ECONOMIC POTENTIAL OF SELECTED LESSER KNOWN AND UNDERUTILIZED INDIGENOUS AGROFORESTRY TIMBER SPECIES IN KILOSA DISTRICT IN TANZANIA

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A DISSERTATION SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN ENVIRONMENTAL AND NATURAL RESOURCES ECONOMICS OF SOKOINE UNIVERSITY OF AGRICULTURE. MOROGORO, TANZANIA.

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ABSTRACT

The main objective of this study was to determine the economic potential of Lesser Known (LK) indigenous agroforestry timber tree species mainly *Lonchocarpus capassa, Lannea schimperi, Combretum adenogonium, Pseudolanchnostylis maprouneifolia* and *Vitex keniensis*. Specifically the study aimed at estimating the standing volume of the LK Indigenous Agroforestry Timber Species (IAGTS) in farms, determine their economic value and estimate their profitability for timber production. Structured and semi structured questionnaires, personal observation, focused group discussion and forest inventory methods were used in data collection. One hundred and twenty households in four villages were sampled purposively. The data was analyzed using the Statistical Package for Sosial Sciences (SPSS) programme version 16 and Microsoft Excel programme. Descriptive analysis was used to generate frequencies, percentages, sums and means which were used to discuss the results. Findings indicated that a total of 7247 trees with volume of 1114.3 m^3 were obtained in conserved as Lesser Known IAGTS and hardwood woodlots respectively. The economic value for conserved LK IAGTS and planted hardwood woodlots per household was 328 900 TZS and 3 180 000 TZS respectively. Profitability at 10% discounting factor, NPV were TZS 4 892 453 and TZS 6 161 247, at 22 and 19 years rotation ages for LK IAGTS practices and hardwood woodlots respectively. Obtained standing volume, total value and average annual income of LK IAGTS in conserved trees and woodlots increases additional income and serves as off farm income to households hence improves livelihoods as well as reducing dependence on the reserved forests. I therefore recommend optimizing production of IAGTS in woodlot at households' level; hence will improve the conservation of the resources with positive socio-economic implication to farmers.

DECLARATION

I, GODLIVA ANGELUS MVANDA, 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.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF PLATES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS AND ACRONYMS

B/CR	Benefit Cost Ratio
CBA	Cost Benefit Analysis
CBFM	Community Based Forest Management
DBH	Diameter at Brest Height
DPs	Development Partners
EAMCEF	Eastern Arc Mountains Conservation Endowment Fund
EPINAV	Enhancing Pro-poor Innovation in Natural Resources and Agricultural Value chain
EU	European Union
EURAF	European Agroforestry Federation
FAO	Food and Agriculture Organization
FBD	Forestry and Beekeeping Division
GDP	Gross Domestic Product
GN	Government Notice
Ha	Hectare
IAGTS	Indigenous Agroforestry Timber Species
ICRAF	World Agroforestry Centre
IR	Interest Rate
IRR	Internal Rate of Return
Kg	Kilogram
LGA	Local Government Authority
LKS	Lesser Known Species

LKTS	Lesser Known Timber Species
M	Meters
M^3	Meter cube
MKUKUTA	Mkakati wa Kupunguza Umasikini na Kukuza Uchumi Tanzania
MNRT	Ministry of Natural Resources and Tourism
MOECO	Morogoro Environmental Conservation Organization
N	Number
NAFORMA	National Forest Resources Monitoring and Assessment
NBS	National Bureau of Statistics
NFP	Non Forest Product
NGO	Non-Governmental Organization
NIPF	Non Industrial Private Forests
NPV	Net Present Value
NTF	Non Timber Forest
NTFPs	Non Timber Forest Products
NWFPs	Non Wood Forest Products
PFM	Participatory Forest Management
PRA	Participatory Rural Appraisal
S	South
Sp	Species
SPSS	Statistical Package for Social Science
SUA	Sokoine University of Agriculture

SNAL	Sokoine University of Agriculture National Library
t	time
TTSA	Tanzania Tree Seed Agency
TZS/Tsh.	Tanzanian Shillings
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
URT	United Republic of Tanzania
USD	United State Dollar
VCs	Village Council
VECs	Village Environmental Committees
VEO	Village Executive Officer
VNRCs	Village Natural Resources Committees
Yr	Year

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background Information

Tanzania has a large land area of approximately 94.5 million hectares, with tropical climate and 10 ecological zones. Tanzania has a total of 33.4 million hectares of forests and woodlands (FAO, 2011), rich in biodiversity and in carbon. Carbon stored in trees plays an important role in climate change mitigation. According to Gillah *et al.* (2007), the natural forests of Tanzania are reported to harbor a number of useful tree species for timber production. According to FAO (2005), the rate of deforestation, which led to the annual loss in the country's forest cover between 1990 and 2000, was estimated to be 2%. Through the current discussions under the United Nations Framework Convention on Climate Change (UNFCCC) there is a possibility for developing countries including Tanzania to receive financial benefits for Reducing Emissions from Deforestation and Forest Degradation; forest conservation, sustainable management of forests and enhancement of forest carbon stocks (REDD+) (Zahabu, 2012). The Forestry sector through its products and services has a significant contribution to both national and local economies especially in the rural areas. However, the current supply of these products and services does not meet the market demand, and this trend leads to gradual forest degradation (MNRT, 2001).

Agroforestry refers to a combination of agriculture and forestry. According to ICRAF (2012) and European Agroforestry Federation (EURAF) (2012), agroforestry is a collective name for land use systems and practices in which woody perennials are deliberately integrated with crops and/or animals on the same land management unit;

therefore, there are normally both ecological and economic interactions between woody and non wood components in agroforestry.

Agroforestry systems are important in increasing food production, and in conserving and protecting natural resource base. According to Quandt *et al.* (2010), both timber/lumber and fuel wood are often collected from natural forests but they can alternatively be collected from agroforestry trees when these natural forests become degraded and scarce. This trend reduces significantly the burden of carrying firewood over long distances and it also reduces the time spent especially by women searching for wood (Ajayi *et al.*, 2008). As Kwesiga and Coe (1994) report, fertilized tree systems can provide up to 10 tones of wood biomass per hectare.

Lesser known timber species (LKTS) are potential tree species whose physical and mechanical wood properties as well as their possible end-uses have not been incorporated in the international market; these timber species are often referred to as unknown because they are rarely recognized and utilized. According to Makonda *et al.* (2008), the terms lesser-known wood species, secondary species and little-used species have been used to characterize insufficiently used wood species. On the other hand according to Forest and Beekeeping Division (FBD) (2005); MNRT and Indufor (2011), Tanzania has reasonably large harvestable area and volume in the natural forests, mostly from the lesser known species and some of which are commercially unknown species.

Although Tanzania has more than 700 indigenous wood species ranging from low to high densities, the timber market is dominated by a small number of commercially well known species. As Ishengoma *et al.* (1998) report, out of 700 species only 20 well known tree species are utilized commercially and often for purposes which even the lesser known can equally be suitable and cheaply available. As a result, majority of timber species in Tanzania are lesser known hence underutilized. Therefore studying and understanding the economic potential of lesser-known and underutilized agroforestry timber species reserved and or planted in farms will help in reducing the pressure on the well known timber species and will also increase their on-farm production and productivity as the result of increasing household's income.

1.2 Problem Statement and Justification

An increase in human population creates more demand for timber and other forestry products. The demand for fuel wood especially charcoal continues to rise while the growth of trees and shrubs in the miombo woodlands are at a slower rate (Sileshi *et al.,* 2007; Hezron *et al.,* 2001). Many sawmill industries prefer harvesting the well known tree species which are overexploited in many places. Ishengoma *et al.* (1997) observed these well known species have become scarce hence raising timber prices which necessitate the search for substitute tree species.

Due to high demand of timber and other forestry products for household's consumption and industries in Tanzania, there is a need for optimizing production of timber and other forest products using these lesser known and underutilized species. Utilization of LK IAGTS is one of the potential alternatives in overcoming this problem. Many studies on physical and mechanical properties of some species such as *Trichilia emetica,* and *Pterocarpus stolzii* (Ishengoma *et al.,* 1997), *Milletia oblata sub spp stolzii* (Ishengoma *et al.,* 1998), *Pteleopsis myrytifolia* and *Uapaca kirkiana* (Gillah *et al.,* 2007) *Aphloia theiformis* (Gillah *et al.*, 2008) *and Albizia schimperiana* (Makonda *et al.*, 2008) have been documented; however, such studies did not include economic potentials of these species. Therefore there is a need to conduct a study on the economic potentials of some LKTS species.

Traditionally, many farmers tend to leave some trees species in their farms when clearing land for farming. Also, trees are planted in agricultural or silvopastoral systems to provide shade, windbreak, medicines, or to meet household energy needs Jama *et al.* (2006). A study done by Makonda and Augustino (2011) under Enhancing Pro-poor Innovation in Natural Resources and Agricultural Value chain (EPINAV) project showed, that most of these trees are left to provide shelter, climate amelioration and fuelwood, but some of them can produce timber with different strength properties and substitute the highly valued timber species.

Some of the lesser known indigenous timber species found in the farms at Kilosa district include *Lonchocarpus capassa*, *Lannea schimperi*, *Combretum adenogonium*, *Pseudolanchnostylis maprouneifolia* and *Vitex keniensis*. According to Barany *et al.* (2003), Ishengoma *et al.* (1998) and MNRT and Indufor (2011) the limited promotion at both national and international markets of these lesser known timber species are caused by among other factors, lack of information regarding their physical and mechanical properties. The physical and mechanical properties of these species are already being tested on another project under EPINAV. Nevertheless, the economic potential of the selected five species have not been studied, disseminated and documented hence limiting their market promotion.

This study therefore aimed was assessing the economic potential of *Lonchocarpus capassa*, *Lannea schimperi*, *Combretum adenogonium*, *Pseudolanchnostylis maprouneifolia* and *Vitex keniensis* to the rural people in Kilosa. This study will help to know if these LK IAGTS can be used for timber production with the ultimate goal of optimizing their utilization and production in order to maximize profit from timber products grown on the farms and increase household income. Using LKTS species for timber production will also contribute to poverty reduction through increased market values (Gillah *et al.*, 2007).

1.3 Objectives of the Study

1.3.1 General objective

The overall objective of the study was to assess economic potential of indigenous agroforestry timber tree species mainly *Lonchocarpus capassa, Lannea schimperi, Combretum adenogonium, Pseudolanchnostylis maprouneifolia* and *Vitex keniensis* in Kilosa District, Tanzania.

1.3.2 Specific objectives

The specific objectives of the study were to:

1. Estimate standing volume of the IAGTS including the selected five LKTS in agroforestry farms in Kilosa District
2. Determine economic value of the IAGTS including the selected five LKTS used in agroforestry farms in Kilosa District
3. Estimate the profitability of the IAGTS including the selected five LKTS for timber production

1.4 Research Questions

This study was guided by the following research questions;

1. What was the estimated standing volume of the IAGTS including the selected five LKTS in agroforestry farms?
2. What are the economic values of the IAGTS including the selected LKTS used in agroforestry system?
3. What was the profitability of the IAGTS including the selected LKTS for timber production?

CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Overview of Forestry Sector

About 38 % of Tanzania's total land is covered by forests and woodlands. These forests are however, affected by deforestation at a rate of between 130 000 and 500 000 hectares per year, resulting from heavy pressure caused by agricultural expansion, livestock grazing, wild fires, overexploitation, and unsustainable utilization of wood resources coupled with other human activities (MNRT, 2001). Through its products and services, forestry sector contributes significantly to both national and local economies especially in rural areas. Forests are increasingly important for rural and urban livelihoods (Ngaga, 2011). However, the current supply of these products and services does not meet the market demand sustainably hence gradual forest degradation. Deforestation is occurring at the rate of 3.1% per year due to forest conversion, forest fires, the collection of fuel wood and illegal logging (USAID, 2012). According to Malimbwi (2008), the rate of deforestation in Tanzania which is estimated at more than 500 000 hectares per annum is mostly impacting general land forests. In Zambia on the other hand, it is estimated that the Miombo woodlands forests are being deforested for development purposes at a rapid rate of between 200 000 and 300 000 hectares per year, and majority of these woodlands are categorized as *miombo* (Winrock International, 2006).

2.2 Forestry Situation in the World

Forest situation in Tanzania have been affected by human activities. Since the supply of rural resources obtained in forest villages is not enough, the existing areas with forests are harvested illegally in order to meet their basic needs from forests, grazing of animals, collecting construction materials, fuel wood and secondary forest products as well as opening up land for agriculture (USAID, 2012). It is also reported (Ngaga, 2011) that fire seems to be a major problem in Tanzania's forest plantations. Also, pressure on forests in Honduras country, was high between 1990 and 2005, whereby the country lost 37% of its forest cover to deforestation, conversion of forestland to agriculture land or cattle ranching, forest fires, collection of fuel wood and illegal logging (USAID, 2012).

2.2.1 Importance of forests in the world

Forests are important assets in Tanzania, offering numerous goods and services in the national economy and local livelihoods (Winrock International, 2006). According to Gausset *et al.* (2007), trees are useful to people for many different reasons; they provide firewood, timber, fruits, medicines, wild vegetables, and fodder for animals, shade and materials for making various tools. Trees can also fulfill different ecological functions such as securing water sources, preventing soil erosion, enhancing soil fertility, providing habitat for various animals that can also be valuable (game, bees, etc). Natural forest improves living standard of rural people and reduces poverty by improving household's income and leading to human development (Winrock International, 2006). Therefore, the Forest sector has a great role to play in environmental conservation, agricultural production and the supply of water, besides direct benefits related to employment opportunities and contribution to the national economy (MNRT, 2001). As reported by Ebodaghe (2010), in Washington more than 90% of the wood for the nation's forest product industry comes from private land.

Forest industry and products contribute to the national income. Forests provide over 75% of all construction materials in the country (Ngaga, 2011). The industry produces about $175 billion of products annually and employs nearly 900 000 men and women, and thus exceeding employment levels in the automotive, chemicals, and plastics industries (Ngaga, 2011).

In Tanzania, the annual payroll is approximately $50 billion (Ebodaghe, 2010) and the annual per capital GDP is about USD 284.5, which places Tanzania among the poorest countries in the world. According to the World Bank (2006), the gross national income (GNI) per capita is estimated at US$340, placing Tanzania as 188th of 208 countries in the economic ranking. The forest products industry accounts for approximately 5 percent of the total U.S. manufacturing GDP (Ebodaghe, 2010). However, the linkages between forest resources in rural areas and poverty reduction have been heavily studied in Tanzania than elsewhere in Sub-Saharan Africa. According to the estimates by Monela *et al.* (2000), honey, charcoal, fuel wood, and wild fruits contribute 58 percent of the cash incomes of farmers in a semiarid region of Tanzania.

Also, as reported by Ngaga (2011), the overall assessment of revenue collection by Forest and Beekeeping Division (FBD) shows that the revenue collection has increased from TAS 4.55 billion in 2003/04 to TAS 46.60 billion in 2009/10. The dependence by resource-poor households on cash income from the sale of forest products, such as charcoal, honey, wild fruits, and firewood appears to be another major driver of deforestation (Winrock International, 2006). Many households in the world are depending on natural resources including forests. Poverty is particularly acute in rural areas; in Honduras country is approximately 30% of the people live below the international poverty line of US $2 per day, while 18% live below US $1.25 per day, whereby many households are landless or land-poor (USAID, 2012). The high poverty levels are attributed to income inequality and a relatively low rate of economic growth in rural areas (URT, 2005).

Tanzania has been exporting forest products such as logs, sawn timber, floor boards, planks, sandalwood and poles. Until in the last few years when non-traditional products were introduced, the leading export of forest products had been sawn timber (rough sawn) and in 2010 Kenya absorbed some 67% of all exports (Ngaga, 2011). The forest sector has an important role to play in Tanzania's economy. Although in absolute terms its contribution to the total GDP is still low, its relative share of the GDP has increased considerably during the past 10 years, from 2.6 to 3.4%, and in other words the increase has amounted to 35% (Ngaga, 2011).

2.2.2 Problems facing forestry sector

Forest reserves, like any other forest categories, suffer from encroachment, wildfires and illegal harvesting (Ngaga, 2011). However, if the economy grows at the same pace as now, and also the population and urbanisation continue to grow, the demand for wood from plantations is forecast to exceed supply by about 2 200 000 m^3 by year 2030 (Ngaga, 2011). The causes of deforestation in Tanzania, according to FAO (2009), include charcoal production, forest fires, clearing for agriculture and illegal logging. An estimated 90 % of Tanzania's energy needs are met through the use of wood fuels. Thus, charcoal production is the main cause for deforestation (Ngaga, 2011).

2.2.3 Tree planting programme

Tree planting is a long-term investment that pays off in personal satisfaction, family enjoyment and monetary profits; also planting a tree is an act of an optimist, it represents faith in the future and a hope for generations which are yet to be born, it also represents a commitment to the land (Hall, 2012). In Tanzania, the village afforestation programme was initiated in the early 1970s as an attempt to improve wood fuel supply in the rural areas and reduce pressure on the natural forest and woodland resources. Also, planting trees in private woodlots can help address some of the fuel wood problems through getting firewood from the planted trees. Also, planted trees can help to eliminate the burden of collecting firewood far away. The major consumer of trees were found to be households which use trees for cooking (95.4%), rural industries (2.8%) and agriculture (1.4%) Gausset *et al.*, 2007).

According to (Ngaga, 2011), each tree planted in southern regions has its purpose as follows; tree species planted for timber production are mostly exotic species, including pines, cypress and *Grevillea.* However, tree species planted for building, firewood and charcoal production include eucalyptus, black wattle and *Cussonia spp.* and trees planted for shade and water sources protection include *Cussonia*, *Ficus*, *Syzygium*, *Albizia spp.*, and others. Also, people in the southern regions have been planting trees for other purposes, which may include land improvement, hedges and boundary but; in many areas in Tanzania specifically the southern part, pines are the dominant species in most of the government and private plantations with about 78% of the total area planted and the remaining 22% is shared among hardwoods and other softwood species (Ngaga, 2011). Some villages in Iringa region through facilitation by Green Resource Ltd have through carbon markets earned USD 120 000 (Ngaga, 2011).

2.3 Agroforestry Practices

Agroforestry is defined as a land use system in which trees and shrubs are grown together with crops or animals in the same land unit. According to HDRA - the organic organization (2001) and Tolunay (2012) agroforestry is a collective name for land-use system and technologies in which woody perennials are deliberately combined with herbaceous crops and/or animals on the same crops management unit. Some kind of spatial arrangements on temporal sequence are made in such a way that there are both economic and ecological interactions among the different components." Also the potential to arrest land degradation and rural poverty in the dry lands through their service and productive functions. HDRA - the organic organization (2001), considers agroforestry as a broad term for land-use systems where; Woody perennials such as trees, shrubs or bamboos are grown and used in fields and farming landscapes. This can be carried out at the same time as in intercropping systems where trees and crops are grown either together or at different times such as in rotational practices, and whereby also either livestock or crops are introduced as part of forest systems. This describes ways in which crops and trees can be grown together in an attempt to increase productivity and diversity whilst ensuring sustainability.

2.3.1 Agroforestry systems

According to HDRA - the organic organization (2001) and Tolunay (2012), there are many agroforesty practices some of which are divided into three agroforestry systems namely agrisilvicultural Systems (crops-including shrub/-vine/tree crops-and trees) with practices such as Improved fallow,Taungya, Alley cropping, Multilayer tree garden, Multipurpose trees on crop lands, Plantation crop combinations, Home gardens, Trees in soil conservation and reclamation, Trees in soil conservation and reclamation, Shelterbelts and windbreaks as well as Fuelwood production. The second system is Silvopastoral Systems (trees+pastureand/or animals)/or animals) which include; Trees on rangeland or pastures, Protein banks, and Plantation crops with pastures and animals. The third is Agrosilvopastoral Systems (trees+crops+pasture/animals) which include; Home gardens involving animals, multipurpose woody hedgerows, Apiculture with trees Aqua forestry and multipurpose woodlots.

These agroforesty practices are explained bellow

1) Alley cropping: Woody species such as trees, shrubs, bushes, and the like are planted at regular spaced intervals. Agricultural crops can be grown among the woody species which are planted and grown in the area, forming a regularly spaced lines or live fences.

2) Multilayer tree garden: This practice refers to a haphazard planting of woody species such as trees, shrubs, bushes, and the like without a particular pattern and the creation and management of a multilayer tree garden.

3) Multipurpose trees and shrubs on agricultural lands: This practice refers to the growing of trees, which bear fruits and produce fuel/building material wood, within and around agricultural lands where agricultural crops are grown.

4) Home gardens: This practice refers to the production technique whereby land patches which are found in portions of homes in rural areas are used to cultivate fruit trees and vegetable plants in order to meet nutritional needs of the residents and to cultivate woody species to meet other needs (such as wood for fuel and building material, shade, and so forth) and various ornamental plants for aesthetic purposes. It is possible to see examples of cultivation of various woody species such as trees, shrubs, bushes, and the like and agricultural crops as well as livestock husbandry in or around dwellings in the rural areas.

5) Trees in soil conservation and reclamation: This practice involves the planting of trees, shrubs, bushes and so forth on road inclines, sloped terrains and platform borders in order to prevent landslides and soil erosion.

6) Shelterbelts and windbreaks: This method refers to the planting of tree varieties that serve as screens at appropriate areas on agricultural lands or along field edges in order to prevent wind related damages.

7) Trees on rangeland or pastures: This practice refers to the planting of tree species with multipurpose uses (such as those providing building material and fuel, feed leaves, shade, etc.) in a random manner or according to a specific pattern on pastures and rangelands, grazing of animals on rangelands and gathering of herbaceous plants for feed produce.

8) Protein banks: This refers to the cultivation of plants with nutritional feed value. This practice may also be referred to as feed banks.

9) Plantation crops with pastures and animals: This system involves grazing of small and large livestock on plantation land.

10) Multipurpose woody hedgerows: Woody hedgerows have been planted on agricultural terrains in order to provide branches and leaves as feed, for grazing animals and for the protection of land.

11) Apiculture with trees: This production technique involves woody plant species, such as trees, shrubs, bushes which are preferred by bees and produce flowers or pollens. It (the method) involves herbaceous plant varieties that provide feed value and use in apiculture and bee colonies as the animal element.

12) Aqua forestry: This technique involves examples in the region geared toward the cultivation of various water products in water resources such as lakes, brooks, creeks, pools, and the like, and which are present in the forest resources and agricultural lands.

13) Multipurpose woodlots: Examples of this technique include woodlots, village parks, and school woodlots and which are aimed at providing

various needs such as wood, feed, land protection, land gain, and the like, and particularly at providing outdoor recreational uses. This production technique prefers the cultivation of multipurpose woody species that providc wood for building material and fuel, feed leaves and shade. It involves herbaceous plant varieties that have feed value and are edible by animals. The other element of the cultivation system involves domesticated small and large livestock raised for milk and meat. The example for this includes woodlots cultivated particularly for use as outdoor recreational areas in the vicinity of provinces, counties, villages and towns. It is possible to employ farm forestry methods. For example, a family involved in agricultural production, whereby only agricultural products are obtained, can also become involved in the production of various forest and tree products by means of agro forestry applications.

2.3.2 Benefits of agroforestry systems

When land is scarce or when soil has either low fertility or is sensitive to erosion, agroforestry techniques offer considerable benefits for long term agricultural sustainability. Trees and shrubs have an important ecological and economic role in farming systems. According to HDRA - the organic organization (2001), the following benefits were identified as useful in agroforestry:

1. Soil, protecting soils from erosion, increasing nutrients in poor soils and improving the structure of soils to enable it to hold more water.
2. Energy supply, providing cheaper and more accessible fuelwood, producing better quality fuelwood depending on the species planted.

3. Shelter and structure, providing cheaper building materials, protecting animals, crops and humans from wind and sun and providing fencing to protect crops from livestock and wild animals.
4. Plant resources / biodiversity, improving local environmental conditions for naturally occurring plants to grow and maintaining and increasing the number of species of plants.
5. The cash income providing additional or off-season employment, enabling the sale of tree products and providing investments such as orchards, tree products, agro-business and long-term supply of materials for the production of crafts. Agroforestry systems have the potential of providing additional financial and environmental services and benefits beyond timber, livestock, and forage production. One potential application is wildlife habitat creation and conservation banking (Ebodaghe, 2010).

2.3.3 Agroforestry practices at household's level

In many parts of Africa, farmers traditionally practice agroforestry whereby trees are planted in agricultural or silvopastoral systems to provide shade, windbreak, medicines, or to meet household energy needs. Agroforestry production techniques have emerged in underdeveloped countries as traditional methods and the initial classifications of production techniques were made taking these countries into consideration (Tolunay, 2012). Traditional agro-forestry system takes the form of trees scattered on crop fields, woodlots, and homestead tree planting and multi-storey home garden (Eyasu, 2002; HDRA, 2001).

Agroforestry technologies focus on the role of trees on farms and agricultural landscapes to meet economic, social and ecological needs (Garrity, 2006). The 2004 National

Agroforestry Strategy envisions four million rural households adopting and benefiting from agroforestry practices by 2025. The goals of the 2004 National Agroforestry Strategy are that by 2020, agroforestry technologies should be adopted and contribute to improving the livelihoods of 60% of the country's resource-poor households (URT, 2006). This goal complements the National Strategy for Growth and Reduction of Poverty "MKUKUTA", which aims at increasing household income while conserving the environment (UN FAO, 2007). This, together with the recommended change in the national-level MKUKUTA poverty-environment indicator and other measures presented in this report will go some way towards providing data on how forests and other natural resources are contributing to sustaining rural livelihoods and supporting poverty reduction (Winrock International, 2006). It has been demonstrated that agroforestry innovations provide options for reducing poverty, improving food and income security and sustaining environmental quality.

2.3.4 Economic importance of agroforestry practices at household's level

The use of agroforestry technologies mitigate biodiversity loss and provide opportunities for improving diversification and provide a range of livelihood options for rural households (Akinnifesi *et al.,* 2008). The harvesting of woodland products is widely recognized as an integral component of the rural livelihoods throughout the developing world, offering goods for both household consumption and income generation (Kalaba, 2008). The impact of agroforestry in the adoption on livelihoods of farmers in Malawi, Mozambique and Zambia includes an increase in crop yields, an increase in income, increased savings resulting into a change of wealth and soil improvement. Forest products contribute significantly to the national export earnings although the GDP undervalues the contribution of forestry to the national economy (Winrock International, 2006).

Tanzania's economy depends heavily on agriculture, majority around 60 to 80% of Tanzania's adults in rural areas report agriculture as their main economic activity. The sale of agricultural products has been the main source of cash income for 62% of Tanzanian households and provides approximately 50% of the total household income (Winrock International, 2006). Despite the importance of agriculture, particularly in rural areas, some 40% of rural household income is derived from sources outside household on-farm production (URT, 2002). Therefore, integrating trees and shrubs with other enterprises on a farm can create additional sources of income, spread farm labor throughout the year, and increase the productivity of those other enterprises while protecting soil, water and wildlife (Beetz, 2011).

2.4 On farm Indigenous Agroforestry Practices

Land conservation using agroforestry system is the oldest agricultural system and is the least scientifically studied. However many people especially in the rural areas don't have enough knowledge of agroforestry system. O'kting'ati and Shayo, (1998), found out that, the system is operating bellow its potential efficiency and is not spreading fast enough in other potential agro ecological zones. Research in agroforestry is expanding and a special attention is being paid to promoting these techniques (Swinkles and Scherr, 1991).

According to Garrity (2009), there are three main principles for practicing conservation agriculture with trees. First, the soil should be disturbed as little as possible. Second, farmers should aim at keeping the soils covered with organic matter in the form of crops and crops residues which are compatible with crops. Third, rotating and diversifying of the crops, making use of leguminous crops as well as cover crops and trees that generate additional sources of soil fertility replenishment during the off seasonal (Garrity, 2009). Results from a recent study which assessed the financial profitability of five soil fertility management technologies of some agroforestry timber species show that over a five year period, agroforestry-based soil fertility management technology ("fertilizer tree fallows") are more profitable than farmers' practices of continuous maize production without external inputs (Ajayi *et al.*, 2006). However, the success of any tree program must be evaluated in terms of its contribution to satisfying human needs for various types of ecological degradation and excessive woodland cleaning (Kajembe and Wiersum, 1998).

Generally, agroforestry practices are very important in developing countries because they contribute to poverty reduction by improving productivity and providing a significant amount of fuel wood. For instance, fuelwood production in the *Chagga* home gardens of Tanzania is estimated to be 1.5 - 3 m^3 per ha per year. According to Fernandes *et al.* (1984), with a minimum consumption of 1 m^3 per adult per year, each family will require 4-6 m^3 per year which means that a home garden will supply about 25 - 33% of the household's fuelwood requirements per annum. As Ajayi *et al.* (2008) report, biomass transfer offers smallholder farmers the opportunity of supplementing their incomes by growing cash crops that fetch high prices in the urban markets. The value of benefits from individual *ngitili* is higher than that from communal *ngitili,* because households are more inclined to consume goods and services from their own individual *ngitili,* than is the case with communal *ngitili* (Winrock International, 2006). The average production in farmer managed plots is $6.3m^3$/ha/yr as opposed to 0.96 m^3/ha/yr in non managed areas (Malimbwi *et al.*, 2008).

Studies by Akinnifesi *et al.* (2006), Mithöfer and Waibel (2003) indicate that, rural communities can increase their income by utilizing and marketing tree products from forestry crops grown on-farm. Agroforestry practices are significant and potential systems for meeting local firewood demand as well as conserving natural forests because more wood yields will be obtained from farms (Kimaro *et al.*, 2007).

A vigorous tree planting and tree retention habit was found to be an important part of the local farming systems (Bisong *et al.*, 2009). As reported by Bisong *et al.* (2009), more than seventy one (71) tree/shrubs species are either purposely cultivated on farms or retained from the wild in the process of land conversion to agriculture. Therefore when these products are commercialized, trees provide an either an important source of income or an important way of saving expenses since people can access products that they would otherwise have to buy on the market (Gausset *et al.*, 2007).

2.5 The Lesser Known Timber Species

The unknown tree species are termed as lesser-known species. *Manilkara discolor* is one example of Lesser Known Timber Species (LKTS) have more good properties than is the case with known species; this makes a few well known species to be over-exploited unlike the case with unknown valuable tree species which are left in the forests as wastes (Gillah *et al.*, 2009). Some of the lesser known timber species are reserved in farms for various timber uses, but most of the reserved lesser known timber species are underutilized, because information on the quality and quantity of such species is not documented hence not available to users. Unavailability of such information limits not only economical and rational utilization of LKTS, but also market promotion of these species (Lockyer, 1994).

It is likely that some of the lesser-utilized species will become merchantable when something more is known about them. This results into overexploitation of the few well known timber species thereby causing deforestation and environmental degradation. Formally, the selection of tree species to a given use depended on the experience of the user and availability of that tree species (Gillah *et al.*, 2009). Some of the better-known timber species include among others, *Khaya anthotheca, Olea welwitschii, Afzelia quanzensis, Dalbergia melanoxylon, Pterocarpus angolensis, Ocotea usambarensis, Milicia excelsa, Belschmediam kweo, Adina microcephala, Afromorsia angolensis* and *Podocarpus usambarensis, Cephalosphera usambarensis, Juniperus procera, Milletia stuhlmanii, and Brachyleana hutchinsii* (Gillah *et al.*, 2009).

A study by Ishengoma *et al.* (1997) shows that, younger trees of the well known species with inferior properties are cut to temporarily meet the market demand.This could reduce pressure on better-known species (Gillah *et al.*, 2008). If the technical properties of lesser-known species are known and found to be suitable for different uses, and if, through promotion, the properties and uses of such species are brought to the attention of different users, they (lesser-known species) can replace or substitute some of the primary well known timber species which are threatened by over exploitation, and leading to the expansion of timber market as a result (Gillah *et al.*, 2005). In most cases, such species remain in the forest as waste after creaming operations (Ishengoma *et al.*, 2004 in Gillah *et al.*, 2009). Studies by Ishengoma *et al.* (2004) and Gillah *et al.* (2004) on determining the properties of some LKTS were reported to have contributed to getting some of the LKTS into the market. In order for lesser known and underutilized species to penetrate the domestic market, information on the quality and quantity of such species must be known and promoted.

2.5.1 Factors influencing the use of timber species

Wood is among the valuable products which are obtained from the forest, and which when used appropriately, has a very high value. Wood can also be used in many forms for a long time; furthermore wood is a single, but wonderful material that can be used in either raw form or processed into a number of products. It (wood) can be used in a round form, split, sawn into lumber, sliced into veneer, chipped into particles, broken into fibers, ground into flour and broken down into a number of chemicals (Gillah *et al.*, 2009). According to Bryce (1967), the selection of timber for specific use depends on four factors namely technical performance, the cost, the size and availability. However, factors such as the price, availability in large quantities and uniformity of appearance from one consignment to another are responsible for the selection of one or two species out of a great many which would be suitable technically (Gillah *et al.*, 2009). According to Gillah *et al.*, (2008), the utilization is only concentrated on a few of these species. But few well-known timber species are already scarce if not depleted and that some of the lesser known and lesser-utilized timber species will likely become merchantable when more is known about them (Gillah *et al.*, 2008). Knowing the basic physical and mechanical properties of this species and the provision of this information to timber stakeholders may help reducing the scarcity of timber, relieving pressure on the traditional timber species and therefore promoting their regeneration and reducing poverty through the increased market value of some of the LKTS (Gillah *et al.*, 2009). Makonda *et al.* (2008) compared wood properties of LKTS with other well known and utilized tree species, to see if LKTS can be used to substitute some of these well known and utilized tree species, with the aim of giving out recommendations on the efficient use of LKTS. Therefore, research on some lesser-known timber tree species could provide good technical knowledge leading to the utilization of such species by majority and hence substituting the suitable fewer well known and over exploited ones (Gillah *et al.*, 2007).

2.5.2 Economic potential of LKTS

The promotion of lesser known and lesser utilized tropical hard wood timber species for commercial utilization as structural and furniture timber is important and will in the long term be of interest to both timber producing and consuming countries in terms of seeking new ways of reducing pressure on the already degraded forests (Gymfi and Breese, 1994 in Ishengoma *et al.*, 2000). If lesser-known timber could be utilized as noted by Ishengoma *et al.* (2000), a great volume of timber could be available for quality utilization or export since a few known species are already scarce if not depleted.

2.6 The Contribution of Forests and Agroforestry Practices to Livelihoods and the National Economy

Forests are important assets in Tanzania offering numerous goods and services to local communities and a Tanzanian society in general. Forests and woodlands are recognized as an important resource base for Tanzania's social and economic development and for the provision of many basic benefits and opportunities to rural and urban communities (Mariki, 2001). According to Salmi and Monela (2000), the official contribution of the forestry sector to the national economy is between 2 and 3 percent of the total GDP.

The values of forest goods and services is often underestimated or entirely omitted, and this includes non marketed timber, non-timber forest products and forest products which are harvested illegally (Winrock International, 2006). The estimated amount of fuel wood alone is more than 30 million cubic meters per year (MNRT, 2001). Forest products contribute significantly to the national export earnings; however, the net exports in forest products fluctuated greatly from mid to late 1990s and ranged from US$2.5 to US$14.1 million. The main forest products are timber, carvings, tree seeds, and bee products; however, in the national accounting systems, revenue from forestry sector is aggregated and summarized under fisheries, livestock and other agricultural crops. As a result, the GDP also undervalues the contribution of forestry to the national economy (Winrock, International, 2006). Specifically, the estimated value of benefits from *ngitili* in Shinyanga is US$14 per person per month. This value is significantly higher than the value of the rural Tanzania's average per person of a monthly spending of US$8.50 (Monela and others 2005). This indicates that households could benefit more by concentrating on the production of goods and services from *ngitili* that yield high direct values to household and village economies to maximize benefits (Winrock International, 2006). Several studies indicate that rural communities can increase their incomes by utilizing and marketing tree products from forests and horticultural tree crops grown on-farm (Campbell, 2000; Akinnifesi *et al.*, 2006; Mithofer, 2003; Schreckenberg *et al.*, 2006).

2.7 Woodlots

2.7.1 An overview of woodlots

Tree farming activities in most villages in Tanzania is carried out as a result of individual farmers' initiatives, and the species grown for commercial purposes include pines, especially *Pinus patula*, cypress, eucalyptus, some grevillea and black wattle (Ngaga, 2011). Woodlots have long played an important role in the development of households. In the United States, woodlots provided wood for shelter, warmth, and cooking and they (woodlots) served as habitat for forest wildlife that provided sustenance to early settlers (Ebodaghe, 2010). A study by Singunda (2009) shows that 35% of family tree growers in Mufindi district are new (less than 8 years of engagement in tree planting), most of whom have been attracted by the growing demand for wood raw materials.

2.7.2 Importance of woodlots

In many areas in the world, woodlots of today provide much more for their owners, including income from selling wood and non-wood products, forest-based income opportunities such as lease hunting and recreation, solitude and escape from emotional pressures and stress of modern living and working, and lastly, it is a pride to own and care for the land (Ebodaghe, 2010). Tree farming is reportedly ranked as a 2^{nd} or 3^{rd} economic activity by most of the participant farmers in Iringa region (Ngaga, 2011). The advantages of considering a woodlot as part of the total farm plan pays off in terms of added income, increased land value over time, increased wildlife and recreational value, and increased pride of ownership that strengthens the bond between generations (Hall, 2012). The efforts of promoting private forest plantations should continue to meet the growing demand for wood materials (Ngaga, 2011).

CHAPTER THREE

3.0 MATERIALS AND METHODS

3.1 Description of the Study Area

3.1.1 Location

Kilosa District Council is one of the seven districts of Morogoro Region. It is located in the Eastern central Tanzania in about 300 km west of Dar es Salaam and between latitude 5°55' and 7°53' South and longitudes 36°30' and 37°30 East. Kilosa shares borders with Mvomero district to the East, Kilombero and Kilolo Districts to the South, Kiteto (Manyara region) and Kilindi (Tanga region) to the North; and Mpwapwa District (Dodoma Region) to the West (URT, 2010).

The district is comprised of 8 administrative divisions, which are in turn subdivided into 39 wards and 134 registered villages. Major settlements are Kimamba, Mikumi, Ruaha and Dumila. Kilosa District has two parliamentary constituencies which are Kilosa and Mikumi. The total land area in this district is 12 662 square kilometers of which only about 9 817 square kilometers are habitable and the rest are occupied by national parks (URT, 2010). Out of this land area only about 536 590 hectares is suitable for agriculture (URT, 2010). This study was undertaken in four villages namely Rudewa Gongoni, Ulaya Kibaoni, Madudu and Mabana.

This study was conducted in four villages namely Madudu, Mabana, Rudewa Gongoni and Ulaya Kibaoni. The villages are within the three divisions. Madudu and Mabana villges are located at Dumila division; Rudewa Gongoni located in Kimamba Division and Ulaya Kibaoni village is located at Ulaya Division. The selection of these villages was based on the fact that farmers in the study villages have purposely conserved/planted indigenous timber species in their farms for timber production.

3.1.2 Topography

The district topography ranges in the central and southern flood plains of the Wami, Mkata and Ruaha rivers which stand at 400 m in elevation, while the cultivation steppe in the north around Gairo reaches 1100 m. The highest parts of the district are found in the Ukaguru, Rubeho and Vindunda mountains, which form an almost continuous north-south spine along the western side of the district and reach an elevation of 2200 m. The district is divided into three physio-geographic units, which also constitute different agro-ecological zones (URT, 2010).

3.1.3 Climate

The climatic condition of the district varies depending on the agro-ecological zones. The highest parts of the district, which is found in the Rubeho and Vidunda Mountains, and which is 2 200 m above the sea level, gets annual rainfall of between 1000 mm – 1600 mm. The district is characterized by moderately fertile well drained soil, which comprises sandy (clay) loam soil. The central and southern parts experience an average rainfall of 800 mm – 1400 mm with poorly drained black clay and loamy soils which are suitable for maize, paddy, sisal, sugarcane, and onion cultivation. Normally short rains start in October to December and long rains start in February and continue to May. The annual temperature is typically between 25°C -30°C (URT, 2010).

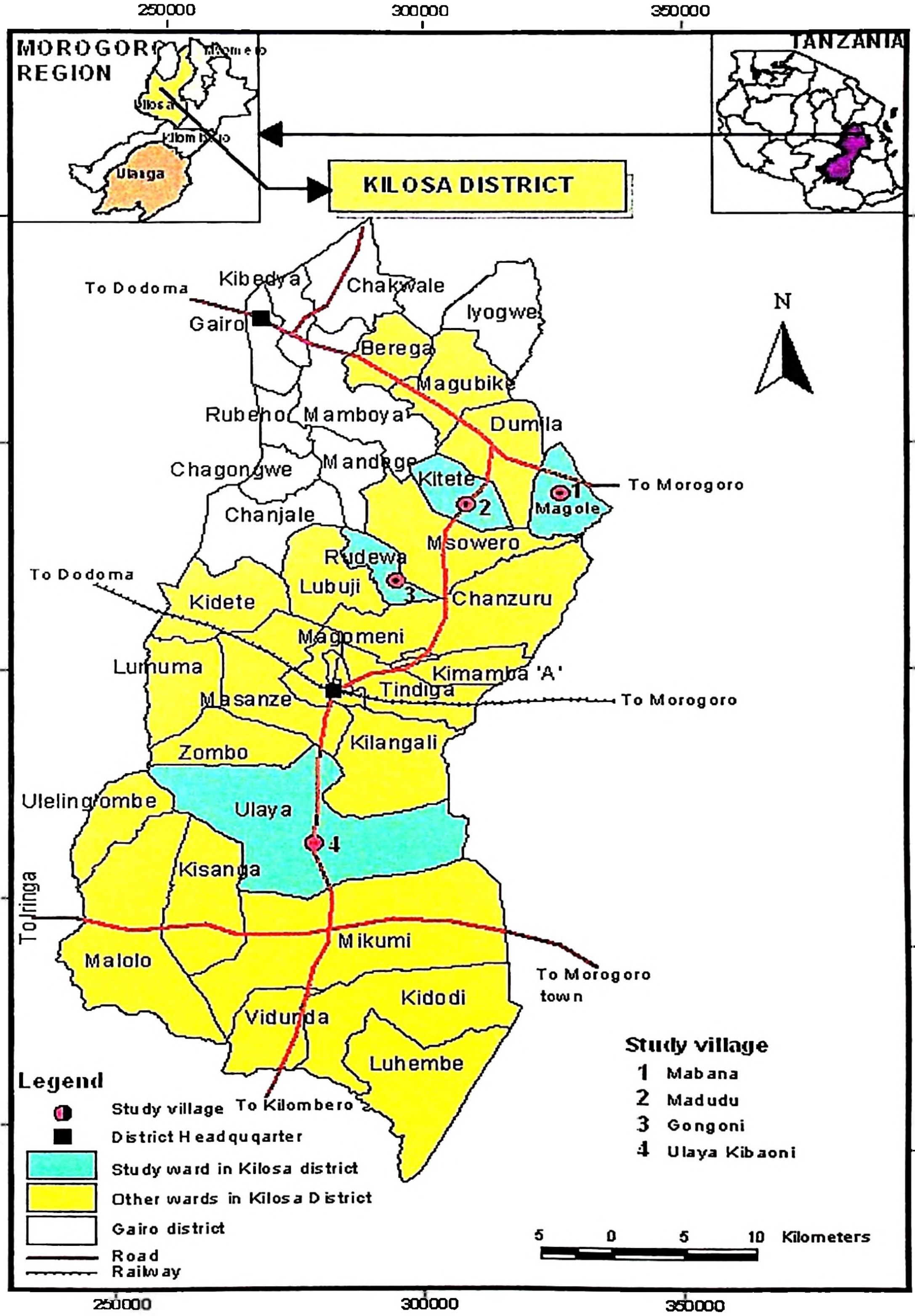

Figure 1: Map of Kilosa District showing study villages and other bordering villages

3.2 Sampling Procedures

The study used both quantitative and qualitative methods to gather data with an extensive use of focus group discussion and key informants interviews. Data were collected at a single point in time from the selected sample of respondents to represent the population. A sampling unit for this study was a household. According to the World Bank (1986), a household is defined as " A unit consisting of one or more persons related or unrelated who live together in one part or of more than housing/dwelling and have common catering arrangement''. This approach was adopted to enable gathering of data at households. Both purposive and random sampling procedures were used to select households for primary data collection. The selected four villages were sampled purposively based on conserving LK IAGTS in their households' farms and planting hardwood woodlots timber trees in Kilosa District. The sampling frames were 856 households for Mabana, 354 households for Madudu, 950 households for Rudewa Gongoni and 826 households for Ulaya Kibaoni (Table 1). Thirty (30) households in each village were randomly interviewed. According to Bailey (1994), a sub sample size of 30 from one observation unit is considered adequate provided that characteristics of the study population were well excluded. To make sure that the number of households for interviews in each village is not less than 30, different random samples were selected (Table 1) to represent the village population. The study involved a total of 120 respondents (Table 1).

A total of 120 sampled farms and woodlots (in ha) in the sampled households were randomly selected and measured. The size of agroforestry farms/woodlots were different from one village to another depending on the population and village size (Appendix 7).

Table 1: Demographic profile and sample intensity of the survey villages

Ward	Village	Village populations	Village H/H	Household interviewed
Rudewa	Rudewa Gongoni	4 106	950	30 (3%)
Magole	Mabana	3 049	856	30 (4%)
Kitete	Madudu	1 764	354	30(9%)
Ulaya	Ulaya Kibaoni	3 796	826	30 (4%)
Total		**12 715**	**2 986**	**120 (20%)**

3.3 Data Collection Methods

Both primary and secondary data were collected. In this study, three days pre-testing was done to test the fitness of the questionnaires at Madudu village where some questions relating to income obtained from LK IAGTS/woodlots were changed to capture specific objectives. The data were collected from November to January 2013.

3.3.1 Estimation of volume in household farms and woodlots

This survey was conducted using inventory techniques to obtain data for volume estimation in household farms/woodlots. All timber trees with Diameter at Breast Height (DBH) above 10cm (utilizable poles) within each sampled farms/woodlots were measured and recorded for diameter at breast height for volume determination (Appendix 6). The heights for all tree sizes were measured. The aim was to estimate standing volume of the selected five LKTS in agroforestry farms and woodlots in the study area. The main purposes for conserving or planting indigenous agroforestry trees in farms was established with the aid of local people knowledgeable with ethinobotany and aspect of timber and wood utilization in the study areas.

In this study, individual trees with DBH 1 to <15 cm are defined as small tree for poles, while > 15 cm are tree for charcoal and timber depending on species and proximity of sawing platform or charcoal kiln (Government Notice No 429, 2011). Some other information obtained during inventory was farming systems practiced in the study area, the type of crops preferred to be mixed with these indigenous timber trees and the social and economic benefits obtained from conserved timber trees and woodlots.

3.3.2 Social-economic survey

The main tools used to collect data for social economic information were Participatory Rural Appraisal (PRA) approaches and questionnaire survey methods (Appendix 1). The survey aimed at collecting information concerning the number of trees and the volume of indigenous agroforestry timber species conserved in the farms and woodlots per unit area, and social-economic values of the selected five LK IAGTS at household level in the study area and their economic profitability for timber production.

3.3. 2.1 Questionnaire survey

Information was collected at households' level. In the survey, information about standing timber in the farms and woodlots was collected from farmers in the study area. Structured questionnaires with both close and open-ended questions were used. The data were purposely collected for preferred indigenous/hardwoods agroforestry timber species conserved in the farms and planted woodlots by households. The types of information gathered from the sampled households included socio-economic data which included household economic activities, farm sizes, agroforestry practices and the types of crops farmed and crop yields in the agroforestry farms, income earned from LK IAGTS per year per household and the costs involved in timber production. Some other types of information included household characteristics example personal detailed of respondents like education level, agroforestry practices, deforestation and forest degradation.

3.3.2.2 Focus group discussion

Focus Group Discussions (FGDs) were conducted with the village leaders where by a checklist (Appendix 2) was used to guide the discussions. In this study, the members of the focus group involved village government leaders (Chairperson and the Village Executive Officer (VEO), Village Natural Resources Committee (VNRC) members and other environmental related groups as well as groups concerned with tree planting and nursery establishment. A total of 15 participants in each of the four villages of Rudewa Gongoni, Mabana, Madudu and Ulaya Kibaoni participated in the FGD. Stratified random sampling procedures were adopted aiming at including groups of people with different economic status, power in decision-making, gender, education level, experiences, perceptions, attitude and the farmers practicing agroforesty in the study areas. FGD provided information which supplemented the data obtained through questionnaire survey, and which specifically related to the conservation of LK IAGTS and planting woodlots at household level.

3.3.2.3 Interviewing key informants

Both formal and informal interviews were conducted with representatives of the four village officials from each of the four villages, five carpenters, five timber sawyers and five charcoal burners in each village. Participants involved here included government officials in the forestry sectors such as District Natural Resources Officer (DNRO), District Forest Officer (DFO), Non Governmental Organizations (NGOs) namely Morogoro Environmental Conservation Organization (MOECO) and Eastern Arc Mountains Environmental Management which were working in the area in a pilot project and are still working in the study. These informants helped the researcher to obtain more information on reserving and planting trees, their prices and profitability at household's level in the study area. The information collected included activities in the communities, timber trees available and the preferred agroforestry practiced in the household's farms and indigenous agroforestry trees in the study areas (Appendix 3).

3.3.2.4 Participant observation

This method involved actual observations made by the researcher during the field visits. Documentation by the use of visual aids such as digital camera helped to take photographs as evidence of availability and distribution of timber trees in the household's farms, the preferred mixed crops with these timber trees and other related activities happening in the study area.

3.3.3 Determination of economic value

To determine the economic value of identified timber species special form (Appendix 1) was used to guide a researcher in obtaining important information like values of timber, quantity (timber products per tree), prices of timber products in study areas and type of timber products obtained in IAGTS (in farms) and planted hardwood (in woodlots) timber trees per tree species per households in study areas. The volume/amount of timber products obtained was multiplied by the respective prices in the local area to get the potential total income per household (as household economic value) in TZS/M^3 or per piece of timber or per bag of charcoal (Appendix 16).

3.3.4 Secondary data

Secondary data were collected from different past research records and reports available from various sources (District Forest and Agricultural Offices of Kilosa, environmental NGOs (eg. MOECO) which had undertaken different conservation activities in the study areas and Tanzania Tree Seed Agency (TTSA). Published materials including journals and books were obtained from Sokoine University of Agriculture National Library (SNAL) and online web resources.

3.4 Data Analysis

3.4.1 Estimation of standing volume of timber trees

Standing volume of both conserved trees in farms and woodlots in the sampled households was obtained using volume determination model for miombo woodland developed by Malimbwi *et al.* (1994 cited by Luoga *et al.*, 2002). The volume equation was used to compute volumes of single trees for sampled trees in the surveyed areas. This equation was chosen because the vegetation type in the study area is also miombo woodland. The volume was calculated from stems DBH (1.3 m) for all the trees in each single standing tree. The formula below was used to compute volumes of single trees;

$$V = 0.0001D^{2.032}H^{0.66} \quad \text{..........} \quad (1)$$

Where, V – Volume in m^3

D – Diameter at breast height (dbh) in cm

H – Tree height (h) in m

The measured tree diameter at breast height (cm) and trees heights (in m) were then used to calculate the volume of a single tree. The single tree volume was computed by multiplying the diameter at breast height and the height of each tree measured to get the total volume per tree. The average amount of volume and number of trees obtained per farm or per woodlots were then estimated as the total volume of timber trees or number of trees obtained per household.

3.4.2 Socio-economic data analysis

Both quantitative and qualitative data analysis methods were used to analyze data collected using questionnaires. The statistical Package for Social Sciences (SPSS) was used for analyzing the social economic data in the study area in improving the livelihoods of the community in the household's level.

3.4.2.1 Structured questionnaires

The data collected by questionnaires were analyzed using the Statistical Package for Social Sciences (SPSS) a computer software package and the excel computer program. The questions were first coded and the data were computed. Descriptive statistical analysis was used in the analysis of socio-economic characteristics of the study area in which the results were presented into frequencies, percentages, and cross tabulation.

Data on average total incomes from crops per hectare per households in the study villages were obtained by adding all the annual crops harvests from the sampled households captured in the questionnaires during survey. Then each crop was multiplied by its respective prices to get the total income. The total annual incomes from crops were divided by the number of the households interviewed in each village to get the average total crops income per hectare per household.

3.4.2.2 Participatory Rural Appraisal data

The data from PRA were analyzed with the assistance of the local communities representative right in the field and the information obtained was immediately communicated back to them. Pair wise ranking was used to identify preferences on whether IAGTS and planted woodlots which are more preferred and economically viable to the households in the study area.

3.4.2.3 Qualitative analysis

The components of verbal discussion collected through PRA were analyzed. The record conventions with the respondents were broken down into the smallest meaningful units of information to ascertain values and attitudes of the respondents. This information was then used to supplement the results from the household questionnaires.

3.4.3 Economic value of timber trees

To determine the economic values of identified timber species the volume of timber obtained was multiplied by the respective prices in the local market to get the potential total income per household and which could be obtained by selling timber from conserved indigenous agroforestry timber trees in the farms and woodlots. Thereafter, the computed volume and the estimated number of trees per farm/woodlot per households were multiplied by the suggested prices of volume of single tree to get the economic value of the IAGTS and the selected LKTS estimated per farm and woodlot per household.

The formula bellow was used,

$$TEV = V*P \quad \ldots\ldots\ldots\ldots\ldots\ldots \quad (2)$$

Where by, TEV = Total Economic Value (TZS/m^3)

V = Volume (m^3)

P = Price per m^3

3.4.4 Quantitative analysis

The average retail price of timber products per tree, a piece of timber and m^3 in the villages of the study area was calculated by dividing the mean timber price. The average retail price was used to find the annual income of timber harvested from both conserved trees in farms and planted hardwood woodlots as timber products per farm per household in the study area.

The formula used was,

$$Arp = Av/Mtp \quad \text{......} \quad (3)$$

Where by,

Arp = Average retail price (TZS.)

Av = Average price (TZS.)

Mtp = Mean timber price (TZS.)

3.5 Estimation of Economic Profitability in Household Farms and Woodlots

To estimate the economic profitability of indigenous agroforestry timber species in the study area, Microsoft Excel computer program was used to analyze the economic data so as to obtain the net annual profit and then the NPV. The aim was to calculate potential profitability for each agroforestry timber specie grown in the woodlots or the conserved trees in the farms in order to know their economic profitability for timber and charcoal production. The profitability analysis was calculated using Cost Benefit Analysis (CBA) measured by using Net Present Value (NPV) criteria.

This considers all the establishment/retention costs and all the costs and revenue over the lifetime (for this study it was an average of 22 years for the conserved trees and 19 years for woodlots) of the production systems according to experience and information obtained from villagers. All labour was valued at the local market wage and outputs valued by farm-level prices. The returns of timber products in the households were calculated as the present discounted value of net profits that a household would expect to earn from the conserved and planted hardwood woodlots when harvested. The discount rate can be equated to the cost of borrowing money. The interest rate on loans (often between 5 and 10% annually) is a useful proxy (White and Minang, 2011). A 22 year and 19 years as time horizon for conserved LK IAGTS and planted hardwood woodlot respectively was used on the assumption that the households would sell trees at that age and earn money which would improve their livelihood. Although agricultural loans are rarely available especially in remote forest margin regions, bank interest rates do serve as a good indicator of the time value of money (White and Minang, 2011).

The analysis used a discount rate of 10%. For discount rates, NPV analyses typically use loan interest rates which are set by National Bank or the Government. Such rates can range from 10 to 30%. The net profit obtained by subtracting the total costs from the total revenue for each item was discounted and summed to produce n estimates of the net present value (NPV).

The value of NPV was calculated using the formula below:

$$NPV = \sum_{1=t}^{T} \frac{\Pi_t}{(1+r)^i} \quad \text{(4)}$$

Where t = time in year, T = length of time horizon in years, Π_t = net annual profits in Tanzanian Shillings and r = discount rate. The major assumptions to be made at the stage of NPV calculation were the discount rate (r) and the time horizon (T). The costs and benefits considered were seedlings costs, labour costs and administrative costs. Thereafter, the computed NPV was used to determine which option is profitable in order to maximize profit of indigenous agroforestry timber species at the household level. The assumption was that farmers would sell their trees as full trees to pit sawyers; the revenue obtained from the sales of trees was used in the analysis. The price of standing trees given by farmers during survey was used as the market price for trees.

3.6 Limitations of the Study

During the study some difficulties were encountered, these include:

i. Majority of the respondents in the study area were very poor in estimating their farm sizes and record keeping. It was a problem for them to remember their total yields they get per hectare per year. However, the problem was solved by requesting and giving them sufficient time to remember their approximate yield figures and approximate estimates of their farm sizes.

ii. Some respondents were not very much open to the questions pertaining to IAGTS establishment, harvesting and income obtained from them because more timber products were not obtained from households farms or woodlots instead some of these products were harvested illegally from the reserved forests. Thus, the respondents thought that the research would report to the authorities some information about illegal harvesting of natural timber trees in the reserved forests.

iii. Some people were reluctant to respond to the questions because large amount (quantity) of timber they are using including selling is not from their conserved farms as IAGTS products but mostly found in forest reserve illegally.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSIONS

4.1 Household Socio-economic Characteristics

It is considered that the social-economic activities of the respective population in the study villages can influence the LK IAGTS practices and establishment of hardwood woodlots in study areas. The discussion in this section covers age, gender, marital status, household's size, household's farm size and education level of the respondents (head of the households).

4.1.1 Respondent's age, gender and marital status

The social economic characteristics of the respondents regarding to age, gender and marital status are summarized in Table 2. The age of the farmers interviewed ranged from 18 years to above 60 years. The middle age group (between 36 and 60 years) was the most dominant in all the villages (50.8%). This implied that most of the agroforestry adopters were at the active age. This is the potential group who could be involved in the dissemination of agroforestry practices in communities as they are likely to easily adopt new technologies (Table 2). Similar findings are reported by Boateng (2008) who observed that younger farmers are more likely to adopt a new technology or perhaps they have been exposed to new ideas as migrant laborers. Old people above 60 years composed 26 respondents (21.6%) but young people below 18 years were not involved because are not the head of households.

Table 2: Characteristics of respondents in the study villages (n=120)

Characteristics	R.Gongoni % (No.)	Mabana % (No.)	Madudu % (No.)	Ulaya Kibaoni % (No.)	Total % (No.)
Age					
18-35 years	16.7 (5)	50 (15)	6.7 (02)	33.3(10)	27.5 (33)
36-60 years	56.7(17)	43.3 (13)	53.3(16)	63.3(19)	50.8(61)
Above 60 years	26.7(8)	6.7 (2)	40(12)	3.3(01)	21.7(26)
Sub total	(30)	100 (30)	100(30)	100(30)	100(120)
Gender					
Male	66.6(20)	90 (27)	90(27)	83.3(25)	57.5(69)
Female	33. 3(10)	10 (3)	10(3)	16.7(05)	42.5(51)
Sub total	(30)	100 (30)	100(30)	100(30)	100(120)
Marital status					
Single	16.7(5)	26 (8)	3.33(01)	20(06)	16.7(20)
Married	66.7(20)	73.3(22)	93.3(28)	70(21)	75.8(91)
Divorced	3.3(1)	0(0)	3.3(01)	6.7(02)	3.3(04)
Widower	13.3(4)	0(0)	0(00)	3.3(01)	4.2(05)
Sub total	100(30)	100(30)	100(30)	100(30)	100(120)
Education level of head of households					
None educated	0 (0)	0(0)	20(06)	0(00)	6.7(08)
Primary	90(27)	76.7(23)	73.3(22)	93.3(28)	83.3(100)
Secondary	0(0)	13.3(4)	0(00)	3. 3(01)	4.2(05)
College	10(3)	10(3)	6.7(02)	3. 3(01)	5.8(07)
Sub total	100(30)	100(30)	100(30)	100(30)	100 (120)
Household size					
Below 5 people	43(13)	63(19)	47(14)	33(10)	47(56)
5-9 people	47(14)	37(11)	40(12)	67(20)	48(57)
10-14 people	10(03)	00(00)	13(04)	00(00)	06(07)
Above 15 people	00(00)	00(00)	00(00)	00(00)	00(00)
Land size					
Landless family	17 (05)	63(19)	00(000	00(00)	20(24)
Less than 2 hectares	07(02)	03(01)	00(00)	03(01)	24.2(29)
2-8 hectors	50(15)	30(09)	40(12)	43(13)	48.3(58)
8-14 hectors	13(04)	00(00)	37(11)	33(10)	6.7(08)
More than 15 hectors	13(04)	03(01)	23(07)	20(06)	0.8(01)

About 58% and 43% of the total respondents were males and females respectively (Table 2). This implied that men are the majority as household heads. This is consistent with the typical traditional African societies where the majority of households are male headed (Luoga, 1994). With regards to gender at the village level, about 67%, 90%, 90% and 83% of the total respondents at Rudewa Gongoni, Mabana, Madudu and Ulaya Kibaoni villages respectively were males.

It is because of this gender distribution, most of the households in the study villages are headed by men while female headed households were for unmarried and divorced women (Table 2). The uncounted women household heads during the survey were either separated or single 16.7%, widow 4.2% and divorced 3.3% (Table 2). This means that, men as heads of households have significant influence on the implementation of LK IAGTS and planting hardwood woodlots at a household level.

4.1.2 Respondents educational level

The level of education of heads of households was generally high. About 83% of the household heads had attained primary education, 4.2% had secondary education and 5.8% had college education while 6.7% of household heads had no any formal education (Table 2). Since the heads of households are the decision makers in the family, education level can influence decision making process in the family including tree planting (Table 2). Education is among the important factors for making various decisions in life. As NBS (2007) observed, farmers who are knowledgeable are more likely to adopt new interventions compared to those who are not knowledgeable. Education is considered to be one of the strongest determinants of household income and has a big bearing on household decisions made by household heads (NBS, 2007). From these findings, one could say that after completing primary education most rural children usually remain in the villages and take up farming activities, while those who finish education above primary school level tend to migrate to urban areas to look for jobs. Therefore, the low level (4.2%) (Table 2) of secondary education observed in this study could negatively influence behaviors in planting, conserving LK IAGTS and establishment of hardwood timber trees in woodlots for their survival. This could also contribute to the acceptance of agroforestry innovations. As Boateng (2008) observed, education is an important socio economic variable that may make a farmer more receptive to advice from an extension agency or more able to deal with technical recommendations that require certain level of literacy.

4.1.3 Household size and farm sizes

The mean households' size was 4 persons with an average of less than 5 persons per household (Table 2). According to National Population and Housing Census of 2013, the mean household size in Kilosa District was reported to be 4.2 persons. The household size obtained in this study is within the reported range. Household size is one of the important factors of production including agricultural activities such as agroforestry practices and planting woodlots at the household level using the available household labour power.

The majority of households (48%) had land sizes ranging from 2-8 hectares (Table 2). Some households own land less than 2.0 hectares (24.2%). Few households (6.7%) own land ranging from 8 – 14 hectares (Table 2). Households having more than 15 hectors were (0.8%) and 24 (20%) were landless households found in Mabana and Rudewa Gongoni villages with 19 (63%) and 05 (17%) households respectively (Table 2). This amounted to 20% of the total sampled landless houses, land size and land ownership at the household level in study areas is one of the most influential factors in agroforestry practices. The majority (48.3%) of the households owned large land for meeting the demands of land for cultivating food crops; while conserving indigenous timber trees as LK IAGTS but some have planted trees in woodlot in the remaining land. A small farm size can be an obstacle to farm improvement, because it is difficult for smallholder farmers to expand their farms. The findings are supported by Hosny (2004) and Boateng's (2008) who observed that small farm sizes is an obstacle to farm improvement since it does not enable farmers to take advantage of economies of scale in production. Similar observations are made by Kajembe and Luoga (1996), Kajembe *et al.* (2000), and Aalbaek

(2000) who reported that the size of land holding has a very strong positive effect on tree planting.

4.3 Timber Species and Quantity in Farms

4.3.1 Major timber species

4.3.1.1 Number of trees

Farmers were found to have planted and conserved hardwood trees, with an average of 34 different timber species (Appendix 5). In the planted farms, farmers (households) had woodlots of hardwood trees planted in household's land for timber production in Madudu village (Appendix 6). The most preferred planted trees in the woodlots were *Khaya anthotheca* (36.8%), *Cedrella odorata* (27.7%), *Milicia excelsa* (18.2%) and *Tectona grandis* (7.9%) as dominant species, and most of these trees were used for timber production (Appendix 5). However Ulaya Kibaoni, Rudewa Gongoni and Mabana villages conserved indigenous timber trees mixed with their food crops for various purposes. Similar finding was reported by Makonda *et al.* (2008) who said that in Tanzania, some LKTS for example *Albizia schimperiana* found in Kilimanjaro region is kept in the agroforestry systems as a shade tree for coffee. In this study, the results showed that dominant trees which are found conserved in agricultural farms were *Pterocarpus angolensis* (0.5%), *Combretum adenogonium* (0.3%), *Lannea schimperi* (0.3%), *Pterocarpus tinctorius* (0.3%), *Vitex keniensis* (0.2%) and *Acacia nigrescens* (0.2%) (Appendix 5). Since among the conserved trees in agricultural farms are LKTS, if farmers are supported with seeds and seedlings from IAGTS and plant in their agricultural farms following agroforestry practice, they (farmers) can earn some money through harvesting timber trees and reduce pressure on reserved forests. The main promotional method was to supply villages with seedlings that produced and delivered in different areas and with the support of a number of Rural Development Projects (Nduwamungu *et al.*, 2008). Farmers should therefore be advised on good management practices geared towards production of suitable timber and which is compatible with other agro-forestry components (Makonda *et al.*, 2008).

There were variations in the distribution of trees in the farms with conserved agroforestry timber species may be due to types of crops grown in the land, different economic activities, variation of prices of timber products in study areas, this may be attributed to different economic activities of the households in their villages. According to Paul, (2011) the capacity of plantation projects to reduce pressure on natural forests depends on people's socio economic activities. Also, a wide distribution of these species may be attributed to natural climatic conditions which favor the growth of these species, high survival of seedlings and or high demand (economic important) of trees for timber and charcoal production. As explained by Winrock International (2006), the degree of economic contribution of *ngitili* also varies across districts; districts with better tree stocks due to a better climate have a higher value of economic benefit. Therefore, if these quantities of tree products which are obtained in the household farms and woodlots optimize their production and utilization at a household level, the life standard of farmers is likely to improve through sales of tree products especially timber. According to Makonda *et al.* (2008), the greater use of the lesser-known species of commercial importance adds to the benefit of consumer as well as that of the nation as a whole. Also farmers will get other multiple benefits for households' consumption such as firewood, addition of nutrients in the farms due to decomposition of leaves and other Non Timber Forest Products (NTFP). According to Jama *et al.* (2006), trees in the crop fields are used for the production of some valuable products such as fuelwood, charcoal, construction materials and fodder for livestock. Trees also provide other services such as improving soil fertility, conserving soil moisture and improving micro-climate., resulting into increased crop yields.

Therefore, if well managed, trees on the farms and woodlots for timber products from indigenous or hardwood trees which are found in the households' farms produce the same quantities and qualities of timber products obtained from natural forests; and the households are likely to obtain income from the LK IAGTS. Under proper management, the timbers can be harvested for sustainable utilization so as to reduce poverty as well as conserve the forests by diversifying the timber harvestable species (Gillah *et al.*, 2009). As Bisong *et al.* (2009) reported, the weigh/volume and income from harvested forest products of priority species derived from farm and forest lands at household level compares favorably with those of the same products harvested from forest lands. Hence, the income which is derived from harvested forest products from agricultural lands compares favorably with the same products harvested from forestlands (Bisong *et al.*, 2009). The report from Winrock International, (2006), despite the importance of agriculture, particularly in rural areas, some 40 percent of rural household income is derived from sources outside household on-farm production (Winrock International, 2006).

4.3.1.2 Tree volume

The total volume of timber trees obtained in the surveyed area was 1114 m^3 (Appendix 5). The total volume per tree species (m^3) obtained in the surveyed areas were *Khaya anthotheca* 251.6 m^3 (22.6%), *Cedrella odorata* 194 m^3 (17.4%), *Milicia excelsa* 170.7 m^3 (15.3%), *Tectona grandis* 228.7 m^3 (20.5%), *Pterocarpus angolensis* 41.5 m^3 (3.7%), *Combretum adenogonium* 8.4 m^3(0.8%), *Lannea schimperi* 17 m^3 (1.5%), *Pterocarpus tinctorius* 16 m^3 (1.4%), *Vitex keniensis* 20.9 m^3 (1.9%), and *Acacia nigrescens* 12

m^3(1.1%) (Appendix 5). Therefore, if the volume which is obtained from the farms as agroforestry timber or hardwood woodlot timber products is harvested and or sold as standing tree/volume, household income would be raised and pressure on reserved forests would significantly be reduced. As explained by Paul, (2011), plantations have to provide direct pecuniary benefits to rural households in order to divert pressures from natural forests. Some conserved trees in the farms were found to have high average volume of above one m^3 per tree for example *Pterocarpus angolensis* (1.1m^3), *Vitex keniensis* (1.2 m^3) and *Pericopsis angolensis* (1.3 m^3) (Appendix 5). However, most of the conserved trees are known while others are lesser known to users. The lesser known timber species are less profitable in the households when sold due to insufficient information on their economic potential and their timber properties. According to Makonda *et al.* (2008) and Gillah *et al.* (2009), these are known as lesser-known species with large number of timber species that are currently less known by users and are largely under-utilized due to lack of information on their physical and mechanical properties and therefore not easily acceptable in the local and export markets.

4.3.2 Contribution of Lesser known timber species

4.3.2.1 Number of trees

The contribution of selected LKTS in the farms was 21% of the total trees conserved (Table 3). Dominant LKTS conserved in the surveyed farms were *Combretum adenogonium* (33.3%), *Lannea schimperi* (28%), *Vitex keniensis* (22.7%), *Lonchocarpus capassa* (13.3%) and *Pseudolachnostylis maprouneifolia* (2.7%) (Table 3). According to the respondents, *Combretum adenogonium, Lannea schimperi* and *Vitex keniensis* tree species were mostly preferred in the farms than others, due to high economic potential in the production of timber and charcoal at household level. Observations from the surveyed areas showed that the distribution of LKTS in the farms varied from one village to another probably due to variation in economic activities which were identified during focus group discussion as well as ecological differences.

Table 3: The selected Lesser Known (LK) IAGTS found in individual farms

Botanical name	No. of Trees per species	% of total no. of trees per species	Total Volume per tree species (m3)	Average volume per tree species (m3)	Total % of Volume
Combretum adenogonium	25	33.3	8.4	0.3	17
Lannea schimperi	21	28.0	16.9	0.8	33
Vitex keniensis	17	22.7	20.9	1.2	41
Lonchocarpus capassa	10	13.3	2.8	0.3	6
Pseudolachnostylis maprouneifolia	2	2.7	1.8	0.9	3
Total	75	100	51		100

4.3.2.2 Tree volume

The major volume contribution of the the LKTS studied indicate to come from *Vitex keniensis* (41%), *Lannea schimperi* (33%), *Combretum adenogonium* (17%), *Lonchocarpus capassa* (6%) and *Pseudolachnostylis maprouneifolia* (3%) (Table 3). A total of 51m^3 from LKTS were found during inventory in the households farms of the surveyed area (Table 3). The results showed that some of the conserved trees had large average volume per tree species due to good management due to agroforestry system and good climatic condition of the area, for example *Vitex keniensis* (1.2m^3) and *Pseudolachnostylis maprouneifolia* (0.9m^3) contributing large volume to the total (Table 3). Other species had less average volume per tree for example *Combretum adenogonium* (0.3m^3). This showed that some IAGTS and LKTS, however small volume per tree species of some timber species studied may be some of them do not let these species reach big dimensions as result there are less returns in the long time. Therefore, farmers cannot wait for the trees to have big dimensions and harvest as timber in stead they use it for charcoal which uses even the small dimension trees. Some of the studied LKTS, were IAGTS for example *Albizia schimperiana*; a species which can be grown in agroforestry systems and plantations and used for other purposes before it reaches its rotation age (Makonda *et al.*, 2008). Therefore if the LK IAGTS obtained in the farms and know their physical and mechanical properties as well as their economic potential if harvested and or sold as standing timber will raise household's income.

4.3.3 Indigenous agroforestry timber trees in agricultural farms

The average IAGTS reserved in agricultural farms per household was about 4 trees and 2.8 m^3 per farm (Table 4). Few trees are probably reserved in the farms to avoid interference with food crops which are grown in specific area such as maize, sorghum, beans and other mixed food crops. The crops grown in the study villages include paddy, maize, beans, simsim, sweat potatoes, sunflower and groundnuts. However, maize is commonly grown in a mixture with other crops mentioned above except paddy. These crops are normally found mixed with indigenous tree species left in the farms (Plate 1).

Plate 1: Indigenous tree (*Pterocarpus angolensis*) mixed with simsim crop as agroforestry practises

Table 4: Number of trees and volume per tree in conserved farms

Botanical name	Trees per species	Volume per specie	Avrage volume per species	Total % of Vo.
OthersSpecies (unknown)	100	44.8	0.5	17.92
Pterocarpus angolensis	39	41.5	1.1	16.6
Combretum adenogonium	25	8.4	0.3	3.36
Lannea schimperi	21	17	0.8	6.8
Pterocarpus tinctorius	18	16	0.9	6.4
Vitex keniensis	17	20.9	1.2	8.36
Acacia nigrescens	17	12.1	0.7	4.84
Diplorhynchus condylocarpon	17	7.7	0.5	3.08
Vitex mombassae	15	14	0.9	5.6
Dalbergia melanoxylon	14	3.1	0.2	1.24
Combretum molle	12	4.9	0.4	1.96
Pericopsis angolensis	11	14.3	1.3	5.72
Lonchocarpus capassa	10	2.8	0.3	1.12
Tamarindus indica	8	8.6	1.1	3.44
Sterculia africana	8	4.5	0.6	1.8
Brachstegia spiciformis	7	11.2	1.6	4.48
Annona senegalensis	4	1.7	0.4	0.68
Sterculia quinqueloba	3	1.8	0.6	0.72
Ficus sycomorus	3	1.8	0.6	0.72
Acacia robusta	3	1.7	0.6	0.68
Pseudolachnostylis maprouneifolia	2	1.7	0.9	0.68
Ficus sycomorus	1	2.4	2.4	0.96
Acacia polyacantha	1	2.4	2.4	0.96
Brachystegia microphylla	1	2.3	2.3	0.92
Brachystegia Boehmii	1	1.8	1.8	0.72
Kigelia africana	1	1.8	1.8	0.72
Brachystegia Boehmii	1	1.7	1.7	0.68
Acacia polyacantha	1	1.6	1.6	0.64
Xeroderris stuhlmannii	1	1.2	1.2	0.48
Total	**362**	**255.7**	**30.6**	**100**
Average per farm	**4.0**	**2.8**		

4.3.4 Suitable LK IAGTS for timber production

The selection of trees species for timber production is based on the species properties of producing suitable lumber with high strength, high durability and easy to machine, work, and polish. These species can increase income to sawyers and farmers hence increase household's income from indigenous timber products. According to Gillah *et al.* (2009), most LKTS are under-utilized, and this is largely a result of lack of information on physical and mechanical properties of such trees. If these properties are known and found to be more suitable than the traditional timber species, they can either complement or substitute traditional timber species.

However, it was found that, there are other multiple benefits obtained from the studied LKTS including the Non Timber Forest Product (NTFP) whose economic values were not estimated in the study. For example, some LKTS such as *Vitex keniensis, Combretum adenogonium* and *Lannea schimperi,* were reported to produce fruits and medicines which are sold and thereby adding some income to the households (Appendix 10).

According to households' responses, the average preference scores for LKTS which are suitable for timber and charcoal production were 41.2% for *Lannea schimperi* 29% for *Vitex keniensis*and 29% for *Pseudolachnostylis maprouneifolia* (Table 5). These were more preferred indigenous agroforestry trees for timber production because of some particular reasons. The respondents indicated that *Lannea schimperi* is highly preferred for timber production than others because it has good timber properties. Also, *Lannea schimperi* was found to have big dimensions due to its fast growing characteristics. For charcoal production, the preferred indigenous agroforestry species were *Combretum adenogonium* (56.3%), *Pseudolachnostylis maprouneifolia* (25%), and *Lonchocarpus capassa* (18.8%) (Table 5). *Combretum adenogonium* was more preferred for charcoal production (56.3%) than other trees, likely due to its high density and calorific value of producing good amount and marketable charcoal (Table 5). *Pseudolachnostylis maprouneifolia* is highly preferred for the production of both timber and charcoal (Table 5).

Therefore, some of the indigenous agroforestry LKTS are potential for both timber and charcoal production. This suggests that, more of these species could be planted in farms to optimize production, management and their consumption, so as to add more income to households. The management of common woodlands must therefore be complemented by private tree planting (Gausset *et al.,* 2007). There is a need promote sustainable forest resources management, through increasing forest resources and forest products to meet rural and urban primary energy requirements, while providing realistic economic base for the communities surrounding the forest reserve (Malimbwi *et al.*, 2006).

Table 5: Prefered LK IAGTS suitable for timber and charcoal production in surveyed areas

Specie name	Average preference score (%)	
	Lumber production	Charcoal production
Combretum adenogonium		56.3
Lannea schimperi	41.2	
Pseudolachnostylis maprouneifolia	29.4	25
Vitex keniensis	29.4	
Lonchocarpus capassa		18.8
Total	100	100

4.4 Economic Value of the Selected Five LK IAGTS used in the study area

4.4.1 Average income obtained from LKTS indigenous agroforestry at household level

The average price of both timber and charcoal is given in Table 6. At the time of data collection, the calculated average price for sawn lumber per piece was about 5 100 TZS having an average size of 1"x 12"x12" (Table 6). A single bag of charcoal weighing about 60kg was 12 200 TZS in the village sites (Table 6). The pieces of the timber and bags of the charcoal obtained from the farms were not uniform in size.

Table 6: Average income from timber and charcoal from selected indigenous agroforstry LK species per households' responses

Tree Product	Average price per unit (TZS)	Average Production per tree	Average no. of trees per household	Average Total income per household (TZS)
Timber	5 100	19.1	4	393 400
Charcoal	12 200	5.4	4	263 400
Total				656 800
Average per household				328 900

The average total income from timber and charcoal production obtained from the selected five indigenous agroforestry LKTS per household could be 393 400 TZS and 263 400 TZS respectively, which gives a total of 656 800 TZS with an average of both timber and charcoal products per household to be 328 900 TZS (Table 6). The income obtained from timber products may serve as off-farm income to improve livelihood of farmers as well as reducing dependence on the reserved forests. However such income obtained by the households cannot be a sustainable source of income unless harvesting is done sustainably because trees take many years to be harvested. As reported by Ishengoma *et al.* (2000) in Makonda *et al.* (2008), the well known commercial timber species are very scarce if not depleted and their regeneration is threatened. Hence, the studied LKTS can be used as an asset and as security which could be harvested whenever households experience financial problems. Such forest resources provide an important “safety net” for resource-poor households, especially when other income sources are not available (Winrock International, 2006). The forest resources are also important natural assets for rural households, providing both subsistence and market-oriented livelihood strategies (Kalaba, 2010). Therefore, more efforts are needed on planting indigenous agroforestry timber species at a household level. As reported by Makonda *et al.* (2008), more efforts are also needed to introduce lesser known species and to intensify regeneration.

A study by Bisong *et al.* (2009) showed the an income derived from timber products from agricultural lands if well retained and re-invested in the farms it substitutes timber obtained from forestland, hence adding income to households and reduce pressure from forest destruction. Although this was not part of the study, the selected five IAGTS from LKTS could add income to the household due to the fact that they (the IAGTS) produce various Non Timber Forest Products (NTFPs) which bear fruits from *Vitex keniensis* and *Lannea schimperi,* local medicine and other wood products such as firewood (from tree branches) used for brick burning and cooking. Trees commonly used for NTFPs were *Combretum adenogonium* and *Lonchocarpus capassa*. Some indigenous fruits from miombo woodland such as *Parinari curatellifolia, Strychnos cocculoides, Vitex mombassae, Flacourtia indica, Sclerocarya birrea, Syzygium guineense* to mention few, have attained higher value by achieving commercial production of NTFPs in Tanzania and thereby providing income generating opportunities (in processing and enterprise development) to the rural women. Such products have also been promoted at national and international trade fairs and some local supermarkets (Pye-Smith, 2008). However, Non Forest Products (NFP) like mushrooms, soil nutrients and favorable condition for micro organisms are among the benefits derived from the LKTS trees. An environmental consideration is also an important factor for all the cited LKTS trees in the farms. If LKTS are managed and used sustainably they can potentially contribute to the efforts devoted to poverty alleviation and mitigation of climate change (Makonda *et al.*, 2008).

4.4.2 The standing value of conserved LK IAGTS

The importance of the selected five LKTS namely *Vitex keniensis, Combretum adenogonium Lannea schimperi, Lonchocarpus capassa and Pseudolachnostylis maprouneifolia* were estimated to know the importance of conserved trees by households in their farms. Normally, farmers sell these LKTS trees as standing trees or poles to customers in the study area. The prices of timber trees vary according to the demand of the products in the village and the surrounding areas. The total value of the indigenous agroforestry and selected five LKTS was 616 266 TZS. The estimated total number of trees of the selected indigenous agroforestry LKTS in this study is presented in Table 7.

Table 7: The values of standing trees found in the surveyed farms and woodlots

No.	Species	Standing trees								
1	Selected five LKTS	Total number of farms surveyed	Total number of trees	Average total number of trees per farm	Distribution of average total number of trees per farm in (%)	Total volume (m^3)	Average total volume per farm (m^3)	Distribution of average total volume per farm (%)	Total value of species per volume (TZS)	Average total value of species per volume per farm (TZS)
	Vitex keniensis		17	0.19	24.57	20.89	0.23	41.82	286710	3 185.67
	Lannea schimperi		20	0.22	28.57	16.95	0.18	28.73	232140	2 579.33
	Combretum adenogonium		22	0.24	31.17	8.32	0.09	16.36	74970	833.00
	Lonchocarpus capassa		9	0.10	12.99	2.77	0.03	05.46	12300	136.67
	Pseudolachnostylis maprouneifolia		2	0.02	2.60	1.702	0.02	03.71	10146	112.73
	Sub Total for LKTS	**90**	**70**		**100**	**50.53**	**0.5**	**100**	**616 266.00**	**6 847.4**
2.	**Hardwood woodlot**									
	Milicia exclsa		1889	62.97	29.91	399.4	13.31	37.60	27477920	915 930.67
	Tectona grandis		572	19.07	09.06	228.7	7.62	21.52	18296000	609 866.67
	khaya anthotheca		2450	81.67	38.80	251.61	8.387	23.69	8362080	278 736.00
	Cederela odorata		1404	46.8	22.23	182.61	6.087	17.20	816880	27 229.33
	Sub Total for Woodlots	**30**	**5 747**		**100**	**834**		**100**	**36 656 880**	**1 221 896**

The distribution of the average total number of trees per farm was for each of the selected LKTS in this study is as follows *Combretum adenogonium* 31%, *Lannea schimperi* 29%, *Vitex keniensis* 25%, *Lonchocarpus capassa* 13% *and Pseudolachnostylis maprouneifolia* 3% (Table 7). However, the average total number of trees per farm was as follows *Combretum adenogonium* 0.24 trees, *Lannea schimperi* 0.22 trees, *Vitex keniensis* 0.19 trees, *Lonchocarpus capassa* 0.10 trees and *Pseudolachnostylis maprouneifolia* 0.02 trees (Table 7). The results show that, the average total number of LKT trees per farm was very small (less than one tree); this is because farmers have conserved known and lesser known timber trees depending on its economic potential and its known wood properties for timber production. However, the known timber trees like *Pterocarpus angolensis* were more conserved than LKTS (Appendix 5).

The average total value of the species per farm of the selected LK IAGTS was as follows *Vitex keniensis* TZS 3 186 (42%), *Combretum adenogonium* TZS 833 (16%), *Lannea schimperi* TZS 2 579 (33%), *Lonchocarpus capassa* TZS 137 (6%) and *Pseudolachnostylis maprouneifolia* TZS 112 (4%) (Table 7). Therefore, conserving indigenous timber trees generates additional income to the households if sold. If LKTS are managed and used sustainably they can significantly contribute to poverty alleviation and climate change mitigation efforts (Makonda *et al.*, 2008).

4.4.3 Estimated values of hardwood woodlots trees

In estimation of the value of trees from woodlot, two methods were used in the study area. Communities sell standing trees either by volume using royalty rates or as individual trees.

4.4.3.1 Using royalty rates

Farmers use the Government Notice (GN) No. 429 of 2011 (URT, 2011), whereby species are sold according to diameter classes as classified in the GN. According to the GN hardwoods are classified into four groups and are in diameter classes; and royalty for species is set according to diameter classes (Table 8).

The total value of the species in hardwood woodlots was TZS 36 656 880. The total number of trees was 5 747 in 30 surveyed farms (Table 7). The average total number of trees per woodlot in the surveyed areas was about 82 (39%) for *Khaya anthotheca*, 63 (30%) for *Milicia excelsa*, 47 (22%) for *Cederela odorata* and 19 (9%) for *Tectona grandis* (Table 7). The average total value of the species per hardwood woodlot was about TZS 915 931 (38%) for *Milicia excelsa*, TZS 278 736 (24%) for *Khaya anthotheca*, TZS 609 867 (22%) for *Tectona grandis* and for TZS 27 229 (17%) for *Cederela odorata* (Table7). However during the survey, all the trees measured were young of between 9 and 11 years. Therefore, planting hardwood woodlot increases additional income to the households when timber products are sold. With care and planning, some hardwood stands can manage to grow to $200 or more in timber value per acre each year (Hall, 2012).

Table 8: Royalty for plantation of hardwood in relation to group and diameter classes in Tanzania

Timber class	Species	Royalty/m³ TZS			
				Diameter classes	
		11-20	21-30	31-35	>35
I	Teak	32 000	8 0000	120 000	16 0000
III	Cederella, Grevillea, Acacia, Acrocarpus and Maesopsii	4 000	8 000	15 000	20 000
IV	All other hardwood	3 000	6 000	12 000	15 000
II	Eucaliptus saligna&grandis	6 400	16 000	28 000	

Source: Government Notice No 429 (2011)

4.4.3.2 Selling standing single tree

The majority (86%) of the respondents in the village have adopted planting hardwood woodlot. During PRA exercise, it was established that hardwood woodlots have increased in the village for the past 10 years. This is mainly because local people have been involved in indigenous tree planting unlike in the past when it was only the government which was responsible for tree planting. As Kajembe (1988) argues, farmers place very low priority on trees which produce fuelwood and put more emphasis on planting trees which produce timber for construction, poles, fruit or other non-fuel purposes. In Madudu village, some households have planted indigenous timber species in woodlots with an average of 0.4 hectare per household having about 265 trees per woodlot (Table 9).

Table 9: Hardwood timber trees planted per woodlot per household in Madudu village

Sientific name	Number of trees	Total volume
Cedrella odorata	2010	194.1
Khaya anthotheca	2668	251.5
Milicia excelsa	1317	179
mangifera indika	311	8.4
Mkomba	7	0.1
Tectona grandis	572	228.7
Total	6885	853.4
Average per woodlot	**265**	**33**
Total woodlot no.	**26**	
Total area in hectore	**11.1 (0.4/h.h)**	

Therefore the value which could be realized per household by selling standing trees was an average of TZS 3 180 000 (Table 10).

Table 10: Average income obtained from selling standing trees at the household level

Tree Product	Average price per tree (TZS)	Average number of trees	Total income per household (TZS)
Timber tree	12 000	265	3 180 000
Total			**3 180 000**

The selling of trees in the study area is one of the alternatives of generating additional income among the households. Therefore, this implies that agroforestry practices have a significant contribution to farmers' income generation. In many areas, poles are in high demand locally and do fetch a high price. Therefore, planting trees for poles cannot only address the shortage of building or craft materials, but it can also help to increase an income among the farmers (Gausset *et al.*, 2007). However, trees cannot bring cash flow all the time, but it can be used as an asset. Paychecks from wood come only periodically, and sometimes only once in a lifetime; farm woodlots are often viewed as a source of cash in an emergency and a place to hunt deer. They are seldom considered in the total farm economic plan (Hall, 2012). Therefore, there is need to invest in woodlots at a household level. According to Ngaga (2011), given the expected severe shortage of sawlogs in the near future, there is need to improve private and public forest plantations in terms of forest management especially fire management, growing stock, use of improved seeds and germplasm.

4.5 Economic Benefits of the Selected Five LKTS IAGTS for Timber Production

The profitability analysis of IAGTS and LKTS in both agricultural farms and woodlots in the study area was done in order to estimate the profit obtained at a household level. One can distinguish two ways of increasing the quantity and quality of trees locally: planting new trees and improving the management of the existing trees. These two options tend to be associated with two different kinds of land use, since planting trees is generally done on a private land while management of the existing vegetation is a concern among the common woodlands (Gausset *et al.*, 2007).

4.5.1 Income generating activities in the study villages

Different income generating activities carried out at household level in the study villages are shown in Table11. Such activities are agriculture (crop cultivation), livestock keeping, forest relating activities, hunting, employment on someone else's farm, beekeeping and other off-farm activities such as running small businesses (Table 11).

Table 11: Response based on income generating activities in the study areas

	R.gongoni		Mabana		Madudu		Ulaya		Total	
Sources of Income	F	%	F	%	F	%	F	%	F	%
Agriculture	29	39.19	29	42.65	29	50	30	44.12	117	43.66
Small business	11	14.86	20	29.41	9	15.52	17	25	57	21.27
Forest harvesting	21	28.38	6	8.82	14	24.13	7	10.29	48	17.91
Livestock keeping	9	12.16	4	5.88	2	3.45	6	8.82	21	7.84
Beekeeping	0	0	3	4.41	2	3.45	4	5.88	9	3.37
Employment	0	0	3	4.41	2	3.45	4	5.88	9	3.36
others	4	5.41	3	4.41	0	0	0	0	7	2.61
Total	74	100	68	100	58	100	68	100	268	100

According to the responses, (44%) of the farmers in all the villages were more involved in agricultural activities and were participating in other mentioned income generating activities in order to diversify their income sources (Table 11). This implies that, a village with different socio-economic activities (crop cultivation, livestock keeping and small business) is in a better position, in relative terms, not to be affected economically compared to a village which depends on only one socio-economic activity. However IAGTS is the system which was commonly used by farmers for many years in study areas. A study by Frank *et al.* (1999) also reveals that communities with different sources of income for their livelihood are not much affected when a change happens to one of their income sources.

The main income generating activities practiced in the study area were agriculture (cropping cultivation) for both food and cash crops (44%) small business (off farm activity) (21%) and forest harvesting and forest products business (18%) (Table 11). A total of 117 (98%) out of 120 households surveyed were found to be engaged in agricultural activities for both food and as a major source of income in the study area (Table 11). This shows that, practicing IAGTS at a household level helps to add some profit especially when perennial crops are mixed with annual crops like maize. It was also found that these were small business (off farm activity) like food crop shops, small food hotels and the like. Farmers in the study area also practice agricultural value chain through buying food crops such as rice and maize flour during harvesting, processing, packing and selling the products to maximize profit. Some of them do cook and sell the products as catering services business. Most of the off farm activities are done during summer season or after agricultural duties.

Forest harvesting and selling forest products or a service was one of the major incomes generating activity. Good examples include charcoal making and selling, selling timber, poles and logs, which were commonly practiced in Rudewa Gongoni village (28%) and Ulaya Kibaoni (10%) due to availability of natural forests with mature and large diameter trees (Table 11). In these villages, farmers have been trained on sustainable harvesting of natural resources under Participatory Forest Management (PFM) program. Farmers received training and financial support from MOECO, also they received training on nursery establishment for tree planting (in woodlots), selling seedlings and performing forest activities which mostly took place in Madudu village (Table 11). Also some (21%) farmers were involved in other duties such as livestock keeping (Table 11). Livestock was mostly kept for household consumption. Beekeeping was practiced in a few areas (9%) due to lack of beekeeping knowledge and capital, despite that trees are available in both the reserved forests and in the agricultural farms (Table 11).

4.5.1.1 Agriculture

The main activity in the study villages is agriculture (Table 11). Almost 70% of the population lives in the rural areas and 80% of these depend on agriculture and natural resources for their daily needs (TNRF, 2009 in Ngaga, 2011). The leading food and cash crops grown in the surveyed households include maize, paddy, simsim, sunflower, beans, and vegetables especially beans and fruit vegetables, sweat potatoes, cassava, nuts (especially groundnuts) and fruits like watermelon, mangos and pineapples (Table 12). Although maize and paddy were the main food crops, paddy was more preferred by farmers because of its contribution in generating income in households as opposed to other crops (Table 11). Other crops grown were tomatoes, cauliflower, onion and pepper. All the crops grown in the study villages were mixed with indigenous trees except paddy which was grown in low lands.

The households whose livelihoods depend on agriculture were about 39%, 43%, 50% and 44% at Rudewa Gongoni, Mabana, Madudu, and Ulaya Kibaoni villages respectively (Table 11). Practicing indigenous agroforestry at the household level is one of the alternative sources of income for farmers' livelihoods and entails that planting and conserving IAGTS particularly in the household farms will economically change the life style of farmers through selling timber trees and their non timber products. However, those who practice value chain addition get higher profit than those who do not. Value chain addition is practiced through harvesting and processing logs to timber/lumber in order to add value of timber tree while continuing planting food crops each year.

4.5.1.2 Crop cultivation

Majority (31 %) of the respondents in the study villages cited crop cultivation as the main socio-economic activity undertaken by many households (Table 12). According to the respondents, crops grown in the study area include maize (31%), paddy (18%), simsim (14%), sunflower (10%), vegetables/beans (17%), sweat potato/cassava (4%), nuts (5%) and fruits (2%) (Table 12). About 31% of the households interviewed were engaged in maize cultivation because maize is used as food as well as cash crop in the households. However, paddy (18%) and simsims (14%) were mainly cultivated as cash crops. Only 2% of the respondents in the households specifically in Mabana village cultivated fruit trees as a cash crop (Table 12). In all the study villages, maize was widely produced by households than any other crops. The distribution of the respondents involved in maize production across villages was as follows, Rudewa Gongoni (39%), Mabana (26%), Madudu (31%) and Ulaya Kibaoni (29%) of the respondents (Table12). Also, in many areas, maize crop was mixed with trees as part of the indigenous agroforestry practices.

Table 12: Responses on the type of crops grown in the study villages

	Rudewa Gongoni		Mabana		Madudu		Ulaya Kibaoni		Total	
	F	%	F	%	F	%	F	%	F	%
Maize	29	39.19	29	26.13	29	30.85	30	29.12	117	30.63
Paddy	14	18.92	28	25.23	14	14.89	12	11.65	68	17.80
Sims	12	16.22	16	14.41	13	13.83	13	12.62	54	14.14
sunflower	8	10.81	14	12.61	8	8.51	9	8.74	39	10.21
Vegetables/beans	6	8.11	17	15.32	20	21.28	22	21.36	65	17.02
Sweat potato/cassava	3	4.05	1	0.90	5	5.32	6	5.83	15	3.93
Nuts	2	2.70	0	0	5	5.32	11	10.67	18	4.71
Fruits	0	0	6	5.41	0	0	0	0	.6	1.57
Total	74	100	111	100	94	100	103	100	382	100

4.5.1.3 Average total incomes of crops grown

Average incomes per hectare per household obtained from crops grown by households in the study villages are summarized in Table 13. The results indicate that the average total income earned vary from one crop to another and also from one village to another (Table 13). Paddy is the leading crop with very high income in the households compared to other crops such as sims, sunflower, vegetables/beans, sweat potatoes, bananas, nuts and fruits grown in the study villages (Fig. 2). The average annual total income of paddy in Mabana and Ulaya villages was as high as TZS 2 809 286 and TZS 2 396 667 respectively unlike the case in any other village (Table 13). The average annual total income from maize crop in Madudu village was TZS 1 443 793 per household which was higher than was the case in any other villages (Table 13). This trend is likely a result of using agricultural inputs especially fertilizers. Also, in Madudu village, farmers are not practicing indigenous agroforestry which may have resulted into occupying more space and causing shade effects. However, in some villages (e.g.Madudu village) farmers practice hardwood woodlot planting which gives them high yields and profit. The difference in the total crops average income in the study villages is mainly caused by the amount of crops harvested per year (site factor) and the marketability of the crops.

This implies that, efforts are required to increase land productivity through modern farming systems including agroforestry systems using indigenous timber trees so that a small piece of land a family owns can support them throughout the year while waiting for timber trees to be harvested after few years. The logical interpretation of this finding is that, if the villages attain much of their earnings from the crop production as opposed to from forest products, due to crops income factor, then farmers will not interfere much with natural forests and reserved trees. The commonly crops found to be mixed with indigenous trees as IAGTS as agroforestry practices in study areas were maize, sims and sunflower (Fig 2).

Table 13: Annual average income per hectare per household from crops grown in indigenous agroforestry farms in the study areas

	R. Gongoni		Mabana		Madudu		Ulaya	
	Annual total income	Average annual total income	Annual total income	Average annual total income	Annual total income	Average annual total income	Annual total income	Average annual total income
Maize	21 260 000	733 103	28 000 000	965 517	41 870 000	1 443 793	24790000	826 333
Paddy	13 110 000	936 429	78 660 000	2 809 286	13 800 000	985 714	28760000	2 396 667
Sims	4 145 000	345 417	3 000 000	187 500	25 330 000	1 948 461	7340000	564 615
Sunflower	8 150 000	1 018 750	5 400 000	385 714	7 430 000	928 750	2400000	266 666
Vegetables/beans	1 390 000	231 667	38 590 000	2 270 000	4 444 000	222 200	24620000	1 119 090
Sweat potato/cassava/banana	2 512 000	837333	300000	300 000	2 300 000	460 000.00	2360000	393 333
Nuts	1 220 000	610000	0	0	1 400 000	280 000.00	180000	16 363
Fruits	0	0	7070000	1 178 333.33	0	0	0	0
Total	51787000	4712699	161020000	8 096 350.58	96 574 000	6 268 918.93	90450000	5 583 070

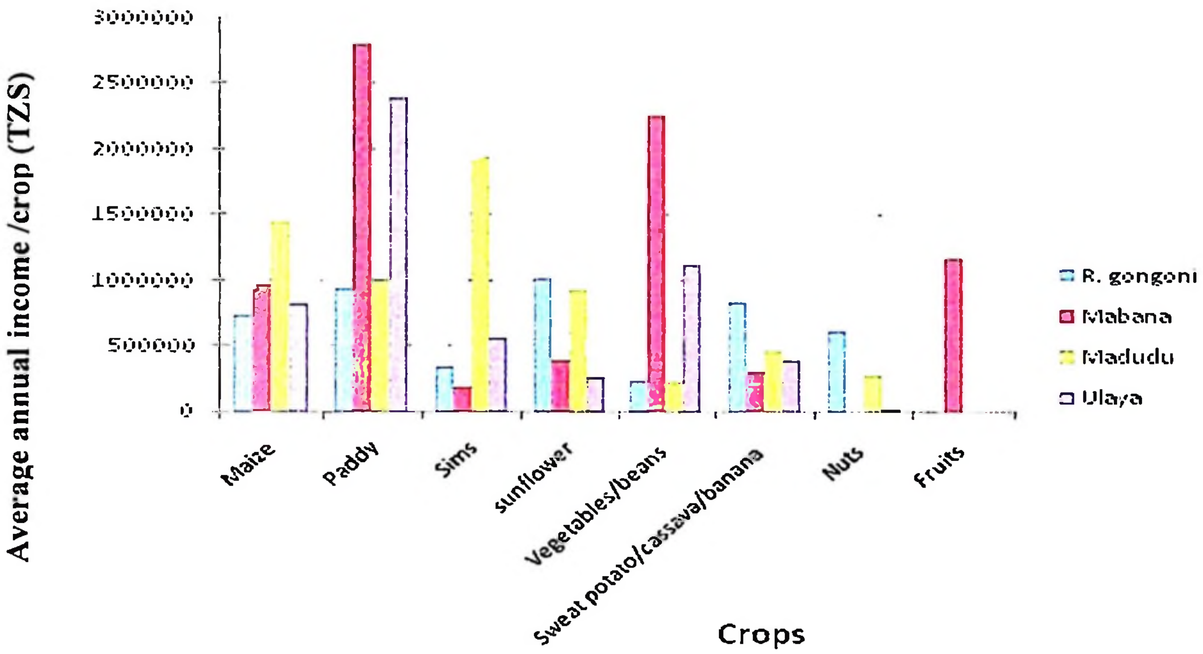

Figure 2: Total average annual income/crop/year of households from common food and cash crops grown in the study villages

4.5.2 Profitability of indigenous agroforestry LKTS for timber production

About 70% of all the respondents in the surveyed areas were conserving trees in their agricultural farms through agroforestry in such villages as Mabana, Rudewa Gongoni and Ulaya Kibaoni. In many parts of Africa, farmers traditionally practice agroforestry Jama *et al.* (2006). According to Eyasu (2002), traditional agro-forestry system takes the form of trees scattered on crop fields, woodlots and homestead tree planting and multi-storey home gardens. The production of maize (food) crop involves similar stages of management which include land preparation, planting, weeding and harvesting (Appendix 15). Most of the farmers in the study area use family labour for all farm activities because the main purposes of cultivation was production of maize and other food crops. However, they conserved trees because having trees was an asset in the family and which could be utilized at times of financial difficulties in the household.

4.5.2.1 Factors for profitability of IAGTS

(a) Seeds and fertilizers

Maize seeds in the households were recycled. Those which were used last season could be reused although few of the households buy new ones. In the study area, maize was as one of the mixed crops with trees. Fertilizer application in the study area was not commonly used across all the villages. Some villages used fertilizers while others did not depending on one's economic ability and accessibility to fertilizers. In some cases insufficient rainfall makes it difficult to apply fertilizers due to the risk of damaging crops.

(b) Production and farm size

The results show that the average production of maize per 1.26ha per season per household is about 37.40 bags (140kg per bag) (Appendix 15). Many farmers do not apply fertilizer because the area is still fertile although some are using the fertilizer for planting and growing. These might be the reasons for the big difference in productivity per ha among the farmers. In the study areas, the average farm size per household was 1.26 ha for crop production. This implies that the farm size per household was small and this might be a result of using a hand hoe which is not profitable for cultivation.

(c) Land preparation, planting and pruning costs

In the surveyed villages of Mabana, Rudewa Gongoni and Ulaya Kibaoni many of the activities were carried out using family labour. Trees were grown using agroforestry system until they reach their rotation age. Trees were mixed with maize (and other food crops) with an estimated total costs of TZS 36 555 724 per farm per household for all the activities done in 22 years for both conserved trees and maize production using agroforestry practices (Appendix 10). This makes an average production cost of TZS 1 661 624 per year per household (Appendix 10). Trees were not planted in the farms but remained when the farm was cleared for the first time and therefore the cost of land preparation and planting was included in the maize production. The cost of pruning was estimated to be about TZS 103 000 per household for buying pruning equipments, although pruning was done by family labour during weeding of maize (Appendix 15).

(d) Preferred conserved IAGTS, rotation age and selling prices

The most preferred indigenous timber species for business purposes especially timber production in the study area were *Pterocarpus angolensis* (18.0%), *Combretum adenogonium* (11.5%), *Lannea schimperi* (9.7%), *Pterocarpus tinctorius* (8.3%), *Vitex keniensis* (7.9%) and *Acacia nigrescens* (7.9%). Others were *Diplorhynchus condylocarpon* (7.9%), *Vitex mombassae* (6.9%), *Dalbergia melanoxylon* (6.5%) *Combretum molle* (5.6%) *Pericopsis angolensis* (5.1%) and *Lonchocarpus capassa* 4.6% (Table 14). The preferred conserved indigenous agroforestry timber tree in the agricultural farms were both known and LKTS for various purposes. The respondents concentrated on the conservation of the highly valuable timber species so as to get more profit due to high demand for timber production.

These trees are normally expected to be harvested when they reach a rotation age with an average of 22 years. However, harvesting depends on the use purposes. Some trees are used with small dimension so they can be harvested before the rotation age of 22 years. Normally farmers sell such trees as standing trees and buyers cut and saw to get timber at their own costs. The standing trees were sold at an average price of TZS 48 000 per tree when they reach a rotation age.

Table 14: Preferred indigenous species conserved in agricultural farms

Botanical name	Total No. of Trees per species	% of total no. of trees species	Total volume per tree species (m^3)	Average volume per tree species (m^3)	% of total Volume
Pterocarpus angolensis	39	18.0	41.5	1.1	25.5
Combretum adenogonium	25	11.5	8.4	0.3	5.2
Lannea schimperi	21	9.7	17	0.8	10.5
Pterocarpus tinctorius	18	8.3	16	0.9	9.8
Vitex keniensis	17	7.9	20.9	1.2	12.8
Acacia nigrescens	17	7.9	12.1	0.7	7.4
Diplorhynchus condylocarpon	17	7.9	7.7	0.5	4.7
Vitex mombassae	15	6.9	14	0.9	8.6
Dalbergia melanoxylon	14	6.5	3.1	0.2	1.9
Combretum molle	12	5.6	4.9	0.4	3.0
Pericopsis angolensis	11	5.1	14.3	1.3	8.8
Lonchocarpus capassa	10	4.6	2.8	0.3	1.7
	216	**100**	**162.7**		**100**

4.5.3 Profitability of LKTS from indigenous agroforestry

The option of practicing IAGTS through mixing crops with indigenous trees in the same unit of land, particularly in the agricultural farms can help to improve the livelihood of communities. All the respondents from the study villages opted to practice indigenous agro forestry timber trees. The main reasons, according to the respondents, include the fact that agrofoestry can provide timber mainly for sale as a source of income in the household. Furthermore, timber can be used for household consumption and assist to reduce pressure on the surrounding reserved forests.

The profitability of maize production in the study area was estimated by calculating the NPV of the main crop cultivated by the farmers as food and cash crop. Maize was found to be commonly mixed with IAGTS as well as grown together with indigenous hardwood timber trees (Appendix 10). The results were then discounted to get NPV for 22 year time horizon for both maize and IAGTS. The NPV of IAGTS which was mixed with maize was estimated to be TZS 4 892 454 per household (Table 15). However, the average NPV per household/farm per year was about TZS 222 384 (Table 15). Besides community's opinions, agro forestry practice got a higher NPV (Tshs 247 780) per hectare compared to the woodlot option (Mazengo, 2010). Undiscounted net benefit per household was 16 316 276 TZS/household/farm, which gives an average of TZS 741 649 of undiscounted net benefit per household per year (Table 15). During the production process, the first year of the production was the year of investment and it had negative net revenue compared to other years of production.

Table 15: Profitability of indigenous agroforestry timber species and woodlots practices in surveyed households

	Agriculture Practices	
	IAGTS with maize (food crop)	Woodlots
Years	22	19
NPV	4 892 454	5 729 984
Average NPV/yr	222 384	301 578
Benefit Cost ratio (B/C)	1.34	3.8
Internal Rate of Return (IRR)	44.74%	94%
Undiscounted net benefit	16 316 276	31 463 584
Average undiscounted net benefit/yr	741 649	1 655 978

The profitability of IAGTS was determined by calculating the NPV at a discount rate of 10% and a time horizon of 22 years assuming that the conserved trees and maize crop would be harvested after 22 years while maize is harvested each year because it is an annual crop. Financial analysis by using cost benefit analysis of IAGTS in the farms was done in order to get the Net Present Value (NPV), the Benefit Cost ratio (B/C) and the Internal Rate of Return (IRR) (Table 15). The results show a positive NPV of about TZS 4 892 454 at a 10% discount rate (Table 15). This implies that conserving indigenous tree in the household's farms is economically profitable. It is therefore advisable for the households to invest in conserving and planting more indigenous timber species in their farms through agroforestry practices to improve households' income from the selling of timber products.

However, this analysis considered only agroforestry and timber products while other benefits such as Non Timber Forest Products (NTFP), Non Forest Product (NFP) and some intangible benefits from IAGTS were not considered. According to Gausset *et al.* (2007), with a few exceptions, most of the fuel wood used in the country is collected free from indigenous miombo woodlands or farmlands. The first harvest can be made at a range of between 20 and 25 years with the products of an increasing value harvested at seven- to ten-year intervals thereafter (Hall, 2012). Therefore, using NPV profitability criteria, investment in IAGTS in household is profitable.

4.5.3.1 Internal Rate of Return

The Internal Rate of Return (IRR) which was obtained was about 45%, (Appendix 10); this shows that the household is likely to recover its investment and operating expenses in 22 years time with profit. This shows that even if the households are able to pay maximum interest of about 45 %, there will be no loss and no benefit (Table 15) implying that the conserving and planting of indigenous trees through agroforestry practices investment is very profitable. The IRR obtained implies that any invested money in IAGTS at the household level will add value and show the return as a result of improving livelihood at the household level.

4.5.3.2 Benefit Cost ratio

The Benefit Cost ratio (B/C) obtained was 1.34, (Table 15). Since B/C is greater than one, this also shows that the project is very profitable.

4.5.3.3 Sensitivity analysis of IAGTS

Sensitivity analysis was calculated at a discount rate of 10%, 15% and 17% (Appendix 10). The NPV which was obtained when there is an increase in the establishment costs, labour cost, a change of price of timber and other forest products, a change of costs of maize production as well as other costs which may change during production as increase of these costs by 25% were TZS 1 239 869 at a discount rate of 10% for 22 years (Table 15). Also, the change of these costs by 25% may occur, assuming that, there will be an increase of production costs for both timber products and agriculture crops through buying land for farming activities, labour power costs including cost for preparation of farms, cultivation, planting and all activities done during production processes. Also there may be an increase of costs of agriculture inputs like seeds, seedlings, fertilizer and costs of pesticides. However, in some areas where farms are very far from residential areas there may be increase of transport costs. Sometimes may be natural disasters which may change normal rainfall and temperature as the result of low production of crops especially food crops (annual crop). The benefits of IAGTS were assumed to be profitable at a discount rate of 17%; however, the number of uncertainties such as diseases, fire outbreaks and drought were expected to occur (Appendix 11). Therefore, it is advised to convince farmers to invest in planting and conserving more IAGTS in their farms because the present value of future benefits is reasonably high.

4.5.4 Profitability of woodlots in household for timber production

4.5.4.1 Woodlot

About 87% of all the respondents in the Madudu village own hardwood woodlots (Appendix 12). A study by (Mazengo, 2010) about 35% of the respondents interviewed preferred *Gravillea robusta* to be planted in the Uluguru landscape, *Khaya anthotheca* was the second with 17% respondents, other species scored less than 10%. The reasons behind their preference were that the species were good as timber tree (*Khaya anthotheca*) and *Gravillea robusta* was preferred an agroforestry tree species at same time they all provided firewood to the local communities around (Mazengo, 2010). Many farms have woods that can provide income from time to time (Ebodaghe, 2010). The average size of the hardwood woodlot per household was 0.43ha (Plate 2). A survey in many places show that tree species which were planted include those for timber production, building poles, firewood and charcoal production, fruit trees, shade provision, and water sources protection and conservation (Ngaga, 2011). Most of the farmers in the study area used trained labour at a village level to manage their woodlot activities which include land preparation, planting and pruning. These trees are expected to be harvested when they reach a rotation age of 19 years (Appendix 12). However, farmers normally sell such trees as standing trees and buyers cut and saw such trees to get timber at their own costs.

Plate 2: Woodlot of hardwood (*Khaya anthotheca*) in Madudu village as one of agroforestry practise

4.5.4.2 Factors for production of hardwood woodlots

(a) Land preparation, planting and pruning costs

In Madudu village, many of the activities were carried out using labour specialized in silvilcultural activities. Employment is one of the major economic contributions of the forest sector in Tanzania (Ngaga, 2011). Employment is provided through forest industries, government forest administration and self-employment in forest related activities (Ngaga, 2011). However, trees were grown using the agroforestry system in the first three years (Plate 2). Trees were mixed with maize (other food crops) with an estimated total costs of TZS 360 961/0.43ha/household for one year production of maize alone (Appendix 14). However, the total cost obtained for tree planting alone for the first year was an average of TZS 608 167/0.43ha/household, which gives a total of about TZS 1 044 256/ha/year for all activities done in the year for both tree planting and maize production through agroforestry practices (Appendix 14). Such activities were land preparation, maize and tree planting, weeding/fire line making, pruning activities and buying equipments. This cost was included together with the cost of maize grown in the first three years when trees are young.

(b) Preferred species, rotation age and selling price

The most preferred planted hardwood plantation for business purposes especially timber production in the study area were *Khaya anthotheca* (18.0%), *Cedrella odorata* (11.5%), *Milicia excelsa* (9.7%), and *Tectona grandis* (8.3%), (Table 16). The respondents concentrated on the planting of these species because they are highly valuable planted hardwood timber species, which provide more profit due to high demand for timber in various places (Plate 2). However in many areas of Tanzania, people prefer to plant soft wood timber trees and other exotic timber trees rather than indigenous trees may be due to poor accessibility of seeds, seedlings and knowledge of nursery establishment and tree planting. As reported by Ngaga (2011), tree planting and woodlot establishment by farmers and communities have taken place in all the districts, and particularly in the Southern Highlands, especially in Mufindi, Njombe and Makete districts in Iringa region.

Table 16: Preferred planted hardwood woodlots for surveyed farms of households in Madudu village

Botanical name	Total No. of Trees per species	% of total no. of trees per species	Total volume per tree species (m^3)	Average volume per tree species (m^3)	% of total Volume
Khaya anthotheca	2668	40.63	251.6	0.1	29.78
Cedrella odorata	2010	30.61	194.0	0.1	22.10
Milicia excelsa	1317	20.05	170.7	0.1	20.20
Tectona grandis	572	8.71	228.7	0.4	27.07
	6567	100	845		100

Some indigenous timber species were observed outside the woodlots conserved in their agricultural farms for various purposes but these were not cited by the respondents as potential for timber production. During the study, the age of the trees in the woodlots was found to be of an average of 11 years; as the respondents started to plant them in early 2000 years when the project (MOECO) started. Thus, the expected rotation age was estimated to be of an average of 19 years depending on the purpose of the use either for poles or for timber. The first harvesting was expected to be done when a tree reaches an average of 10 years. The selling price for standing trees was an average of TZS 48 000 per tree when it reaches a rotation age; farmers sell it as standing trees and buyers cut and saw to get timber at their own costs.

(c) Profitability of woodlots

The profitability of tree planting was determined by calculating the NPV at a discount rate of 10% and time horizon of 19 years assuming that woodlots will be harvested after 19 years. The financial analysis by using cost benefit analysis of planting trees in the woodlots was done in order to get the Net Present Value (NPV), the Benefit Cost ratio (B/C) and the Internal Rate of Return (IRR) (Table 15). The results show positive NPV of about TZS 5 729 984 at a 10% discount rate. However, the average NPV per household/woodlot per year was about TZS 301 578 (Table 15). According to Mazengo (2010), the NPV calculated for the woodlot option gave the lowest NPV (TZS 32 645) compared to the other three options. The low value is attributed by the low prices of the woodlot products in the village markets as communities leaving close to protected forest uses free forest products from the protected forests instead of buying them from the woodlots (Pamela and Luckier, 2005). Since NPV is greater than zero therefore, investment in hardwood woodlots at a household level is profitable. This implies that the planting hardwood trees in the woodlots by households will be economically profitable because the present value of future benefits is reasonably high. The undiscounted net benefit per household for 19 years was about TZS 31 463 585 per household/woodlot which gives an average undiscounted net benefit of TZS 1 655 978 per year/household/woodlot (Table 15). It is therefore advisable for the households to invest in hardwood woodlots for timber production because these results show that households having hardwood woodlots is profitable and earn improve households' income. However, this analysis considered only hardwood woodlots agroforestry and timber products while other benefits such as Non Timber Forest Products (NTFP), Non Forest Product (NFP) and some intangible benefits from hardwood woodlots were not considered.

Plate 3: Profitability of hardwood woodlots in households in Madudu village

(d) Internal Rate of Return

The Internal Rate of Return (IRR) which was obtained in hardwood woodlot was about 94% (Appendix 13). This shows that if a household recovers its investment and operating costs in 19 years time, it will be able to pay maximum interest rate of about 94% without loss but no benefit (Table 15). This implies that planting of hardwood woodlots timber trees through agroforestry practices investment is very profitable (Plate 3). The IRR obtained indicates that any invested money for hardwood woodlots at a household level will add value and show the return as a result of improving livelihood at the household level.

(e) Benefit Cost ratio

Benefit Cost ratio (B/C) which was obtained was 3.8 (Table 15), since B/C is greater than one implies that the project of hardwood woodlots in households is very profitable. As reported by Gausset *et al.* (2007), the few villagers who have already invested in large tree plantations have generally chosen to plant trees that produce timber or poles, because of the positive cost/benefit ratio (saving time and investment, increasing income) when compared with other agricultural activities.

(f) Sensitivity analysis of investing hardwood woodlots

Sensitivity analysis was calculated at a discount rate of 10.0%, 25.0%, 30.2% and 31.34% (Appendix 13). The NPV which was obtained with an increase in the establishment costs, labour cost, change of price of timber and other forest products, change of costs of maize production, change of costs of seeds and seedlings as well as change of other costs which may occur during production as increase of these costs by 25% were TZS 5 225 292 at discount rate of 10% (Table 15). Also, the change of these costs by 25% may occur, assuming that, there will be an increase of costs for both timber products (woodlots) and agriculture crops for the first three years, through buying land for farming activities, labour power costs which are cost for preparation of farms, cultivation, planting and all activities done during production processes. Also there may be an increase of costs of agriculture inputs like seeds, seedlings, fertilizer and costs of pesticides. However, in some areas where farms are very far from residential areas there may be increase of the transport costs. Sometimes may be natural disasters which may change normal rainfall and temperature as the result of low production of crops especially food crops (annual crop).

The benefits of hardwood woodlots were assumed to be profitable at 30.2% (Appendix 13). However, the number of uncertainties which were expected to occur were diseases, fire outbreaks and droughts expected to occur in woodlots (Appendix 13). According to (Ngaga, 2011), some of the macroeconomic parameters in tree planting which cause high risks for investment include high interest rates, exchange rates, governance issues and fiscal policies. Therefore, it is advised to convince farmers to invest in planting hardwood woodlots because the present value of future benefits is reasonably high (Plate 3).

4.5.5 Income obtained in households

Basing on the income generating activities practiced in study areas, generally each household surveyed shows to get high income from agriculture activities especially production of paddy and maize (Fig. 3). These two crops mainly produced in households are mainly used for food but the remained were sold to get households income. During the study, the households practiced hardwood woodlot planting found to earn more income compared to households practicing indigenous agroforestry (Fig. 3) (Table 16). This may be due to good management of woodlot and used of knowledge on tree planting with improved seeds and seedling as result of high yields. According to Mazengo (2010), (35%) who opted for a pure stand of trees (woodlot) gave reasons that a farm mixed with trees (agro forestry farm), if not well managed it can cause shade and food competition and lead to low food crop productivity.

Table 17: Estimated total real incomes/households from food crops (grown in households), Agro forestry and Woodlot in study areas

Crops cultivated	Average annual total income	Average annual income
Maize	3 968 746	992 187
Paddy	7 128 096	1 782 024
Sims	3 045 994	761 499
sunflower	2 599 882	649 971
Vegetables/beans	3 842 958	960 740
Sweat potato/cassava/banana	1 990 667	497 667
Nuts	906 364	226 591
Fruits	1 178 333	294 583
IAGTS net benefits	741 649	741 649
Woodlots Net benefits	1 715 100	1 715 100

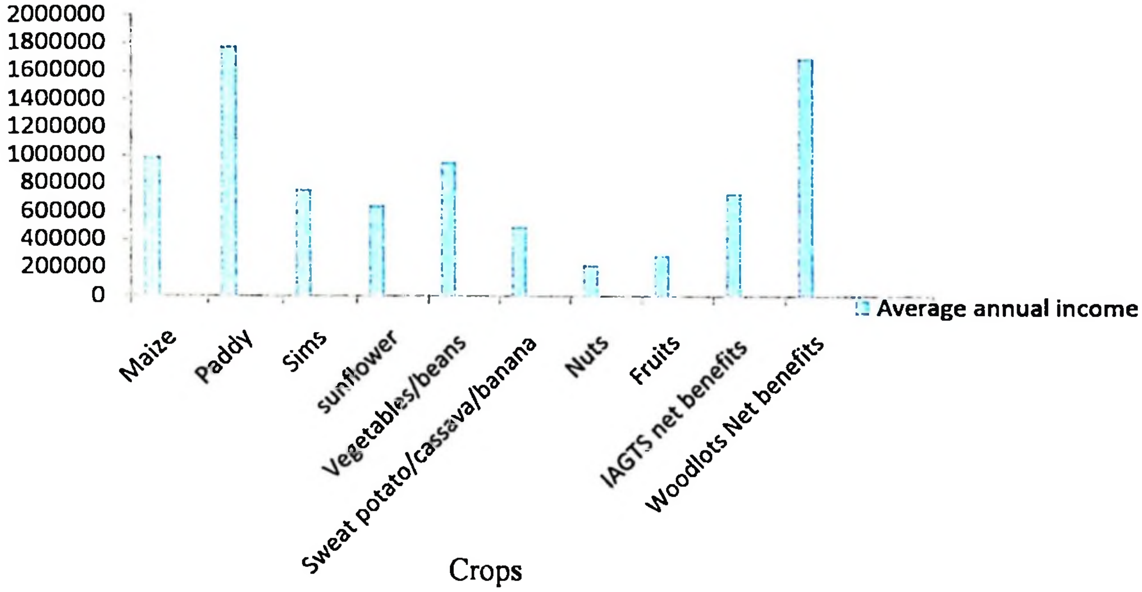

Figure 3: Estimated total real incomes/households from food crops (grown in households), Agro forestry and Woodlot in study areas

CHAPTER FIVE

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

Conserving indigenous agroforestry timber trees and the selected five LKTS namely *Vitex keniensis, Combretum adenogonium Lannea schimperi, Lonchocarpus capassa and Pseudolachnostylis maprouneifolia* and planting hardwood timber trees as woodlots by households were found to be very important socio-economic activities in the household economies of the local communities in the study area.

The standing volume of IAGTS and LKTS conserved in an average of 1.26 ha farm size was about 4 trees and 2.8 m^3 per household per farm. While for the planted hardwood woodlots there was an average of 0.4 ha farm size with 265 trees and 33 m^3 per household per farm. Therefore, the amount of trees and volume which was found conserved in the households per farm looks very small when compared with other sources of income per households. Also, standing trees which were found conserved in the household farms were found to be used for various purposes including timber and non timber uses because some are known and some are LKTS to farmers and users. This contributed to low economic profit among the households in the study area.

Moreover, the conserved selected five LKTS, that is, *Vitex keniensis, Combretum adenogonium Lannea schimperi, Lonchocarpus capassa and Pseudolachnostylis maprouneifolia* are sold by farmers as standing trees or poles to customers in the study area. The standing value of IAGTS and LKTS was about TZS 328 939 per household per farm which is an average income obtained through the selling of timber and charcoal products.

The average total value of planted hardwood woodlots per species in the total surveyed areas estimated by the selling of standing trees in volume using royalty rates was as follows *Milicia exclsa* TZS 915 900, *Tectona grandis* TZS 609 900, *Khaya anthotheca* TZS 278 700 and *Cederela odorata* TZS 27 200. Therefore, planting hardwood woodlot, if sold in volume, increases additional income at the household level.

Also, the average annual income from the selling of standing hardwood woodlot trees was about TZS 3180 000 per household. This implies that indigenous agroforestry practices for timber production and planting hardwood woodlots contribute significantly to farmers' income generation. Therefore, conserving indigenous agroforestry timber trees and planting hardwood woodlots if sold increases additional income to the households. Furthermore, the income obtained from timber products serves as an off-farm income hence improves livelihood of farmers as well as reducing dependence on the reserved forests.

5.2 Recommendations

Based on the findings and conclusion, the following measures are recommended for the decision and policy makers.

a) Basing on the data and the case study above, more emphasis should be put on planting hardwood timber trees in woodlots in the household's farms which give more trees and volume per household per farm by providing seeds and seedlings to farmers rather than conserving more indigenous agroforestry timber trees.
b) According to the findings, more research on economic potential of IAGTS including LKTS need to be done in order to add their values when conserved in household's farms as timber trees to promote their production, economic potential and their consumption.

c) Usually farmers in study area, sell standing timber trees locally, hence my advise to use royalty prices as per GN instead of selling timber (both in IAGTS and woodlots trees) products as standing trees or poles to customers in order to maximize profit in the household level.

d) According to the findings, planting hardwood woodlots at the household level has indicated the highest NPV; this implies that, if hardwood woodlots are planted at the household level, they are likely to give a big profit to farmers, have an asset and use timber trees as one of the alternative sources of income.

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APPENDICES

Appendix 1: Questionnaire for household data collection

Basic Information

Section 1: Household Characteristics

(This is to be completed by the head of the household)

A: General information:

1. Date........................2. Village ....3. Ward ....
1. Division ....

B: Personal detailed of respondent

5. Name of respondent ....

6. Marital status ....7.Sex ....8. Age ....

9. Age of head of household ....

10. Sex of household head ....

11. Occupation of household head ....

12. Level of education of household head ....

Level of education	No. of years
Primary school	
Secondary school	
College	
University	
Non educated	

13. In your family how many people with Secondary education level and above ....

14. Number of people living in the household / compound

Adult .... Children ....

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B: Personal detailed of respondent

5. Name of respondent ....

6. Marital status ....7.Sex ....8. Age ....

9. Age of head of household ....

10. Sex of household head ....

11. Occupation of household head ....

12. Level of education of household head ....

Level of education	No. of years
Primary school	
Secondary school	
College	
University	
Non educated	

13. In your family how many people with Secondary education level and above ....

14. Number of people living in the household / compound

Adult .... Children ....

C: Agroforestry Practices

1. How much land does manage /have (acres) family .... respondent...........
2. Who own the land in your family, family land .... respondent ....
3. Are you planting trees, YES ....NO.........................
4. What are your main motives of planting / conserving trees in your land?
5. Have you ever planted /conserved LAGTS in your farm /land?

(a) Yes (b) No, If yes which tree species put numbers for priority purposes

Tree species	No. (amount) of trees	IAGTS	Non IAGTS	PURPOSES OF PLANTING TREES			
				Timber	Firewood	Charcoal	Others

6. Do you plant tree (both indigenous and exotic species) in your land /farm?

   YES .... NO................

Put numbers for priority purposes if YES

Tree species	No. (amount) of trees	AGTS	Non AGTS	PURPOSES OF PLANTING TREES			
				Timber	Firewood	Charcoal	Others

7. Any reasons for not planting the trees if NO.......................................

D: Deforestation and Forest Degradation

1. Can you comment on the situation of forest resources in the village?

   ....
2. Which institutions are engaged in tree planting in the village?

   (a) .... (b)..............................(c).........................
3. How many forest nurseries are in the village? ....
4. Do you own any forest nursery? ....

5. What types of species are grown in the nurseries and what are the uses of such species

Species	Common use
1.	....
2.	....
3.	....
4.	....
5.	....

6. Do you earn any income from the nurseries? How much earned in Tshs?

....

7. What knowledge's /skills related to nurseries do you possess? and where do you poses it?...

6. Income from **other sources** (if any) the household managed to get in the last 12 months?

Source of income	Number of units sold	Value per unit (Tshs)	Total income (Tshs)
Beekeeping Honey (kgs)			
Fish farming			
Seedlings sellin (Tree/Fruit)			
Others (specify)			
Total			

Appendix 2: Checklist for village leaders (VNRCs, VCs and elders)

1. Name of village ....
2. Human activities in the village
    - Total population
    - Actively working adults (16-60 years)
    - Children (< 16 years)
    - Aged people
    - Males
    - Females
3. Number of households in the village
4. Average size of households
5. Social services and infrastructure in the village
6. Main economic activities in the village
7. Estimation of average revenue or income from each activity per household
8. Estimation of average revenue or income from timber products?
9. What benefits are obtained from indigenous agro forestry timber species?

THANK YOU FOR YOUR COOPERATION.

Appendix 3: Research questions for key informants

1. What are the major economic activities/resources of income in the village?
2. What type of crop/livestock do you keep in the village?
3. Where do you get the timber products?
4. How do you benefit from agroforestry practices?
5. What is the availability of timber species in the village from 2007-2012?
6. Comparatively, what has been the situation of timber exploitation out breaks in the area for the past 10 years ago? Has the situation being increasing or decreasing of no changes?
7. What is the relative abundance of timber species in farms?
8. Are there any trees in your farms?
9. What are uses of these trees in your farm (purposes)?
10. How many people are involved in agrofostry practices (small/medium/many)?
11. Do you plant any timber tree?
12. If yes where do you plant?
13. Which trees type i.e indigenous or exotic?
14. How many have you planted?
15. Where do you get the seedlings?
16. Who pays for them?
17. Have you received any training regarding to agroforestry practices in the village?

THANK YOU FOR YOUR COOPERATION.

Appendix 4: Research questions for carpenters and timber sawyers

1. Name ....
2. Age ....
3. Sex ....
4. Occupation ....
5. Marital status ....
6. Are you a resident of this village? .... How long have you been here?
   ....
7. Where do you get timber species ....

No.	Timber specie	Source/location	Distance (km)

8. How much do you sell/purchase per piece?

No.	Timber specie	size	Price/unit (Tshs)	
			Dry season	Rain season

9. What are preferred timber species?

No.	Ranking	Timber specie	Uses

10. What is the capacity of market

No.	Timber specie	Size	Cubic meters

11. What are current extra rates e.g. charges in timber stock in past 10 years (low, medium, large)

No.	Timber specie	Extraction rate	
		Past 10 years	Current

12. What is perception towards how much of timber extracted is illegal (low, median, high)

No.	Timber specie	Illegal	Legal

THANK YOU FOR YOUR COOPERATION.

Appendix 5: Major timber species found in farms

Botanical name	Total No. of Trees per species	Total %of no. of trees pe species	Total volume per tree species (m^3)	Average volume per tree species (m^3)	Total % of Volume
Khaya anthotheca	2668	36.8	251.6	0.1	22.6
Cedrella odorata	2010	27.7	194	0.1	17.4
Milicia excelsa	1317	18.2	170.7	0.1	15.3
Tectona grandis	572	7.89	228.7	0.4	20.5
Mangifera indica	324	4.47	11.7	0.0	1.1
Other tree species	92	1.27	44.8	0.5	3.1
Pterocarpus angolensis	39	0.54	41.5	1.1	3.7
Combretum adenogonium	25	0.34	8.4	0.3	0.8
Lannea schimperi	21	0.29	17	0.8	1.5
Pterocarpus tinctorius	18	0.25	16	0.9	1.4
Vitex keniensis	17	0.23	20.9	1.2	1.9
Acacia nigrescens	17	0.23	12.1	0.7	1.1
Diplorhynchus condylocarpon	17	0.23	7.7	0.5	0.7
Vitex mombassae	15	0.21	14	0.9	1.3
Dalbergia melanoxylon	14	0.19	3.1	0.2	0.3
Combretum molle	12	0.17	4.9	0.4	0.4
Pericopsis angolensis	11	0.15	14.3	1.3	1.3
Lonchocarpus capassa	10	0.14	2.8	0.3	0.3
Tamarindus indica	8	0.11	8.6	1.2	0.8
Sterculia africana	8	0.11	4.5	0.6	0.4
Brachstegia spiciformis	7	0.1	11.2	1.6	1.0
Annona senegalensis	4	0.06	1.7	0.4	1.2
Sterculia quinqueloba	3	0.04	1.8	0.6	0.2
Ficus sycomorus	3	0.04	1.8	0.6	0.2
Acacia robusta	3	0.04	1.7	0.6	0.2
Eucalyptus saligina	2	0.03	1.9	1.0	0.2
Pseudolachnostylis maprouneifolia	2	0.03	1.7	0.9	0.2
Ficus sycomorus	1	0.01	2.4	2.4	0.2
Acacia polyacantha	1	0.01	2.4	2.4	0.2
Brachystegia microphylla	1	0.01	2.3	2.3	0.2
Brachystegia Boehmii	1	0.01	1.8	1.8	0.2
Kigelia africana	1	0.01	1.8	1.8	0.2
Brachystegia Boehmii	1	0.01	1.7	1.7	0.2
Acacia polyacantha	1	0.01	1.6	1.6	0.2
Xeroderris stuhlmannii	1	0.01	1.2	1.2	0.1
	7247	**100**	**1114.3**	**32.3**	**100.6**

Appendix 6: List of Villages involved in the study and inventory data considered

Village name	Plot no.	Plot size	Local name of tree	Botanical name	No. of trees	DBH (cm)	Ht (m)	Volume	Total volume per tree
Ulaya	1	1	Mkambaa	*Acacia nigrescens*	1	33	13	0.66	0.7
			Mzeza	*Pterocarpus rotundifolius*	1	32	11	0.56	0.6
			Mninga	*Pterocarpus angolensis*	1	39	14	0.98	1.0
			Mninga dume	*Pterocarpus tinctorius*	1	49	15	1.62	1.6
			Mninga	*Pterocarpus angolensis*	1	39	11	0.83	0.8
	2	2	Muani(myombo)	*Brachystegia Boehmii*	1	44	22	1.68	1.7
			Muwanga	*Pericopsis angolensis*	1	33	20	0.88	0.9
			Muwanga	*Pericopsis angolensis*	1	11	5	0.04	0.0
	3	4	Muwanga	*Pericopsis angolensis*	1	25	12	0.36	0.4
			Muwanga	*Pericopsis angolensis*	1	56	24	2.91	2.9
			Embe	*Mangifera indica*	1	19	6	0.13	0.1
			Embe	*Mangifera indica*	1	16	4	0.07	0.1
			Pera	*Gsidium guajava*	1	8	4	0.02	0.0
			Mgung'u	*unkown*	1	36	9	0.62	0.6
	4	0.5	Mninga	*Pterocarpus angolensis*	1	48	14	1.49	1.5
			Mlama Mwesi	*Combretum schumanii*	1	27	11	0.39	0.4
	5	3	Mninga	*Pterocarpus angolensis*	1	42	19	1.39	1.4
			Mtogo	*Diplorhynchus condylocarpon*	1	39	10	0.78	0.8
			Muwanga	*Pericopsis angolensis*	1	43	16	1.30	1.3
			Embe	*Mangifera indica*	1	19	7	0.14	0.1
	6	2	Mninga	*Pterocarpus angolensis*	1	33	8	0.48	0.5
			Mninga dume	*Pterocarpus tinctorius*	1	36	13	0.79	0.8
			Mlama Mweupe	*Combretum adenogonium*	1	12	7	0.06	0.1
			Mgurukaziva	*Lonchocarpus bussei*	1	12	4	0.04	0.0
			Msungwi	*Vitex mombassae*	1	8	4	0.02	0.0

Village name	Plot no.	Plot size	Local name of tree	Botanical name	No. of trees	DBH (cm)	Ht (m)	Volume	Total volume per tree
	7	2.5	Msungwi	*Vitex mombassae*	1	36	10	0.66	0.7
			Mtogo	*Diplorhynchus condylocarpon*	1	30	8	0.40	0.4
			Mkambaa	*Acacia nigrescens*	1	15	8	0.10	0.1
			Mgegele	*Drypetes sp.*	1	8	3	0.01	0.0
			Mgegele	*Drypetes sp.*	1	8	3	0.01	0.0
			Mkambaa	*Acacia nigrescens*	1	11	5	0.04	0.0
			Mmemenambeva	*unkown*	1	20	8	0.17	0.2
			Mgulumo	*Lannea schimperi*	1	32	9	0.49	0.5
	8	4	Mninga dume	*Pterocarpus tinctorius*	1	63	22	3.48	3.5
			Mnyenye	*Xeroderris stuhlmannii*	1	45	12	1.18	1.2
			Mkwaju	*Tamarindus indica*	1	65	28	4.36	4.4
			Muwanga	*Pericopsis angolensis*	1	48	20	1.88	1.9
			Mtopetope	*Annona senegalensis*	1	17	5	0.09	0.1
			Muwanga	*Pericopsis angolensis*	1	40	16	1.12	1.1
			Mninga	*Pterocarpus angolensis*	1	53	16	1.99	2.0
			Mgunga	*Acacia polyacantha*	1	56	10	1.63	1.6
	9	3.5	Msungwi	*Vitex mombassae*	1	43	18	1.41	1.4
			Mbiobio	*unkown*	1	21	9	0.21	0.2
			Mtogo	*Diplorhynchus condylocarpon*	1	24	7	0.23	0.2
			Mtogo	*Diplorhynchus condylocarpon*	1	30	8	0.40	0.4
			Msani	*Brachystegia microphylla*	1	51	22	2.27	2.3
			Mtondoo	*Brachystegia spiciformis*	1	42	16	1.24	1.2
			Mtondoo	*Brachystegia spiciformis*	1	42	30	1.88	1.9

Village name	Plot no.	Plot size	Local name of tree	Botanical name	No. of trees	DBH (cm)	Ht (m)	Volume	Total volume per tree
	10	2.5	Msolo	*Pseudolachnostylis maprouneifolia*	1	47	18	1.68	1.7
			Msondoo	*unkown*	1	53	14	1.8	1.8
			Mgungwi	*Vitex mombassae*	1	45	10	1.05	1.1
			Mgumambula	*Sterculia quinqueloba*	1	16	8	0.11	0.1
			Mtalula	*Acacia polyacantha*	1	29	9	0.40	0.4
	11	6	Mpingo	*Dalbergia melanoxylon*	1	33	10	0.56	0.6
			Mpingo	*Dalbergia melanoxylon*	1	26	9	0.32	0.3
			Msungwi	*Vitex mombassae*	1	8	5	0.02	0.0
			Msungwi	*Vitex mombassae*	1	12	4	0.04	0.1
			Mtogo	*Diplorhynchus condylocarpon*	1	30	7	0.36	0.4
			Msondo	*unkown*	1	19	7	0.14	0.1
			Mtondoo	*Brachystegia spiciformis*	1	9	5	0.03	0.0
			Msungwi	*Vitex mombassae*	1	19	11	0.19	0.2
	12	8	Msungwi	*Vitex mombassae*	1	23	9	0.25	0.3
			Mlama-mwesi	*Combretum molle*	1	10	5	0.03	0.0
			Mng'ongo	*Lannea schimperi*	1	16	15	0.17	0.2
			Mgumuwamvula	*Sterculia quinqueloba*	1	9	6	0.03	0.0
			Mpingo	*Dalbergia melanoxylon*	1	33	16	0.76	0.8
			Mgumuwamvula	*Sterculia quinqueloba*	1	45	6	0.75	0.8
			Mpingo	*Dalbergia melanoxylon*	1	28	13	0.47	0.5
			Msakulang'wale	*unkown*	1	11	4	0.03	0.0
			Msungwi	*Vitex mombassae*	1	14	4	0.05	0.1
			Mzeza	*Pterocarpus rotundifolius*	1	11	7.5	0.05	0.1
			Mzeza	*Pterocarpus rotundifolius*	1	9	6	0.03	0.0
			Mng'ongo	*Lannea schimperi*	1	15	6	0.08	0.1
			Msakulang'wale	*unkown*	1	9	5	0.03	0.0
			Mmemenambeva	*unkown*	1	12	6	0.05	0.1

Village name	Plot no.	Plot size	Local name of tree	Botanical name	No. of trees	DBH (cm)	Ht (m)	Volume	Total volume per tree
	13	3	Mninga	*Pterocarpus angolensis*	1	47	17	1.62	1.6
			Mninga	*Pterocarpus angolensis*	1	35	18	0.93	0.9
			Mninga	*Pterocarpus angolensis*	1	39	17	1.11	1.1
			Mninga	*Pterocarpus angolensis*	1	43	18	1.41	1.4
			Mtondoo	*Brachstegia spiciformis*	1	55	12	1.77	1.8
			Mninga	*Pterocarpus angolensis*	1	38	17	1.05	1.1
			Mninga	*Pterocarpus angolensis*	1	41	16	1.18	1.2
	14	3	Mtogo	*Diplorhynchus condylocarpon*	1	42	10	0.91	0.9
			Mninga	*Pterocarpus angolensis*	1	39	15	1.02	1.0
			Mtondolo	*Brachstegia spiciformis*	1	64	30	4.42	4.4
			Mtondoo	*Brachstegia spiciformis*	1	55	12	1.77	1.8
			Mninga	*Pterocarpus angolensis*	1	38	17	1.05	1.1
			Mninga	*Pterocarpus angolensis*	1	37	16	0.96	1.0
			Mfudu	*Vitex keniensis*	1	46	15	1.43	1.4
			Mfudu	*Vitex keniensis*	1	50	18	1.91	1.9
	15	3.5	Mfudu	*Vitex keniensis*	1	23	8	0.23	0.2
			Mfudu	*Vitex keniensis*	1	63	26	3.89	3.9
			Mfudu	*Vitex keniensis*	1	23	19	0.41	0.4
			Embe	*Mangifera indica*	1	9	3	0.02	0.0
			Mfudu	*Vitex keniensis*	1	51	12	1.52	1.5
			Mkuyu	*Ficus sycomorus*	1	28	8	0.34	0.4

Village name	Plot no.	Plot size	Local name of tree	Botanical name	No. of trees	DBH (cm)	H (m)	Volume	Total volume per tree
	16	4	Embe	*Mangifera indica*	1	16	6	0.05	0.1
			Mkuyu	*Ficus sycomorus*	1	48	13	1.41	1.4
			Mtalula	*Acacia polyacantha*	1	12	6	0.05	0.1
			Mfudu	*Vitex keniensis*	1	21	7	0.18	0.2
			Mfudu	*Vitex keniensis*	1	26	9	0.32	0.3
			Mtopetope	*Annona senegalensis*	1	38	11	0.79	0.8
			Mfudu	*Vitex keniensis*	1	30	16	0.63	0.6
			Mfudu	*Vitex keniensis*	1	34	14	0.741	0.7
	17	2	Mninga	*Pterocarpus angolensis*	1	33	15	0.73	0.7
			Mninga	*Pterocarpus angolensis*	1	49	18	1.83	1.8
			Msegese	*Piliostigma thonningii*	1	20	9	0.19	0.2
			Muwanga	*Pericopsis angolensis*	1	62	24	3.57	3.6
			Mninga	*Pterocarpus angolensis*	1	46	16	1.49	1.5
	18	4.5	Gamelina	*unkown*	1	57	16	2.30	2.3
			Gamelina	*unkown*	1	58	17	2.49	2.5
			Mninga	*Pterocarpus angolensis*	1	17	12	0.16	0.2
			Mninga	*Pterocarpus angolensis*	1	43	18	1.41	1.4
			Mninga	*Pterocarpus angolensis*	1	38	16	1.01	1.0
			Embe	*Mangifera indica*	1	28	8	0.34	0.3
			Embe	*Mangifera indica*	1	35	12	0.71	0.7
	19	3.5	Mkaratusi	*Eucalyptus saligina*	1	39	24	1.39	1.4
			Mfudu	*Vitex keniensis*	1	63	21	3.38	3.4
			Embe	*Mangifera indica*	1	28	10	0.40	0.4
			Mfudu	*Vitex keniensis*	1	62	14	2.50	2.5
			Mkaratusi	*Eucalyptus saligina*	1	25	21	0.52	0.5
			Embe	*Mangifera indica*	1	40	9	0.77	0.8

20	2.5	Mkwaju	*Tamarindus indica*	1	45	12	1.18	1.2
		Msondo	*unkown*	1	46	16	1.49	1.5
		Mkorosho	*Anacardium occidentale*	1	21	5	0.14	0.1
		Embe	*Mangifera indica*	1	23	7.5	0.22	0.2
		Mdampa	*unkown*	1	41	10	0.87	0.9
		Mninga	*Pterocarpus angolensis*	1	55	22	2.65	2.6
21	4	Mtogo	*Diplorhynchus condylocarpon*	1	35	5	0.40	0.4
		Mng'ongo	*Lannea schimperi*	1	20	7.5	0.17	0.2
		Mtondolo	*Brachstegia spiciformis*	1	19	4	0.10	0.1
		Mtalula	*Acacia polyacantha*	1	19	7.5	0.15	0.2
		Mtalula	*Acacia polyacantha*	1	29	8	0.37	0.4
		Mtamba	*unkown*	1	22	7.5	0.20	0.2
		MmemenaMbeva	*unkown*	1	15	5	0.08	0.1
		Embe	*Mangifera indica*	1	16	5	0.08	0.1
		Mtamba	*unkown*	1	50	8	1.12	1.1

Village name	Plot no.	Plot size	Local name of tree	Botanical name	No. of trees	DBH (cm)	Ht (m)	Volume	Total volume per tree
	22	3	Mtogo	*Diplorhynchus condylocarpon*	1	23	8	0.23	0.2
			Mtogo	*Diplorhynchus condylocarpon*	1	34	8	0.51	0.5
			Mtamba	*unkown*	1	55	10	1.57	1.6
			Mtogo	*Diplorhynchus condylocarpon*	1	30	5	0.29	0.3
			Mtogo	*Diplorhynchus condylocarpon*	1	38	6	0.53	0.5
			Mmemenambeva	*unkown*	1	15	8	0.10	0.1
			Mtopetope	*Annona senegalensis*	1	11	8	0.05	0.1
	23	2	Mfudu	*Vitex keniensis*	1	54	14	1.89	1.9
			Mninga	*Pterocarpus angolensis*	1	43	15	1.25	1.3
			Mkuyu	*Ficus sycomorus*	1	16	5	0.08	0.1
			Embe	*Mangifera indica*	1	26	9	0.32	0.3
			Mfudu	*Vitex keniensis*	1	21	7	0.18	0.2
			Mfudu	*Vitex keniensis*	1	26	9	0.32	0.3
			Mtopetope	*Annona senegalensis*	1	38	11	0.79	0.8
			Mfudu	*Vitex keniensis*	1	30	16	0.63	0.6
			Mninga	*Pterocarpus angolensis*	1	40	13	0.98	1.0
			Mninga	*Pterocarpus angolensis*	1	38	10	0.74	0.7
	24	6	Mmemenambeva	*unkown*	1	48	12	1.34	1.3
			Mng'ongo	*Lannea schimperi*	1	62	25	3.67	3.7
			Mninga	*Pterocarpus angolensis*	1	38	13	0.88	0.9
			Mninga	*Pterocarpus angolensis*	1	38	14	0.93	0.9
			Mmemenambeva	*unkown*	1	34	9	0.55	0.6
			Mninga	*Pterocarpus angolensis*	1	41	17	1.23	1.2
			Mninga	*Pterocarpus angolensis*	1	38	13	0.88	0.9
			Muwanga	*Pericopsis angolensis*	1	47	15	1.49	1.5
			Msigi	*unkown*	1	28	7	0.32	0.3

Village name	Plot no.	Plot size	Local name of tree	Botanical name	No. of trees	DBH (cm)	Ht (m)	Volume	Total volume per tree
	25	4	Mtogo	*Diplorhynchus condylocarpon*	1	38	8	0.64	0.7
			Mninga	*Pterocarpus angolensis*	1	41	9	0.81	0.8
	26	2	MnyongaMembe	*Steganotaenia araliacea*	1	30	6	0.33	0.3
			Mhani	*Brachystegia Boehmii*	1	54	13	1.80	1.8
			Mtogo	*Diplorhynchus condylocarpon*	1	42	8	0.78	0.8
			Mninga	*Pterocarpus angolensis*	1	18	6	0.12	0.1
			Muwambangoma	*bado*	1	16	5	0.08	0.1
	27	3	Mgung'u	*unkown*	1	49	4	0.68	0.7
			Mgung'u	*unkown*	1	58	21	2.86	2.9
			Gamelina	*unkown*	1	47	10	1.14	1.1
			Mgung'u	*unkown*	1	59	24	3.23	3.2
			Embe	*Mangifera indica*	1	15	5	0.07	0.1
	28	2	Mninga	*Pterocarpus angolensis*	1	28	9	0.37	0.4
			Gamelina	*Tectona grandis*	1	52	16	1.91	1.9
			Mmemenambeva	*unkown*	1	36	9	0.62	0.6
			Mpingo	*Pterocarpus angolensis*	1	25	8	0.27	0.3
			Mninga	*Pterocarpus angolensis*	1	25	10	0.32	0.3
	29	2	Msungwi	*Vitex mombassae*	1	63	18	3.05	3.1
			Mpingo	*Pterocarpus angolensis*	1	27	11	0.39	0.4
			Mfudu	*Vitex keniensis*	1	34	14	0.74	0.7
			Mndulu	*Dichrostachys cinerea*	1	32	11	0.56	0.6
			Msungwi	*Vitex mombassae*	1	52	18	2.07	2.1
			Msombe	*Ficus sycomorus*	1	53	21	2.38	2.4
			Msungwi	*Vitex mombassae*	1	47	22	1.92	1.9
			Msungwi	*Vitex mombassae*	1	55	18	2.32	2.3
			Mgung'u	*Vitex mombassae*	1	33	16	0.76	

Village name	Plot no.	Plot size	Local name of tree	Botanical name	No. of trees	DBH (cm)	Ht (m)	Volume	Total volume per tree
	4	3	Mfumbili	*Lonchocarpus capassa*	1	30	18.5	0.69	0.7
	30	5.5	Mninga	*Pterocarpus angolensis*	1	35	17	0.89	0.9
			Msungwi	*Vitex mombassae*	1	31	8	0.42	0.4
			Mtogo	*Diplorhynchus condylocarpon*	1	21	5	0.14	0.1
			Mtogo	*Diplorhynchus condylocarpon*	1	32	9	0.49	0.5
			Msungwi	*Vitex mombassae*	1	37	9	0.66	0.7
			Mninga	*Pterocarpus angolensis*	1	36	11	0.71	0.7
			Mtogo	*Diplorhynchus condylocarpon*	1	29	8	0.37	0.4
			Mtogo	*Diplorhynchus condylocarpon*	1	25	8	0.27	0.3
			Mninga	*Pterocarpus angolensis*	1	32	18	0.77	0.8
			Mninga	*Pterocarpus angolensis*	1	42	24	1.62	1.6
			Mninga	*Pterocarpus angolensis*	1	25	14	0.40	0.4
R.Gongni	1	2	Mlama-mweupe	*Combretum adenogonium*	1	10	7.5	0.04	0.0
			Mkole	*Grewia similis*	1	8	6.5	0.02	0.0
			Mlama-mweupe	*Combretum adenogonium*	1	23	15	0.35	0.4
			Mlama-mweupe	*Combretum adenogonium*	1	10	7	0.04	0.0
			Mlama-mweupe	*Combretum adenogonium*	1	8	5.5	0.02	0.0
	2	1.5	Mfiligisi	*unkown*	1	52	15	1.83	1.8
			Mmbinji	*unkown*	1	24	5.5	0.20	0.2
			Mhegea	*Kigelia africana*	1	47	19	1.75	1.7
	3	1	Mnjenja	*unkown*	1	29	22	0.72	0.7
			Mlama-mweupe	*Combretum adenogonium*	1	19	24	0.32	0.3
			Mlama-mweupe	*Combretum adenogonium*	1	23	23	0.46	0.5
			Mlama-mweupe	*Combretum adenogonium*	1	23	22	0.45	0.5
			Mlama-mweupe	*Combretum adenogonium*	1	26	25	0.63	0.6
			Mlama-mweupe	*Combretum adenogonium*	1	31	14	0.61	0.6
			Mnjenja	*unkown*	1	29	13.4	0.52	0.5
			mnjenja	*unkown*	1	31	9.5	0.47	0.5

		Mfumbili	*Lonchocarpus capassa*	1	17	24	0.26	0.3
		Mfumbili	*Lonchocarpus capassa*	1	19	18	0.27	0.3
		Mbiobio	*unkown*	1	20	16	0.27	0.3
		Mbiobio	*unkown*	1	36	22	1.12	1.1
5	4	Mnjenja	*unkown*	1	25	23	0.55	0.6
		Mnjenja	*unkown*	1	32	19	0.80	0.8
		Mnjenja	*unkown*	1	31	18	0.72	0.7
		Mng'ongo	*Lannea schimperi*	1	48	15	1.56	1.6
		Mlama Mweupe	*Combretum adenogonium*	1	38	14	0.93	0.9
6	1.5	Mlama mwesi	*Combretum molle*	1	30	23	0.80	0.8
		Mkambaa	*Acacia nigrescens*	1	25	19.5	0.49	0.5
		Mkani	*Allanblackia ulugurensis*	1	27	22	0.62	0.6
		Mkambaa	*Acacia nigrescens*	1	46	24	1.95	1.9
		Mlama Mweupe	*Combretum adenogonium*	1	12	8.5	0.06	0.1
7	3	Mkambaa	*Acacia nigrescens*	1	38	21	1.21	1.2
		Mfumbili	*Lonchocarpus capassa*	1	19	13	0.22	0.2
		Mfumbili	*Lonchocarpus capassa*	1	18	11.5	0.18	0.2
		Mnjenja	*unkown*	1	35	19	0.96	1.0
		Mng'ongo	*Lannea schimperi*	1	24	9	0.27	0.3
		Mninga dume	*Pterocarpus tinctorius*	1	28	11	0.43	0.4
		Mng'ongo	*Lannea schimperi*	1	16.5	8.5	0.12	0.1
8	4	Mfumbili	*Lonchocarpus capassa*	1	22	13	0.29	0.3
		Mfumbili	*Lonchocarpus capassa*	1	25	11.5	0.35	0.4
		Mnjenja	*unkown*	1	39	22	1.32	1.3
		Mkambaa	*Acacia nigrescens*	1	53	21	2.38	2.4
		Mpingo	*Dalbergia melanoxylon*	1	7	5	0.02	0.0

9	3	Mlama-mweupe	*Combretum adenogonium*	1	20	12	0.23	0.2
		Mng'ongo	*Lannea schimperi*	1	32	12	0.59	0.6
		Mtalawanda	*Markhamia zanzibarica*	1	19	9	0.17	0.2
		Mkizingwi	*unkown*	1	22	11	0.26	0.3
		Muozaoza	*Sterculia africana*	1	33	14	0.70	0.7
		Muozaoza	*Sterculia africana*	1	30	13.5	0.56	0.6
		Muozaoza	*Sterculia africana*	1	29	13.5	0.52	0.5
		Muozaoza	*Sterculia africana*	1	38	14.5	0.95	1.0
		Muozaoza	*Sterculia africana*	1	29	13.5	0.52	0.5
		Muozaoza	*Sterculia africana*	1	30	15	0.60	0.6
		Mhembeti	*Sterculia quinqueloba*	1	34	12.5	0.69	0.7
10	2	Mtalula	*Acacia polyacantha*	1	45	16.6	1.46	1.5
		Mkambaa	*Acacia nigrescens*	1	42	22	1.53	1.5
		Mng'ongo	*Lannea schimperi*	1	23	12.5	0.31	0.3
		Mng'ongo	*Lannea schimperi*	1	36	14.5	0.85	0.8
		Mng'ongo	*Lannea schimperi*	1	28	10.5	0.41	0.4
		Mng'ongo	*Lannea schimperi*	1	44	15.5	1.33	1.3
11	4.5	Mninga dume	*Pterocarpus tinctorius*	1	32	13.5	0.64	0.6
		Mninga dume	*Pterocarpus tinctorius*	1	31	14	0.61	0.6
		Mninga dume	*Pterocarpus tinctorius*	1	17	9.5	0.14	0.1
		Mkole	*Grewia similis*	1	29	9	0.40	0.4
		Mng'ongo	*Lannea schimperi*	1	43	13.5	1.16	1.2
		Mkwaju	*Tamarindus indica*	1	17	7.5	0.12	0.1
		Mkwaju	*Tamarindus indica*	1	23	7.5	0.22	0.2

12	3.5	Muozaoza	*Sterculia africana*	1	30	7	0.36	0.4
		Mlama mwesi	*Combretum molle*	1	37	14.5	0.90	0.9
		Mkambaa	*Acacia nigrescens*	1	44	15	1.31	1.3
		Mlama Mwesi	*Combretum molle*	1	19	10	0.18	0.2
		Mlama Mwesi	*Combretum molle*	1	13	9.5	0.08	0.1
		Mlama mwesi	*Combretum molle*	1	12	10	0.07	0.1
		Mng'ongo	*Lannea schimperi*	1	38	11	0.79	0.8
13	2	Mlama Mweupe	*Combretum adenogonium*	1	14	9	0.09	0.1
		Mkongowe	*Acacia robusta*	1	38	15.5	0.99	1.0
		Mng'ongo	*Lannea schimperi*	1	53	19.5	2.27	2.3
14	2.5	Mng'ongo	*Lannea schimperi*	1	41	10	0.87	0.9
		Mlama-mweupe	*Combretum adenogonium*	1	40	10.5	0.85	0.9
		Mng'ongo	*Lannea schimperi*	1	36	10.5	0.69	0.7
		Mng'ongo	*Lannea schimperi*	1	31	11	0.52	0.5
		Muozaoza	*Sterculia africana*	1	22	10.5	0.25	0.3
		Mlama Mwesi	*Combretum molle*	1	30	14	0.57	0.6
		Mlama Mwesi	*Combretum molle*	1	32	19	0.80	0.8
		Mlama-mweupe	*Combretum adenogonium*	1	10	4.5	0.03	0.0
		Mlama-mweupe	*Combretum adenogonium*	1	10	4.5	0.03	0.0
		Mlama-mweupe	*Combretum adenogonium*	1	5	3.5	0.01	0.0
		Mlama-mweupe	*Combretum adenogonium*	1	9	5.5	0.03	0.0
		Mng'ongo	*Lannea schimperi*	1	34	12	0.67	0.7

15	4	M-dume	*Pterocarpus tinctorius*	1	21	15	0.29	0.3
		M-dume	*Pterocarpus tinctorius*	1	9	8	0.03	0.0
		M-dume	*Pterocarpus tinctorius*	1	10	7.5	0.04	0.0
		Mhembeti	*Sterculia quinqueloba*	1	31	11	0.52	0.5
		Mhembeti	*Sterculia quinqueloba*	1	32	11	0.56	0.6
		Mkambaa	*Acacia nigrescens*	1	26	15	0.45	0.5
		Mkambaa	*Acacia nigrescens*	1	24	13	0.35	0.4
		Mkambaa	*Acacia nigrescens*	1	18	12.5	0.19	0.2
		Mkambaa	*Acacia nigrescens*	1	19	11	0.19	0.2
		Mkambaa	*Acacia nigrescens*	1	14	10	0.10	0.1
		Mninga	*Pterocarpus angolensis*	1	47	21	1.86	1.9
16	2	Mfuleto	*Albizia anthelmintica*	1	16	10	0.13	0.1
		Mfuleto	*Albizia anthelmintica*	1	21	12	0.25	0.3
		Mfuleto	*Albizia anthelmintica*	1	16	10.5	0.13	0.1
		Mlama mweupe	*Combretum adenogonium*	1	18.5	15.5	0.23	0.2
		Mlama mwesi	*Combretum molle*	1	25	12.5	0.37	0.4
		Mninga dume	*Pterocarpus tinctorius*	1	58	23	3.03	3.0
17	3	lkambaa	*cacia nigrescens*	1	21	12	0.25	0.3
		llama-mweupe	*ombretum adenogonium*	1	26	25.5	0.64	0.6
		llama-mweupe	*ombretum adenogonium*	1	22	19.5	0.38	0.4
		llama-mweupe	*ombretum adenogonium*	1	23	18.5	0.40	0.4
		llama mwesi	*ombretum molle*	1	23	12.5	0.31	0.3
		lninga dume	*terocarpus tinctorius*	1	23	12.5	0.31	0.3
		lninga dume	*terocarpus tinctorius*	1	24	13	0.35	0.4

	18	7	Mlama mweupe	*Combretum adenogonium*	1	35	17	0.89	0.9
			Mlama mwesi	*Combretum molle*	1	25	12.5	0.37	0.4
			Mninga dume	*Pterocarpus tinctorius*	1	61	22	3.26	3.3
			Mninga dume	*Pterocarpus tinctorius*	1	9	8	0.03	0.0
			Mninga dume	*Pterocarpus tinctorius*	1	10	8	0.04	0.0
			Mfumbili	*Lonchocarpus capassa*	1	17	24	0.26	0.3
			Mfumbili	*Lonchocarpus capassa*	1	19	18	0.27	0.3
			Mlama mweupe	*Combretum adenogonium*	1	31	13	0.58	0.6
			Mnjenja	*unkown*	1	29	15	0.56	0.6
	19	5	Mninga dume	*Pterocarpus tinctorius*	1	22	18	0.36	0.4
			Mninga dume	*Pterocarpus tinctorius*	1	25	20	0.50	0.5
			Mkwaju	*Tamarindus indica*	1	33	13	0.66	0.7
			Mkwaju	*Tamarindus indica*	1	39	14	0.98	1.0
Mbana	1	2	Mkole	*Grewia similis*	1	3	5	0.00	0.0
			Mfumbili	*Lonchocarpus capassa*	1	2	4.5	0.00	0.0
			Mfunganyumbu	*unkown*	1	2.5	4.5	0.00	0.0
	2	1	Mfunganyumbu	*unkown*	1	4	5	0.01	0.0
			Mng'ongo	*Lannea schimperi*	1	3.5	4.5	0.00	0.0
	3	3	Mkambaa	*Acacia nigrescens*	1	4.5	7	0.01	0.0
			Mkonga	*Azadirachta indica*	1	2.5	5	0.00	0.0
			Mfunganyumbu		1	2.5	5	0.00	0.0
			Mkole	*Acacia nigrescens*	1	5	6	0.01	0.0
			Mkambaa	*Acacia nigrescens*	1	38	13	0.88	0.9
	4	3	Mng'ongo	*Lannea schimperi*	1	31	9	0.46	0.5
			Mwarobaini	*Azadirachta indica*	1	9	6	0.03	0.0
			Mwarobaini	*Azadirachta indica*	2	8	4.5	0.02	0.0
			Mkongowe	*Acacia robusta*	1	30	9.5	0.44	0.4
			Muwanga	*Pericopsis angolensis*	1	3	4	0.00	0.0

5	3	Mpingo	*Dalbergia melanoxylon*	3	12	6.5	0.05	0.2
		Msegese	*Piliostigma thonningii*	2	8	4.5	0.02	0.0
		Mkonga	*Azadirachta indica*	2	18	7.5	0.14	0.3
6	4	Mkongowe	*Acacia robusta*	1	23	8	0.23	0.2
		Mpingo	*Dalbergia melanoxylon*	2	10	4.5	0.03	0.1
		Msegese	*Piliostigma thonningii*	1	7	8	0.02	0.0
		Kinzasa	*unkown*	1	40	6	0.59	0.6
		Mkudekude	*unkown*	1	15	6	0.08	0.1
7	1	Kinzasa	*unkown*	1	10	3.5	0.02	0.0
8	8	Mpingo	*Dalbergia melanoxylon*	1	11	6	0.04	0.0
		Mpingo	*Dalbergia melanoxylon*	1	10	7.5	0.04	0.0
		Msegese	*Piliostigma thonningii*	1	22	7.5	0.20	0.2
9	2	Muwanga	*Pericopsis angolensis*	1	32	18	0.77	0.8
		Mkwaju	*Tamarindus indica*	1	25	16	0.43	0.4
		Mkwaju	*Tamarindus indica*	1	30	18	0.68	0.7

Madudu	1	1	Sedlela	*Cedrella odorata*	118	10	6.5	0.04	4.4
			Mkangazi	*Khaya anthotheca*	420	17	11	0.15	64.7
	2	0.5	Sedlela	*Cedrella odorata*	92	11	8	0.05	4.7
			Mvule	*Milicia excelsa*	238	10	6.5	0.04	8.8
	3	0.5	Sedlela	*Cedrella odorata*	80	12	9	0.07	5.3
			Mkangazi	*Khaya anthotheca*	119	10	7	0.04	4.6
	3	0.5	Sedlela	*Cedrella odorata*	48	12	9	0.07	3.2
			Mkangazi	*Khaya anthotheca*	152	17	11	0.15	23.4
	4	0.5	Sedlela	*Cedrella odorata*	50	11	10	0.06	3.0
			Mkangazi	*Khaya anthotheca*	130	18	12	0.18	23.8
	6	0.5	Embe	*mangifera indika*	311	10	4	0.03	8.4
			Mkangazi	*Khaya anthotheca*	14	27	14	0.46	6.5
	7	10	Mvule	*Milicia excelsa*	31	18	12	0.18	5.7
	8	0.5	Sedlela	*Cedrella odorata*	14	30	11	0.49	6.8
			Mtiki	*Tectona grandis*	4	21	22	0.37	1.5
			Mkomba	*unkown*	7	5	5	0.01	0.1
			Mvule	*Milicia excelsa*	34	20	13	0.24	8.1
			Mtiki	*Tectona grandis*	312	21	15	0.29	90.6
	9	0.5	Sedlela	*Cedrella odorata*	49	23	12	0.30	14.8
			Mvule	*Milicia excelsa*	148	20	11	0.21	31.7
	10	0.5	Sedlela	*Cedrella odorata*	180	14	10	0.10	17.6
	11	0.5	Mvule	*Milicia excelsa*	116	16	12	0.14	16.7
			Sedlela	*Cedrella odorata*	92	21	13	0.26	24.3
	12	0.5	Mvule	*Milicia excelsa*	125	23	12	0.30	37.7

	13	0.5	Mkangazi	*Khaya anthotheca*	54	10	7	0.04	2.1
	14	0.5	Sedlela	*Cedrella odorata*	172	15	9	0.11	18.0
	15	0.5	Sedlela	*Cedrella odorata*	285	15	10	0.11	32.0
	16	0.5	Mvule	*Milicia excelsa*	310	12	10	0.07	22.1
	17	0.5	Mvule	*Milicia excelsa*	315	15	12	0.13	39.9
	18	0.5	Mkangazi	*Khaya anthotheca*	640	9	10	0.04	25.4
	19	0.5	Sedlela	*Cedrella odorata*	310	9	7	0.03	9.7
	20	1	Mkangazi	*Khaya anthotheca*	241	10	7	0.04	9.4
	21	1	Sedlela	*Cedrella odorata*	310	8	7	0.03	7.7
	22	0.5	Mkangazi	*Khaya anthotheca*	218	9	7	0.03	6.8
	23	1	Mtiki	*Tectona grandis*	256	24	25	0.53	136.6
	24	1	Sedlela	*Cedrella odorata*	210	18	14	0.20	42.6
	25	2	Mkangazi	*Khaya anthotheca*	430	14	13	0.12	49.8
	26	1.5	Mkangazi	*Khaya anthotheca*	250	15	14	0.14	35.0
Total	**84**	**212**			**7247**				**1113.6**
Average	**21**	**2.5**							**2.8**

Appendix 7: Total number of trees and Volume per village per farm/woodlot

Village name	Plot no.	Plot size	n ame of tree	Botanical name	Number of trees	Total volume per tree
Ulaya	1	1	Mkambaa	*Acacia nigrescens*	1	0.66
			Mzeza	*Pterocarpus rotundifolius*	1	0.56
			Mninga	*Pterocarpus angolensis*	1	0.98
			Mninga dume	*Pterocarpus tinctorius*	1	1.62
			Mninga	*Pterocarpus angolensis*	1	0.83
	2	2	Muani(myombo)	*Brachystegia Boehmii*	1	1.68
			Muwanga	*Pericopsis angolensis*	1	0.88
			Muwanga	*Pericopsis angolensis*	1	0.04
	3	4	Muwanga	*Pericopsis angolensis*	1	0.34
			Muwanga	*Pericopsis angolensis*	1	2.91
			Embe	*Mangifera indica*	1	0.13
			Embe	*Mangifera indica*	1	0.07
			Pera	*Gsidium guajava*	1	0.02
			Mgung'u	*unkown*	1	0.62
	4	0.5	Mninga	*Pterocarpus angolensis*	1	1.49
			Mlama mwesi	*Combretum schumanii*	1	0.39
	5	3	Mninga	*Pterocarpus angolensis*	1	1.39
			Mtogo	*Diplorhynchus condylocarpon*	1	0.78
			Muwanga	*Pericopsis angolensis*	1	1.30
			Embe	*Mangifera indica*	1	0.14
	6	2	Mninga	*Pterocarpus angolensis*	1	0.48
			Mninga dume	*Pterocarpus tinctorius*	1	0.78
			Mlama mweupe	*Combretum adenogonium*	1	0.06
			Mgurukaziva	*Lonchocarpus bussei*	1	0.04
			Msolo	*Pseudolachnostylis maprouneifolia*	1	0.02
			Msungwi	*Vitex mombassae*		0
	7	2.5	Msungwi	*Vitex mombassae*	1	0.66
			Mtogo	*Diplorhynchus condylocarpon*	1	0.40
			Mkambaa	*Acacia nigrescens*	1	0.10
			Mgegele	*Drypetes sp.*	1	0.01
			Mgegele	*Drypetes sp.*	1	0.01
			Mkambaa	*Acacia nigrescens*	1	0.04
			Mmemenambeva	*unkown*	1	0.17
			Mgulumo	*Lannea schimperi*	1	0.49
	8	4	Mninga dume	*Pterocarpus tinctorius*	1	3.49
			Mnyenye	*Xeroderris stuhlmannii*	1	1.18
			Mkwaju	*Tamarindus indica*	1	4.36
			Muwanga	*Pericopsis angolensis*	1	1.88
			Mtopetope	*Annona senegalensis*	1	0.09
			Muwanga	*Pericopsis angolensis*	1	1.12
			Mninga	*Pterocarpus angolensis*	1	1.99
			Mgunga	*Acacia polyacantha*	1	1.63

Appendix 8: The selected five LK IAGTS in farm

Local name	Botanical name	No. of species	BDM (cm)	DBH (cm)	Height (m)	Volume of single tree	Total volume of single tree
Mfudu	Vitex keniensis	1	25	21	7	0.18	0.18
Mfudu	Vitex keniensis	1	25	21	7	0.18	0.18
Mfudu	Vitex keniensis	1	39	23	8	0.23	0.23
Mfudu	Vitex keniensis	1	37	26	9	0.32	0.32
Mfudu	Vitex keniensis	1	37	26	9	0.32	0.32
Mfudu	Vitex keniensis	1	25	23	19	0.41	0.41
Mfudu	Vitex keniensis	1	38	30	16	0.63	0.63
Mfudu	Vitex keniensis	1	38	30	16	0.63	0.63
Mfudu	Vitex keniensis	1	48	34	14	0.74	0.74
Mfudu	Vitex keniensis	1	48	34	14	0.74	0.74
Mfudu	Vitex keniensis	1	51	46	15	1.43	1.43
Mfudu	Vitex keniensis	1	53	51	12	1.52	1.52
Mfudu	Vitex keniensis	1	56	54	14	1.89	1.89
Mfudu	Vitex keniensis	1	57	50	18	1.91	1.91
Mfudu	Vitex keniensis	1	64	62	14	2.50	2.50
Mfudu	Vitex keniensis	1	65	63	21	3.38	3.38
Mfudu	Vitex keniensis	1	65	63	26	3.89	3.89
Mfumbili	Lonchocarpus capassa	1	3	2	4.5	0.00	0.00
Mfumbili	Lonchocarpus capassa	1	20	18	11.5	0.18	0.18
Mfumbili	Lonchocarpus capassa	1	21	19	13	0.22	0.22
Mfumbili	Lonchocarpus capassa	1	19	17	24	0.26	0.26
Mfumbili	Lonchocarpus capassa	1	19	17	24	0.26	0.26
Mfumbili	Lonchocarpus capassa	1	22	19	18	0.27	0.27
Mfumbili	Lonchocarpus capassa	1	22	19	18	0.27	0.27
Mfumbili	Lonchocarpus capassa	1	24	22	13	0.29	0.29
Mfumbili	Lonchocarpus capassa	1	29	25	11.5	0.35	0.35
Mfumbili	Lonchocarpus capassa	1	38	30	18.5	0.69	0.69
Mng'ongo	Lannea schimperi	1	5	3.5	4.5	0.00	0.00
Mng'ongo	Lannea schimperi	1	17	15	6	0.08	0.08
Mng'ongo	Lannea schimperi	1	18	16.5	8.5	0.12	0.12
Mng'ongo	Lannea schimperi	1	23	20	7.5	0.17	0.17
Mng'ongo	Lannea schimperi	1	18	16	15	0.17	0.17
Mng'ongo	Lannea schimperi	1	30	24	9	0.27	0.27

Village name	Plot no.	Plot size	n ame of tree	*Botanical name*	Number of trees	Total volume per tree
	14	3	Mtogo	*Diplorhynchus condylocarpon*	1	0.91
			Mninga	*Pterocarpus angolensis*	1	1.02
			Mtondolo	*Brachstegia spiciformis*	1	4.42
			Mtondoo	*Brachstegia spiciformis*	1	1.77
			Mninga	*Pterocarpus angolensis*	1	1.05
			Mninga	*Pterocarpus angolensis*	1	0.96
			Mfudu	*Vitex keniensis*	1	1.43
			Mfudu	*Vitex keniensis*	1	1.91
	15	3.5	Mfudu	*Vitex keniensis*	1	0.23
			Mfudu	*Vitex keniensis*	1	3.89
			Mfudu	*Vitex keniensis*	1	0.41
			Embe	*Mangifera indica*	1	0.02
			Mfudu	*Vitex keniensis*	1	1.52
			Mkuyu	*Ficus sycomorus*	1	0.34
	16	4	Embe	*Mangifera indica*	1	0.05
			Mkuyu	*Ficus sycomorus*	1	1.42
			Mtalula	*Acacia polyacantha*	1	0.05
			Mfudu	*Vitex keniensis*	1	0.18
			Mfudu	*Vitex keniensis*	1	0.32
			Mtopetope	*Annona senegalensis*	1	0.79
			Mfudu	*Vitex keniensis*	1	0.63
			Mfudu	*Vitex keniensis*	1	0.74
	17	2	Mninga	*Pterocarpus angolensis*	1	0.73
			Mninga	*Pterocarpus angolensis*	1	1.83
			Msegese	*Piliostigma thonningii*	1	0.19
			Muwanga	*Pericopsis angolensis*	1	3.57
			Mninga	*Pterocarpus angolensis*	1	1.49
	18	4.5	Gamelina	*unkown*	1	2.31
			Gamelina	*unkown*	1	2.49
			Mninga	*Pterocarpus angolensis*	1	0.16
			Mninga	*Pterocarpus angolensis*	1	1.41
			Mninga	*Pterocarpus angolensis*	1	1.01
			Embe	*Mangifera indica*	1	0.34
			Embe	*Mangifera indica*	1	0.71
	19	3.5	Mkaratusi	*Eucalyptus saligina*	1	1.39
			Mfudu	*Vitex keniensis*	1	3.38
			Embe	*Mangifera indica*	1	0.40
			Mfudu	*Vitex keniensis*	1	2.50
			Mkaratusi	*Eucalyptus saligina*	1	0.52
			Embe	*Mangifera indica*	1	0.77

Village name	Plot no.	Plot size	n ame of tree	Botanical name	Number of trees	Total volume per tree
	20	2.5	Mkwaju	*Tamarindus indica*	1	1.18
			Msondo	*unkown*	1	1.49
			Mkorosho	*Anacardium occidentale*	1	0.14
			Embe	*Mangifera indica*	1	0.22
			Mdampa	*unkown*	1	0.87
			Mninga	*Pterocarpus angolensis*	1	2.65
	21	4	Mtogo	*Diplorhynchus condylocarpon*	1	0.40
			Mng'ongo	*Lannea schimperi*	1	0.17
			Mtondolo	*Brachstegia spiciformis*	1	0.10
			Mtalula	*Acacia polyacantha*	1	0.15
			Mtalula	*Acacia polyacantha*	1	0.37
			Mtamba	*unkown*	1	0.20
			Mmemenambeva	*unkown*	1	0.07
			Embe	*Mangifera indica*	1	0.08
			Mtamba	*unkown*	1	1.12
	22	3	Mtogo	*Diplorhynchus condylocarpon*	1	0.23
			Mtogo	*Diplorhynchus condylocarpon*	1	0.51
			Mtamba	*unkown*	1	1.57
			Mtogo	*Diplorhynchus condylocarpon*	1	0.29
			Mtogo	*Diplorhynchus condylocarpon*	1	0.53
			Mmemenambeva	*unkown*		0
			Mtopetope	*Annona senegalensis*	1	0.05
	23	2	Mfudu	*Vitex keniensis*	1	1.89
			Mninga	*Pterocarpus angolensis*	1	1.25
			Mkuyu	*Ficus sycomorus*	1	0.08
			Embe	*Mangifera indica*	1	0.32
			Mfudu	*Vitex keniensis*	1	0.18
			Mfudu	*Vitex keniensis*	1	0.32
			Mtopetope	*Annona senegalensis*	1	0.79
			Mfudu	*Vitex keniensis*	1	0.63
			Mninga	*Pterocarpus angolensis*	1	0.98
			Mninga	*Pterocarpus angolensis*	1	0.74

Village name	Plot no.	Plot size	n ame of tree	Botanical name	Number of trees	Total volume per tree
	24	6	Mmemenambeva	*unkown*	1	1.34
			Mng'ongo	*Lannea schimperi*	1	3.67
			Mninga	*Pterocarpus angolensis*	1	0.88
			Mninga	*Pterocarpus angolensis*	1	0.93
			Mmemenambeva	*unkown*	1	0.55
			Mninga	*Pterocarpus angolensis*	1	1.23
			Mninga	*Pterocarpus angolensis*	1	0.88
			Muwanga	*Pericopsis angolensis*	1	1.49
			Msigi	*unkown*	1	0.32
	25	4	Mtogo	*Diplorhynchus condylocarpon*	1	0.64
			Mninga	*Pterocarpus angolensis*	1	0.81
	26	2	Mnyongamembe	*Steganotaenia araliacea*	1	0.33
			Mhani	*Brachystegia Boehmii*	1	1.80
			Mtogo	*Diplorhynchus condylocarpon*	1	0.78
			Mninga	*Pterocarpus angolensis*	1	0.12
			Muwambangoma	*unkown*	1	0.09
	27	3	Mgung'u	*unkown*	1	0.68
			Mgung'u	*unkown*	1	2.86
			Gamelina	*unkown*	1	1.14
			Mgung'u	*unkown*	1	3.28
			Embe	*Mangifera indica*	1	0.07
	28	2	Mninga	*Pterocarpus angolensis*	1	0.37
			Gamelina	*Tectona grandis*	1	1.91
			Mmemenambeva	*unkown*	1	0.62
			Mpingo	*Pterocarpus angolensis*	1	0.27
			Mninga	*Pterocarpus angolensis*	1	0.32
	29	2	Msungwi	*Vitex mombassae*	1	3.05
			Mpingo	*Pterocarpus angolensis*	1	0.39
			Mfudu	*Vitex keniensis*	1	0.74
			Mndulu	*Dichrostachys cinerea*	1	0.56
			Msungwi	*Vitex mombassae*	1	2.07
			Msombe	*Ficus sycomorus*	1	2.38
			Msungwi	*Vitex mombassae*	1	1.92
			Msungwi	*Vitex mombassae*	1	2.32
			Mgung'u	*Vitex mombassae*	1	0.76
			Msungwi	*Vitex mombassae*	1	0.94

Village name	Plot no.	Plot size	n ame of tree	Botanical name	Number of trees	Total volume per tree
	30	5.5	Mninga	*Pterocarpus angolensis*	1	0.89
			Msungwi	*Vitex mombassae*	1	0.42
			Mtogo	*Diplorhynchus condylocarpon*	1	0.14
			Mtogo	*Diplorhynchus condylocarpon*	1	0.49
			Msungwi	*Vitex mombassae*	1	0.66
			Mninga	*Pterocarpus angolensis*	1	0.71
			Mtogo	*Diplorhynchus condylocarpon*	1	0.37
			Mtogo	*Diplorhynchus condylocarpon*	1	0.27
			Mninga	*Pterocarpus angolensis*	1	0.77
			Mninga	*Pterocarpus angolensis*	1	1.62
			Mninga	*Pterocarpus angolensis*	1	0.40
			98.5		**200**	**180.01**
R.Gongoni	1	2	Mlama mweupe	*Combretum adenogonium*	1	0.04
			Mkole	*Grewia similis*	1	0.02
			Mlama mweupe	*Combretum adenogonium*	1	0.35
			Mlama mweupe	*Combretum adenogonium*	1	0.04
			Mlama mweupe	*Combretum adenogonium*	1	0.02
	2	1.5	Mfiligisi	*unkown*	1	1.83
			Mmbinji	*unkown*	1	0.20
			Mhegea	*Kigelia africana*	1	1.75
	3	1	Mnjenja	*unkown*	1	0.72
			Mlama mweupe	*Combretum adenogonium*	1	0.32
			Mlama mweupe	*Combretum adenogonium*	1	0.46
			Mlama mweupe	*Combretum adenogonium*	1	0.45
			Mlama mweupe	*Combretum adenogonium*	1	0.63
			Mlama mweupe	*Combretum adenogonium*	1	0.61
			Mnjenja	*unkown*	1	0.52
			Mnjenja	*unkown*	1	0.47
	4	3	Mfumbili	*Lonchocarpus capassa*	1	0.69
			Mfumbili	*Lonchocarpus capassa*	1	0.26
			Mfumbili	*Lonchocarpus capassa*	1	0.27
			Mbiobio	*unkown*	1	0.27
			Mbiobio	*unkown*	1	1.12
	5	4	Mnjenja	*unkown*	1	0.55
			Mnjenja	*unkown*	1	0.80
			Mnjenja	*unkown*	1	0.72
			Mng'ongo	*Lannea schimperi*	1	1.56
			Mlama mweupe	*Combretum adenogonium*	1	0.93

Villag e name	Plot no.	Plot size	n ame of tree	*Botanical name*	Number of trees	Total volume per tree
	6	1.5	Mlama mwesi	*Combretum molle*	1	0.79
			Mkambaa	*Acacia nigrescens*	1	0.49
			Mkani	*Allanblackia ulugurensis*	1	0.62
			Mkambaa	*Acacia nigrescens*	1	1.95
			Mlama mweupe	*Combretum adenogonium*	1	0.06
	7	3	Mkambaa	*Acacia nigrescens*	1	1.30
			Mfumbili	*Lonchocarpus capassa*	1	0.22
			Mfumbili	*Lonchocarpus capassa*	1	0.18
			Mnjenja	*unkown*	1	0.96
			Mng'ongo	*Lannea schimperi*	1	0.27
			Mnig-mpini	*Pterocarpus tinctorius*	1	0.42
			Mng'ongo	*Lannea schimperi*	1	0.12
	8	4	Mfumbili	*Lonchocarpus capassa*	1	0.29
			Mfumbili	*Lonchocarpus capassa*	1	0.35
			Mnjenja	*unkown*	1	1.32
			Mkambaa	*Acacia nigrescens*	1	2.38
			Mpingo	*Dalbergia melanoxylon*	1	0.02
	9	3	Mlama mweupe	*Combretum adenogonium*	1	0.23
			Mng'ongo	*Lannea schimperi*	1	0.59
			Mtalawanda	*Markhamia zanzibarica*	1	0.17
			Mkizingwi	*unkown*	1	0.26
			Muozaoza	*Sterculia africana*	1	0.70
			Muozaoza	*Sterculia africana*	1	0.56
			Muozaoza	*Sterculia africana*	1	0.52
			Muozaoza	*Sterculia africana*	1	0.95
			Muozaoza	*Sterculia africana*	1	0.52
			Muozaoza	*Sterculia africana*	1	0.60
			Mhembeti	*Sterculia quinqueloba*	1	0.69
	10	2	Mtalula	*Acacia polyacantha*	1	1.46
			Mkambaa	*Acacia nigrescens*	1	1.53
			Mng'ongo	*Lannea schimperi*	1	0.31
			Mng'ongo	*Lannea schimperi*	1	0.85
			Mng'ongo	*Lannea schimperi*	1	0.41
			Mng'ongo	*Lannea schimperi*	1	1.33
	11	4.5	Mninga dume	*Pterocarpus tinctorius*	1	0.64
			Mninga dume	*Pterocarpus tinctorius*	1	0.61
			Mninga dume	*Pterocarpus tinctorius*	1	0.13
			Mkole	*Grewia similis*	1	0.39
			Mng'ongo	*Lannea schimperi*	1	1.16
			Mkwaju	*Tamarindus indica*	1	0.12
			mkwaju	*Tamarindus indica*	1	0.22

Villag e name	Plot no.	Plot size	n ame of tree	*Botanical name*	Number of trees	Total volume per tree
	12	3.5	Muozaoza	*Sterculia africana*	1	0.36
			Mlama mwesi	*Combretum molle*	1	0.90
			Mkambaa	*Acacia nigrescens*	1	1.31
			Mlama mwesi	*Combretum molle*	1	0.18
			Mlama mwesi	*Combretum molle*	1	0.08
			Mlama mwesi	*Combretum molle*	1	0.07
			Mng'ongo	*Lannea schimperi*	1	0.80
	13	2	Mlama mweupe	*Combretum adenogonium*	1	0.09
			Mkongowe	*Acacia robusta*	1	0.99
			Mng'ongo	*Lannea schimperi*	1	2.27
	14	2.5	Mng'ongo	*Lannea schimperi*	1	0.87
			Mlama mweupe	*Combretum adenogonium*	1	0.85
			Mng'ongo	*Lannea schimperi*	1	0.69
			Mng'ongo	*Lannea schimperi*	1	0.52
			Muozaoza	*Sterculia africana*	1	0.25
			Mlama mwesi	*Combretum molle*	1	0.57
			Mlama mwesi	*Combretum molle*	1	0.80
			Mlama mweupe	*Combretum adenogonium*	1	0.03
			Mlama mweupe	*Combretum adenogonium*	1	0.03
			Mlama mweupe	*Combretum adenogonium*	1	0.01
			Mlama mweupe	*Combretum adenogonium*	1	0.03
			Mng'ongo	*Lannea schimperi*	1	0.67
	15	4	Mninga dume	*Pterocarpus tinctorius*	1	0.29
			Mninga dume	*Pterocarpus tinctorius*	1	0.03
			Mninga dume	*Pterocarpus tinctorius*	1	0.04
			Mhembeti	*Sterculia quinqueloba*	1	0.52
			Mhembeti	*Sterculia quinqueloba*	1	0.56
			Mkambaa	*Acacia nigrescens*	1	0.45
			Mkambaa	*Acacia nigrescens*	1	0.35
			Mkambaa	*Acacia nigrescens*	1	0.19
			Mkambaa	*Acacia nigrescens*	1	0.19
			Mkambaa	*Acacia nigrescens*	1	0.10
			Mninga	*Pterocarpus angolensis*	1	1.86
	16	2	Mfuleto	*Albizia anthelmintica*	1	0.13
			Mfuleto	*Albizia anthelmintica*	1	0.25
			Mfuleto	*Albizia anthelmintica*	1	0.13
			Mlama mweupe	*Combretum adenogonium*	1	0.23
			Mlama mwesi	*Combretum molle*	1	0.37
			Mninga dume	*Pterocarpus tinctorius*	1	3.03

Village name	Plot no.	Plot size	n ame of tree	*Botanical name*	Number of trees	Total volume per tree
	17	3	Mkambaa	*Acacia nigrescens*	1	0.25
			Mlama mweupe	*Combretum adenogonium*	1	0.64
			Mlama mweupe	*Combretum adenogonium*	1	0.38
			Mlama mweupe	*Combretum adenogonium*	1	0.40
			Mlama mwesi	*Combretum molle*	1	0.31
			Mninga dume	*Pterocarpus tinctorius*	1	0.31
			Mninga dume	*Pterocarpus tinctorius*	1	0.35
	18	7	Mlama mweupe	*Combretum adenogonium*	1	0.89
			Mlama mwesi	*Combretum molle*	1	0.37
			Mninga dume	*Pterocarpus tinctorius*	1	3.26
			Mninga dume	*Pterocarpus tinctorius*	1	0.03
			Mninga dume	*Pterocarpus tinctorius*	1	0.04
			Mfumbili	*Lonchocarpus capassa*	1	0.26
			Mfumbili	*Lonchocarpus capassa*	1	0.27
			Mlama mweupe	*Combretum adenogonium*	1	0.58
			Mnjenja	*unkown*	1	0.56
	19	5	Mninga dume	*Pterocarpus tinctorius*	1	0.36
			Mninga dume	*Pterocarpus tinctorius*	1	0.50
			Mkwaju	*Tamarindus indica*	1	0.66
			Mkwaju	*Tamarindus indica*	1	0.98
	19	58.5			126	74.67
Mabana	1	2	Mkole	*Grewia similis*	1	0.00
			Mfumbili	*Lonchocarpus capassa*	1	0.00
			Mfunganyumbu	*unkown*	1	0.00
	2	1	Mfunganyumbu	*unkown*	1	0.01
			Mng'ongo	*Lannea schimperi*	1	0.00
	3	3	Mkambaa	*Acacia nigrescens*	1	0.01
			Mkonga	*Azadirachta indica*	1	0.00
			Mfunganyumbu		1	0.00
			Mkole	*Acacia nigrescens*	1	0.01
			Mkambaa	*Acacia nigrescens*	1	0.88
	4	3	Mng'ongo	*Lannea schimperi*	1	0.46
			Mwarobaini	*Azadirachta indica*	1	0.03
			Mwarobaini	*Azadirachta indica*	2	0.04
			Mkongowe	*Acacia robusta*	1	0.44
			Muwanga	*Pericopsis angolensis*	1	0.00

Village name	Plot no.	Plot size	n ame of tree	Botanical name	Number of trees	Total volume per tree
			Msegese	*Piliostigma thonningii*	2	0.04
			Mkonga	*Azadirachta indica*	2	0.27
	6	4	Mkongowe	*Acacia robusta*	1	0.23
			Mpingo	*Dalbergia melanoxylon*	2	0.05
			Msegese	*Piliostigma thonningii*	1	0.02
			Kinzasa		1	0.59
			Mkudekude		1	0.08
	7	1	Kinzasa		1	0.03
	8	8	Mpingo	*Dalbergia melanoxylon*	1	0.04
			Mpingo	*Dalbergia melanoxylon*	1	0.04
			Msegese	*Piliostigma thonningii*	1	0.20
	9	2	Muwanga	*Pericopsis angolensis*	1	0.77
			Mkwaju	*Tamarindus indica*	1	0.43
			Mkwaju	*Tamarindus indica*	1	0.68
	9	**27**			**36**	**5.52**
Madudu	1	1	Sedlela	*Cedrella odorata*	118	4.37
			Mkangazi	*Khaya anthotheca*	420	64.69
	2	0.5	Sedlela	*Cedrella odorata*	92	4.74
			Mvule	*Milicia excelsa*	238	8.81
	3	0.5	Sedlela	*Cedrella odorata*	80	5.32
			Mkangazi	*Khaya anthotheca*	119	4.63
	3	0.5	Sedlela	*Cedrella odorata*	48	3.19
			Mkangazi	*Khaya anthotheca*	152	23.41
	4	0.5	Sedlela	*Cedrella odorata*	50	2.99
			Mkangazi	*Khaya anthotheca*	130	23.82
	6	0.5	Embe	*mangifera indika*	311	8.36
			Mkangazi	*Khaya anthotheca*	14	6.47
	7	10	Mvule	*Milicia excelsa*	31	5.68
	8	0.5	Sedlela	*Cedrella odorata*	14	6.84
			Mtiki	*Tectona grandis*	4	1.50
			Mkomba	*unkown*	7	0.05
			Mvule	*Milicia excelsa*	34	8.14
			Mtiki	*Tectona grandis*	312	90.60
	9	0.5	Sedlela	*Cedrella odorata*	49	14.77
			Mvule	*Milicia excelsa*	148	31.72

Village name	Plot no.	Plot size	n ame of tree	*Botanical name*	Number of trees	Total volume per tree
	10	0.5	Sedlela	*Cedrella odorata*	180	17.55
	11	0.5	Mvule	*Milicia excelsa*	116	16.73
			Sedlela	*Cedrella odorata*	92	24.31
	12	0.5	Mvule	*Milicia excelsa*	125	37.69
	13	0.5	Mkangazi	*Khaya anthotheca*	54	2.10
	14	0.5	Sedlela	*Cedrella odorata*	172	17.10
	15	0.5	Sedlela	*Cedrella odorata*	285	31.96
	16	0.5	Mvule	*Milicia excelsa*	310	22.09
	17	0.5	Mvule	*Milicia excelsa*	315	39.85
	18	0.5	Mkangazi	*Khaya anthotheca*	640	25.42
	19	0.5	Sedlela	*Cedrella odorata*	310	9.73
	20	1	Mkangazi	*Khaya anthotheca*	241	9.37
	21	1	Sedlela	*Cedrella odorata*	310	7.66
	22	0.5	Mkangazi	*Khaya anthotheca*	218	6.85
	23	1	Mtiki	*Tectona grandis*	256	136.61
	24	1	Sedlela	*Cedrella odorata*	210	42.60
	25	2	Mkangazi	*Khaya anthotheca*	430	49.84
	26	1.5	Mkangazi	*Khaya anthotheca*	250	35.0 0
	26	**27.5**			**6885**	**863.56**
Total	**84**	**212**			**7247**	**1114**
Average vol.	**21**	**2.52**				**2.8**

Appendix 9: The selected five LK IAGTS in farm

Local name	Botanical name	No. of species	BDM (cm)	DBH (cm)	Height (m)	Volume of single tree	Total volume of single tree
Mfudu	Vitex keniensis	1	25	21	7	0.18	0.18
Mfudu	Vitex keniensis	1	25	21	7	0.18	0.18
Mfudu	Vitex keniensis	1	39	23	8	0.23	0.23
Mfudu	Vitex keniensis	1	37	26	9	0.32	0.32
Mfudu	Vitex keniensis	1	37	26	9	0.32	0.32
Mfudu	Vitex keniensis	1	25	23	19	0.41	0.41
Mfudu	Vitex keniensis	1	38	30	16	0.63	0.63
Mfudu	Vitex keniensis	1	38	30	16	0.63	0.63
Mfudu	Vitex keniensis	1	48	34	14	0.74	0.74
Mfudu	Vitex keniensis	1	48	34	14	0.74	0.74
Mfudu	Vitex keniensis	1	51	46	15	1.43	1.43
Mfudu	Vitex keniensis	1	53	51	12	1.52	1.52
Mfudu	Vitex keniensis	1	56	54	14	1.89	1.89
Mfudu	Vitex keniensis	1	57	50	18	1.91	1.91
Mfudu	Vitex keniensis	1	64	62	14	2.50	2.50
Mfudu	Vitex keniensis	1	65	63	21	3.38	3.38
Mfudu	Vitex keniensis	1	65	63	26	3.89	3.89
Mfumbili	Lonchocarpus capassa	1	3	2	4.5	0.00	0.00
Mfumbili	Lonchocarpus capassa	1	20	18	11.5	0.18	0.18
Mfumbili	Lonchocarpus capassa	1	21	19	13	0.22	0.22
Mfumbili	Lonchocarpus capassa	1	19	17	24	0.26	0.26
Mfumbili	Lonchocarpus capassa	1	19	17	24	0.26	0.26
Mfumbili	Lonchocarpus capassa	1	22	19	18	0.27	0.27
Mfumbili	Lonchocarpus capassa	1	22	19	18	0.27	0.27
Mfumbili	Lonchocarpus capassa	1	24	22	13	0.29	0.29
Mfumbili	Lonchocarpus capassa	1	29	25	11.5	0.35	0.35
Mfumbili	Lonchocarpus capassa	1	38	30	18.5	0.69	0.69
Mng'ongo	Lannea schimperi	1	5	3.5	4.5	0.00	0.00
Mng'ongo	Lannea schimperi	1	17	15	6	0.08	0.08
Mng'ongo	Lannea schimperi	1	18	16.5	8.5	0.12	0.12
Mng'ongo	Lannea schimperi	1	23	20	7.5	0.17	0.17
Mng'ongo	Lannea schimperi	1	18	16	15	0.17	0.17
Mng'ongo	Lannea schimperi	1	30	24	9	0.27	0.27

Local name	Botanical name	No. of species	BDM (cm)	DBH (cm)	Height (m)	Volume of single tree	Total volume of single tree
Mng'ongo	Lannea schimperi	1	25	23	12.5	0.31	0.31
Mng'ongo	Lannea schimperi	1	32	28	10.5	0.41	0.41
Mng'ongo	Lannea schimperi	1	36	31	9	0.46	0.46
Mng'ongo	Lannea schimperi	1	36	31	11	0.52	0.52
Mng'ongo	Lannea schimperi	1	37	32	12	0.59	0.59
Mng'ongo	Lannea schimperi	1	39	34	12	0.67	0.67
Mng'ongo	Lannea schimperi	1	37	36	10.5	0.67	0.69
Mng'ongo	Lannea schimperi	1	44	38	11	0.79	0.79
Mng'ongo	Lannea schimperi	1	39	36	14.5	0.87	0.85
Mng'ongo	Lannea schimperi	1	48	41	10	0.87	0.87
Mng'ongo	Lannea schimperi	1	47	43	13.5	1.16	1.16
Mng'ongo	Lannea schimperi	1	49	44	15.5	1.33	1.33
Mng'ongo	Lannea schimperi	1	50	48	15	1.56	1.56
Mng'ongo	Lannea schimperi	1	56	53	19.5	2.27	2.26
Mng'ongo	Lannea schimperi	1	65	62	25	3.67	3.67
Msolo		1	15	10	3	0.02	0.02
Msolo		1	49	47	18	1.68	1.68
Mlama mweupe	Combretum adenogonium	1	7	5	3.5	0.01	0.01
Mlama mweupe	Combretum adenogonium	1	11	8	5.5	0.02	0.02
Mlama mweupe	Combretum adenogonium	1	11	9	5.5	0.03	0.03
Mlama mweupe	Combretum adenogonium	1	12	10	4.5	0.03	0.03
Mlama mweupe	Combretum adenogonium	1	5	10	4.5	0.03	0.03
Mlama mweupe	Combretum adenogonium	1	14	10	7	0.04	0.04
Mlama mweupe	Combretum adenogonium	1	14	10	7.5	0.04	0.04
Mlama mweupe	Combretum adenogonium	1	16	12	7	0.06	0.06
Mlama mweupe	Combretum adenogonium	1	15	12	8.5	0.06	0.06
Mlama mweupe	Combretum adenogonium	1	16	14	9	0.09	0.09
Mlama mweupe	Combretum adenogonium	1	24	20	12	0.23	0.22
Mlama mweupe	Combretum adenogonium	1	26	18.5	15.5	0.23	0.23
Mlama mweupe	Combretum adenogonium	1	23	19	24	0.32	0.32
Mlama mweupe	Combretum adenogonium	1	26	23	15	0.35	0.35

Local name	Botanical name	No. of species	BDM (cm)	DBH (cm)	Height (m)	Volume of single tree	Total volume of single tree
Mlama mweupe	Combretum adenogonium	1	23	22	19.5	0.38	0.38
Mlama mweupe	Combretum adenogonium	1	28	23	18.5	0.40	0.40
Mlama mweupe	Combretum adenogonium	1	26	23	22	0.45	0.45
Mlama mweupe	Combretum adenogonium	1	25	23	23	0.46	0.46
Mlama mweupe	Combretum adenogonium	1	34	31	13	0.58	0.58
Mlama mweupe	Combretum adenogonium	1	34	31	14	0.61	0.61
Mlama mweupe	Combretum adenogonium	1	30	26	25	0.63	0.63
Mlama mweupe	Combretum adenogonium	1	32	26	25.5	0.64	0.64
Mlama mweupe	Combretum adenogonium	1	42	40	10.5	0.85	0.85
Mlama mweupe	Combretum adenogonium	1	38	35	17	0.89	0.89
Mlama mweupe	Combretum adenogonium	1	45	38	14	0.93	0.93
Total		75				50.66	50.66
Average				28	13	0.68	
						2.70	

Appendix 9: Availability of LK IAGTS in farms per species

Local name	Botanical name	Family name	No. of species	BDM (cm)	DBH (cm)	Height (m)	Total volume single tree
Mfudu	*Vitex keniensis*	Combretaceae	1	25	21	7	0.18
Mfudu	*Vitex keniensis*	Combretaceae	1	25	21	7	0.18
Mfudu	*Vitex keniensis*	Combretaceae	1	39	23	8	0.23
Mfudu	*Vitex keniensis*	Combretaceae	1	37	26	9	0.32
Mfudu	*Vitex keniensis*	Combretaceae	1	37	26	9	0.32
Mfudu	*Vitex keniensis*	Combretaceae	1	25	23	19	0.41
Mfudu	*Vitex keniensis*	Combretaceae	1	38	30	16	0.63
Mfudu	*Vitex keniensis*	Combretaceae	1	38	30	16	0.63
Mfudu	*Vitex keniensis*	Combretaceae	1	48	34	14	0.74
Mfudu	*Vitex keniensis*	Combretaceae	1	48	34	14	0.74
Mfudu	*Vitex keniensis*	Combretaceae	1	51	46	15	1.43
Mfudu	*Vitex keniensis*	Combretaceae	1	53	51	12	1.52
Mfudu	*Vitex keniensis*	Combretaceae	1	56	54	14	1.89
Mfudu	*Vitex keniensis*	Combretaceae	1	57	50	18	1.91
Mfudu	*Vitex keniensis*	Combretaceae	1	64	62	14	2.50
Mfudu	*Vitex keniensis*	Combretaceae	1	65	63	21	3.38
Mfudu	*Vitex keniensis*	Combretaceae	1	65	63	26	3.89
			17				**20.88**
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	3	2	4.5	0.00
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	20	18	11.5	0.18
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	21	19	13	0.22
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	19	17	24	0.26
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	19	17	24	0.26
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	22	19	18	0.27
Mfumbili	*Lonchocarpus capassa*	Combretaceae	1	22	19	18	0.27
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	24	22	13	0.29
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	29	25	11.5	0.35
Mfumbili	*Lonchocarpus capassa*	Fabaceae	1	38	30	18.5	0.69
			10				**2.77**
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	5	3.5	4.5	0.00
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	17	15	6	0.08
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	18	16.5	8.5	0.12

Local name	Botanical name	Family name	No. of species	BDM (cm)	DBH (cm)	Height (m)	Total volume single tree
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	18	16	15	0.17
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	30	24	9	0.27
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	25	23	12.5	0.31
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	32	28	10.5	0.41
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	36	31	9	0.46
Mng'ongo	*Lannea schimperi*		1	36	31	11	0.52
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	37	32	12	0.59
Mng'ongo	*Lannea schimperi*		1	39	34	12	0.67
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	37	36	10.5	0.69
Mng'ongo	*Lannea schimperi*	Combretaceae	1	44	38	11	0.79
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	39	36	14.5	0.85
Mng'ongo	*Lannea schimperi*	Combretaceae	1	48	41	10	0.87
Mng'ongo	*Lannea schimperi*		1	47	43	13.5	1.16
Mng'ongo	*Lannea schimperi*		1	49	44	15.5	1.33
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	50	48	15	1.56
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	56	53	19.5	2.27
Mng'ongo	*Lannea schimperi*	Anarcadiaceae	1	65	62	25	3.67
			21				**16.95**
Msolo	*Pseudolachnostylis maprouneifolia*		1	15	10	3	0.02
Msolo	*Pseudolachnostylis maprouneifolia*		1	49	47	18	1.68
			2				**1.71**
Mlama mweupe	*Combretum adenogonium*		1	7	5	3.5	0.01
Mlama mweupe	*Combretum adenogonium*		1	11	8	5.5	0.02
Mlama mweupe	*Combretum adenogonium*		1	11	9	5.5	0.03
Mlama mweupe	*Combretum adenogonium*		1	12	10	4.5	0.03
Mlama mweupe	*Combretum adenogonium*		1	5	10	4.5	0.03
Mlama mweupe	*Combretum adenogonium*		1	14	10	7	0.04
Mlama mweupe	*Combretum adenogonium*		1	14	10	7.5	0.04
Mlama mweupe	*Combretum adenogonium*		1	16	12	7	0.06
Mlama	*Combretum*		1	15	12	8.5	0.06

mweupe	*adenogonium*					
Mlama mweupe	*Combretum adenogonium*	1	16	14	9	0.09
Mlama mweupe	*Combretum adenogonium*	1	24	20	12	0.23
Mlama mweupe	*Combretum adenogonium*	1	26	18.5	15.5	0.23
Mlama mweupe	*Combretum adenogonium*	1	23	19	24	0.32
Mlama mweupe	*Combretum adenogonium*	1	26	23	15	0.35
Mlama mweupe	*Combretum adenogonium*	1	23	22	19.5	0.38
Mlama mweupe	*Combretum adenogonium*	1	28	23	18.5	0.40
Mlama mweupe	*Combretum adenogonium*	1	26	23	22	0.45
Mlama mweupe	*Combretum adenogonium*	1	25	23	23	0.46
Mlama mweupe	*Combretum adenogonium*	1	34	31	13	0.58
Mlama mweupe	*Combretum adenogonium*	1	34	31	14	0.61
Mlama mweupe	*Combretum adenogonium*	1	30	26	25	0.63
Mlama mweupe	*Combretum adenogonium*	1	32	26	25.5	0.64
Mlama mweupe	*Combretum adenogonium*	1	42	40	10.5	0.85
Mlama mweupe	*Combretum adenogonium*	1	38	35	17	0.89
Mlama mweupe	*Combretum adenogonium*	1	45	38	14	0.93
		25				8.35

Appendix 10: Cost Benefit Analysis of Agroforstry practices of maize and IAGTS for 22 years in household level per farm of 1.26 hector

Years	Cost	Benefit	Net revenue	DC	DR	NPV in % 10	35	45	44.72	r = 44.74
1	1709941	864000	-845941	1554493	785455	-769038	-626624	-583408	-584447	-584447
2	1656942	864000	-792942	1369374	714050	-655324	-435084	-377142	-378487	-378487
3	1656941	2604000	947058	1244885	1956424	711539	384924	310650	312314.	312314
4	1656941	2532000	875058	1131714	1729390	597677	263452	197954	199368	199368
5	1656941	2532000	875058	1028831	1572173	543343	195149	136520	137740	137740
6	1706941	2604000	897058	963524	1469890	506365	148189	96518	97555	97555
7	1656941	2532000	875058	850273	1299316	449043	107078	64932	65746	65746
8	1656941	2532000	875058	772976	1181198	408221	79317	44780	45423	45423
9	1656941	2604000	947058	702705	1104350	401645	63587	33424	33964	33964
10	1656941	2532000	875058	638823	976195	337373	43521	21298	21681	21681
11	1656941	2532000	875058	580748	887450	306703	32237	14688	14979	14979
12	1656941	2604000	947058	527953	829715	301762	25844	10963	11200	11200
13	1656941	2532000	875058	479957	733430	253474	17688	6986	7149	7149
14	1656941	2532000	875058	436325	666755	230431	13102	4818	4939	4939
15	1656941	2604000	947058	396658	623377	226718	10504	3596	3693	3693
16	1656941	2532000	875058	360598	551037	190438	7189	2291	2357	2357
17	1656941	2532000	875058	327817	500943	173125	5325	1580	1629	1629
18	1656941	2604000	947058	298016	468353	170336	4269	1179	1218	1218
19	1656941	2532000	875058	270923	414002	143078	2922	751	777	777
20	1656941	2532000	875058	246294	376365	130072	2164	518	537	537
21	1656941	2604000	947058	223904	351880	127977	1735	386	401	401
22	1656941	2532000	875058	203548	311046.0	107497	1187	246	256	256
	36555724	**52872000**	**16316276**	**14610339**	**19502793**	**4892454**	**347684**	**-6461**	**0.07**	**-0.224**

Appendix 11: Sensitivity Analysis for conserved trees in farms at household level

Years	Cost	Benefit	DC	DR	Net benefit	NPV at % 10%	15%	17%
1	2137428	864000	1943116	785455	-1273428	-1157661	-1107328	-1087117
2	2071178	864000	1711717	714050	-1207177	-997667	-912800	-879783
3	2071178	2604000	1556106	1956424	532823	400318	350340	331504
4	2071178	2532000	1414642	1729391	460823	314748	263477	244761
5	2071178	2532000	1286038	1572173	460823	286135	229110	208951
6	2133678	2604000	1204405	1469890	470323	265485	203333	182057
7	2071178	2532000	1062841	1299317	460823	236475	173240	152282
8	2071178	2532000	966219	1181197	460823	214977	150644	130002
9	2071178	2604000	878381	1104351	532823	225969	151462	128322
10	2071178	2532000	798528	976196	460823	177667	113908	94745
11	2071178	2532000	725935	887451	460823	161516	99051	80883
12	2071178	2604000	659941	829715	532823	169774	99588	79838
13	2071178	2532000	599946	733430	460823	133484	74897	58947
14	2071178	2532000	545405	666755	460823	121349	65127	50323
15	2071178	2604000	495823	623377	53282	127553	65480	49673
16	2071178	2532000	450748	551037	460823	100288	49245	36675
17	2071178	2532000	409771	500942	460823	91171	42822	31309
18	2071178	2604000	372519	468352	532823	95832	43054	30904
19	2071178	2532000	338654	414002	460823	75348	32379	22817
20	2071178	2532000	307867	376366	460823	68498	28156	19479
21	2071178	2604000	279879	351880	532823	72000	28309	19227
22	2071178	2532000	254435	311046	460823	56610	21290	14197
	45 694 655	**52 872 000**	**18 262 924**	**19 502 793**	**7 177 346**	**1239869**	**264788**	**-0.004298**

Appendix 12: Cost Benefit Analysis for planting hardwood woodlot at household level

Years	Cost	Benefits	Net Benefit	NPV at % DC	DB	r=10%	r=50%	r=94%	r=95%
1	1044256	807745	-236511	949324	734314	-215010	-157674	-121913	-121288
2	436089	807745	371656	360404	667558	307154	165180	98750	97740
3	436089	807745	371656	327640	606871	279231	110120	50902	50123
4	407173	0	-407173	278104	0	-278105	-80429	-28745	-28161
6	92930	0	-92930	52457	0	-52457	-8158	-1743	-1690
7	21465	154548	133083	11014	79308	68292	7789	1286	1241
9	64395	231822	167427	27310	98315	71005	4355	430	411
10	0	643950	643950	0	248270	248270	11167	852	810
11	0	289777	289777	0	101566	101565	3350	198	187
12	21500	0	-21500	6852	0	-6851	-165	-8	-7
14	21500	0	-21500	5661	0	-5662	-73	-2	-2
15	0	3477330	3477330	0	832445	832445	7941	168	155
19	0	26788320	26788320	0	4380104	4380104	12084	91	83
TOTAL	2545397	34008982	31463585	2018766	7748750	5729984	75486	267	-398

NPV 5 729 984
IRR 94 %
B/C 3.8

Appendix 13: Sensitivity Analysis for planting hardwood woodlot at household level

Years	Cost	Cost-Sensitvity	Benefits	Net benefit	DC	DR	r=10%	r=25%	r=30%	r=31.34%
1	1044256	1305320	807745	-497575	1186655	734313	-452340	-414645	-382750	-378845
2	436089	545111	807745	262633	450505	667557	217052	182384	155404	152249
3	436089	545111	807745	262633	409550	606870	197320	151987	119541	115920
4	407173	508966	0	-508966	347630	0	-347630	-245450	-178203	-171041
6	92930	116162	0	-116163	65570	0	-65570	-38902	-24066	-22629
7	21465	26831	154548	127717	13768	79307	65538	35643	20353	18943
9	64395	80493	231822	151328	34137	98315	64177	29328	14270	13012
10	0	0	643950	643950	0	248270	248270	104001	46710	42158
11	0	0	289777	289777	0	1015651	101565	39000	16169	14444
12	21500	26875	0	-26875	8563	0	-8563	-3014	-1153	-1019
14	21500	26875	0	-26875	7077	0	-7077	-2093	-682	-591
15	0	0	3477330	3477330	0	832445	832445	225697	67935	58249
19	0	0	26788320	26788320	0	438010	4380104	838497	183240	150800
TOTAL	**2545397**	**3181746**	**34008982**	**30827235**	**2523457**	**7748750**	**5225292**	**902434**	**36771**	**-8349**

Appendix 14: Cost and benefits obtained in each year in planted hardwood woodlot in household level in Madudu area

Cost	Year 1	Year 2	Year 3	Year 4	Year 6	Year 7	Year 9	Year 10	Year 11	Year 12	Year 14	Year 15	Year 19
Maize production	360961	360961	360961	0	0	0	0	0	0	0	0	0	0
Tree planting	608167	0	0	0	0	0	0	0	0	0	0	0	0
Weeding	0	0	0	107325	0	0	0	0	0	0	0	0	0
Fire break	75128	75128	75128	214650	0	21465	21465	0	0	21500	21500	0	0
Pruning -1	0	0	0	32198	0	0	0	0	0	0	0	0	0
Pruuning equipment	0	0	0	53000	0	0	0	0	0	0	0	0	0
Prunning -2	0	0	0	0	42930	0	0	0	0	0	0	0	0
Prunning -3	0	0	0	0	0	0	42930	0	0	0	0	0	0
Vifaa vya prunning	0	0	0	0	0	0	0	0	0	0	0	0	0
Msumeno mkubwa	0	0	0	0	50000	0	0	0	0	0	0	0	0
TOTAL	**1044256**	**436089**	**436089**	**407173**	**92930**	**21465**	**64395**	**0**	**0**	**21500**	**21500**	**0**	**0**
Benefits													
Maize production	807745	807745	807745	0	0	0	0	0	0	0	0	0	0
Firewood collection	0	0	0	0	0	154548	0	0	0	0	0	0	0
Poles and firewood collection	0	0	0	0	0	0	231822	0	289777	0	0	579555	25242840
Harvesting - 1	0	0	0	0	0	0	0	643950	0	0	0	0	0
Harvesting - 2	0	0	0	0	0	0	0	0	0	0	0	2897775	0
Harvesting - 3	0	0	0	0	0	0	0	0	0	0	0	0	1545480
TOTAL	**807745**	**807745**	**807745**	**0**	**0**	**154548**	**231822**	**643950**	**289777**	**0**	**0**	**3477330**	**26788320**

Appendix 15: Investment in woodlot practice in the Households

Year	Activity	Item	Amount	Unit cost (Tshs)	Total cost (Tshs)	Unit Revenue (Tshs)	Total Revenue (Tshs)
	Maize farming	Production cost	1	336326	360961	0	0
		Benefits	1	0	0	752616	807745
	Tree Planting	Purchase of tree seedlings	640	750	515160	0	0
		Transport of Seedling (trips)	6	2000	12879	0	0
		digging hole (hector)	1	50000	53662	0	0
		Measuring rope	1	5000	5000	0	0
		Planting(kufukia)(hector)	1	20000	21465	0	0
1	Weeding	Fire break (hector)	140	500	75127	0	0
	Maize planting	Production cost	1	336326	360961	0	0
		Benefits	1	0	0	752616	807745
2	weeding	fire break (hector)	140	500	75127	0	0
	Maize planting	Production cost	1	336326	360961	0	0
		Benefits	1	0	0	752616	807745
3	Weeding	fire break (hector)	140	500	75127	0	0
	Weeding	kupalilia	1	100000	107325	0	0
		kupalilia	1	200000	214650	0	0
	Pruning 1		1	30000	32197	0	0
		overall	1	20000	20000	0	0
		kofia	1	5000	5000	0	0
		miwani	1	5000	5000	0	0
		buti	1	15000	15000	0	0
		Panga	1	5000	5000	0	0
4		kisu	1	3000	3000	0	0
	Firewood	Headload	0	0	0	0	0
	Pruning 2		1	40000	42930	0	0
6	insruments	msumeno	1	50000	50000	0	0
	Firewood	Headload	8	0	0	18000	154548
7	barabara ya moto		1	20000	21465	0	0
	Pruning 3		1	40000	42930	0	0
9	Firewood	Headload	12	0	0	18000	231822
	barabara ya moto		1	20000	21465	0	0
10	harvest - 1		60	0	0	10000	643950
11	kuni na mijengo		15	0	0	18000	289777
	harvest -2		90	0	0	30000	2897775
15	kuni na mijengo		30	0	0	18000	579555
	harvest -3		490	0	0	48000	25242840
19	kuni na mijengo		80	0	0	18000	1545480

Maize Production Cost)	Amount in ha/household	Cost per unit (Tsh)	Total cost (Tshs)	Total Revenue (Tshs)
Rent of area (Hekta)	1.3	50.000	160000	
Farm preparation	1.3	200,000	640000	
Cuttivation of farm using tractor (Hekta)	1.3	80,000	256000	
Transport of seeds	3	3000	9000	
Buying planting equipments like ropes e.t.c	3	5,000	15000	
Buying seeds (Kg)	1.3	4,000	12800	
Buying fertilizers (DAP)	0	0	0	
Planting costs /ha	1.3	0	0	
Weeding costs (2 times)	2.6	0	0	
Buying top dreesing fertilizers (UREA)	0	0	0	
Cost package materials	37	2,000	74000	
Cost of transiporting crops from field	1.3	0	0	
Cost of buying Actellic (Kg)	3	15,000	45000	
Number of bags harvested per unit area (bags of 140kg)	37.4	60000	0	**2 244 000**
TOTAL			**1 096 800**	**2 244 000**

Appendix 16: Investment in indigenous agroforestry practiced at household's level

Year	Activity	Item	Amount	Unit cost (Tshs)	Total cost (Tshs)	Unit Revenue (Tshs)	Total Revenue (Tshs)
			Unit	item		per item	
1	Maize production	Production	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
	Instruments	-overall	1	20000	20000		0
		-kofia	1	5000	5000		0
		-miwani	1	5000	5000		0
		-buti	1	15000	15000		0
		-Panga	1	5000	5000		0
		-knife	1	3000	3000		0
2	Maize production	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
3	Maize production	Production cost	1	1656941	1656941	2244000	2244000
		Tree harvesting	4		0	18000	72000
		firewood/poles	16		0	18000	288000
4	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
5	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
6	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
		Tree harvestiong	4		0	18000	72000
	insruments	msumeno	1	50000	50000		0
7	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
8	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
9	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		Tree harvesting	4		0	18000	72000
		firewood/poles	16		0	18000	288000
10	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
11	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
12	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
		Tree harvestiong	4		0	18000	72000

	Year	Item	Amount	Unit cost (Tshs)	Total cost (Tshs)	Unit Revenue (Tshs)	Total Revenue (Tshs)
13	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
14	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
15	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
		Tree harvestiong	4		0	18000	72000
16	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
17	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
18	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
		Tree harvestiong	4		0	18000	72000
19	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
20	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
21	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
		firewood/poles	16		0	18000	288000
		Tree harvestiong	4		0	18000	72000
22	Maizeproduction	Production cost	1	1656941	1656941	2244000	2244000
22	Firewood	firewood/poles	16		0	18000	288000