuelwood
Mibhombo	*Brachystegia spp*	Shade,fuelwood,charcoal,timber,fodder,medicines
Umulalangwe	Not found	Shade,fuelwood,fodder,medicine
Mchenza	*Citrus reticulata*	Fruits,fuelwod,shade,ornamental
Umusilasi	*Garcinia buchananii*	Fruits,carving/utensils,fodder,medicines
Mibono	*Ricinus communis*	Windbeak,livefence
Umuyama	Not found	Fuelwood,shade,carving,fodder,medicine
Iminyale	*Euphorbia tirucalli*	Livefence,boundary,medicines
Umsasa	*Cordia monoica*	Timber,fuelwood,tools,medicines,beeforage,
Umulama	*Syzygium guineense*	Timber,charcoal,fuelwood,poles,carving,fodder
Umgunga	*Acacia nilotica*	Fuelwood,charcoal,poles,fodder

Source:Mbuya, *et al.*(2002), Natural Resource Office, Kasulu District

Appendix 38: Percentages for the uses/services of tree species in Kasulu District

Use	**Division**				
	Makere	**Heru chini**	**Buyonga**	**Heru juu**	**Means**
Fruits	22.6	19.2	24.0	11.0	19.2
Fuel	19.2	16.4	22.6	17.8	19.0
Timber	21.2	19.9	24.0	17.8	20.7
Manure	15.8	0.0	0.0	0.0	3.9
Shade	15.1	8.2	6.2	5.5	8.7
Windbreak	4.8	3.4	5.5	2.1	3.9
Building	0.7	1.4	2.1	1.4	1.4
Environment	6.2	3.4	6.2	5.5	5.3
Cooking	11.6	6.8	5.5	5.5	7.4
Tradition	0.0	0.0	0.7	5.5	1.5
Fodder	11.6	5.5	3.4	1.4	5.5
Beverage	15.8	11.0	11.6	11.6	12.5
Carving	0.7	4.8	11.6	0.0	4.3

Least Significant Difference (LSD) 5.0384

Appendix 39:ANOVA for the uses/services of tree species in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	12	2272.422308	189.368526	15.34	<.0001
Columns	3	161.388462	53.796154	4.36	0.0102
Error	36	444.371538	12.343654		
Total	51	2878.182308			

Appendix 40: Percentages for the factors enhancing the adoption of Agroforestry systems and technologies in Kasulu District

Factor	**Division**				
	Makere	**Heru chini**	**Buyonga**	**Heru juu**	**Means**
Availability of land	13.0	8.9	3.4	2.7	7.0
Income	24.0	21.2	20.5	19.9	21.4
Extension services	20.5	16.4	14.4	11.0	15.6
Awareness	20.5	18.5	21.2	17.8	19.5
Cultural norms	12.3	13.0	11.6	11.0	12.0
Manure	13.0	11.0	13.0	7.5	11.1
Shade	10.3	8.2	5.5	8.2	8.0
Food	5.5	3.4	6.8	2.1	4.5
Environmental conservation	13.0	11.6	14.4	4.8	11.0
Soil conservation	11.0	6.2	6.8	2.7	6.7
Fuel	6.2	8.2	4.8	5.5	6.2
Building materials	0.7	1.4	2.1	0.7	1.2
Health	1.4	2.7	0.7	1.4	1.5
Windbreak	1.4	4.8	1.4	4.1	2.9

Least Significant Difference (LSD) 3.118

Appendix 41: ANOVA for the factors enhancing the adoption of Agroforestry system and technologies in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	13	2063.143036	158.703310	33.39	<.0001
Columns	3	106.420536	35.473512	7.46	0.0005
Error	39	185.351964			
Total	55	2354.915536			

Appendix 42: Percentages of the factors that limit adoption of Agroforestry systems and technologies in Kasulu District

Factor	Division				
	Makere	Heru Chini	Buyonga	Heru Juu	Means
Lack of income	21.4	14.3	7.1	21.4	16.1
Unawareness	28.6	42.9	21.4	28.6	30.4
Cultural norms	7.1	7.1	0.0	7.1	5.4
Lack of extension services	21.4	7.1	0.0	21.4	12.5
Lack of land	21.4	21.4	14.3	21.4	19.6
Lack of tree seeds	0.0	0.0	7.1	0.0	1.8

Least Significant Difference (LSD) 9.1443

Appendix 43: ANOVA for the factors which limit adoption of Agroforestry systems and technologies in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	5	2122.302083	424.460417	11.53	0.0001
Columns	3	289.217917	96.405972	2.62	0.0891
Error	15	552.169583	36.811306		
Total	23	2963.6895832			

Appendix 44: Percentages for the measures required to improve adoption of Agroforestry systems and technologies in Kasulu District

Measure	**Division**				
	Makere	**Heru Chini**	**Buyonga**	**Heru Juu**	**Means**
Develop policy which advocates agro forestry	27.4	26.0	26.7	23.3	25.9
Improve extension services	27.4	26.0	25.3	25.3	26.0
Formulate and enforce village bylaws	19.2	24.7	23.3	14.4	20.4
Harmonize	13.7	2.7	6.8	2.1	6.3

land tenure policy					
Introduction of improved species	26.0	24.0	22.6	25.3	24.5
Promote traditional rules	13.0	16.4	17.1	4.8	12.8
Improve institutional linkages	0.7	0.0	2.1	0.0	0.7
Provide agricultural input	13.0	8.2	11.0	13.0	11.3

Least Significant Difference (LSD) 4.639

Appendix 45: ANOVA for the measures required to improve adoption of Agroforestry systems and technologies in Kasulu District

Source of Variation	Df	SS	MSS	F-value	P -value
Rows	7	2592.289687	370.327098	37.21	<.0001
Columns	3	74.168437	24.722812	2.48	0.0888
Error	21	209.024063			
Total	31	2875.482187			