AGROBIODIVERSITY AND FOOD SECURITY AMONG SMALLHOLDER FARMERS IN ULUGURU MOUNTAINS, TANZANIA

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ABSTRACT

The study was done in Uluguru Mountains to determine the linkage between agrobiodiversity and household food security among smallholder farmers. Specifically the study sought to: identify the major farming systems including the management and organizational aspects of agrobiodiversity and the associated indigenous practices; determine household food security status and coping strategies among smallholder farmers in the study area; analyse factors influencing household food security in the study area; determine crop diversity; and analyse socio-economic factors influencing agrobiodiversity and household food security. Using PRA, questionnaire surveys and diversity inventory from four villages and 120 randomly selected households, the study found that food security in the study area depends largely on the diversity of crops maintained by the households. The study showed further that food security as a concept is locally perceived and therefore what constitutes food security may be something that goes beyond conventional thinking. The study concludes that communities have inherent abilities to deal effectively with vulnerabilities based on their past experiences and anticipated outcomes. Such experiences and outcomes bring, among other things, agrobiodiversity for household food security. While food security perceptions and food preferences may be quite localized, they point to the fact that interventions to solve problems of food insecurity may only succeed when local perceptions and preferences are considered. The study draws a number of policy and research implications including the: development of policies and strategies away from mono cropping to diversity as a means for sustainable food and the overall livelihood security of the smallholder farmers in the study area and areas with similar conditions; development of policies

for awareness raising in terms of the value of agrobiodiversity for sustainable agricultural production and the need to protect potentially useful crops and the value of agrobiodiversity as a cultural heritage. The study ends by proposing areas for further research including the establishment of the level of genetic diversity needed for ecologically sound and economically sustainable agriculture; documentation of seed exchange systems and minor and less known crops and their contribution to household food security. Other recommendations include genetic mapping and the role of market integration on agrobiodiversity.

DECLARATION

I, Jonathan Stephen Mbwambo, do declare to the SENATE of Sokoine University of Agriculture that this thesis is my original work and has not been submitted for a higher degree awards in any other university.

-- 17/10/2007
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The above declaration is confirmed by

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This work is dedicated to my Mother Joyce Salehe and my Father Stephen Salehe who, through their hard work and prayers have always been an inspiration to me. Dedication is also extended to Joan and Karen who, despite being too young, brought a sense of humor to the family during the difficult time of my work.

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LIST OF ACRONYMS

AIDS	Acquired Immunodeficiency Syndrome
CBD	Convention of Biological Diversity
CI	Confidence Interval
D.R.C	Democratic Republic of Congo
DDS	Dietary Diversity Score
FAO	Food and Agriculture Organization
FVS	Food Variety Score
G.P.A	Global Plan of Action
GIEWS	Global Information and Early Warning Systems
HIV	Human Immunodeficiency Virus
HYV	High Yielding Varieties
ICARDA	International Centre for Agricultural Research in the Dry Areas
IFRCTZ	International Federation of Red Cross-Tanzania
MT	Metric Tons
NGOs	Non-Governmental Organizations
PCA	Principal Component Analysis
PLEC	People, Land and Environmental and Conservation
PRA	Participatory Rural Appraisal
SCBD	Secretariat of the Convention on Biological Diversity
SCSRD	SUA Centre for Sustainable Rural Development
SD	Standard Deviation
SPSS	Statistical Package for Social Sciences

UNESCO	United Nations Educational, Scientific and Cultural Organization
URT	United Republic of Tanzania
USD	United States Dollar
WFP	World Food Programme

CHAPTER ONE

INTRODUCTION

1.1 Overview

Tanzania like any other sub-Saharan African countries is faced with a challenge for maintaining sustainable food security to all the people at all times. The 2003/2004 vulnerability assessment data by the Food Security Information Team of the Tanzania Red Cross showed a national food deficit of approximately 500,000 MT of grain for 2003/4 based on an estimated availability of food of 8,000,000 MT with a domestic utilization of 8,500,000 MT (IFRCTZ, 2004). A preliminary crop production forecast reported by IFRCTZ, (2004) from the Ministry of Agriculture and Food Security in May, 2003, revealed an acute food shortage in 52 districts mostly found in the central regions of Dodoma, Singida and Shinyanga. Results from Rapid Vulnerability Assessment conducted in June 2003 by the Food Security Information Team composed of government representatives, the UN agencies and NGOs identified 1.9 million people in 47 districts were in need of food assistance of 77,490 MT (IFRCTZ, 2004). The same authors reveal further that the number of people in need of food assistance increased from 1.9 million to 4.1 million by February, 2004 including 1.09 million in the three worst affected central regions.

While the situation remains precarious for a large number of households, there are policy strategies including Food and Nutrition Policy which call for use of local foods as a means of finding sustainable intervention for national food insecurity. This is in line with the fact that the majority of the Tanzanian population lives in rural and marginalized areas with bare minimum market integration and limited resources.

They depend on locally produced foods for food security and other livelihoods opportunities. While the national food and nutrition policy encourages the use of local foods for food security, there are no sufficient empirical data linking household food security and locally produced food materials. Using agrobiodiversity coined as a diversity of crops, livestock and management practices, this study seeks to link agrobiodiversity and food security among smallholder farmers in Uluguru Mountains.

While the specific results may not be representative of all smallholder farming systems in Tanzania, the research process and findings from this study have the potential to broaden understanding of agrobiodiversity and its role in maintaining household food security. Instead of looking into new and modern technologies and food aid, food security researchers and policy makers will be informed of an alternative approach to sustainable food security interventions. While this study addresses the number one priority of the millennium development goals, it also conforms to the Convention of Biological Diversity which emphasizes sustainable use of agrobiodiversity as most appropriate for environmentally friendly, low-input agriculture for marginal conditions (CBD, 2001).

Moreover, the government food and nutrition strategies of Tanzania as framed by Tanzania Food and Nutrition Policy of 1992 encourage people to produce various food crops (which implies increased diversity) with the aim of enabling everyone to get food that is adequate and nutritious at all times (URT, 1992). The policy therefore associates food insecurity with lack of diversity based on improper land use, lack of farm inputs, droughts, floods or other disasters and increased women workload. However, the policy does not state the necessity for identification and promotion of locally diverse systems inherent of smallholder farmers.

Moreover, the present policy on biodiversity is more focused on forestry resources including wildlife than overall genetic diversity encompassing agricultural crops. The country lacks co-ordinated research and development action plans and programs to formulate and implement policies relevant to agrobiodiversity. The notion that "economic benefits can be derived only from the promotion of modern varieties/ technologies" is still the guiding philosophy in the policy formulation. Despite the potential roles of agrobiodiversity in local and national food security, and future improvement in agricultural productivity of Tanzania, policy makers are less informed and aware of the benefits of conserving crop genetic resources. Consequently, there are no policies, action plans and programmes designed to conserve, utilize and protect rich agrobiodiversity for food and livelihoods of the majority of the population. This study therefore looks at agrobiodiversity and its linkages to household food security as an entry point to influence policy and programs focused on agrobiodiversity for food security in the country.

1.2 Organization of the thesis

This thesis is organised into five chapters divided in several sections. The first chapter provides background information to the study by detailing the problem of food security in Africa and in Tanzania. The chapter describes challenges of the Green Revolution and its relevance to sustainable food security across the world with special focus on smallholder farmers. The problems of modern agriculture and the importance of agrobiodiversity are some of the facts discussed in this chapter. Problem statement, objectives of the study and the conceptual framework used in this study are presented in this chapter.

Chapter Two gives a review of the literature on food security and agrobiodiversity. The chapter begins by giving a detailed analysis of the evolution of the concept of food security from the past macro perception to the contemporary viewpoint where individual food security is at the centre of analysis. Various theoretical analyses including entitlement theory of Sen are presented. Multiple roles in sustaining genetic diversity under agrobiodiversity and household food security are also discussed in Chapter Two. This chapter ends by giving an overview of what has been done with respect to food security and agrobiodiversity and what remains to be done.

Chapter Three presents the methodology used in the study. In this chapter, description of the location of the study area is presented, sampling methods are elaborated and methods of data analysis are described. Chapter Four presents major findings of the study and gives a critical analysis of what has been found and possible implications of the findings. The last chapter, Chapter Five, makes some conclusion based on the results. Chapter Five ends with policy recommendations and proposes areas for further research.

1.3 Background

Food and nutrition security remains Africa's most fundamental challenge for human welfare and for economic growth. Far too many people on the continent are unable to acquire and effectively utilize at all times the food they need for a healthy life. In many countries, sufficient food to meet the needs of all citizens is not even available at a national level. In one-third of African countries the mean daily calorie availability per capita is below the recommended intake level of 2 100, and in D.R. Congo, Burundi, Eritrea, and Somalia calorie availability is below the minimum intake level of 1,800 (FAO, 2003).

As a consequence of low food availability and profound poverty, an estimated 200 million people on the continent are undernourished or unable to meet their dietary energy requirements (Benson, 2004). Their numbers according to Benson (2004) have increased by almost 20 per cent since the early 1990s and doubled since the late 1960s. In many African countries, food and nutrition security at both the national and the household level is dismal. Whereas 14 percent of the global population is undernourished, in Africa this prevalence is almost double with 27.4 percent of the population of Africa as a whole, and under 33 percent of Sub-Saharan Africans are undernourished (FAO, 2003). In more than a dozen countries, the rate of undernourishment is above 40 percent and in countries experiencing or emerging from armed conflicts the rates exceed by 50 percent (Benson, 2004).

The problems of food insecurity in Africa and Tanzania in particular are also compounded by the fact that the majority of the population remains trapped in poverty and social exclusion (Gari, 2004). While modernization of agriculture may increase the potential availability of food and the levels of food trade, it is becoming increasingly clear that these innovations may not be able to help and meet the basic agricultural needs, nutrition and livelihoods of most small farmers. This is so because the modern agricultural innovations do not suit the real situation of smallholder farmers including the prevailing poverty and low capacity and knowledge to use high inputs and expensive farming. Increasing food insecurity coupled with poor economic, social and environmental conditions of the smallholder farmers in Africa demand for an urgent revision of agricultural development strategies including innovations on local plants and animal resources.

This is important because while the world has been depending on a handful of crops such as maize, wheat and rice contributing approximately 60% of the global calorie intake (Cromwell *et al.*, 1998), the regional, national or local level food requirements are dependent on other crops such as cassava and other traditional lesser-known crops. For example in Central Africa, cassava supplies over 50 percent of plant derived energy intake although at global level, the figure is only 1.6 percent (Almekinder *et al.*, 2003).

Moreover, household food security in poor marginal areas continues to depend on a diversity of crops and animal resources maintained on the farms and home gardens. The management of a diversity of crops, livestock and their wild counterparts are considered under the contemporary concept of agrobiodiversity. Agrobiodiversity entails the many ways in which farmers use the natural diversity of the environment for production including not only their choice of crops but also the management of land, water and biota as a whole (Brookfield and Padoch, 1994). Agrobiodiversity management is a result of thousands of years of accumulation of traditional knowledge and skill, varieties and species by smallholder farmers for their food and livelihood security (Brookfield *et al.*, 2002; Liang, 2002).

Contemporary efforts to improve agriculture have been following two approaches (i) modern biotechnology (such as genetic engineering) and (ii) the classical biotechnology (e.g. wide hybridization). Both the approaches depend on genetic resources or agricultural biodiversity or agro-biodiversity. However, modern biotechnological innovations are protected through patents and are beset with environmental concerns and the fear of dependence on foreign companies by farmers from developing countries.

Moreover, this technology may not spread easily in the poor and food deficit countries because it does not meet requirement of small farmers who cannot afford heavy investments in terms of (i) importing expensive proprietary herbicides and pesticides and (ii) royalties as patent compensation (Brown, 1996; Farooq and Azam, 2002). Poor smallholder farmers are thus left out and are therefore continuing to use agrobiodiverse and traditional farming systems for their food security and livelihoods security. This system is important not only for smallholder farmers, but also to scientists and researchers seeking to improve crops and livestock for the future.
However, the fundamental role of agrobiodiversity and indigenous knowledge in rural food security and development suffer from neglect, erosion and is sometimes discredited as being inefficient with limited productivity (Gari, 2004). This makes the valuable agrobiodiversity to be seriously jeopardized and lost to the detriment of future food security and agricultural development. This deterioration is also

threatening food security in many parts of the world such as Tanzania where the majority of the people depend on agrobiodiversity for food security. Studies by Mwalukasa *et al.* (1999) and Kaihura *et al.* (2002); under the United Nations PLEC (People, Land and Environmental Conservation) project, reported the socio-economic factors influencing agrobiodiversity and agrobiodiversity as a means of sustaining smallholder dry land farming systems in Tanzania.

While these studies touched on issues related to household welfare, their focus was mainly on conservation of agrobiodiversity and loss of locally adapted landraces. The linkage between agrobiodiversity and particularly crop diversity and its influence on household food security was not fully established from these studies. This study therefore analyses crop diversity and its linkage to household food security among smallholder farmers in Uluguru Mountains.

1.4 Problem statement

Uluguru Mountains are known for their importance on biodiversity conservation (Lovett and Wasser, 1998; Burgess *et al.*, 1998; Mittermeier *et al.*, 1998; Stattersfield *et al.*, 1998; and Myers *et al.*, 2000). These mountains are also one of the most important in Tanzania for their water catchments functions (Burgess *et al.*, 1998) and provision of food especially vegetables for people living in Morogoro, Coast (Pwani) and Dar-es-Salaam regions. While many studies have been done in Uluguru Mountains (see for example, Lovett and Wasser, 1998; Burgess *et al.*, 1998; Olson and Dinerstein, 1998; Mittermeier *et al.*, 1998; Stattersfield *et al.*, 1998 and Myers *et al.*, 2000), few have addressed agrobiodiversity and its importance to household food security. The focus of the named studies was on conservation and management of forest biodiversity with limited analysis of agrobiodiversity and its role in maintaining household food security among smallholder farmers. Other studies including Hartley and Kaare, (2001) reported on livelihood strategies and policy implications for smallholder farmers in the area, but did not provide a detailed report on agrobiodiversity as a means for food security. Diversification of off-farm activities, resource use patterns and gender issues are some of the aspects that were covered by Hartley and Kaare (2001). Thus, specific areas where previous studies are inconclusive include the following interrelated issues;

i. Limited knowledge on the state of agrobiodiversity produced and maintained by smallholder farmers.
ii. Limited understanding of the importance and linkage between agrobiodiversity and household food security.
iii. Inadequate understanding of the influence of socio-economic factors, including gender, on agrobiodiversity and household food security.

This study therefore seeks to explore and fill the lacuna of knowledge regarding agrobiodiversity and food security using issues listed earlier as entry point.

1.5 Justification

The fundamental roles of agrobiodiversity on household food security and in sustaining the agricultural dynamics of rural communities throughout Sub-Saharan Africa have been absent from policies and programmes related to agriculture, natural resource conservation, and rural development. However, agrobiodiversity represent locally available resources with enormous value and potential for food security and rural development. All too often, the only assets which remain in poor rural communities for livelihood and even survival are the local biodiversity which assume increasing significance as other resources dwindle or disappear.

Among millions of poor and small-scale farmers, agrobiodiversity represents the foundation of food security, livelihood options, and well-being. The interaction between agrobiodiversity and the management practices provides the rural poor with numerous benefits and opportunities, such as capacity to provide food and nutritional supplies, access to local market opportunities and options to cope with evolving needs. In essence, the way rural people conserve, use and manage agrobiodiversity shapes their food security, livelihood, cultural dynamics and development opportunities. However, these fundamental roles of agrobiodiversity have not been accordingly recognized and supported in policies and programmes relevant to rural development.

Instead of promoting locally available agrobiodiversity, national programs and strategies have focused mainly on higher yielding varieties linked with the Green Revolution of the 1970s. It is worth to remind ourselves that when the Nobel Peace Price of 1970 was awarded to the crop scientist Norman Borlaug for his contribution to the Green Revolution, the Norwegian Nobel Price Committee was convinced that advances in agricultural research would not only enhance yields, but also put an end to food insecurity and thereby reduce the basis for conflict (Mwaseba *et al.*, 2004). According to Borlaug and Dowswell, yield increasing technology is a "plus-plus" solution since it can increase food production and farmers incomes, while reducing the cost of food to consumers and improving diets (Borlaug and Dowswell, 1995).

Many proponents of the Green Revolution assumed that progress and achieving development in traditional agroecosystems would inevitably require the replacement of local crop varieties with improved ones, and that the economic and technological integration of traditional farming systems into the global system would be a positive step for increased production, income and well-being (Wilkes and Wilkes, 1972; Tripp, 1996). However while green revolution has increased the yield of staple crops (wheat, maize and rice) from 1.06 to 2.50 metric tones per hectare, food security remains an unfulfilled dream for more than 800 million people across the world (Farooq and Azam, 2002). This is particularly important in countries like Asia and Latin America where green revolution was considered successful.

Green Revolution is also claimed to be responsible for reduced genetic diversity, increased vulnerability to pests, soil erosion, and water shortage, reduced soil fertility, micronutrients deficiencies and reduced availability of food crops for local populations (Shiva, 1991). Moreover, the promotion of package that included modern high yielding varieties, fertilizers and pesticides under the idea of Green Revolution marginalized a great number of resource poor farmers who could not afford the technology. While we all agree that modernization of agriculture may increase the potential availability of food and the level of food trade, it will not be able to meet the basic agricultural, nutritional and livelihood needs of most smallholder farmers (Gari, 2004). Agricultural modernization may also accelerate environmental degradation and dislocate the cultural dynamics that have sustained the agriculture of those farmers. In this, agrobiodiversity and indigenous knowledge are the major victims.

It is against the above background that there is currently a broader acceptance that the future for sustainable food production depends not on the modern, mechanised and input intensive farming (given its higher negative environmental externalities and limited potential for use by smallholder farmers) but on diverse landscape and biodiversity rich farming systems most of which are maintained under smallholder farming communities around the world. In other words, there is a growing recognition that food security and the conservation and sustainable use of agrobiodiversity are inextricably linked. This calls for promotion of not only globally important staples (wheat, maize, and rice) but also other locally important crops such as sorghum, millet and cassava that are consumed by smallholder often marginalized farmers (Farooq and Azam, 2002).

This recognition is backed by FAO policy and program efforts since in the 1980s and the Earth Summit in 1992 where agrobiodiversity and its potential for sustainable food security were at the centre of discussion. Since then, agrobiodiversity has received increasing attention and is already inspiring innovative grassroots initiatives, research programs, global environmental actions and even international treaties (FAO, 2001; FAO, 2003; Jianchu and Mikesell, 2003). This recognition signifies the emergence of a new paradigm shift for agriculture that embraces not just the most technically advanced and efficient farming, but also recognises that the great diversity of traditional farming systems and practices in many cultures of different parts of the world and thousands of species that are locally cultured or semi domesticated in home gardens or in other polycultures under agrobiodiversity make a major and essential contribution to food security for hundred of millions around the world.

However, these seemingly complex practices of agrobiodiversity management, frequently found in remote and marginal regions (with estimated 1,500 million smallholder farmers) where industrial agriculture has not yet penetrated are often missed in regional and national policies and strategies for enhancement of food security (Altieri, 2002, Brookfield, 2001; Brookfield *et al.*, 2003; IPGRI, 2003). They are excluded in agricultural policies and food and nutrition programmes to the extent that their use and dignity have even declined (Gari, 2003, and Gari, 2004). This exclusion is not only confined to agrobiodiversity but also to smallholder farmers who conserve agrobiodiversity for humankind's long term food security throughout the world (Boyce, 2004). Unfortunately, around 1,500 million smallholder farmers living in marginal areas lack policies and technical support for improvement of their farming systems (Altieri, 2002). This exclusion has negative consequences including; first, the continuing loss of crop genetic resources due to the restricted focus on agricultural policies on a few introduced species. Secondly, despite the wealth and potential of agrobiodiversity to contribute to food production it has not been explored to address the decline in food productivity and the increased dependence on food aid. These factors call for a critical review of current agrobiodiversity status, policies, and programs that impinge on agrobiodiversity both directly and indirectly.

It is noteworthy that agrobiodiversity, according to by Lambrou (2005), is directly linked to both sustainable livelihoods and food security. This study therefore addresses not only the number one Millennium Development Goal on poverty and food security but also the sustainable livelihoods implied under the Millennium Development Goal number seven. The study is also in line with the National Strategy for Growth and Reduction of Poverty (NSGRP) which lay emphasis on increased agricultural productivity to address the problem of inadequate household food security as indicated in Chapter Two and Section 2.4.3 (URT, 2005).

1.6 Objectives

1.6.1 General objective

The general objective of this study was to determine the linkage between agrobiodiversity and household food security among smallholder farmers in Uluguru Mountains. This objective is based on the fact that, while there are adequate information and corresponding policies for conservation and management of wild biodiversity in Tanzania, few exist on agrobiodiversity and its role in providing food security to the smallholder farmers. The purpose is to provide empirical data for recommendations to policies including the 1992 Tanzania Food and Nutritional Policies and the 2005 Tanzania National Food Security Policy that convey incentives for farmers to conserve agricultural biodiversity for food security and the overall conservation of biological resources in line with international agreements such as Convention of Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture.

1.6.2 Specific objectives

Specifically the study intended to:

i. Identify the major farming systems including the management and organizational aspects of agrobiodiversity and the associated indigenous practices;

ii. Determine household food security status and copping strategies among smallholder farmers in the study area;

iii. Analyse factors influencing household food security in the study area;

iv. Determine the diversity of crops (farmers varieties, local varieties or traditional varieties) maintained by smallholder farmers; and

v. Analyse socio-economic factors influencing agrobiodiversity and household food security.

1.7 Conceptual framework

This study defines "food security" as access for all people at all times to enough food to lead to an active healthy life (World Bank, 1986) and uses a conceptual framework that includes three components of "food security"— availability (a measure of food that is, and will be, physically available in the relevant vicinity of a population during a given time), accessibility (a measure of population ability to acquire available food during a given time), vulnerability (a measure of population or household or individuals risk of exposure to different types of shocks and the ability to cope with them) and food utilization. The entry point of analysis is the household and individuals within the household. A household is food secure if it can reliably gain access to food in sufficient quantity and quality for all household members to enjoy a healthy and active life (Gillespie and Haddad, 2001; Stamoulis and Zezza, 2003).

Accessibility in this regard refers to entitlement to production, exchange and utilization of food to all members of the household. Access can be analysed using various indicators including land ownership and inheritance systems, food utilization taboos and customs, food sharing and exchange dynamics.

Vulnerability as used in this study refers to what is described by Chambers (1989), as an exposure to contingencies and stress, and difficulty in coping with them. It is an aggregate measure for a given household or an individual within the household of the risk of exposure to different types of shocks and disaster events and the household ability to cope with these events. Vulnerability thus has two sides; an external side of risks, shocks and stress to which an individual is subject; and an internal side which is defencelessness, meaning a lack of means to cope without damaging loss (Chambers, 1989 and Maxwell and Frankenberger, 1992).

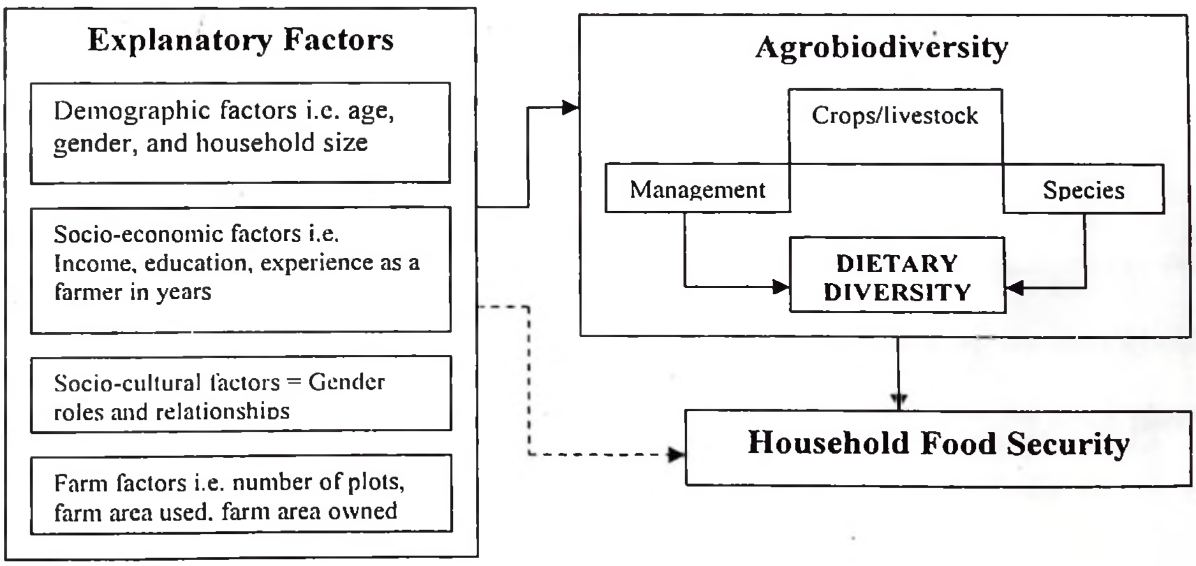


Figure 1: Conceptual framework

This study assumes that food access, availability, and vulnerability depend on the diversity of crops maintained by the households. Thus, as Figure 1 shows, food security can be measured using dietary diversity as an indicator for both agrobiodiversity and household food security.

Figure 1 depicts that household food security among smallholder farmers depends on agrobiodiversity maintained on their farms. This relationship and linkage may be established using dietary diversity as a proxy indicator for both household food security and agrobiodiversity. However, the amount of agrobiodiversity maintained by smallholder farmers is directly influenced by demographic, socio-economic, socio-cultural and farm factors. Demographic factors included in this study are age of the household head and household size. Socio-economic factors on the other hand include education level of the household head and distance to the nearby market. Socio-cultural factors include gender roles and a relationship in agrobiodiversity management. Lastly, farm factors include number of plots, size of the plots used for farming and total area owned by the household.

It is important to note from the adopted definitions and the conceptual framework that the level of analysis is the household and individuals within the household. Crehan (1992) defines a household as a social group which resides in the same place, share the same meal and make joint or coordinated decisions over resources allocation and income pooling. It is a site where particular intense social and economic interdependencies occur between individuals. It is also accepted that households are sites of conflicts and cooperation. The internal power relations, legitimised by social norms have critical effect on the production and sharing of benefits including foods in the household (Crehan, 1992).

Food security analysis at household level is quite different from the national level of analysis most commonly encountered in discussions of hunger and malnutrition in developing countries (Benson, 2004). The underlying principle in this analysis is that households in the rural and marginal areas depend on the food sources mainly from own production i.e. from farms, home gardens and other sources including wild sources.

Thus, unlike urban households whose food availability depends on sufficient income to acquire food from the market, the rural households depend on cropland, livestock together with sufficient labour and tools to produce their own food. This implies that, rural household must maintain sufficient agricultural biodiversity to supply and satisfy household food requirements throughout the year. Agricultural biodiversity used in this framework is defined by Thrupp, (1997) in Kaihura *et al.* (2002) as the variety of plants, species and varieties on the lands of farmers. These plant varieties and species are one of the most crucial elements of environmental riches, providing the basis of the food or livelihood security of billions of people today, as well as the resources for future agricultural innovations in semi-subsistence as well as commercial farming systems (FAO, 1999).

Agricultural biodiversity exists at two levels; first, genetic resources for food and agriculture which encompasses all cultivated and domesticated species, including their wild relatives and managed stocks of wild animals and plants; secondly, components of agrobiodiversity that provide ecological services which includes, for instance, beneficial organisms that control pests, soil organisms that process nutrients for crop plants, pollinators, and plants that contribute to controlling erosion or stabilizing the water balance. Reliable access to food is also closely linked to notions of sustainability and vulnerability. When households are unable to acquire sufficient food using their regular means of access to food—for example, because of poor crop production, they will employ a sequence of coping strategies to meet their food needs (Corbett, 1988). The nature of the coping strategies employed by rural households relies largely on the crop/animal diversity maintained by the household. These coping strategies might include sale of land or other productive assets or shifting consumption from popular food staples to inferior foods grown as hunger crops grown on farms and home gardens or collected from the wild or from abandoned fallows.

In this framework, dietary diversity as an indicator for household food security and household food security coping strategies are determined by agrobiodiversity maintained on the farms and home gardens of smallholder farmers. Both household characteristics and farm factors are assumed to influence availability, access and vulnerability of food by smallholder farmers. In this framework, the dependent variable food security is assumed to be influenced by independent variables under agrobiodiversity, farm and household factors described in Table 1. One can therefore relate agrobiodiversity and food security using indicators including those summarised in Table 1.

Table 1: Variables measured by the study

	VARIABLES	INDICATORS/LABELS
Dependent Variable	**Food security**	Household dietary diversity i.e. number of food groups consumed
Independent Variables	**Agrobiodiversity**	Total number of crops grown
	Households characteristics	
	➢ Age	Age of the household head in years
	➢ Household size	Number of household members
	➢ Labour	Household members working on farm
	➢ Income	Total annual income in Tsh.
	➢ Farming experience	Number of years working as a farmer
	➢ Market	Distance to the nearest market
	Farm factors	
	➢ Fields	Number of plots cultivated
	➢ Land owned	Land owned in acres
	➢ Land used	Land used for farming in acres

1.8 Research questions

1.8.1 Central research question

The central research question for this study was "what is the nature and pattern of agrobiodiversity maintained by smallholder farmers in Uluguru Mountains and how is this linked to household food security"?

1.8.2 Specific research questions

Specific research questions were tackled under the following sub-sections;

(i) Description of farming and cropping system, local varieties and their management system

Detailed information on local practices and preferences is necessary in order to be able to understand the nature and meaning of agrobiodiversity in the context of the study area. In this context, the study is intended to examine the major farming and cultivation systems. Other questions include; how is farming organised over seasons and locations? And what are the existing farming practices?

(ii) Household food security

What are the local perceptions of household food security? What is the household food security status based on dietary diversity? How do households cope with household food insecurity? What are the factors responsible for household food security? How is dietary diversity associated with agrobiodiversity?

(iii) Agrobiodiversity

What is the diversity of crops maintained by smallholder farmers? Which crops are grown? What are the existing farmers' varieties? What is the diversity of crops maintained by smallholder farmers? What are factors responsible for the diversity of crops (not livestock because it is scantly practiced by the Waluguru) maintained by the household? How is this diversity linked to dietary diversity and hence household food security?

(iv) Linkage between agrobiodiversity and household food security

Is there any linkage between agrobiodiversity and household food security (dietary diversity)? This question explores the linkage between agrobiodiversity and food security both conceptually and in practice.

1.9 Relevant output of the study

The study builds and complements upon the ongoing research and development works in biodiversity conservation and management of Uluguru mountains as a biodiversity rich area of international importance having adequate information on wild biodiversity but minimum information on agrobiodiversity. The study provides quantitative and qualitative knowledge base, management practices and tested experiences on agrobiodiversity and its role in household food security and proposes policies and practices of sustainable food security in Tanzania and Uluguru Mountains in particular. Findings from this study also act as an eye opener for agronomic and crop improvement research in the study area.

1.10 Limitations of the study

This study has been limited by a number of factors. First, food security and agrobiodiversity are dynamic concepts in which their perception is influenced by both culture and the existing local and scientific knowledge of both farmers and researchers. This reality posed the first limitation of the study in which differences in perception of the concepts were encountered between enumerators and the respondents. Secondly, data collection on food security relied on specific indicators including dietary diversity and measures of household food security coping strategies which depended on the respondents' ability to recall. Recall methods are prone to bias or response errors. Finally, although the questionnaire was translated in Kiswahili, the communication errors brought about by differences in the level of understanding between the enumerators and respondents cannot be ruled out. However, efforts were made to ensure that realistic information is collected by employing several methods (triangulation) or verified by asking the same questions to a third party.

CHAPTER TWO

LITERATURE REVIEW

2.1 Overview

This chapter bestows a succinct review of literature beginning with the definition of key concepts used in this study. The chapter looks at agrobiodiversity and the evolution of the concept of food security ending with the importance of food access and entitlement as the contemporary benchmarks for household or individual food security. The chapter also gives an account of food insecurity in the world and across Africa and describes the importance of agrobiodiversity for food security among smallholder and marginalized farmers. The chapter ends with a review on the knowledge gap existing in food security and agrobiodiversity research in Tanzania and gives a theoretical background for the analysis of household food security and agrobiodiversity using theories of agricultural change and peasant behaviour.

2.2 Definition of key concepts

2.2.1 Agricultural biodiversity

While the term 'agricultural biodiversity' has tended to be used to signify the variety of plants, species and varieties on the lands of farmers and their relation to welfare (Thrupp, 1997 in Kaihura *et al.,* 2002), the term is much more broadly defined. It encompasses "the many ways in which farmers use the natural diversity of the environment for production, including their choice of crops and the management of land, water, and biota" (Brookfield and Padoch, 1994). It embraces all plants used by or useful to people and other biota with indirect value to people. It takes into account not only genetic, species and agroecosystem diversity and the different ways in which water and land resources are used for production, but also cultural diversity, which influences human interactions at all levels (FAO, 1999). It comprises the diversity of genetic resources and species used directly or indirectly for food, fodder, fibres, fuel and pharmaceuticals. Kaihura *et al.* (2002) asserts that the concept of agricultural diversity goes beyond the concept of species and genetic diversity of plants and animals to incorporate other aspects of the farming system that relate to obtaining sustainable livelihoods. It includes the enormous diversity of crops and crop varieties that smallholder farmers conserve and cultivate, representing both the basis for subsistence and source of income (Gari, 2003). For purposes of description and analysis, agricultural diversity can be classified into four interrelated elements: biophysical diversity, management diversity, agrobiodiversity and organizational diversity and their interactions (Brookfield *et al.,* 2003). Information in Table 2 describes each component together with their specific indicators.

Table 2: Main components of agrodiversity diversity and their respective indicators

Agrodiversity category	Description	Indicators
Biophysical diversity	Diversity of natural environment including the intrinsic quality of natural resource base	Soil types and hydrology, soil biota, soil biochemical characteristics (NPK, CEC, pH, organic carbon content
Management diversity	All methods of managing the land, water and biota for crop and livestock production	Management practices
Agrobiodiversity	All species and varieties used by or useful to people, with emphasis on crop, plants and animal combination	Number of crops and number of varieties produced
Organizational diversity	The manner in which farms are operated, owned and used	Labour size, capital asset and reliance on off-farm employment

Source: Stocking, (2002).

This study concentrates on one element of agricultural diversity, namely, agrobiodiversity. This element of agricultural diversity was selected because it involves management and direct use of biological species, including all crops, semi-domesticated and wild species. This element of agricultural diversity as noted by Guo *et al.* (1996) and Brookfield and Stocking (1999) embraces all plants used by or useful to people. It is the only element of agricultural diversity that links well with household food security as a component of livelihoods (see Figure 2).

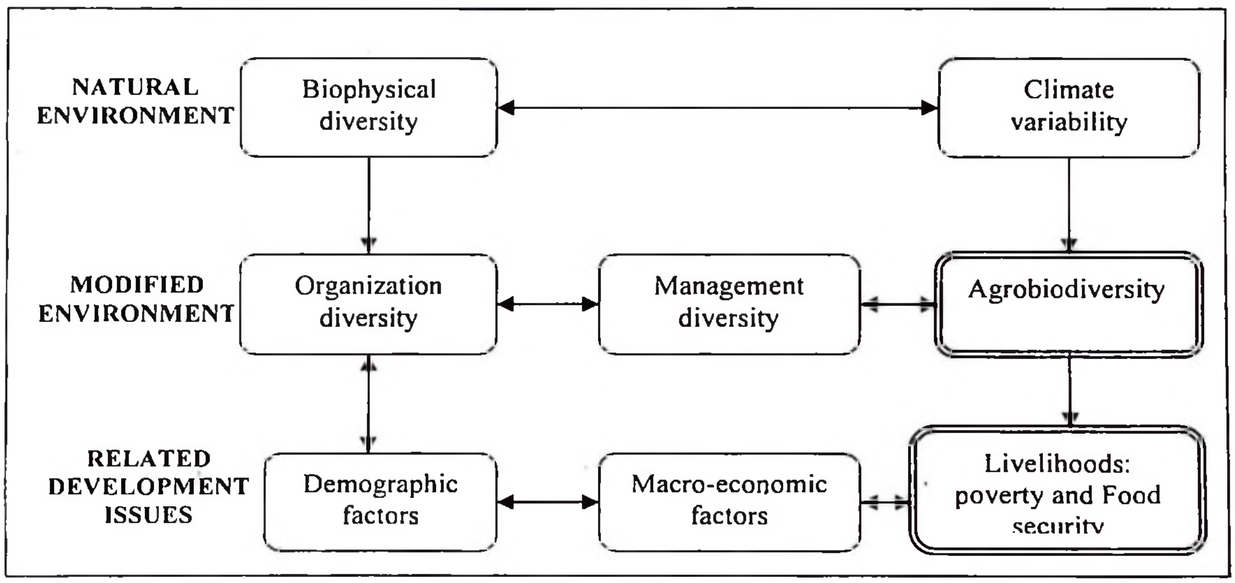


Figure 2: Linkage between elements of agricultural diversity and food security. Modified from Brookfield and Stocking, 1999.

2.2.2 Agrobiodiverity

The term agrobiodiversity has only evolved in recent years in the wake of the general biodiversity discourse, which really began in the 1980s. Analogous to the term biodiversity, agrobiodiversity encompass different levels. It relates to the diversity of agro-ecosystems as well as that of species of crops and farm animals, and to the genetic variance within populations, varieties and races.

However, though the term agrobiodiversity emerged late, a wide intersection of the topic was already analyzed under the term "genetic resources" in the 1960s when the Food and Agriculture Organisations (FAO) of the United Nations started to discuss the genetic foundations of plant breeding (Gollin and Smale, 1999). During the last three decades the understanding of agrobiodiversity has developed from the recognition of the importance of genetic diversity, particularly for crops and an emphasis on the *ex situ* conservation of genetic resources in the 1970s, to the adoption of an *in situ*/on farm approach where plants and animals are kept in natural surroundings or used within agricultural production systems in the 1990s. Finally, agrobiodiversity thinking has become embedded in an integrated, holistic agro-ecosystem approach (Aarnink, 1998).

The crucial difference between wild biodiversity and agrobiodiversity (for the most part) is characterized by the proximate interaction between natural 'material' and human action. The diversity of productive livestock and crops is the result of a century of human breeding efforts based on locally differentiated resources. It reflects the diversity of various agricultural production systems and their cultural and social dependency. Maintenance of agrobiodiversity is inseparably linked to the use and utilization by human beings (unlike with wild biodiversity, protection in the sense of 'leaving it alone' does not suffice). These differences are broadened in the political discourse.

While "general" biodiversity was made a central theme by nature protectionists, agrobiodiversity or plant and animal genetic resources were embraced as a topic by agriculturalists and breeders. Since agriculture has been, and still is, seen as one of the destructive factors for biodiversity, it somewhat stands to reason that agrobiodiversity was not on the agenda of nature protectionists. Therefore, also in the context of the Convention on Biological Diversity (CBD), agrobiodiversity was only explicitly addressed from 1996 onwards. However, agrobiodiversity as a concept branching from the broader concept of biodiversity as seen in the next section has been evolving over time with specific dynamics that have made it gain significant recognition in the overall conservation and management of biological resources across the world.

It is important to note that the recognition of agrobiodiversity as a concept and as an issue is a major conceptual breakthrough reinforced by the Convention of Biodiversity and the Global Plan of Action (GPA). However, agrobiodiversity has different dimensions and dynamic attributes. Brookfield and Stocking (1993) distinguishes between short-term and long term diversity. Short-term (inter-seasonal and intra-seasonal) diversity is basically diversity which is in line with farmers' decision making on use of land, labour, capital and other farming resources, and in the security or risk of harvest. Long-term diversity is a change in the cropping and management practices, in response to environmental, demographic, social, economic and political change.

This change in the cropping and management practices includes shifts through time in cropping patterns, land use allocation, reliance on different income sources and adoption of new varieties and or new practices. The short-term diversity can be observed and directly monitored over a short time period. But the long term diversity is much broader and appears as a result of continued experimentation by the farming communities (Brookfield, 2001). This study focused on the short-term diversity as it employed a cross sectional research design. However, while a cross sectional research design captures short-term diversity, it is of importance to appreciate that short-term diversity is a product of long term and continuous experimentation by farmers. Thus, what is captured by the cross sectional design represents long-term efforts by farmers to maintain diversity for various reasons including their own household food security.

It is important to underscore that in the dominant trend towards uniformity in agricultural landscapes, a significant proportion of farmers and communities continue agrodiverse practices - a dynamic patchwork of different land use stages (such as annual cropping, orchard, agroforest, fallow, home garden, edges, etc.) in many small-farmers' agricultural systems (Brookfield, 2001). On the ground, those land use stages can be identified as field types which are the finest scale of land management patterns farmers recognize.

The field types may be sequential management (such as seasonal variations of crops or varieties, shifting cultivation, etc.) and concurrent management such as mixed cropping and agroforestry (Liang, 2002). It is pointed by Liang (2002.) that land use stages are not fixed, but in flux. For example, small scale farmers in Yunnan, China, convert centuries old rice paddy terraces into vegetable gardens, while others convert old maize fields into fruit and timber trees based agroforestry. The dynamic patchwork of land use stages and field types mimics transitional stages of vegetation succession, maintains diversity of habitats and harnesses biodiversity in space and time (Brookfield, 2001). In "Exploring Agrodiversity", Brookfield (2001) documents many examples of agrodiversity around the world from forest islands in West Africa to multi-storey forest gardens in Southeast Asia, to successional fallows in many parts of tropics.

Thus, agrodiversity can be viewed in two major overlapping categories. One category is environment-adaptive technologies that emphasize skilful, but essentially passive, adaptation to local diversity (Brookfield, 1995). For example, management of successional fallows widely practiced in humid tropics is often an effective adaptation to local environments. Another category is environment-formative technologies, which stress creation of substantial and endurable physical changes as the landesque capital with a life expectation well beyond the present crop or crop cycle (Tanaka, 1995). For example, building and maintenance of rice paddy terraces on the slopes is a long-term investment for cultivation.

It is important to note, however, that agrobiodiversity and agroecosystems are the products of not just the physical elements of the environmental and biological resources but varies according to the cultural and management systems adopted by farmers. Farmers, and especially smallholder farmers, not only select and manage crops, but also choose, modify and create the suitable microenvironments and soils for production. For example, natural or artificial forest is managed and conserved for farming snails, butterflies or medicinal plants (Liang, 2002).

Farmers use domesticated or wild species for livelihoods. For example, selective weeding in the field, and transplanting wild tree seedlings enable farmers to use many wild species (Liang, 2002). Thus, smallholder farmers are custodians of a rich diversity of crops and crop varieties. From the highland maize plots of Southern Mexico and Guatemala to the paddies of Eastern India and Bangladesh, smallholder farmers sustain a diversity of crops and livestock that underpins humankind's long-term food security (Boyce, 2004). Not only do individual smallholder farmers choose to cultivate several varieties of the same crop, but also, and probably more importantly, different farmers in a given locality often cultivate different varieties.

However, most of these crops are neglected and under-utilized. Some of these crops are sometimes despised of as "traditional" or "indigenous" in opposition to the handful of economically valuable crops that are relevant in agricultural trade and urban food habits (Boyce, 2004). These traditional, neglected and under-utilized crops, as noted earlier, are excluded in agricultural policies and programmes, to the extent that their use and dignity have even declined among rural people themselves (Gari, 2003).

However, they often represent strategic crop genetic resources in household food security and nutrition, whilst providing many options for improving rural livelihoods and addressing evolving needs, such as food security and nutrition concerns.

2.2.3 Food security

Interest in food security has waxed and waned over time, particularly in relation to changes in the extent and nature of food problem worldwide. Since the first world

Food Conference in Rome in 1974, the perception of food security has changed significantly. Initially, food security was almost equivalent to avoiding transitory shortfalls in the aggregate supply of food (Staatz *et al.*, 1990).

This notion was based on the perception of food situation during the early 1970s, particularly in several Asian and African countries as a results of shortfalls in food supply, low reserves of cereals and raising prices of foods in the world market and the severe shortage of foreign exchange among low income countries to cover their food import needs (Sijm, 1997). Hence, the major proposal of the 1974 conference to improve food security focused on the raising domestic production of food deficit countries towards self-sufficiency. Another strategy from the world conference was to enhance global food delivery and creation of coordinated system of national and international cereal buffer stocks (Eicher and Staatz, 1986; Sijm, 1989).

Soon after the 1974 world conference, the world food situation changed remarkably. World cereal production and reserves increased considerably, while cereal prices on the world market dropped sharply in the mid 1970s and continued to drop (Martin and Brokken, 1983; Sijm, 1997). However, the incidences of hunger and under nutrition remained high. What came out of this unforeseen circumstance is recourse of perception of food security. Instead of looking at food security as a transitory shortfall or lack of food supply at the national or international level, food security was looked upon as a chronic lack of access to enough food for vulnerable groups due to lack of purchasing power or what Sen (1981) calls entitlement to food.

The new perception brought attention to issues of access to food by households and individuals which could be constrained by economic, social and cultural factors. These factors affect the manner in which the household manages their food resources, either by affecting initial food selection and acquisition or by affecting the use of food once it has been selected.

According to this view, food insecurity could occur at the household level, and was occurring in the absence of regional and national food insecurity. (Sen, 1981). Once household food security was identified as an important variable in the food security-nutritional status continuum, a variety of definitions including some from the World Bank were proposed.

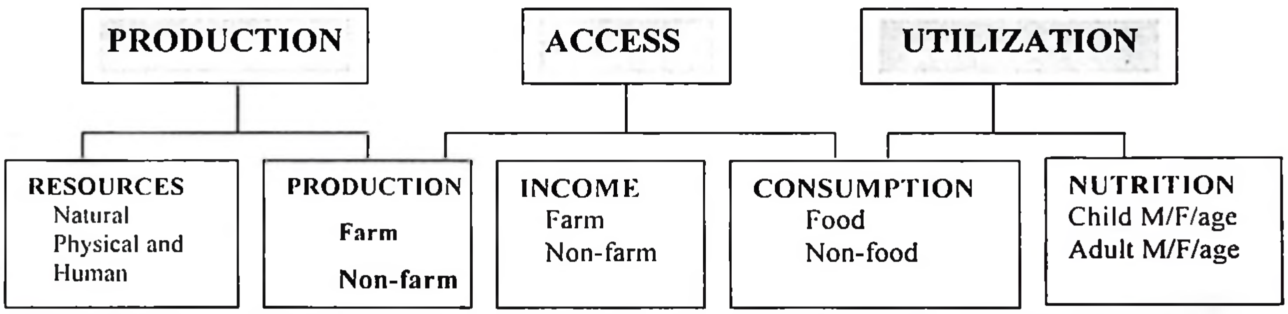
In 1986, the World Bank defined food security as access by all people at all time to enough food for an active healthy life (World Bank, 1986). In this study the World Bank definition is used because it sufficiently contains the four dimensions of food security namely food availability, food access, meeting nutritional requirements and stability. This definition may be put in the context of subsistence farming as ability to establish access to productive resources such as land, livestock, agriculture inputs, and family labour to produce food for the household. Thus, agriculture constitutes the most important factor in food availability, access, and quality. The four dimensions of household food security implies that food security measurements employ various and dynamic indicators as presented in the next section.

2.2.4 Household Food Security Indicators

It was seen from the previous sections that food security is a concept that has evolved considerably over time. This evolution has resulted into the development of different indicators for food security analysis. For example, one volume on household food security by Maxwell and Frankenberger (1992) lists 25 broadly defined indicators. Riely and Moock (1995) list 73 such indicators, somewhat more disaggregated than those found in Maxwell and Frankenberger. Chung *et al.* (1997) note that even a simple indicator such as a dependency ratio can come with many different permutations which can add up to 450 indicators. Consequently, an important methodological problem for researcher and development practitioners is to determine which indicators are appropriate. This problem is driven by the lack of a " gold standard" measure for food security (Chung *et al.*, 1997 and Coates, 2004). Measures of consumption, poverty, and malnutrition are all used as proxy measures and an indicator of assets and income are used as more distal determining factors (Maxwell *et al.*, 1999; Chung *et al.*, 1997, Haddad *et al.*, 1994; Bouis, 1993; Maxwell and Frankenberger, 1992).

All measures are related to food security, yet none of them capture the concept accurately or completely. In particular none of them get at the crucial issue of vulnerability. This is because food security, in the words of Maxwell *et al.* (1999), is probably too complex to ever adequately be captured by a single indicator. It is therefore important to search for reliable and cost effective indicators to use based on the three pillars of food security- production, access, and utilization.

These indicators based on the work by Maxwell and Frankenberger (1992) can be grouped into "process indicators"—those that describe food supply and food access—and "outcome indicators" which serve as proxies for food utilization or consumption. Figure 3 depicts some of the important indicators by grouping them with respect to the pillars of food security namely food production, access and utilization.



RESOURCES	PRODUCTION	INCOME	CONSUMPTION	NUTRITION
Natural Rainfall levels, stability, Soil quality, Water availability, Forest resource access **Physical** Livestock ownership Infrastructure access, Farm Implement ownership Land ownership or security of tenure/access and control Other physical assets **Human** Gender and age of H/H) head Education, H/H size, Ages of other H/H members	Total area cultivated, Irrigated area Area in fallow Access to and use of inputs Number of cropping seasons Crop diversity Crop yield Food production Cash crop production Number of sources of non-farm income Gender division of labour	Total income Crop income Livestock income Wage income Self employment Migrant income Producer prices Market, road access	Total expenditure Food prices Non-food Consumer Prices Dietary intake and diversity.	Anthropometrical data, Serum micronutrient Levels, Morbidity rates, Mortality rates, Fertility rates, Access to health services Access to potable Water, Access to Adequate sanitation

Figure 3: Food security indicators based on three pillars of food security
Source: Webb and Brown, (1993) and Chung *et al.* (1997).

This study uses some of the named indicators including those under food production and access. However, nutrition indicators such as anthropometrical data, serum micronutrient levels, morbidity rates, mortality rates, fertility rates food consumption indicators are not directly used based on the fact they are time consuming, expensive, and requires a high level of technical skill both in data collection and analysis (Coates, 2004). This study therefore used dietary diversity as a proxy indicator for food consumption and nutrition. Dietary diversity is defined by Hoddinott and Yohanness (2002) as the number of individual foods or food groups consumed over a given period of time. Dietary diversity is also used as a proxy indicator of household food access (Anne and Bilinsky, 2005).

Dietary diversity is an attractive indicator for household food security measurements for the following reasons. First, a more varied diet is a valid outcome in its own right. Second, a more varied diet is associated with a number of improved outcomes in areas such as birth weight (Rao, 2001), child anthropometrical status (Allen *et al.*, 1991; Hatloy *et al.,* 2000; Onyango *et al.,* 1998; Taren and Chen, 1993; and Tarini *et al.*, 1999), improved haemoglobin concentrations (Bhargava *et al.,* 2001), reduced incidence of hypertension (Miller *et al.,* 1992), reduced risk of mortality from cardiovascular disease and cancer (Kant *et al.,* 1995).

Third, questions on dietary diversity can be asked at the household or individual level, making it possible to examine food security at the household and intra-household levels. Fourth, obtaining these data is relatively straightforward. Field experience indicates that training field staff to obtain information on dietary diversity is not complicated, and that respondents find such questions relatively straightforward to answer, not especially intrusive, and not especially burdensome (Anne and Bilinsky, 2005).

It was seen from the theoretical background on the analysis of household food security that food security is a dynamic concept reflected from a number of indicators described in Figure 3. The next section dwell on the theoretical perspectives on agrobiodiversity and how food production, agricultural intensification and disintensification affect diversity at farm level.

2.3 Theoretical aspects of agrobiodiversity and household food security

2.3.1 Agrobiodiversity and the theories of agricultural change

Conservation and management of agrobiodiversity by smallholder farmers may be linked to the theories of agricultural change and peasant behaviour. Theories of agricultural change and peasant behaviour present changes not just to the differences between the first plantings 10,000 years ago but also to today's computerised, industrialised and genetically engineered production system (Stone, 2004). Agricultural change occurs on daily basis, as farmers in every country of the world make decisions about what, where and how to cultivate.

Scholarship on agricultural change entails the relationship between farming and population. In 1798, a British Clergyman Thomas Malthus argued for an intrinsic imbalance between rate of population increase and food production, concluding that it was the fate of human numbers to be checked by "misery and vice", generally in the form of starvation and war (Malthus 1798 cited in Stone, 2004). Malthus argued that the power of population is indefinitely greater than the power in the earth to produce. Population when unchecked increases in geometric ratio while subsistence production increase only in an arithmetic ration.

However, Malthus argument on agriculture change was challenged by the publication of Boserup's provocative thesis, and the rediscovery particularly in anthropology of the work of Chayanov on theories of peasant behaviour (Turner and Ali, 1996). Boserup avowedly anti-Malthus thesis of agriculture change argued that population growth is the central source of demand driving the intensification of cultivation particularly among subsistence and peasant producers (Turner and Ali, 1996). She reversed the simple but prevalent Malthusian based view of the time, that state of technology determined the level of cropping intensity. Changing pressure placed on the cultivation, Boserup argued, endogenously drives much of the technology. Endogenous technological strategies include those developed by the community but not employed as well as those developed within the community through continuous experimentation of the farming. These technologies are similar to indigenous knowledge systems shaping agrobiodiversity among smallholder farmers across the world.

Reviewing argument posed by Boserup, Turner and Ali (1996) while citing Chayanov (1966) showed that agriculture change may also involve production behaviour strongly paralleling that found in Chayanov Theory of "peasant behaviour". Chayanov thesis, drawn from detailed village studies in Russia, argued that the "drudgery of labour" in peasant production was such that farm household did not seek to produce as much as was possible, as in profit maximization but sought a more restrained and less elastic goal to produce for household uses. The amount of labour expended depended on the consumer-producer ratio of the household (Turner and Ali, 1996). Additional inputs to production would not follow unless the consumer-producer ratio is changed. The insight provided by Chayanov and Boserup were powerful stimuli to researchers dealing with agriculture beyond the confines of economics.

Empirical analyses based on cultural ecology, international development and farming systems demonstrated the general applicability of these insights for understanding the spatial and temporal variability of cultivation behaviours including crop intensification. However, examining theories of agricultural change, Brookfield (1972) showed that agricultural intensification and maintenance of agrobiodiversity varies with local environments and with the relationship between production concentration and efficiency.

Other factors shaping agricultural change as pointed by Brookfield includes social set up of a given community in which food requirements may be affected by not only calorific needs, but also social demands including prestation, ceremonies and rituals. This implies that agricultural production and its inherent diversity is not only practiced for social ends but also by social means which can have a marked effect on how agriculture methods respond to changes in population and subsequent demand for food. It is also shaped by external systems including markets that may affect the cost of inputs and values of outputs beyond local dynamics. Market according to Eders (1991) may reduce the amount of diversity under farmers' fields as it enhances intensification in the absence of land shortage. However, market involvement does not totally negate the Boserup model, but it clearly introduces variables that can override effects of local population and energetics. It is important to note that farmers, especially smallholder farmers under limited roads and market condition make use of agrobiodiversity as a source of food. In other words, household food security dynamics of smallholder farmers lie on the diversity of crops and animals than on other factors. The next section looks at the theories explaining household food security.

2.3.2 Food security

The World Bank (1986) definition adopted in this work points to the four pillars of food security namely; food availability, food access, meeting nutritional requirements and stability (having adequate food at all times). Access refers to entitlements which is defined by Stamoulis and Zezza (2003) as all the sets of commodity bundles over which a person can establish command given the legal, political, economic and social arrangements of the community in which s/he live (including traditional rights- e.g. access to common resources).

The term "access", according to Saad (1999), is inclusive of both the supply side (availability) and the demand side (entitlement). Access is ensured when all households and all individuals within those households have sufficient resources to obtain appropriate foods for a nutritious diet (Riely *et al.*, 1995). Access is dependent on household resources including capital, labour and knowledge and on prices (Hoddinott, 1999).

In their exhaustive review of the literature Bentley and Pelto and Pelto, (1991) and Maxwell and Frankenberger (1992) noted several caveats related to the uses of the household as a unit of analysis. Firstly, while a household may be food secure some members may be food insecure due to intra-household inequalities in the distribution of food and access by individuals within the household.

This demands not only knowledge of overall household needs and consumption, but also an understanding of intra-household dynamics affecting procurement and distribution of food. Secondly, household food security should be considered a necessary but not sufficient condition for adequate nutrition. Stated differently, food security at the household or even at an individual level is an "input," not an "outcome"—hence the distinction between food security and nutrition security (Babu and Pinstrup-Andersen, 1994; Haddad *et al.*, 1994).

Thirdly, food security must be understood in terms of the rationality and logic of the persons or social units involved. Acquiring food and the provision of adequate nutrition are among the most basic of human pursuits. Thus, human beings are not simply passive victims of either adequate or inadequate nutrition (de Garine, 1972). Other than food availability and access, food security entails other principle components including food utilization and stability as summarised in Figure 4.

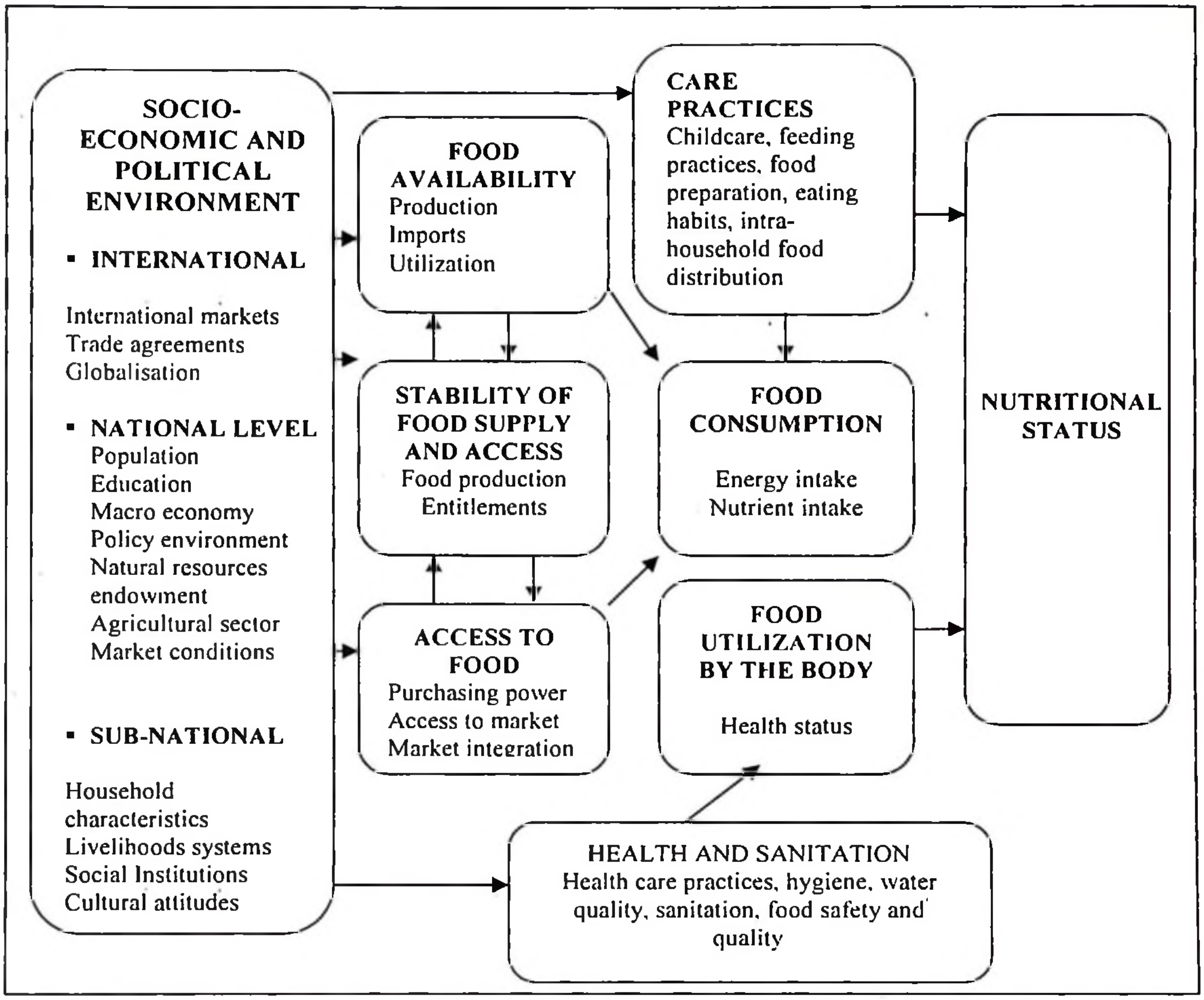


Figure 4: Food and Nutrition security, a graphic depiction adopted from Stamoulis and Zezza, 2003.

Food utilization as pointed by Stamoulis and Zezza (2003) entails the need to meet nutritional requirements through adequate diets, clean water, sanitation and health care. This brings out the importance of non-food inputs in food security. It is not enough that someone is getting what appears to be an adequate quantity of food if the person is unable to make use of the food because he/she is often falling sick. Food stability on the other hand points to the fact that to be food secure a population, a household or an individual must have access to adequate food at all time (Stamoulis and Zezza, 2003). The population should not be at the risk of loosing access to food as a consequent of shock (e.g. an economic or climatic crisis) or cyclically (e.g. during a particular period of the year – seasonal food insecurity). Thus all dimensions of food security as indicated in Figure 4 must be fulfilled for household to be food secure.

Therefore as Figure 4 shows, all four dimensions of food security have to be present before it can truly be said that a person is food secure. Moreover, food security is defined at the level of the individual even though it is brought about by a combination of individual, household, community, national and even international factors. Thus implies that the mere presence of food does not entitle a person to consume it. The quantity of food required must lie within that person entitlement set. It is important to point out however that, at household level, the four pillars depends on household's current food supplies, past stable food supply and the potential future supply (Gittelsohn *et al.*, 1998).

The potential future food supply is a function of the household available resources, such as capital (e.g. land), labour and time. As Figure 5 shows, between household food security and individual nutritional status are patterns of food distribution within the household and individual food consumption, which may include differences in dietary quality and quantity (Gittelsohn *et al.*, 1998).

Therefore the analysis of household food security requires making a series of assumptions about household structure and organization in order to identify the activities, relationships and processes essential to improving food security and to maintaining adequate nutrition status.

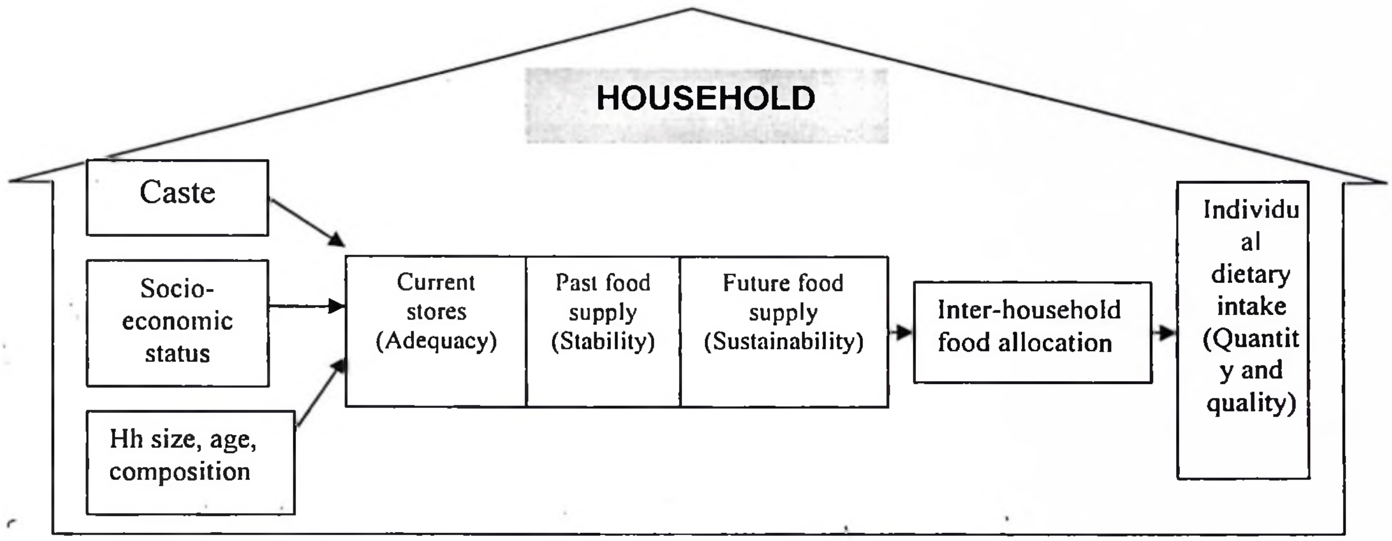


Figure 5: Framework for food security within the household modified from Gittelsohn *et al.* (1998)

In the theoretical literature on economic models of household behaviour, all household members are jointly assumed to maximize some household level welfare function (Becker, 1981). Essentially, as long as the household remains intact, it may be treated as if it acts as a single individual. All resources are pooled and then reallocated according to some common rule (Becker, 1981).

The implications of this model of household behaviour for food security issues as shown by Becker, (1981) are: (a) household members share a common set of preferences in resource allocation; (b) household income and food resources are pooled and allocated to maximize collective welfare – income under the control of different household members has the same impact on outcomes such as child health, nutrient intake, fertility; and (c) households with similar endowments respond similarly but independently to price, income and other exogenous changes – hence "average" demand/supply responses are meaningful for research and policy purposes.

However, the underlying model of the household is open to serious questioning and the implications are also doubtful. What is known is the consensus that:

(i) Conventional economic analysis of household behaviour inadequately accounts for the heterogeneous preferences of different household members, the constraints faced by different decision-makers and actors within the household in guiding resource allocation and the contribution they make to individual and household food security (Berry, 1984; Folbre, 1986; Behrman and Deollallikar, 1990; Thomas Evans, 1991; Kabeer, 1991)

(ii) The assumption that households are discrete entities, adjusting to changes in economic and environmental variables independently of other households and wider social/political institutions (kin, lineage, "community," and "state") is at variance with reality, at least in most agrarian contexts (Friedmann, 1979)

If this new consensus is correct, an operational concept of the "household" for food security purposes must go beyond standard economic analysis to accommodate what Friedman (1979) has termed, a "dual specification" of household, as internally diverse organization, embedded within and shaped by a wider structure.

This brings two important implications for household food security analysis; Firstly, the extent of "latitude" household members' face in allocating labour and non-labour resources differs, depending on the "caste/class" position of household (Behrman and Deollalikar, 1990). In very poor, landless households, women and men may be less circumscribed in allocating their labour to all kinds of (low-income, low productivity) activities regarded by less poor households as "demeaning" or "unsuitable". In less poor households there may be more intense pressure to emulate cultural/ideological norms regarding work befitting class/caste/gender status; and risk-diversification takes on different forms – early marriage of sons, male migration (Behrman and Deollalikar, 1990).

Diversity of food and income sources (cash in kind, farm and non-farm) is considered to be one of the main "buffers" households can develop against risk in agrarian environments (Maxwell and Smith, 1996). It is vital, therefore, to point out that any understanding of household coping and survival strategies should consider the relative importance of different income source, the characteristics of these income sources in terms of seasonal fluctuations and sustainability etc. and the response of individuals and the households to these characteristics (von Braun, 1991). Diversification may entail a fair amount of specialization within the household according to gender or age. In the Gambia, for instance, most subsistence crops are produced by males, and most income from craft-work and services is generated by specialized individuals in the extended household system (von Braun, 1989).

Secondly, there are important questions about the allocation and control of household income. Thomas (1990), working on urban Brazilian data, has shown that the effect of unearned income on child health depends largely on who controls that income. Maternal income effects on family health are generally 4 to 8 times bigger than paternal income effects; for child survival probabilities the effect is almost 20 times bigger. Similarly, Behrman and Deollallikar, (1990), working in rural South India, found that household allocation of food means that the implications of price and income changes for particular types of individuals may differ substantially from those for households average. They showed that there was significant evidence of differential adjustment in male and female food intake as a result of changes in prices. This finding suggests that the period of food insecurity precipitated by sudden price rises may have differential outcome for male and female household members.

It is important to note further that food security for rural households depends on own food production which is enhanced by the amount and type of agrobiodiversity. However, agrobiodiversity like the concept of food security is equally dynamic. Reviewing theories of agricultural change the next section looks at agrobiodiversity dynamics relevant to household food security. It is important to point out that farmers' behaviour and agricultural intensification are all revolving around farmers' production decisions whose theories are discussed in the next section

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2.3.3 Theories of farmers' production decisions

There is substantial amount of literature on the theories of farmers' production decisions (Dillon, 1971; Andersen, 1979; Huijsman, 1986; Akinwumi and Sanders, 1991). However, these theories centre on farm as a business enterprise aiming at profit maximization. Other attempts to understand farmers' production decision uses bio-economic and multicretaria models (Hella, 2003). The former adjusts for production and consumption decision of the smallholder farmer while the latter adjusts for conflicting multicretaria associated with farmers' circumstances (Van Huylenbroeck and Damasco-Tagarino, 1998). However, these models fail to capture all explanatory variables related to uncertain resources constraint and survival algorithms which characterise smallholder farming communities in developing countries (Shapiro and Sanders, 1998; Hella, 2003).

To understand farmers' production decision and behaviour especially on the management of agrobiodiversity, a Farming System Approach model is proposed (see for example Hella, 2003). A farming system is a population of individual farm systems that have broadly similar resource base, enterprise patterns, and household livelihoods constraints and for which similar development strategies and interventions would be appropriate (FAO, 2002).

A farming system model allows us to explore the interconnections between farming and other aspects of the environment in which the farm operates. This approach is important because a farming space embraces more than crops and livestock production (Brookfield, 2001). It adopts not only the environment but also the social and economic conditions and reflects the objectives of the farmer. Since a farm household, crops and livestock husbandry are not the only aspects of an overall farm management system but a subset in a heterogeneous and complex production system, the decisions for crop and livestock production are made in the context of goals and objectives of the farmer, resources controlled by the farmer and resources outside the control of the farmer (Matata *et al.*, 2001; Chilonda and Huylenbroeck, 2001).

The farming system model assumes that smallholder farming is different from that of large scale commercial farming. Smallholders are resource limited, utilize family labour to produce and may rely upon income produced from off-farm activities to meet their family needs. They operate in less adequately developed inputs and output markets and the context in which production decision are made may be understood using a Farming System Approach Model described under Figure 6.

Figure 6 combines aspects of food security and agrobiodiversity discussed in the previous sections. It shows that farmers' decisions on the management of agrobiodiversity (crops, livestock) and the environment in which they are found (the farming system) are influenced by household characteristics (age, sex, size land area etc), household objectives, and goals.

The policy environment also influences farmers' production decisions and the nature of the farming system including use of farm inputs and availability of extension services determines the amount of agrobiodiversity maintained by the smallholder farming environment.

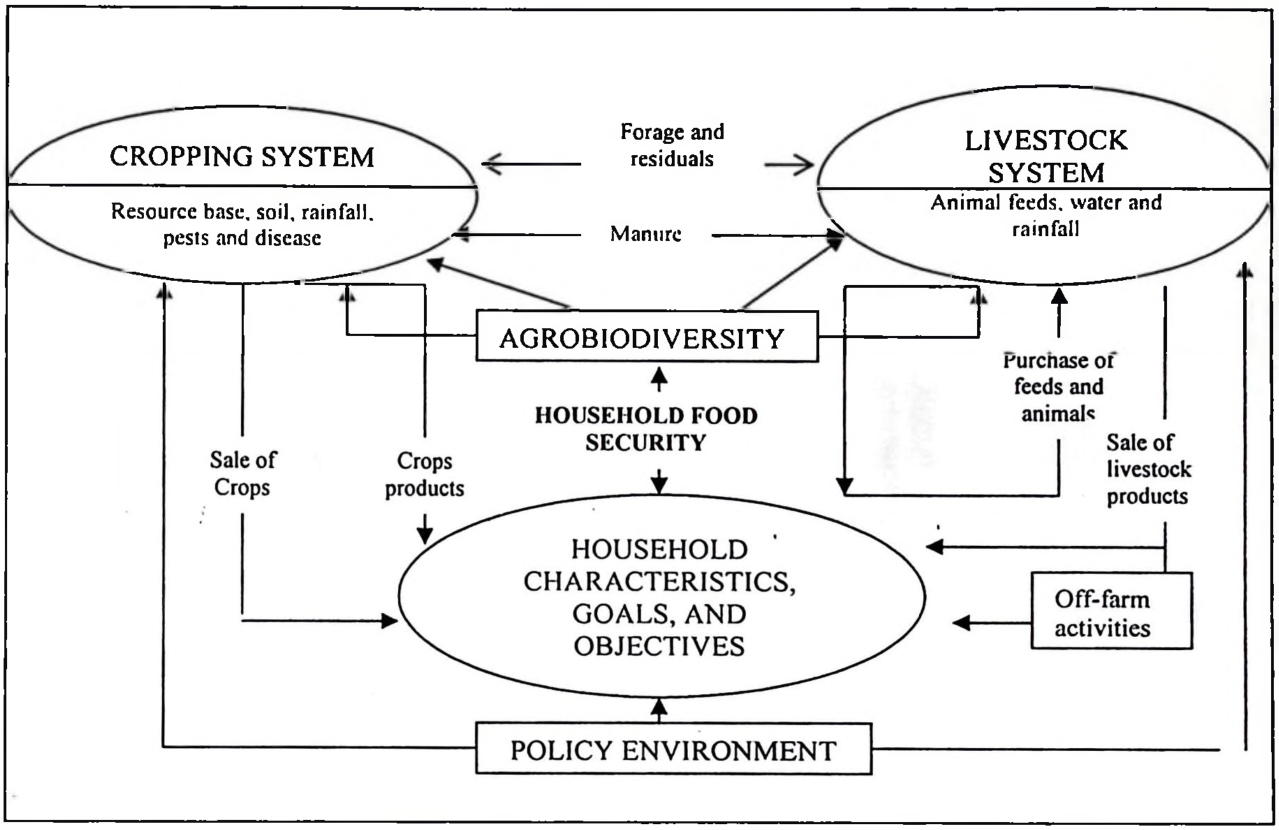

Figure 6: Smallholders farming system model modified from Hella, 2003

These, in turn, determine the livelihood and food security of the smallholder farmer. Other determinants of diversity based on adoption models are explained in Section 2.2.4.

2.3.4 Determinants of diversity

Maintenance of diversity of traditional varieties at household and farm level could be explained as the inverse of the adoption of modern varieties explained by various authors including Feder *et al.* (1985) and Feder and Umali, (1993). Adoption literature explains household activities and how they impart on the portfolio of varieties maintained by farmers. Adoption studies usually use a discrete dependent variable for adoption with examples from studies by Pitt and Sumodiningrat, (1991) and Meng, (1997) that modeled the amount of land devoted to each variety.

These studies and others not cited in this thesis modeled and found empirically that adoption is caused by a variety of different factors, such as a Bayesian learning process where farmers update the subjective yield probability, risky inputs mixed with deterministic yield functions, large fixed costs of adoption or lumpy complementary inputs. However, the adoption process can be partial when only some of the farmers in a heterogeneous population adopt, or on a heterogeneous farm where the technology is only adopted on part of the farm (Caswell and Shoemaker, 1993). A "lumpy" technology with large transaction costs is adopted only by certain farmers as they meet a threshold for discrete adoption; a "divisible" technology with low transactions costs and with limited economies of scale is adopted only on certain plots of land as warranted by the productivity of that technology (Feder and Umali, 1995).

Moreover, farmers may adopt individual components of a technological package as they learn about the profitability of a new technology (Leathers and Smale, 1991). The profitability of a new technology is found to drive adoption, but the profitability of each technology may be specific to each plot due to agro-ecological conditions (Pitt and Sumodiningrat, 1991). Thus, agro-ecological conditions that create constraints to farm productivity are important explanatory components in any economic model of the adoption process.

Risk is another important variable which may explain why farmers maintain a given set of diversity. Among the most important for the application to the diversity modelling are safety first specifications, where consumption demand for a basic grain or any other staple must be satisfied before the profit maximization decisions on other resources are made Smale *et al.* (1994). They were able to show that the safety-first approach was warranted in the case where the difference between High Yielding Varieties (HYV) and traditional maize was compounded by the effect of inputs (fertilizer) on both moments of the yield distribution.

Rosenzweig and Binswanger (1993) modelled the ability of different farmers to bear weather related risks. The ability of wealthier farmers to smoothen their consumption ex post increases their ability to adopt more risky technologies. Accordingly, Rosenzweig and Binswanger (1993) to conclude that poorer households suffer more from an efficiency loss due to production diversification, including presumably their failure to adopt superior but risky technologies. In the crop genetic diversity case, the fact that poor households are the guardians of traditional cultivars gives rise to equity implications that need to be investigated. However, when other crop income or off farm income provides risk hedging against crop variability, there is less need for crop diversity as a means for risk spreading.

Moreover, the demand for diversity may reflect consumption demands for basic staples and the demand for cash income from the production of alternative crops. When households consume a large percentage of their production, an increase in price variability may lead households to dedicate a larger share of resources to producing the staple in order to cover subsistence needs (Finkelshtain and Chalfant, 1991). The continued cultivation of traditional varieties to satisfy the subsistence requirements of the household may reflect high transaction costs in the marketing of specific consumption traits that households prefer.

If traditional varieties are locally consumed goods, the effect of wealth on farm level diversity will depend partly on whether the traditional varieties are normal or inferior goods (Meng, 1997). For instance, if a traditional variety is valued for family consumption or for ritual use it should receive a price premium. On the other hand, if a traditional variety or wild relative is an inferior good that will be displaced by substitution with an increase in the use of markets for consumption, the signs of the wealth effect are ambiguous. Furthermore, factor and commodity substitutability are usually constrained in the developing country cradle areas of diversity. The effects of high transaction costs on the substitution of hired labor for household labor and purchased food for domestically produced food have been shown to have drastic effects on the impacts of Green Revolution technical change (de Janvry *et al.*, 1995). Missing markets decrease the own and cross price elasticities of supply for food crops; the market or policy effects on basic grain diversity will be less than those predicted by a model that assumes the existence of perfect markets.

This short review showed theoretically that farm households maintain a given set of diversity in response to a number of factors. These factors as noted in this review are specific reflecting different socioeconomic and farm characteristics of the household in question. In most cases, the amount of diversity maintained by farmers saves a number of purposes including household food security. Thus agrobiodiversity as explained in the next section form the basis for food and nutritional security.

2.4 Importance of agrobiodiversity to household food security

Agricultural biodiversity is one of the most crucial elements of environmental riches, providing the basis of food or livelihood security of billions of people today as well as the resources for future agricultural genetic improvements in semi-subsistence as well as commercial farming systems (FAO, 1999). This is because agricultural biodiversity acts as a repository of genetic materials which are under constant manipulation and modification by farmers. In recognition of the importance agrobiodiversity, international agreements such as the Convention on Biological Diversity (CBD) and the International Treaty on Plant Genetic Resources for Food and Agriculture encourage the design of policies that convey economic incentives for farmers to conserve agricultural biodiversity (CBD, 2002).

Agrobiodiversity is important based on the fact that global food requirement is no longer confined to wheat, maize and rice, but to a diversity of other crops maintained under subsistent agriculture. For example, there are about 320,000 species of vascular plants available in low income and poor countries of the South of which, about 3000 species (both wild and domesticated) are regularly exploited as food (FAO, 1996; Farooq and Azam, 2002). Among these species, the total collected for food exceeds 7,000 of which 103 species are considered responsible for supplying 90 percent of the world's plant food supply (Robert and Prescott, 1990; Farooq and Azam, 2002). With the current food production and consumption of about 2700 number of purposes including household food security. Thus agrobiodiversity as explained in the next section form the basis for food and nutritional security.

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This deficiency can be overcome if crops other than the present day staple crops are encouraged for food. In other words, if the three crops (maize, wheat and rice) can provide 50 percent of our total energy intake (UNEP, 1995, World Bank, 1996; Farooq and Azam, 2002), the potential of other crops is certainly beyond realization. Thus, the present day commercial agriculture depends on a handful of commodity crops that are being reinvestigated continually to enhance their agronomic potential, thinking that humanity depends only on these crops, which is not the case. Such mistaken decisions had played significant role in undermining the food security of the poor and increasing the spectre of hunger in many areas of the world. This is because, for poor people in the marginal farming areas especially of the south, survival depends on minor species under agrobiodiversity that are adapted to harsh climates and poor soils and that have been neglected or ignored by institutional agricultural research.

Most of the agro-biodiversity is kept in small farms adding up to 60 percent of the world's agricultural land providing food for the majority of the poor (David, 1993, Berg, 1995; Berg, 1996; Farooq and Azam, 2002). These crops are supported under variable microclimatic conditions which favours varietal diversity reflected from farmers' knowledge and practices. Farmers' knowledge and practices involve not only the crop species or varieties that they choose to grow but also the way in which they manage the soil, water, land and surrounding vegetation (Brookfield *et al.*, 2003). The choice of crops and the associated management practices serve farmers with cultural and nutritional requirements that may not be provided by other systems. However, like other biological resources, agrobiodiversity, continues to be lost in the face of various factors including anthropogenic factors.

2.5 Factors influencing loss of agrobiodiversity

As discussed earlier, agrobiodiversity provides the basis of food security and livelihood security of billions of people and the future development of all food production, both for industrial agriculture and for the biotechnology industries. Agrobiodiversity is therefore one of the most crucial environmental resources as emphasized by FAO, (1999).

However, agrobiodiversity has been left to erode in an unprecedented rate throughout the 20th century. For example, of the about 7,000 plant species that have been cultivated and collected for food by humans since agriculture began 12,000 years ago, only about 15 plant species and 8 animal species supply 90% of our food consumption (CBD, 2002). If the genetic erosion which refers to a loss of individual gene, gene complexes and/or loss of a variety (FAO, 1994), is not strictly stopped, some 60,000 plant species which is about 25% of the world existing plant species could be lost by the year 2025 (ICARDA, 1996).

Assuring food security under such circumstances would partly depend on finding ways to conserve areas rich in crop plant diversity as well as on expending germplasm production and collection (World Bank, 1996) especially in the areas where biodiversity is extremely threatened. The most important reason for the loss of genetic diversity is the replacement of traditional varieties with green revolution varieties, which, by 1990 covered 115 million hectares. Decline in agrobiodiversity is also threatening wild relatives that are the only hope in time of crises especially for the people living in the marginal areas. Not only the locally diverse food production systems but their accompanying local knowledge, culture and skills are also disappearing.

The erosion of this resource is regarded by ecologists as one of the most fundamental aspects of the problem of biodiversity loss. It is also frequently cited as an example of the loss of an important form of naturally supplied insurance and a potential threat to entire civilisations, past and present. This unprecedented rate of loss of agricultural biodiversity during the past century has been attributed to several interlinked and intertwined reasons, including development policies and failure to recognise the value of agricultural biodiversity, and mainly to specific changes in agricultural practices that have come about with economic development.

Policies including those that target assistance to enhance agricultural intensification through inputs and price subsidies may lead to reduced diversity. The connection between agricultural assistance and biodiversity relates to the trade-off between farm support and crop choice in the management of production and marketing risks. The risky nature of the agricultural business is a key factor in farmers' acreage allocation and inputs use decisions (e.g. Chaves and Holt, 1990; Leathers and Smale, 1991).

Further, risk-averse farmers will use more of the risk-reducing input than the risk-neutral farmers. In this thesis, these issues are exploited in order to shed light on the connection between financial assistance to farmers and crop biodiversity when farmers are risk averse.

Risk may play a pivotal role in determining crop biodiversity. In fact, if allocating land to different species is a risk-reducing strategy, the risk-averse farmer would grow a higher number of crop species to hedge against uncertainty (Di Falco and Perrings, 2004). This would result in a more diverse agroecosystem (Di Falco and Perrings, 2003). At the same time, policies aiming to support or stabilize farmers' revenues – such as price support, grants, financial compensation – offer an alternative means of hedging against risks. Increasing financial support to one crop affects positively its profitability, expands its acreage and reduces the acreage of substitute crops (Chaves and Holt, 1990). Other observers have traced recent erosion of agricultural biodiversity to the rapid diffusion and expansion of Green Revolution agriculture, which consists of cultivation of relatively few, high yielding varieties of crops in monocultures and intensive livestock production in a limited number of high yielding breeds of animals (Shiva, 1991).

Another important factor is the relationship between markets and farmers' choices of production technology, which, in turn, specifies the level of agricultural biodiversity on farms (e.g. Fafchamps, 1993; de Janvry *et al.,* 1995). Fafchamps (1993) demonstrates that when markets are thin and isolated and/or farmers cannot participate in the markets due to high transaction costs, food prices become stochastic, and for smaller farmers a large covariance between price and income may exist. Consequently, farmers, especially smaller ones who are more risk averse due to their inability to rely on alternative insurance mechanisms, choose to be self-sufficient in food production in order to insure themselves against price and income, and hence consumption risks.

Thus, farmers allocate farm resources (e.g. land or household time endowment) to production of food crops implicating higher levels of agricultural biodiversity rather than cash crops. Fafchamps (1993) further demonstrates that as markets get integrated, price risks decline, agricultural productivity increases and transaction costs fall. Consequently, the need to become self-sufficient in food production diminishes, freeing farm resources to be used in production of cash crops, thereby causing a loss of agricultural biodiversity, other things remaining equal.

The influence of markets on agrobiodiversity was also examined by Meng (1997) and Meng *et al.* (1998). The authors found that the level of market integration as well as farmers' attitudes towards risk, measured by off farm income availability determines varietal diversity of wheat on Turkish farms. Van Dusen (2000) also investigated the impact of the extent of market integration on demand for agricultural biodiversity in Mexico and found out that imperfect markets result in higher levels of within and between species diversity maintained in the Milpa systems on farms in Mexico.

Finally, Bellon *and* Taylor (2001), who investigated the demand of farmers for traditional varieties of maize in Mexico, observed a negative relationship between infrastructure such as, transportation, communication, and education and inter species diversity, signifying diminishing levels of agricultural biodiversity as farmers gain access to markets. The common finding and conclusion from the above review is that market integration is one of the causes of agricultural biodiversity loss on farms with considerable consequences on food security across the world.

2.6 Loss of agrobiodiversity and its impact on food security

One central concern in the second half of the twentieth century has been the major loss of cultivated traditional varieties and landraces across the world. A great many have been replaced by uniform higher yielding varieties of a smaller number of crops produced by modern plant breeding which by 1990 covered 115 million hectares (Farooq and Azam, 2002). Since the early 1980s, it has been known that more than 90 percent of worldwide nutritional needs are met by some 30 crops (Thrupp, 1997). Studies by Prescott-Allen and Prescott-Allen, (1990) reveal further that only 150 plant species are cultivated globally, 12 of which provide approximately 75 percent of the world's food and four of which produce over 50 percent of food. Moreover, Thrupp (1997) showed that people consume approximately 7000 species of plants, of which only 150 are commercially important and about 103 species account for 90 percent of the world's food crops. According to Prescott-Allen and Prescott-Allen (1990), the range quoted in the literature is seven plant species providing 75 percent of human nutrition to 30 plant species providing 95 percent of human nutrition.

These figures point to genetic erosion, which according to FAO (1994) refers to the loss of individual gene, gene complexes and/or loss of a variety. The growing narrow range of crop diversity is also coupled with a loss of habitat in many parts of the world. The loss of habitat diversity, which is very widespread in modern times, may be even a more serious reality as it threatens the integrity of the whole dynamic ecosystems. Moreover, with genetic erosion often go the accumulated indigenous knowledge, culture and skills of farmers about varieties and their cultivation (Thrupp, 1997; Farooq and Azam, 2002). Moreover, declining diversity is also threatening wild relatives that are the only hope in time of crisis especially for the people living in marginal areas whose food requirements depend on both wild, semi-wild and domesticated crops and animals.

2.7 Overview of global food security

2.7.1 Historical overview of the world food situation

At the 1974 World Food Conference, government leaders proclaimed that "every man, woman, and child has the inalienable right to be free from hunger and malnutrition" (Gebremedhin, 2000). The 1974 Conference set an ambitious goal: to eradicate hunger from human society within a decade. At the time of the 1996 World Food Conference, two decades and two years later, many children still went to bed hungry, many families still feared for their next day's bread, and many individuals' potential continued to be stunted by hunger and malnutrition (Gebremedhin, 2000).

Although world food production, overall and per capita, has risen, the goal of the 1974 Conference has not been fulfilled. According to a World Food Program estimates, hunger affects one out of seven people on the planet. In 1996, the World

Bank estimated that more than one billion of the world's people do not have enough food to lead healthy and productive lives. Furthermore, another 1-2 billion are at risk of falling into the ranks of the hungry and, if this trend continues, the number is expected to rise dramatically (Foster, 1992; World Bank, 1996). Based on assessments by Population Action International (1997), more than three billion people, or half of humanity in 1997, subsisted on less than $2 a day and both the number of people and the proportion of total population living in such extreme poverty were rising.

These numbers, as indicated in Figure 7, are more than just statistics; they represent real people suffering from poverty and hunger. The consequences of hunger and malnutrition are adversely affecting the livelihood and well being of massive numbers of people and inhibiting the development of many poor countries. Unfortunately, the number of food insecure as shown in Figure 7 keeps on rising especially in developing countries.

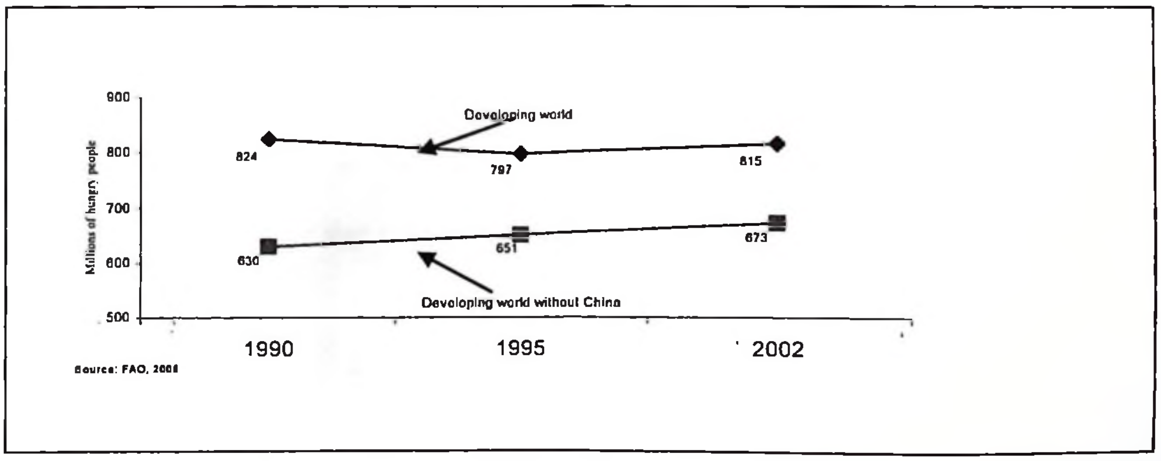


Figure 7: Millions of hungry people across the world

Figure 7 accentuates the common challenges that the world faces in terms of food production and maintenance of sustainable food security to all. However, food production as reviewed in the next section has never been stable especially in developing countries.

2.7.2 World food situation from the 1990s

Over the past two decades, the world has made remarkable progress in increasing food production (von Braun, 2003). World grain production (mainly wheat, corn, and rice) has shown an upward trend, with the exception of slight fluctuations in some years due, primarily, to drought and other natural disasters (Foster, 1992). Despite this growth, the majority of the world's populations, especially in developing countries, are still food insecure. What is important is the fact that there is a growing gap in food requirement in most sub-Saharan countries.

Studies by Shapouri and Rosen (2001) show the *status quo gap* (food needed to maintain per capita consumption at 1997-99 levels) is estimated at 7 million tons for 2000. By 2010, the gap is projected to increase by 80 percent, at which time 42 countries are expected to face declines in per capita consumption. Shapouri and Rosen (2001) estimate the nutritional gap (food needed to meet minimum nutrition levels) to be 17 million tons for 2000. By 2010, the gap is projected to increase by 29 percent, at which time food consumption is projected to fall short of nutritional requirements in about half of the 67 countries in developing countries. Africa, which reversed from being a key exporter of agricultural commodities into being a net importer, has the highest percentage of undernourished people and has shown the least progress on reducing the prevalence of undernourishment in the last 30 years (WFP, 2002). Food insecurity and malnutrition affect about 200 million people, and over 40 percent of the population in Central, East and Southern Africa (FAO, 2002). In late 2001, 15 countries in this region were facing "exceptional food emergencies" (FAO/GIEWS, 2001). In more than half of African countries, hunger is even increasing coupled with prevalence of number of stunted children (FAO, 2002; Jallow, 2004). Table 3 summarises the prevalence of stunted children less than five years of age across Africa.

Table 3: Prevalence of stunted children in Africa

	Percent		Millions	
Region	**1990**	**2000**	**1990**	**2000**
Africa	37	35	32.8	45.1
Eastern	44	44	12.0	19.4
Central	42	38	4.5	6.8
Northern	27	22	6.2	4.6
Southern	25	25	1.3	1.5
Western	35	33	8.8	12.7

Source: Jallow, 2004.

While the prevalence of stunted children in Eastern Africa remained the same, the absolute numbers indicated in Table 3 show a clear increase in the number of stunted children. Figures for other regions are as indicated in the same table. Moreover, chronic food insecurity now affects some 28 percent of the population—that is, nearly 200 million people are now suffering from malnutrition (Clover, 2003). Acute food insecurity in 2003 in Africa affected 38 million people with 24,000 dying from hunger daily (Clover, 2003). In Sub-Saharan Africa, the population living in hunger jumped by nearly 20 percent, reaching 30 million more food-insecure people at the end of the 1990s (von Braun, 2003).

FAO report cited by Clover, (2003) shows that 16.7 million people in Southern Africa needed an emergency assistance to survive the first half of 2003. This has been a crisis that has emerged in slow motion, the extent of which has become apparent only gradually although the first warning bells were rung as early as mid 2001. During the course of 2002, Lesotho, Malawi, Zambia and Zimbabwe, each declared a national disaster and appealed to the international community for help. The most dangerous situation is developing in Zimbabwe, a country which until recently was a surplus food producer. Developments in Swaziland and Mozambique are also of great concern. The continuing response to the food crisis has not stabilised food security and with the 2002/03 crop already compromised and food shortages likely to increase, the current emergency conditions are worsening (Clover, 2003).

It is important to note that, today, the incremental improvement in the world food situation is a more challenging task than what the world faced in the past 10 years. Freeing the next 400 million people from hunger, as pointed out by von Braun (2003) requires much more complex investments, innovations and policy actions than those needed in the last decade. Note further that the world has worked hard to address global food shortage through policy formulation and implementation of various strategies including promotion of modern agricultural technologies. However, modern agricultural models have promoted high material inputs which cannot be afforded by common smallholder farmers. Inputs such as fertilizers are prohibitively very expensive. Urea in western Kenya, for example, costs about 400 USD per ton compared to Europe where the same ton of Urea costs about 90 USD (Conway, 2004).

Moreover, the modern agricultural models have impaired the economic development of smallholder farmers because the investment efforts have not often resulted in decreased gains, in a downward cycle of financial debits, development dependency, environmental degradation and health impoverishment (Gari, 2003). The current trend is to enhance low–input agriculture using locally adopted management practices. Agro-biodiversity represents an important entry point for the promotion of low-input technologies targeting smallholder farmers. Dynamics and suitability of agro-biodiversity to local conditions discussed in Section 2.7, provides local mechanisms to manage local, often marginalized landraces, which have been important in maintaining food security for the majority of smallholder farmers.

2.8 Status of agro-biodiversity and food security research

2.8.1 In the world

Studies on Agrobiodiversity and food security may be linked to earlier works on sweet potatoes, (Bourke, 1982; Amante and Bader, 1991), Andean potatoes (Brush *et al.*, 1981), beans in Malawi (Ferguson and Sprecher, 1987; Martin and Adams, 1987) and traditional tropical agriculture (Clawson and Thurston, 1992). However, focused studies in agrobiodiversity over the last two decades include studies on classification of traditional varieties conducted by Wood and Lenné (1999) who present a varietal classification of traditional varieties by local people. In their work, Wood and Lenné (1999) show that "traditional landraces usually .differ in agromorphological characters which are used by farmers as markers for taste, texture, yield, storage characters, resistance to environmental stresses, use and maturity time. Remarkable parallels exist across crops and cultures and continents".

Reviewing studies of farmers' classification, Jarvis and Hodgkin (1998) recognized that most farmers use an agromorphological definition. The authors give examples from around the world, including rice in Nepal (Sthapit *et al.*, 1996), millet in India (Weltzien *et al.*, 1996), sorghum in Ethiopia (Teshome *et al.*, 1999), potatoes in the Andes (Zimmerer and Douches, 1991) and maize in Mexico (Louette *et al.*, 1997).

Recent work by applied economists have so far focused on identifying the factors that positively and negatively affect the prospects that intra-specific diversity is maintained on farms and characterizing those farmers most likely to continue conserving it (Brush *et al.*, 1992; Meng, 1997; van Dusen, 2000; Smale *et al.*, 2001). As a tool for targeting conservation efforts, Meng, (1997) profiled those farmers as would most likely continue to grow wheat landraces. Van Dusen (2000) explored both inter-specific and infra-specific diversity in the Mexican *milpa* system.

None of these studies sought to identify and systematically determine the linkage between agrobiodiversity and food security among communities. Aguirre Gómez *et al.* (2000) compared levels of diversity indices constructed for maize types (mostly maize landraces) grown in regions of southeast Guanajuato, but not in the context of agrobiodiversity and food security. This is particularly important to Tanzania where studies in agrobiodiversity and as indicated in the next section are limited to few places with emphasis on socioeconomic factors as influencing agrobiodiversity.

2.8.2 In Tanzania

Research on agrobiodiversity in Tanzania dates back to 1998 after the introduction of People, Land Management and Environmental Change Project (PLEC) in Arumeru District (see Kaihura and Rugangira, 1999). The aims of the project, as pointed by Kaihura and Rugangira (1999) were first, to establish historical and baseline comparative information on agrobiodiversity at the landscape level in representative diverse sites; second, to develop participatory and sustainable models of biodiversity management based on farmers technologies and knowledge within agricultural systems at the community and landscape levels; and finally, to recommend approaches and policies for sustainable agrobiodiversity management to key government decision makers, farmers, and field practitioners.

Since its inception, the project has been able to carry the assessment of biophysical diversity of crop, land and livestock management (Kaihura *et al.*, 2003). Other work that was done by the project includes identification of land use stages and field types as reported by Kaihura *et al.* (2002). In another study by Mwalukasa *et al.* (2001) reported on socio-economic factors influencing farmers' livelihood and agrodiversity. Another work by Ngailo *et al.*, 2001 reported on land use changes and their impact on agricultural biodiversity in Arumeru, Tanzania. Kaihura *et al.* (2002) also reported on aagrobiodiversity as a Means of Sustaining Small Scale Dry land Farming Systems in Tanzania. It is evident from the above studies that food security was not fully addressed. These findings are also applicable in Uluguru Mountains where despite the fact that so much research has been done, only a handful has addressed the issue of food security with respect to agrobiodiversity.

This study therefore opens up a relatively new research challenge for smallholder farmers living on the slopes of Uluguru Mountains. The reason why this is important is that the pressure to produce food has been inexorable in both developed and developing countries. However, for several reasons, pockets of smallholder agriculture and land use systems have still remained a major source of livelihoods and food security. These gardens and small plots are both productive and diverse, but they do not contribute to the wider market except in certain very specific commodities, such as coffee. Elsewhere, physical isolation, as in mountain communities, has buffered land use from the pressures of the market. This means that while we consider developing agriculture in the direction of high yielding uniform systems of land use, smallholder and less input and diverse system may be the choice for small hold farmers across the country. These farms contain high biodiversity value and farmers have a wealth of knowledge that perhaps have more resonance for food security among smallholder, and often marginalized farmers than the large-scale high input farming system.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Overview

It was seen from Chapter One that this study intended to link household food security among smallholder farmers with diversity of crops and livestock maintained under farmers' fields. The aim was to determine the right variables that may be used for this linkage. Beginning with food security, it is obvious from Chapter Two that there are a number of variables and research methods used for collection of data for household food security. In this context, devising an appropriate measure of food security outcomes is a challenging undertaking.

Moreover, the juxtaposition of the value of indicators of food security, together with the difficulties in obtaining detailed information poses a great deal of a challenge for the right choice of indicators for household food security. It is important to reiterate that food security can be assessed using both process indicators and outcome indicators. However, Chung *et al.* (1997) found that there is little correlation between a very large set of process indicators and measures of food security outcomes. Therefore outcome indicators such as individual intakes, household calorific acquisition, dietary diversity and indices of household food security are mostly used in the contemporary research in food security. However, work by Hoddinott, (1999) shows that these indicators have both advantages and disadvantages. Some of these methods are regarded as being accurate but are skill and time intensive while others can easily be implemented with minimum time requirements. It is noteworthy that, to obtain empirical information that would capture issues under the study, both iterative and interactive approaches were adopted.

This chapter entails the methods used for data collection and analysis. The purpose of this chapter is to provide methodological and analytical process used to answer specific research questions given in Chapter One. The second section of this chapter describes the study area. In this section, the location of the study area, vegetation and climate are succinctly described and explained. The succeeding sections present research phases, sampling strategies, and methods of data collection for specific research objectives and research questions. Chapter Three ends with methods of data analysis focused on specific research objectives.

3.2 Description of the study area

3.2.1 Location and geographical features

Uluguru Mountains (Figure 8) forms part of the famous Eastern Arc Mountains located in the central-eastern part of Tanzania, elongating between $06^0 51'$ and $07^0 12'$ South and $37^0 36'$ and $37^0 45'$ East (Lovett, 1988; Lovett, 1990). The area is located approximately 180 km from the capital city of Tanzania (Dar-es-Salaam) and the Indian Ocean.

The mountain raises out of the coastal savannah plains at about 300m to 2,638m above sea level (Bhatia and Ringia, 1996). The mountains are physically divided by the Mgeta-Bunduki depression onto the Northern Uluguru which is 20.5km long and 8km wide, and the Southern Uluguru having a length of 25km and the width of 15.5 km. The Uluguru Mountain is characterised by a mountainous and hilly landscape consisting of extensive cliffs, rock outcrops and steep and deep valleys of slopes ranging between 10-100% (Kilasara and Rutatora, 1993).

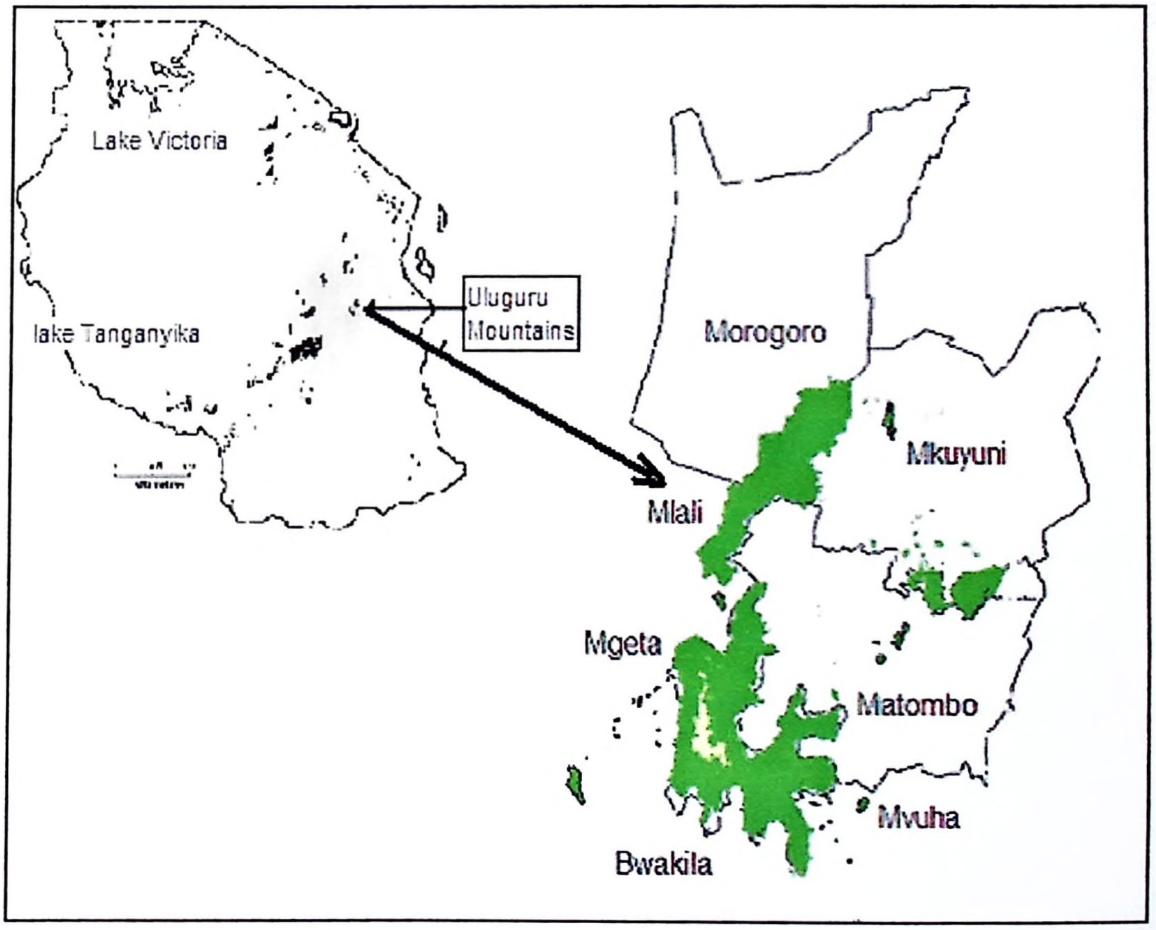


Figure 8: Location of the study area

3.2.2 Climate and vegetation

The Uluguru Mountains climate falls within intermediate tropical climate zone and is influenced by the Indian Ocean currents. The area receives two rainfall cycles per year with the long rainy season from March to May and shorter rains around November to December. The average rainfall is over 1800mm per year, sometimes exceeding 2500-3000mm per annum in some places. There is a pronounced dry season on the western slopes due to rain shadow effect but the eastern slopes of the Uluguru is noted to experience heavy rains reaching as high as 100 mm of rain per month in some areas (Lovett and Pocs, 1993). The lower altitude below 600 m receives rainfall between 700 and 900 mm with longer dry period lasting for four to six months.

It is important to point out that the Eastern side of the Uluguru Mountains is tropical and wet allowing people to grow valuable tropical fruits and spices. Tropical fruits common in the area include pineapple, mangoes, oranges, and mandarins. Common spices grown in the area include cardamom, black peppers, cloves and cinnamon. The western Uluguru consists of subtropical to temperate climatic feature and is usually drier but highly suitable for the production of vegetable and fruits such as plums, apples and peas.

Other than agriculture, the above climatic condition results into differences in the natural vegetation along the slopes of Uluguru Mountains. The upper part of the Uluguru Mountains above 1500m above sea level is covered with Montane forest while the lower part ranging between 900-1500 is dominated by the *Prerocaupus-*

Compretum and Miombo woodland. The middle to lower slopes originally covered by sub-montane evergreen forests is now occupied by cultivated fields and fallow vegetation. Some patches of riparian forests are found along the streams and main rivers. Uluguru Mountains are also known for their high biodiversity value (Lovett and Wasser, 1998; Burgess *et al.*, 1998; Mittermeier *et al.*, 1998; Stattersfield *et al.*, 1998; Myers *et al.*, 2000). Apart from exceptional biodiversity, the Uluguru Mountain forests are also very important as a major catchments area for rivers that supply water to the municipality of Morogoro and Dar es Salaam.

3.2.3 Socioeconomic and socio-cultural characteristics

According to the poverty and welfare indicators for 1999 of the Vice President's Office the study area is generally poor, rural, and is among the 50% most deprived regions in Tanzania. The main ethnic groups are the Luguru, Sagara, and Pogoro. Indigenous languages are commonly spoken in the villages, but Kiswahili, the national language, is widely understood and spoken by the majority. The main occupation of people of all ages in the area is farming. A few of the people are involved in off-farm activities such as carpentry and petty trade. Other detailed demographic and socio-economic characteristics are presented and discussed in Section 4.2 of Chapter Four.

3.3 Research design and data collection procedure

3.3.1 Research design

This study adopted a cross-sectional research design. Unlike retrospective and longitudinal research designs, cross-sectional research design allows data to be collected at one point in time (Bernard, 1996). In this type of research design, either the entire population or a subset thereof is selected, and from these individuals, data are collected to help answer research questions. Moreover, the design is suitable for descriptive analysis and for determining the relationships between and among variables.

3.3.2 Data collection and sampling procedures

The guiding principle for data collection and eventually data analysis was that household food security in rural and marginal areas depends on food produced by the households and that maintenance of diverse cropping systems, crops and livestock ensures food availability and access. This linkage was to be established by collecting information on the diversity of crops maintained by smallholder farmers and the diversity of food consumed at the household level. The main hypothesis depicted in the conceptual framework was that the score of dietary diversity is correlated with the diversity indices as measures of crop diversity maintained at the household level. The establishment of this relationship required different tools and methods using various indicators as indicated in the conceptual framework.

3.3.3 Research phases

To capture issues and indicators described in the conceptual framework, the data were collected in two phases. The first phase of data collection was based on socio-economic aspects of the study. Socio-economic data covered agrobiodiversity aspects of food security including basic data (household characteristics, gender roles, farm size, income, level of education to name just a few). The second stage dealt with the quantification of agrobiodiversity particularly crop diversity. In this case, crop diversity from home gardens, farms and fallows were collected and analysed. It is important to note that Uluguru Mountains like other Eastern Arc Mountains are highly influenced by the Indian Ocean currents. The eastern part of Uluguru Mountains receives more rainfall than the western part due to shadow effect (Temple, 1972). Thus climatic orientation has stronger influence on the crop and livestock farming system for both West and Eastern Uluguru. It is from this background that two villages from both West and East Uluguru were randomly selected for data collection. In each study village, four farming systems namely hilly slopes, valley bottoms, lower plains and home gardens following Bhatia and Ringia (1996) were included in the study. A total of 120 households were sampled for this study. This sample was randomly selected from 245, 225, 520, and 329 households from Kibogwa, Milawilila, Pekomisegese and Nyandira, respectively. Figure 9 shows stages taken to determine sampling villages and consequently sample households.

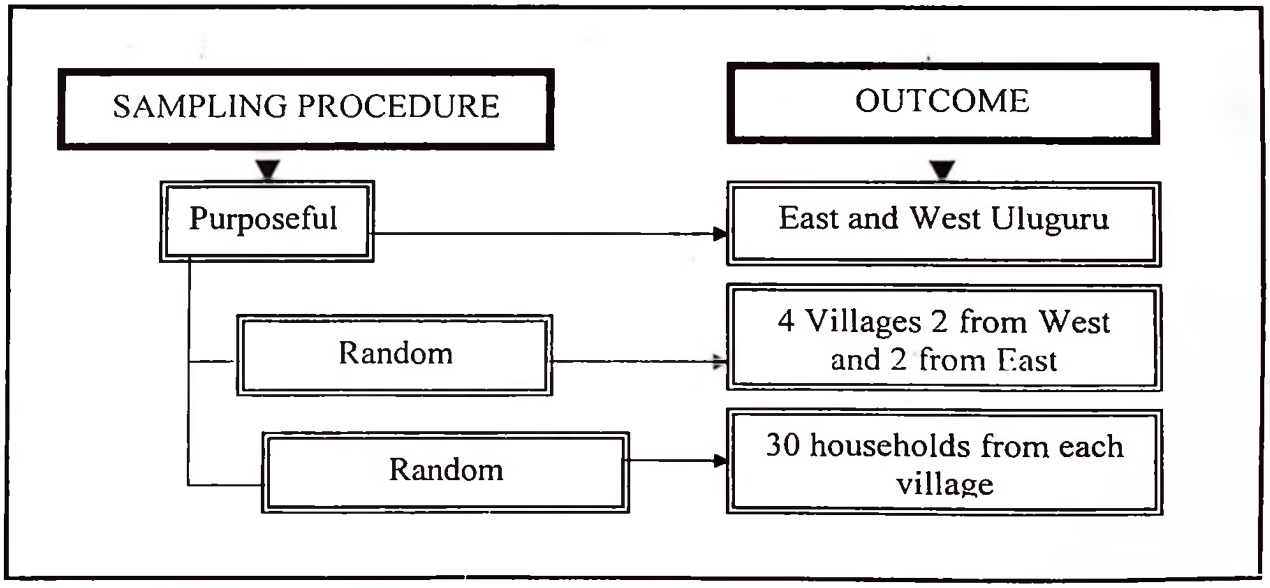


Figure 9: Overall sampling procedure

Both inter-household and intra-household variables were considered for data collection. This as noted by Gittelsohn (1991) and Gittelsohn *et al.* (1997) is important because household decisions are often compromised by factors from within and outside the household.

For example, household crop production and farmer decision-making may be influenced by inter-household factors such as the land tenure system or the size of land holdings and intrahousehold factors including differential access to inputs, responsibility, and control over products. Consideration for both inter-household and intra-household variables calls for the use of several types of data sets using different methods of data collection as described in the next section.

3.3.4 Data collection for objective one

Objective number one aimed to identify the management and organizational aspects of agrobiodiversity including the associated indigenous knowledge systems and practices associated with agrobiodiversity maintenance. Specific research questions that guided this investigation were; how is farming organised over seasons and locations? What are the existing indigenous knowledge systems (farming practices)? Most of the information for this objective were obtained using PRA (Appendix 4) and semi-structured interviewed.

3.3.4.1 Participatory Rural Appraisal

Participatory Rural Appraisal (PRA) is a growing family of approaches, methods, and tools (Table 4) used to study farmers' attitudes, behaviours and livelihoods strategies under local conditions. According to Chambers (1989), PRA enables and empowers people to share, analyse and enhance their knowledge of life and conditions.

Table 4: PRA tools used in this study

Tool	Description	Types of data/information
1. **Transect walk**	Is a walk through the village along a defined route to identify and discuss things which are relevant to the study.	Land management practices, enterprises (crops, livestock), farm sizes, land tenure arrangements, farming practices.
2. **Community mapping**	Mapping of the village using locally available materials.	To generate information on the location of resources and patterns of resource usage, local infrastructure, land tenure systems, spatial distribution of crops and their relationship to natural resources.
3. **Seasonal and labour calendar**	Is the outline of of the agricultural season, crop sequence and associated tasks.	To generate information on agricultural season, the crop sequences and labour sequences.
4. **Focused group interview**	Gathering of a small group of people for the discussion of a given issue.	General and commonly shared information on food security and its linkage to agrobiodiversity, commonly held perception of the uses and values of particular crops, predominant crop varieties raised by the community and dietary diversity/food groups
5. **Gender analysis**	Collection of gender disaggregated data using focused group interview to reveal gender roles and relations.	To generate information on activities, knowledge, preferences and priorities of both men and women.
6. **Matrix ranking and scoring**	Ranking and scoring of varieties/landraces to explored qualities and general characteristics of varieties by farmers.	Compare and contrast and finalyse itemize important varieties/landraces with respect to farmers knowledge and gender.
7. **Indepth interview**	Was done to collect specific information on food security coping strategies and dietary diversity.	Household food security coping strategies.

It is an intensive, iterative, and expeditious form of research, which relies on small multidisciplinary teams that employ a range of methods, tools, and techniques specifically selected to enhance understanding of rural conditions by tapping the knowledge of local inhabitants (King, 1999).

An important aspect of PRA process includes strengthening the role of farmer knowledge and experimentation within formal agricultural and scientific research. The areas where this has made the strongest impact have been in participatory plant breeding, *in situ* conservation, and work to characterise farmer perceptions and management of genetic diversity. In this study, 15-20 randomly selected household members were picked to form a PRA team. Consideration was given for equal representation of sex, age and wealth in the group. Such consideration is because of the diversity of knowledge, perception and understanding of agrobiodiversity conservation and management associated with sex, age and wealth of the groups.

3.3.5 Data collection for objective two

The objective number two of the study focused on the determination of household food security status and coping strategies and how these coping strategies are linked to the diversity of crops and/or livestock maintained by the smallholder farmers on the slopes of Uluguru Mountains. However, food security copping strategies were analysed after establishing the household food security status. This objective was steered by specific research questions which included: What are the household food security copping strategies and how these strategies are associated with the diversity of crops and/or livestock maintained by smallholder farmers in their home gardens, farms, fallow land, and wild sources. These questions were answered by the employment of in-depth interviews as described in the next section.

3.3.5.1 Interviews for household food security coping strategies

Interviews were done to determine household food security copping strategies. The score of household food security copping strategies is an index based on the manner in which households adapt to the presence or threat of food shortages. The person who has primary responsibility for preparing and serving meals within the household is asked a series of questions regarding how households are responding to food shortages. This method was first developed by Radimer, *et al.* (1990) and later adopted by Maxwell and Frankenberger (1992) and Maxwell (1996). The most knowledgeable person in the household regarding food preparation and distribution is asked a series of questions as shown in Appendix 2.

In this method, the frequency of use of a particular strategy is recorded as "often", "from time to time", "rarely" and "never". Later the information is quantified such that, "often" is counted as 4, "from time to time" is counted as 3, "rarely" is counted as 2, and "never" is counted as 1. This approach was repeated in two seasons, wet and dry season. Finally, a weighted sum of household food security copping strategies (reflecting the frequency of use by the household) was calculated. The calculated weighted sum forms an individual household food security coping strategy index. The higher the sum, the more food insecure the household is and vice versa.

3.3.6 Data collection for objective three

The third objective intended to determine the diversity of crops (farmers varieties, local varieties or traditional varieties) maintained by smallholder farmers. Research questions that guided data collection for this objective included; what is the diversity of crops maintained by smallholder farmers? Which crops are grown? What are the existing farmers' varieties? How do smallholder farmers describe the varieties and what are their preferences?

3.3.6.1 Sampling strategies for crop diversity

A stratified random sampling procedure was used to select home gardens and farms for collecting crop diversity data. In this study, 10 randomly selected home gardens and 10 farmers plots from each of the four sampled villages were picked for data collection. The selection of 10 randomly selected home gardens and farms follows PLEC, (1999)'s suggestion of a 1 x 1m sample plot for collection of herbaceous plant species, and 5 x 5 m sample plots for taller and bigger plant species. It is suggested that five 1 x 1m sampling plots for every 20 x 20m be used for data collection for both home gardens and farmers' fields (Appendix 3).

3.3.6.2 Data collection on crops diversity and utility

Data on crop diversity was collected using the approach also proposed by Brookfield *et al.* (2003). Crop diversity in this respect is determined by collection on the presence, abundance and utility of crops grown by farmers in two seasons, first during the wet season i.e. between March and July and secondly during dry season between September to December. Data on the species presence was collected through listing of species from the sampled plots and abundance was determined by recording the number of individuals of each species. Data on utility was collected using major utility categories suggested by Zarin *et al.* (1999). Major utility groups were determined based on whether the crop is used for food or other uses including medicinal or cultural uses.

3.3.7 Data collection for objectives four and five

Data collection for analysis of socio-economic factors including gender influencing agrobiodiversity and household food security was collected using questionnaire survey. The base line for these objectives was to provide answers to questions: what are socio-economic and agroecological factors influencing the existing agrobiodiversity and the overall household food security among smallholder farming community? Who have access and control over which resources, and what implication does this have on household food security? What are the specific roles of women in maintaining agrobiodiversity? Questionnaire survey also covered issues related to objectives one and two given in Chapter One.

3.3.7.1 Questionnaire Design

Both qualitative and quantitative information were collected using a structured questionnaire containing factual questions for such information as years and quantities, subjective or opinion/open-ended questions and the pre-coded questions with predetermined answers. In using the questionnaire, the emphasis was placed on the collection of information related to household food security and the dependence of smallholder farmers on agrobiodiversity as a means for food production, utilization and food vulnerability. The questionnaire (Appendix 1) was therefore divided into three important sections. The first section was designed to solicit background information from the respondents including: household profile, household resources ownership, and crops and livestock production systems. The second section of the questionnaire dealt with the collection of food security and related aspects.

The final version of the questionnaire was developed after pre-testing of the first draft of the questionnaire. Pretesting in this study was done in the same study area. In this study, 30 randomly selected individuals from the study area were picked for pretesting the questionnaire items. The proposed number of people follows Ron

(1998) who contends that 20-70 respondents are sufficient for pretesting a given questionnaire. Pretesting was done to solicit answers to the several questions as follows (i) Do the respondents understand the question or the task being asked of them and whether they answer choices from which they are to select? (ii) Does the respondent's interpretation of the question coincide with what the researcher intends the question to measure? (iii) Does the respondent use different response categories or choices than those offered in the question? (iv) Are the respondents attentive and interested in the questions? A final version of the questionnaire was produced based on the results from pretesting. Thereafter, a fully developed questionnaire was administered to randomly selected households. Randomisation and sampling strategies are described in the next section.

3.3.7.2 Sampling strategy for questionnaire survey

The need for both qualitative and quantitative information and appropriate generalization of the research findings call for a statistically representative sample from the target population. Before generalization, it is also important to have a clear definition of the sampling unit. In this study, a household as indicated in the previous section was taken as a sampling unit. It was defined as a group of people eating from the same pot, cultivate the same land and recognise the authority of one person, the household head who is the ultimate decision maker of the household (Poate and Daplyn, 1988 cited in Kajembe, 1994).

Thirty (30) households from each village were randomly picked making a total of 120 households for questionnaire survey. This sample size was thought to be sufficient following Bailey (1998) who contends that regardless of the population size, a sample of not less than 30 is the minimum acceptable size for statistical analysis. Moreover, the size of the population (as long as the population is much larger than the sample) does not influence the sample size we need (More and McCabe, 1998).

However, small sample sizes are prone to larger sampling error and may show stronger correlations and statistical results compared to larger samples (de Vaus, 2002). Moreover large sample sizes have the tendency of showing statistically significant results even for very trivial relationships. Considering all these and the available time and financial resources (commonly affecting most research programs) the study decided to stick to 30 households for each of the randomly selected villages. However, whenever possible, confidence intervals are reported to avoid confusion between statistical and substantive significance related to the selected sample size. Confidence intervals take into account the sample size and the degree of variation in the population and estimates the likely margin of error of the sample estimates (de Vaus, 2002).

3.3.8 Data collection for the linking agrobiodiversity and food security

Guided by specific research questions regarding for example, farmers' perceptions on food security, and the linkage between agrobiodiversity (diversity indices) and household food security (dietary diversity), the study used dietary diversity as a measure of household food security. This indicator provides the opportunity to link agrobiodiversity (crops and varieties) and household food security (using dietary diversity). The main assumption as explained earlier is that household food security in rural and marginal community depends on food produced from farms. A household is food secure if it can produce a diversity of crops from both home gardens and in the fields. The determination of dietary diversity was done using in-depth interview and general observation.

3.3.8.1 Determination of dietary diversity

The term dietary diversity is defined by Drewnowski *et al.* (1997), Hoddinott, (1999) and Ruel (2002) as the number of different foods or food groups consumed over a given reference period. Hoddinott (1999) reports that this indicator is useful and easy to use, takes shorter time (approximately 10 minutes per individual), and the field testing (see for example, Hoddinott, 1999 and Hoddinott and Yohannes, 2002) has indicated that dietary diversity is correlated with levels of caloric acquisition and tracks season changes in food security. It is also showed by Hotloy *et al.* (1998) that it is associated with nutritional adequacy of a household or individuals in the household.

This indicator was therefore used to link food security and agrobiodiversity. In this case, dietary diversity as an outcome indicator for household food security was correlated with diversity indices as a measure of the diversity of crops maintained by the smallholder farmers. This selection is based on the assumption that rural population and especially smallholder farmers, unlike their urban counterparts whose real income is important for food security, uses crop and livestock diversity as their means for household food security.

Dietary diversity can be measured using various approaches. Researchers in China (e.g. Taren and Chen, 1993 and Tarini *et al.*, 1999), used food group counts, while studies from Ghana and Malawi (Ferguson and Sprecher, 1997) and in Kenya (Onyango *et al.*, 1998), used the number of individual foods consumed. Studies from Mali (Hatloy, *et al.*, 1998), and Viet Nam (Ogle *et al.*, 2001) used both single food counts (called Food Variety Score [FVS]) and a food group count (called Dietary Diversity Score [DDS]). It may be a simple arithmetic sum, the sum of number of different food groups consumed or a weighted sum of different food groups consumed (Hoddinott, 1999). In this study, a weighted sum of dietary diversity is adopted. In this context, a person responsible for the preparation of food was asked to indicate types of food groups (e.g. vegetables, cereals, meet, fruits etc) the family has eaten in the last 30 days. These food groups are location specific and in this study, food groups were developed from PRA and focused group interviews. The score (Appendix 5) was done using the following categories; 16-30 days in the last month (score of 24) i.e. at least every other day; 4-15 days in the last month (score of 10) i.e. once or twice a week; 1-3 days in the last month (score of 3) and 0 days i.e. not at all (score of 0).

Data on dietary diversity was taken twice (during wet season and dry season). The dietary diversity index was achieved by the calculation of the weighted sum adopted from Hoddinott (1999). The weights reflect the frequency of consumption, and not merely the number of different foods. The following weights are assigned: J: 24; S: 10; M: 3; and R; 0. The household with higher weighted score consumes less diversity of food and vice versa. However, it is important to point out that Hoddinott

(1999) did not indicate the reason for use of letter J, S, M and R for weighting scores of dietary diversity. It is plausible that such letters were used for convenience purposes in data coding and analysis.

3.3.9 Methods of data processing and analysis

Data analysis permitted the establishment of the basic typology of the households and villages with respect to the agrobiodiversity and food security issues covered by the study. However, qualitative and quantitative data from PRA, questionnaire survey and crop inventory consisted of raw and unorganised figures and statements from the respondents. These were scrutinised, summarized and analysed to provide information intended for this study.

Although it is not acceptable to manipulate or disregard data, literature contends that data have to be scrutinised to avoid mistakes which may be carried over to the stage of data analysis (Barbier, 1998). It is important to point out that since food security and agrobiodiversity linkages are both very dynamic concepts, data analysis was a daunting exercise requiring careful judgements and choice of methods that presented results with reasonable patterns. Starting with descriptive statistics the next section presents methods of data analysis used in this study.

3.3.9.1 Descriptive statistics

Data from PRA, in-depth interviews group interviews and questionnaire survey generated both qualitative and quantitative information/data. Qualitative information from observation, verbal discusion, reports and other documents were analysed using content and structural-functional analysis.

In content analysis the recorded discussion was broken into units of information or themes to synthesise meaning, values and attitudes. Structural functional analysis was used to analyse social facts (which in this study are facts on food security and its linkage to agrobiodiversity) and the way they relate to each other within the social system and the physical environment.

Quantitative data was analysed using STATA or SPSS computer softwares. In this analysis, frequency tables, cross tabulations, mean medians and modes for household characteristics and score of household dietary diversity and household food security coping strategies were presented. The aim of data analysis was to use analytical methods that was able to identify reasonable pattern of variation around variables under the study.

3.3.9.2 Data from crop inventory

Data from crop inventory were analysed using Shannon-weaver diversity index. Shannon weaver index is a good index as it combines both evenness and richness into a single value. Shannon index was estimated from:

$$H = -\sum_{i=1}^{S} p_i \ln p_i \text{ --(1)}$$

where $p_i = {n_i}/{N}$ --(2)

Thus, equation (1) becomes;

$$H = -\sum_{i=1}^{S} \left[\left(\frac{ni}{n} \right) \ln \left(\frac{ni}{n} \right) \right] \text{ --(3)}$$

Where: ni = number of individuals belonging to i^{th} of total (s) species

N = total number of individuals in the sample

NB. Shannon values often falls between 1.5 and 3.5 and rarely surpasses 4.

3.3.9.3 The influence of socio-economic factors on agrobiodiversity

The influence of socio-economic factors on agrobiodiversity was determined using a multiple linear regression. The multiple regression model was used to account for (predict) the variance in the dependent variable, in this case named diversity index based on linear combinations of interval, dichotomous, or dummy independent variables. Multiple regression can establish that a set of independent variables explains a proportion of the variance in a dependent variable at a significant level (significance test of R^2), and can establish the relative predictive importance of the independent variables (comparing beta weights). The multiple regression equation used for this analysis was as follows;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 ....\beta_n X_n + \varepsilon \text{ -- (4)}$$

Where: Y = number of crops grown by the household,

β = Regressions coefficients

β_0 = intercept

X = Explanatory variables (age, gender, marital status, education, farm size, family size, farms, income .

The underlying assumptions for the model were that agricultural diversity is determined by the diversity index from the number of crops maintained by the farmer. However, the diversity variance results from a number of factors including factors used in the model. In this model R^2 is used to assess the variance of dependent variable from independent variables. Table 5 presents dependent and independent variables used for multiple regression analysis.

Table 5: Variables used for multiple regression analysis

Variables	Indicator
Dependent Variable	Number of crops planted on farms
♦ Agrobiodiversity	
Independent variables	
♦ Age	Age of household head (years)
♦ Sex	Being male or female
♦ Household size	Number of household members
♦ Household labor	Household members working on farms
♦ Education	Years of education of the household head
♦ Farm size owned	Size of the farm owned in acres
♦ Farm size used	Size of the farm used in acres
♦ Farming experience	Number of years as a farmer
♦ Fields	Number of plots maintained by the household
♦ Income	Average annual income (Tsh)

3.3.9.4 Relationship between agrobiodiversity and food security

The linkage between agrobiodiversity and household food security was determined from the establishment of household food securty status based on the number of food food groups comsumed. Food groups in this case were used as a proxy indicator for agrobiodiversity.

Therefore the relationship was established through a multiple regression analysis using the number of food groups consumed as a dependent variable and other factors such as number of crops, distance to the market and age of the hpusehold as independent variables. A multiple regression model used was based on the following equation;

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 ....\beta_n X_n + \varepsilon \quad --- (5)$$

Where: Y = Dietary diversity,

β = Regressions coefficients

β_0 = intercept

X = Explanatory variables (age, sex, education, farm size, family size, farms, income

In this model the variance of the dependent variable as a result of the influence of the independent variables was explained using the same assumption given is Section 3.2.9.3.

Table 6 gives an account of the variables used for multiple regression analysis. However, variables used in the regression analysis were subjected to the Principal Component Analysis. Principal component analysis is a variable reduction procedure. It is useful when you have obtained data on a number of variables (possibly a large number of variables), and believe that there is some redundancy in those variables.

Table 6: Variable definition

Variable name	Indicators
Dependent variable	Total number of food groups consumed by the household
♦ Food groups	
Independent Variables	
♦ Crops	Total number of crops grown by the household
♦ Market distance (km)	Distance to the nearest market
♦ Education	Number of years in school
♦ Family size	Total household residents related or unrelated
♦ Family labour	Total residents providing household labour
♦ Age	Age of the household head in years
♦ Income	Total household income in Tanzania shillings
♦ Plots	Total number of plots operated by the household
♦ Farm size	Total farm area in acres

In this case, redundancy means that some of the variables are correlated with one another, possibly because they are measuring the same construct. Because of this redundancy, you believe that it should be possible to reduce the observed variables into a smaller number of principal components (artificial variables) that will account for most of the variance in the observed variables. In this study, some redundant variables were dropped before the determination of the regression model as presented in section 4.8 of Chapter Four.

It is important to point out that both quantitative and qualitative data were used for this work. While quantitative data were used for building up a regression model, qualitative data from participant observation and field experiences were used for the interpretation of the results.

CHAPTER FOUR

RESULTS AND DISCUSSIONS

4.1 Overview

This chapter presents results from both qualitative and quantitative methods described in Chapter Three. This chapter is divided into eight sections. The first section presents the socio-economic and demographic profiles of the respondents. Socio-economic and demographic characteristics provide relevant information showing the social and economic set up of the community under the study. This is particularly important in farming communities where social characteristics such as age, gender, marital status, education, and income have influence on resources access and ownership, farming knowledge systems and practices. Others include availability of labour and access to and utilization of extension services.

The second section focuses on farming systems with relevance to household food security and agrobiodiversity. In this section, land tenure and inheritance systems are analysed and discussed. The third section of this chapter deals with crops and lands management systems in which, fallow, multiple cropping, and home gardens are analysed and discussed. The fourth section discusses the use of wild sources of food. This section shows the extent of use of wild sources of food and gender roles in the collection of wild foods.

The fifth and sixth sections of this chapter present the analysis of household food security status and factors responsible for household food security, respectively. The two sections end by showing that household food among smallholder farmers depends largely on the amount of crops maintained by individual households. The last two sections i.e. section seven and eight, present results from the analysis of agrobiodiversity and factors influencing agrobiodiversity from home gardens and farmers' fields. Section eight ends by giving a discussion on the determinants of agrobiodiversity using a multiple regression model.

4.2 Demographic and socioeconomic characteristics of the respondents

This section presents the demographic and socioeconomic characteristics of 120 households randomly selected from the study population. An average household size was 7.8 with the maximum and minimum sizes of 9.2 and 6.8 from Kibogwa and Nyandira villages, respectively. This household size is higher than the 2002 census which reported Morogoro Region household size of 4.6. It is possible that hefty households size results from extended family and the presence of other unrelated household members recorded at the time of interview.

It is important to note however that large household size does not correspond to the available household labour. The average household labour was 5.3 with the maximum of 6.3 and the minimum of 3.6. Other demographic and socioeconomic characteristics of the respondents are presented in Table 7. Demographic and socio-economic factors presented in Table 7 show notable differences across villages as detailed in the next sections.

Table 7: Demographic and social economic characteristics of the respondents

Characteristic	Village				Total
	Milawilila (n=30)	Kibogwa (n=30)	Pekomiseg ese (n=30)	Nyandira (n=30)	(N = 120)
Age of Household head (mean)	51.7	54.4	48.2	40.8	48.8
20-30 years	3.3	0.0	10.0	33.3	11.7
31-40 years	23.3	20.0	26.6	20.0	22.5
41-50 years	26.7	16.7	16.7	36.7	24.2
Above 50 years	46.7	63.3	46.7	10.0	41.7
Sex					
Male	66.7	46.7	43.3	40.0	49.2
Female	33.3	53.3	56.7	60.0	50.8
Marital status					
Married	70.0	80.0	50.0	46.7	61.7
Single	6.7	6.7	10.0	33.3	14.2
Widow/widower	3.3	3.3	26.7	13.3	11.7
Divorced	16.7	6.7	6.7	6.7	9.20
Separated	3.3	3.3	6.7	0	3.3
Education					
Standard VII	46.7	46.7	53.3	66.7	53.3
Standard IV	36.7	26.7	33.3	13.3	29.2
None Formal	6.7	27.7	6.7	0.0	10.0
Secondary	10.0	0.0	6.7	13.3	7.5
Household size	7.8	9.2	7.5	6.8	7.8
Household labour	5.6	6.3	4.5	3.6	5.0
Main Occupation					
Farm	66.7	70.0	80.0	46.7	65.8
Farm and Off-farm	33.3	20.0	10.0	16.7	20.0
Off-farm only	4.1	10.0	6.7	36.7	14.3
Sources of land					
Inherited	56.7	73.3	20.0	36.7	46.7
Purchased	23.3	3.3	60.0	53.3	35.0
Village government	10.0	13.3	16.7	3.3	10.8
Borrowed	10.0	10.0	3.3	6.7	7.5
Farm size used (acres)	4.9	6.1	3.5	1.7	4.1

4.2.1 Age of the respondents

Age is an important variable because it determines various inter-households and intrahousehold characteristics including ownership and control of resources such as land and household assets. Age may also give a picture of a household's labour and income. A two sample t-test shows significant differences (t-value 3.139, sig. Value

0.003 at p<0.05) in the average age across villages. The mean age for the study population is 48.8 years with the highest mean value from Kibogwa village (54.4) and the lowest mean value from Nyandira village (40.8).

More than half (57%) of the population (Figure 10) was below the age of 50 years and the remaining population was more than 50 years of age. About 12 percent of the population was at the age of 20-30. The lower percentage of population of youth age may be attributed by the tendency of young people to migrate from rural to urban centers.

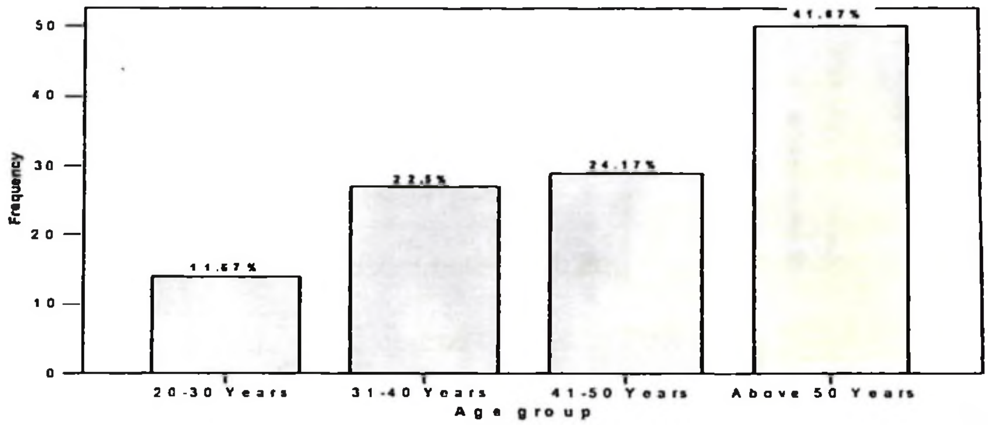


Figure 10: Age structure of the respondents

Moreover, different age groups were compared to sex of the respondents and the results are given in Figure 11. Nearly 45 percent of the male respondents were above 50 years of age while only less than 40 percent of the female respondents are in the same age category (Figure 11).

These results should however be interpreted with caution because respondents in this study were not necessarily heads of households. While more than three thirds of the male respondents were also heads of their households, only 30 household heads out of 120 respondents were female.

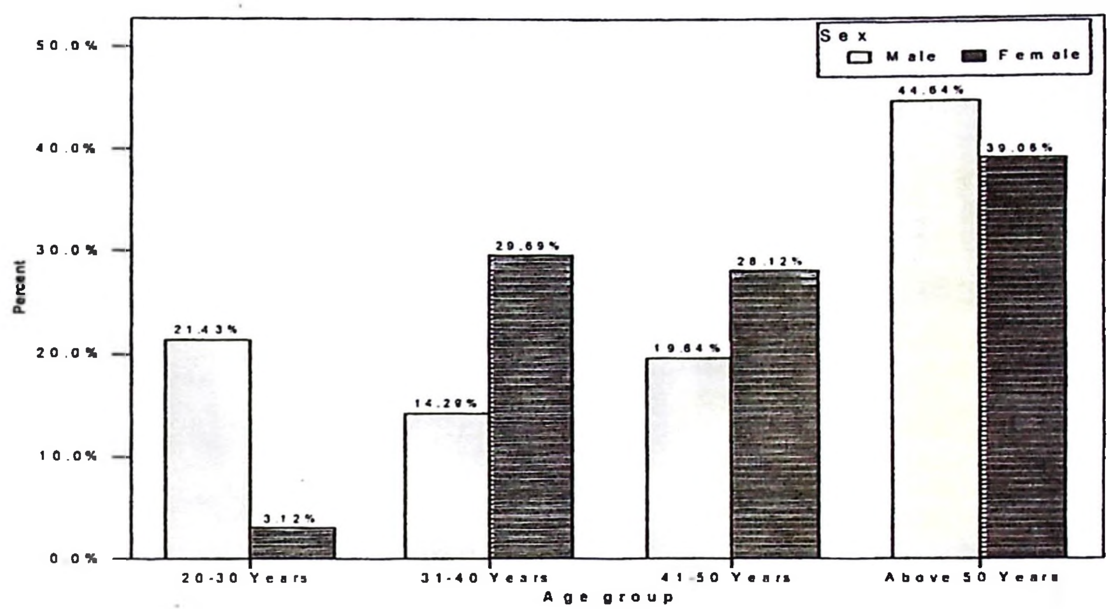


Figure 11: Age groups and sex of the respondents

4.2.2 Sex and marital status of the population

The study intended to seek opinion from both male and female over issues related to household food security. This was important because households food security and agricultural practices are determined by different decisions and roles played by both men and women in a given society. Figure 12 shows a slightly large percentage of men (50.83) compared to women (49.17). This implies that we have a reasonable number of female household heads in the study area. This may be plausibly explained by the matrilineal descendancy of Waluguru community. However, these results should be taken with caution because data collection was based on the cross-sectional research design. Cross sectional research design allows data to be collected at one point in time. It is possible that some of the female respondents represented their husbands at the time of interview and hence they were not necessarily household heads.

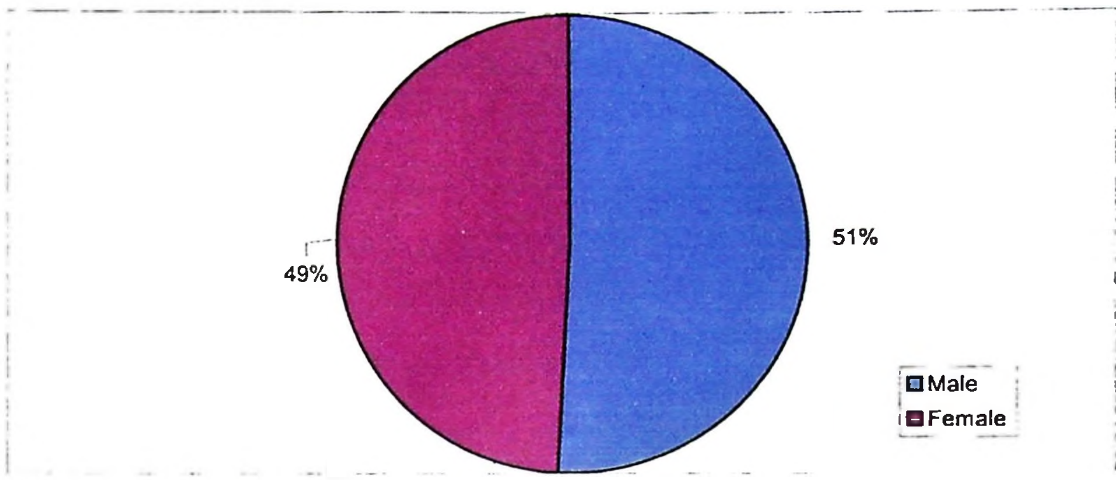


Figure 12: Sex division of the study population

Moreover, Figure 13 shows a slightly lower number of married female respondents compared to male respondents. The number of divorces, separated and widowed females is proportionally higher than males in terms of percentage. It is therefore possible that other than matrilineal arrangement, divorce, separation and widowing contribute to the number of female headed household in the study area.

Figure 13 also shows generally that more than half of the respondents were married and the rest were either, single, divorced, widowed, or separated. However, Chi-square analysis indicated significant difference ($p<0.05$) in marital status between villages with nearly two thirds of the total population being married.

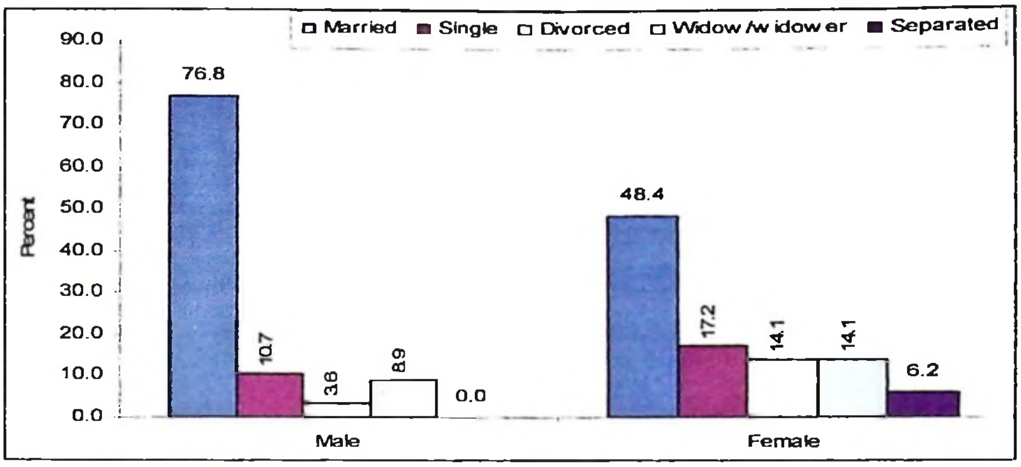


Figure 13: Marital status by sex of the respondents

It is important to note further that significant differences ($p<0.05$) between sexes were also observed amongst marriage categories. Figure 14 shows that more than three quarters of the male respondents are married compared to nearly half of the female respondents.

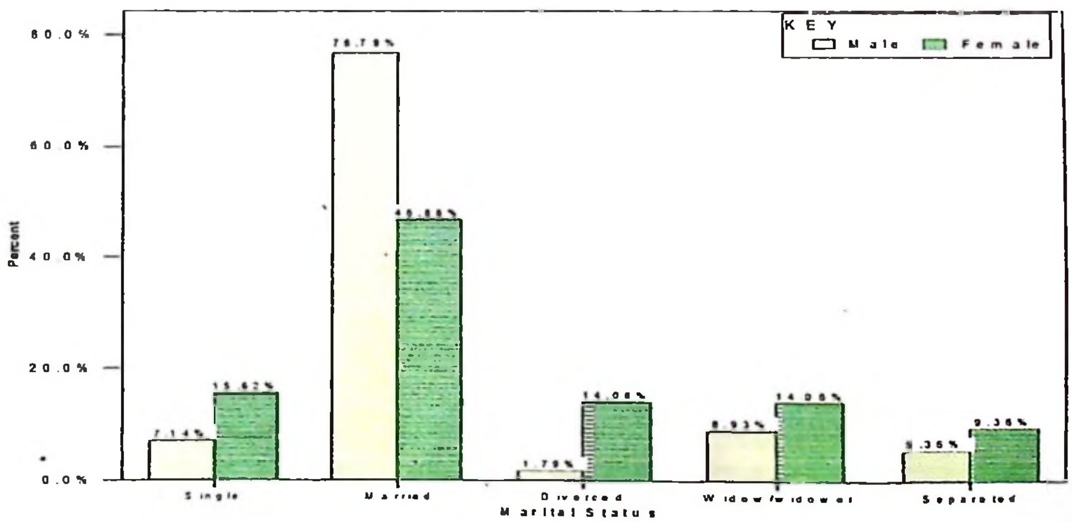


Figure 14: Marital status and corresponding sex of the respondents

Figure 14 also shows that more than half of the female respondents are single, divorced, widowed, or separated. There are a number of reasons associated with this pattern. While divorce and separation may be attributed by early marriage among women, single life may be attributed by migration of males to urban centres. It is not easy to directly link widowed females to HIV and AIDS scourge. But the fact that HIV/AIDS is increasingly becoming a rural phenomenon, it is possible that those who are widowed may also be linked to HIV and AIDS though no data were encountered during the survey to substantiate the argument.

4.2.3 Migration

Most respondents (77%) as presented in Figure 15 agreed that at least one or two of the household members had migrated to urban centers or the nearby commercial centers to look for better income opportunities.

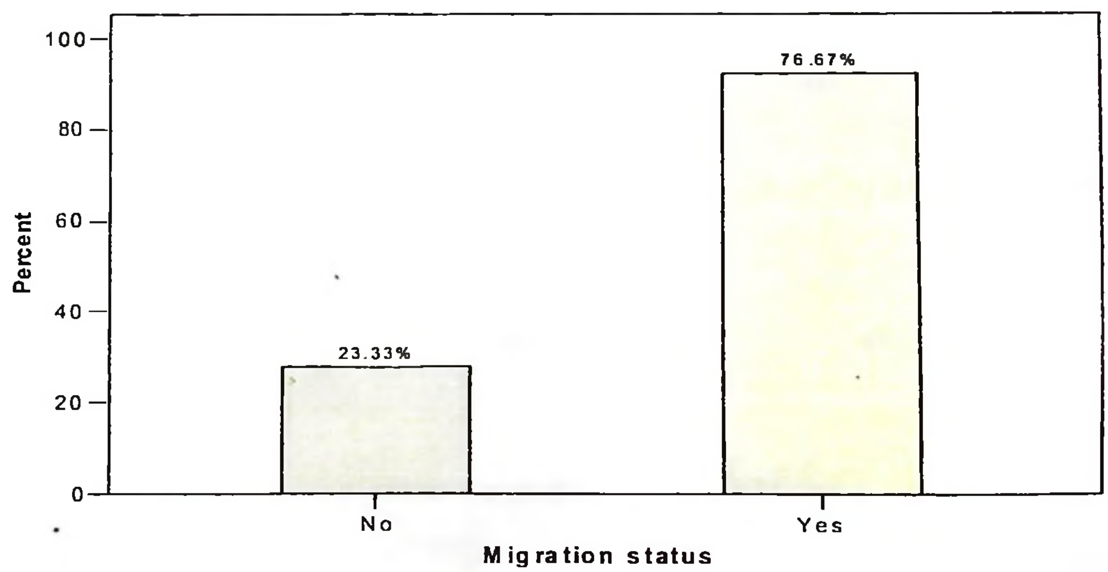


Figure 15: Out migration status at household level

There is however significant discrepancy in the proportion of male compared to female out migration. While nearly two thirds (62 percent) of the people who migrate are males, only 37.4 indicated in Figure 16 are females.

Figure 16: Sex of migrating household members

There may be three reasons for this pattern. First, land is, in most part of Uluguru, inherited through matrilineal arrangements in which females have exclusive rights to own land inherited from their uncles. Ownership of land by women through matrilineal land inheritance system reduces the proportion of women migration. The second reason is that the women in Uluguru Mountains are supposed to be initiated into marriage at the younger age. The initiation is locally known as *kunemwa.*

This initiation exposes young ladies to early marriage followed by early child bearing. Early marriage and child bearing may limit female migration. The last reason may be due to the tendency of young male to look for expected higher wage income from urban centers. This tendency is explained by the wage differential model of Ranis and Fei (1961) and Harris and Todaro, (1970) and De Jong (1992) which shows that expected higher wages in urban centers may stimulate rural urban migration. In this respect, the rural worker may be enticed to migrate to the urban area in search of work if their expected urban income exceeds their guaranteed rural wage. That is, the choice to migrate depends on a comparison of the expected income from the remaining in the rural sector with the expected urban wage.

The overall outcome of male out migration is increased feminization of agriculture in the study area. Study from Malawi indicated more or less similar trend in male migration. In Malawi, the rural male population plummeted by 21.8 percent between 1970 and 1990 (FAO, 1999). During the same 20-year period, the rural female population declined by only 5.4 percent. This trend resulted in an increase in the proportion of households headed by women. Results from the study area and Malawi are consistent with studies by FAO (1999) which show that approximately one-third of all rural households in sub-Saharan Africa are headed by women due to, among other things, increased male migration from rural to urban centres (FAO, 1999).

4.2.4 Household size and labour

The study investigated the average household size in the study population. It was found out that more than half (54%) of the population had household size ranging between 5-8 members including husband and wife (Figure 17). The average household size is 7.8 with (SD = 2.36) the minimum and the maximum being 2.0 and 12 members, respectively. This household size is higher compared to Morogoro Region average household size.

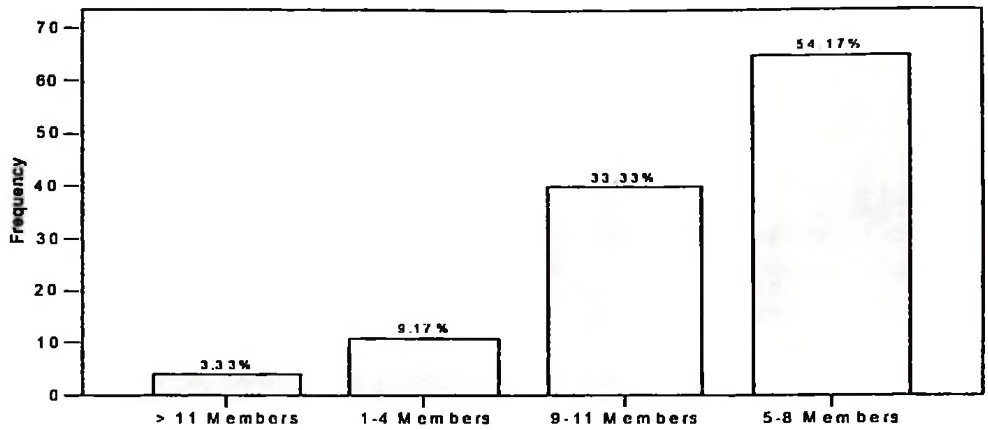


Figure 17: Household size

The regional household size according to URT (2002) is 4.6 and that of Morogoro Rural and Mvomero District where the study is centered is 4.7 and 4.5, respectively. Large household size may be attributed by the propensity of adult sons or daughters (unmarried or married) to remain in the parental household. Moreover, large household size tends to be allied generally with rural areas characterized by pronatalism and extended family relations.

The tendency of some distant relatives living in one household may also elevate their respective household size. Moreover, the presence of polygamous marriage arrangements under Islam (Milawilila and Kibogwa villages) may also be the reason for large household size.

The study noted further that not all household members are capable of working on farms. It is for this reason that the study compared the total number of household members and those capable of working on farms. The results showed linear relationship between household size and the number of household members working on farms ($R^2 = 67.2$).

The results also showed notable discrepancies between the two variables as indicated in Figure 18. The mean household size is 7.87 with 2.36 standard deviations and that of household members working on farms is only 5.03 with 2.17 standard deviations. The difference represents the proportion of dependants including old people, children and the sick.

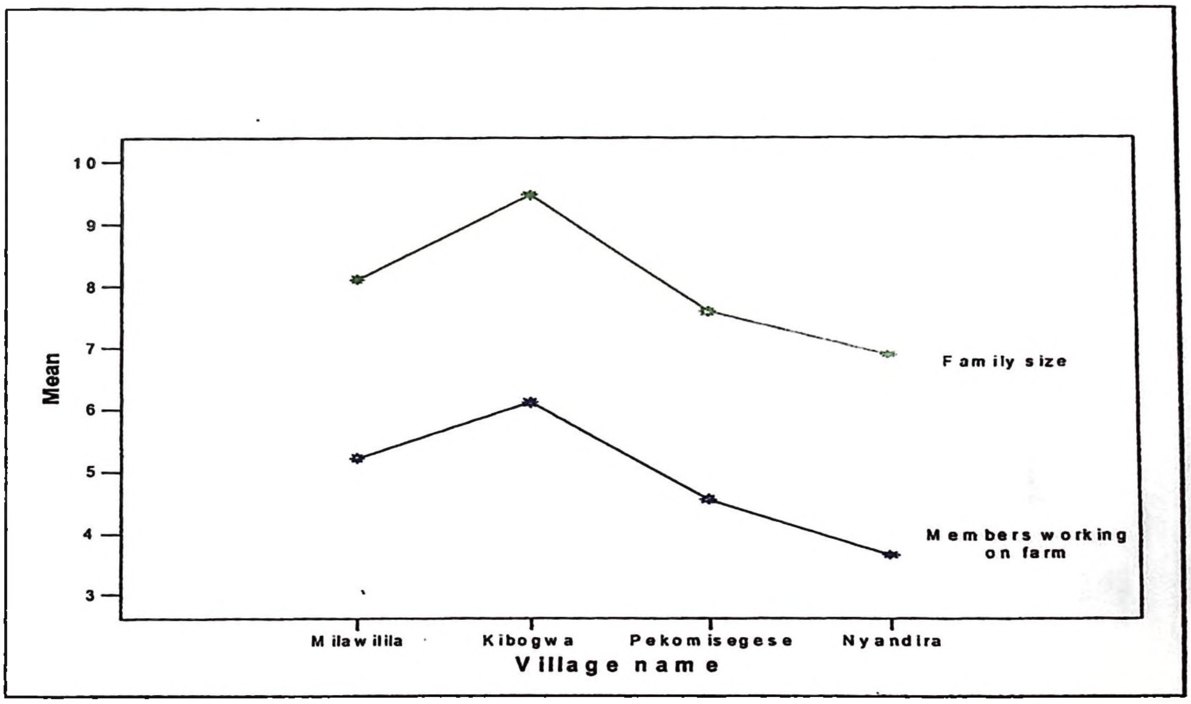


Figure 18: Difference between household size and household labour

Other than discrepancy between the household size and household labour (i.e. number of people capable of working on farms), a clear gender division of labour was observed between men and women (Table 8).

Table 8: Household responsibilities by gender

Task	Men	Women	Children	Both: Men and women	Both: Women and children
Cooking					√
Firewood collection					√
Fetching water					√
Milling cassava/rice					
Milling by Machine	√				
Pounding		√			
Cleaning					√
Rearing of children		√			
Taking care of livestock					
Goats	√				
Chicken		√			
Crop Production					
Slashing	√				
Burning	√			√	
Ploughing	√				
Planting	√	√			√
Weeding			√		
Chasing birds				√	
Chasing rodents					
Harvesting	√				
Carrying products from farms					
Processing for storage		√			
Taking products to the market					
Yams		√			
Potatoes (S/potatoes)		√			
Mwidu					√
Delega					√
Pigeon peas		√			
Ngogwe					√
Tomato				√	
Oranges	√				
Cassava products		√			
Coconut	√				
Spices	√				

The data in Table 8 show clearly that women and children play a great role in food production compared to men. While men are often responsible for the heavy work (e.g. slashing, burning, and clearing) that requires their good health and physical well-being, women bear the responsibility for clearing the ground, sowing seeds, transplanting rice seedlings into the fields, putting maize seeds into fixed holes dug by their husbands, weeding, clearing pests, harvesting, selecting and keeping varieties for seed. Specialization of different activities performed by men and women points to the difference in the agrobiodiversity conservation and management knowledge systems between men and women. These gender-differentiated local knowledge systems may play a decisive role in the *in situ* conservation, management and improvement of genetic resources for food and agriculture.

However, the role of women as seen from this study and from literature is much more pronounced than that of men. In this study, women were found to be responsible for seed selection and storage, planting, harvesting and storage of farm produce. It is possible that that these roles contribute to the preservation of agrobiodiversity as one of the main sources of household food security. It also reflects a profound knowledge of preservation of seeds and plants. It can therefore be argued that the role played by women places them at the core of conservation and management of agricultural diversity.

Such observations are also shared by the United Nations Convention of Biological Diversity and The world Food and Agricultural Organization (FAO). Both the Convention of Biological Diversity (CBD, 2001) and United Nations Food and Agriculture Organization (FAO, 2004) identify women as users, managers and preservers of biological diversity and give priority to their recognition and consequent involvement. Moreover, agricultural research and development have identified women as key actors in the management of agrobiodiversity. This role emerges not only on processing and preservation of seeds but in the preparation of food at the household level. Thus, a kitchen managed by a woman emerges as an important center where diversity based on cooking and culinary characteristics is determined. Unfortunately, the kitchen and the role played by women are the most undervalued contributors of plant biodiversity conservation and management (Padmanabhan, 2004). Their contribution to maintenance of agrobiodiversity needs special research and policy intervention. In terms of marketing, results revealed that men are more involved in crops with relatively high market values (e.g. spices and aromatics) than crops with low market values. Thus, women and their children are left to sale crops with low market values including local vegetables (*mwidu* and *betse*). This follows a common trend of men dominance over real income and income based activities.

4.2.5 Education

It is noted from URT (2003) that education in developing countries is the most important tool for enhancing people's ability to fight poverty and build awareness on various interventions including agricultural extension. It may also be a survival strategy in which few educated members of the family may be formally employed and hence be able to help other family members through remittances. Table 9 summarizes education level of the population under the study.

Table 9: Education level of the respondent

	Level of Education	Sex (%)		Total (%)
		Male	Female	
1	None formal	16.1	4.7	10.0
2	STD IV	25.0	32.8	29.2
3	STD VII	53.6	53.1	53.3
4	Secondary	5.4	9.4	7.5
	Total	**100.0**	**100.0**	**100.0**

Figure 19 show the percentage of the total respondents at different level of education for both males and females. Figure 19 show further that more than half of the respondents had primary education while the rest either had no formal education or had secondary education and others had their education up to standard IV.

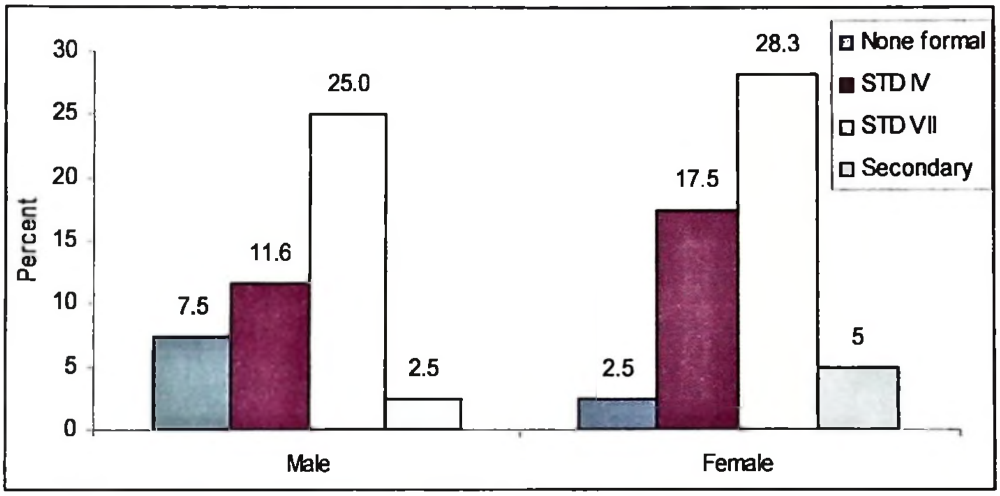


Figure 19: Education levels of the population by sex

It is important to point out however that despite the differences between male and female as indicated in Figure 19, the overall results emphasize the general picture that rural areas of Tanzania are occupied by people with low education. Those who are educated, up to secondary education, seldom stay in the rural areas. They normally migrate to urban centres to seek for formal or clerical jobs in the urban areas. Arguments for migration based on education may be explained by human capital migration model discussed by Barry (2000). The human capital migration model explains why some rural dwellers are more prone to migration than others. This model asserts that there are individuals that are more prone to migration. These individuals are called highly favourable because they have aspects that make them better candidate for migration. Those aspects normally include higher education.

Those with higher education levels or those that are just naturally smarter have a greater potential to have a larger income at the destination city and they may therefore easily migrate than otherwise.

4.2.6 Main Occupation of the respondents

Looking at the main occupation the study found out that nearly two thirds of the respondents are working as farmers and the rest are combining farm and off-farm activities as indicated in Figure 20. Off-farm activities in the study population include brick making, carpentry, sale of local brew and petty trade.

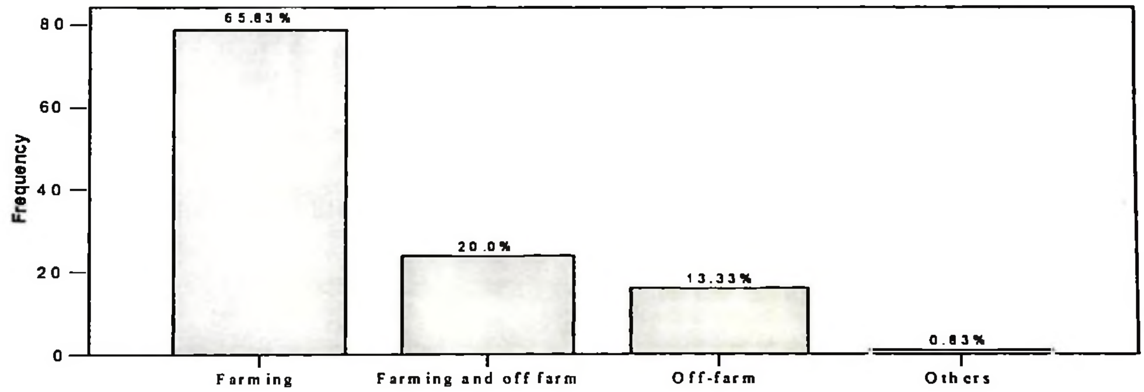


Figure 20: Main occupation

The results from Figure 20 emphasize the general trend in Tanzania where most of the rural inhabitants find most of their livelihoods from farms. They have also developed distinct farming systems as presented in the next section.

4.3 Farming system in the Uluguru Mountains

The previous section looked into demographic and socio-economic characteristics of the study population as an icebreaker to this study. This and subsequent sections cover aspects of agrobiodiversity and food security reflected from specific objectives and research questions. Thus, this section is organised to respond to specific objective number one by giving a detailed account of the farming systems in Uluguru Mountains. The section begins with an account of the major land inheritance system in which matrilineal land inheritance systems, among others, are explained and discussed. The section also presents farm size, major crops food and cash crops grown and the extent of the use of wild foods for household food security. This section ends with the description of the cultivation systems in which home gardens, fallow and multiple cropping are succinctly described.

4.3.1 Land tenure and inheritance system

The study identified four ways of land acquisition in the study area namely; inheritance, purchase, borrowing and allocation by the village government as indicated in Table 10. Further analysis shows significant differences ($p < 0.05$ and Chi-square = 0.001) between villages with respect to the modes of land acquisition. Table 10 shows that more than half of the respondents from Milawilila and Kibogwa obtained their land through inheritance while more than half of respondent from Pekomisegese and Nyandira acquired land through purchase. Others got their land from their respective village governments.

Table 10: Land inheritance system

Sources of land	Village Name				Total
	Milawilila (n=30)	Kibogwa (n=30)	Pekomisegese (n=30)	Nyandira (n=30)	
Inherited (%)	56.7	73.3	20.0	36.7	46.7
Purchased (%)	23.3	3.3	60.0	53.3	35.0
Village Government (%)	10.0	13.4	16.7	3.3	10.8
Borrowed (%)	10.0	10.0	3.3	6.7	7.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

It is important to note however that despite significant variation between villages, the overall results as indicated in Figure 21 show that the majority (More than 46 percent) obtain their land through inheritance.

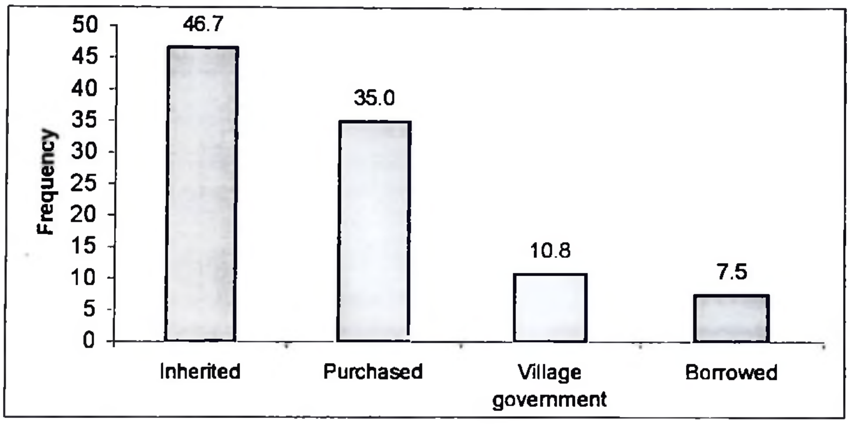


Figure 21: Land inheritance system

It can be noted further that the prominence of inheritance from Milawilila and Kibogwa villages may be due to the verity that the two villages are remote and they are still far from commercial and local market integration. Both villages at the time of this study had no market centers and the nearest market was about five and nine km for Milawilila and Kibogwa, respectively. Poor market opportunities reduce land market value and that few people migrate into the area for farming. As a consequence, most of the land is still obtained through inheritance.

Inheritance of land is done under the matrilineal descendent system in which all descendants are from the women's parents. Under this system, children belong to the woman and that a brother to the mother also known as *Mjomba* (Uncle) has a sole power over resources (in this case land) and the children. An elderly clan leader is therefore descending from the mother's side. This clan leader also known as *mjomba* *wa ukoo* (Family uncle) is regarded as the custodian of the clan land and has all the rights of ownership and allocation of land to clan members. Under this system, sisters are allowed to inherit land given to them by their brothers. Land may be bequeathed to the husband through his wife but he is not allowed to sell the same piece of land once the marriage is broken.

However, while this arrangement is common in remote areas of Milawilila and Kibogwa, it is slowly diminishing, moving from clan ownership to individualized ownership. Farmers from the same villages have started buying pieces of land to do away with the locally adopted land inheritance system. Once the husband has bought the land, he is entitled to do anything including planting trees. Therefore, there is a growing tendency of diminishing matrilineal land acquisition replaced by monetary exchange through purchase especially in Pekomisegese and Nyandira villages (Figure 22). The two villages are highly integrated in the market with higher commercial land values.

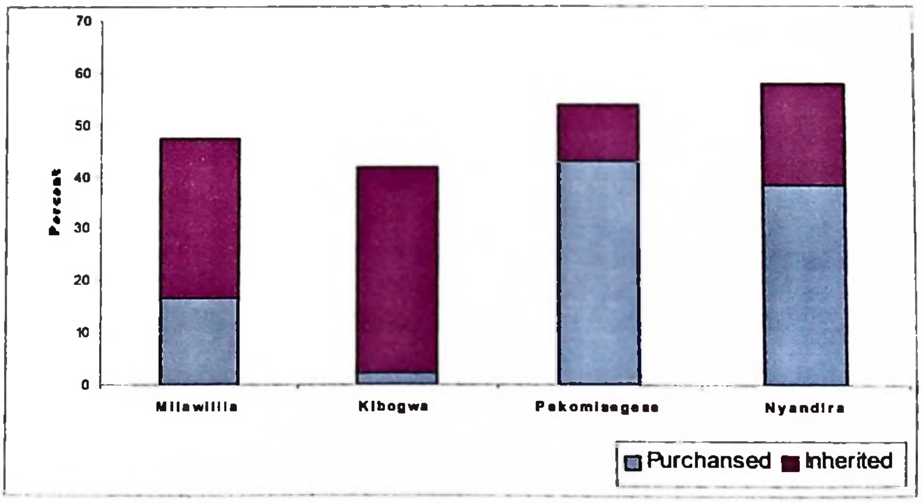


Figure 22: Comparative land acquisition

Another system of land acquisition is borrowing, contributing less than eight percent of the land sources in the study area. Uncultivated fallow land is borrowed to landless or members of the extended family through a system called *kubaka*. *Kubaka* is a locally determined arrangement where the landowner and the landless enter into an agreement in which the landless pays a token of 2000-10,000 TAS per an average of 1 acre as a rent. The borrower is also obliged to pay *ngoto* which is usually a small part of the harvest given to the landowner as a way of appreciation. However, discussion with farmers from the study population indicated that *kubaka* and *Ngoto* systems are currently being replaced by expensive non-traditional land renting systems with rent fees as high as 50,000 Tanzanian shillings per acre per season.

This suggests that land in the study area is becoming more individualized and, together with matrilineal land transfer systems, borrowing is slowly being abolished. Individualized land tenure may be attributed by various factors including an increase in population pressure in Uluguru Mountains currently at 150 persons/km^2 in many areas with annual growth rate of between 2.8-6.5% (SCSRD, 2004; Mbwambo *et al.*, 2005).

Population pressure and individualization of land can be explained by the evolutionary model of farming systems of Boserup (1965) and a theory of property rights developed by Demsetz (1967). The two assert that population pressure on land induces changes in customary land tenure institutions from clan ownership to individualized ownership. It can plausibly be said that it is for the same reason that Nyandira and Pekomisegese (which were observed to have higher population density) had more of purchased land than Kibogwa and Milawilila villages. However, this should be taken with caution because no population density data were taken during the study to ascertain the observation.

4.3.2 Farm size

The study found out a significant difference between the land owned by the household and the size of land that is actually used for farming. The average land owned was 5.6 acres while the average land used for farming is 4.07. It was also noted that majority of the respondents i.e. 61 percent own between 0.5 – 3.0 acres of land. About 32 percent own land between 3-4.5 acres, and only 6.7 percent own more than 4.5 acres (Figure 23).

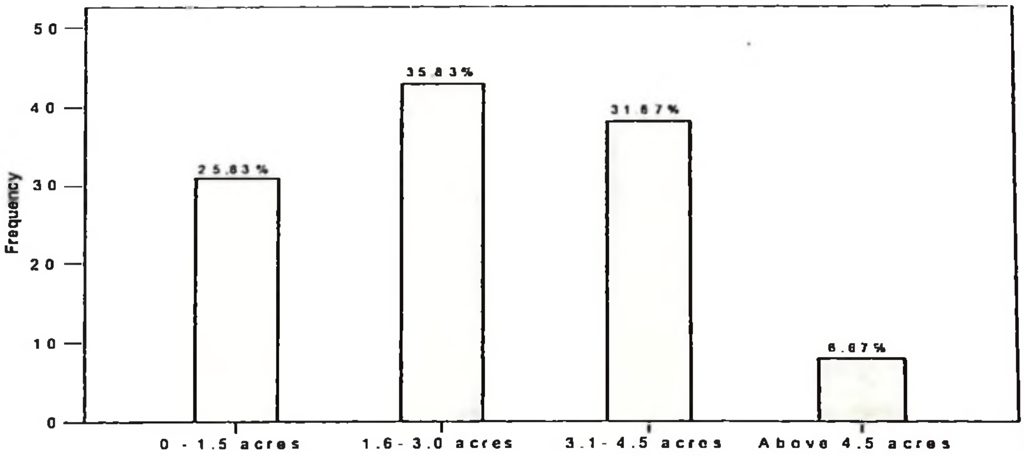


Figure 23: Average farm size

Significant differences ($p < 0.002$) were also found on average land size between villages. Figure 24 shows large land sizes for Kibogwa and Milawilila villages followed by Pekomisegese and Nyandira villages. While the maximum land size for

Pekomisegcse is six acres, the mean land size as indicated in Figure 24 is 3.43 acres which is much lower than Kibogwa village whose maximum land size is nine acrcs.

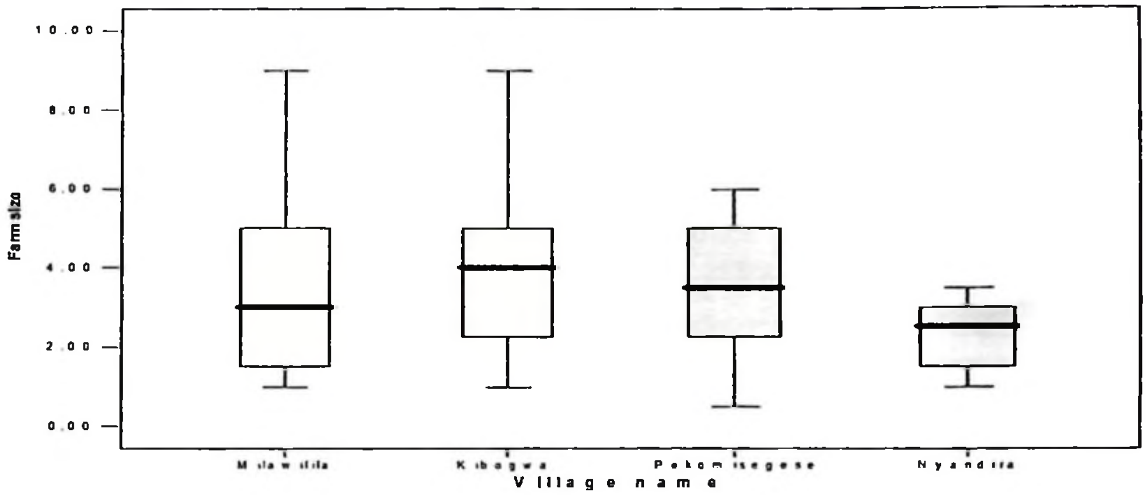


Figure 24: Minimum, Maximum and Median farm size across villages

It was noted from this study that most of the land owned is not effectively used for farming. This is argued from the results of a paired samples t-test statistics comparing land owned and land used which gave significant differences ($p<0.05$ at 1.95-2.78 CI.

This as seen from Figure 24 implies that most of the land especially in Kibogwa and Milawilila villages is either abandoned or cultivated under fallow. It is possible that limited household labour and inferior equipments limits cultivation of large portions of land. However, farmers from the study area have developed indigenous practices to make use of the excessive land. Such practices include establishment of crop and land management systems as explained in the next section.

4.4 Crop and land management systems

4.4.1 Fallow systems

Unlike Nyandira and Pekomisegese, fallowing is the major staple food production system in Milawilila and Kibogwa villages. Fallowing (Figure 25) is categorized according to fallow periods. Seasonal fallow of up to three months, locally known as *lubua* is common in the valley bottoms and other productive sites. Other fallow systems include *Luvinze* i.e. a fallow period of between 2-5 years. Long fallows of more than five years locally known as *gonela* or *Lugonela* are common in the eastern Uluguru.

Figure 25: Fallow land in Kibogwa village

Fallow system is divided into cassava based slash and burn system on the sloping land. The cassava based slash and burn fallow system follows a number of steps. In the first year, open sloping land is slashed and burnt followed by intercropping cassava with annual crops such as rice, bean and maize. The first year is characterized by a continuous annual cropping (between January and March and September until November). In the second year, the annual cropping is limited and cassava is allowed to cover the field with intermittent weeding of the remaining crops. Harvesting of young cassava commences during this period. In the third year, fields are left to return into fallow vegetation with cassava.

Cassava left in the fallow land is allowed to grow to be used for food. This means that most fallows are left with a crop, in this case cassava or pigeon peas. These fallows may therefore be termed as "improved fallows" and whose crops are harvested to save for household food security. One important variety of cassava grown under "improved fallow" is locally known as *Kilusungu*.

This landrace is known to be resilient and may be left under fallow for up to six years. It can be harvested throughout the fallow period. It cannot be eaten raw as it is bitter and need to be fermented before it is grinded for *mkembe* i.e. stiff porridge made from cassava flour. Thus, *Kilusungu* is the only crop left during longer fallow periods i.e. *gonela or ligonela.* Soil fertility is believed to recover during longer fallow periods. It appears that farmers are aware that slash and burn system is prone to land degradation which can be corrected through developing both short and long fallows. Other crop and land management systems are home gardens and multiple cropping described in the next sections

4.4.2 Home gardens

Home gardens are defined as a land use system whose structure resembles a forest and it combines the natural architecture of a forest with species fulfilling the social, economic and cultural needs of the people (Abdullah *et al.*, 2001). Home gardens are a component of rural ecosystem that has been used for centuries by the villagers from the study area. Home gardens are typically cultivated with a mixture of annual and perennial plants that can be harvested on a daily or seasonal basis with a wide variety of plants. They (home gardens) form an important component in the farming system of the people living on the slopes of Uluguru Mountains.

However, home gardens in the study area vary among villages depending on the rainfall distribution and market integration. While in Milawilila and Kibogwa villages home gardens are dominated by banana, coconut, tropical fruits, and spices, Nyandira and Pekomisegese home gardens are dominated by less diverse home gardens varying significantly from lower to higher altitudes. Home gardens in the lower altitudes of Pekomisegese are mainly made of small maize plots, vegetable gardens and tropical fruits especially mango. Temperate fruits and vegetables dominate home gardens of the Upper western Uluguru.

The difference in the structure of home gardens may be explained by agroecological characteristics and market integration explained earlier. Home gardens under poor market integration of Milawilila and Kibogwa villages are more oriented towards subsistence production whereas home gardens close to major market centers including Nyandira and Pekomisegese focus more on commercial production. The tendency is to have less diverse market focused production systems in the areas with higher market integration and more diverse and subsistent production systems with poor market integration.

4.4.3 Multiple cropping

Multiple cropping is practiced throughout the year mostly under fragmented and scattered plots. The number of plots however varies significantly (p = 0.05, CI = 1.57 – 3.02) between villages. The mean number of plots for Milawilila and Kibogwa is 3.1 and that of Pekomisegese and Nyandira is 5.4 with 0.29 and 0.21 standard errors of the mean, respectively. Farmers grow both food and cash crops. Major cash and food crops grown are presented in Table 11. Results in Table 11 show a variation between types of crops grown across villages. While Kibogwa and Milawilila villages have more crops grown, Pekomisegese have fewer. This results from differences in the agroecological characteristics between the eastern and western Uluguru. The eastern side of Uluguru being tropical has wet agroecological characteristics which allow people to grow crops throughout the year. The western Uluguru is subtropical and drier and hence allow people to produce few but commercially oriented cropping system.

Table 11: Most common cash and food crops grown

Village	Most common food crops	Most common cash crops	Both
Milawilila	Cassava, rice, sweet potatoes, kidney beans, Pigeon peas, *mwidu*, *kisamvu* (cassava leaves), *matembele* (sweet potato leaves)	Black pepper, pineapples, cardamom, cinnamon, Coconut,	Bananas, maize Coconuts, Oranges Jackfruits, Breadfruits Mangoes, and Tangerines.
Kibogwa	Cassava, sweet potatoes, kidney beans, Pigeon peas, *mwidu, kisamvu* (cassava leaves), *matembele* (sweet potato leaves)	Cloves, black pepper, pineapples, cardamom, cinnamon, bananas	Bananas, rice
Pekomisegese	Cassava, sweet potatoes	Tomatoes, onion, carrots	Maize, bananas
Nyandira	Maize, cassava and vegetables.	Exotic vegetables (celery, parsley, radish, Cauliflower, Broccoli	Maize, cassava, peas, round potatoes

It is important to point out however that, despite the differences in the types of crops grown, farmers have the general tendency to grow certain types of food crops for household food security. In this respect, several root crops such as potatoes (*Solanum tuberosum*), taro (*Colocasia antiquorum*) and cassava (*Manihot escullenta*) are grown as food security crops in the study area. This is particularly important because regardless of higher rainfall distribution in most parts of Uluguru Mountains, cassava remains to be the main staple food. While cassava is treated as a food security crop especially in arid and semi-arid areas of Tanzania, it is an important staple food in the study area. Focused group discussion showed that a household is food insecure if it runs out of cassava supply. While different households eat banana, rice and maize regularly, they may not replace cassava as the main dish. The importance of cassava as a staple and food security crop will be discussed later in this chapter.

Other crops grown mainly for cash are vegetables and fruits. It is striking to note from this study that nearly all (94%) farmers in Nyandira village are involved in vegetable production for food and cash income. Important vegetables grown in the area include cauliflower (*Brassica oleraceae*), lettuce (*Lactuca sativa*), carrot (*Daucus carota*), leek (*Allium porum*), garlic (*Allium sativum*), celery (*Apium graveolens dulce),* parsley (*Petroselinum crispum*), onions (*Allium spp*) and a variety of pepper. Vegetables are grown in pure stand or intercropped with other annual and perennial crops. Most of these vegetables are sold to distant markets mainly in Morogoro town and in the city of Dar-es-Salaam.

Fruit production in Nyandira and the surrounding area is mostly transformed from indigenous fruit trees to exotic deciduous fruit trees. The most predominant exotic fruit trees are plums (*Prunus salicina*), peaches (*Prunus persica* L.), pears (*P. communis*) and apples (*Malus communis*). Passion fruits (*Passiflora* spp) and tomato trees (*Cyphomandra betacea*) are quite common as home garden fruit trees and are used for both home consumption and for sale.

Other sub-tropical species occasionally found in the area include avocado (*Persea Americana*), guava (*Psidium spp*) and fig (*Ficus spp*), but these are left unattended by most farmers. Kibogwa and Milawilila villages are popular for tropical fruits including pineapples, oranges, tangerines, jackfruits, and mango. The villages are also popular for spices such as black pepper, cinnamon, cardamom, and cloves.

It is important to point out at this juncture that despite the presence of a diversity of crops maintained in the fields and home gardens, there are appreciable amount of wild plants consumed by the households as presented in the next section.

4.5 Use of wild products as a source of food

4.5.1 Wild foods status and source

This study examined the extent of use of indigenous foods and found that nearly 73 percent (Figure 26) of the respondents are using wild plants and animals as a source of food.

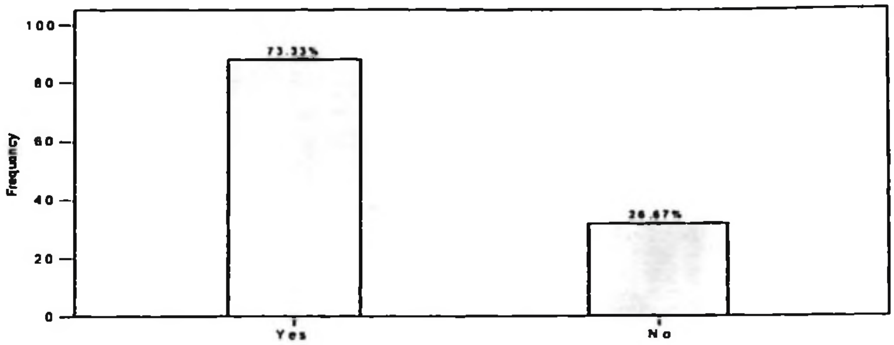


Figure 26: Use of wild plants as a source of food

However, there are significant differences (Chi-square 49.2 and $p < 0.05$) between villages in the extent of use of wild foods as presented in Table 12. While Milawilila, Kibogwa and Nyandira villages show more or less similar patterns, Pekomisegese show relatively high percentages as indicated in Figure 27.

Table 12: Use of wild foods across villages

Village name	Response to use of wild plants for food (%)		Total
	Yes	No	
Milawilila	71.0	29.0	100.0
Kibogwa	63.3	36.7	100.0
Pekomisegese	90.0	10.0	100.0
Nyandira	69.0	31.0	100.0
Total	**73.3**	**26.7**	**100.0**

Pekomisegese is comparatively drier than other villages. It is therefore possible that the village experiences recurring food insecurity and have developed the habit and knowledge of harvesting and consuming wild sources of food as a food security coping strategy.

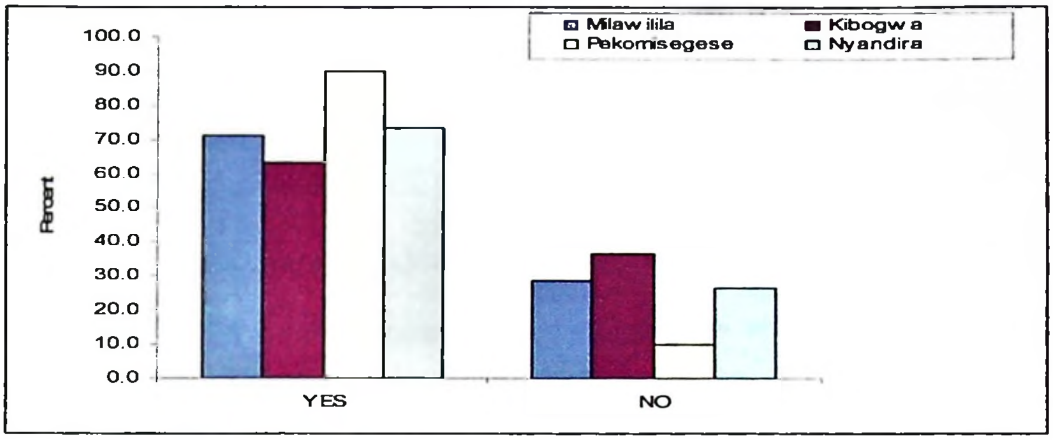


Figure 27: Use of wild food across villages

It is important to note that the initial conception of this study was that most of the wild foods would be obtained from forest reserves and forest patches. However, results from this study show that most of the wild plants are obtained from farmers' plots (Figure 28). It appears from this finding that domestication of wild plants along with the restriction to enter most of government forests reserves in Uluguru Mountains have enabled people to develop skills and practices for the domestication of wild plants.

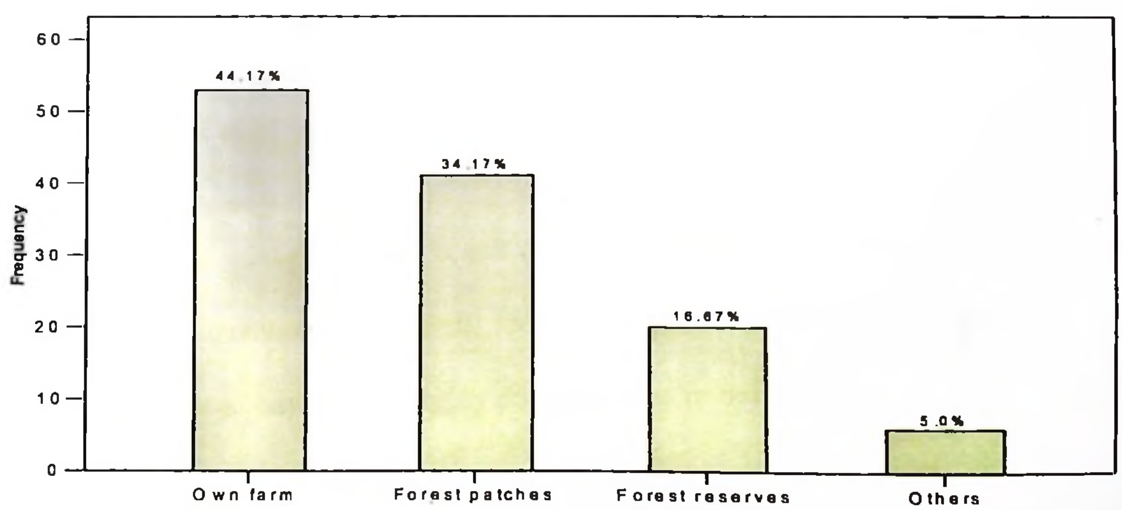


Figure 28: Sources of wild foods

While Figure 28 show that own farms are main the contributors of wild plants, the trend varies from villages to villages as indicated in Figure 29. While own farm as a source of wild plants predominates, the extent of sources from forest patched and forest reserves varies across villages. Milawilila and Kibogwa are more close to forest reserve compared with Pekomisegese and Nyandira villages. They therefore collect wild food from the nearby forest patches, (Figure 29) but own farm still predominates because of the continuous domestication of wild plants.

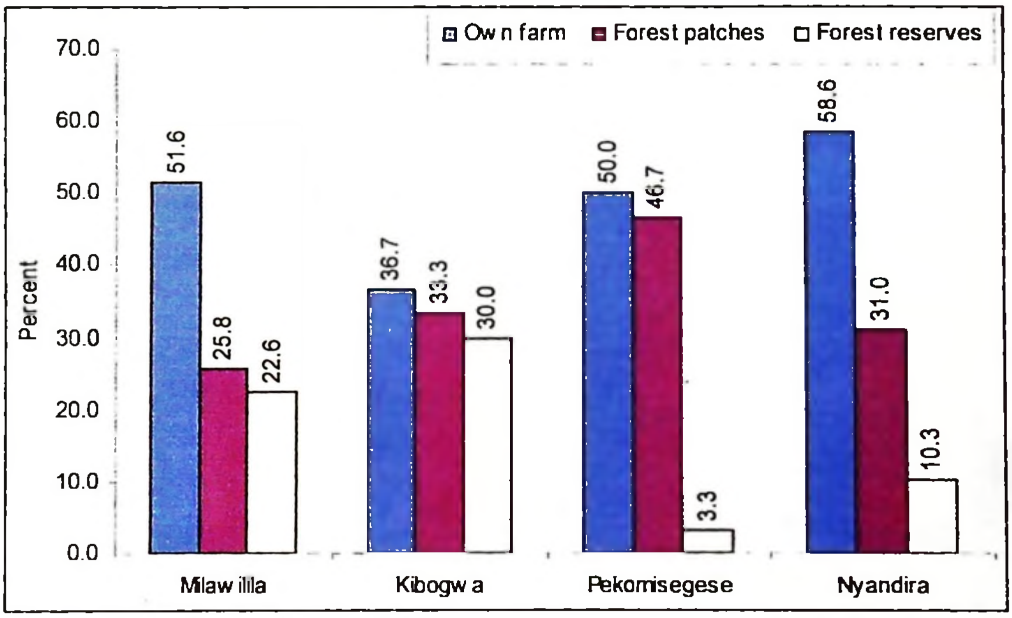


Figure 29: Sources of wild plants by village

Domestication of wild plants is a result of the co-evolutionary relationships between humans and their environment (Bell, 1995). People have indirectly shaped many of the plants and some have been largely domesticated in home gardens and in the fields together with farmers' cultivated food and cash crops.

Some of the most common semi domesticated wild foods include indigenous vegetables i.e. *Mwidu (Justicia heterocarpa)* and *Colocasia* spp leaves locally known as *Betse*. Others are as indicated in Table 13.

Table 13: Indigenous plant species used as edible fruits, nuts and seeds

Local name	Scientific name	Family name
Mpera	*Adansonia digitata*	*Bombacacea*
Mkani	*Allanblackia Uluguruensis*	*Cluciaceae*
Nyahumbu	*Berchemia discolor*	*Rhamnaceae*
Msumba or Mwiza	*Bridelia micrantha*	*Euphorbiaceae*
Mgwata	*Cordyla africana*	*Ceasalpiniaceae*
Mmoyomoyo	*Deinbollia bornonica*	*Sapindaceae*
Mgora/mgura	*Flacourtia indica*	*Flacourtiaceae*
Muula	*Parinari excelsa*	*Chrisobalanaceae*
Mhilihili/mkungwina	*Sorindeia spp*	*Anacardiacea*
Mkumburu	*Synsepalum msolo*	*Sapotaceae*
Mdai	*Tamarindus indica*	*Ceasalpiniaceae*
Msofu	*Uvaria acuminata*	*Annonaceae*
Mfuru	*Vitex doniana*	*Verbenaceae*
Mwidu	*Justicia heterocarpa*	*Acanthaceae*
Betse	*Colocasia esculenta*	*Araceae*

It can be noted that of the species listed in Table 13, *Mwidu* and *Betse* are also sold in the local market at the price of Tsh 50-100 per bundle as indicated in Figure 30. This implies that wild foods are collected for consumption as well as for sale.

Figure 30: Sale of wild and semi-wild foods in Tawa market

However, the perception of the economic importance of wild foods appears to be gender specific. For women, wild foods are also used as an important source of income which can be used to buy important non-food items such as soap, cooking oil and kerosene. For example, during the field work it was found that the cost of approximately 1/4 kgs of the wild vegetable called *Mwidu* costs about Tsh 50-150. A woman with 10 to 20 bundles may earn between Tsh 1000 to 1500. This is enough for purchase of kerosene, cooking oil and salt for the entire week..

Income generation activities for men tend to be focused on cash crops, though some sell wild foods but usually only if other options are very limited. Most women (89%) interviewed during the field research claimed to be selling wild foods especially vegetables. It was noted from the field observation that wild foods including vegetables are not usually sold in a prominent place in the market but on the periphery with a significant amount of barter trade being undertaken at village level.

The most important reason for trade and use of wild foods as indicated in Table 14 is that of supplementing diets.

Table 14: Reasons for use of wild foods

Response	Village name				Total
	Milawilila (%)	Kibogwa (%)	Pekomisegese (%)	Nyandira (%)	(%)
No response	19.4	16.7	10.0	0.0	11.7
Diet supplement	54.7	43.3	80.0	100.0	69.2
Easily available	19.4	40.0	10.0	0.0	17.5
Others	6.5	0.0	0.0	0.0	1.7
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Other reasons as indicated in Figure 31 are based on their easy availability. Easy availability is attributed by the fact that wild food grows in a wide range of spaces. Some are only located in bushes or in specific natural habitats. Some typically grow close to the fields or in anthropogenic ecosystems, having somehow coevolved with human agricultural systems. Most of them are semi-domesticated because local people manage them in ways that ensure their conservation and regular availability.

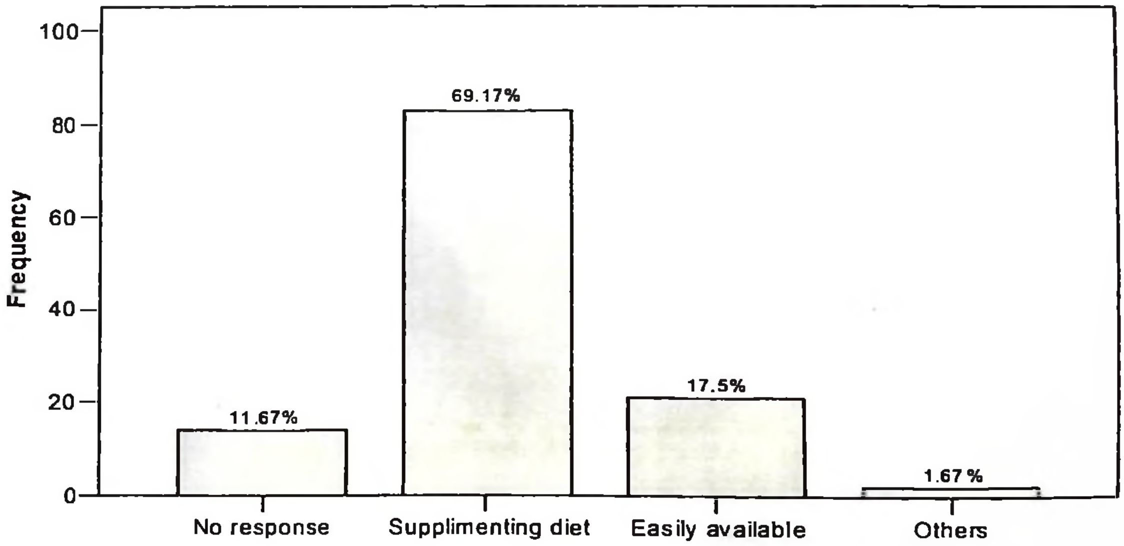


Figure 31: Reason for use of wild foods

4.5.2 Person responsible for the collection of wild foods

The study went further to examine the persons responsible for the collection of wild sources of food. Results from Table 15 indicate variation between villages in terms of the person responsible for the collection of wild foods. Generally women are the main collectors of wild food in the study area.

Table 15: Person responsible for the collection of wild foods

Response	Village name				
	Milawilila (%)	Kibogwa (%)	Pekomisegese (%)	Nyandira (%)	Total (%)
Men	0.0	3.3	10.0	3.4	4.2
Women	54.8	80.0	30.0	62.1	56.7
Both men and women	38.7	3.4	56.7	24.2	30.8
Children	6.5	13.3	3.3	10.3	8.3
Total	100.0	100.0	100.0	100.0	100.0

The domination of women in the collection of wild foods (Figure 32) may be attributed by the fact that women in the rural areas have a sole responsibility for the preparation and assuring food availability at the household level. Women hold substantial knowledge on their localization, seasonal availability, properties, preservation practices, and culinary uses.

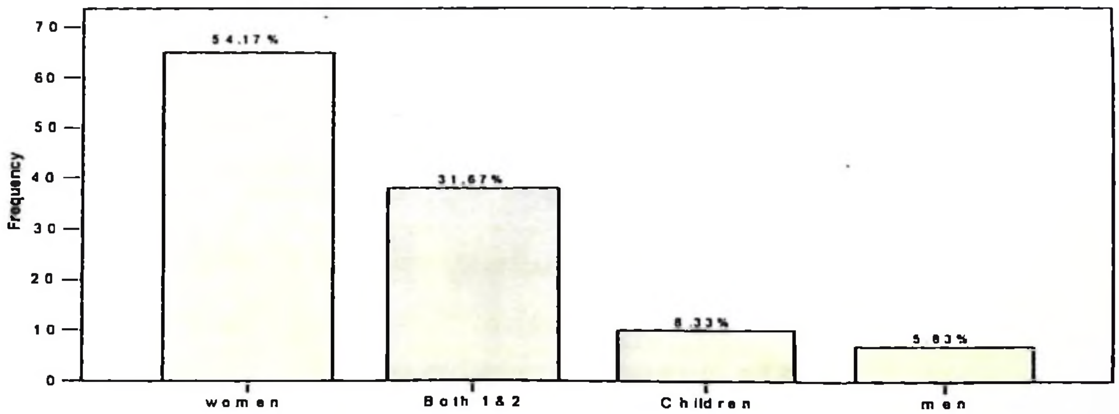


Figure 32: Person responsible for the collection of wild foods

They also hold specific indigenous knowledge and practices on preservation and processing of wild plants. This knowledge and practices optimize the use of wild plants for nutrition, long-term food security and sometimes provides market and hence income opportunities for rural women.

It can be deduced from these findings that wild foods play a crucial role in supplementing dietary needs and the overall household food security. The increased use of wild food plants represents a useful strategy for household food security and nutrition, especially as rural communities confront hunger, malnutrition, and labour shortages. However, while wild foods particularly vegetables may be important for households in the rural areas in Tanzania, they suffer large neglect, disregard and therefore get limited policy and program attention. Moreover, biodiversity conservation initiatives involving wild plants and animals of nutritional importance are equally scarce.

There is poor scientific knowledge and awareness on the values of wild food plants, such as their nutritional qualities, ecological features, and local uses. This scarce attention and support wash away practical and inexpensive efforts to improve nutrition and income among the rural poor, especially those inhabiting areas of high biodiversity values such as the Uluguru Mountains of Tanzania.

Other than farming and cultivation systems, Section 4.4 showed that sources of food extend far beyond farm level production to wild and semi-cultivated sources. This implies that analysis of household food security is not confined to farm and market sources but to also to other sources including wild sources. Thus, beginning with the perception of household food security, the next section looks into the status of household food security and ends with factors responsible for household food security in the study area.

4.6 Household food security status

4.6.1 Perception

The major aim of this study was to analyze the role of agrobiodiversity on household food security. However, it is important to analyze food security status of the population before linking the same with agrobiodiversity. Thus, this section presents household food security status in the study area and ends by describing factors responsible for household food security.

Thus this section begins by examining local perceptions regarding food security. This is important because food security may be having specific indicators and perception based on culture and social orientation of a given community. Despite variation between villages, majority of the respondents (Table 16) perceive food security as a function of having sufficient cassava as a staple food.

Table 16: Perception of household food security

Response	Village name				Total
	Milawilil: (%	Kibogwa (%)	Pekomisegese (%)	Nyandira (%)	(%)
Having enough cassava	71.0	73.3	53.3	58.6	64.2
Not eating less preferred food	25.8	20.0	46.7	41.4	33.3
Others	3.2	6.7	0.0	0.0	2.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

Cassava is prepared as stiff porridge locally known as *Mkembe*. Thus, while most parts of Uluguru Mountains receive enough rainfall, it is cassava (a semi arid crop) that is the pillar of household food security of nearly two third of the population (Figure 33). This implies that local perception based on culture and preference may be important when making decisions on food security intervention. Any food security policy and strategy need to put all considerations including local perceptions based on culture and preferences.

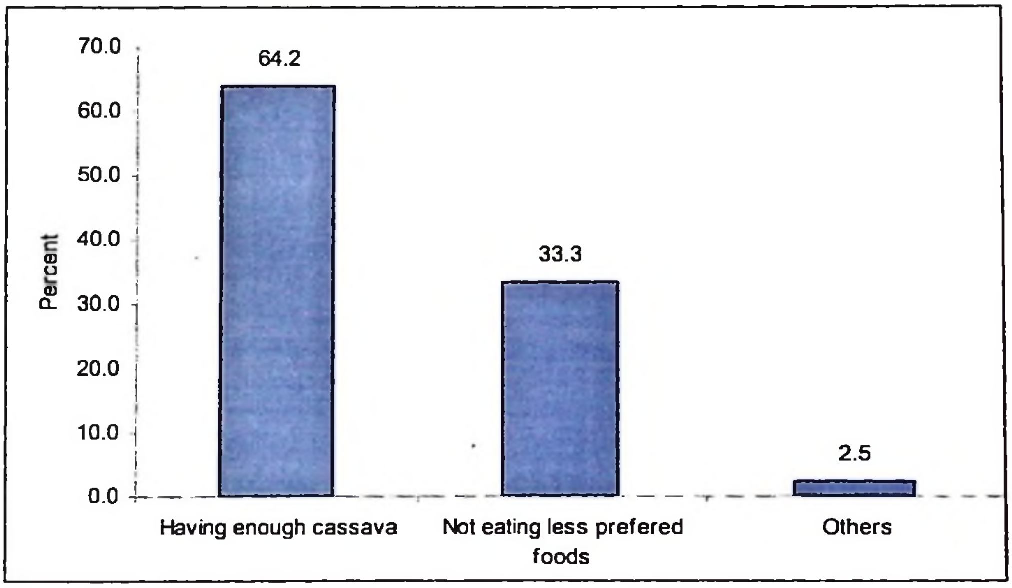


Figure 33: Perception of household food security

However, regardless of projected preference for *Mkembe*, food from other crops including banana, sorghum, millet and maize are also consumed with minimum preference. These foods are generally considered as less preferred and are consumed regularly during food shortage. Therefore less preferred foods may be used as an indicator of household food insecurity or as a coping strategy against food insecurity as presented in the next section.

4.6.2 Coping strategies

Majority of the respondents in Table 17 utilize less preferred foods to cope with food insecurity. Utilization of less preferred food by more than half of the respondent (Figure 34) is an indication that while *Mkembe* is the first priority food for most households, other foods are equally important.

This argument is enforced by findings from household food security coping strategies in which consumption of less preferred food is among the important household food security strategies.

Table 17: Household food security coping strategies

Response	Village name Milawilila (%)	Kibogwa (%)	Pekomisegese (%)	Nyandira (%)	Total (%)
Eat less preferred foods	80.6	56.7	33.3	65.5	59.2
Sale of labour	3.2	13.3	0.0	27.6	10.8
Borrowing	0.0	0.0	33.3	0.0	8.3
Buying of food after sale of other products	12.9	26.7	33.3	6.9	20.0
Sale of labour and borrowing	3.2	3.3	0.0	0.0	1.7
	100.0	**100.0**	**100.0**	**100.0**	**100.0**

Focused group discussion showed that less preferred foods in Uluguru Mountains are bananas, round potatoes, maize and sweet potatoes and vegetables including cabbage and spinach. Other strategies include getting foods from the market after sale of labour or other farm products and household assets.

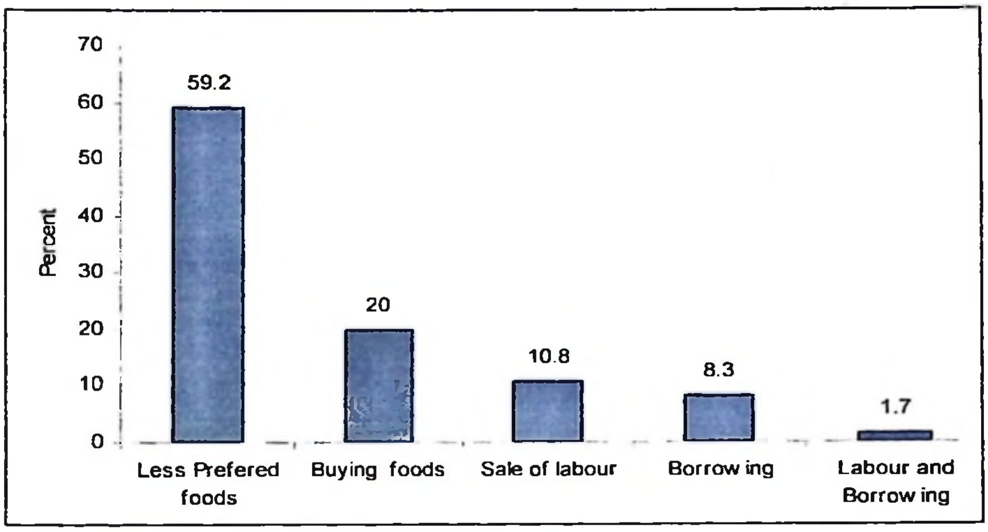


Figure 34: Household food security coping strategies

It is important to reiterate from literature that despite the above named strategies, households may engage in other coping strategies such as the reduction of quantity of food served to men and children and skipping meals by adult men and women as indicated in Appendix 2.

These strategies as noted by Radimer, *et al.* (1990) Maxwell and Frankenberger (1992) and Maxwell (1996) may be used to develop food security coping strategy index that may be used to assess household food security status. Thus in this study household food security coping strategy index was developed and the results from this analysis (Table 18) show significant differences between households ($\chi^2 = 92.41$ and $p<0.05$).

Table 18: Household food security coping strategy index

Village	Score of household food security coping strategies (%)			Total	Mean Score
	< = 5	6-9	> 9		
Milawilila	53.3	46.7	0.0	100	6.0
Kibogwa	60.0	40.0	0.0	100	5.6
Pekomisegese	3.3	16.7	80	100	9.9
Nyandira	13.3	66.7	20	100	8.5
Total	**100.0**	**100.0**	**100.0**	**100.0**	-

Source: Survey data (2004/2005)

Assessment of household food security status is determined by examining the score of the household food security strategies as described in Section 3.2.5.1. The higher the score the more food insecure the household and vice versa. Thus, results from Table 18 shows that Nyandira and Pekomisegese have relatively higher scores implying that they have higher incidences of food insecurity than other villages. Milawilila and Kibogwa are better off with relatively lower score as indicated in Figure 35. This implies that the two villages (Milawilila and Kibogwa) never or rarely consume less preferred foods, do not reduce quantity of food served to men and children and do not skip meals. Note that households scoring above nine often consume less preferred foods; reduce quantity of food served to men and children and skip meals as shown by most respondents from Pekomisegese.

However, these results should be treated with caution because of the difference in perception of food security between men and women. In this study, interviews on household food security coping strategy was done from the most knowledgeable person in food preparation i.e. a woman following the model by Radimer *et al.*

(1990); Maxwell and Frankenberger, (1992) and Maxwell (1996). However, studies by Rime and Giovanni (1986) and Macht (1999) showed that men describe hunger, and therefore household food insecurity, differently from women. These differences point to the possibilities that the results could be different if men were involved. However, the sole role of women on food preparation in the study area and other parts of Tanzania makes finding from this study close to reality.

4.6.3 Sources of less preferred foods

It is of interest to point out however that regardless of the coping strategies put forward by Radimer *et al.* (1990), Maxwell and Frankenberger (1992) and Maxwell (1996), most respondents resort to consumption of less preferred food as a food security coping strategy. When asked to indicate the source of less preferred foods majority of the respondents (Table 19) indicated that most of the food including less preferred is obtained from farmers' own plots. Other sources include local markets, borrowing from neighbours and food exchange between households.

Table 19: Sources of less preferred foods

Sources	Village name				Total
	Milawilila (%)	Kibogwa (%)	Pekomisegese (%)	Nyandira (%)	
Own farm	56.7	70.0	33.3	56.7	54.2
Market	23.3	10.0	36.7	33.3	25.8
Borrowing	13.3	10.0	20.0	0.0	10.8
Others	6.7	10.0	10.0	10.0	9.2
Total	**100.0**	**100.0**	**100.0**	**100.0**	**100.0**

The fact the majority depend on own farms for less preferred foods point to the argument that most of the food sources (whether preferred or not) come from own production. Thus, both food security and food insecurity coping strategies rely on the food produced by the household. Thus, households maintain a diversity of crops including non-preferred to overcome food insecurity which is perceived to occur only when preferred foods run out of stock or production. Thus, food security in the study area may be assumed to depend on the dietary diversity consisting of both preferred and less preferred foods.

4.6.4 Determining dietary diversity

The use of less preferred foods points to the argument that household food security status may be determined by a diversity of foods consumed by the household. However, before we pursue this assumption it is imperative to reiterate that the definition of food security adopted in this work was that of FAO (1986) in which food security is attained when all household members at all time have equal access to adequate and nutritious food. Chapter Two discusses a number of indicators used to capture household food security. It was seen from chapter two that food security as a concept is difficult to determine using a single indicator. However, dietary diversity was considered to be a good indicator because of its proved association with household level access to sufficient calories (see for example Arimond and Ruel, 2004). In this study dietary diversity is used to assess household food security status.

Dietary diversity is usually measured by summing the number of foods or food groups consumed over a reference period (Krebs-Smith *et al.*, 1987; Lowik *et al.*, 1999). The reference period usually ranges from one to three days, but seven days is also often used and periods of up to fifteen days have been reported (Drewnowski *et al.*, 1997). Thus, a seven days recall methods was adopted in this study. Appendix 3 show items used to ask respondents of their dietary diversity over the past seven days. This activity was repeated during wet (February – June) and dry (August – December) seasons to account for seasonal variation of dietary diversity in the study area.

Thus, data in Table 20 show 11 food groups used for the assessment of household dietary diversity. It can be noted that these food groups were developed during focused group discussion as explained in Chapter Three. A six groups cutoff point for food security was adopted following Ruel (2003) who reported on the cutoff point of six groups which provides the best sensitivity and specificity combination to predict nutrient adequacy for individual households. This cutoff point was used to develop two lower groups, namely food insecure and moderately food insecure groups.

Table 20: Food groups associated with dietary diversity

SN	Food Groups	Food Varieties
1	Cereals	Rice, maize and sorghum
2	Roots and tubers	Cassava, taro, sweet potatoes and round potatoes
3	Legumes and pulses	Beans, Pigeon peas
4	Leafy vegetables	Amaranths, taro leaves, sweet potato leaves, mwidu
5	Other vegetables	Cabbage, carrots, tomato, cauliflower, broccoli
6	Banana and plantains	Cooked banana and ripe banana
7	Fruits	Oranges, pineapples, tangerines, apples, pears, plums, papaw
8	Nuts and oil	Coconut, sunflower oils
9	Milk	Cow milk, goat milk
10	Fish	Dried fish, fresh fish and smoked fish
11	Beef	Chicken, cattle, pigs and goats

Households with less than three food groups were considered to be food insecure and those with 4-6 food groups were moderately food secure and the remaining group with more than six food groups were considered as food secure. One can note that while data collection for individual households was repeated twice, only the mean numbers of food groups are presented in the final analysis.

The reason why this is adopted is that, except for Pekomisegese, other villages did not show seasonal variation in the number of food groups consumed. The data in Table 21 present descriptive statistics of the number of food groups consumed and their respective food security categories.

Table 21: Food security status based on food groups consumed

Food security categories	Percent (n=120)	Cumulative Percent
Food insecure	14.2	14.2
Moderately secure	35.8	50.0
Food secure	50.0	100.0
Total	100.0	

Mean = 6.6; Maximum of food groups = 10; Minimum number of food groups = 3

The data in Table 21 show the maximum, minimum and mean number of food groups consumed is ten, three and more than six food groups, respectively. These figures are obtained with the standard deviation of 1.94. Figure 35 presents food security status of the households based on the number of food groups consumed as explained earlier.

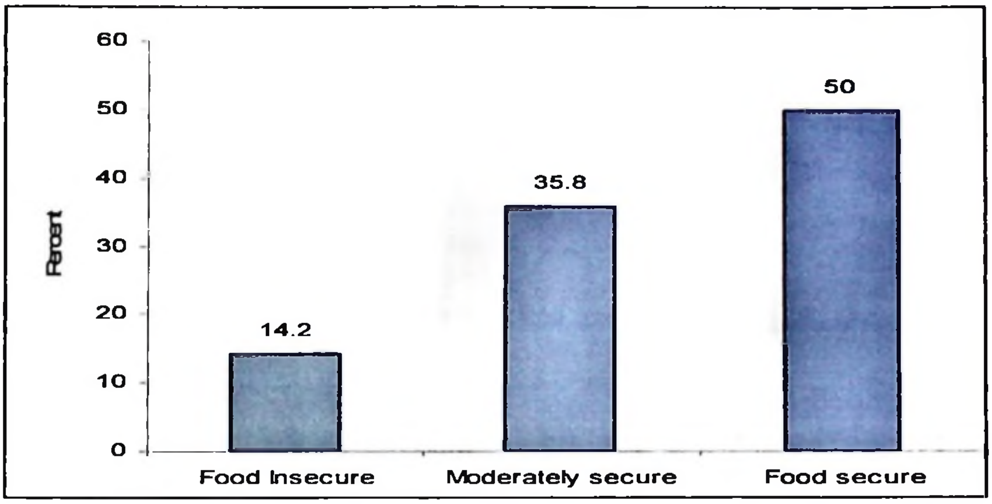


Figure 35: Food security status based on food groups

Figure 36 shows half of the respondents are food secure and consume more that six food groups of food over the reference period of seven days. More than one third of the respondents with four to six food groups are moderately food secure and the rest are food insecure. Nonetheless, further analysis shows significant differences (X^2 = 0.012) between villages with respect to their food security status as indicated in Figure 36.

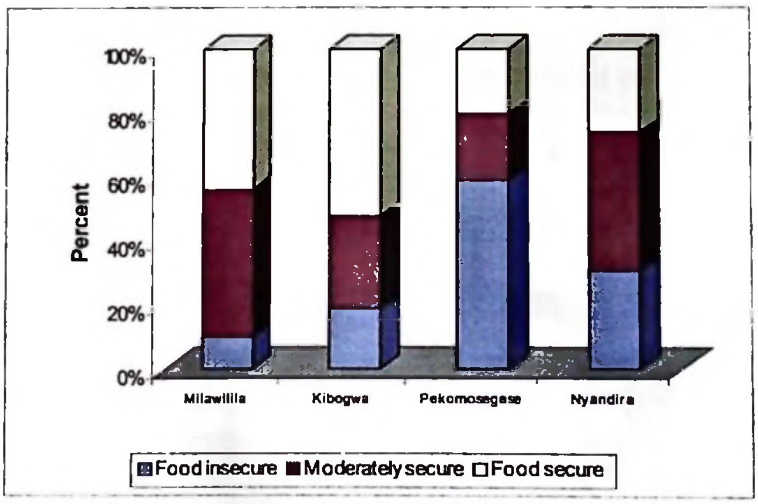


Figure 36: Village percent food security status

Figure 36 shows that food security status based on food groups varies across villages. While Milawilila and Kibogwa villages maintain good percentage of food secure groups, Pekomisegese maintains less. This may be attributed by agroecological characteristics in which the former is characterized by tropical and wet climate throughout the year while the later is subtropical and drier. It is important to note that since the indicator used to determine household food security status was dietary diversity, it is understandable that variation between villages in terms of food groups and hence dietary diversity may be linked to the number of crops maintained by the household. The study therefore assumed that higher dietary diversity depends not on the market availability of food groups (given the rural nature of the study area) but on own sources of food following Geier (1995) and Hindle (1990).

To workout this assumption, the study investigated whether there is linearity between food security status of the household and the number of crops maintained by the same household. The results from this analysis show strong linear relationship (R^2 = 79.7) between food security groups and the number of crops grown. This shows that under poor market and road access condition, it is the number of crops maintained by the household that determine household food security and not any other variable. The number of crops grown may be described under agrobiodiversity defined in this study as all species and varieties used by or useful to people following Brookfield *et al.* (1999). However, the number of crops grown by the household may also be influenced by other factors namely household labour, household size, age, markets, education, income and the number of plots owned by the household. The next section presents the influence of other factors (including the number of crops grown by the household) responsible for household food security status using number of food groups as a dependent variable. The next section looks not only at the importance of number of crops grown for household food security, but also at its contribution to household food security compared with other factors.

4.7 Factors influencing household food security

4.7.1 Regression model

It is important to reiterate that Section 4.5 that, while the number of crops grown may be important for household food security in the rural areas, other factors may also be important for the same reasons. However, this can only be ascertained using statistical analysis. A regression model described in Section 3.2.9.3 of Chapter Three was developed and a number of factors were modeled against the number of food groups consumed by the household as a dependent variable. The data in Table 22 defines and provides the descriptive statistics of the variables used in the regression model.

Table 22: Variable definition

Dependent variable	**Description**	**Mean**	**SD**
Food groups	Total number of food groups consumed by the household	6.64	1.95
Independent Variables			
Crops	Total number of crops grown by the household	8.49	2.56
Mkt distance (km)	Distance to the nearest market	4.15	1.50
Education	Number of years in school	5.90	2.64
Family size	Total household residents related or unrelated	7.87	2.40
Family labour	Total residents providing household labour	5.03	2.02
Age	Age of the household head in years	47.65	2.14
Income	Total household income in Tanzania shillings	152283	1420.74
Plots	Total number of fields operated by the household	4.23	1.65
Farm size	Total farm area in acres	5.62	1.43

In this analysis, the total number of food groups consumed (dependent variable) were modeled against independent variables indicated in Table 22. To test the relationship outlined earlier, a multiple regression model (Equation 5, Chapter Three) was estimated using beta weights and confidence intervals for all variables. The data in Table 23 illustrate the parameter estimate for independent variables on the dependent variable.

Table 23: Multiple regression model to explain factors responsible for household food security.

Total food groups	Coeff.	Std error	Beta	t	P > |t|	95 % CI
Constant	1.1869	.3086913		6.05	0.000	1.2573 - 2.4808
Number of crops	0.4093	0310182	0.590	13.20	0.000*	0. 3479 - 0.4708
Mkt distance (km)	-0.0134	0194341	-0.026	-0.69	0.493	0.0519 - 0.0251
Years of schooling	-0.0291	.0231696	-0.043	-1.26	0.212	0.0750 - 0.0168
Household size	0.0422	0346708	0.058	1.22	0.226	0.0265 - 0.1108
Household labour	1286	.0566712	0.147	2.27	0.025*	0.0163 - 0.2409
Age	-0178	.0048133	-0.148	-3.69	0.000*	-0.0273 - -0.0082
Household Income	4.4299	7.26e-07	0.020	0.61	0.544	-9.9607 - - 1.8806
Number of plots	0.1296	0529942	0.120	2.44	0.016*	0.0245 - 0.2346
Farm size (acres)	0.2793	.0611491	0.236	4.57	0.000*	0.1581 - 0.4005

* = Significant at 0.05; F = 0.000; R^2 = 0.897

The results from regression analysis show a significant model at R^2 = 89.7 and significant F value of 0.0000. This means that the model is significant and more than 89 percent of independent variables explain the dependent variable. Moreover, high R^2 values means that each of the independent variables significantly correlates with the dependent variable and have relatively low correlations among themselves.

However, of the factors introduced into the model, it is only number of crops grown, age of the respondent, number of plots, farm size and household labour that are significant. Note however that, of the significant factors, it is the number of crops maintained by the households that contribute more to the model (beta = 0.59) followed by average farm size and the number of fields at beta weights of 0.24 and 0.12, respectively. The next sections discuss how these factors contribute to household food security.

4.7.2 Number of crops grown and household food security

It was seen from the previous section that the number of crops grown provides the best estimate for household food security as indicated in the Figure 37.

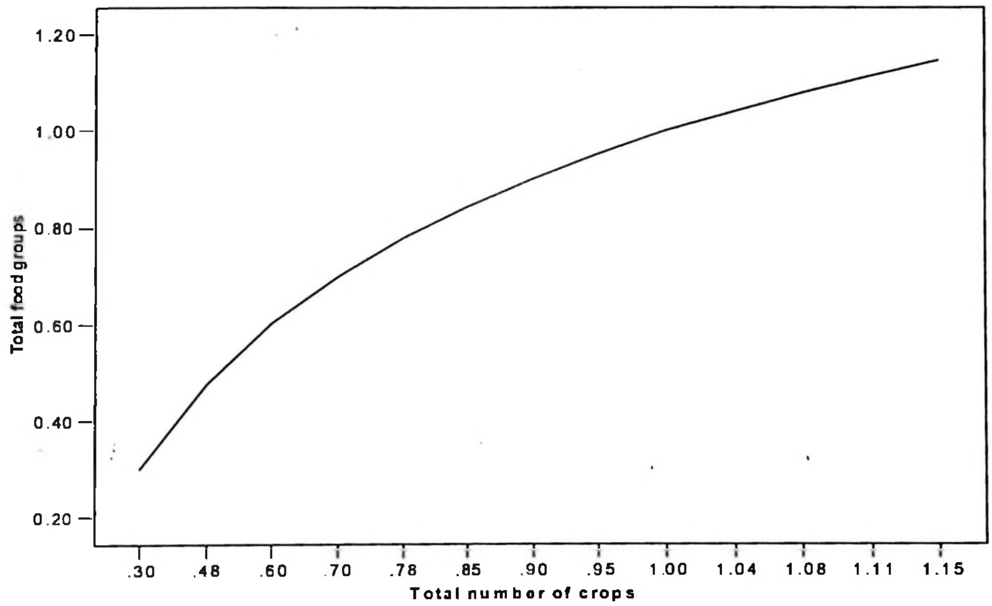


Figure 37: Linear relationship between number of crops grown and the total number of food groups consumed

Figure 37 emphasizes the fact that the considerable amount of total number of food groups consumed by the household comes from food produced by the household with little influence from other sources including the market. However, the number of food groups consumed varies significantly between villages. This, as given in Figure 38, corresponds very well with food security status of the village as described in the previous section.

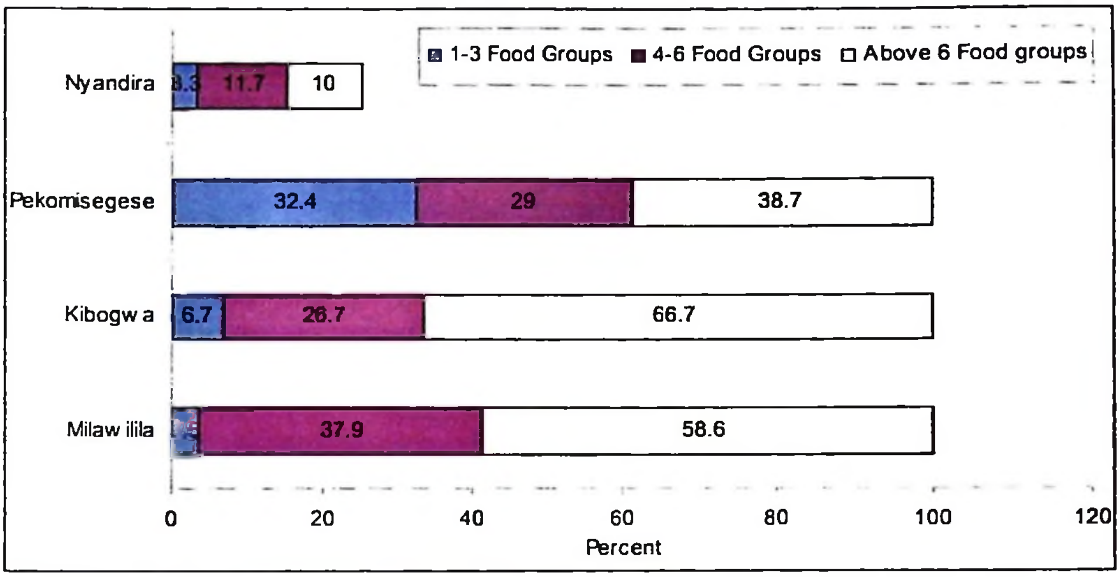


Figure 38: Number of food groups consumed compared between villages

4.7.3. Household size and Food security

It was hypothesized from this study that household food security corresponds with household size and number of household members working on farms. While the results from the regression model (Table 23) on the two variables show relatively low beta weights when compared to the number of crops grown, they show linear and positive relationship between household size and household labour at 0.05 and 0.14 beta weights, respectively. However of the two variables, household labour appears to be relatively stronger in explaining the regression model than the total household residents.

4.7.4 Farm size and food security

The data in Table 23 shows a linear and a significant relationship (p>|t| = 0.000 and 95% CI = 0.16-0.40) between the number of food groups consumed and the mean farm size in acres. However, as Figure 39 shows, the linear relationship goes to a certain level and starts to decline.

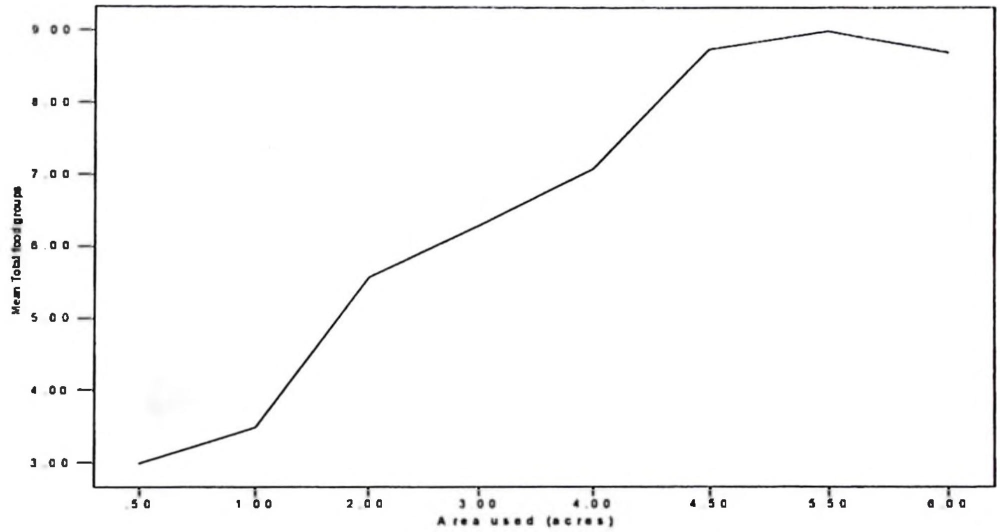


Figure 39: The relationship between number of food groups consumed and the mean farm size (acres)

This pattern points to the fact that the number of crops grown and hence the number of food groups consumed increases with the size of the farm owned by the household. This increase however goes with other factors such as household labour. The turning point therefore points to the influence of other factors, beyond farm size, that may limit the continuous increase in the number of food groups consumed with farm size.

4.7.5 Number of plots and household food security

The data in Table 23 also show a significant ($p>|t| = 0.016$ and 95% CI = 0.02-0.23) relationship between the number of food groups consumed and the number of plots owned by the household. The same relationship is also depicted in Figure 40. This implies that farmer's diversity is confined to the number of plots, and the reason for this, may be due to risk aversion from crop suitability (e.g. upland rice versus valley rice) and seasonal variation.

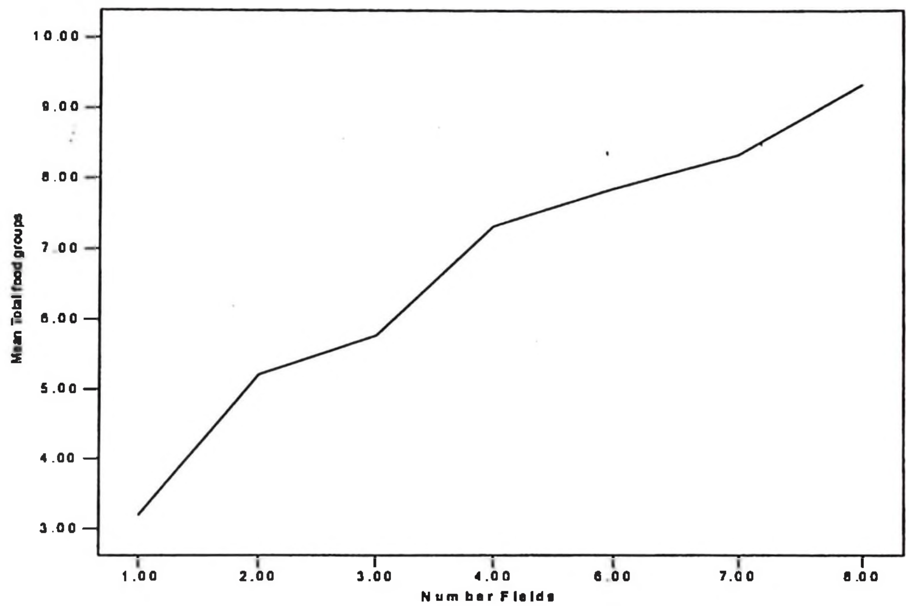


Figure 40: Relationship between number of field and the mean number of food groups

This implies that food production in the study area is not confined to the size of farm owned by the household but to the total number of plots maintained by the household. The mean, minimum and maximum number of plots are more than four, one and nine (SD = 1.65), respectively. There is a large difference between the minimum and the maximum number of field points to the greater variation in the number of plots between villages and even between households. This is supported by Chi-square analysis which compared the number of fields across villages. The results from Chi-square analysis shows significant ($p < 0.0007$) results implying that there is significant differences between villages in the number of fields owned by the households. Other factors including distance to the market and income as seen in Table 23 are insignificant.

It is important to point out that the results and the discussion from this and other sections emphasize the fact that in the rural areas, it is food produced by the household that determine household food security status and not income, markets and infrastructures. The results also show that food security is not determined by few crops such as grain (maize or wheat), but a combination of more than one crop and the diversity involved. Thus, crop diversity and associated variables such as household labour, numbers of plots and farm size make an important contribution to household food security than income and market opportunities. The next section dwells on agrobiodiversity status of the study area and discusses factors determining agrobiodiversity.

4.8 Analysis of agrobiodiversity

Before a complete analysis of agrobiodiversity is done it is important to reiterate that agrobiodiversity is a component of agrodiversity which according to Brookfield *et al.* (1999) is divided into four components namely biophysical diversity, management diversity, agrobiodiversity and organisational diversity. While biophysical diversity is an important element of agrodiversity studies, it cannot easily and directly be described by farmers. Farmers, for example, cannot easily describe and link their household food security status based on soil physical characteristics (e.g. soil texture and soil porosity) chemical characteristics (e.g. Cation Exchange Capacity and Organic Carbon Content) or even biological characteristics (e.g. soil biota). It is for this reason that the biophysical aspects of agrodiversity were left out.

Therefore, this analysis is centred on agrobiodiversity and includes some indicators of management diversity and organizational diversity. These components were selected based on the arguments that the intention of the study was to capture farmers' perspectives on agrobiodiversity and its associated linkages to household food security. So this analysis is centred on the "apparent diversity" different from "latent diversity". Diversity that is "apparent" to farmers is confined to physical characteristics of the crop population while "latent" diversity is revealed through molecular or pedigree analysis (Smale and King, 2006).

Therefore, while understanding latent diversity is of great value, the choice of apparent diversity was necessary because farmers grow their crops or raise their animals based on traits and attributes they observe rather than those they cannot see. In order to understand farmers managed unit of diversity, local variety names were taken as a starting point. Farmers' varieties, as pointed by the respondents in the study area, are presented in Table 24.

The data in Table 24 show that farmers maintain crops with appreciable amount of diversity and it is of interest to note that most of the names given by farmers are associated with particular physical and yielding characteristics. Local names like *Mbawa mbili* i.e. two wings in Kiswahili; *Kigogo* (The famous and rich); and *Sindano* (Needle) are associated with phenotypic characteristic of a given landrace. This implies that farmers develop locally based nomenclature and characterisation typical of formal breeding programs.

Table 24: Farmers' varieties grown by the study villages

Crop	Scientific name	Local name	Farmers varieties	Total varieties
Rice	*Oryza sativa*	*Mpunga*	Faya (M&V)[1]; Kigogo (M&V); Mbawa mbili (M&V); Lomoto (M&V); Linga (V); Seselo (M); Karafulu (M); Bungara (M); Pakapaka (M); Likungwa (M); Hebo (M); Meri (M); Sindano (M); Supa (M); Rangi Mbili (M&V); Shamba la bonde (V); Waya; Nyati	19
Cassava	*Manihot esculenta*	*Muhogo*	Kilusungu (takes 3-6 yrs); Kigoma (6 months); mgeni hana kiwanja (6 months); Kisabuni (3-6 years); Kikaniki (3-6 years); Athumani (6 months);	6
Taro	*Colocasia esculenta*	*Magimbi/mahombo*	Magimbi maji; Magimbi mlima; (Red, leaves used as vegetable locally known as Betse); Kikale (vegetables: Magimbi mlima[2].	3
Sorghum	*Sorghum bicolar*	*Mtama*	Jebere, Nyumbu, Mbangala, Ngilo, Kikombe, Mdeha (Upland and cool areas) (Thick seeds and floury)	6
Ground nuts	*Arachis hypogaea*	*Karanga*	Babu kubwa (iringa- 6 months) Babu ndogo Dodoma- 3 months	2
Beans	*Phaseouls spp.*	*Maharage*	Babu Kumbwa(long seeds and climbing(, Babu ndogo (small seeds)	2
Pegion peas	***Cajanus spp***	*Mbaazi*	Babu kubwa (thin seeds), Babu ndogo (short with thick seeds)	2

It is important to note that while local varieties listed in Table 24 yield relatively very low, they are pointed by farmers to have different qualities including short maturity which means that these varieties may be planted at the end of the season and yet be able to provide good yields. Other qualities include tolerance to harsh conditions and resistance to pests and disease.

Maintenance of a number of varieties for specific crops points to several behaviours. Farmers show innovative behaviours by testing new varieties. Some farmers are

[1] M = Mountain varieties/land races and V= Valley varieties/landraces

[2] The tuber is too hard to cook but once cooked it has high starch contents and may be eaten once a day as a food security strategy.

deviant in being the first to adopt and maintain new varieties while other take time to learn and adopt. Zannou *et al.* (2004) and Dennis (1987) characterize this deviant behaviour as "contrarian behaviour". According to Zannou *et al.* (2004) and Dennis (1987), with "contrarian variety use", the farmer is either the only one who grows a new variety or is one of the few farmers growing such a variety in a given year. These behaviours contribute to the maintenance or broadening of varietal diversity.

Moreover, maintenance of diversity on farms as argued by Zannou *et al.* (2004) and Wood and Lenne (1997) is inherent of three positive characteristics. The first one is constant search by farmers for novel variation or genetic novelty. The ability of farmers to experiment with variation is the second characteristic and the third one is that farmers manage a dynamic portfolio of varieties. The overall result of farmers' experimentation is a dynamic, open system of on-farm management of genetic resources, with both recruitments and loss of local varieties (Zannou *et al.*, 2004). Constant search for new varieties and their subsequent experimentation by farmers is confined to exchanged and own sources than to exotic sources as indicated in Figure 41.

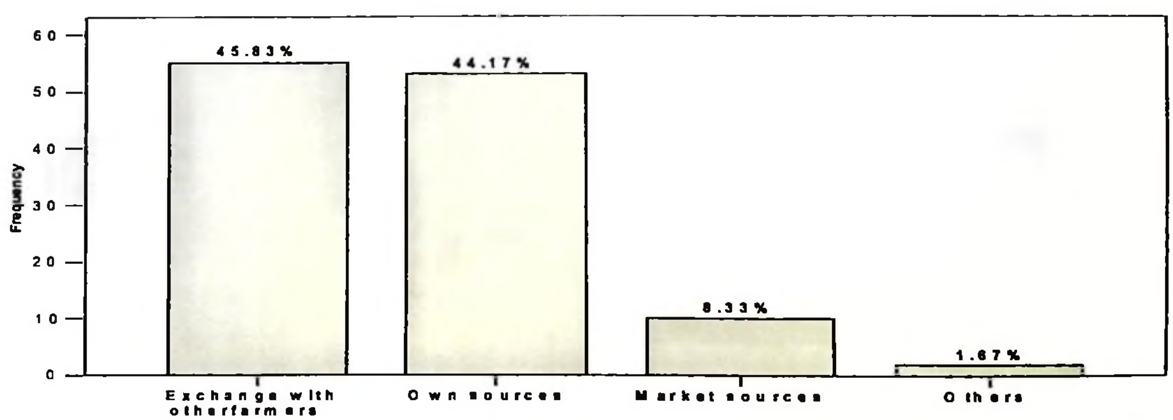


Figure 41: Sources of seeds

Figure 41 shows that exchange and own sources of the seeds are the main ways in which farmers maintain and exchange diversity among them. Figure 41 also emphasizes the idea that farmers do not use exotic varieties but traditional and less known varieties. Exotic varieties are less preferred because their performance is measured and limited to a short time segment which may not be useful to smallholder farmers. Moreover, exotic varieties thrive on a narrow band of climatic regimes and disease challenges. Blench, (1999) shows that unlike traditional varieties, exotic varieties perform better than traditional varieties in the first year of intensive input supply. The next and subsequent years are accompanied by declining yield and susceptibility to pests and diseases. As a consequence, as noted by Bench (1999), the use of exotic varieties is often associated with chronic food shortages in most parts of the developing world including Eastern and Southern Africa. In most cases, food shortages are met by traditional varieties maintained by farmers. It is important to note that other than investigation on the traditional varieties maintained by the farmer, the study also probed for the varieties that have disappeared. More than three quarters of the respondents agreed to have experienced a loss of traditional varieties (Figure 42)

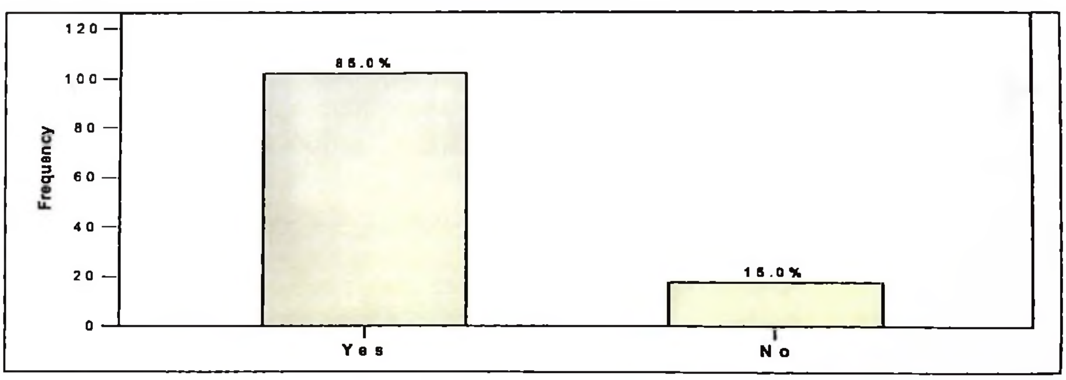


Figure 42: Loss of traditional varieties

Names of traditional varieties lost over the years are presented in Table 25. Nearly half of the respondents indicated that the loss of these varieties results from a continuous replacement of the existing varieties with the "new" local varieties. This implies that despite the presence of a diversity of varieties maintained under farmers' fields, farmers tend to introduce and replace older varieties for various reasons including comparative assessment of performance of the old and new varieties. Other reasons are summarised in Figure 43.

Table 25: Varieties that have disappeared

Crop	Scientific name	Local name	Farmers varieties
Rice	*Oryza sativa*	Mpunga	Lumoto, sindano, Pakapaka, Bungara, seselo, waya, kihogo, lule
Cassava	*Manihot esculenta*	Muhogo	Jawa, Athumani, Kibange, kikaniki, kisabuni
Sorghum	*Sorghum bicolor*	Mtama	Mbangala, Gebere, mbena

Thus as it was said earlier, replacement and subsequent loss of varieties are voluntary and indicate to the tendency of the farmer to abandon a particular variety because it no longer satisfies his/her preferences or could no longer cope with the existing agronomic constraints. However, there are also inadvertent losses of varieties due to other factors including flooding, erratic rainfalls or pests and diseases as represented by 5 percent of the respondents in Figure 43.

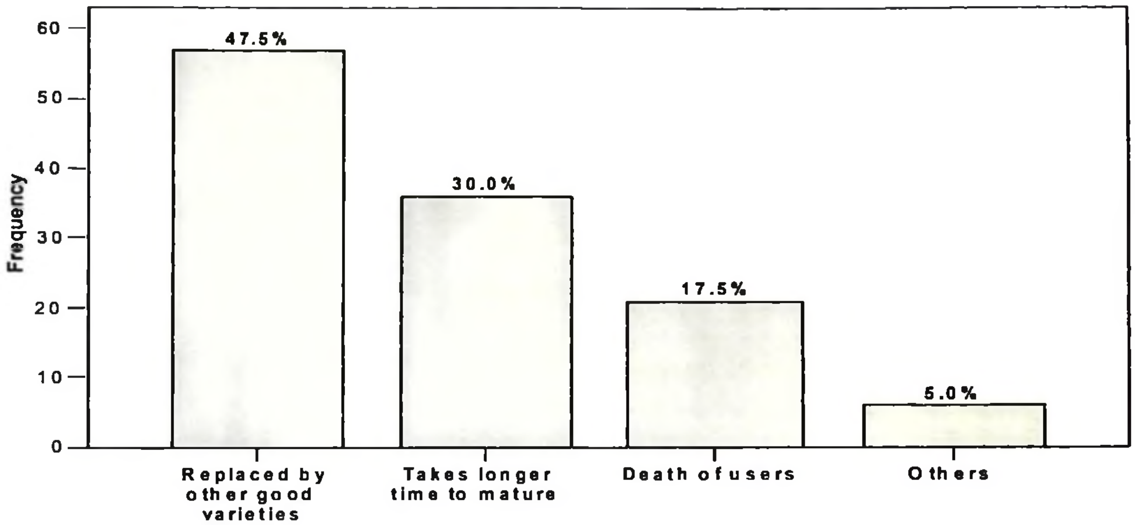


Figure 43: Reasons for loss of traditional varieties

Death of users of traditional varieties accounts for loss of knowledge and practices over the use of traditional varieties. This implies that utilization of traditional varieties depends largely on orally transmitted knowledge. Sometimes only a few or just one or two families may maintain certain kind of knowledge in the entire village.

The chances are that death of the owner of the variety lead to the loss of the associated knowledge, which, in turn, result into the loss of the variety if that knowledge which was not orally communicated to others. However, while the disappearance of varieties points to the loss of biodiversity, it is in some account, a common practice. Farmers, under normal circumstances, adopt new varieties, and phase out old ones. The overall outcome is the enrichment of the genetic pool than gross loss of diversity.

4.8.1 Crop diversity maintained by farmers

The diversity of crops maintained by smallholder farmers in the study area was determined using Equations 1-3 Section 3.2.9.2 of Chapter Three. In this analysis, both species richness and evenness were considered. An index that combines both richness and relative abundance concepts is the Shannon Index.

The Shannon Index, originally used in information theory, has been commonly employed to evaluate species diversity in ecological communities. Shannon Index also known as Shannon-Weiner Index belongs to a set of indices that maintain that diversity can be measured much like the information contained in a code or message (Magurran, 2004). The same author argues that the index assumes that individuals are randomly sampled from an infinitely large community and that all species are represented in the sample. As noted in Chapter Three, Shannon Index is calculated from the equation:

$$H' = -\sum p_i \ln p_i \quad \text{--} \quad (6)$$

The quantity p_i indicated in equation six is the proportion of individuals found in the ith species. The true value of *pi* is unknown but is estimated using its maximum likelihood estimator, n_i/N following Pielou (1969). To determine crops diversity maintained by farmers, 10 home gardens and 10 farmers' fields were randomly selected. The results for diversity in the home gardens are indicated in Table 26.

Table 26: Shannon Diversity Index for home gardens for each village

Milawilila					Kibogwa				
Species	ni	ni/N	ln(ni/N)	ni/N*ln(ni/N)	Species	ni	ni/N	ln(ni/N)	ni/N*ln(ni/N)
Coconut	14	0.10	-2.35	-0.22	Coconut	14	0.16	-1.83	-0.29
Jackfruit	12	0.08	-2.51	-0.20	Jackfruit	12	0.14	-1.98	-0.27
Pineapple	29	0.20	-1.62	-0.32	Pineapple	19	0.22	-1.52	-0.33
Banana	18	0.12	-2.10	-0.26	Banana	18	0.21	-1.58	-0.33
Hot paper	5	0.03	-3.38	-0.11	Hot paper	5	0.06	-2.86	-0.16
Lemons	5	0.03	-3.38	-0.11	lemons	1	0.01	-4.47	-0.05
Black pepper	5	0.03	-3.38	-0.11	Black pepper	5	0.06	-2.86	-0.16
Papaw	1	0.01	-4.99	-0.03	Papaw	1	0.01	-4.47	-0.05
Cardamom	2	0.01	-4.30	-0.06	Cardamom	2	0.02	-3.77	-0.09
mango	2	0.01	-4.30	-0.06	Mango	2	0.02	-3.77	-0.09
Mandarins	12	0.08	-2.51	-0.20	Mandarins	6	0.07	-2.67	-0.18
Breadfruit	6	0.04	-3.20	-0.13	Breadfruits	2	0.02	-3.77	-0.09
Taro	16	0.11	-2.22	-0.24	Total species	12			
Sweet potatoes	20	0.14	-1.99	-0.27	N	87		Shannon=2.10	
Total Species	15								
N	147		Shannon = 2.35						
Pekomisegese					**Nyandira**				
Species	ni	ni/N	ln(ni/N)	ni/N*ln(ni/N)	species	ni	ni/N	ln(ni/N)	ni/N*ln(ni/N)
Mango	3	0.02	-3.89	-0.08	Plums	16	0.11	-2.22	-0.24
Pigeon peas	15	0.10	-2.28	-0.23	Peaches	13	0.09	-2.43	-0.21
S/ potatoes	11	0.07	-2.59	-0.19	Cabbage	17	0.12	-2.16	-0.25
Maize	20	0.14	-1.99	-0.27	Pears	12	0.08	-2.51	-0.20
Guava	2	0.01	-4.30	-0.06	Tree tomato	6	0.04	-3.20	-0.13
Total species	5				Banana	3	0.02	-3.89	-0.08
N	51				Total species	6			
			Shannon = 0.84		N	67		Shannon = 1.12	

The results from Table 26 show higher diversity for home gardens from Milawilila and Kibogwa villages. Despite these results, the analysis of variance (Table 27) shows a significant difference in the number of species and individuals found in each home garden from each village.

It is imperative to note from Tables 26 and 27 that Nyandira and Pekomisegese present a completely different picture by giving very low diversity values. The two villages practice utterly dissimilar home gardens and farming systems. While Nyandira and Pekomisegese are famous for a diversity of vegetable and fruits production, most of the production is oriented towards market. Production for market tends to focus on individual high value crops and hence the reduction in the diversity of crops maintained in both on farm and in the home gardens.

Table 27: Variation in the number of species maintained in the home gardens

	Sum of Squares	df	Mean Square	F	Sig.
Number of species between villages	62.432	13	4.802	5.813	.000
Number of species within a village	87.568	106	.826		
Total	150.000	119			

This is also explained by Brush *et al.* (1992) who studied the diversity of potato Crop Genetic Resources in Latin America and found out that the level of market integration decreased the overall level of diversity as commercial production increased. However, the same authors showed further that the level of diversity decreases to an asymptotic lower bound, at which even commercial households maintain a set of minor varieties in a reduced land area. This may be attributed by the tendency of farmers to maintain a certain level of diversity for none-market motives including culinary properties of certain traditional varieties. However, diversity maintained is influenced by a number of factors as explained in the next section.

4.9 Factors influencing agrobiodiversity

Many studies acknowledge that farmers play a key role in maintaining traditional varieties. Indeed, on-farm maintenance of Crop Genetic Resources (CGR) is a positive externality of the farm activities driven by farmers' survival first motives involving issues far from simple profit maximization. Farmers are not maintaining diversity for its own sake. For this reason, their derived demand for diversification and thereby its effect on the conservation outcome is usually coined in the literature as '*de facto conservation*' (Meng *et al*., 1998).

However, the level of diversity that farmers produce is less than what society wants to have because, first, no farmer produces diversity for its own sake, secondly each farmer decides independently based on observable characteristics of the varieties. For these reasons, there could be landraces not of interest for any farmer (resulting in possible extinction) and there could be landraces of interest for thousands of farmers resulting in redundancy.

Hence, although farmers have a role to play in the conservation of CGRs through managing diversity and maintaining it by the utilization in their production systems, governments cannot entirely depend on their derived conservation activities. Moreover, due to imperfect markets and transaction costs, the social and private marginal benefits are not identical and therefore the level of conservation will again be sub optimal. Non-optimal diversity produced by farmers as impure public good calls for the need to change the *status quo*.

For those landraces which are either not conserved by farmers '*de facto*' and are, hence, threatened by extinction, or are not conserved at a social optimal level, incentives or removing perverse incentives (McNeely, 1993) are needed to improve the non-optimality through harmonizing their variety choice criteria with national CGRs conservation strategies. However, before designing sound incentive mechanisms for promoting on-farm conservation and/or removing perverse incentives (like linking of access to fertilizer or credit with the adoption of specific cultivars), decision-makers have to be informed as to why farmers are doing what they are doing as far as crop variety portfolio management is concerned.

Thus, the focus of this section lies on identifying the socio-economic and farm factors behind farmers' decisions on maintaining a portfolio of plant varieties and landraces on their farms. The main research question addressed in this section is: what are the socio-economic and farm factors influencing the existing agrobiodiversity?

The determination of socio-economic factors influencing agrobiodiversity was done using Equation 4 described under Section 3.2.9.3 of Chapter Three. In this equation, the dependent variable i.e. agrobiodiversity was measured using the total number of crops planted on the farms. Other independent variables are presented in Table 28.

Table 28: Variable definitions and expected signs

Variable name	Description	Mean	SD
Dependent Variable			
♦ Agrobiodiversity	The number of crops planted on-farm	7.8	3.1
Explanatory variables			
♦ Age	Age of the HH head (Years)	48.9	14.4
♦ Lancrops	Land owned (acres)	5.6	3.0
♦ Land used	Total land used (acres)	4.1	2.5
♦ Education	Years of school of the HH head	5.9	2.6
♦ Farexp	Number of years as a farmer	16.3	9.0
♦ Hhsize	Number of household members	7.8	2.3
♦ Hhlabour	Members working on farms	5.0	2.3
♦ Fields	Number of fields	4.2	2.3
♦ Income	Annual income (Tsh)	152 183	81 451

Before multiple regression analysis, variables described in Table 28 were subjected to Principal Components Analysis (PCA). Principal Component Analysis is a variable reduction procedure to reduce variables which correlate with one another. The aim is to come up with a smaller number of principal components (artificial variables) that account for most of the variance in the observed variables.

The use of Principal Component Analysis is justified because, in the course of construction of the regression model, the inclusion of all variables resulted into very low R^2 (0.14) meaning that there is significant multicolinearity among independent variables. Therefore some variables had to be dropped and excluded in the final analysis. Thus, only two Principal components with Eigenvalues greater than one were identified. Figure 44 summarises Eigenvalues accounted from PCA.

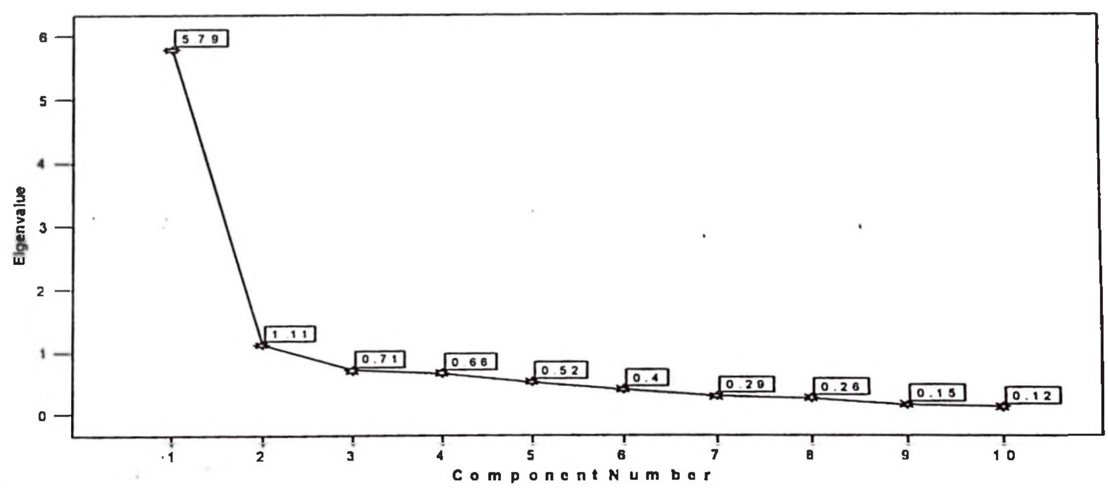


Figure 44: Scree plot for Eigenvalues showing cut-off point for the Principle Components

The correlation between the two principal components and the variables gives a loading matrix (Figure 45) that shows clearly that almost all of the variables load well on the first component except for the variable “income”. The second component is loaded with eight positive variables and one negative variable.

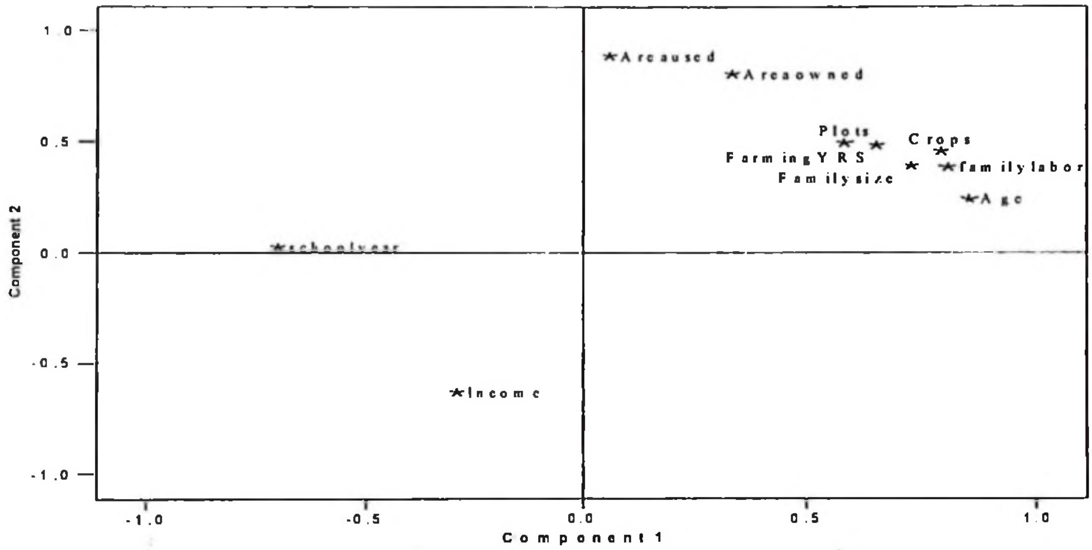


Figure 45: Loading of variables into Principal Components

Thus, “income” as seen from Figure 45 provides small contribution to the variance and is therefore dropped out of the analysis. This implies that income may not be a good predictor of agrobiodiversity maintained under smallholder subsistent farming system. Other variable are therefore taken for multiple regression analysis presented in Table 29.

The results from Table 29 show a significant regression model with adjusted R-Square of 81 percent with several independent variables (age, family labour, area used for farming and the number of plots owned by the household) showing significant results with the number of crops grown by the household as indicated in Figure 48.

Table 29: Demographic and Socio-economic factors influencing agrobiodiversity

Crops	Coef.	Robust Std. Err.	t	P>|t|	95 % Conf. Interval	
Constant	-0.23613	0.50358	-0.47	0.64	0.233905	0.76165
Age (Years)	0.04499	0.01546	2.97	0.004*	0.015359	0.07663
Household size	-0.08740	0.08499	-0.97	0.336	0.025059	0.08612
Household labour	0.49745	0.12307	4.03	0.000*	0.252374	0.74005
Education (Years)	-0.02258	0.05769	-0.39	0.696	0.013691	0.09175
Number of Plots	0.20802	0.89328	2.34	0.021*	0.031820	0.38580
Area owned (acres)	-0.00262	0.07427	0.02	0.984	0.145626	0.14867
Area used (Acres)	0.48679	0.09429	5.10	0.000*	0.293764	0.66744
Farming years	0.02982	0.02327	1.33	0.185	0.015071	0.07718

*** Significant at P<5% Pro. > F = 0.0000; R^2 = 0.8141**

Figure 46 shows the behaviour of each independent variable on the dependent variable. Thus, in this model, the number of crops grown tends to increase significantly with the land area used for farming and the family labour. Other variables that are equally important are the number of plots owned by the household and the age of the household head. Moreover, Figure 47 shows a negative correlation between the number of crops grown with the household size and education.

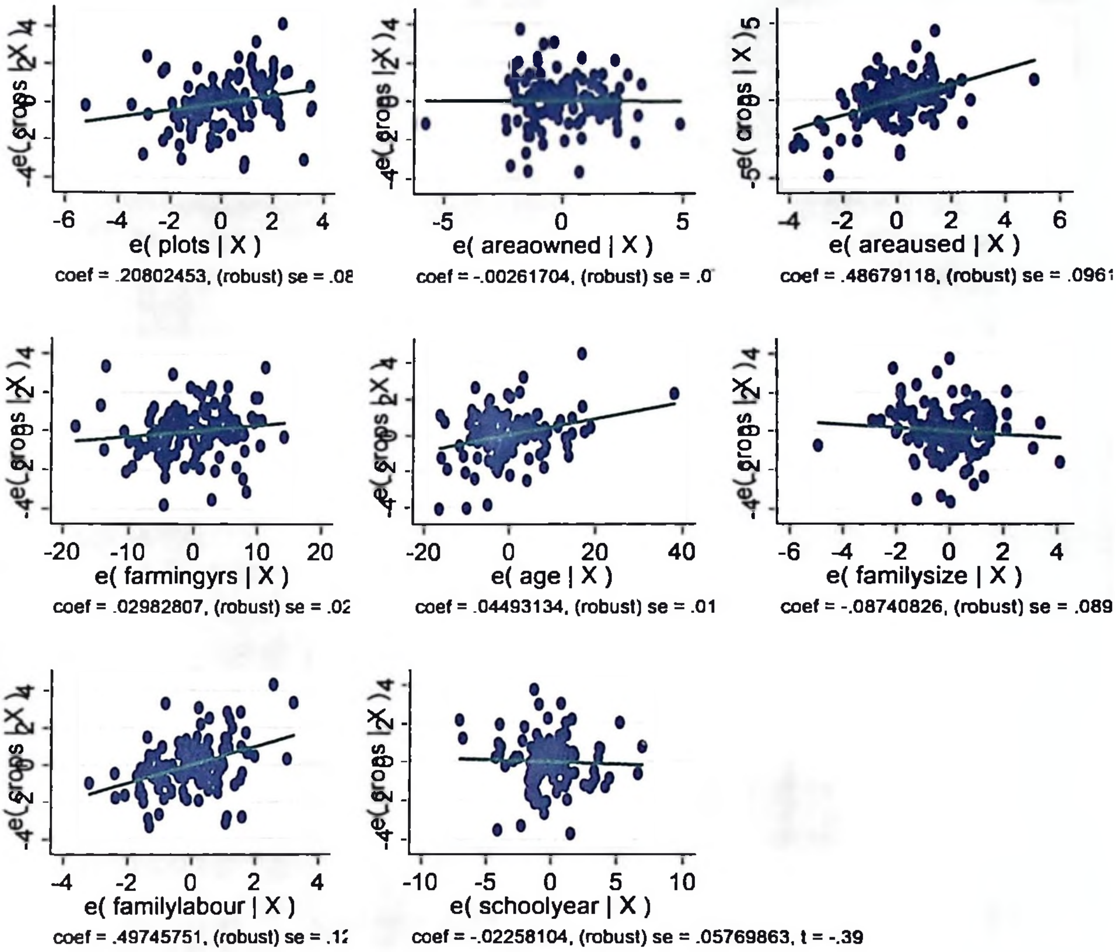


Figure 46: Added-variable plots (avplots) from the regression model

The land area used for farming tends to increase the mean number of crops grown. Nevertheless, this tendency does not go indefinitely. At some point the mean number of crops grown starts to decline with acreage. As acreage increase farmers tend to grow few crops, thereby reducing the number of agricultural diversity (Figure 47). It can therefore be said that agricultural diversity increases to a certain manageable size of land using household labour. Therefore, household labour sets the limit for diversity regardless of the increased acreage.

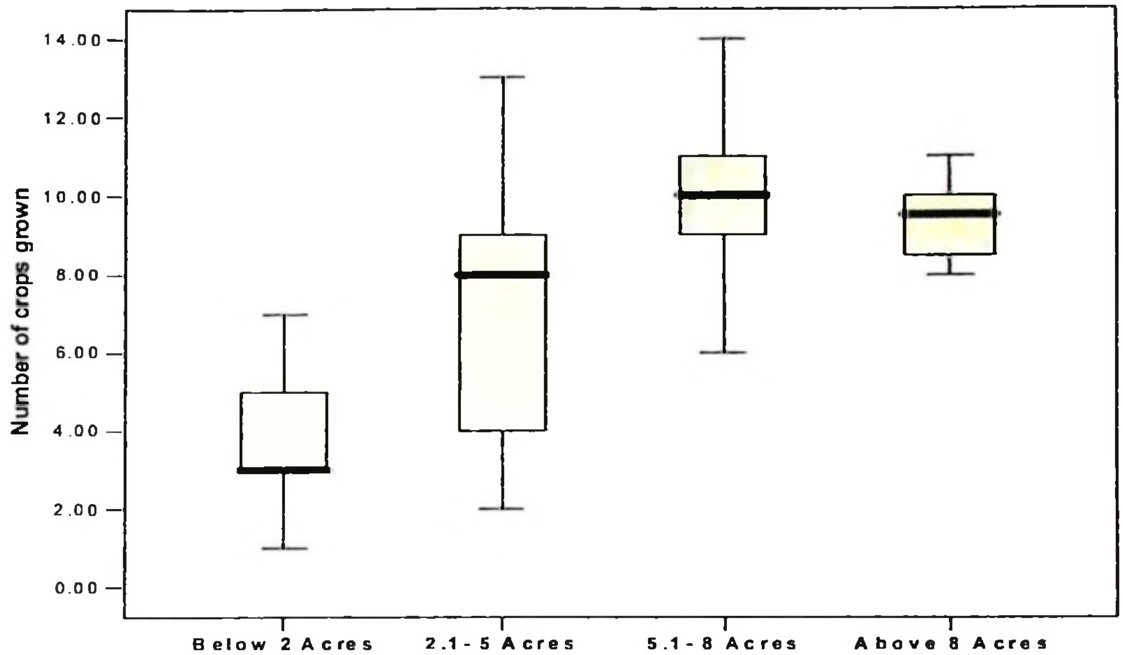
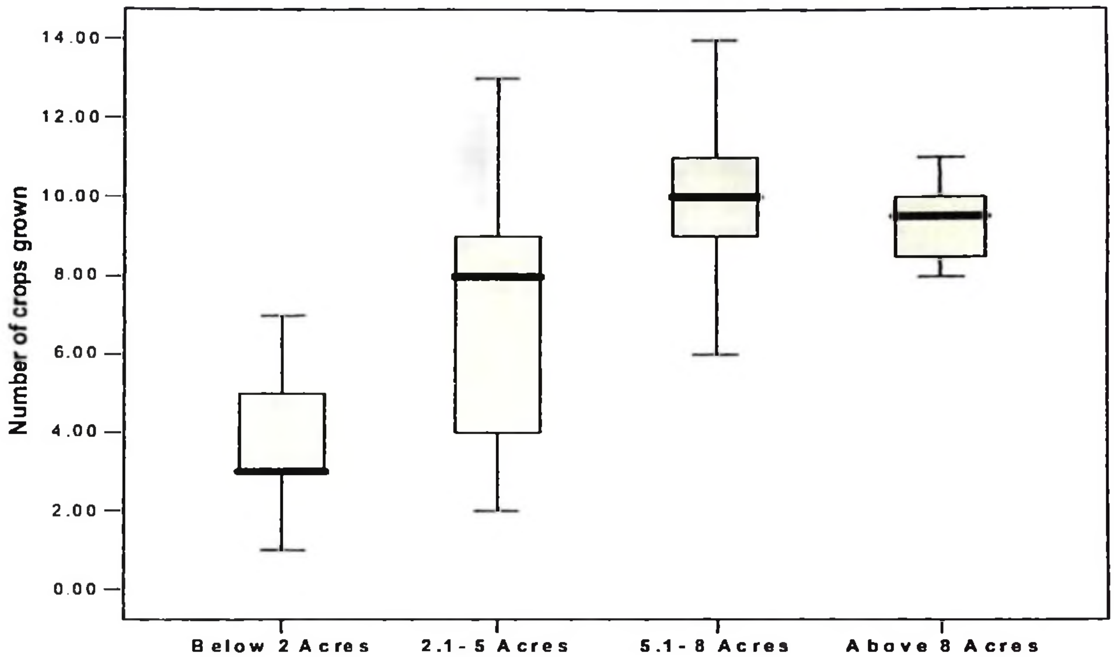


Figure 47: Relationship between number of crops grown and acreage

4.9.1 Relationship between age and number of crops grown

The statistical analysis shows a significant and positive relationship (Prob. < 0.05 with 0.007-0.008 95%, CI) between the number of crops grown and the age of the household head (Table 29). Figure 48 shows an increasing number of crops grown with age of the respondents. It also show further that the household heads below 30 years grow a mean number of crops of 2.5 with the minimum of one and the maximum of four with 0.76 standard deviations. Old farmers above 70 years grow a minimum and a maximum number of crops of five and 14, respectively with the standard deviation of 2.87.



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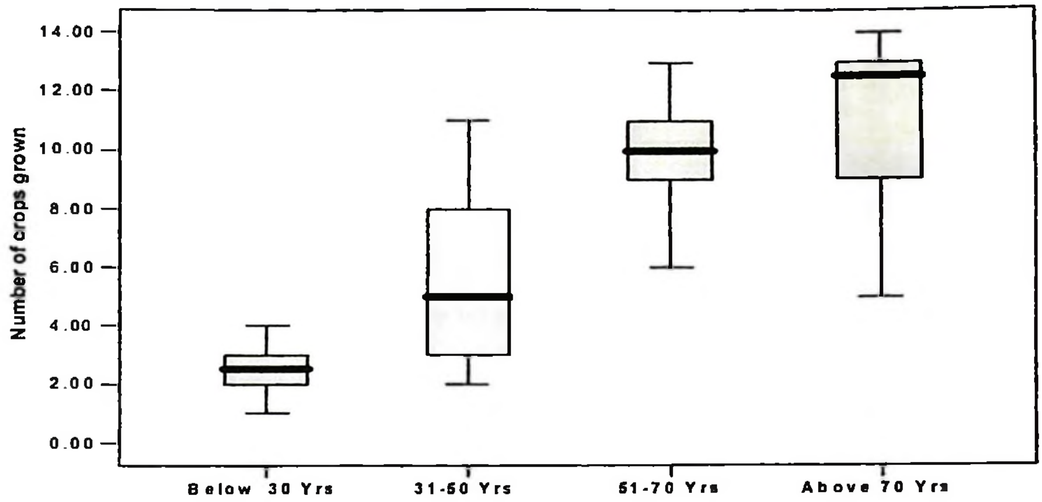

Figure 48: Relationship between number of crops grown and age of the population

There are a number of reasons for linear relationship between age and the number of crops. As results from Table 30 shows, young farmers have less of household labour, land size used for farming and the number of fields for cultivation.

Table 30: Comparison of mean, SD, minimum and maximum values for plots, area and household labour for different age categories

Categories of age		Number Fields	Area used (acres)	Household labour
Below 30 Yrs	Mean	1.3571	2.0	1.857
	Std. Deviation	0.842	0.849	0.770
	Minimum	1.00	1.00	1.00
	Maximum	4.00	3.00	4.00
31-50 Yrs	Mean	3.519	3.1713	4.167
	Std. Deviation	1.988	2.11621	1.988
	Minimum	1.00	0.50	1.00
	Maximum	7.00	8.00	8.00
51-70 Yrs	Mean	5.738	5.4702	6.785
	Std. Deviation	1.483	2.38146	1.200
	Minimum	1.00	1.00	4.00
	Maximum	8.00	10.00	9.00
Above 70 Yrs	Mean	6.0	5.90	6.80
	Std. Deviation	2.44949	2.93258	2.348
	Minimum	1.00	0.50	2.00
	Maximum	9.00	9.00	10.00

Moreover the tendency of young farmers to deal with crops like pineapples, spices and vegetable encourage them to go for single crop (monoculture) than a diversity of crops typical of old farmers.

4.9.2 Relationship between family labour and number of crops

Family labour plays an important role in the maintenance of agrobiodiversity. The results from Table 29 show linear relationship between the number of crops maintained by the household and the number of people in the household who are capable of providing labour on farms (Figure 49). Every additional crops increased in the house depending on seasonality and cultural practices, tend to demand more of the family labour.

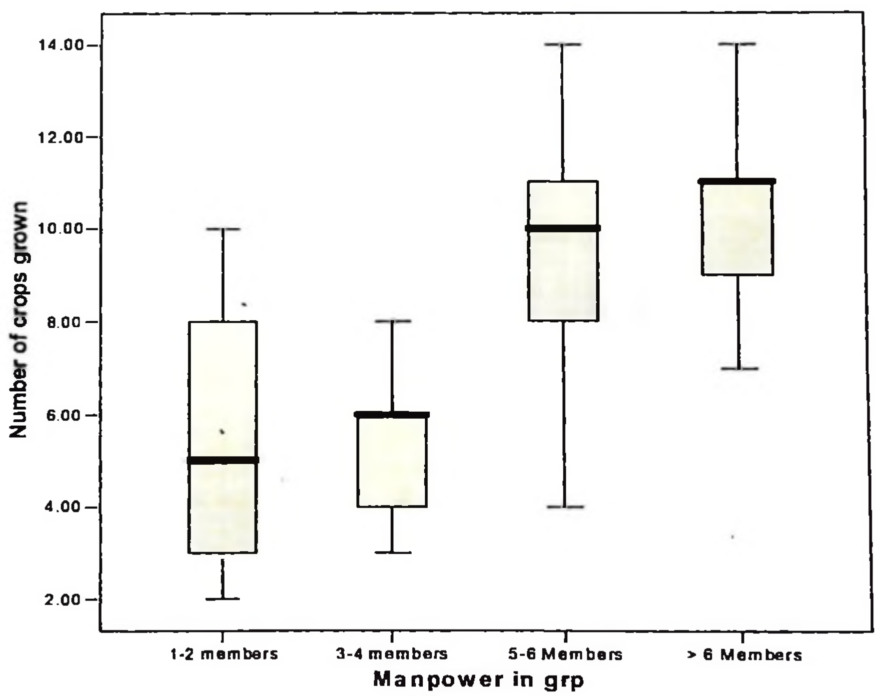

Figure 49: Relationship between household labour and number of crops grown

The study shows that 10 crops in the household may be maintained with the mean household size of 6.6 with the maximum of nine and the minimum of five and standard deviation of 1.024. This is in contrary with less than eight crops that require mean household labour of three, the maximum of six, the minimum one with standard deviation of 1.62.

4.9.3 Relationship between farmers experience and number of crops grown

It is of interest to note that the number of crops grown also increases significantly (F=0.000) with farmer's experiences indicated by the number of years of farming. This means that farmers' experience (in years) may also be an important determinant of agrobiodiversity. Farmers with more experience also own larger farm sizes and more number of plots compared with those with low farming experience. Low experienced farmers may be immigrants who settled recently or young and newly married farmers at the outset of the farming engagement.

CHAPTER FIVE

CONCLUSIONS AND RECOMMENDATIONS

5.1 Overview

The general objective of this study was to determine the linkage between agrobiodiversity and household food security among smallholder farmers in Uluguru Mountains. This objective was based on the fact that, while there are adequate information and corresponding policies for the conservation and management of wild biodiversity in Tanzania, few exist on agrobiodiversity and its role in providing food security of the smallholder farmers.

The purpose was to provide empirical data for recommendations to policies that convey incentives for farmers to conserve agricultural biodiversity for food security and the overall conservation of biological resources. This objective was covered throughout the study. The purpose of this chapter is therefore to present major findings, major conclusions, policy implications and recommendations and implications for further research. Thus, based on specific objective, this chapter is divided into four sections; the first and second sections present major findings and conclusions, respectively. The third section draws a number of policy implications and recommendations based on major findings and conclusions. This chapter ends with a section on the way forward by presenting implications for further research.

5.2. Summary of major findings

5.2.1 Farming systems and indigenous practices associated with agrobiodiversity

The analysis of the major farming and cultivation systems illustrated that farmers have developed complex systems of conservation and management of land and diversity. This is particularly important in the fallow systems where short and long fallows are used to maintain soil fertility in the study area. The shortest fallow period locally known as *lubua* (up to three months) is used for short rotation while others such as *luvinze* (2-5 years) and *Lugonela* (above five years) are used for the restoration of fertility. Most of the fallow land is left with long and enduring type of cassava locally known as *Kilusungu.* This type of cassava is left to grow under the fallow and is used by household as a source of food. Thus, most of the fallows are left with something that may be used as a source of food by the household members.

Analysis of the farming system also revealed that most of the land in Kibogwa and Milawilila village is obtained from inheritance while land from Nyandira and Pekomisegese villages is purchased. This implies that the increased value of land based on commercial oriented agriculture, typical of Nyandira and Pekomisegese, results into the diminishing traditional land acquisition system. Villages with limited market integration and road networks as is the case with Milawilila and Kibogwa maintain traditional land inheritance system at 57 and 73 percent, respectively.

Moreover, land acquisition through traditional inheritance system in the named villages follows matrilineal descendant system in which women are the prime beneficiaries of the land. This provides opportunities for women to own land.

However, the system is vulnerable to changes such as increased market integration and migration (both in and out migration) that bring in opportunities for commercialized agriculture as reflected earlier.

Together with distinct land inheritance system, the study also revealed a distinct division of labour between men and women. While men are involved in more physical activities such as slashing, burning and ploughing, women and children are involved in planting, weeding, harvesting and processing for storage of food. They are also involved in seed selection and storage.

5.2.2 Household food security status and factors influencing food security

Household food security status was measured using dietary diversity. The majority of the respondents i.e. 50 percent were food secure implying that they consume more than six food groups as indicated in Section 4.6.3. The study also found that the main staple food is cassava prepared as stiff porridge, locally known as *Mkembe*. Thus, while most parts of Uluguru Mountains receive sufficient rainfall, it is cassava, a semi-arid crop, which is at the center of household food security as indicated by more than 64 percent of the respondents. Other crops such as banana, potatoes, millet and sorghum are considered as less preferred foods and are therefore consumed at the time of food insecurity. Consumption of less preferred foods, as indicated by more than 59 percent of the respondents, is also one of the household food security coping strategies.

In this study, 59 percent of household food security based on the number of food groups consumed is contributed by the number of crops planted by the household.

The household in the study maintains up to 14 crops per season. These crops are of different varieties and are planted not in a single field but in various plots. Up to nine plots were recorded during the study implying that diversity is not only confined to the number and diversity of crops but also to the number and diversity of plots.

Other equally important factors such as farm size, household labour and the number of plots owned by the household contribute to household food security at 23, 14, and 12 percent, respectively. However, factors such as distance to the nearest market and household annual income contribute less to the overall household food security. This means that, unlike urban areas, market and income contributes less to household food security in rural and marginalized areas.

5.2.3 Analysis of agrobiodiversity

Based on the apparent diversity explained in Section 4.8, farmers from the study area maintain a diverse farming system with some crops having up to 19 different farmers' varieties. For example, Rice (*Oryza sativa*) was found to have 19 different varieties. These varieties were given different Kiswahili names pointing to peculiar characteristics as presented in section 4.8. It is important to point out that high diversity was found in home gardens compared to farmers' fields. High Shannon index presented in Section 4.8.1 for home gardens point to the fact that home gardens are used as a quick source of food and they are also used as experimentitation and multiplication laboratories for new seeds exchanged or obtained from other farmers. Note further that diversity of varieties maintained by smallholder farmers originates from local seed exchange systems as indicated by 90 percent of the respondents.

Sources such as market and government extension services accounted for only 10 percent.

5.2.4 Factors influencing agrobiodiversity

Using principal component and regression analysis the study showed that agrobiodiversity maintained by smallholder farmers is influenced by not only agroecological characteristics but also socio-economic and demographic characteristics. Regression analysis showed a significant regression model at R^2, 0.8141 with age of the household head and household labour showing significant results. Other significant results were obtained from the number of plots used for farming and the area in acres used for crop production.

5.3. Major conclusions

5.3.1 Farming systems and indigenous practices associated with agrobiodiversity

Findings from the farming systems analysis points to the conclusion that farmers are capable of developing and maintaining a diverse and sustainable system of crop management using specific and traditionally evolved practices. Such practices extend beyond use values to practices that lead to a sustainable system such as strategies for fertility maintenance. While farmers may not explain scientifically why they maintain both short and long fallow periods, their practices point to the same scientific knowledge that above ground diversity of crops is possible because of the exiting below ground diversity of flora and fauna.

The study also revealed that women play important role in agrobiodiversity conservation and management. This points to the conclusion that women's role in crops management, seed selection and storage makes then the important custodians in agrobiodiversity conservation and management. Moreover, their primary role in food production and preparation means that they possess sufficient knowledge ranging from crop performance and maintenance in the field to culinary characteristics of different foods. Thus, strategies for conservation and management of agrobiodiversity must include women.

5.3.2 Household food security status and factors influencing food security

The fact that most of the food groups consumed by the household are obtained from farmers' own production points to the conclusion that food security in the rural areas depends largely on the sources from within and not otherwise. Thus, diversity of crops and farmers plots is the key to household food security in rural and marginalized areas. Moreover, farmers own sources point to an important fact that food security as a concept has a lot to do with local perceptions based on culture, taste and preferences of a given society.

These findings show that the current and future options for household food security in the rural areas rest on the improvement of the currently diverse farming systems and practices rather than on income. This is important because most of the food consumed (both preferred and less preferred) is produced locally and very little is brought from the market as shown by the study.

5.3.3 Analysis of agrobiodiversity

These results show that farmers are not only capable of maintaining a diversity of crops and farming systems for household food security, but they also have developed and maintained a local seed exchange and production system capable of perpetuating the existing diversity. This means that farmers are capable of searching and experimenting novel variation that enriches local diversity for various reasons including household food security. The products of farmers' experimentation are used to replace poorly performing farmers' varieties and hence contribute to the disappearance of outperformed varieties.

5.3.4 Factors influencing agrobiodiversity

Results from the analysis of factors affecting agrobiodiversity points to the conclusion that, while agroecological characteristics such as rainfall and soil are important for agrobiodiversity, socio-economic and demographic factors are equally important. Thus, while we propose for a diverse farming system as a means for household food security in rural areas, other factors including household labour (in terms of productivity) and farm size used for production should also be considered.

5.4 Policy implications and recommendations

This study showed that diverse farming systems with farmers' varieties are key to the maintenance of household food security in the rural and marginalized areas. However, the existing policy strategies for food security emphasize on the enhancement of crop productivity using single cropping and high yielding varieties. High yielding varieties are important but may not suit agroecological and socioeconomic circumstances of farmers in rural and marginalized areas. Moreover, high yielding varieties require subsidized inputs which may not benefit rural farmers because of poor infrastructure and financial capabilities.

This means that in many accounts, diversity of farming systems and farmers' varieties can be a sustainable option for household food access and utilization. There are however few policies addressing agrobiodiversity as a means for household food security in the study area and Tanzania at large. There is therefore a need to develop policies and strategies for diversity as a means for sustainable food and the overall livelihood security of smallholder farmers in the study area and other areas with similar conditions.

However, development of policies and strategies for food security and agrobiodiversity maintained by poor and marginalized farmers needs a thorough analysis. It is therefore recommended that an interdisciplinary approach be adopted to understand economic, ecological, social and cultural reasons for maintaining local varieties and the associated indigenous knowledge and practices. This approach will unveil indigenous knowledge systems and practices necessary for policy interventions and improvement. Also, detailed analysis of the system will make concrete actions more appropriate and their impact on management of agrobiodiversity and food security more sustainable.

Building awareness to all stakeholders is also recommended as an important entry point for policy formulation. This is important because few people are aware of agrobiodiversity and its role in household food security. Thus, awareness raising activities will contribute to the maintenance of agrobiodiversity by pointing out the value of agrobiodiversity for sustainable agricultural production; the need to protect potentially useful crops, and the value of agrobiodiversity as a cultural heritage or a combination of these points. Other key points to be considered for building awareness include:

- The importance of local varieties in sustainable low-input production as well as a resource for future crop improvement.
- The importance of fallow and other cultivation systems (as seen in this study) as repositories of valuable agrobiodiversity (both below and above ground).
- The importance of minor, semi cultivated and wild crops as sources of food and genetic resources for future food security options.
- The importance of women in the management of agrobiodiversity at the community level particularly in relation to the minor, semi cultivated and wild crops.

Moreover, this study indicated that Uluguru Mountain's biodiversity potential extends far beyond forest reserves to farmers fields. It is therefore important for the programs and NGOs involved in the conservation of Uluguru Mountains and Eastern Arc Mountains in general to look into agrobiodiversity as part of the important biodiversity that maintains livelihoods options including food security. Inclusion of agrobiodiversity will provide an important opportunity for development of farm based biodiversity conservation programs that a real and at the centre of community livelihoods and food security.

The people of Uluguru Mountains and particularly those involved in this study are reminded that they are maintaining a portfolio of agrobiodiversity that stands as a major source of food. Unfortunately, agrobiodiversity maintained by farmers, as seen from this study, is constantly linked with indigenous knowledge and practices. It is therefore recommended that the existing diversity should be maintained using community initiatives such as formation of farmers' agrobiodiversity conservation groups and networks. The purpose of building groups and networks is to build a social capital that enhances transmission and conservation of agrobiodiversity knowledge and practices between old and new generations.

5.5 Implication for further research

This study provides an ice tip of the work that has a lot of potential for further research. Thus, while the study confined itself to agrobiodiversity for food security, it also points to other knowledge system that is yet to be documented. The study therefore recommends the following as areas for further research;

- The objective for increasing agrobiodiversity for more sustainable agriculture is still largely based on assumptions and anecdotal information rather than on solid ecological and socio-economic evidence. It is, for instance, not clear to what extent local varieties in marginal conditions are better yielding and stable than improved varieties, or to what extent yield stability can be explained by genetic heterogeneity unlike homogeneity. Investigation is therefore needed to establish the level of genetic diversity required for ecologically sound and economically sustainable agriculture.
- Most of the information on the management of crop genetic diversity at the community level relates to the major seed-propagated annual grain crops. However, minor grains, roots and tubers crops that are very important for

location specific food security are not well covered by research. Research therefore has to go beyond and address minor and locally stable crops and varieties for the present and future food security options.

- The study showed that farmers maintain diversity of crops for mostly household food security. This diversity is maintained under marginal conditions usually characterized by complex combination of stress. This provides an opportunity for important gene combination that may be used for future crop improvement. There is therefore a need to carry out genetic mapping research of farmers' varieties from the study area.
- This study showed further that the diversity of crops maintained by smallholder farmers is obtained from own sources and through dynamic seed exchange systems. It is clear therefore that farmers have developed clear seed supply and exchange systems that are not well understood. It is thus important to carry out research to determine seed supply and exchange systems and the associated indigenous practices. This investigation as seen from this study should target on the people who are the main managers of agrobiodiversity in the study area and elsewhere.
- Market integration as seen in this study may be one of the factors leading to loss of diversity through specialization (monoculture). The study did not consistently show the extent to which markets influence agrobiodiversity. There is therefore the need to quantify and establish relationships between diversity and market integration especially in the rural areas where most diversity is found but also threatened by a number of factors including market integration.

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APPENDICES

Appendix I: Household Questionnaire

1: HOUSEHOLD INFORMATION

1.1 Basic respondent's information

DATE OF INTERVIEW	VILLAGE/SUB-VILLAGE NAMES	DIVISION
HOUSEHOLD CODE	NAME	ETHNICITY
RESPONDENT'S AGE (Years)	RESPONDENT'S GENDER	
	[1] = Male; [2] = Female	
AGE OF HHH (Years)	GENDER OF HHH	ORIGIN OF HHH
[1] Less than 55 Years [2] 18-35 Years [3] 36-55 Years [4] Above 55 years	[1] = Male; [2] = Female	[1]= Native; [2] = Immigrant

1.2 Members of household currently resident

Name	Age (Years)	Sex		Relationship		Education		Occupation	
1		1 = Male		1 = Head		1 = None		1 = Child	
2		2 = Female		2 = Wife		2 = Std IV		2 = Student	
3				3 = Husband		3 = Std VII		3 = Farmer	
4				4 = Child		4 = Secondary		4 = C/servant	
5				5 = Other relatives		5 = Higher Ed.		5 = non-farm	
6				6 = None relative					
7									
8									
9									
10									
11									
Total Resident HH members									

1.3. Main occupation of the household head

1 = Farming
2 = Farming and off farm
3 = Off-farm only
4 = Others

1.4 Members of household permanently or mostly away

ID	Name	Age (Years)	Sex		Education level		If sends money home		Estimated Amount last season	
			Code		Code		Yes	No	Amount	
1										
2										
3										
4										
5										
Total family members permanently or mostly away										
Total Remittances in the past year						Period from..................to.........				

2: Cropland owned and operated by the household

2.1. How did you obtain your land?

1 = Inherited
2 = Purchased
3 = Village government
4 = Borrowed

2.2. Total land owned by the household

Field	Area	Ownership	Rent In Land	Rent Out Land	Major crops	Production domain
	Area of each field or plot (acres)	1 = owned (idle) 2 = owned (used) 3 = own (rented out) 4 = rented in 5 = borrowed	Amount paid (Tsh)	Amount received (Tsh)	Crops	1 = Dry season 2 = Rain season
1						
2						
3						
4						
5						
Total number of plots (Sum codes 1 – 3 under ownership)			Total area owned		Total area used for farming (including land rented in or borrowed)	

3: Crop Diversity at Household level

3.1 Main crops

	Crops				
Purpose	[1] Cash [2] Food [3] Both	[1] Cash [2] Food [3] Both	[1] Cash [2] Food [3] Both	[1] Cash [2] Food [3] Both	[1] Cash [2] Food [3] Both
Number of varieties [1] < 2 [2] 3-4 [3] >4					
Name of varieties					
Category [1] Indigenous [2] Exotic [3]Mixed					
Origin of seeds [1] Own seeds [2] From neighbour [3] Bought from shops [4] Other village(s)					
When planted [1] Early in the season [2] Late in the season [3] Throughout the year [4] Others					
Allocate land size					
Estimated Yield [1] During rain season [2] During dry season					

3.2 Other crops

Name / Items	Crops				
Number of varieties [1] < 2 [2] 3-4 [3] >4					
Name of varieties					
Category [1] Indigenous [2] Exotic [3]Mixed					
Origin of seeds [1] Own seeds [2] From neighbour [3] Bought from shops [4] Others					
When planted [1] Early in the season [2] Late in the season [3] Throughout the year [4] Others					
Where planted [1] Home garden [2] Farms [3] Others (specify)					
Allocate land size					
Estimated Yield [1] During rain season [2] During dry season					

4. **Crop outputs and income**

Use the "Month" column to state the harvest month as 1 = January…12 = December. List each harvest separately for crops that had more than one harvest during the past year.

Crop*	Month	Unit	Quantity Consumed		Quantity Sold		Total Produced
			Qty A	% B	Qty C	% D	E = A +C

5: **Outputs and income from non-farm activities**

Code	Type of work	Amount Earned Last Month (Tsh)*	Amount Earned Past Year (Tsh)**	Place of Work	Remarks
				1 = Nearby 2 = District 3 = Town (name) 4 = City (name)	
1	Wages – Seasonal				
2	Wages – Regular				
3	Salary – Govt Sector				
4	Salary – Private Sector				
5	Business Income***				
6	Pension Payment				
7	Other Non-Farm****				
YEAR TOTAL (Tsh)					
Number HH members earning from non-Farm Incomes					
Total Non-Farm Income earned by household members (sum of years total for all non-farm earners in the household (Tsh)					

6. **Food utilization and diversity**

6.1 Food consumption by source

Food item	[1] Own prodn.	[2] Purchased	[3] Both 1 & 2	[4] Others
Maize				
Millet				
Potatoes				
Cassava				
Beans				
Vegetables				
Ground nuts				
Meat				
Eggs				
Oil				
Salt				

6. Food security and coping strategies

6.1 What do you understand by the term food security or insecurity in your village/local context?

1 = Having enough cassava as staple food
2 = Not eating less preferred foods
3 = Others (specify)

6.2. How do you cope with food insecurity?

1 = Eat less preferred food
2 = Sale of labour
3 = Borrowing
4 = Buying after sale of farm products
5 = Sale of labour and borrowing

6.3. What is the source of less preferred foods?
1 = Own farm
2 = Market
3 = Borrowing
4 = Others

6.4 Response to shocks (last 3 years - enter here events such as food insecurity, drought, floods, theft of livestock, animal or crop pests

Event	Response [1] Sale of household assets [2] Sale of animals [3] HH members sale labour [4] HH members migrate [5] Borrow money/food from relatives
[1] Hunger	
[2] Crop loss	
[3] House damage	
[4] Other events (specify)	

6.5. Do you plant a diversity of crops and crop variety as a food security coping strategy

[1] Yes

[2] No

6.6 If yes indicate types of crops planted for food security coping strategy

Name / Items	Crops				
Number of varieties [1] < 2 [2] 3-4 [3] >4					
Name of varieties					
Category [1] Indigenous [2] Exotic [3]Mixed					
Origin of seeds [1] Own seeds [2] From neighbour [3] Bought from shops [4] Other village (s)					
When planted [1] Early in the season [2] Late in the season [3] Throughout the year [4] Others					
Where planted					

[1] Home garden [2] Farms [3] Others (specify)					
Allocate land size					
Estimated Yield [1] During rain season [2] During dry season					

6.7 If yes, what are specific attributes for crops mentioned in 10.1?

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7. Wild sources of food

7.1 Do you use wild sources of food?

1 = Yes
2 = No

7.2. If yes, what are the reasons for collection of wild crops/plants for foods?

7.3. If yes, what are the main sources of wild foods?

1 = owned farm
2 = Forest patches
3 = Forest reserve
4 = Others

7.4. If yes, who is responsible for the collection of wild foods?

1 = Men
2 = Women
3 = Both Men and Women
4 = Children

8. Livelihood diversification

8.1 Has this pattern of activity changed over the past five years or so?
[1] = Yes;
[2] = No

8.2 If yes, then what were the main activities for gaining a living five years ago?

1	
2	
3	
4	

8.3 Paying attention just to <u>farming</u> activities, does the household have
[1] = MORE;
[2] = LESS
[3] = SAME farm activities (i.e., different crops or animal types) than 5 years ago?
Why?

8.4 Has the household started "new" farming activities in the past 5 years?
[1] = Yes;
[2] = No
Why?

8.5 During the past five years, has the situation of this household been
[1] = IMPROVING;
[2] = WORSENING;
[3] = STAYING THE SAME?
12.6 What are the main reasons given by household members for these changes or trends?

8.7 Do you think planting different crops and crop varieties helped your family to survive worst situations?
[1] Yes
[2] No
8.7 If Yes how?

8.8 If no, what may be the reason?
[1] Bad weather
[2] Lack of capital
[3] Lack of land
[4] Others
8.9 Do you have any comments on the importance of crop diversity for household food security?

8.9.1 If Yes, Please give comments---

Thank you very much

Appendix 2: Household Food Security Coping Strategies

1. Has the household consumed less preferred foods
   - [1] Never
   - [2] Rarely (once)
   - [3] From time to time (2 or 3 times)
   - [4] Often (5 or more times)
2. Have you reduced the quantity of food served to men in this household?
   - [1] Never
   - [2] Rarely (once)
   - [3] From time to time (2 or 3 times)
   - [4] Often (5 or more times)
3. Have you reduced the quantity of food served to children in this household in the last seven days?
   - [1] Never
   - [2] Rarely (once)
   - [3] From time to time (2 or 3 times)
   - [4] Often (5 or more times)
4. Have members of this household skipped meal in the last seven days?
   - [1] Never
   - [2] Rarely (once)
   - [3] From time to time (2 or 3 times)
   - [4] Often (5 or more times)
5. Have members of this household skipped meal for the whole day?
   - [1] Never
   - [2] Rarely (once)
   - [3] From time to time (2 or 3 times)
   - [4] Often (5 or more times)

Appendix 3: Crop Inventory Data Sheet

Name of the farmer...
Village..
Season..
Total farm area..
Total area for home garden..

Present	Abundance				Total Area............	
	Crop	Use[1]	Variety	Use[1]	Area share	

Key for use: F = Food; C = Construction; M = Medicine; C = Crafts

Remarks

Appendix 4: Focused Group Interview on Gender Issues in Agrobiodiversity Conservation and Management

1. GENDER ROLES

1.1 HOUSE WORKS

Please indicate the following responsibilities by gender

Responsibility	Men	Women	Both	Remarks
Cooking				
Firewood collection				
Fetching water				
Milling cassava/rice				
Cleaning				
Rearing of children				
Taking care of livestock				
Taking products to the market				
• Yams				
• Potatoes (S/potatoes)				
• Mwidu				
• Delega				
• Pigeon peas				
• Ngogwe				
• Tomato				
• Oranges				
• Cassava products				
• Coconut				
• Spices				

NB:

- Men normally dominate Products with high market values.
- Women are responsible for family upkeep including buying of sugar, salt, kerosene and cooking oil (though not a popular product because of the wide use of coconut oil)

Farm works

Crop name / Activity															
	Men[3]	Wo	Bot	Me	Wo	Bot	Me	Wo	Bot	Me	Wo	Bot	Me	Wo	Bot
Land preparation															
Planting															
Weeding															
Birds chasing															
Harvesting															
Storage															
Selling															
Land preparation															
Planting															
Weeding															
Birds chasing															
Harvesting															
Storage															
Selling															

2. Different sources of seeds

Crop / Source								
1. Own farms								
2. Buying*								
3. Borrowing								
4. Both 1&2								
5. Both 1,2,&3								

2.2 Where do you buy?

____

____

__

3. Names of different varieties

4. Varieties that have disappeared/ close to disappear

[3] Men =Men; Wo = Women; Bot = Both men and women

Appendix 5: Dietary Diversity

Indicate all the different foods that you have eaten in the last 30 days. Enter the following codes as indicated

ITEMS	FREQUENCY			Wt[4]
	[1] 16-30 days in a month			24
	[2] 4-15 days in a month			10
	[3] 1-3 days in a month			3
	[4] 0 days in a month			0
Cereals				
Maize				
Sorghum				
Rice				
Wheat				
Other cereals				
Tubers				
Sweet potato				
Taro				
Cassava				
Round potato				
Other tubers				
Vegetables				
Tomato				
Onion				
Beans				
Carrots				
Cabbage				
Okra				
Leaf vegetables				
Other vegetables				
Fish				
Dried				
Smoked				

ITEMS	FREQUENCY			Wt
	[1] 16-30 days in a month			24
	[2] 4-15 days in a month			10
	[3] 1-3 days in a month			3
	[4] 0 days in a month			0
Fruits				
Bananas				
Mango				
Oranges				
Papaw				
Pineapple				
Other fruits				
Meat				
Beef				
Chicken				
Sheep/goat				
Other meats				
Milk products				
Cow milk				
Goat milk				
Other items				
Tea				
Salt				
Butter				
Juice				

6.3 Source of food groups

	Codes

	Codes

[4] Following IFPRI, 1999.

Items	[1] Own farm/home garden [2] Buying/barter [3] Borrowing [4] Others			
Cereals				
Maize				
Sorghum				
Rice				
Wheat				
Other cereals				
Tubers				
Sweet potato				
Taro				
Cassava				
Round potato				
Other tubers				
Vegetables				
Tomato				
Onion				
Beans				
Carrots				
Cabbage				
Okra				
Leaf vegetables				
Other vegetables				
Fish				
Dried				
Smoked				

Items	[1] Own farm/home garden [2] Buying/barter [3] Borrowing [4] Others			
Fruits				
Bananas				
Mango				
Oranges				
Papaw				
Pineapple				
Other fruits				
Meat				
Beef				
Chicken				
Sheep/goat				
Other meats				
Milk products				
Cow milk				
Goat milk				
Other items				
Tea				
Salt				
Butter				
Juice				