# CLASSIFICATION OF CHAGGA AGROFORESTRY HOMEGARDENS AND THEIR CONTRIBUTIONS TO FOOD, INCOME AND WOOD ENERGY TO COMMUNITIES OF ROMBO DISTRICT, TANZANIA

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**A DISSSERTATION SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN MANAGEMENT OF NATURAL RESOURCES FOR SUSTAINABLE AGRICULTURE OF SOKOINE UNIVER SITY OF AGRICULTURE. MOROGORO, TANZANIA.**

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## ABSTRACT

The present study was carried out in 2014 in Rombo District, Kilimanjaro, Tanzania, in order to classify Chagga agroforestry homegardens and establish their relative contributions to food, income and wood energy to the local communities. The study methodology included random selection of four divisions, one ward from each division, one village from each ward and 30 households per village forming a total sample of 120 households. A social survey was subsequently carried out using questionnaires employed to household heads and checklists of probe questions for key informants. Data were analyzed using the Statistical Package for Social Sciences (SPSS) version 16.0 and Microsoft Excel Programs. Analysis of Variance (ANOVA) was performed to compare means between and within treatments and the Least Significant Difference (LSD) was used to separate the significantly differing means. Results indicated that all five renewable natural resource components of woody perennials, herbaceous crops, animals, insects and aquatic life-forms were present in the Chagga agroforestry homegardens which were in various interactions broadly classified into nine agroforestry systems with the Agrosilvopastoral system being the most widely spread and the Agroaquosilvicultural, Agroaquosilvopastoral, Aposilvopastoral and Silvopastoral systems being, in that order, the least spread throughout the district. Spatial arrangements of components were the most common arrangement forming agroforestry technologies like boundary planting, mixed intercropping and live fences. The Chagga agroforestry homegardens were the major sources of food, income and wood energy for the community contributing about 95%, 86% and 73% respectively. Lack of extension services, pests and diseases and land shortages are the main constraints in the Chagga agroforestry homegardens. Government support in recruiting and training more extension officers to train farmers in appropriate farming technologies and ready availability of improved tree and crop seeds are the main recommended measures for improving the agroforestry homegardens in Rombo District.

## DECLARATION

I, JIMSON MBWIGA, 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 for a degree award in any other institution.

_____ _____

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The above declaration confirmed by

_____ _____

Professor L.L.L. Lulandala Date
(Supervisor)

## COPYRIGHT

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## DEDICATION

This work is dedicated first and foremost to God the Almighty, for his grace and faithful guidance throughout my life. Secondly my sincere dedication is to my beloved mother Marrystella Matatu Laswai, who tirelessly with a lot of sacrifice laid down the foundation of my education. This work is also dedicated to my dear sister Joan Edward who supported and encouraged me diligently. May God the Almighty richly bless them all forever, AMEN!

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## LIST OF ABBREVIATIONS AND SYMBOLS

| | |
|---|---|
| AF | Agroforestry |
| AJISO | Action For Justice In The Society |
| ANOVA | Analysis of Varience |
| CBO | Community Based Organization |
| DALDO | District Agricultural and Livestock Development Office |
| D | Diameter |
| ECHO | Educational Concerns for Hunger Organization |
| FAO | Food and Agriculture Organisation of the United Nations |
| Ha | Hectare |
| ICRAF | International Centre for Research in Agroforestry |
| IFAD | International Fund for Agriculture Development |
| IUCN | International Union for Conservation of Nature |
| Kg | Kilogram |
| L | Length |
| LGA | Local Government Authority |
| LSD | Least Significant Difference |
| M | Metre |
| $m^3$ | Cubic metre |
| m a s l | Meters Above Sea Level |
| MNRT | Ministry of Natural Resources and Tourism |
| MPT | Multipurpose tree |
| NGO | Non-Governmental Organization |
| SNAL | Sokoine National Agriculture Library |
| SPSS | Statistical Package for Social Sciences |

| | |
|---|---|
| sq | Square |
| st | Stacked |
| SUA | Sokoine University of Agriculture |
| TARP II SUA | Tanzania Agricultural Research Project Phase Two of SUA |
| TAWIRI | Tanzania Wildlife Research Institute |
| TZS | Tanzanian Shillings |
| URT | United Republic of Tanzania |
| V | Volume |

# CHAPTER ONE

## 1.0 INTRODUCTION

### 1.1 Background Information

Traditional land use systems around homesteads were multi-purpose trees, shrubs, herbs, annual and perennial agricultural crops and livestock are managed by family members to fulfil their multiple requirements are in some cases known as homegardens (Shrestha *et al.,* 2002; Odebode, 2006). However according to Nair (2012), the word "homegarden" has been used rather loosely to describe diverse practices from growing vegetables in the backyard to complex multistoried systems of trees/shrubs, crops and/or livestock (Bekele-Tessema, 2007). In order to avoid possible confusion with domestic gardens for vegetables or other homegardens which comprise only agricultural crops therefore, they are better called "agroforestry homegardens" (Torquebiau, 2000; Kumar and Nair, 2004). An agroforestry (AF) homegarden is an ancient and widespread agroforestry practiced all over the world (Udofia, 2010) found in most ecological regions of the tropics and subtropics (Pushkaran, 2002; Abebe, 2005). Agroforestry homegardens have persistently endured the test of time and continue to play an important role in providing food and income for families that maintain them (Mendez *et al.,* 2001) even in circumstances where population pressures, soil erosion, climatic change and volcanic eruptions persist (Soemarwoto and Conway 1992; Kitalyi and Soini, 2004; Montagnini, 2005).

Although literature (Nair, 1993; Udofia, 2010) describes AF homegarden as an agroforestry practice however, according to Kumar and Nair (2004) an agroforestry homegarden is a generic concept more like agroforestry itself as it combines various systems and technologies within (Abebe, 2005). Mbwambo (2004) and Tewari (2008) defined agroforestry as a collective name for land-use systems and technologies in which

woody perennials including trees, shrubs, bamboos etc. are deliberately combined on the same land-management unit with herbaceous crops or animals either in some form of spatial arrangement or temporal sequence. According to Fernandes and Nair (1986) most agroforestry homegardens display many of these agroforestry concepts. They therefore make them one of very complex agroforestry practices (Udofia, 2010). Each AF homegarden is unique in its own way despite the larger structural and functional similarities (Kumar and Nair, 2004), composition and appearances (Galhena *et al.,* 2012) even their contributions to communities livelihoods (Galhena *et al*., 2013).

Various sources of literature such as Nair (1985), Tolunay *et al.* (2007) and Hemp and Hemp (2008), have classified agroforestry homegardens into systems such as Agrosilvicultural and Agrosilvopastoral systems, those which consist of woody perennials with intimate interaction with herbaceous crops and/or livestock only. However, in some places agroforestry homegardeners are also engaged in mushroom cultivation and beekeeping (Pulami and Poudel, 2006) for example in some Chagga AF homegardens farmers keep between 3-5 traditional beehives (Kitalyi and Soini, 2004). Small fresh water fish ponds are also incorporated into the AF homegardens (Gautam *et al.,* 2004; Ali, 2005). For instance, in West Java fish production in AF homegardens ponds is common (Soemarwoto and Conway, 1992). Hence there are agroforestry homegardens which include the specialized systems those of insects and aquatic life forms (Chukwujekwu, 2010). However, such practices are not yet classified into appropriate agroforestry systems and, therefore, little have been done to improve agroforestry homegardens practices basin on the incoparated components.

## 1.2 Problem Statement

The Chagga agroforestry homegardens, as is the case with all other agroforestry homegardens, are highly variable both in terms of the components involved and the way they are arranged on the resource management units (Wiersum, 2006; Galhena *et al.*, 2013). Therefore, on this basis, they consist of different systems and technologies. Unfortunately, they have never been formally classified into the specific agroforestry systems on the basis of all their specific systems components and into agroforestry technologies on the basis of the arrangement of their systems components. Composition-wise and structurally, agroforestry homegardens vary widely between those of one farmer and another even within the same location (Mendez *et al.,* 2001). This non specificity of the practices makes it difficult to share information on the specific status of the individual agroforestry homegardens and, therefore, advice on the possible interventions for their improvement cannot be readily communicated both locally and globally. This is a very serious anomaly in effective scaling up of agroforestry homegardens practices.

Moreover, everywhere in the world, agroforestry homegardens are primarily used for subsistence purposes of the individual households in terms of food supply, income generation and wood energy provision (Mendez *et al*., 2001). The contribution of the agroforestry homegardens to food, income and wood energy to communities varies widely between different geographic regions (Galhena *et al.*, 2013). According to Koyenikan (2007), agroforestry homegardening is an important method that can be used for food production but yet neglected a lot as an aspect of food production system over time. Subedi *et al.* (2004) reported that due to the lack of information agroforestry homegardens have never been treated as important contributors to food, income and wood energy for the welfare of farming communities by the implementers and policy makers of agricultural research and development. The present study, therefore, was conducted to fill the knowledge gap.

### 1.3 Study Justification

It has been noted that, agroforestry homegardens are complex agroforestry practices (Udofia, 2010) and within the agroforestry homegardens, several agroforestry technologies can be identified (Kitalyi *et al.,* 2013). With such characteristics it is therefore essential to classify agroforestry homegardens into their proper agroforestry systems and technologies. The classification of agroforestry homegardens will help in better understanding and way forward towards their management basing on their current systems and technologies involved.

In a recent review article, Nair (2001) indicated that although tropical AF homegardens have provided sustenance to millions of farmers and prosperity to many households around the world, the extent of scientific studies on these systems have been disproportionately lower than what their economic value, ecological benefits, or sociocultural importance would warrant. Also, understanding on-farm wood energy production capacity of agroforestry homegardens and household consumption patterns is critically needed in reducing harvesting pressure on native forests (Kimaro *et al.,* 2011). Therefore serious effort must be made on understanding the contributions of the agroforestry homegardens to food, income and wood energy to the local communities. In that basis, this will help in their improvement as well as to apply the lessons to improvement of other systems. By and large, the present study contributes towards a better understanding of agroforestry homegardens.

Findings, conclusions and recommendations from this study will contribute to the improvement of district development planning and also might be utilized by different development practitioners at different levels for example, Central Government, Policy Makers, LGAs, NGOs, CBOs and the community at large for the purpose of improving

the performance of agroforestry homegardens in order to ensure their sustainable contributions towards communities livelihoods.

## 1.4 Study objectives

### 1.4.1 General objective

The overall objective of this study was to classify the Chagga agroforestry homegardens and determine their contributions to food, income and wood energy to the communities of Rombo District, Kilimanjaro Region, Tanzania

### 1.4.2 Specific objectives

i. To determine the components of Chagga agroforestry homegardens and their arrangement,
ii. To classify the agroforestry homegardens into their specific systems and technologies,
iii. To determine the contribution of the agroforestry homegardens to food, income and wood energy of the local communities in the study area and
iv. To identify the constraints to Chagga agroforestry homegardens practices and measures required for improvements.

### 1.4.3 Research questions

i. What are the components forming the Chagga agroforestry homegardens?
ii. How the components are arranged in the resource management units?
iii. What are the agroforestry systems in the Chagga agroforestry homegardens?
iv. From the arrangements of components what are the agroforestry technologies formed?
v. What are the sources of household food, income and wood energy?

vi. How much are the Chagga agroforestry homegardens contributing to the food, income and wood energy of the local communities?

vii. What are the constraints in practising the Chagga agroforestry homegardens?

viii. What measures should be taken to improve the agroforestry homegardens in the study area?

# CHAPTER TWO

## 2.0 LITERATURE REVIEW

### 2.1 Chagga Agroforestry Homegardens Components and their Arrangements

#### 2.1.1 Agroforestry homegardens

Agroforestry homegardens are understood as an intimate, multistorey combination of various trees and crops sometimes in association with domestic animals around homesteads (Kumar and Nair, 2004; Odebode, 2006). They are located close to dwellings for reasons of security, convenience and special care (Kang and Akinnifesi, 2000). Agroforestry homegardens involve a number of components, the like of woody perennials in association with herbaceous crops, livestock, poultry and/or aquatic life-forms and/or insects production, mainly for the purpose of meeting the routine basic needs of the farmers (Lulandala, 2011). Agroforestry homegardens are known by different names in various places, for example, *Talun-Kebun* and *Pekarangan* in Java (Indonesia), *Shamba* and *Chagga homegardens* in East Africa (Nair, 1993). Agroforestry homegardens are widely practiced in the developing countries (Landauer and Brazil, 1990; Udofia, 2011) where farmers seek maximum food production, fodder, fuel, organic mulch, timber and medicinal requirements of the households and to generate income (Udofia, 2010). For they have been shown to provide a diverse and stable supply of socio-economic products and benefits to the families that maintain them (Christanty, 1990; Jose, 2009).

#### 2.1.2 Agroforestry homegardens components

Agroforestry components refer to the three elements of a land-use system, the tree (woody perennial), herb (agricultural crops) and animal while other components (e.g., insects, aquatic life-forms) occur in specialized systems (Tewari, 2008, Chukwujekwu, 2010). For example, according to Shrestha *et al.* (2004) components like, small animals,

fish, and apiary are often included in the agroforestry homegardens systems. Large numbers of components and very sophisticated structures make agroforestry homegardens to be among the very complex practices (Udofia, 2010). Their complexities come from their ability to involve different components which promote favorable microclimates for different species. Good examples are the Javanese homegardens in West Java (Soemarwoto and Conway, 1992) in which the components vary widely depending on the ecological location of the AF homegardens or socio-economic status of the families. Some of the agroforestry homegardens don't include some components such as animals while others include more various components depending on the sizes of the AF homegardens (Wiersum, 2006).

#### 2.1.2.1 Woody perennials (tree or shrubs)

In agroforestry homegardens, as one of the agroforestry practice, the major components are multi-purpose woody perennials (tree/shrubs) which are harvested for firewood, timber and livestock fodder as well as providing shade for coffee trees, in the case of the Chagga homegardens (Hemp and Hemp, 2008). The multi-purpose trees in the AF homegardens may be scattered or arranged at specific points for different purposes (Mathew *et al.,* 1996). Fruit trees may be found integrated with arable crops either in intercropping or along the boundaries of the agricultural fields (Zaman *et al.,* 2010). Their contributions to environmental amelioration are also noted such as the improvement in soil fertility, soil erosion control and carbon sequestration (Albrecht and Kandji, 2003; Montagnini, 2005; Nair *et al*., 2010). The common multipurpose woody perennials found in AF homegardens includes Pawpaw (*Carica papaya),* Mango (*Mangifera indica*), Avocado (*Persea americana*) and Guava (*Psidium guajava*) (Oke and Odebiyi, 2007; Dowiya *et al.,* 2009).

### 2.1.2.2 Herbaceous crops (agricultural crops)

Herbaceous crops in agroforestry homegardens are generally the annual crop plants and mainly include various cereals and leguminous crops such as maize (*Zea mays*), beans (*Phaseolus vulgaris*), bananas (*Musa spp*) and other non woody plants such as various vegetables (Lulandala, 2011). In agroforestry homegardens, herbaceous crops are planted primarily for food consumption or generating additional income through selling of the surplus (Zaman *et al.,* 2010). Other crops which are also kept in practices include the cash crops, for example coffee (*Coffea arabica*) in tropical agroforestry homegardens (Soini, 2003; Abebe, 2005).

### 2.1.2.3 Animals

Some agroforestry homegardens include livestock in their practices (Kumar and Nair, 2004). These are mostly domesticated animals such as cattle (*Bovine spp*), goats (*Capra hircus*), sheep (*Ovis aries*), chicken (*Gallus gallus*) and pigs (*Sus scrofa*) (Wezel and Bender, 2003; Del Angel-Perez and Mendoza, 2004). Wild animals such as buffalos (*Bubalus bubalis*) and other fauna are also found in the agroforestry homegardens for example, in Indonesia (Ali, 2005). Animals are kept for meat, eggs, milk and manure (Njuki, 2001; Chakeredza *et al.,* 2007) or for rituals, religious sacrifices and prestige (Soini, 2003) and in some cases for income generation (Okigbo, 1990). These animals are either kept inside or tethered, sometimes free ranged in the fields (Thaman *et al.,* 2006). According to Del Angel-Perez and Mendoza (2004) chicken was the most reared animal component in agroforestry homegardens in Veracruz, Mexico. Chicken were particularly important in agroforestry homegardens of the developing countries worldwide (Montagnini, 2006). Primarily for their ability to generate cash income from the production of eggs, meat and chicken manure (Garces, 2002). The small sizes of these

animals also make their care and management, besides meat preparation (slaughtering, skinning, and cooking) relatively easy.

#### 2.1.2.4 Insects

Another agroforestry homegarden component is insects (Zeleke, 2009). These include bees (*Apis*), grasshoppers (*Caelifera*) and sometimes butterflies (*Rhopalocera*) (Hemp and Hemp, 2008; Kitalyi and Soini, 2004). As Nair and Sreedharan (1986) reported, beekeeping by farmers who are more resourceful is very popular. Kitalyi and Soini (2004) reported that in the Chagga AF homegardens some farmers keep between three to five beehives in their systems. The bees species commonly kept are the bigger, stinging honey-bee (*Apis mellifera monticola*) and a small stingless bee of the genus *Meliponula* (UNDP, 2002). Insects are kept in agroforestry homegardens for different purposes including food production and income generation (Kihwele *et al*., 1999).

#### 2.1.2.5 Aquatic life-forms

In agroforestry homegardens adjoining water canals, paddy fields and ponds the interaction of aquaculture in agroforestry is extensively practiced with great success in which small fresh water fish are incorporated into the gardens (Ali, 2005; Kumar, 2006). For example, most of the agroforestry homegardens of central Thailand and Nepal have fish ponds (MacDicken, 1990; Gautam, 2004). When incorporated with other component in a resource management unit, special agroforestry systems such as Agroaquosilvicultural system are formed (Lulandala, 2011).

### 2.1.3 Arrangements of components in agroforestry homegardens

According to Nair (1993) the arrangement of components refers to the plant components of the system, especially to the system that involves plant and animal components.

The crops and trees planted in agroforestry homegardens are carefully arranged to provide for specific functions and benefits (Mohan, 2004). These arrangements in agroforestry can be in spatial and temporal arrangements (Sunwar, 2003). According to De Clerck and Negreros-Castillo (2000) the position and shade tolerance of plants found in agroforestry homegardens gives us an idea of the temporal and spatial positions.

### 2.1.3.1 Spatial arrangement

Spatial arrangements refer to how components are arranged in respect to space in the management unit (Sinclair, 1999). Spatial arrangements of plants in agroforestry include the densely or sparsely mixed stands (Tewari, 2008). In these arrangement agroforestry homegardens seems to lack order and pattern, compatible components are often mixed forming technologies like mixed intercropping (Fernandes and Nair, 1986). For example in Southern Ethiopia, spatial arrangements of components are common which facilitate easy management of the mixed agroforestry homegardens (Abebe, 2005). Spatial arrangement also may be in form of zonal planting i.e. edges of the plots or strips that results to technologies such as boundary planting, live fences and contour planting (Hasanuzzaman, 2008). Galhena *et al.* (2013) found AF homegardens are delimited by physical demarcations such as live fences or hedges or boundaries as a form of spatial zonal arrangement in Sri Lanka. According to Torquebiau (2000) the reason to plant trees in a zonal arrangement is often related to the limited space available and to reduce competition problems between trees and crops.

### 2.1.3.2 Temporal arrangement

Temporal arrangement refers to components arrangement where the growing period for food and tree crops on the same plot of land is separated in time (Kang and Akinnifesi, 2000). Temporal arrangements of plants in agroforestry can also take various forms in

different time intervals. However, time complementarity is expected in these arrangements (Torquebiau, 2000). The results in temporal arrangements are rotational agroforestry technologies like shifting cultivation of which component arrangement involves 2 to 4 years of cropping followed by more than 15 years of fallow cycle when a selected woody species or mixture of species is planted or is allowed to regenerate naturally (Sinclair, 1999). These temporal arrangements of components in agroforestry have been described by terms such as coincident, concomitant, overlapping, separate or interpolated (Hasanuzzaman, 2008). Some agroforestry homegardens involving coffee production fall into coincident arrangement (Nair, 1993). Coincident arrangement of the components refers to the arrangement where the component arrangement is parallel in time (Young, 1989). It is in this arrangement where some plants for example coffee/ pasture depend on the shade of the woody perennials (Hasanuzzaman, 2008). In such arrangement components are planted to ensure the respective growth of trees and crops at different rates (Torquebiau, 2000). A good example for these arrangements is the coffee forests of Ethiopia, where coffee has been favoured in the underwood of forests (Torquebiau, 2000).

**2.2 Agroforestry Homegardens Classification**

According to Nair (1993) the main purpose of classifying agroforestry homegardens should be to provide a practical framework for the synthesis and analysis of information about existing practices and development of new and promising ones. Many different types of agroforestry homegardens have been reported from different tropical regions (Landauer and Brazil, 1990). They have most commonly been classified on the basis of AF homegardens characteristics that are easy to investigate, such as size (Jose and Shanmugaratnam 1993; Millate-Mustafa *et al*., 1996) and subsistence/commercial production (Christanty, 1990; Michon and Mary, 1994). Christanty (1990) also suggested

that AF homegardens might be classified using the dominant plant species grown or the level of urbanization. But it is evident that the classification developed by Nair (1993) based upon several criteria (structural, functional, ecological and socio-economic) has been seen and used as among the best approaches of classification (Tolunay *et al*., 2007).

However, Sinclair (1999) and Tewari (2008) argue that, the only most explicit and most segregated criteria for effective classification of various agroforestry practices should be based on their associated components and the way such components are arranged especially the woody perennials on the resources management units. According to Nair, (1993) it is therefore logical, compatible and pragmatic to use the components as the basic criterion in the hierarchy of agroforestry classifications.

### 2.2.1 Classification of agroforestry homegardens into systems and technologies

#### 2.2.1.1 Agroforestry homegardens systems

Systems in agroforestry refer to the specific intimate interactions of the agroforestry components on the same resources management units (Maduka, 2007; Lulandala, 2011). Agroforestry homegardens combine different components, therefore, there are different systems involved in agroforestry homegardens practices. One of the primary criteria in classifying agroforestry systems is the components that constitute the system (Nair, 1985).

In a well planned and managed agroforestry homegarden there are a wide number of components which form various systems that involve two or more components (Lulandala, 2011). For example, an Agrosilvicultural stystem consists of woody perennials interacting with herbaceous crops only (Kumar, 2006). A system of three components for example, the Agrosilvopastoral system (Mamkwe, 2003), that consists of

woody perennials, herbaceous crops and animals. More complex systems of four to five components in that respective order for example, include the Agroaquosilvopastoral system, consisting of the woody perennials, herbaceous crops, aquatic-life forms and animals, and the Agroapoaquosilvopastoral system with the woody perennials, herbaceous crops, animals, insects and aquatic life-forms (Lulandala, 2011).

Tolunay *et al.* (2007) found the major agroforestry systems in Turkey were Agrosilvopastoral system, Agrosilvicultural system and Silvopastoral system. According to Zeleke (2009) agroforestry systems observed in Oromia, Ethiopia were (86%) Agrosilvopastoral systems, (2.7%) Agrosilvicultural system and (1.3%) Silvopastoral system. Sebukyu and Mosango (2012) reported that, Agrosilvopastoral system (45.5%), Agrosilvicultural system (32.9%), Silvopastoral system (16%), Aposilvicultural system (4.5%) and Agroaquosilvicultural system (1.1%) were found in Masaka District Uganda. Nzilano (2013) reported that in Mbeya Rural District the agroforestry systems found were Agrosilvopastoral system (95%) and Agrosilvicultural system (24%). Literature (Lulandala, 2011; Sebukyu and Mosango, 2012) show Agrosilvopastoral system is the most widely adopted agroforestry system. For exemple in Tanzania, Agrosilvipastoral system is highly practiced by the Chagga, Nyakyusa, Haya, Sambaa and various high population rural communities and also spreading fast among the urban and especially peri-urban households throughout the country (Lulandala, 2011). The adoption rate might be mainly because of the benefits that are accrued from the systems. According to Nair and Kumar (2004), Tolunay (2008), Bassullu and Tolunay (2010), a well managed traditional agroforestry homegarden involving animal component with growing various trees and/or shrubs and similar wood-like species and herbaceous crops have high output compared to those without it.

### 2.2.1.2 Agroforestry homegardens technologies

In several sources of literature (Nair, 1993; Sinclair, 1999) technologies and practices have been interchangeably used. Some explain technologies to mean practices (Sinclair, 1999) while to others agroforestry technologies are as agroforestry practices (Nair, 1993). However, agroforestry technologies refer to the sub-systems of agroforestry that are characterized by the way the components constituting the agroforestry systems are structured or arranged on the resources management units (Lulandala, 2011). The agroforestry technologies simply denote a distinctive arrangement of components in space and time (Nair, 1993). AF technologies generally address environmental problems, for example soil erosion, wind blowing, encroachment etc. Thus the selection of the technology to be used in any agroforestry system is always guided by the environmental conditions characterizing the specific site (Lulandala, 2011). Since the components of the agroforestry homegardens might be of various types and arranged in different ways, there might be several technologies within each agroforestry homegarden (Abebe, 2005). These agroforestry technologies includes shifting cultivation, taungya, alley farming, hedgerow intercropping, live fences, wind breaks, shelterbelts, contour planting, relay cropping, rotational woodlots and mixed intercropping (Mbwambo, 2004; Lulandala, 2011). However, mixed intercropping, live fences and boundary planting technologies have been found in most of the agroforestry homegardens in tropics (Mamkwe, 2003; Galhena, 2012).

#### 2.2.1.2.1 Boundary planting

According to Maduka (2007) boundary planting technology is an agroforestry technology in which woody perennials (tree/shrubs) are planted along the farm boundaries to obtain various wood products and for demarcations to avoid boundary conflicts with neighbouring farmers. The common form of boundary planting consists of a single line of widely spaced woody perannials (Gadner, 2009). Boundary planting technologies in

agroforestry homegardens have been observed in several areas for example in Sri Lanka (Galhena *et al.,* 2013) and Ethiopia (Abebe, 2005).

#### 2.2.1.2.2 Live fences

Live fence refers to fences in which the posts are living trees, or in which the entire fence consists of closely spaced trees or shrubs (ECHO, 2007). Maduka (2007) further explained that, these are lines of wood perennials planted closely around a land management unit of herbaceous crops, livestock or homestead with protective purposes or privacy. Live fences are regarded important by farmers as they protect huts and houses from strong winds and also protect field crops from livestock and theft (Kajembe *et al*., 2004; Maroyi, 2009). Ajayi (2007) reported that, for live fences farmers preferred plant species that resprout after being cut because this character eliminates labour and cost that would otherwise be required to reestablish. In Central America live fences are used in delineating crop fields, pastures and farm boundaries and forming elaborate networks of tree cover across rural landscapes (Harvey *et al.*, 2005). Live fences are among the common agroforestry technologies found in the agroforestry homegardens for example in Ghana homegardens, live fences are reported to be the common practices (Yiridoe and Anchirinah, 2005). In Misungwi, Mwanza live fences make up to 20% of all the agroforestry technologies (Maduka, 2007).

#### 2.2.1.2.3 Mixed intercropping

Is the resource management technology characterized by trees widely dispersed in cropped fields either in form of woody perennials arrangements in square spacing or in irregularly scattered trees/shrubs on the landscape (MacDicken and Vergara, 1990). It is a common practice where agroforestry homegardens are dominant especially in Kilimanjaro Region where coffee is intercropped with bananas and trees and other

horticultural crops (Soini, 2005). These technologies are common in Burkina Faso where different types of herbaceous crops and woody perennials are all cultivated on the same unit of land at the same time on the entire garden (Tang, 2011). On the contrary mixed intercropping is not a common practice in some agroforestry homegardens for example in Zimbabwe (Drescher *et al.,* 1999).

## 2.3 Contribution of Agroforestry Homegardens to Food, Income and Wood Energy of Local Communities

### 2.3.1 Sources of food, income and wood energy for the local community

Agroforestry homegardens are the major sources of food and income in the regions that practice them (Abebe, 2005; Maroyi, 2009). For example, apart from the different sources, agroforestry homegardens are the major sources and contributors to household food, followed by livestock keeping and purchases from markets with 13%, 7% and 8% respectively in the Philippines (Magnale-Macandog *et al.,* 2009). However, in some areas agroforestry homegardens are seen as supplementary food production systems (Musotsi *et al.,* 2008).

Mendez *et al*. (2001) reported that, the most frequently cited source of income was the agroforestry homegardens in Nicaragua. They also stressed that agroforestry homegardens represented the source of highest average percentage of income. However, apart from agroforestry homegardens, a community might have other various sources of income (Crookes, 2003). In Tanzania approximately 70% of smallholder households have one or more off-farm income sources (URT, 2005). For example, a study in Shinyanga Region, Tanzania (MNRT and IUCN, 2005) reported that people in the region earn their living through a diverse range of activities including subsistence farming, mining, petty trading, lumbering and charcoal making and even formal employment. All these together

help farmers to get high and more stable farm incomes, greater long-term prospects for farm income growth and more environmentally sustainable farming.

Shanavas and Kumar (2003) reported that, the traditional agroforestry homegardens constitute a principal source of wood energy for the rural households. Most of households' wood energy comes from the agroforestry homegardens, other than from neighboring forests and buying from the market or neighbors (Soini, 2005). For example, about 51% to 90% of the fuelwood collected in various geographical regions in South and Southeast Asia were derived from agroforestry homegardens (Krishnankutty, 1990; Torquebiau, 1992). Therefore agroforestry homegardens almost entirely meet the family needs for food, income and wood energy (Levasseur and Olivier, 2000).

### 2.3.2 Contributions of agroforestry homegardens to food supply

The primary emphasis of agroforestry homegardens is food production for household consumption (Ndaeyo, 2007). It is evident that agroforestry homegardens contribute to food supply in many countries (Galhena *et al*., 2013). In contrast to other types of agroforestry and other production systems, agroforestry homegardens are very important for supplying the household with food products year-round (Eibl *et al.,* 2000; Kebebew *et al*., 2011). The products range from vegetables and staple food crops, animals to insects and aquaculture products (Galhena *et al.,* 2013). In West Usambara agroforestry homegardens produce about 1 000 kg of maize, 500 kg of beans, 1 000 bunches of banana annually (Moshi, 1997). According to Mariro's (2009) survey data in Morogoro Municipality, agroforestry homegardens contribute approximately 21% to household food supply. While in Mbeya Rural District, agroforestry homegardens contribute 17% to household food supply (Nzilano, 2013). In rural areas, homesteads also have other plots away from their homes that contribute to households food supply (Soini, 2003;

Misana *et al.,* 2012) the plots are open field farms or other non-homegarden agroforestry farms. These other sources, for example, the open field farms in Maswa, Tanzania, contributed 28% (Shilabu, 2008).

### 2.3.3 Contributions of agroforestry homegardens to income generation

Local communities especially in developing countries are characterized by poor economies (Ahuja and Tatsutani, 2009) resulted from few opportunities and means to generate income. Nevertheless, for centuries governments and NGOs have seen agroforestry homegardens as the proper means of tackling the problems and as better ways to improving the livelihoods of the local communities (Montagnini, 2006; Galhena *et al.,* 2013). According to Lilleso *et al.* (2011), agroforestry practices are important income generating activities for the millions of smallholders in the tropics, agroforestry homegardens being among them.

Several sources of literature have noted the contribution of agroforestry homegardens to income generation and improved rural livelihoods (Trinh *et al*., 2003; Calvet-Mir *et al*, 2012). Income in most cases is generated by selling products from the agroforestry homegardens (Trinh *et al.,* 2003; Gautam *et al.,* 2004). For example Shayo's survey data (2005) indicated agroforestry homegardens to contribute TZS 61 389 415 to household income. FAO (2011), reported that, a well managed agroforestry homegarden with a size of 1-2 ha was capable of producing about 185 kg of beans/ha and 400 bunches of banana/ha on average. With the current market prices of Tshs 1600 per kg of beans and TZS 10 000 per bunch of banana, the agroforestry homegardens can contribute at least TZS 4 296 000 from beans and bananas only per year. Furthermore, Okigbo (1990) reported that 60% of household income in Southeastern Nigeria came from selling tree crops and livestock from the agroforestry homegardens. Kehlenbeck and Maas (2004)

also reported in Indonesia, about 70% of the gardeners obtained some cash income from their agroforestry homegardens through sales of coffee, cocoa or surplus of fruits or spices. In West Bangladesh and North Eastern Bangladesh, the report showed that an average of 15.9% and 11.8% of household income is derived from agroforestry homegardens respectively (Motiur *et al*., 2005). Apart from agroforestry homegardens, households may have other sources that contribute income to the family. Monela *et al.* (2000) and Valkila (2007) stated that, most poor rural people apart from agriculture depend at least or partially on other types of activities to earn their livelihoods. Other income sources may include employment, remittances and petty trade which are common to rural households (Crookes, 2003). It has been reported that, for example, in Kenya, employment contributed 18% (Kimanju and Tschirley, 2009), business contributed 7% to Swaziland households (Nxumalo, 2012) while in Moshi rural remittances contributed 13% (Meena and O'Keefe, 2007) to local communities' income.

### 2.3.4 Contributions of agroforestry homegardens to wood energy

Agroforestry homegardens have been seen to contribute to wood energy from woody perennials in the farms (Shayo, 2005). The multipurpose trees in the farms help to meet wood energy needs (Salam *et al.,* 1995). Apart from the common solid wood, the dead wood of trees and shrubs and other agricultural residues are gathered as fuel, although these items are seen as secondary outputs from the agroforestry homegardens (Fernandes and Nair, 1986; Abebe, 2005). According to Abebe (2005) in South Ethiopia agroforestry homegardens contribute 88% of fuelwood requirements of the local community, indicating that the actual supply of fuelwood from the farms is higher. In addition Huxley and Ranasinger (1996) reported that, the AF homegardens of Sri Lanka contributed 26% of wood energy to the society. In Bangladesh 85% of wood energy requirements are met by agroforestry homegardens (Zaman *et al.,* 2010). Wiersum (1997) also reported that

the agroforestry homegarden is an important source of fuel wood, particularly for poor households, contributing from 40 to 80 percent of the rural needs.

Apart from agroforestry homegardens communities depend on other sources for wood energy requirements. The sources includes forests, wood energy purchases and/or from other agroforestry practices (Sioni, 2005). For example in Uganda, Budongo Forest contributes up to 75% of wood energy for the local communities around the forest (Kasolo and Temu, 2008). Tewari *et al.* (2003) found that, natural forests of Siloti and Chanoti in the Himalayas support 70% and 80% of the two villages' wood energy requirements respectively. Wood purcheses contribute up to 5% in Kizanda village, West Usambara Mountains (Ray, 2011) and 15% in rural India (Saxena, 1993).

## 2.4 Constraints Facing the Chagga Agroforestry Homegardens Practice and Measures Required for Their Improvements

### 2.4.1 Constraints to agroforestry homegardens practice

Although further studies stressing the importance of agroforestry homegardens have been conducted since the mid-1970s, there is still a need for more information on the problems faced by the gardeners (Thaman *et al.,* 2006). The current constraints to agroforestry homegardens practices include land shortage, labour shortage, shortage of rainfall and in some cases droughts, diseases and pests (Kitalyi and Soini, 2004; Glendenning *et al.*, 2010).

#### 2.4.2.1 Land shortages

Population increase has led to decrease in land sizes in areas once dominated by agroforestry homegardens (Kitalyi and Soini, 2004; Musotsi *et al.,* 2008). Land fragmentation to household members severely limits the level of use of agroforestry

homegardens due to decrease in the agroforestry homegardens sizes hence limiting space for agroforestry homegaderns (Rugalema *et al*., 1994; Kitalyi and Soini, 2004). Land shortages also threaten the spread of agroforestry homegardens. A study by TARP II SUA (2005) revealed that land shortage was among the reasons that limited farmers in adopting agroforestry technologies. Land size influences the diversity of agroforestry homegardens components (Mendez *et al.,* 2001). Farmers with small agroforestry homegardens tend to reduce some components so as to attain more space (Soini, 2005). According to Sahoo (2009), larger agroforestry homegardens had higher numbers of species and they decreased with the decrease in size of the agroforestry homegardens. The average land sizes noted in other agroforestry homegardens range from 0.015-0.5ha in Vietnam (Trinh *et al.,* 2002), 0.01-0.5 ha in Ethiopia (Asfaw, 2002) and Sri Lanka average 0.3 ha (Senanayake *et al*., 2009). Soini (2005) in his study on livelihoods on the Southern slopes of Mt. Kilimanjaro reported that, young individuals are inheriting land of only up to 0.1 ha, which can only be used for building houses hence no space for agroforestry homegardens. Zeleke (2009) and Kabwe (2010), on the other hand, reported that farmers with small plots of land struggle to produce sufficiently to meet the household demands.

#### 2.4.2.2 Labour shortage

Agroforestry homegardens mostly depend on family labour (Shrestha *et al.* 2004; Maroyi, 2009). With the increase in labour migration to urban areas, diseases and ageing of the population who don't have the physical strength to manage the land efficiently (Mamkwe, 2003), the AF homegardens face labour shortages for their proper management. Kitalyi *et al.* (2013) reported that, family labour in Northern Tanzania, Rombo District included, is lately a major problem due to higher proportion of ageing farming communities. In Zimbabwe the average homegardener age was 57 years (Drescher *et al.,* 1999) whilst in Nigeria AF homegardens were managed by household heads of between 30-50 years (Udofia, 2011). According to Drescher *et al.* (1999) high age is due to labour migration

into towns and cities, where only children, women and old people remain in rural areas. Family sizes are determinants of agroforestry homegardens labour (Maduka, 2007). According to Galhena *et al*. (2013) an average of 3 people per household provides labour to agroforestry homegardes. On the other hand, Mamkwe (2003) noted that households with family size of less than 4 face labour shortages. Meena and O'Keefe (2007) in their study in Kilimanjaro Region observed that, those left on the AF homegarden are likely to be the elderly or young, who may not possess the physical condition or knowledge to cultivate as successfully as possible. More so households with married people are able to share household activities such as agricultural production, harvesting of fruits, weeding, fetching of firewood and water, while divorcees, single and widowed household heads have to do all the household activities as they do not have all the support unless from their older children who are fit to assist with the household activities (Zenda, 2002; Buchmann, 2009).

#### 2.4.2.3 Water shortage

Lack of water is another factor that constraints agroforestry homegardens practices (Meena and O'keefe, 2007). For example in Chagga areas according to Soini (2005) mostly in the lower slopes face prolonged dry periods that hinder production in the agroforestry homegardens. Kitalyi and Soini (2004) reported that, Chagga areas were reported to be facing a drastic change in water resources. Farmers noticed reduced water supply in their areas which makes the Chagga agroforestry homegardens vulnerable. Meena and O'keefe (2007) in their study noted that 72% of the respondents stated that drought had a great impact on their agricultural productivity. Monde *et al.* (2006) notes that lack of irrigation water prevented households from considering planting various vegetables in agroforestry homegardens. Thaman *et al.* (2006) also noted that, limited water availability was a constraint to expanding homegardening in Kiribati, Tuvalu, the Marshall Island, and Nauru.

#### 2.4.2.4 Inadequate capital

Economic status of the family influences the level of use of agroforestry homegardens (Washa, 2001; Galhena *et al.,* 2013). Households' sources of income either from farm produces or off-farm activities enhance the level of use or the management of the agroforestry homegardens (Thangata and Alavalapati, 2003; Mgeni, 2008). According to Tang (2011) one major change that has occurred in AF homegardens over the years is the increase in external inputs such as chemical fertilizers or manure. Hence farmers with more sources of income managed their farms better than those with limited sources, as they are able to afford or purchase farm inputs, especially in places where seasonal crop failures are common (Jama *et al.*, 2004).

#### 2.4.2.5 Pest and diseases

Pest and diseases are also the contraints to several agroforestry homegardens productivity in different geographical locations (Howard, 2006; Galhena *et al.,* 2013). Pest and disease attacks are in some cases common when there are different tree/crop/animal interactions in agricultural production. According to Shilabu (2008) trees may attract pests and diseases which may affect the crops, hinder agricultural operations and trees were explained to create bird resting and nesting grounds. In Zimbabwe some AF homegardeners complain about crop damages done by birds (Drescher *et al.,* 1999). In agroforestry homegardens that comprise coffee production, pests include stem borers and berry borers that attack coffee (Kitalyi *et al.,* 2013). The attacks reduce crop yields and lead to high investment costs due to purchases of pesticides and medicines (Zaman *et al.,* 2010). According to Makundi and Magoma (2003) the impact of pests in some African countries accounts for about 30% of the total subsistence production costs annualy.

#### 2.4.2.6 Inadequate extension services

Extension services are a series of sets in communicative interventions that are meant among others to develop and induce innovations which supposedly help to resolve problematic situations (Rutatora and Mattee, 2001). Lack of extension and support means information concerning farming methods and practices do not easily make its way to farmers (Jones, 2014). Lack of extension has been previously reported in different areas example in Kerala (Glendenning *et al.*, 2010). According to Soini (2005), farmers in Kilimanjaro Region complained that extension service was not easily available any more as extension workers were earlier on readily available, travelling around and giving advice to people. Such efforts kept the earlier AF homegardens in good conditions. Zeleke (2009) reported that about 36.5% of the community complained to have had low extension services hence poor productivity in agroforestry in Oromia, Ethiopia. Lack of extension services and effective linkage between extension workers and farmers hinders adoption or improvement of technologies including agroforestry technologies (Orisakwe and Agomuo, 2011).

### 2.4.3 Measures required for improving Chagga agroforestry homegarden practices

For improvements of agroforestry homegardens, extension services are highly needed (Soini, 2005; Kabwe, 2010) to advice on the proper ways and techniques to improve productivity and conservation.

#### 2.4.3.1 Improvement of extension services

Lack of knowledge by farmers and of supporting organizations like extension services have been among the factors limiting the agroforestry homegardens level of use (Galhena *et al.,* 2013). Lack of information on the best practices, is a common problem in the areas where agroforestry homegardens are being practiced (Galhena, 2012), thus provision of extension services to farmers leads to the sought improvement in agroforestry

homegardens (Hoogerbrugge and Fresco, 1993). Buyinza *et al.* (2008) reported that agroforestry was a knowledgeable and management intensive practice which required ability to manage the tree crop combinations so as to achieve the optimal results in Kabale District, Uganda. The homegardeners in Sri Lanka strongly stated the need for training in specific areas such as bee keeping, composting, maintaining nurseries of planting materials, pest and soil management (Galhena, 2012). Despite the fact that homegardening activities demand a lesser amount of horticultural and agronomic know-how, negative implications and crop losses can be reduced when the household members are empowered with better skills and knowledge (Turner and Brush, 1987; Buyinza *et al.,* 2008). Zeleke (2009) recommended that district agricultural workers, rural development officers and other stakeholders should provide suitable extension services so that existing traditional practices and traditional knowledge that farmers have been using in managing agroforestry practices show beneficial advantages in Ethiopia. Generally for better agricultural practices extension services are important for improving farm produce (Rutatora and Rwenyagira, 2005) also as incentive to farmers to invest more in agroforestry technologies. According to Kabwe (2010) in Zambia, various extension methods like field visit and demonstration plots were used to attract farmers to invest in agroforestry systems and technologies.

#### 2.4.3.2 Government support

Farmers need government support in the aspects like finding proper market for their products. According to Mellor and Desai (1986) once basic consumption demands are met, smallholders respond to prevailing market opportunities which change their aspiration levels and induce them to move increasingly into commodity production that further intensifies homegarden cultivation. According to Baiphethi and Jacobs (2009)

reliable markets to rural farmers may increase productivity which leads to improvement in the community livelihoods.

The government should also ensure availability of timely inputs like seeds and fertilizers (Kitalyi and Soini, 2004). Myaka *et al*. (2003) reported that, the majority of the farmers cannot afford the purchase of pesticides, insecticides and organic fertilizers due to removal of subsidy on agricultural inputs and lack of credit facilities hence support in ensuring provision of inputs to farmers is important. Moreover, the provision of extension workers will help the farmers to produce more in their agroforestry homegardens and establishment of public policies and stimulate as well as sustaining the farmer's interests in agroforestry homegardens (Galhena, 2012).

Support to strengthen farmers groups is also important (Shilabu, 2008). According to (TARP SUA, 2002) the farmers groups were seen important in solving some of major problems such as lack of capital, unreliable markets channels for crops and livestock products, availability of monetary services at farmers' level such as savings and credit banks. Farmers groups are also important versals towards the adoption of agroforestry technologies (Reed, 2007).

# CHAPTER THREE

## 3.0 MATERIALS AND METHODS

### 3.1 Materials

#### 3.1.1 Location of the study area

The study was conducted in Rombo District, Kilimanjaro Region, an area that has a long history in practicing agroforestry homegardens. Therefore the District through the selected study villages was able to provide practical information on the Chagga agroforestry homegardens in accordance to the purpose of the present study.

Rombo District is located in the Northern part of Tanzania between Latitudes $3^{o}$ 09' South and Longitude $37^{o}$ 33' East. It is bordered in the north and east by Kenya, in the west by Hai District, and in the south by Moshi Rural District (DALDO, 2000). The District is also located in the Eastern slope of Mount Kilimanjaro and it contains a large portion of Mount Kilimanjaro. Rombo District has the advantage of being the host of the two peaks of Mount Kilimanjaro, Kibo and Mawenzi (Rombo District Council, 2013). A map showing the location of the study area and the studied villages is presented in Figure 1.

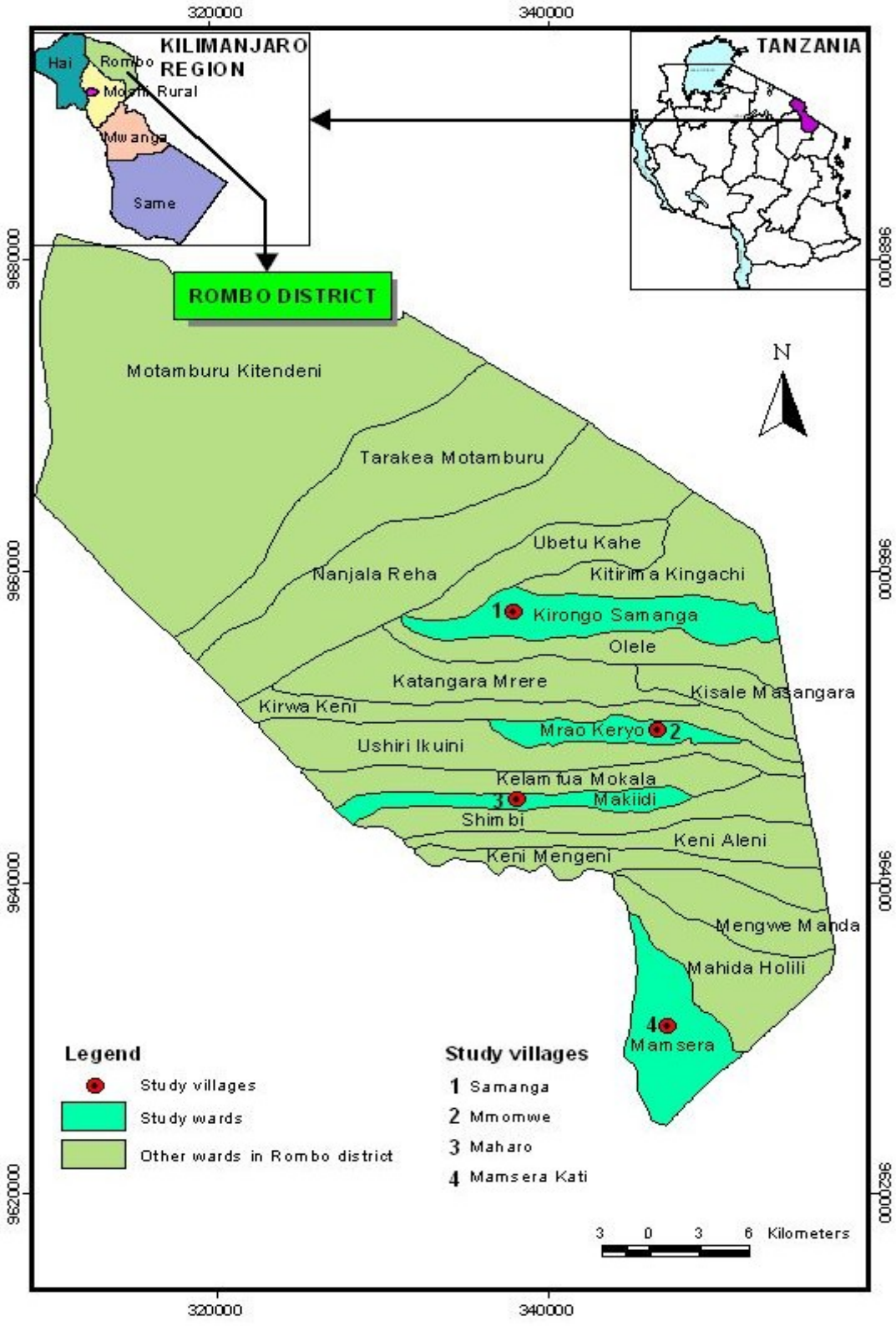


**Figure 1: A map of Rombo District showing study villages**

### 3.1.2 Description of the study area

#### 3.1.2.1 Climate

The District receives bimodal rainfall pattern of 500 - 2000 mm per annum. Short rains fall from October to December while the long rains fall from March to May. Temperature ranges from $14^{o}$ to $20^{o}$C (Shayo, 2005). The highlands receive rainfall of 1200 -2000 mm per annum. The middle zone receives rainfall ranging from 900 - 1100 mm per annum, while the lowlands receive 400 - 900 mm per annum. These areas of the middle and lowland zones experience occasional crop failures because of inadequate rainfall (URT, 2000).

#### 3.1.2.2 Land use

The District has a total area of 144 000 hectares (ha). Land use is classified as follows; 44 114 ha are for farming (Arable land), 83 194 ha are covered by forests, 1200 ha are suitable for irrigation. Human settlements use 1820 ha of land area while the land for pastures is 13 672 ha (Rombo District Council, 2013).

#### 3.1.2.3 Topography and soil characteristics

The District is sub divided into three agro ecological zones; the highland zones, lies between 1600 - 2000 metres above see level (m a s l). The middle zone lies between 1000 - 1500 m a s l and it is the most populated zone. The lowland zone lies between 800 - 1000 m a s l and crop failure is common due to unreliable rainflall (URT, 2000).

As the District is at the foot of Mount Kilimanjaro its soil is of volcanic in origin and has a high base saturation and cation exchange capacity. The distribution of soil by zones is as follows; Upper zone (altitude 1000 - 1800 m with volcanic soil), middle zone (altitude

900 - 1000 m have variable clay loam soil) and lowlands zone (below 900 m the soil is variable sandy clay) (Rombo District Council, 2013).

#### 3.1.2.4 Population

Rombo District has a population of 260 963 people whereby females are 136 435 and males 124 528 (URT, 2013). The population is distributed in 5 Divisions, 24 Wards and 65 Villages.

#### 3.1.2.5 Socio-economic activities

Economic activities are agriculture, agroforestry, livestock keeping, small businesses and employment (Mamkwe, 2003; Rombo District Council, 2013). Other economic activities are petty trade, local brewing, masonry, mechanics and tailoring (Soini, 2005).

## 3.2. Methods

### 3.2.1. Sampling procedure

The sampling procedure used for this study was Probability sampling. The procedure ensures that every item in the universe has an equal chance of being included in the sample (Kothari, 2004). A simple random sampling procedure without replacement (Barreiro and Albandoz, 2001; Westfall, 2008) was employed as the method is more precise than sampling with replacement. According to Kothari (2004), random sampling ensures the law of Statistical Regularity which states that if on an average the sample chosen is a random one, the sample will have the same composition and characteristics as the universe which is the reason why random sampling is considered as the best technique of selecting a representative sample. From each division, 1 ward and 1 village from each of the selected ward were selected randomly. This was done by writing each of the possible samples (wards, villages and households) on a slip of paper, mixed those slips of

paper thoroughly in a container and then drawn as a lottery (Westfall, 2008). The sampling unit for the study was the household as the decisions in homegardens investments, consumption and production are made at the household level (Corbett, 1988; Lubida, 2004).

A sample of 30 households per each village was randomly selected for detailed study. According to Bailey, (1994) cited in Swai *et al.* (2012), Nzilano (2013) and Mbeyale (2014), stated a sample or sub-sample of 30 respondents is a bare minimum for a study in which statistical data analysis is to be done, regardless of the population size. Sample size of the study was, therefore, made of 120 respondents (Table 1), which is considered adequate to fulfill the requirement of representativeness. Matata *et al.* (2001) argues that having 80-120 respondents is adequate for socio-economic studies in Sub-Saharan African households.

**Table 1: The distribution of respondents in households of Rombo District**

| Division | Ward | Village | Number of households | Sampled households |
|---|---|---|---|---|
| Mkuu | Makiidi | Maharo | 880 | 30 |
| Mengwe | Mamsera | Mamsera kati | 850 | 30 |
| Mashati | Mrao Keryo | Mmomwe | 420 | 30 |
| Usseri | Kirongo Samanga | Samanga | 900 | 30 |
| Total | | | 3 050 | 120 |

### 3.2.2 Data collection

Both primary and secondary data were collected for this study.

#### 3.2.2.1 Primary data

##### 3.2.2.1.1 Reconnaissance survey

The survey was used to orient the researcher to the study area (UNDP, 2002; Kasolo and Temu, 2008). The researcher used the method to get basic data that helped to adjust and improve the study plans (Chukwujekwu, 2010). It was through this method that the researcher identified the key informants and introduced the study objective to the district, division, ward and village officers. Key informants involved were Village leaders, Ward Executive Officers, DALDO, Beekeeping Officer, Livestock and Fisheries Officer and Agriculture Extension Officers. Selection of case study villages and pre-testing data collection tools was also done during reconnaissance survey (Malinza and Chingonikaya, 2015). A pre-test of the questionaires was done within ten households (Liberio, 2012). The pre-testing facilitated the researchers to examine the suitability of different questions and status of the instruments (Zaman *et al.,* 2010: Karwani, 2012).

##### 3.2.2.1.2 Social survey

In social surveys both qualitative and quantitative data were collected. Qualitative data were collected through households' surveys using structured questionnaires (Appendix 1) and a checklist of probe questions for key informants (Appendix 2). Qualitative data provide a more in depth description and understanding of the study (Babbie and Mouton, 2001). Information collected was the type of components found in the Chagga agroforestry homegardens and their arrangement, information on the sources of food, income and wood energy of the households in the district and information on the constraints to Chagga agroforestry homegardens practice and measures required for their improvements.

Quantitative data collected included the amount of food acquired from different sources. In the case of foods consumed from households own production, the amounts of foods acquired and consumed will be the same (Smith and Subandoro, 2007), therefore the quantitative data collected were the amount of food acquired. Also qualitative data on products for sale from different sources as source of household income generation was collected as well as the amount of income generated from different sources. Data on the quantity of wood energy from different sources for household use were also collected as quantitative data.

#### 3.2.2.1.3 Field survey

Data were also collected though researcher surveys to the Chagga agroforestry homegardens to confirm information from households' heads and different key informants. Researcher's observations include the Chagga agroforestry homegarden components and their arrangements (Kasolo and Temu, 2008). Measurements to get the amount of food and income products (different units i.e kg for maize, beans, coffee e.t.c littre for milk and honey, counts on banana bunches and animals and prices for each product) were taken during field survey. Measurements were also done on the quantities of wood energy from various sources for household use.

### 3.2.2.2 Secondary data

Secondary data which is basically literature review were collected from different sources by consulting relevant published and unpublished literature from Rombo District offices and Sokoine National Agriculture Library at Sokoine University of Agriculture and various information media such as google scholar.

### 3.2.3 Data analysis

Data analysis was done using Statistical Package for Social Sciences (SPSS) software 16.0 and Microsoft Excel 2010. Descriptive statistics (means, frequencies and percentages) were used to describe components distribution and their arrangements, sytems and technologies, constraints to agroforestry homegarden practice and measures required for their improvement. A Chi square test was used to find the association between components arrangements and their associated agroforestry technologies. Microsoft excel was used for computations of different means of food and income products from different sources and also transforming into a uniform unit (monetary values) for comparisons.

#### 3.2.3.1 Food supply computation

The computation was done on all food acquired by the household on month/year recall period (Jones *et al.,* 2013). As most products are self produced by farmers, the quantities of food purchased were also included in the computations (Research Council of the National Academies, 2012). For comparison to get the significant source of food supply the food quantities were transformed into monetary values by multiplying the food products total quantity by market prices to get monetary values as uniform units (Smith and Subandoro, 2007) then compared using ANOVA.

#### 3.2.3.2 Computation of income generation

Income generation was calculated by multiplying the products from different sources i.e from agroforestry homegardens, open field farms and other agroforestry practices acquired for sale with the market price. Salaries from employed household heads, businesses and remittances were included in the computations of the total household

income. For statistical comparisons the income from different sources were summed up and analysed using two-way ANOVA (Motulsky, 2005).

### 3.2.3.3 Computation of household wood energy

The wood energy volume was calculated using Huber's formula (Wood and Wiant, 1993). The formula is said to be the easiest and accurate method in volume calculations by using only one diameter (Hewage and Subasinghe, 2005; Leon and Luisa, 2013).

Huber's formula; $V = \pi dm^2 l/4$

Where:

V = Volume ($m^3$)

d = Diameter of the wood bundle

l = Length of the wood bundle

The daily wood energy supply was computed by measuring the total bundle volume and then the bundle was left in the household with instructions to cook with wood only from the bundle. On the next day the remaining wood were measured to calculate the actual consumption per day, which was subsequently used to determine the volume consumed per year (Agea *et al.,* 2010). The volume is presented in stacked volume according to Kofman (2010) the stacked volume ($m^{3\ st}$) is calculated when the loads/bundles have air space between them.

Their relative contributions were then identified and two-way ANOVA tables were used to determine whether there were significant differences between the studied means. Two-way ANOVA was selected as the parameters studied provided sufficient guarantee for the use of parametric statistics (Motulsky, 2005). A post hoc analysis, applying the Least

Significant Differences (LSD) was used to separate the differing treatment means as suggested by Kothari (2004).

### 3.3 Data Validity

In social researches the ability to ensure that the information gathered is valid, accurate and a true representation of the population from which the research sample is drawn is very challenging (Ritchie and Lewis, 2003; Tang, 2011). However, to ensure validity of data for this study, a number of measures were put in place. The measures include triangulation where a combination of methods for data collection was used so as to increase validity and reliability (Odell, 2001; Hoza, 2009). For example, information collected during key informant interview was cross checked with that attained from household interviews as well as personal observation during field surveys.

Information from household heads was also patterned with those obtained from field survey example the components involved in the agroforestry homegardens. Similarly, market survey served as a way of cross checking information gathered from household interviews about prices of agroforestry homegarden products. Moreover, the researcher use key informants like village leaders to make homegardeners understand questions, get the information and provide answers precisely which helps in improving the quality of data (Zaman *et al.*, 2010).

### 3.4 Limitations of the Study

While conducting this study, some setbacks were encountered. These include the problem of farmers not recalling the data or information. Data collection especially on the quantity of products for food consumed or for sale from different sources some depended on the respondents' memory (Mpagama, 2011), therefore probing techniques were used to elicit

such amounts acquired and/ or sold. Questions asked during the interview, focused on everyday life which needed simple recal memory, example daily, weekly, monthly or seasonal acquisition estimetes so results on food acquired are estimates given by the respondents. To make it simple for farmers to recall well the consumption amount, questions asked were focused on food acquired rather than food consumed. According to Smith and Subandoro (2007) when reporting quantities of foods consumed, the respondents must undertake a number of complex calculations and report uncertain amounts rather than actual amounts or closer estimates associated with single events therefore it was easier for respondents to respond on food acquired from different sources. Manyika (2000) stresses that, information based on memory cannot be reliable but if no records exist it may be the only way to get at least an idea of change.

Due to poor quality of stacking and roughness of the wood, conversion of stacked volume to solid volume was also a limitation to the study. According to Kofman (2010) the amount of wood can be converted to solid volume ($m^{3\ s}$) by assessing, the quality of the stacking, the length of the bundle, the straightness of the logs and the quality of the delimbing with the said criteria it was not possible to convert the volume of the stacked bundles to solid volume.

Respondents were also reluctant to state the actual amount of money given by family members as remittances hence respondents were asked to estimate the approximate figures. Also due to legal restriction that prohibits harvesting of timber in the district, there is a danger that some of information especially on timber production might not have been revealed by respondents in fear of being arrested and charged by relevant authorities.

# CHAPTER FOUR

## 4.0 RESULTS

### 4.1 Socio-economic Characteristics of the Respondents

The sampled households had different socio-economic characteristics as shown in Table 2. About 67% of the household heads had primary education and there were an equal proportion between those with no education and those with secondary education both with 13% and very few 8% have college/university education. 79% depend on farming as their main occupation while others, 14% are employees in government or private offices. Very few (2%) respondents engaged on activities like carpentry, masonry and tailoring. 76% of the interviewed household heads were men while only 24% were female household heads. Majorities (76%) of the household heads were married followed by widowed 17% and the least (3%) were single. The largest proportion (41%) of the respondents were in the age group of 51- 65 years followed by 33% age group of 36-50 years while the age group of less than 35 years only makes 6% of the respondents.

Most respondents about 46% had a land size ranging from 0.25- 0.5 ha followed by 33% in land size group of 0.75 – 1 ha. Moreover, the family size of 59% households was 1- 4 members while 39% of the respondents households had a family size of 5-8 members and the least 2% in family size of 9-12 members.

**Table 2: Respondents and Household socio-economic characteristics**

| Socio-economic characteristics | | Frequency | Percentage |
|---|---|---|---|
| Education level | | | |
| | Primary | 80 | 67 |
| | Secondary | 15 | 13 |
| | None | 15 | 13 |
| | Collage/University | 10 | 8 |
| Occupation | | | |
| | Farmer | 95 | 79 |
| | Employee | 17 | 14 |
| | Trader | 6 | 5 |
| | Others (Carpenters,Tailor, Mason) | 2 | 2 |
| Household head by sex | | | |
| | Male | 91 | 76 |
| | Female | 29 | 24 |
| Marital Status | | | |
| | Married | 91 | 76 |
| | Widowed | 20 | 17 |
| | Separated | 5 | 4 |
| | Single | 4 | 3 |
| Age | | | |
| | <35 years | 7 | 6 |
| | 36-50 years | 39 | 33 |
| | 51-65 years | 49 | 41 |
| | >66 years | 25 | 21 |
| Average age | 55 years | | |
| Land Size | | | |
| | 0.25-0.5ha | 55 | 46 |
| | 0.75-1ha | 39 | 33 |
| | 1.25-1.5ha | 6 | 5 |
| | 1.75-2ha | 11 | 9 |
| | >2.25ha | 9 | 8 |
| Average land size | 0.99ha | | |
| Household size | | | |
| | 1-4 member (s) | 71 | 59 |
| | 5-8 members | 47 | 39 |
| | 9-12 members | 2 | 2 |
| Average household size | 4 members | | |

## 4.2 Components of the Chagga Agroforestry Homegardens and their Arrangements

### 4.2.1 The agroforestry homegardens components

The components forming the agroforestry homegardens practices in Rombo District are as shown in (Table 3). Woody perennials (trees/shrubs) and herbaceous crops (agricultural crops) were the most dominant components 100% and 98% respectively. The least used components were the insects 13% and aquatic life-forms 5%. Basing on classification criteria of components and their arrangements, the components are preferably presented individually rather than in combination to facilitate their system classification as presented in Table 3.

**Table 3: Components of the Chagga agroforestry homegardens practiced in Rombo District**

| Chagga homegardens components | Frequency | % in combination | % individual components |
|---|---|---|---|
| Woody perennials (tree/shrubs) | 120 | 33 | 100 |
| Herbaceous crops (agricultural crops) | 118 | 33 | 98 |
| Animals | 99 | 28 | 83 |
| Insects | 16 | 4 | 13 |
| Aquatic life-forms | 6 | 2 | 5 |

#### 4.2.1.1 The trees/shrubs (wood perennials) preferably used by the local communities in the agroforestry homegardens

Several tree/shrub species were found to be used by the local communities in Rombo District (Figure 2). Gravillea (*Gravilea robusta*) was the most common timber specie, Avocado (*Persea americana*) and Mango (*Mangifera indica*) were the common fruit trees while the Madras Thorn (*Pilhecellebium dulce*) was the most used shrub.

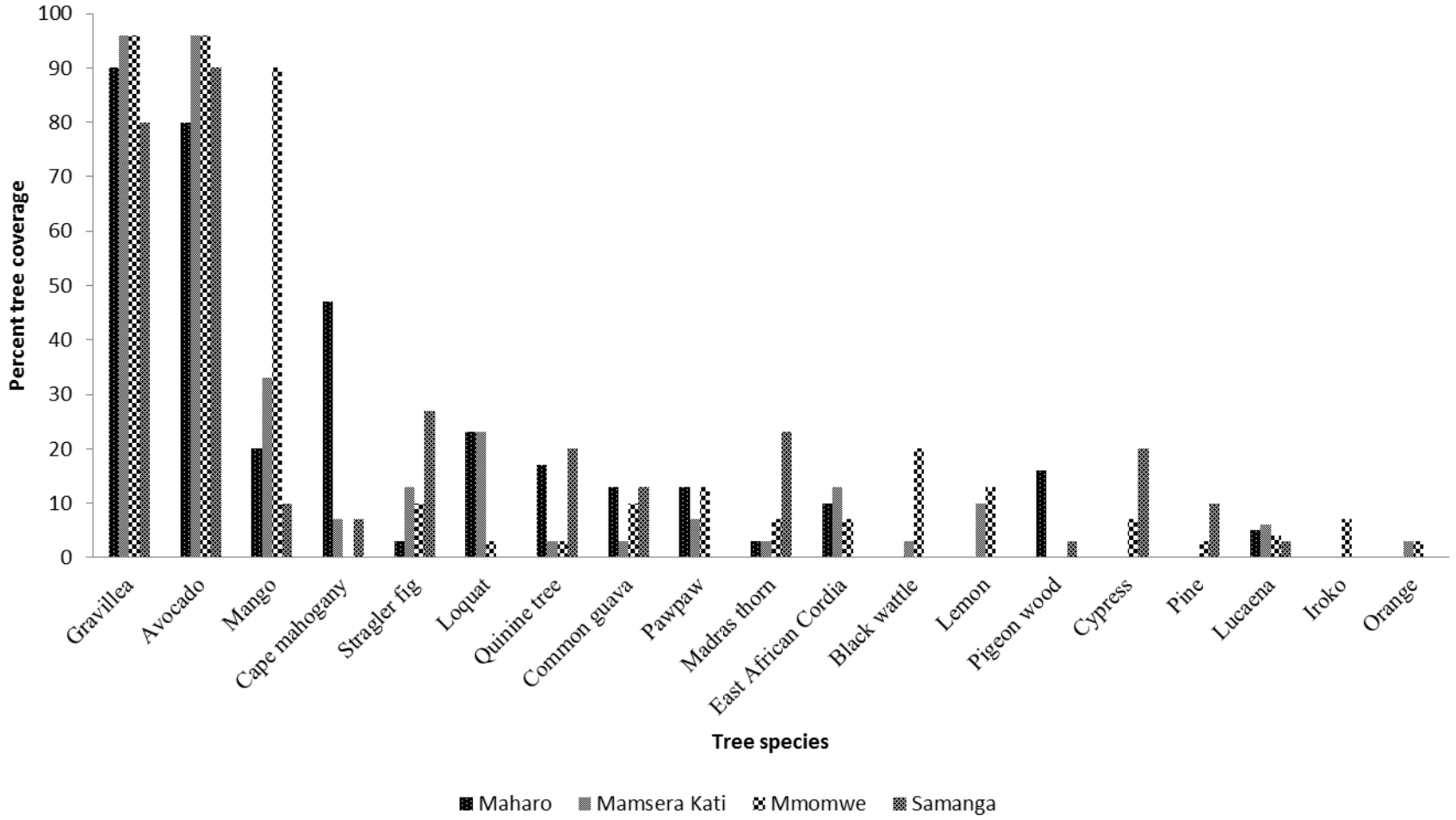


**Figure 2: Most dominant (woody perennials) trees/shrubs grown by households in Rombo District**

Figure 3 shows the fruit tree species that were commonly found in the Chagga agroforestry homegardens in Rombo District. Avocado (*Persea americana*) and Mango (*Mangifera indica*) were the fruit trees widely grown in almost all the villages.

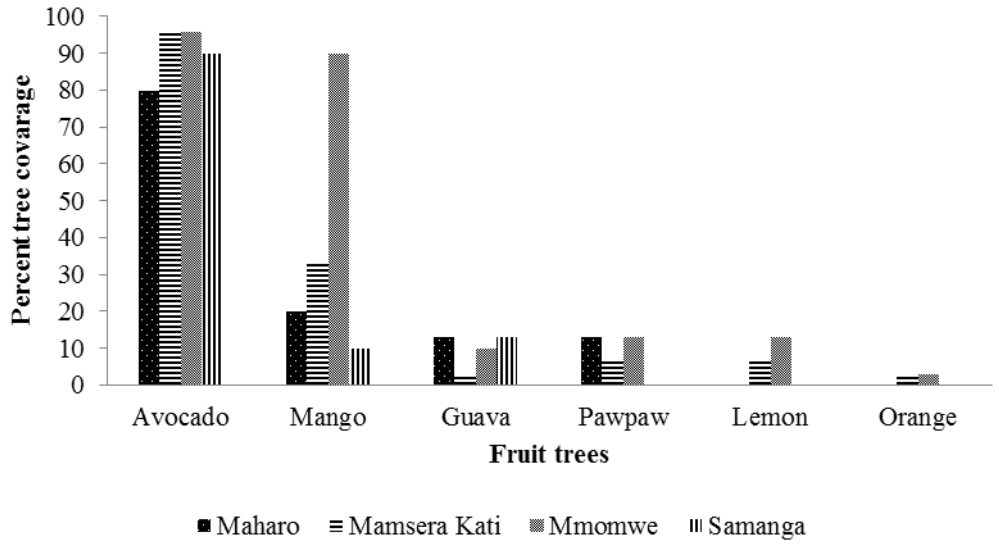


**Figure 3: The fruit tree species (woody perannials) found in the selected villages of Rombo District**

#### 4.2.1.2 Herbaceous crops (agricultural crops) grown in the Chagga agroforestry homegardens

Bananas (*Musa spp*) were the most common crop found in all the villages (Figure 4). The district's cash crop was coffee (*Coffea arabica*) and in some instances maize (*Zea mays*) and beans (*Phaseolus vulgaris*) which were variously found in all of the villages except in Mamsera kati village as the agroforestry homegardens in Mamsera Kati village were too dense for the crops to grow. Vegetables like Pumpkin leaves (*Curcubita moschata*) and Amaranthus (*Amaranthus spp*) were found in few (7%) and (10%) agroforestry homegardens in Maharo and Mamsera Kati villages respectively.

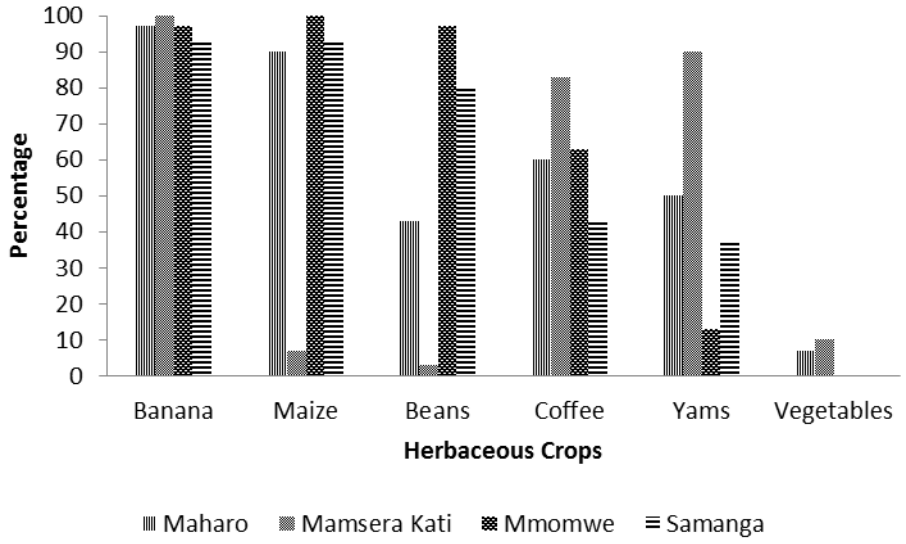


**Figure 4: Herbaceous crops (agricultural crops) found in the selected villages in Rombo District**

### 4.1.1.3 Domestication of animals in the Chagga agroforestry homegardens in Rombo District

Several animals were found to be domesticated in the Chagga agroforestry homegardens (Figure 5), which include mammals and bird species. In Rombo District the chickens (Gallus gallus) were mostly reared in the AF homegardens of all the villages, it has also been found that, the least domesticated animals were the rabbits (*Oryctolagus cuniculus*).

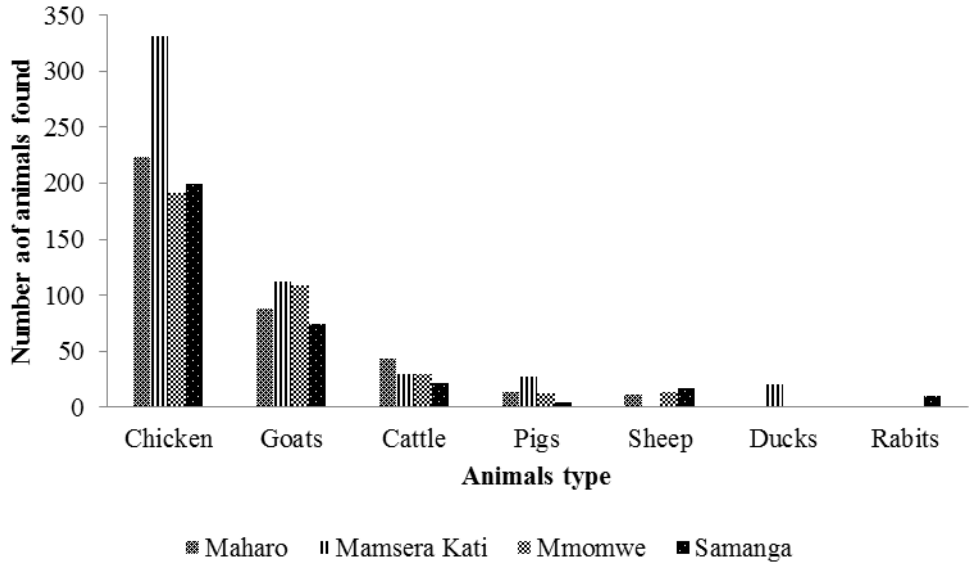


**Figure 5: Animals domesticated in the Chagga agroforestry homegardens in Rombo District**

#### 4.1.1.4 Common insects (bees) kept in the Chagga agroforestry homegardens in Rombo District

Insects found in the Chagga agroforestry homegardens were mostly bees of the stingless bees (*Apis trigona*) and the least kept were the stinging bees (*Apis mellifera*). It was found that Maharo village has the most (60) bee hives while Mommwe village was the least involved in beekeeping (Figure 6).

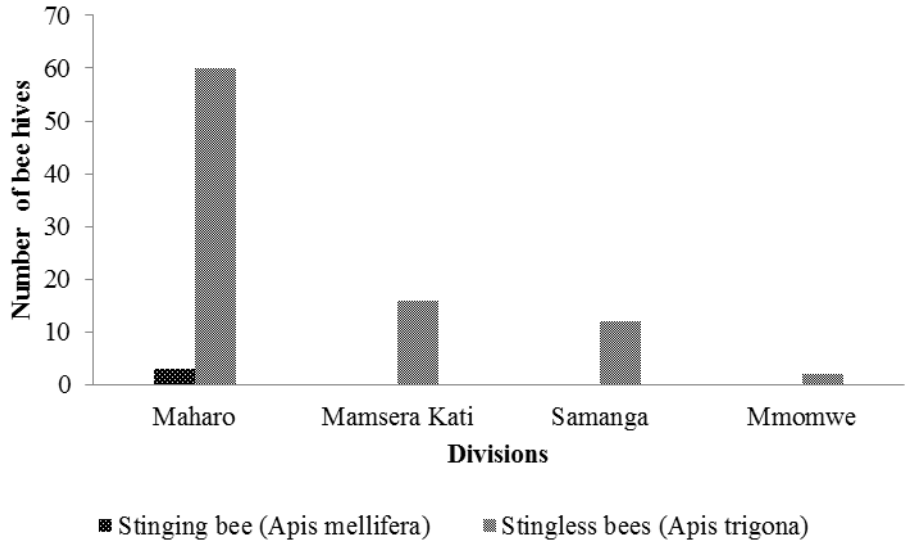


**Figure 6: Insects (bees) found in the Chagga agroforestry homegardens in Rombo District.**

#### 4.1.1.5 The aquatic life-forms commonly found in the Chagga agroforestry homegardens in Rombo District

Few Chagga agroforestry homegardens include aquatic life-forms component in their practices. Most (3) fish ponds of Nile tilapia (*Oreochromis niloticus)* were found in Samanga village and there was no involvement in keeping aquatic life-forms in Mmomwe village as shown in Figure 7.

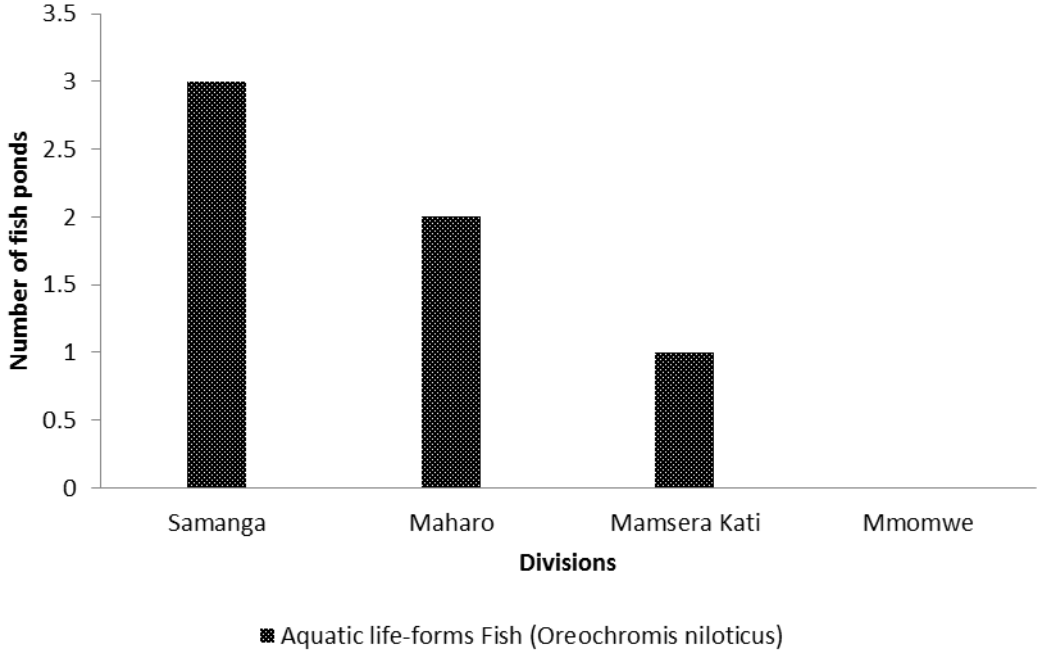


**Figure 7 : The extent of keeping aquatic life-forms in the selected villages of Rombo District**

### 4.2.2 Arrangement of the Chagga agroforestry homegardens components

The Chagga agroforestry homegardens components mostly (95%) were in spatial arrangement and in some cases (5%) in temporal arrangement (Table 4). Spatial arrangement includes component arrangements in a form of zonal planting 44%, mixed planting 30% and in some cases both mixed and zonal planting 21% also coincident-temporal arrangement 5% as shown in Figure 8

**Table 4: Arrangement of components in Chagga agroforestry homegardens**

| Agroforestry arrangement | Frequency | Percentage |
|---|---|---|
| Spatial arrangement | 114 | 95 |
| Temporal arrangement | 6 | 5 |

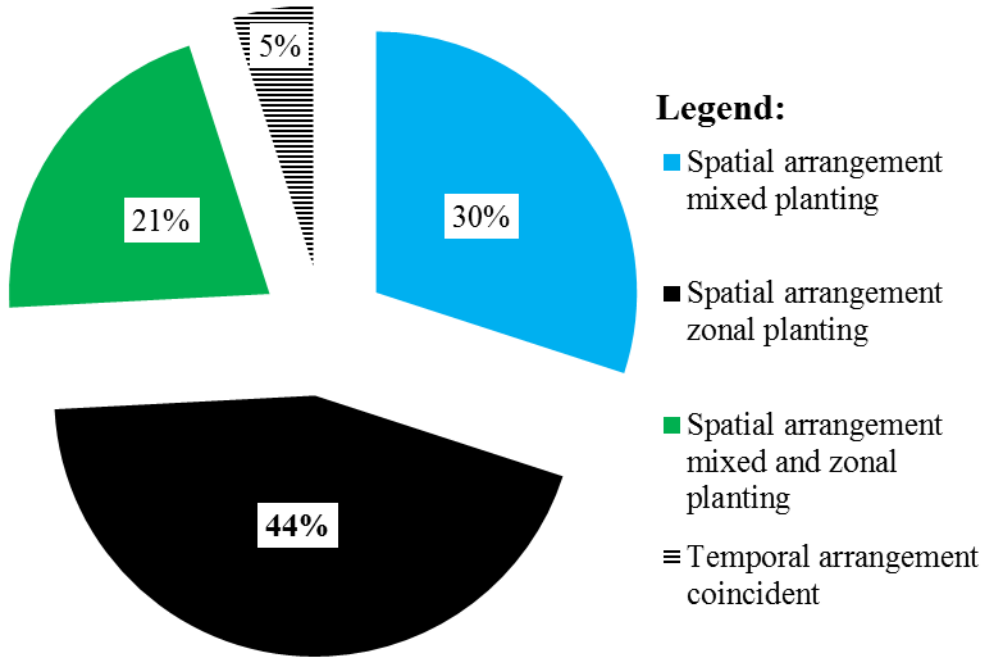


**Figure 8: Proportions of components arrangement and their respective forms**

### 4.3 Classification of the Chagga Agroforestry Homegardens in Rombo District

#### 4.3.1 Classification of the Chagga agroforestry homegardens into various systems

The variation in the components that associate in the Chagga agroforestry homegardens lead to the formation of various agroforestry systems. The agroforestry homegardens systems found to be practiced in Rombo District are as shown in Table 5. The classification was based on the type of components involved (Nair, 1993; Sinclair, 1999; Hasanuzzaman, 2008) in the agroforestry homegardens and grouped to form the systems (Kang and Akinnifesi, 2000).

Table 6 indicates Agrosilvopasture (Agrosilvopastoral system) to be the most widely (70%) used agroforestry system in Rombo District followed by Agrosilviculture (Agrosilvicultural system) (14%) and the least used systems (1% each) were the Agroaquosilviculture (Agroaquosilvicultural system), Agroaquosilvopasture (Agroaquosilvopastoral system), Aposilvopasture (Aposilvopastoral system) and Silvopasture (Silvopastoral system).

**Table 5: The Chagga agroforestry homegardens components forming the various agroforestry systems practiced in Rombo District**

| **Chagga agroforestry homegarden Systems** | **Chagga agroforestry homegarden components** | | | | |
|---|---|---|---|---|---|
| | Woody Perannials | Herbaceous Crops | Animals | Insect | Aquatic life-forms |
| Agrosilvopasture (Agrosilvopastoral system) | ✓ | ✓ | ✓ | | |
| Agroapoaquosilvopasture (Agroapoaquosilvopastoral system) | ✓ | ✓ | ✓ | ✓ | ✓ |
| Agroaposilvopasture (Agroaposilvopastoral system) | ✓ | ✓ | ✓ | ✓ | |
| Agrosilviculture (Agrosilvicultural system) | ✓ | ✓ | | | |
| Agroaquosilviculture (Agroaquosilvicultural system) | ✓ | ✓ | | | ✓ |
| Agroaposilviculture (Agroaposilvicultural system) | ✓ | ✓ | | ✓ | |
| Agroaquosilvopasture (Agroaquosilvopastoral system) | ✓ | ✓ | ✓ | | ✓ |
| Aposilvopasture (Aposilvopastoral system) | ✓ | | ✓ | ✓ | |
| Silvopasture (Silvopastoral system) | ✓ | | ✓ | | |

✓ = The components that appeared to form the system

**Table 6: Agroforestry systems found in the Chagga agroforestry homegardens in Rombo District**

| **Chagga agroforestry homegarden systems** | **Frequency** | **Percentage** |
|---|---|---|
| Agrosilvopasture (Agrosilvopastoral system) | 84 | 70 |
| Agrosilviculture (Agrosilvicultural system) | 17 | 14 |
| Agroaposilvopasture (Agroaposilvopastoral system) | 9 | 8 |
| Agroapoaquosilvopasture (Agroapoaquosilvopastoral system) | 4 | 3 |
| Agroaposilviculture (Agroaposilvicultural system) | 2 | 2 |
| Agroaquosilviculture (Agroaquosilvicultural system) | 1 | 1 |
| Agroaquosilvopasture (Agroaquosilvopastoral system) | 1 | 1 |
| Aposilvopasture (Aposilvopastoral system) | 1 | 1 |
| Silvopasture (Silvopastoral system) | 1 | 1 |

### 4.3.2 Classification of the Chagga agroforestry homegardens into various technologies

Table 7 shows the common agroforestry technologies and their associated arrangement in the Chagga agroforestry homegardens. The Agroforestry technologies found were Boundary planting 43% followed by Mixed intercropping (42%) and Live fences (15%). The Chi square test for association between components arrangements and the agroforestry technologies results are presented in Appendix 3 which shows there was a significant association amongst components arrangements and the AF technologies.

**Table 7: The agroforestry technologies found in the Chagga agroforestry homegardens**

| Arrangement of the components | | AF technologies found in the homegarden: Boundary planting | Mixed intercropping | Live fences | Total | % |
|---|---|---|---|---|---|---|
| Spatial Arrangement | Zonal planting | 52 | 0 | 1 | 53 | 44 |
| | Mixed planting | 0 | 36 | 0 | 36 | 30 |
| | Mixed and zonal planting | 0 | 8 | 17 | 25 | 21 |
| Temporal Arrangement | Coinceident | 0 | 6 | 0 | 6 | 5 |
| Total | | 52 | 50 | 18 | 120 | |
| % | | 43 | 42 | 15 | | |

% - Percentages

## 4.4 Contribution of the Chagga Agroforestry Homegardens to Food, Income and Wood Energy

### 4.4.1 Contribution of Chagga agroforestry homegadens to food

Different products from agroforestry homegardens have contributed to food supply to the community. The quantities acquired from different sources are as presented in Table 8 where the community on average acquired 130 bags of maize, 6620 kgs of beans from agroforestry homegardens while other sources contributed 20 bags, 1 bag, 7 bags of maize from open field farms, food purchases and other agroforestry practices respectively.

**Table 8: Quantities of food acquired from different sources**

| Source of food | Product | Quantity/Yr |
|---|---|---|
| Agroforestry homegardens | Banana (Bunds) | 7 638 |
| | Maize (Bag =100kg) | 130 |
| | Beans (Kg) | 6 620 |
| | Cowpea (Kg) | 530 |
| | Milk (Littre) | 35 640 |
| | Chickens | 237 |
| | Eggs | 97 200 |
| | Honey (Littre) | 33 |
| | Fish (Kg) | 72 |
| | Fruits* | |
| | Yams* | |
| | Meat* | |
| Open field farms | Maize (Bag) | 20 |
| | Beans(Kg) | 1 445 |
| | Cowpea (Kg) | 290 |
| Food purchases | Maize (Bag) | 1 |
| | Beans (Kg) | 60 |
| Other agroforestry practice | Maize (Bags) | 7 |
| | Beans (Kg) | 465 |
| | Cowpea (Kg) | 100 |
| | Honey (Littre) | 5 |

*No actual measurable amount
1 bag of maize = 100kg

For statistical tests the acquired food quantities were transformed into monetary values as a single measurable unit for comparisons (Appendix 7). Agroforestry homegardens are seen as the major sources with significant contributions of 95% to food supply to the community of Rombo District (Table 9). ANOVA table for statistical test are presented in Appendices 4 a and b.

**Table 9: Sources of food and their contributions to local communities**

| Sources of food | Quantity (TZS) | Contributions (%) |
|---|---|---|
| Agroforestry homegardens | 21 753 975a | 95 |
| Open field farms | 812 113b | 4 |
| Other agroforestry practices | 295 625b | 1 |
| Food purchases | 33 750c | 0 |
| Total | 22 895 463 | 100 |

Quantities followed by the same letter do not differ significantly (P<0.05),
LSD= 4 809 436

### 4.4.2 Contribution of Chagga Agroforestry Homegardens to Income Generation

Results in (Table 10) show the Chagga agroforestry homegardens to be the main contributor (86%) to income generation of the studied villages. Other sources of income have varying but limited contributions to income generation of the local community. Statistical test for ANOVA are in Appendices 5a and b).

**Table 10: Sources of Income generation and their contributions to the local community**

| Sources of Income | Quantities (TZS) | Contribution |
|---|---|---|
| Agroforestry homegardens | 16 269 650a | 86 |
| Employments | 1 062 500b | 6 |
| Business | 612 500b | 3 |
| Remittances | 445 000bc | 2 |
| Open field farms | 435 500bc | 2 |
| Other agroforestry practices | 133 625c | 1 |
| Total | 18 958 775 | 100 |

Quantities followed by the same letter do not differ significantly (P<0.05),
LSD= 3 704 241

### 4.4.3 Sources and their contributions to wood energy in Rombo District

The results in (Table 11) show the large part (73%) of the wood energy is acquired from agroforestry homegardens while other sources of wood energy contribute 13%, 10% and 3% from wood energy purchases, nearby forests and other agroforestry practices respectively. Culculations for statistical tests for comparisons are summarized in Appendices 6 a and b.

**Table 11: Sources of wood energy and their daily contributions to local community**

| Sources of wood energy | Quantity ($m^{3\ st}$) | Contribution (%) |
|---|---|---|
| Agroforestry homegardens | 1.50a | 73 |
| Wood energy purchases | 0.27ab | 13 |
| Nearby forest | 0.21b | 10 |
| Other agroforestry practices | 0.07b | 3 |
| Total | 2.04 | 100 |

Quantities followed by the same letter do not differ significantly (P<0.05), LSD= 0.25

## 4.5 Constraints to Chagga Agroforestry Homegardens Practices and Measures Required for their Improvement

### 4.5.1 Constraints to Chagga agroforestry homegardens in Rombo District

Despite the agroforestry homegardens being the main source of households food, income generation and wood energy in the district, however, there are various constraints to their development in Rombo District as shown in Table 12.

**Table 12: Percentage distribution and ranking of constraints faced in Chagga agroforestry homegarden**

| Constraints | Percentage (%) |
|---|---|
| Lack of extension services | 28 |
| Pests and diseases | 22 |
| Water shortages | 14 |
| Labour shortage | 8 |
| Land shortages | 8 |
| Inadequate manure | 7 |
| Inadequate capital | 5 |
| Other off-farm activities | 5 |
| Poor farm equipments | 3 |

### 4.5.2 Measures required for improving the level of use of the Chagga agroforestry homegardens practices.

In order to improve the level of use of the Chagga agroforestry homegardens practices in the district, communities have suggested a number of measures (Figure 9), the main being the need for extension services (59.1%) and availability of improved tree and crop seeds (10.8%).

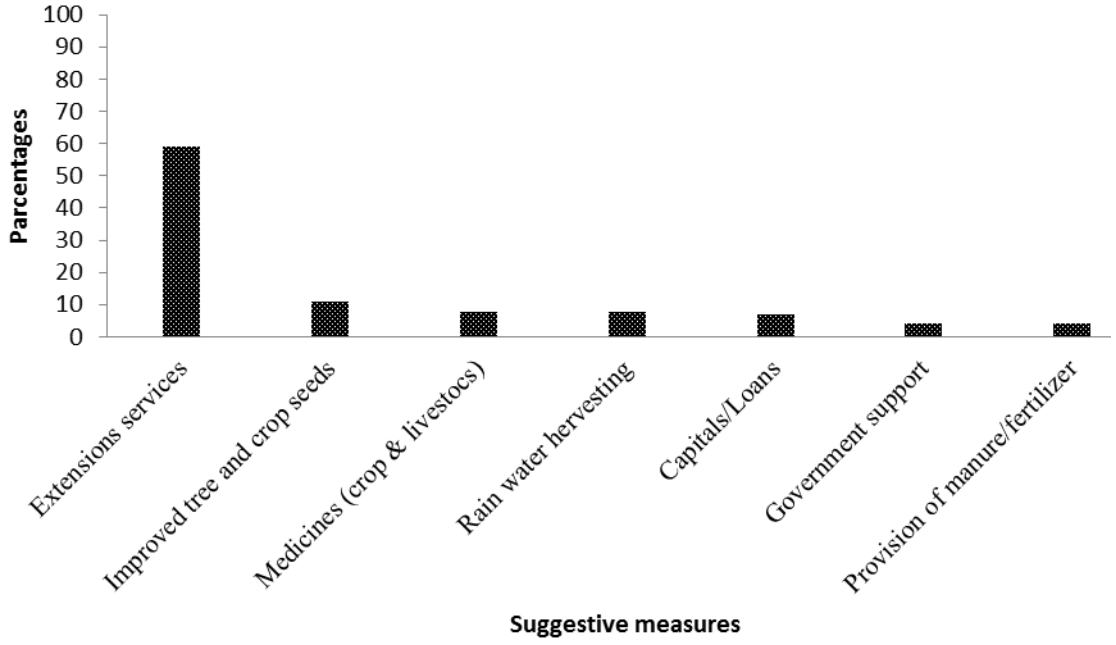


**Figure 9: The measures required for improving the Chagga agroforestry homegardens practice in Rombo District**

# CHAPTER FIVE

## 5.0 DISCUSSION

### 5.1 Socio-economic Characteristics of the Respondents in Rombo District

The finding of this study (Table 2) shows that most of the respondents (60%) had primary education. These findings were similar to those observed in Musoma Rural, Mara Region where the highest number of the respondents (77%) had primary education (James, 2004). Similar findings were also observed in the AJISO (2012) report in Rombo District where, the highest number of respondents (69%) had primary education. Also, Soini (2003), in his findings reported that most of the farmers had finished about seven years of primary education. Primary school enrolment in Kilimanjaro Region is amongst the highest in the country (Meena and O'Keefe, 2007). According to Kitalyi *et al.* (2013) for many years coffee and banana have been sustaining the livelihoods of farmers in Northern Tanzania hence farmers afford to take their children to school, making Kilimanjaro Region one of the well educated regions.

The majority of the respondents (79%) were farmers in Rombo District. In support to this (URT, 2000) stated about (85%) of the population in Kilimanjaro Region are thought to be involved in agriculture on a full time basis. Very few depend on other occupations as Employment (14%), Business (5%) and Others (Carpentry, Tailoring or Masonry) are depended by only 2%. These lower involvements in other occupations is explained by Meena and O'Keefe (2007) who stated that, households' reliance on natural capital is greater in Rombo District because off-farm diversification options are not much available hence farmers rely much on their AF homegardens for their livelihoods.

A high number (76%) of the respondents were married and most (76%) of the household heads were men. According to Soini (2003) a Chagga father customarily provides his sons with homegarden plots when they marry to start a family. This was the reason for having high number of married respondents. Similar findings were observed by Udofia (2011) in Nigeria homegardens where the majorities (87.9%) of agroforestry homegardeners were married. The findings on sex of respondents male (76%) and female (24%), shows the male as the managers of the agroforestry homegardens which are in contrast to findings of WinklerPrins and de Souza (2010) that, in Brazil 78% of the agroforestry homegardens listed were managed by women. In the present study most of the households (59%) had family sizes of 1-4 members followed by (39%) of family sizes of 5-8 members and the least (2%) made by family sizes of 9-12 members. These findings are contradicting those of Zaman *et al.* (2010) that in Bangladesh 60% of homegardeners households were medium sized family of 5-10 members.

The highest number of respondents (41%) was of the age ranging from 51- 65 years. According to Mamkwe (2003) the age group consisted of adults who returned home after retirement from employment or casual labour in the urban areas. At this age, mature adults tend to settle at home and take care of their AF homegardens as preparation of their security at old age (Maroyi, 2009). Very few (6%) of household heads age was less than 35 years old. This was because most of the youth were in urban areas or not married to be given a plot for AF homegarden (Soini, 2003). Contrary to these findings it has been observed in the Eastern Cape, South Africa, that agroforestry homegardens were managed by households with the age group ranging from 31-45 years (Adekunle, 2013). The average age of the respondents in the present study was 55

years. These results are in line with those observed by Drescher *et al.* (1999) in Zimbabwe.

Land size in the study area ranges from 0.25 to 2 ha of which the majority (46%) of the respondents fall in the land size of 0.25-0.50ha. This was because most of the people live on inherited land, the average size of an inherited plot being 0.56 ha (Soini, 2003). This outcome was consistent with the general features of agroforestry homegardens as being of small plots near the family dwellings (Mitchell and Hanstad, 2004; Kumar and Nair, 2004). The results are larger than those observed in Vietnam homegarden sizes which were ranging from 0.015-0.5 ha (Trinh *et al.,* 2002) and in Ethiopia 0.01-0.5 ha (Asfaw, 2002). The average land size in Rombo District was 0.99 ha which is higher than that of 0.3 ha recorded in Sri Lanka (Senanayake *et al*., 2009).

## 5.2 Components of the Chagga Agroforestry Homegardens and their Arrangements

### 5.2.1 Components of the Chagga agroforestry homegardens

The results on the components of the Chagga agroforestry homegardens practiced in Rombo District are presented in Table 3. Whereas all components are found in the Chagga agroforestry homegardens, the wood perennials were the most widely used components as reported in other studies on agroforestry homegardens (Fernandes *et al*., 1984; Sioni, 2005) in the Chagga area and Mendez *et al*. (2001) in Nicaragua where AF homegardens were reported to constitute over 85% of all the homegardens components. The woody perennials in the Chagga agroforestry homegardens were mostly multi-purpose trees of which details on their local and botanical names and uses are as provided in appendix 9. Those were the most common features of trees grown by smallholder farmers (FAO, 1995). The multi-purpose trees were found scattered

throughout the homesteads or at specific points (Mathew *et al.*, 1996) for different purposes including to provide shade for coffee, fodder, timber and firewood and as live fences (Ali, 2005; Kitalyi *et al.,* 2013). Also used for environmental and production systems conservation (Montagnini, 2005; Nair *et al*., 2008; Jose, 2009; Nair *et al*., 2010).

In the study area, farmers prefer Gravillea (*Gravilea robusta*) and Avocados (*Persea americana*) which were found in most of the agroforestry homegardens (Figure 2). The finding are similar to those observed in other areas, for example in Ondo State Nigeria, Oke and Odebiyi (2007) reported that farmers preferred Avocados (*Persea americana*)*,* Mangoes (*Mangifera indica*), Oranges (*Citrus sinense*s) and Guavas (*Psidium guajava*) as the most important exotic tree species cultivated to provide edible fruits in addition to shade for cocoa crop. Dowiya *et al.* (2009) reported that farmers practiced agroforestry homegardens in North and South Kivu in the Democratic Republic of Congo and they grew *Eucalyptus* spp. for fuelwood and *Carica papaya, Mangifera indica*, *Persea americana* and *Psidium guajava* as multi-purpose trees. Farmers prefer more fruit tree as fruits are harvested for household consumption and often are the sole source of food for the family in times of scarcity (Montagnini, 2006), but aalso for sale to get income. The Avocado *(Persea Americana)* was the most preferred fruit tree by the communities in the study area (Figure 3) probably due to its climatic adaptability, fruits provision and shelter. This agrees also with the findings of Kefleketema (2006) and Ajayi (2007) who reported that trees selected must be preferred and acceptable by the people who are going to use them, nonetheless be able to establish and grow well in their local environmental conditions.

Herbaceous crops found in the study area include banana, maize, beans, yams, vegetables and coffee as their supplement cash crops. Similar results have been observed in Nicaragua (Mendez *et al*., 2001), Southern Ethiopia (Abebe, 2005) and Zimbabwe (Maroyi, 2009). Crop diversity in agroforestry homegardens ensures a year round supply of food and balanced nutrition (Ali, 2005; Lulandala, 2011). In Mamsera kati village (Figure, 4) due to their agroforestry homegardens characteristics of having a dense mixed structure, other highly light demanding herbaceous crops like maize and beans were not widely grown. The results align with those of Mendez *et al.* (2001) in Nicaragua, where he found that light demanding species like maize, beans and vegetables were in only one agroforestry homegarden.

Animal components provide household manure that helps in agroforestry homegardens (Ali, 2005; Soini, 2005), milk and in some cases meat for food (Njuki, 2001). Animals were widely found in all villages, the most reared ones were the chicken (*Gallus gallus*) as they were easiest source of investment for all the farmers (Soini, 2005) and they could be reared in small areas, with little capital and labour inputs (Mamkwe, 2003). Similar results were observed elsewhere for example in Mexico (Angel-Perez and Mendoza, 2004; Montagnini, 2006). Chicken are important for food and in some cases income even in a female headed and poorest household with the advantage that their products are easy to sell in the local markets and their year round production (Del Angel-Perez and Mendoza, 2004). Garces (2002) reported that, with an average of 5 chicken, a woman could have an income increase of up to 9.5% hence a good source of income.

Other animals were cattle, goats, pigs, sheep and rabbits (Figure 5). Due to increasing scarcity of fodder and limited extensive grazing lands (Soini, 2005) these animals were

not large in numbers. These animals were also reported in other studies for example, in the Totonac agroforestry homegardens of Veracruz, Mexico, pigs, chicken and other small livestock were common (Del Angel-Perez and Mendoza, 2004). In Cuba, animals such as pigs, sheep, chicken, and to a lesser extent ducks, rabbits, and turkeys abound in the agroforestry homegardens (Wezel and Bender, 2003).

The presence of insects and aquatic life-forms in the Chagga agroforestry homegardens, especially bees and fish had been previously reported (Ali, 2005; Hemp and Hemp, 2008). Bees especially the stingless (*Apis trigona*) were generally being kept by the homegardeners in Rombo District (Figure 6), contrary to the findings of Galhena (2012) who reported that, in Sri Lanka only two AF homegardeners were practicing apiculture. According to (Rombo District Beekeeping Officer personal communication, 2014), "although beekeeping is currently on a very small scale, it has a promising development as the farmers are increasingly being aware of the profits that can be generated from the practice. Moreover the Tanzania Wildlife Research Institute (TAWIRI) is implementing a project that involves farmers in beekeeping as an approach to keep away elephants from the villages (TAWIRI-personal communication, 2014), which will surely steer up the practice.

Fish farming was not widely practiced in the district although some villages such as Samanga and Maharo were actively involved (Figure 7). The findings concur with those of Ali, (2005) that small fish ponds are also integral part of agroforestry homegardens in Bangladesh. In the study area, Mmomwe Village fish farming was not in practice. According to Mrao Keryo Ward Officer at Mashati Division (Personal communication, 2014), "Lack of knowledge and severe water shortages kept farmers away from fish farming". Similar observations have been observed by Galhena (2012)

who reported that, in some parts of Sri Lanka none of the AF homegardeners were engaged in fish farming.

### 5.2.2 Arrangement of the Chagga agroforestry homegardens components

The agroforestry homegardens in Rombo District were mostly (95%) arranged in a spatial arrangement and very few (5%) temporal arrangement as shown in Table 4. Spatial arrangements denotes mixed planting and zonal planting (Figure 8). Zonal planting were widely observed in other AF homegardens where the majority of the woody perennials were found on the boundaries of the homegardens as boundary planting and live fence technologies (Yiridoe and Anchirinah, 2005; Galhen *et al*., 2013). The other arrangement was mixed planting where few multi-purpose trees are scattered in the resource management unit resulting into dense or sparce mixed structures (Nair, 1993). Similar arrangements have been observed in other agroforestry homegardens (Abebe, 2005; Tang, 2011) where spatial arrangement of mixed planting of herbaceous crops intercroped with the wood perennials to form a mixed intercropping technology. Other arrangements were the combination of mixed planting and zonal planting whereby mixed planting in the middle was surrounded by a zonal planting of live-fences (Mamkwe, 2003) nonetheless, both arrangements were managed separately. According to Sinclair (1999) it is useful, therefore, to view the mixed garden-live fence complex as a spatial group of two practices because of their discrete functionality. With that regard from Sinclair (1999) they were reported separately during the survey.

Temporal arrangement was seen in some typical tree/coffee agroforestry homergadens where the components are in coincident arrangements (Coffee under tree shade). It has been reported by Kumar and Nair (2004) that, it is with these arrangements that allow

farmers to provide shade to their coffee or reduce competition among the components. The enset-coffee-tree homegardens of Southern Ethiopia were also seen to be arranged in coincident arrangement (Abebe, 2005).

## 5.3 Classification of the Chagga Agroforestry Homegardens Into Agroforestry Systems and Technologies

### 5.3.1 Classification of the Chagga agroforestry homegardens systems

As Table 3 shows, almost all broad five categories of renewable natural resources components were found in the Chagga agroforestry homegardens in the various categories of associations. This leads to their classification into several agroforestry systems (Table 5). The Chagga agroforestry homegardens included 9 agroforestry systems. Based on the present classification, these findings contradict with those reported by Nair, (1993) which stated agroforestry homegardens to be typically of Agrosilvicultural and Agrosilvopastoral systems. Fish ponds were seen in some Chagga agroforestry homegardens example in (Plate 1) making two agroforestry systems of Agroaquosilvopastoral and Agroapoaquosilvopastoral systems, contradicting with the earlier two systems reported by Nair (1993) and Tolunay *et al.* (2007).

**Plate 1: Agroaquosilvopastoral system found in Rombo District**

*Livestock not seen in the plate
Source: Survey data (2014)

The Aposilvopastoral, Agroaposilvopastoral, Agroaposilvicultural and Agro-apoaquosilvopastoral systems as shown in Table 5 are properly classified agroforestry homegarden systems which include insects.

The agroforestry systems involving insects were also observed elsewhere for example in Uganda (Sebukyu and Mosango, 2012). Insects were also mentioned in earlier studies on the Chagga agroforestry homegardens (Kitalyi and Soini, 2004; Soin, 2005; Hemp and Hemp, 2008) however, they were not put into their appropriate agroforestry systems classification as those reported by Lulandala (2011).

Yet still the Agrosilvopastoral system remains the widely used agroforestry system in Rombo District (Table 6). Similar results were observed by Zeleke (2009) who found 86% of Agrisilvopastoral systems in agroforestry homegardens of Oromia, Ethiopia.

Also, in Mbeya Rural District the Agrosilvipastoral system was preferred mostly 96% by AF homegardeners (Nzilano, 2013). The preference to the system was its diversity that allowes multiple components with maximum benefits if well managed (Tolunay, 2008; Bassullu and Tolunay, 2010). Silvopastoral system was among the least 1% agroforestry homegarden system in use in the study area. Similar results observed by Zeleke (2009) who reported that about 1.3% of the community practiced Silvopastoral system in Oromia, Ethiopia.

### 5.3.2 Classification of the Chagga agroforestry homegardens into associated technologies

The survey data (Table 7) revealed that the arrangement of components which led to the classification of the most practiced agroforestry technologies in the Chagga agroforestry homegardens. Agroforestry technologies were the boundary planting (43%) followed closely by mixed intercropping (42%) and live fences technologies (15%). This is in agreement with the results of Galhen *et al*. (2013) study which found agroforestry homegardens to be delimited by the physical demarcations such as boundary planting or live fences. These agroforestry technologies are employed by farmers to mark their AF homegardens boundaries to shelter off intrusions, or as a way that allows farmers to use the middle space more effectively (Torquebiau, 2000). Similar results were also observed in Ghananians homegardens where Yiridoe and Anchirinah (2005) found that, live fences were observed to be used for management of agroforestry homegardens as a way to protect them from invasion of animals and theft. Mixed intercropping was also widely used as it allows farmers to maximumly utilize the space by mixing all the components that have positive interaction (Abebe, 2005) within their AF homegardens. This was also observed by Kitalyi and Soini (2004) and Tang (2011) that farmers typically have a coffee-banana farm with many other food

crops and trees intercropped in their agroforestry homegardens. In contrast to the findings mixed intercropping was not found in some other AF homegardens for example in Zimbabwe (Drescher *et al.,* 1999).

## 5.4 Contribution of the Chagga Agroforestry Homegardens to Food, Income and Wood Energy to the Local Communities

### 5.4.1 Sources of food and their contribution to the local community

From survey data, Table 8 shows that in Rombo District, highest quantities of food come from the Chagga agroforestry homegardens as the primary producer, contrary to Musotsi *et al.* (2008) stating agroforestry homegardens as being supplementary food production systems and not the households' primary source of food. The Chagga agroforestry homegardens food components play the major part in ensuring a year around supply of food from different products such as maize 130 bags, beans 6629 kg, banana 7638 bunches and in some cases fish 72 kg and honey 33 littre all contributing up to 95% of food supply followed by other sources. These contributions were more than those observed from other findings example, in West Usambara homegardens (Moshi, 1997) and in Morogoro (Mariro, 2009). The lower contributions of AF homegardens to food in other areas, for example in Morogoro, may be because, most of the Morogoro Municipality household members are employed in various paying activities and income received is used to purchase food (Mariro, (2009), while most of the households in Rombo District depend on Chagga agroforestry homegardens for food production. Food purchases contribute up to (0.1 %) while (3.58%) and (1.29%) come from open field farms and other agroforestry practices respectively (Table 9). Contrary to these findings it has been observed that, these other food sources contributed more in other areas for example in Mbeya Rural District open field farms

contributed 47% to food supply (Nzilano, 2013) and in Maswa District where agroforestry contributes up to 13% to food supply (Shilabu, 2008).

Other sources of food supply to the households like open field farms and other agroforestry practices were the results of farmers to have other plots apart from their agroforestry homegardens (Soini, 2003; Misana *et al.,* 2012). These other practices contributed maize 20 bags, beans 1445 kg from open field farms while other agroforestry practices contributes up to 7 bags of maize and 465 kg of beans which were all lower than quantities produced in agroforestry homegardens. These contrasts were due to the farmers' interest in agroforestry homegardens that allows mixed intercropping which contradicts with agriculture monoculture characteristics and farmers see agroforestry homegardens as a living food store that ensure a year around supply of food (Ali, 2005) making Chagga agroforestry homegardens a significant source and contributor to the community food supply. These findings contradict with those of Nzilano (2013) in Mbeya Rural District where agriculture (open field farms) was the significant source of food with the highest contribution.

### 5.4.2 Sources of income generation and their contributions to the local community

In Rombo District like in other local community majorities have recognized agroforestry homegardens as the main source of income generation that contributes up to 86% (Table 10). Similar results were observed by Mendez *et al.* (2001) in Nicaragua. The findings are in contrast to those of Hoogerbrugge and Fresco (1993) who reported that agroforestry homegardens were not observed to be the main source of income to the households.

In Rombo District as the majority are farmers, they obtain their income from the selling of on-farm produce. In support of this Meena and O'Keefe (2007) reported that, the respondents in Rombo District relied significantly on farm production for income generation. The Chagga AF homegardeners sell farm products such as maize, coffee, livestock products like meat, milk and eggs, woody perennials products like timber, wood fuel and fruits as well as honey and fish from insects and aquatic life forms. Appendix 8 shows the income products in the district. All these income products made Chagga agroforestry homegardens to be the highest contributor (86%) to income of the local communities. The finding was more than those of Trinh *et al.* (2003) and Ali (2005) who report that agroforestry homegardens in Vietnam and Bangladesh contributed about 22% and 52% of household income respectively.

Apart from agroforestry homegardens, the Chaggas also depend on various sources for income generation which have slight contributions as shown in Table 10. Parallel findigs were observed by Crookes (2003) who found employment, remittances by kin who live and work elsewhere and petty trade to be other sources of income to rural households. According to Kitalyi and Soini (2004) devotion of farmers to other income generating activities has been due to decline of coffee prices in the world market and rise of production costs in the Chagga agroforestry homegardens hence household heads involve themselves partly in other income generating activities.

However, the contributions of other income generating sources in Rombo District were lower when compared to other areas. For example from off-farm sources Shilabu (2008) reported that, in Maswa District employment and business contributed 38% and 18% respectively. Moshi rural remittances contributed 13% to houdehold income (Meena and O'Keefe, 2007) which was also higher than 2% in Rombo Distict. This

implies that off-farm diversification options are not available in Rombo District, therefore, households reliance on natural capital that includes agroforestry homegardens is greater as observed by Meena and O'Keefe (2007).

### 5.4.3 Sources of wood energy and their contributions to the local community

Chagga agroforestry homegardens were the main source and contributor to wood energy of the local communities (Table 11). The findings are in line with the findings of (Wiersum, 1997) who reported agroforestry homegardens as being important source of wood energy by contributing 40% to 80% of the rural needs. From the current situation in Rombo District, the villagers are not allowed to cut down trees hence farmers depend on their Chagga agroforestry homegardens for fuel wood. This was the reason for lower contribution (10%) from nearby forests in the study area. Contrary to Tewari *et al.* (2003) and Kasolo and Temu (2008) who found nearby forests to have higher contributions to local community wood energy needs in Himalaya and Uganda respectively. Higher contribution of AF homegardens to wood energy needs than nearby forests imply that agroforestry homegardens are a better substitute for communities that depend on forests for their wood energy requirements which helps in reducing forest encroachments (Torquebiau, 1992).

Purchasing wood fuels was also a common source for those who don't have enough wood fuels from their agroforestry homegardens, as was also noted by Soini (2003). The findings of this study show 13% of wood energy consumed was acquired through purchases. In line with these findings Ray (2011) found 5% of household wood energy in Kizanda Village, West Usambara Mountains, was acquired through purchases. Also Saxena (1993) reported wood energy purchase contributed up to 15% of total firewood consumed in rural India.

In general both sources contribute up to 2.04 $m^{3\ st}$ daily to the local community. The large consumption quantity was caused by the fact that villagers still use the traditional three stone fire stove for their cooking, from which more firewood was burned than it was necessarily required in the cooking process. Similar findings were observed in Uganda by Agea *et al.* (2010) that, much of the heat generated is often wasted because the cooking is usually done in the open.

## 5.5 Constraints to Chagga Agroforestry Homegardens Practices and Measures Required for their Improvements

### 5.5.1 Constraints to Chagga agroforestry homegardens practices in Rombo District

Table 12 shows constraints to Chagga agroforestry homegardens practices in Rombo District where lack of extension services, pests and diseases were the major constraints to effective management of agroforestry homegardens.

In this study AF homegardeners reported lack of extension services as one among the major constraints which have limited access to new agroforestry technologies and appropriate farming and market information. The results are in agreement with those of Zeleke (2009) in Oromia, Ethiopia and Glendenning *et al.* (2010) in Kerala. Extension services are not effectively reaching the target farmers which results to poor production in agroforestry homegardens (Soini, 2003). Ineffective linkage between extension workers and farmers is responsible for low productivity and ofcourse adoption of the technologies in general including agroforestry technologies (Orisakwe and Agomuo, 2011). Moreover, the current extension services are fragmented and sectoral based with unharmonized and conflicting messages (Ndilahomba, 2009), that confuse AF homegardeners on components and their arrangements. Some AF homegardeners have

already declared interest in specialized agroforestry systems which include insects and aquatic life-forms. Similar findings were also observed by Galhena (2012) in Sri Lanka that homegardeners expressed a strong interest to learn and adopt beekeeping in their gardens, however, knowledge in such specializations was not readily available hence slowing down their adoptions.

Labour supply in the study area was another challenge as most of the active age was not involved in AF homegardening leaving aged groups of 51-65 years making 41% of the homegarden practitioner which are relatively old people, 55 years old by average who managed the homegardens. The results contradict those of Udofia (2011) in Nigeria where agroforestry homegardens were managed by active age of 30-50 years. According Kitalyi and Soini (2004) very few youths are ready to get to farm work hence many are migrating to urban areas leaving the elderly with limited physical strength in the villages to manage the agroforestry homegardens. Hence labour challenges are high in the agroforestry homegardens due to high rate of aging population (Kitalyi *et al.*, 2013). According to Mamkwe (2003) the older people who remain in AF homegardens management, are no longer able to perform heavy tasks that demand high physical energy such as planting and thinning of banana plants and pruning as well as felling of higher and large trees.

The majority (59%) of the households in the present study area, have 1- 4 family members (Table 2) since agroforestry homegardens depend on family labour (Maroyi, 2009). According to Mamkwe (2003), a household with a family size of less than 4 was regarded as a household with low labour force, contrary to Galhena *et al*. (2013) results on family labour in AF homegardens. These study findings concur with those of Mamkwe (2003). This was because to a large extent the family size in Rombo District

consists of grandfathers and/or grandmothers raising their grandsons/daughters who are not active to farm works (Meena and O'Keefe, 2007).

The problem of labour shortage is also associated with the household heads having other off-farm economic activities which are also metioned as one of the constraints in agroforestry homegarden production (Torquebiau, 1992). Having other off-farm activity leads to decrease of attention given to the AF homegardens by the household heads. According to Meena and O'Keefe (2007) increasing reliance on off-farm income can have significant consequences for on-farm production. The reduction of time spent undertaking agricultural activities can reduce knowledge of the techniques required to maintain the complex agroforestry homegardens.

Population increase resulted to increasing land shortages (Musotsi *et al.,* 2008), which is another constraint to the Chagga agroforestry homegardens practice. According to Rombo District Council (2013), land carrying capacity has exceeded the 7 people per hector scale instead of the recommended 5 people. Therefore land shortage is becoming a serious threat to the agroforestry homegardens level of use/adoption. The findings in this study (Table 2) noted almost (46%) of agroforestry homegardens are practised on a land size of 0.25 to 0.5 ha. The land sizes are similar to those observed in Vietnam (Trinh *et al.,* 2002), Ethiopia (Asfaw, 2002) and Sri Lanka (Senanayake *et al*., 2009). However, due to the chagga tradition of dividing the farms to the sons to inherit, the land sizes are also in threat to be reduced (Kitalyi and Soini, 2004). Soini (2003) reported, over the years that the Chagga AF homegardens have become increasingly fragmented due to sub-division. This has among other things its implications on agroforestry homegardens components. Land sizes influence the diversity of components in the agroforestry homegardens (Abebe, 2005). Land shortages lead to

reduction of some components (Wiersum, 2006), for example livestock and woody perannials, hence failure to produce enough for household food, income and in someway wood energy (Zeleke, 2009; Kabwe, 2010). Moreover, land shortages threaten the spread of agroforestry homegardens. A study by TARP II SUA (2005) revealed that land shortage was among the reasons that limited farmers in adopting agroforestry technologies.

Pests and diseases also constrain the Chagga agroforestry homegardens practices and other agricultural related activities in the district. Pests and diseases threat in Rombo District are higher (28%) than those reported in other AF homegardens, example, 20% in Morogoro AF homegardens (Mariro, 2009). These results are in line with those of Galhena (2012) in Sri Lanka where pests and diseases were among the major constraints (87%) to agroforestry homegardens that need to be prevented so as to reduce crop damage and losses. Makundi and Magoma (2003) found that the income spent on the management of pests in some African countries accounted for about 30% of the total subsistence production cost annually. Thus measures to combat these contraints are mandatorly required for ensuring improvement in the AF homegardens productivity and as a way of motivating farmers to engage more in agroforestry homegardens (Kitalyi and Soini, 2004).

Water shortage and generally drought especialy in low land in Rombo District was another constraint to agroforestry homegardens productivity (Meena and O'keefe, 2007). The respondents (14%) of mentioned water shortage as a serious problem to the practice even to the adoption of water demanding components like aquaculture. Soini (2005) pointed out that farmers are suffering from decreasing water supply or completely drying up of furrows. The water shortage could be due to a number of

factors which according to Kitalyi and Soini (2004) are the changes from indigenous vegetation to exotic species in the AF homegardens area and cultivation of the immediate riverbanks is believed to have contributed to the drying up of rivers and springs. The Chagga AF homegardens had a well functioning community managed network of irrigation furrows (Soini, 2003) which are now collapsing resulting to the reduction in water supply to the agroforestry homegardens especially in the low lands. The water shortage constraint was also observed in AF homegardens found in rural areas of South Africa (Monde *et al.,* 2006) and in the Pacific Region (Thaman *et al*., 2006).

Other constraints include inadequate capital as AF homegardeners fail to purchase farm inputs. According to Washa (2001) lack of credits/capital hinders smallholder farmers in undertaking their activities. Meena and O'Keefe (2007) reveal that in Kilimanjaro Region only few people (4%) in rural areas, for example Rombo District and Moshi Rural had access to credit despite the support made to enhance financial capital of poor rural household. Credit currently provides only negligible assistance for the majority of households in the region (Meena and O'Keefe, 2007). Soini (2003) stated that lack of funds or credit to invest in farming to buy pesticides, fertilisers and/or seeds for better yields are a perceived problem mentioned by farmers. Poor farming equipments like the local/tradition tools such as hand hoe, matchet are still in use in the study areas (Shilabu, 2008; URT, 2012) which in some cases delay production and affect production in the agroforestry homegardens and agriculture at large (Lyimo-Macha *et al.,* 2005). Father more due to current land shortages for livestock grazing and fodder collection, the households keep a small number of livestock, which could not supply enough manure to apply to the agroforestry homegardens (Soini, 2005).

### 5.5.2 Measures required for improving the Chagga agroforestry homegardens practices

Agroforestry homegardens contribute a lot to rural communities' livelihoods (Galhena, 2012). As was seen earlier, they immensely contribute to food supply, income generation as well as wood energy for the local communities in different geographical regions. Therefore measures should be taken to ensure sustainability of the Chagga agroforestry homegardens.

In Rombo District, the measures required to improve Chagga agroforestry homegardens performance are shown in Figure 9. Training and extension/demonstration plots for farmers learning inject new skills and confidence in managing agroforestry homegardens and handling environmental threats like drought and fertility loss (Kabwe, 2010). According to Rutatora and Rwenyagira (2005), agricultural extension services are of great importance in knowledge provision of better agricultural practices. Hence crop losses and other negative implications can be reduced when the household members are empowered with better skills and knowledge through demonstration plots (Turner and Brush, 1987). However, according to Hoogerbrugge and Fresco (1993), improvements in homegardening are not possible without a proper understanding of the diversity of existing systems hence the extension staff should also be knowledgable on the agroforestry systems.

Improved crop and tree seeds will help to increase productivity in the agroforestry homegardens as many are still using the low grade local seeds for production, which result in poor yields. Better seeds and improved cultivars such as those of coffee have been proven to give higher yields in the Chagga agroforestry homegardens (Rombo District Council, 2013) and has, also, been reported in the Pacific Region (Thaman *et al*., 2006). Fertility improving nitrogen fixing tree species and those that help to

prevent land degradation through limiting soil erosion like Lucaena (*Leuceana leucocephala*) and Iron wood (*Senna siamea* ) should be encouraged as suggested in Swaziland (Nxumalo, 2012). Knowledge to make compost heaps and recycle crop residues (Tang, 2011) should also be provided as a response to manure/fertilizer suggestion made by the respondents. Similar suggestions were made by AF homegardeners in Sri Lanka (Galhena, 2012).

Farmers associations have been found to be important measures for scaling up the Chagga agroforestry homegardens (Soini, 2005) and help in the adoption of other new technologies (Reed, 2007). They are forms of government support in providing loans to farmers, facilitating the needed farmer to farmer interactions and in managing the prices of AF homegardens products like coffee. According to Kitalyi and Soini (2004), lack of capital for purchasing inputs, such as, fertilizers is considered as the biggest problem in the farming activities in the area. Therefore loans and proper government mechanisms to control prices of farm inputs will help in ensuring improvements in the Chagga agroforestry homegardens. Farm credits availability has generally been strong incentives for farmers to engage in production (Rugalema, 1992).

# CHAPTER SIX

## 6.0 CONCLUSIONS AND RECOMMENDATIONS

### 6.1 Conclusions

On the basis of the results and the discussion of the present study, the following conclusions are made:

i. The Chagga agroforestry homegardens in Rombo District consist of all the five currently available renewable natural resources components of woody perennials, herbaceous crops, animals, insects and aquatic life-forms.

ii. While the woody perennials, herbaceous crops and animal components are the most common and are more or less equally widely spread throughout the district, the insects and the aquatic life-forms components are less frequently encountered.

iii. Based on the combination of various associated components, the Chagga agroforestry homegardens practised in Rombo District are broadly classified into nine agroforestry systems of Agrosilvopastoral, Agroapoaquosilvopastoral, Agroaposilvopastoral, Agrosilvicultural, Agroaquosilvicultural, Agroaposil vicultural, Agroaquosilvopastoral, Aposilvopastoral and Silvopastoral systems with the Agrosilvopastoral system being the most widely spread throughout the District.

iv. The Chagga agroforestry homegardens were the highest contributor to food supply and income generation to the communities in Rombo District while the other contributions come from open field farms, employment, businesses and other non-homegardens agroforestry practices.

v. The Chagga agroforestry homegardens were also the main sources and the significant contributors to wood energy supplies in Rombo District. Other

sources include wood purchases from the market and neighborhoods, nearby forests and other agroforestry practices.

vi. Major constraints to the Chagga agroforestry homegardens practices in Rombo District include lack of extension services, pests and diseases, land shortages, labour shortages as well as inadequate capital and poor farm equipment.

vii. Measures required to improve the level of use of the Chagga agroforestry homegardens in Rombo District include improvement of extension services, improved tree and crop seeds and in general a strong government support.

**6.2 Recommendations**

Based on the findings of this study, the following recommendations are made

i. Strengthening extension services in the district by recruiting and empowering extension officers with equipment and tools and relevant agroforestry homegarden knowledge.

ii. Farmers trainings on best arrangement of agroforestry homegardens components in the resources management unit to ensure wide diversity of components that will contribute to household food, income and wood energy. Moreover it will act as the best way to tackle land shortage in the district.

iii. Formation and strengthening farmers groups which have interests in other specialized components like, insects and aquatic life-forms and provide them with appropriate knowledge and skills on how best they can incorporate the components in their AF homegardens for maximum utilization of resources.

iv. Promotion of other environmental improvement technologies and woody perennials that help to improve soil fertility which will support to combat the on going land degradation and degrading soil fertility in the district in order to boost the production in the Chagga agroforestry homegardens.

v. The government should provide incentives that will motivate the youth to engage in agroforestry homegardens by ensuring affordable supply of farm inputs to farmers, reliable water channels and promising markets for AF homegardens products.

vi. Futher researches should be undertaken to assess the dominant components that fall under each classified agroforestry homegardens systems.

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# APPENDICES

## Appendix 1: Questionnaire for Heads of Households

**Basic information**

Division; _____ Ward; _____ Village; _____

Household No.; _____ Name of household head; _____

Occupation; _____ Age _____ Sex _____

Marital status _____ Size of Household member _____

Education level_____ Total area of the land _____

### 1.0 Agroforestry homegarden components and their arrangements

1.1 What type of components do you have in your AF homegarden?

1. Woody perennials ( )
2. Herbaceous crops ( )
3. Animals ( )
4. Insects ( )
5. Aquatic life forms ( )

1.2 How do you arrange your AF homegarden components ?

1. _____
2. _____
3. _____

Others _____

1.3 Which woody perennials (trees/shrubs) are found in your farm and their uses?

Local name_____Scientific name_____

1.3.1 Uses:

1. Fruits_____ 2. Fodders _____ 3. Poles_____

4. Timber_____ 5. Local medicine _____ 6.Soil improvement _____ 7. Fuel woods _____ 8. Shade

Other (specify) _____

2.4 What type of agroforestry systems do you practise on your AF homegarden?

1. Agrosilviculture ( ) 2. Silvopasture ( ) 3. Aposilviculture ( )

4. Agrosilvopasture ( ) 5. Aquosilviculture ( )

Other (Mention) _____

2.5 What are the benefits and challenges from such systems?

| Benefits | Challenges |
|---|---|
| 1. | 1. |
| 2. | 2. |
| 3. | 3. |
| 4. | 4. |

Others (specify) _____

2.6 What other types of agroforestry technology do you practise in your AF homegarden?

1. Live fences ( ) 2. Contour-ridge/bunds planting ( ) 3. Boundary planting ( ) 4. Rotation/Relay cropping ( ) 5. Mixed intercropping ( )

6. Integrated tree-pasture management ( ) 7. Taungya ( )

8. Alley farming/Hedgerow intercropping ( ) 9. Shifting cultivation ( )

Others (specify) _____

2.7. What are the benefits and challenges that you face from such practices?

| Benefits | Challenges |
|---|---|
| 1. | 1. |
| 2. | 2. |
| 3. | 3. |
| 4. | 4. |

Others _____

2.7 Do you keep animals in your AF homegardens? 1. Yes ( ) 2. No ( )

2.7.1 If yes what type of animals do you keep and how many?

1. Cattle ( ) 2. Goats ( ) 3.Sheep ( ) 4.Pigs ( ) 5. Chicken ( )

Others (Specify) _____

2.7.2 If None (Reasons) _____

2.8 Do you have Herbaceous/Agricultural crops in your AF homegarden? 1. Yes ( )

2. No ( )

2.8.1 If yes what type of Herbaceous/Agricultural crops you have?

1. _____ 2._____

3. _____ 4. _____

Others (Specify) _____

2.8.2 What are the uses of the crops you have?

1. Food ( ) 2. Income ( ) 3. Both Income and Food ( )

Other (Specify) _____

2.8.3. If No (Reasons) _____

2.9 Do you keep Insects in your AF homegarden? 1. Yes ( ) 2. No ( )

2.9.1 If yes what type of insects do you keep?

1. _____ 2. _____

3. _____ 4. _____

Others (Specify) _____

2.9.2 What are the uses of the insects you keep?

1. Food ( ) 2. Income ( ) 3. Both Income and Food ( )

Others (Specify) _____

2.9.3 If None (Reasons) _____

2.10 Do you keep aquatic life forms (Fish) in your AF homegarden?

1. Yes ( ) 2. No ( )

2.10.1 If yes what type of aquatic life forms do you keep?

1. _____ 2. _____

3. _____ 4. _____

Others (Specify) _____

2.10.2 What are the uses of aquatic life-forms do you keep?

1. Food ( ) 2. Income ( ) 3. Both Income and Food ( )

Others (Specify) _____

2.10.3 If No (Reasons) _____

**3.0 Contribution of agroforestry homegardens to the household**

**3.1 Sources of household food, income generation and wood energy**

3.1.1. What are the sources of food your household

1. Agroforestry homegardens ( )
2. Other agroforestry practices ( )
3. Forestry ( )
4. Animal husbandry ( )
5. Employment ( )

Others mention; _____

3.1.2. What are the sources of income in your household

1. Agroforestry homegardens ( )
2. Other agroforestry practices ( )
3. Forest products ( )
4. Animal husbandry ( )
5. Employment ( )

Others mention; _____

3.1.3. What are the sources of wood energy for your household?

1. Agroforestry homegardens ( )
2. Nearby Forest ( )

Others mention; _____

**3.2. Agroforestry homegarden contribution to food, income generation and wood energy**

3.2.1 What are the contribution of AF homegardens to food and income generation

| Component | Product | Quantity Acquired | Home uses (Food) | For sale (Income) | Value |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

Other source(s) _____

| Component | Product | Quantity Acquired | Home uses (Food) | For sale (Income) | Value |
|---|---|---|---|---|---|
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |
| | | | | | |

3.2.2 Does agroforestry homegarden provide you wood energy?

1. Yes ( ) 2. No ( )

3.2.2.1 If yes how much? _____

3.2.2.2 How much is used per day? _____

3.2.2.3 If No what other sources? _____

3.2.2.4 How much? _____

3.2.3. Have you experienced wood energy shortage from your AF homegarden?

1. Yes ( ) 2. No ( )

3.2.3.1 If yes how did you cope with the situation (Wood energy shortage?)

1. Collecting from forests {Natural/planted} ( ) 2. Collecting from neighbors homegardens ( ) 3. Purchase ( )

Others _____

3.2.3.2 How much do you collect/buy? _____

3.3 Have you experienced food shortage in your household? 1. Yes ( ) 2. No ( )

3.3.1 If yes when? Month(s) _____ Year _____

3.3.2. What mechanism did you use to handle the situation (Food Shortage?)

1. Food aid from Government ( ) 2. Aid from Neighbors ( )

3. Sale of land ( ) 4. Hunting and gathering ( ) 5. Sale of livestock ( ) 6. Depending on agroforestry homegarden products ( )

Others _____

3.4 Is the income you generate from your AF homegarden sufficient?

1. Yes ( ) 2. ( )

3.4.1 If Yes how much is your annual income from AF homegarden? _____

3.4.2 If No what mechanism do you use to generate more income?

1. _____ 2. _____ 3. _____

4._____ 5. _____

3.5 How did you use the income you generated from your AF homegarden?

1. Paying for Education ( ) 2. Paying for health services ( )

3. Purchase HH food ( ) 4. Purchase livestocks food ( )

5. Purchase livestock's medicine ( ) 6. Purchase seeds ( )

7. Paying water services ( ) 8. Paying electricity bills ( )

9. House maintenances ( ) 10. Building quality house ( )

11. Purchase household furniture ( ) 12. Purchase farm equipments ( )

Others _____

3.6 Do you store agroforestry homegarden products? 1. Yes ( ) 2. No ( )

3.6.1 If yes

| Product type | product | Quantity | Reason for storage |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

Others _____

3.6.2 If no, why don't you store your products? _____

**4.0 Constraints to agroforestry homegardens practice and measures required for their improvements**

4.1. Constraints to agroforestry homegardens practice

4.1.1. What inspire you to practise agroforestry homegarden?

1. _____
2. _____
3. _____

Others mention; _____

4.1.2. When did you start practicing agroforestry homegarden?

1. Before 1980 ( ) 2. In 1980s ( )

3. In 1990s ( ) 4. From 2000 ( )

4.1.3. What were the earliest homegarden components in your agroforestry homegarden?

_____

4.1.4. What are the new AF homegardens components and reason for their adoption?

| New AF homegarden components | Specific | Reason for adoption |
|---|---|---|
| | | |

| | | |
|---|---|---|
| | | |

Others: _____

4.1.5. What are the constraints from practicing agroforestry homegarden and why?

| Constraints | Reason |
|---|---|
| 1. | |
| 2. | |
| 3. | |

Others; _____

**4.2 Measures required for improving agroforestry homegardens level of use**

4.2.1 Is there any training provided in practising agroforestry homegarden?

1. Yes ( ) 2. No ( )

4.2.1.1 If Yes, what is it all about?

1. If for specific component (s), mention the components

   _____

2. If for specific system(s) mention the system

   _____

3. If for specific technology (ies), mention technology

   _____

4. For general practice (agroforestry homegarden)

   _____

4.2.1.2. What did you benefit from the training provided?

1. _____
2. _____
3. _____

Others: _____

4.2.3. What needs to be done to improve the agroforestry homegarden?

a. _____
b. _____
c. _____

d. _____

Others _____

**Appendix 2: Checklist of probe questions for Key Informants**

**Village Leaders, Ward Leaders, Extensionists, Agricultural Officers, NGOs**

Division: _____ Ward; _____

Village; _____ Organisation _____

Key Informant's Status _____

1. What are the main agroforestry homegarden components in this area?

   1. Woody perennials ( ) 2. Herbaceous crops ( ) 3.Animals ( ) 4.Insects ( )

   5. Aquatic life forms ( )

2. In this area what are the main sources of

   i. Food _____

   ii. Income generation _____

   iii. Wood energy _____

4. What are the main agroforestry systems in this area?

   1. Agrosilviculture ( ) 2. Silvopasture ( ) 3. Aposilviculture ( )

   4. Agrosilvopasture ( ) 5. Aquosilviculture ( )

Other _____

5. What are the main agroforestry technologies found in this area?

   1. Live fences ( ) 2. Contour-ridge/bunds planting ( )

   3. Boundary planting ( ) 4. Taungya ( ) 5. Mixed intercropping ( )

   6. Integrated tree-pasture management ( ) 7. Shifting cultivation ( )

   8. Tree-bee management technology ( ) 9. AF homegardens ( )

   10. Alley farming/Hedgerow intercropping ( ) 11. Rotation cropping ( )

Others _____

6. How many households practice agroforestry homegardens?

_____

7. How long agroforestry homegarden have been practiced in this village?

_____

8. What are the changes in agroforestry homegardens practice since early years until now and reasons for change?

1. Composition wise _____
2. Arrangements _____

9. Are there food shortages in this area? _____

10. When does a food shortage occurs in this area? _____

11. How do villagers handle the situation?

_____

12. Do farmers get sufficient wood energy from their AF homegarden? _____

13. If not where do they get additional wood energy?

_____

14. Does agroforestry homegarden generate income for the villagers?

_____

15. Is there market for AF homegarden products in this village? _____

16. What are these markets?

_____

17. On your opinion, can the villagers who depend on agroforestry homegarden pay for social services? _____

18. Are there extension services provided for agroforestry homegardens?

_____

19. Extension service provided is on what component/system/technology?

_____

20. How is Apiculture practice in this area? _____

21. Do villagers keep other insects more than bees in this area? _____

If yes what are those? _____

22. Do farmers integrate bees in their agroforestry homegardens? _____

23. How many farmers practice beekeeping around their AF homegardens? _____

24. Those who practice beekeeping how many beehives do they own per household?

_____

25. For your experience what challenges face households to practice beekeeping in this area? _____

26. What do you think should be done to improve beekeeping practice in this area?

_____

27. How is aquaculture practice in this area? _____

28. Are there fish-ponds in this area and if yes who owns these fish ponds? _____

29. Do farmers have fishponds within their agroforestry homegardens? _____

30. Using your expertise what challenges face aquaculture in this area? _____

31. What should be done to improve aquaculture in this area? _____

32. In general what are the constraints to agroforestry homegardens practice?

1. _____
2. _____

Others _____

33. What measures would be required to improve the agroforestry homegardens level of use?

1. _____
2. _____

Others _____

**THANK YOU VERY MUCH FOR YOUR PATIENCE AND COOPERATION**

## Appendix 3: Chi square results on association between component arrangements and agroforestry technologies

| Chi-Square Tests | | | |
|---|---|---|---|
| | Value | df | Asymp. Sig. (2-sided) |
| Pearson Chi-Square | 1.819E2a | 6 | 0 |
| Likelihood Ratio | 201.548 | 6 | 0 |
| Linear-by-Linear Association | 3.508 | 1 | 0.061 |
| N of Valid Cases | 120 | | |

a. 4 cells (33.3%) have expected count less than 5. The minimum expected count is .90.

## Appendix 4: Detailed data and ANOVA table on the sources and their contributions to food for the local communities in Rombo District

### a. Detailed data on souces and contricution

| | Villages | | | |
|---|---|---|---|---|
| **Sources of food security** | **Maharo** | **Mamsera Kati** | **Mmomwe** | **Samanga** |
| Agroforestry homegardens | 24 623 550 | 28 599 000 | 19 947 750 | 13 845 600 |
| Open field farms | 435 000 | 2 640 800 | 0 | 172 650 |
| Other agroforestry practices | 0 | 1 182 500 | 0 | 0 |
| Food purchase | 0 | 0 | 0 | 135 000 |

NOTE: Figures are in TZS

### b. ANOVA table for sources of food in Rombo District

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Sources of food (Treatments) | 1.37E+15 | 3 | 4.57E+14 | 50.57256 | 0.00* | 3.862548 |
| Divisions (Blocks) | 4.51E+13 | 3 | 1.5E+13 | 1.664159 | 0.24 | 3.862548 |
| Error | 8.14E+13 | 9 | 9.04E+12 | | | |
| Total | 1.5E+15 | 15 | | | | |

*Significant at 0.05

### c. Calculations for LSD

LSD = $(t_{0.05, 9})$ S.E.D

LSD = 2.262* 2 126 187

LSD = 4 809 436

## Appendix 5: Detailed data and ANOVA table on the sources and their contribution to income generation for the local communities in Rombo District

### a. Detailed data on sources and contribution of income generation

| | Villages | | | |
|---|---|---|---|---|
| **Sources of Income generation** | **Maharo** | **Mamsera Kati** | **Mmomwe** | **Samanga** |
| Agroforestry homegarden | 13 686 500 | 22 221 000 | 9 067 000 | 20 104 100 |
| Employment | 1 100 000 | 1 000 000 | 150 000 | 2 000 000 |
| Businesses | 300 000 | 200 000 | 1150 000 | 800 000 |
| Open field farm | 457 500 | 213 000 | 363 500 | 708 000 |
| Remittances | 100 000 | 830 000 | 720 000 | 130 000 |
| Other agroforestry practice | 0 | 534 500 | 0 | 0 |

NOTE: Figures are in TZS

### b. ANOVA table for sources of annual income generation in Rombo District

| **Source of Variation** | **SS** | **df** | **MS** | **F** | **P-value** | **F crit** |
|---|---|---|---|---|---|---|
| Treatments (Sources) | 8.27E+14 | 5 | 1.65E+14 | 27.36402 | 0.00 | 2.901295 |
| Villages (Blocks) | 2.11E+13 | 3 | 7.04E+12 | 1.164964 | 0.355832 | 3.287382 |
| Error | 9.06E+13 | 15 | 6.04E+12 | | | |
| | | | | | | |
| Total | 9.39E+14 | 23 | | | | |

*Significant at 0.05

### c. Calculations for LSD

$LSD = (t_{0.05, 15})$ S.E.D

LSD = 2.131* 1 738 264.3

LSD = 3 704 241

## Appendix 6: Detailed data and ANOVA table on sources and their contribution to wood energy for the local communities in Rombo District

### a. Detailed data sources of wood energy and their contribution

| | Villages | | | |
|---|---|---|---|---|
| **Sources of wood energy** | **Maharo** | **Mamsera Kati** | **Mmomwe** | **Samanga** |
| Agroforestry homegarden | 1.29 | 0.30 | 2.72 | 1.67 |
| Wood energy purchases | 0.65 | 0.06 | 0.19 | 0.17 |
| Nearby forest | 0.00 | 0.40 | 0.11 | 0.32 |
| Other agroforestry practice | 0.00 | 0.27 | 0.00 | 0.00 |

NOTE: Figures are in $m^{3\ st}$

### b. ANOVA table for sources of wood energy in Rombo District

| Source of Variation | SS | df | MS | F | P-value | F crit |
|---|---|---|---|---|---|---|
| Sources of wood energy | 5.268745 | 3 | 1.756248 | 5.531726 | 0.019779 | 3.862548 |
| Villages | 0.497247 | 3 | 0.165749 | 0.522067 | 0.677764 | 3.862548 |
| Error | 2.857379 | 9 | 0.317487 | | | |
| Total | 8.623371 | 15 | | | | |

*Significant at 0.05

### c. Calculations for LSD

$LSD = (t_{0.05,\ 9})\ S.E.D$

LSD = 2.262* 0.112248

LSD = 0.25

## Appendix 7: Food products from various sources and their monetary values

| Source of food | Product | Quantity/Yr | Price @ | Total | Ttl source income |
|---|---|---|---|---|---|
| Agroforestry homegarden | Banana (Bunds) | 7 638 | 7 000 | 53 466 000 | |
| | Maize (Bag =100kg) | 130 | 45 000 | 5 850 000 | |
| | Beans (Kg) | 6 620 | 1 500 | 9 930 000 | |
| | Cowpea (Kg) | 530 | 700 | 371 000 | |
| | Milk (Littre) | 35 640 | 1 000 | 35 640 000 | |
| | Chickens | 237 | 8 000 | 1 896 000 | |
| | Eggs | 97 200 | 300 | 29 160 000 | |
| | Honey (Littre) | 33 | 20 000 | 660 000 | |
| | Fish (Kg) | 72 | 10 000 | 720 000 | |
| | Fruits* | | | | |
| | Yams* | | | | |
| | Meat* | | | | 137 693 000 |
| Open field farms | Maize (Bag) | 20 | 45 000 | 900 000 | |
| | Beans(Kg) | 1 445 | 1 500 | 2 167 500 | |
| | Cowpea (Kg) | 290 | 700 | 203 000 | 3270 500 |
| Food purchases | Maize (Bag) | 1 | 45 000 | 45 000 | |
| | Beans (Kg) | 60 | 1 500 | 90 000 | 135 000 |
| Other agroforestry practice | Maize (Bags) | 7 | 45 000 | 315 000 | |
| | Beans (Kg) | 465 | 1 500 | 697 500 | |
| | Cowpea (Kg) | 100 | 700 | 70 000 | |
| | Honey (Littre) | 5 | 20 000 | 100 000 | 1 182 500 |

*No actual measurable amount

**Appendix 8: Income generating products from various sources**

| Source | Product | Quantity/yr | Price @ | Total | |
|---|---|---|---|---|---|
| Agroforestry homegardens | Banana | 3855 | 7 000 | 26 985 000 | |
| | Maize (Bags) | 37.2 | 45 000 | 1 674 000 | |
| | Beans (Kg) | 140 | 1 500 | 210 000 | |
| | Coffee (Kg) | 3 557 | 2 500 | 8 892 500 | |
| | Chickens | 67 | 8 000 | 536 000 | |
| | Eggs | 805 | 300 | 241 500 | |
| | Milk (Littre) | 17 280 | 1 000 | 17 280 000 | |
| | Honey (Littre) | 118 | 20 000 | 2 360 000 | |
| | Fish (Kg) | 36 | 10 000 | 360 000 | |
| | Pigs | * | | 2 830 000 | |
| | Goats | 16 | 45 000 | 720 000 | |
| | Fruits (Bags) | 54 | 20 000 | 1 080 000 | |
| | Rabbits | 1 | 4 000 | 4 000 | |
| | Cattle | | ** | 1 350 000 | |
| | Timber | | ** | 350 000 | 64 873 000 |
| Open field farms | Maize (Bags) | 21 | 45 000 | 945 000 | |
| | Beans (Kg) | 547 | 1 500 | 820 500 | |
| | Pnuts (Kg) | 65 | 2 000 | 130 000 | |
| | Cowpea (Kg) | 130 | 700 | 91 000 | 1 986 500 |
| Other agroforestry practices | Maize (Bags) | 3 | 45 000 | 135 000 | |
| | Honey (Littre) | 20 | 20 000 | 400 000 | |
| | Pnuts (Kg) | 110 | 2 000 | 220 000 | 755 000 |

* Different quantity ** Sold at different prices depending on owner

## Appendix 9: Local names and uses of tree/shrub species found in Rombo District

| Local name | Common name | Scientific name | Uses |
|---|---|---|---|
| Meresi | Gravillea | *Gravilea robusta* | Fw, Ti, Sh, So Con, bee fo, Fod, Windbreak |
| Mchengo/Mwavai | Cape mahogany | *Trichilia emetica* | Fw,Ti, Po, Fod, Bee for, Oil, Med, Sh, S-con, soap |
| Mparachichi | Avocado | *Persea americana* | Fw, Fr, Fod, Bee for, Sh, Mul, S-con |
| Mtangawizi | Loquat | *Eriobotrya japonica* | Fw, , Bee for, Sh, Po,Bo |
| Mborori | Parasol tree | *Polyscias fulva* | Fw, Med, Ven, Mul, M-traps, Beeh |
| Msesewe | Quinine tree | *Rauwolfia caffa* | Fw, Ti, Sh, Bee for, Med, Be |
| Mriri | Red-hot-poker tree | *Erythrina abyssicica* | Fw, Carv, , Fod, Bee for, S- impr, Mul |
| Mwesi | Pigeon wood | *Trema orientalis* | Fw, Po, Fod, Bee for, Sh, Oil, Mul, S-impr, Nfix |
| Mzambarau | Jambolan | *Sysygium cuminii* | Fw, Ti, Fr, Sh, S- con |
| Mpapai | Pawpaw | *Carica papaya* | Fr |
| Mwembe | Mango | *Mangifera indica* | Fw, Fr, Fod, Bee for, Sh, Mul, S-con |
| Mfenesi | Jackfruit | *Artocarpus heterophyllus* | Fw, Ti, Fr, Fod, Sh |
| Mpira | Manicoba rubber | *Manihot glaziovii* | Fod, Sh, S-con |
| Mpera | Guava | *Psidium guianense* | Fr, Fw |
| Mlusina | Lucaena | *Leucaena leucocephala.* | Fw, Bee for, Fod, Gr, S-con,Sh, Fe |
| Mringa | East African cordia | *Cordia africana* | Fw, Ti, Be, Bee for, Sh, S-con, Bo |
| Mkuyu | Stragler fig | *Ficus thonningii* | Fw, Fod, Sh,Mul, Med, Fe |
| Mfuranje | Long-podded albizia | *Albiza schimperiana* | Fw, Ti,Bee For,Sh, S-con,Nfix |
| Mchongoma | Madras thorn | *Pilhecellebium dulce* | Bee for, Fe |
| Pine | Pine | *Pinus patula* | Fw, Ti, Sh |
| Mlatangao | * | *Calpurnia aurea* | Fw, Fod, Fe |
| Mhogani | Mahogany bean | *Afzelia quanzensis* | Ti, Sh, Med, Orn |
| Mlimao | Rough Lemon | *Citrus limona* | Fw, Fr |
| Mwati-Accasia | Black Wattle | *Acacia mearnsii* | Fw, Sh, |
| Mvule | Iroko | *Milicia excelsa* | Fw, Ti,Sh, Mul |
| Mtarakwa | Cypress | *Cupressus lusitanica* | Fw, Po, Ti, Sh, Orn, Fe |
| Mwarobaini | Margosa tree | *Azadirachta indica* | Fod, Bee for, S-con, Sh |
| Mchungwa | Orange | *Citrus sinensis* | Fr |
| Mlebanoni | * | *Maesopsis eminii* | Fw, Ti, Sh, S-con, Bee for, Fod |

*common name not recognized during survey

**KEY:**

| | | | | |
|---|---|---|---|---|
| Bo- Boundary | Fe- Fences | M-traps-Mole traps | Nfix- Nitrogen fixation | S-impr- Soil improvement |
| Be – Bee hives | Fo - Fodder | Med- Medicines | Orn- Ornamental | Sh- Shade |
| Bee for –Bee forage | Fr -Fruit | Mul - Mulch | Po- Poles | Ti- Timber |
| Carv- Carvings | Gr- Green manure | | S-con- Soil conservation | Ven - Veneer |