



Enset- Based Agrobiodiversity in the Agricultural Landscape of Kambatta Tembaro (KT), Southern Ethiopia

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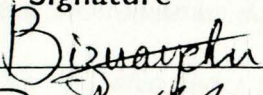
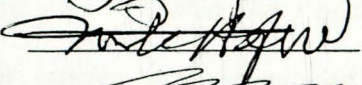
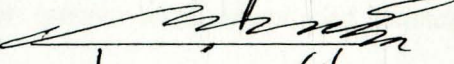
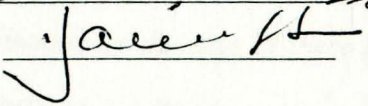
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(KT), Southern Ethiopia

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ABSTRACT

The management of agrobiodiversity (AB) by farmers buttresses sustainable food security and continuous ecosystem services against the predicted future global environmental change. However, the loss of traditional knowledge on local landraces and breeds, inadequate information on AB distribution, and the focus on improved varieties are becoming threats for the long-term conservation of AB. The current study focuses on agrobiodiversity of enset- based agricultural landscape of KT, southern Ethiopia. The agroclimate of the areas was used for selecting a total of 12 study sites (farmscapes). To understand the roles of the socio-economic conditions on AB, 180 households (HHs) were selected based on the wealth status. Environmental data such as slope and elevation were recorded for each sampling sites. The area share of the crop as well as woody species was measured, and the species were inventoried. Standard ethnobotanical methods were used to collect information on the uses of these plant species. The data analyses were carried out by CANOCO for Windows ver. 4.52, R program 2.14.0, Minitab ver 15, and SAS ver. 8.02.

*A total of 371 plant species were recorded whereby crops are 92 and woody species are 186. A total of 170 medicinal plant species that are helpful in the primary health care of the human and the livestock are reported. Seventeen plant species endemic to Ethiopia were identified, of which thirteen are medicinal plants. Years of farming, livestock holding, and distance to market influenced the number of crop species significantly. There are 111 landraces of enset (*Ensete ventricosum*) recorded from the study area. The number of landraces increases with increase in the farmland size and the elevation. The slope, age of farmland, area of the woodlot, and available HH labour influence the woody species richness. One exotic tree species, *Eucalyptus camaldulensis* was identified as the most important woody species. Finally, it is recommendable to train extension agents on the areas of AB maintenance so that they would assist farmers effectively. Moreover, avoiding extensive plantation of *Eucalyptus* on crop fields may contribute to the long-term persistence of AB of the study area.*

Key words: Agrobiodiversity, crop landraces, Enset, Kambatta Tembaro, medicinal plant, traditional management, and tree diversity

DEDICATION

This study engaged many individuals, institutions and resources. I would like to extend my words of gratitude to a few of the many that rendered me support directly or indirectly during my study. Above all, I am most grateful to my family and friends.

I am grateful to my supervisors Professor Shashy Nour-Eldin, and Dr. Farouk Jaleel for their indispensable advice, constructive comments and encouragement that enabled me to

complete this study. I am also grateful to my colleagues for their support and cooperation

This thesis is dedicated to my late father, Maryo Salamo

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Different government officers cooperated in facilitating data collection for this study. Due

to a few, the management and staff of Kombaba Tamboro, Gadda and Darbaya,

Donggala, Angara, Kacha, Hadero and Tando Zaria, Terbaro, and Kacha district

Office of agriculture as well as management members and sampled households of Arco,

Sadicho, Hobiachaka, Kazaia, Sigaro, Chamo, Menale, Korocho, Tera Agari, Ka-

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ITPGR - International Treaty on Plant Genetic Resources

IVI - Importance Value Index

KT - Kambatta Tembaro

KTRADP - Kambatta Tembaro, Rural Agriculture and Rural Development Project

KTRDO - Kambatta Tembaro Rural Health Office

MP - Medicinal Plants

PA - present associations

SNRP - Southern Nations, Nationalities Peoples Region

TK - Traditional Knowledge

TLIP - Traditional Livelihoods Index

TRIP - Trademark - Trade Related Aspects of Intellectual Property Rights

UNEP - United Nations Environment Program

WTO - World Trade Organization

ZARD - Rural Agriculture and Rural Development

LIST OF ACRONYMS

AB- Agrobiodiversity
AF- Agroforestry
CBD -Convention on Biological Diversity
CBDC- Community Biodiversity Development and Conservation
CGB - Community Gene Banks
DBH- Diameter at Breast Height
DPPC- Disaster Prevention and Preparedness Commission
FAO- United nations Food and Agricultural Organization
FGD- Focus Group Discussion
GDP – Gross Domestic Product
GHGs- Green House Gases
HG- Homegardens
HH- household
IBC- Institute of Biodiversity Conservation
IDRC- International Development Research Center
IPRs - Intellectual Property Rights
ITPGR- International Treaty on Plant Genetic Resources
IVI -Importance Value Index
KT- Kambatta Tembaro
KTZARD - Kambatta Tembaro Zonal Agriculture and Rural Development
KTZHO - Kambatta Tembaro Zone Health Office
MPs- Medicinal Plants
PAs- peasant associations
SNNPR- Southern Nations, Nationalities Peoples Region
TK- Traditional Knowledge
TLU-Tropical Livestock Unit
TRIPS Agreement - Trade Related Aspects of Intellectual Property Rights
UNEP – United nations Environmental Program
WTO- World Trade Organization
ZARD- Zonal Agriculture and Rural Development

CHAPTER ONE

1. INTRODUCTION

1.1. BACKGROUND AND JUSTIFICATION

Agrobiodiversity or agricultural biodiversity is a new discipline that has developed from a synthesis of biodiversity researches (Qualset *et al.*, 1995) and has been recently considered as an issue worthy of special attention and study (Mwalukasa *et al.*, 2003). It refers to the variety and variability of plants, animals and micro-organisms used directly or indirectly for food and agriculture (e.g., production of food and fodder), supporting and determining the diversity of agroecosystems (FAO, 1999a). Agrobiodiversity also includes the associated cultural knowledge (Rudebjer *et al.*, 2009).

The richness of AB increases productivity (Thrupp, 2003), medicinal uses, feed, fiber, and food and livelihood security (Melaku Worede *et al.*, 2000), rituals benefit (Frankel *et al.*, 1995), and against diseases, pests, drought, and other stresses (Thrupp, 2003) by offering raw material for improving the adaptability and resilience of the farming systems (PAR, 2010), provides vital ecosystem services for farms (Schroth *et al.*, 2004).

Agricultural biodiversity is developed and protected by indigenous farmers, forest dwellers, livestock keepers and fishermen (Munzara, 2007) who are the custodians (PAR, 2010), and their knowledge is vital for its conservation (von Lossau and Qingsong, 2011). Yet, the concept of agricultural biodiversity is by no means a new concept (Thrupp, 1998). The neologism 'biodiversity' was coined in 1986 as a catchy replacement for 'biological diversity' (Jablonski, 2003) but the term agrobiodiversity was not mentioned and published until 1994 (Brookfield and Padoch, 1994).

Recognizing the urgency of biodiversity losses in 1992 in the international policy arena (UNCED, 1992; Thrupp, 1998), AB was addressed for the first time in a comprehensive manner by the 3rd conference of parties of the Convention on Biological Diversity (CBD) in 1996 (Jarvis *et al.*, 2007). Subsequently, the importance and major contributions of AB were recognized (Munzara, 2007). The Convention on Biological Diversity (UNCED, 1992) and the International Treaty on Plant Genetic Resources for Food and Agriculture (FAO, 2001) created a formal international legal mandate for agrobiodiversity conservation (Jarvis and Hodgkin, 2008). Later on the first large scale researches on AB were published (Collins and Hawtin, 1999; Lenne and Wood, 1999).

Ethiopia is rich in agrobiodiversity. It represents one of the eight centres of crop genetic diversity (Engels and Hawkes, 1991) and is endowed with endemic flora. Most of these flora (about 1000 taxa) were also reported to play key roles in the primary health care system of the country (Edwards, 2001; IBC, 2007). Nearly 80% of the people, and 90% of livestock population in Sub-Saharan countries rely on medicinal plants (MPs) for primary health care (Rao and Rao, 2006). Recently, Edwards (2010) reported that more than 480 species of wild trees, shrubs and herbs are useful forest-food sources and medicinal plants in Ethiopia. The majority of these MPs are used for treatment of livestock ailments as well. Furthermore, tree species scattered across farmlands also play key ecological functions and have high socio-economic values (Tesfaye Abebe *et al.*, 2006). Ethiopia also has the highest livestock population in Africa (IBC, 2009). Therefore, sustainable management of the diversity of woody species at a landscape level ensures long-term persistence of these multiple purpose agrobiodiversity resources.

Agriculture is the main source of about 85% of the rural livelihoods of Ethiopia and this sector contributes about 55% of the country's GDP (EPA, 2012), 86% of the total export earnings (Wolday Amha, 2011). Nonetheless, the current trend in crop production is shifting towards cultivation of cash crops (e.g., khat and ginger), heavily relies on a small group of crops (Melaku Worede *et al.*, 2000) and uses of pesticides (Thrupp, 2000), and animals production that focuses on new livestock breeds and breeding practices (Thrupp, 2000; FAO, 2007; IBC, 2009). Population growth (FAO, 1996), land use changes and habitat loss (Tomich *et al.*, 2011) and climate change (IBC, 2009) are also recognized as the main factors leading to the decline of natural vegetation. This trend in agricultural practices and both human and natural factors are mainly affecting sustainable management of AB in Ethiopia.

The loss of biodiversity in natural habitats surrounding agricultural areas results in the disruption of the ecosystem services such as pollination (Thrupp, 2000). It also reduces the available potentially useful pool of genetic resources (Sinafikeh Asrat *et al.*, 2009) that may negatively affect sustainable food security (Thrupp, 2004). Furthermore, AB loss increases vulnerability to climatic stresses (Sinafikeh Asrat *et al.*, 2009) and enhances susceptibility to diseases (Regassa Feyissa, 1999). The tendency to look mainly at the major food crops masks the importance of plant species diversity (Munzara, 2007). Crops grown in Ethiopia are diverse (IBC, 2007). Nonetheless, a checklist of crop diversity is incomplete (Teshome Hunduma, 2006), particularly from the homegardens (Zemedede Asfaw, 2002). Although the understanding of the factors explaining these variations of AB across the farmscapes of Ethiopia need further in depth studies, little information is available for selected parts of Ethiopia.

Farmland size and aspect of the farmland (Awegechew Teshome, 2001), education of the farmers (Benin *et al.*, 2003), years of farming experiences (Sinafikeh Asrat *et al.*, 2009), access to markets, altitude, slope of the farmland and livestock holding (Tesfaye Abebe, 2005) are some of the vital factors influencing crop diversity across the farmscapes of Ethiopia. Therefore, in depth knowledge of these factors may assist to understand how farmers manage AB under various circumstances.

The enset-based farming systems of southern Ethiopia encompass grain crop species, root and tuber crops, multiple purpose trees/shrubs species and herbs. It is also supplemented by livestock rearing (Brandt *et al.*, 1997; Eyasu Elias, 2003). KT Zone is one of the 13 Zones of SNNPR State practicing enset-based farming system (SNNPR, 2008). Ninety-four percent of the Ethiopian population relies on wood-based and biomass fuel for household energy (Edwards, 2010), which may show the need to grow trees on agricultural lands as natural forests and wood lands are dwindling in size and quality. There are tree/shrub species scattered across the enset-based farmscapes, their diversity and future long-term persistence is not known. Besides, agroforestry, in most cases is dominated by *Eucalyptus* (Edwards, 2010). This trend may influence the traditional AB management and diversity of tree/shrub species. In the long-term, the exotic, fast growing tree species may dominate traditional farmscapes of the study area. Although there are now mounting evidences which support the relative importance of *Eucalyptus* trees for a regeneration of native tree/shrub species such as *Olea europaea* subsp. *cuspidata* (Desalegn Tadele and Demel Teketay, 2010), *Coffea arabica* and climate change mitigation (Gil *et al.*, 2010), the traditional understanding that it completely inhibits natural regeneration of native flora is still the point for debate in an Ethiopian context.

Farmers usually grow and manage medicinal plants close to their homegardens. As part of the agrobiodiversity, this group of useful plant resources is threatened with local extinctions from their natural environment surrounding the traditional farmscapes due to human activities and modernization (Solomon Mequanente, 2009; Edwards, 2010). Homegardens are their current viable repositories and the knowledge how farmers manage these plants are key for understanding their long-term persistence.

Enset-based farming system is dominated with various landraces of enset, which have different uses. However, there are mounting challenges for the management of these landraces by farmers due to factors like pests, diseases and the scarcity of farm land. The study on the diversity of enset landraces has given attention and well documented across considerable ethnic groups (Almaz Negash, 2001; Admasu Tsegaye, 2002; Bizuayehu Tesfaye and Lüdders, 2003) although studies on various aspects of enset were done by earlier scholars in southern Ethiopia (Tsedeke Abate *et al.*, 1996). However, no study was conducted in KT Zone on enset landraces and its management. Hence, the current study encompasses this issue to fill the gap.

Previous studies with regard to agrobiodiversity have focused on homegardens alone (Tsfaye Abebe, 2005). Farmscape level studies are required to understand the regional and cultural dynamics of agrobiodiversity management. The current study focuses at farmscapes across different agro-climatic zones of KT Zone to examine the regional biophysical and socio-economic factors contributing to the management of crop, woody species and other useful plant agrobiodiversity. It also investigates factors influencing the long-term persistence and management of these biological resources.

1.2. OBJECTIVES OF THE STUDY

1.2.1. General objective

The main objective of this study is to investigate the diversity, ethnobotanical uses and the effects of natural and social environment on the management of the overall agrobiodiversity in enset-based agricultural landscapes of KT Zone.

1.2.2. Specific objectives

The specific objectives of this study are to:

1. Study the diversity and distribution of crop agrobiodiversity and functional groups in different farmscapes across agroclimatic zones;
2. Investigate the morphological diversity of enset landraces of the study area;
3. Investigate the composition and diversity of woody species and factors influencing their distribution across farmscapes (homegarden, crop field, woodlot, hedge/field margin) ;
4. Examine the cultural uses of native plants with respect to their medicinal values;
5. Understand the long-standing indigenous knowledge for the management of agrobiodiversity, and
6. Develop sound conservation strategies for long-term persistence of the agrobiodiversity of the study area

Based on the above objectives the study, therefore, hypothesized the following:

1. Native woody species decrease with increasing crop diversity across farmscapes.
2. The diversity and density of native tree/shrub species decreases with decreasing wealth status of the farmers but instead crop diversity increases to compensate for the scarcity of farmland.
3. Stressed livelihoods forced the farmers to grow more *Eucalyptus* on their crop fields.
4. Socio-economic factors (e.g. market access) decrease the diversity and density of native trees/shrubs across the farmscapes but instead increase crop diversity.
5. Enset landraces increase with increase in the number of livestock and farm size across the agroclimatic zones.
6. Agrobiodiversity increases with increasing elevation, years of farming and available labour but decreases with education.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. AGROBIODIVERSITY

Although sometimes used interchangeably, the words “agrodiversity” and “agrobiodiversity” have discrete meanings. According to Brookfield and Stocking (1999), agrobiodiversity is one of the components of agrodiversity. Agrodiversity refers to interactions between agricultural management practices, farmers’ resource endowments, bio-physical resources, and species. It covers four elements: **Biophysical diversity**- the diversity of the natural environment including the inherent quality of the natural resource base; **Management diversity** -all methods of managing the land, water, and biota for crop and livestock production, and the maintenance of soil fertility; **Organizational diversity**- includes the manner in which farms are operated, owned, and managed, and the use of resource endowments from different sources, and **Agrobiodiversity**- refers to all species and varieties useful to people, with a particular emphasis on crop, plant, and animal combinations.

Agrobiodiversity is a part of biodiversity (FAO, 2005), the variability among living organisms from all sources (UN, 1993), including the diversity of the agro-ecosystems (FAO, 1999a) (Fig.1). Agroecosystems are those ecosystems that are used for agriculture, and comprise polycultures, monocultures, and mixed systems, including crop-livestock systems, agroforestry, agro-silvo-pastoral systems, aquaculture as well as rangelands, and fallow lands (FAO, 1998).

The diversity in agroecosystem may be described according to its hierarchy, genetic (the variability within plant and/or animal species), species (the variability in kind and number of organisms), and ecosystem level- the different mix of crops, trees, livestock, and topographies (Long *et al.*, 2000).

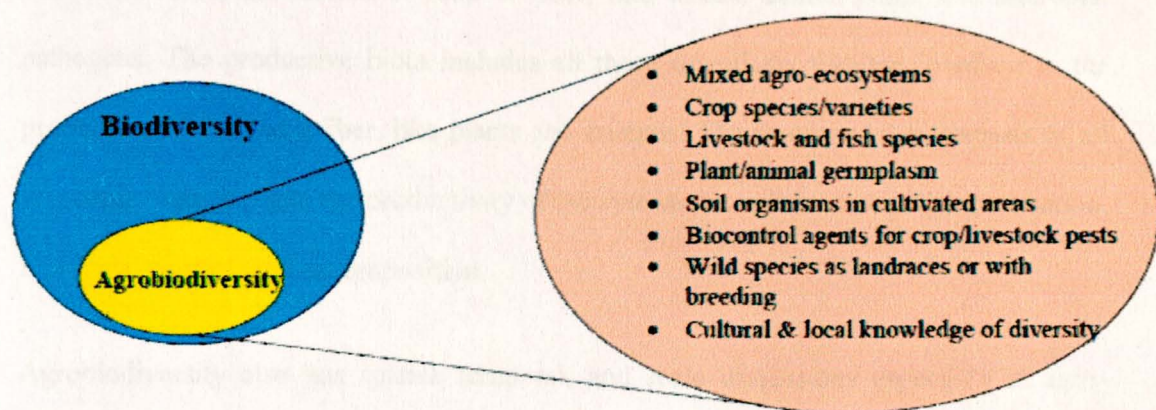


Figure 1. The components of agrobiodiversity

Source (FAO, 1999a; Rapport *et al.*, 2003)

The diversity in an agroecosystem is also grouped as “planned” and “unplanned” (Altieri, 1999; Lenné and Wood, 2011b). The planned agrobiodiversity refers to the plants and animals subject to purposeful incorporation and specific management (Altieri, 1999) that involve the varied local biotic and abiotic environments, and the human ability to introduce crops and their pests and diseases from elsewhere, and the selection within and between these varieties (Lenné and Wood, 2011b). On the other hand, unplanned agrobiodiversity consists of indirectly managed organisms such as pollinators, weeds and pests whose role in the agroecosystem is mediated by the planned diversity (Altieri, 1999). Agrobiodiversity therefore includes not only a wide variety of species and genetic resources that directly or indirectly affect agriculture but also local knowledge and culture essential for agrobiodiversity conservation (Brookfield, 1995; Rudebjer, 2009).

Moreover, diversity in agroecosystem is described in terms of classifying the biological components in agricultural areas into destructive, productive, and resource biota (Swift and Anderson, 1994; Altieri, 1999). The destructive biota are those which do not contribute to the production of food or fiber, like weeds, animal pests, and microbial pathogens. The productive biota includes all those organisms that are involved in the production of food and fiber, like plants and animals. The resource biota consists of all organisms that chip into the productivity of the system through processes like pollination, biological control, and decomposition.

Agrobiodiversity also has spatial, temporal, and scale dimensions especially at agroecosystem levels (Kameri-Mbote and Cullet, 1999). Diversity can be enhanced in time through crop rotations and sequences and in space in the form of cover crops, intercropping, agroforestry, and crop/livestock mixtures (Altieri, 1999). The three sets of factors, namely the genetic resources, the physical environment and human management practices determine the agroecosystem (Kameri-Mbote and Cullet, 1999).

Agrobiodiversity exists because of the wide range of varying climates, habitats and farming practices found within the centres of diversity and the natural selection (Cohen and Potter, 1993), including the practice of culturally diverse peoples (FAO, 2005). The major components of agrobiodiversity include:

2.1.1. Crop diversity

Crop biodiversity refers to all diversity within and among domesticated crop species (Lenne and Wood, 1999). Crop genetic resources are the product of the interaction between human and natural selection of plants, yielding a set of domesticated crops and

varieties used in agricultural production (Cavatassi *et al.*, 2006). Ethiopia represents one of the eight centres in the world where there is high crop diversity (Engels and Hawkes, 1991). The socioeconomically crucial teff and coffee are represented in the country by landraces and wild types (Melaku Worede *et al.*, 2000). The rich crop resources of Ethiopia that originated through domestication or introduction have been conserved in-situ in crop fields and homegardens (Zemedu Asfaw, 2002). Much of this crop diversity is found in the fields of small holder farmers, who have played a central role in the maintenance of these resources (Melaku Worede *et al.*, 2000).

2.1.1.1. Crop landraces

Traditional crop varieties, generally known as 'landraces', but also called 'farmer varieties' or 'local varieties' have been persistently maintained by farmers within their local biological, cultural and socio-economic context (Veteläinen *et al.*, 2009). Landraces are the earliest cultivated forms of a particular crop that evolved from the wild populations (Poehlman, 1987). These display varying degrees of morphological and genetic integrity, but they are recognized by farmers on the basis of a number of morphological and agronomic criteria (Brush, 2000; van de Wouw *et al.*, 2009). Farmers have names for them and different landraces are understood to vary in adaptation to soil type, time of seeding, date of maturity, height, nutritive value, use, and other properties (Harlan, 1975). In short, a landrace is a dynamic population(s) of a cultivated plant that has historical origin, discrete identity and lacks recognized crop improvement, genetically diverse, locally adapted and culturally selected populations (Camacho Villa *et al.*, 2005).

Farmers need genetic diversity for the multiple subsistence purposes of the farmer-household (e.g., consumption and market) as well as to cope with environmental variation (Almekinders, 2001). Farms in Ethiopia are small in size and spread across highly heterogeneous agro-ecologies. They display high variability over time with climatic and production conditions. This highly heterogeneous production environment brings about a demand for diversity of varieties that can meet diverse needs of the farm HHs (Kontoleon *et al.*, 2009). Landraces have attributes that farmers desire, e.g., taste (Cavatassi *et al.*, 2006). Local varieties in the course of selection, recombination, and mutation have developed their distinctive traits to adapt to marginal production areas for example, crops like sorghum are adaptive to drought (Thijssen *et al.*, 2008).

Landraces that tolerated the harsh environmental factors became the ancestors of the modern crops (Poehlman, 1987), which are maintained on each peasant farm following the traditional practices of selection, production, storage, and utilization (Melaku Worede *et al.*, 2000). Therefore, landraces are the result of selection pressures arising from interactions between cultivars, the natural environment and human communities that husband the crop (Biber-Klemm and Cottier, 2006; Kontoleon *et al.*, 2009).

The distinctions between landraces and modern cultivars is that modern variety is the product of a formal crop-breeding process undertaken with clear breeding objectives (Biber-Klemm and Cottier, 2006). Landraces are preferred to modern high yielding varieties due to their adaptability to low moisture, superior cookery and nutritional qualities, and specific adaptation to marginal areas with little or no access to agrochemical input, more tolerance to environmental stresses, yield stability, multiple

food use, etc (Thijssen *et al.*, 2008). In addition, they provide good animal feed, have religious, ceremonial and cultural significance (Frankel *et al.*, 1995).

The diversity of landraces in a certain area can be recorded practically based on landrace nomenclature and expert knowledge. More recently, a study of a list of landraces that are each distinct from one another, can be identified by molecular method (Del Greco *et al.*, 2007). Two classes of landraces were recognized: autochthonous (landraces cultivated for more than a century in a specific region) and allochthonous (a landrace that is introduced into another region and becoming locally adapted) (Zeven, 1998).

Landraces have various uses. For instance, the genetic diversity of traditional varieties of crops are the basic raw materials for breeders (Wood and Lenné, 1997; Melaku Worede *et al.*, 2000; Padulosi *et al.*, 2012), a defence against pests, diseases and environmental changes (Bellon, 1996; Kontoleon *et al.*, 2009; Veteläinen *et al.*, 2009), making them more suitable than commercial varieties. A gene from Ethiopian barley landrace protects California barley from viruses, and saves American farmers some 160 million dollars per year (Hoyt, 1988). Landraces are used in some cultural rituals, in generating prestige, and forging social ties (Bellon, 1996), and guarantee food security (Bellon, 1996; Cavatassi *et al.*, 2006). Therefore, the importance of farmers' varieties for food security needs to be recognized, and international marketing opportunities need to be further investigated (Bellon, 1996; Thijssen *et al.*, 2008)

There are various potential methods that help to maintain landraces, namely participatory crop breeding using local varietal knowledge, creating tourism attraction to the local landraces, and establish seed bank to provide the communal institutions with desired

landraces. Furthermore, homegardening and the use of landraces for medical and religious traditions also help to preserve landraces (von Lossau and Qingsong, 2011).

2.1.2. Uses of plants growing in farming systems

Nearly 80% of the people, and 90% of livestock population particularly living in Sub-Saharan African countries (Endashaw Bekele and Shigeta, 2008) rely on MPs for primary healthcare (Kumar and Nair, 2006; Rao and Rao, 2006). The relative high price of synthetic medicines makes traditional medicines the only feasible choice for the poor people (Trivedi, 2009). MPs are the richest bio-resources of drugs of traditional medicinal systems, modern medicines, nutraceuticals, food supplements, folk medicines, pharmaceuticals (Hammer *et al.*, 1999), and pesticides to protect crops (Rao and Rao, 2006). The indigenous peoples of different localities have developed their own specific knowledge of plant resource uses, management and conservation. Accordingly, traditional medicine has become an integral part of the culture (Pankhurst, 1965; Pankhurst, 2001). MPs have cultural, social, ecological and economic uses in addition to their major role (Emiru Birhane *et al.*, 2011).

In the Ethiopian Flora about 1000 identified MP species have been reported (Abebe Demisse, 2001; Edwards, 2001; Edwards, 2010). There are about 887 plant species, of about 6500 species of higher plants in Ethiopia (Tewolde Berhan Gebre Egziabher, 1991; Mesfin Tadesse and Brook Mesfin, 2010) to be utilized in treating nearly 300 physical and mental disorders. The larger proportion of MPs are herbs (31%), followed by shrubs (19%) and trees (12.4%), and 24 of the MPs are endemic to Ethiopia (IBC, 2009).

Most of the MPs have traditionally been collected from forests and natural habitats (Kumar and Nair, 2006; Edwards, 2010). They can be distributed in farmlands, grazing and browsing lands, farm borders and spiritually protected areas, roadsides, and areas surrounding agricultural lands such as degraded woodlands (Debela Hunde *et al.*, 2006). But MPs used by the herbalists in Ethiopia are collected mostly from the natural vegetation, and imported informally by traders (Endashaw Bekele, 2007). In Ethiopia, the reported MPs distribution by their state of existence for wild, cultivated, weedy and undetermined was 40.2, 10, 5.9 , and 43.8%, respectively (IBC, 2009).

In the past, taboos, and social restrictions on collecting MPs and the nature of plant gathering equipment all served to limit MP harvesting (Trivedi, 2009). Currently, MPs are under threat largely due to anthropogenic factors (Abebe Demisse, 2001; Belachew Wassihun *et al.*, 2003; Mirutse Giday, 2007; Mirutse Giday *et al.*, 2009; Emiru Birhane *et al.*, 2011), particularly environmental degradation, and change in the peoples' lifestyles (Edwards, 2001; Debela Hunde *et al.*, 2006), agricultural expansion, deforestation and over harvesting of species (Ensermu Kelbessa *et al.*, 1992; Edwards, 2001; Trivedi, 2009), fire and overgrazing (Haile Yineger *et al.*, 2008b), the impact of alien species and climate change (Muthuswamy and Solomon Mequanente, 2009), and agrochemical applications (Mirutse Giday *et al.*, 2009). Further, insects, pests, floods and other natural calamities may also deplete MPs (Abebe Demisse, 2001). The knowledge of MPs is decreasing as less and less MPs are being utilized by the contemporary society. Similarly, the lack of schemes for equitable sharing of benefits, poor market opportunities, and lack of full alliance of some traditional healers may be threats to MP conservation (Endashaw Bekele, 2007).

The targeted conservation measures can be achieved by encouraging people to grow MPs in their homegardens, live fences, farmlands (Rao *et al.*, 2004; Debela Hunde *et al.*, 2006; Trivedi, 2009), and in agroforestry (Rao *et al.*, 2004). Furthermore, developing systems of benefit sharing for conservation of vegetation (Debela Hunde *et al.*, 2006) and human capacity building (Oryem *et al.*, 2010) assist as conservation measures.

2.1.2. Agroforestry in the agricultural matrix

The word agroforestry (AF) was accepted as a new concept in late 1970s (Nair, 1993), although it is as old as humanity (Genesis 2: 5—10). Agroforestry is regarded as a dynamic, ecologically based, natural resources management system that integrates trees on farms and agricultural landscapes, diversifies and sustains production for increased social, economic, and environmental benefits for land users at all levels (ICRAF, 2000). It is an integrated approach to solving land-use problems by allowing farmers to produce food, fiber, fodder, and fuel simultaneously from the same unit of land (Badege Bishaw and Abdu Abdelkadir, 2003). It also recognizes the use of trees and shrubs on farms to support agricultural production, protect soil and water resources (Nuberg *et al.*, 2009; Galluzzi *et al.*, 2010), cope with environmental variation (Almekinders, 2001) such as climate change mitigation (Zimmerer, 2010), enhance biodiversity, improve landscape values (Nuberg *et al.*, 2009), and provide multiple subsistence for farm HHs (Almekinders, 2001).

Thus, the presence of diverse on-farm tree species that serve different socio-economic and ecological functions could contribute to the sustainability of agricultural systems (Tesfaye Abebe *et al.*, 2006), and biodiversity conservation (Motuma Tolera *et al.*, 2008).

Agroforests are uniquely suited to provide eco-agricultural remedies that increase food security (Atta-Krah *et al.*, 2004; Zenebe Gebreegziabher *et al.*, 2010). Agroforestry also provides non-timber forest products (NTFPs) such as honey, construction materials, farm tools, and medicine (Zenebe Gebreegziabher *et al.*, 2010). Farmers grow trees in search of their livelihood goals of income generation (Alemnew Alelign *et al.*, 2007), risk management, and optimal use of land, labour and capital (Arnold and Dewees, 1995).

AF was meant to address challenges associated with deforestation, land degradation, loss of biodiversity, risks of climate change, and rising hunger, poverty and malnutrition (Badege Bishaw and Abdu Abdelkadir, 2003; Leakey *et al.*, 2005). From the analysis of different studies, it was shown that Ethiopia is losing an average of 1.0–1.5 percent of its woody biomass annually through deforestation (Mulugeta Lemenih and Tadesse Woldemariam, 2010). In Ethiopia, deforestation, accelerated soil erosion, and land degradation are becoming serious problems, particularly in the highlands where about 85% of people and 75% of livestock live (Jijo, 2005). The population pressure on the land has resulted the ecological imbalances (Efrem Bechere, 2006). The shortage of firewood has enforced rural people to use animal dung and crop residues than adding to the soil (Edwards, 2010).

Thus, the revival of AF was expected to meet growing demands of increasing population, to compensate forests in the wake of fast increasing rate of deforestation and soil degradation, and to conserve biodiversity (Batish *et al.*, 2008). It is an important strategy towards the Millennium Development Goals of eradicating poverty and hunger,

promoting social equity and environmental sustainability (Leakey *et al.*, 2005), and considered as an alternative paradigm to rural development (FAO, 1995).

The most commonly used criteria to classify agroforestry systems and practices are: (1) structure of the system (nature and arrangement of components, e.g. vertical stratification); (2) function of the system (role and output of components e.g., windbreak); and (3) socio-economic scales of management and commercial goals, and 4) ecological distribution, e.g., agroforestry systems for tropical highlands (Nair, 1993). But these classifications of AF are not independent. All systems are characterized by three basic components, namely, woody perennials (trees/shrubs); herbaceous plants (crops); and animals; thus, three basic types of agroforestry systems are classified according to their component compositions (Nair, 1989; Nair, 1993) a) Agrosilvicultural systems (crops and trees/ shrubs); b) Silvopastoral systems (trees + pasture and/or animals), and 3) Agrosilvopastoral systems (trees + crops + pasture/animals).

The diversity of woody species in AF is influenced by age and size of farmlands, wealth status of the HHs, moisture distribution (Motuma Tolera *et al.*, 2008), and land and tree tenure (Muneer, 2008). Furthermore, soil nutrients (Kiros Hadege *et al.*, 2004), type of farming and the surrounding landscape (Boutin *et al.*, 2008), socioeconomic factors like marketing (Jensen, 1993), level of education, contact with extension agents (Muneer, 2008), and the physical environmental factors e.g., altitude (Motuma Tolera *et al.*, 2008), slope and aspect (Parker and Bendix, 1996), and population pressure (EFAP, 1994) also influence tree species diversity in agroecosystems.

Farmers maintain diversity and density of woody plants on their fields through enrichment planting using indigenous and exotic species (Motuma Tolera *et al.*, 2008). Farm forestry, in most cases is dominated by Eucalyptus as the largest source of income (Edwards, 2010). Studies distinguished four main reasons for local tree planting: maintaining the supply when availability of trees/tree products decline due to deforestation; meeting the growing demand for tree products as populations grow; helping to maintain crop productivity in the face of declining soil quality, and reducing socioeconomic risks by providing a reserve of capital available for use as a buffer in times of stress (Arnold, 1997; Buck *et al.*, 1999).

2.1.3. Livestock

Livestock is a major component of mixed crop–livestock systems and makes significant contributions to food production (protein source), income, and social security in east Africa (German *et al.*, 2012). It is important in an enset production system to provide manure to maintain fertility in enset fields. It is also needed for traction, transporting, and draught work (Knips, 2004). The integration of crop–livestock systems is a form of agricultural intensification (Chakeredza *et al.*, 2007). Although livestock resource accounts for 35 to 40% of total agricultural production worldwide, its investment is small due to little awareness. Of the 5,000 known domesticated and semi-domesticated animal breeds, about 30% of those remaining are considered at risk (Gemmill, 2001).

Livestock production is contributing about 18.8% to the total GDP (FAO, 2003) and about 1/3 of agriculture's share of GDP (Cavatassi *et al.*, 2006). It also provides opportunities to about 31% of the total employment opportunities (Getachew Feleke,

2003). The domestic animal population of Ethiopia is estimated to be 47.5 million cattle, 26.1 million sheep, 21.7 million goat, 1 million camel, 39.6 million chickens, 1.8 million horses, 0.4 million mules and 5.6 million donkeys (CSA, 2009). At present there are about 30 cattle, 14 sheep, 14 goat, 4 camel, 4 donkey, 2 horse, 2 mule, 5 chicken and 5 honey bee breeds (IBC, 2009). Because of its favorable climate, the majority of the livestock are found in the highlands (Badege Bishaw, 1993). This may require incorporating the tree and shrub forages into cattle feeding systems without compromising crop production since the grazing land is declining due to human and livestock population pressure (Chakeredza *et al.*, 2007).

2. 2. AGROBIODIVERSITY AND FARMING SYSTEMS IN ETHIOPIA

The farming systems in Ethiopia are diverse, mainly traditional, and are based on combined crop and livestock production (CBDC, 2009). Four main food production systems, namely cereal-based cultivation of the north, the hoe and *enset* complex of south, the shifting cultivation of south west and the pastoral complex of the lowlands of east have evolved (Westphal, 1975). Among these, the *enset* planting complex in the highlands of south and southwestern parts of Ethiopia is supporting a denser population than any of the other systems (Brandt *et al.*, 1997). *Enset* has various landraces which can tolerate considerable environmental stress, once established. Moreover, during environmental hazards and food shortage, *enset* can be harvested and consumed before it is fully mature, though the quality of food and the production may be poor. Because of such qualities of the plant, *enset* growing regions have suffered few food crises in the past (Dessalegn Rahmato, 1996).

Wheat, rice and maize, which are the three major and historically dominant food plants of the world, have had a deep influence on the material and spiritual cultures in their respective regions of cultivation. These include the wheat-growing civilizations of pre-modern Europe and West Asia, the rice growing civilizations of Asia, and the maize growing civilizations of the pre-Colombian America (Braudel, 1985). Similarly, one study (Dessalegn Rahmato, 1996) has reassessed the agro-cultural diversity of Ethiopia, and has identified three major food crops, which can be associated with three broad cultural ecologies. These crops include: *enset*, a major or co-staple in the more humid Southern and South-western, *teff* in the Northern highlands produced as a staple and cash crop, and maize and sorghum in the Eastern and Western parts of the country. However, currently, one can see that many crop plants have been dispersed from one cultural landscape/geographic area to the other through various means, probably with the exception of *enset* whose production has remained mostly to the humid Southern and South-western agroecological and ethnic areas of the country.

2.2.1. Crop cultivation in Ethiopia

The transition from hunter-gathering to animal herding and the growing of crops first occurred 10,000 years ago (Wood, 2011). The collection of useful plants and animals has steadily led to small-scale plant and animal husbandry, whose sustained intensification resulted in the appearance of full-scale agriculture in gardens and fields (Zemedu Asfaw and Ayele Nigatu, 1995). Primeval farmers had effectively experimented with invading wild “weedy” species in their settlement clearances and domesticated probably the first crops. Thus, domesticated crops are culturally created human artifacts-valued for multiple qualities such as taste (Zimmerer, 1991), drought and disease tolerance. The frequency of

crop growing and maintenance of the selected plants under specific agroecological conditions has resulted in a highly diverse landraces.

The domestication of a plant passes through stages from intensified usage of the wild plant to the development of a domesticate (Edwards, 1991; Wood, 2011). CBD defined 'domesticated or cultivated' species as species in which the evolutionary process has been influenced by humans to meet their needs' (Article 2.7) (CBD, 1992). Thus, domestication refers to a process of knowledge and skill, taking the best biodiversity available and changing it to agrobiodiversity, including crops (Wood, 2011).

The biogeographical centers of origin of important food crops are called Vavilov centers (Schmidt and Wei, 2006). Vavilov was the first to observe that the density of interspecific and intraspecific variation of crop species was found in "centers of domestication" which tended to be in the ecologically complex mountainous regions in Africa, Asia, and Latin America (Vavilov, 1926).

Ethiopia is one of the eight world's Vavilov centres (IBC, 2005), a home for a number of food crop varieties suited to various agroclimatic zones (Vavilov, 1949). It is a centre of origin and genetic diversity for a number of crops. According to the International Treaty 'centre of origin' is defined as a geographical area, where a plant species, either domesticated or wild, first developed its distinctive properties, whereas 'Centre of crop diversity' refers to a geographic area that contains a high level of crop genetic diversity in *in-situ* conditions where crop species have developed their distinctive properties' (Article 2) (Biber-Klemm and Cottier, 2006). Ethiopia has a long history of crop cultivation

(Clark, 1976), which can be evidenced by the presence of high agricultural biodiversity, including endemic crops such as teff (Engels and Hawkes, 1991).

The basis for Ethiopian farming is comprised of the traditional landraces (Melaku Worede *et al.*, 2000). A very diverse cultural history of its people over years of artificial selection within the landrace populations resulted an extremely high diversity (Engels and Hawkes, 1991). The highly dissected highland of Ethiopia includes natural barriers formed by mountains or ravines where crop plants would have evolved in isolation. The agroecological diversity and high altitudes made Ethiopia both the center of origin and the center of diversity for many crops such as *Ensete ventricosum* (Edilegnaw Wale, 2004), yielding the country to be one of the richest crop genetic resource centres.

Many crops that are known to have their centres of origin in the fertile crescent of south-west Asia, such as durum wheat (*Triticum durum*), had their highest genetic diversity in Ethiopia. Thus, Ethiopia is a secondary centre of diversity for *T. durum*. That means Ethiopia is a region to which durum wheat was introduced and domesticated. A long history of cultivation of a crop, the movement and exchange of crops, combined with environmental and social factors probably yielded crop diversification (Vavilov, 1926). Further, Ethiopia is also known for its high genetic diversity of crops such as *Hordeum vulgare*, *Guizotia abyssinica*, *E. ventricosum*, and *Plectranthus edulis*. Over 100 plant species used as crops have been identified (Edwards, 1991). Ethiopian farmers developed and maintained different crops and their varieties through saving enough representative seed samples, buying local seed from the village markets, and through farmer-to farmer seed exchange (Regassa Feyissa, 2006; Thijssen *et al.*, 2008).

Ethiopia's crop agriculture continued to be dominated by the numerous small farms that grow mainly cereals: smallholders account for 96% of total area cultivated. The five major cereals (teff, wheat, maize, sorghum and barley) occupy almost 75% of the total area cultivated, 29 % of agricultural GDP in 2005/06 (Alemayehu Seyoum *et al.*, 2011).

2.2.2. Enset farming system in Ethiopia

According to Westphal (1975), within the enset agricultural system, four major enset sub-systems can be recognized, based upon environmental, agronomic, and cultural criteria, as well as the extent to which people depend upon enset as a staple crop. These sub-systems include:

1) *Ensete ventricosum* is the main staple food, which is common in Sidama and Gurage where enset is grown in dense plantations, and is highly dependent upon cattle to produce manure for fertilizing enset fields, 2) *E. ventricosum* as a co-staple crop with cereals (e.g. *Zea mays*) and tuber crops (e.g., *Colocasia esculenta*). The Gamo, Hadiya, Wolayta, and Ari, among other groups of SNNPR, depend upon enset as a co-staple food. The study area is a part of this system. However, many low income HHs of highland areas of KT Zone rely on enset as a main staple crop. Livestock is important to use the manure for fertilizing the fields, 3) *E. ventricosum* and root crops are of secondary importance whereas cereals are dominant, e.g., the Oromo farmers of southwestern Ethiopia where enset is grown largely for security reasons. Livestock are far less important for producing manure as enset fertilizer, and 4) *E. ventricosum* and cereals of secondary importance whereas tuber crops are dominant, e.g., the Sheko, the Northern Omotic-speaking people in southwestern Ethiopia practice hoe-based shifting cultivation, in which *C. esculenta*

and *Dioscorea alata* are the most important crops, while enset, cereals, and cattle-herding are of minor importance.

In enset- based farming systems of the study area most individual holdings comprise of arable crop fields and wood plots, or rarely grassland. There are two farm section units within the arable area namely, the enset based homegarden, and non-enset crop fields away from the homestead. In the enset culture, vegetables, root crops and tubers are chief elements, supplemented by livestock raising that supplies manure to fertilize the soil. Consequently, enset cultivation promotes agricultural diversification.

2.2.2.1. *Enset landraces*

Enset (*Ensete ventricosum* (Welw.) Cheesman) (Fig. 2) belongs to Family Musaceae of order Zingiberales. It is widespread in uplands of tropical Africa south to Angola. The genus *Ensete* has less than ten species in Africa, of which *E. ventricosum* is the only species found cultivated in Ethiopia (Edwards *et al.*, 1997), particularly in the HGs of south and south-western parts (Brandt *et al.*, 1997). It grows at altitudes between 1600 and 3000m asl (Westphal, 1975). This monocarpic herb (flowers and fruits only once) forms a single corm underground and a pseudostem above the ground (Edwards *et al.*, 1997). Enset has entomophilous flowers with abundant sweet smelling nectar. The flowering raceme is cylindrical, 30-40 cm in diameter and 1 m long (Shigeta, 1990).

Depending on agroclimate and the landrace, enset plant may require from 8–16 years to complete its life cycle (Almaz Negash *et al.*, 2002). Then, the true stem emerges through the leaf sheaths, and forms multiple flowers, fruits and seeds (Brandt *et al.*, 1997). Enset (diploid, $2n = 18$) is the species that phenotypically resembles the banana plant (Almaz

Negash *et al.*, 2002), but the edible banana has different ploidy levels (diploid, triploid or tetraploid), with haploid $n = 10$ or $n = 11$ (Ude *et al.*, 2002). The fruit of enset is not edible, hence the name 'false banana'. Enset is robust perennial with swollen base up to 3m in circumference. Pseudo-trunk can grow to about 12m tall, but usually only 2-5 m, and about 40 produced during the life-time of the plant (Edwards *et al.*, 1997).

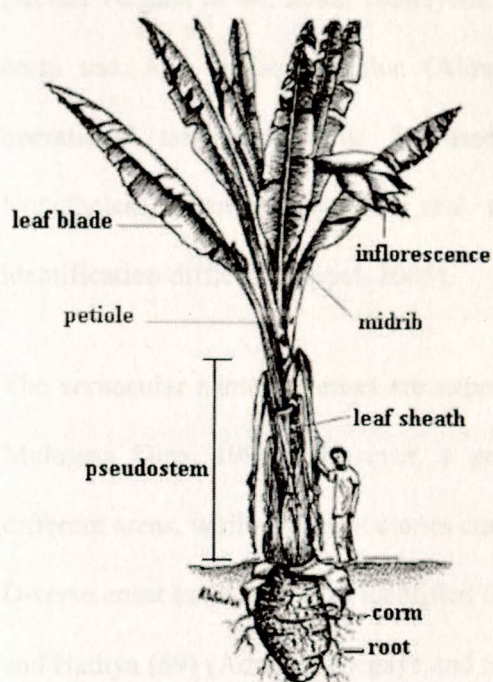


Figure 2. The parts of enset plant

Source: (Admasu Tsegaye, 2002)

The enset plant is usually harvested before it reaches maturity (starting 3 years and above), before or just at flowering, for the carbohydrate-rich pseudostem and underground corm (Brandt *et al.*, 1997). Pseudostems and corms are cut up, pounded and fermented for some weeks. Fermentation takes place in a pit usually dug up to about 1.5m deep and about 1m in diameter, which is also covered with enset leaves. The fermentation process depends on the type of landraces. The fermentation is enhanced by adding a starter called *gammama*. Some landraces that are named by female sex can ferment even before a

week. After fermentation the material is further processed for eating, commonly after making into a flat bread *Kocho*, or flour for gruel *bullā* (Edwards *et al.*, 1997).

Farmers differentiate a large number of enset landraces by their uses, colour (pseudostem, midrib and petiole) and shape, demands of climate, and tolerance to pests and diseases (Almaz Negash *et al.*, 2002; Bizuayehu Tesfaye, 2002), fiber quality, time to maturity, corm use, and medicinal value (Almaz Negash *et al.*, 2002). These can serve as operational taxonomic units for assessing infraspecific diversity (Harlan, 1975). Nonetheless, changing weather and soil causes phenotypic variability, and make identification difficult (Zippel, 2005).

The vernacular names of enset are expected to be 200 in Ethiopia (Endale Tabogie and Mulugeta Diro, 1994). However, a particular variety may have different names in different areas, while different clones could have the same name (Endale Tabogie, 1997). Diverse enset landraces were identified from different regions: Sidama (52), Wolaita (55) and Hadiya (59) (Admasu Tsegaye and Struik, 2002). However, another study in Sidama identified a total of 86 named landraces. The average number of enset landraces per farm varied between nine and 14 (Bizuayehu Tesfaye and Lüdgers, 2003). A large number of landraces are cultivated for manifold purposes (Zippel, 2005), and planting many different landraces is an indication of esteem (Admasu Tsegaye and Struik, 2002).

2.2.2. 2. Uses of enset

The major foods obtained from enset are locally known as *kocho* (*Waasa*), *bullā* (*bu'ulla*) and *amicho* (*hamicho in kambatissa*). *Kocho* is the bulk of the fermented starch obtained from the mixture of the decorticated leaf sheaths and grated corm. *Bullā* is water

insoluble starchy product obtained by squeezing the scrapped leaf sheath and corm, and *amicho* is the inner part of the corm eaten boiled (Brandt *et al.*, 1997). *Kocho* (Waasa) provides carbohydrate and mineral nutrients (Minaleshewa Atlabachew, 2007). The main feature of enset foods is their high energy value (1410–1950 kJ per 100 g dry matter of *kocho*. Per 100 g dry matter the approximate composition of *kocho* is: protein 1.1–2.8 g, fat 0.2–0.5 g, carbohydrates 95–98 g, fibre 2.3–6.2 g, ash 1.7 g, Ca 60 mg, P 68 mg, Fe 7 mg, thiamine 0.06 mg, riboflavin 0.08 mg, niacin 0.6 mg (Agren and Gibbison, 1968). The quality of *Kocho* depends on the age of the harvested enset plant, the type of landrace, and harvesting season. Currently, many rich farmers in the study area export *kocho* to the market to earn cash.

Non-food uses of enset include fiber as a byproduct of decorticating the leaf sheaths. In rural areas, the fiber is used to make sacks, bags, ropes, cordage, mats, construction materials, and sieves. Enset fiber accounts for more than 30% of the Ethiopian fiber production and its strength is equivalent to the fiber of Abaca (Brandt *et al.*, 1997). Fresh enset leaves are used as bread wrappers, serving plates, and pit liners to store *kocho*. The dried petioles and midribs are used as fuel, and to make mats and tying materials for house construction. The pulp from the dried leaf sheaths, petioles, and midribs is used as cleaning rags and brushes, and baby diapers. Dried leaf sheaths are used as wrappers for butter, *kocho*, and other items to transport to local markets. It is an ornamental crop around homes. Enset is considered as a security food crop as it can withstand long periods of drought (Brandt *et al.*, 1997), heavy rains, and flooding, which normally devastates other crops.

2.2.2.3. Factors influencing number and distribution of enset landraces

Enset landraces are not evenly distributed across regions mainly due to variations related to elevation and relative geographic distance. Only few landraces were found to be very abundant and widely distributed (Bizuyeyhu Tesfaye and Lüdders, 2003). The genetic diversity of enset is related to the extent of cultivation and the culture and distribution pattern of the different ethnic groups than geographical distance (Genet Birmeta, 2004).

A combination of factors, including HH resources, use value, population pressure and agro-ecology (Admasu Tsegaye and Struik, 2002), food preferences, climate, pests and diseases, and cultivation systems (Zippel, 2005) influence the number of enset landraces on a given farm. The selection criteria for HH use include the quality and quantity of food products, maturation period, disease and drought tolerance, forage and fibre quality, medicinal value, ease of scraping, quickness of fermentation, quality of corm, and productivity on marginal soils. Since one landrace can never fulfill all criteria, farmers tend to maintain a diverse range of enset types (Admasu Tsegaye and Struik, 2002; Eyasu Elias, 2003). The lack of access to markets accounts for the high diversity of crop plants along elevation (Brush, 1986). As to Bizuyeyhu Tesfaye and Lüdders (2003), maximum diversity of enset is more at high elevation areas, and more landraces are grown by wealthy farmers with more resources, notably land, livestock, and labour force.

2.2.3. Homegardens and agrobiodiversity conservation

The concept of HGs refers to small plots located close to the habitation or adjacent to an area for raising a variety of plant species and sometimes livestock, which are enriched with household wastes and are diverse in plant species, often maintaining 30 to 100

species (Altieri and Koohafkan, 2008). They are micro-environments composed of multi-species, multi-storied structure, and being multi-purpose in use (NHGW, 2004; Gautam *et al.*, 2006). Homegardening is one of the oldest traditional agroecological systems in the humid tropics where humans imitated nature through integrating trees and other perennials, with a mixture of crops, mostly vegetables, herbs and other ornamentals (Altieri and Koohafkan, 2008). They are often bordered from their surroundings by hedges, fences, etc. (Zemedu Asfaw, 2002). HGs are also vital social and cultural areas where knowledge related to agricultural practices is transmitted (Galluzzi *et al.*, 2010).

HGs are commonly referred to as backyard gardens, compound farms, kitchen-gardens, homestead farms, house-gardens, mixed-gardens, village-forest garden and the like (Soemarwoto, 1975; Watson and Eyzaguirre, 2002). The term “homegarden” is preferred since it emphasizes the close relationship between the garden and the social group inhabiting the home (Gautam *et al.*, 2006). It is believed that almost all HGs have evolved over time under the influence of resource constraints, physical limitations, and lack of markets (Fernandes and Nair, 1986).

On the other hand, the history of homegardening in Ethiopia is believed to have been linked with the start of agriculture (Zemedu Asfaw, 2002). HGs with their distinct boundaries may vary in the number of species hosted (Galluzzi *et al.*, 2010), shapes, including the living house, animal houses, grain stores, and plots of garden species (Zemedu Asfaw, 2002), and in their size ranging from 0.01 to 4.0 ha (Fernandes and Nair, 1986). But in extreme cases, HG sizes are as low as 20m² and as high as 6000m². Common locations for gardens in relation to the house in Ethiopia are backyards (48%),

front yards (26%), side yards (13%) and encircling the house (13%). The enset-related HGs of southern Ethiopia with *E. ventricosum* being the key species of the agroecosystem, maintain a large number of species than other types of agricultural production systems (Zemedu Asfaw, 2002).

Homegardens are sites for production (Watson and Eyzaguirre, 2002), AB conservation (Das and Das, 2005), and climate change mitigation (Watson and Eyzaguirre, 2002; Kumar, 2011). They support the conservation of diverse species by sustaining various annual, biannual and perennial plants, and offer a warehouse and domestication testing plots for new crops, as nurseries for plantlets (Altieri and Koohafkan, 2008). In most cases seeds of useful wild plant species that arrived into the garden by wind or animals are integrated into the HGs, subsequently form multi-storied agroforest and contain a mixture of minor crops, fruits, ornamental and medicinal plants, representing over a dozen tree, shrub and herb species (Gautam *et al.*, 2006; Altieri and Koohafkan, 2008). Furthermore, many farmers are found growing several crops in a cyclical pattern (Watson and Eyzaguirre, 2002). The multistory nature of homegardens accompanied with continuous cultivation paved the way for the existence of plant diversity.

The richness of biodiversity enables HGs to provide ecosystem services such as pollination, refuge sites and allowing for gene-flow between plant populations inside and out of the garden (Galluzzi *et al.*, 2010). They also assist in managing pests and disease (Gautam *et al.*, 2006). HGs produce is 'clean' because no pesticides are applied (Watson and Eyzaguirre, 2002). The richness of , especially woody perennials may ensure greater stability of the soil organic matter fractions (Kumar, 2011), and thus retain water and

protect soil erosion (Watson and Eyzaguirre, 2002), increase carbon sequestration (Gautam *et al.*, 2006; Kumar, 2011), and thus contribute to environmental resilience (Zemedu Asfaw and Zerihun Woldu, 1997; Tesfaye Abebe, 2005). Further, maintaining species with different life cycles in the HGs provides multiple purposes (e.g., food, fodder, and medicine) (Galluzzi *et al.*, 2010). Generally, HGs are vital centres of experimentation, domestication, crop improvements, and production (Sthapit *et al.*, 2005)

The structure of HGs varies from place to place according to local physical circumstances, ecological characteristics, social, economic and cultural factors (Christanty, 1985). Moreover, HGs as an ecosystem contain multiple levels of diversity, including cultural, genetic and agronomic diversity (Watson and Eyzaguirre, 2002). The highest biodiversity and complexity among human-made agroecosystems (Swift and Anderson, 1994; Kumar, 2011) made HGs become self-sustaining systems both ecologically and socio-economically (Tesfaye Abebe *et al.*, 2010).

2.2.3.1. Significance of homegardens for rural households

HGs provide diversification of economically significant crop species (Tesfaye Abebe *et al.*, 2010). They harbor rich agrobiodiversity (Garí, 2003) from which food products containing a heterogeneous group of edible food plants are gained. A country wide survey of HGs in Ethiopia showed 172 plant species, of which about 90 species were considered typical HG species while 48 were cultivated both in HGs and crop fields (Zemedu Asfaw, 2002) but a total of 254 species were recorded in Nepal, excluding the ornamental plant species (Gautam *et al.*, 2006). HGs provide key micronutrients such as vitamins, calcium and iron that complement staple crops (Garí, 2003; Gautam *et al.*,

2006). Thus, HGs ensure food security (Zemedu Asfaw and Zerihun Woldu, 1997; Tesfaye Abebe, 2005), and medicinal plants, spices, and some cash income all year round (Schroth *et al.*, 2004; von Lossau and Qingsong, 2011). Further, livestock is kept in the gardens and different tree species are grown to serve as firewood, as well as protection (Tesfaye Abebe *et al.*, 2010). A capacity to represent AB at multiple levels over small spaces made HGs relevant site for *in-situ* conservation (Watson and Eyzaguirre, 2002).

Homegardens are also valued for the maintenance of indigenous knowledge through farmers' social seed networks. By saving seeds and planting materials from home gardens and exchanging it with neighbours, friends and relatives indigenous people are able to maintain both AB and a cultural legacy from generation to generation (Gautam *et al.*, 2006). Accordingly, they are watched with much more care than other fields (von Lossau and Qingsong, 2011).

2.2.3.2. *The nature of homegardens*

Homegardens are dynamic systems whose structure, composition, and species and cultivar diversity are influenced by changes in the socioeconomic circumstances and cultural values (Watson and Eyzaguirre, 2002). The specialized edaphic, microclimatic and biotic conditions make HGs markedly different from the surrounding landscape (Galluzzi *et al.*, 2010). In general the three main determinants of HGs are:

- a) **Socio- cultural and economic factors** including, food habit, ethnicity, market, religious values and norms, gender role, structure of society, access to market, demand and supply of food materials (Gautam *et al.*, 2006), and taboos of the

community (Ahmed and Rahman, 2004). For instance, in Peru native communities in isolation from other ethnic groups with preferences to certain cultivable species resulted in low species diversity (Wezel and Ohl, 2005).

- b) **Ecological factors** : this comprises factors like the availability of the flora and fauna, altitude and the management and ecological functions by soils, water and forest, and
- c) **Farmers' knowledge and awareness**: this includes formal and informal education, extension support; relationship with other people (Watson and Eyzaguirre, 2002; Gautam *et al.*, 2006), and political factors (land use system, marketing policies, conservation policies, etc.) (Watson and Eyzaguirre, 2002).

2. 3. SIGNIFICANCE OF AGROBIODIVERSITY STUDY

Agrobiodiversity, including crops, domestic animals and others originated before 10,000 years ago (Lenné and Wood, 2011a) with careful selection of the traits, tastes and textures that make good food resulted in a copious diversity of genetic resources, varieties and breeds of the relatively few plants and animals. Such diversity permitted farmers to utilize the full range of the highly varied microenvironments differing in features such as soil, water, temperature, and altitude (Melaku Worede *et al.*, 2000).

The maintenance of diversity and systems underpin food security and provide insurance against future threats (Munzara, 2007; Altieri and Koohafkan, 2008). The richness of AB enhances productivity (Thrupp, 2000; Altieri and Koohafkan, 2008), income generation (Brush, 1991; Thrupp, 2000; Kontoleon *et al.*, 2009), rituals benefit (Frankel *et al.*, 1995), nutritional values, feed, and medicinal uses (Melaku Worede *et al.*, 2000; Thrupp, 2000), and acts against adverse environmental stresses (Bellon, 1996; Thrupp, 2000;

Altieri and Koohafkan, 2008; Lenné and Wood, 2011a) caused due to pest, disease attack, or drought (Melaku Worede *et al.*, 2000; Di Falco and Perrings, 2003; CBDC, 2009; Kontoleon *et al.*, 2009; Lenné and Wood, 2011a). The deployment of diversity provides a buffer against the spread of vagaries of weather (FAO, 2010) such as the Irish potato famine (1846–1851), which resulted in a loss of 25% of the population in 10 years (Heal *et al.*, 2004). AB also provides farmers and breeders with raw material (Chaffrin *et al.*, 2006; Galluzzi *et al.*, 2010) for example, plant breeders can develop a new variety by transferring a desired gene into an existing crop variety (Chaffrin *et al.*, 2006), which can improve the resilience of the farming systems (PAR, 2010).

Goods and services provided by AB are endless. Agricultural biodiversity provides ecosystem services, such as pollination and nutrient enhancement (Schroth *et al.*, 2004; Shames, 2008), insect and disease management (Batish *et al.*, 2008), and water retention. Tree covers on-farm provide habitat and maintain the regional climate. For example, they offer habitat for birds and other species (Schroth *et al.*, 2004). Crop genetic diversity also assists the ecosystem to sequester soil carbon, and prevent soil erosion by providing continuous biomass cover (Hajjar *et al.*, 2008).

2.4. TRADITIONAL KNOWLEDGE AND POLICY ISSUES ON AB

Traditional Knowledge (TK) is the information that people in a given community, based on experience and adaptation to a local culture and environment, have developed over time, and continues to develop. It includes mental inventories of local animal breeds, local plant, crop and tree species (Hansen and VanFleet, 2003), and innovations, traditional life styles and practices. TK is a collective asset of a given local community,

which is passed on to next generation in such forms as stories, songs, cultural values, traditional laws, local languages, rituals, medical lore and agricultural practices (von Lossau and Qingsong, 2011).

Agrobiodiversity is developed and protected by indigenous peoples (Munzara, 2007). Traditional agricultural communities depend on, and are custodians of AB (PAR, 2010). For example *Erygrostis tef* is associated with the cultures of the Ethiopian highlands (Biber-Klemm and Cottier, 2006).

TK supports in maintenance and protection of landraces from disease, pests, and the like. For instance, in Areka, Southern Ethiopia farmers employed local knowledge to control mole rats, vertebrate pests causing yield reductions of up to 60% in root crops where conventional methods of controlling the pest had evidenced to be ineffective. But a combination of local and conventional techniques proved to work, and were both less costly and more environmentally friendly (German *et al.*, 2012). Therefore, the maintenance of TK and AB is an indispensable part of rural society (Lengkeek, 2004). Traditional local communities often have a profound understanding of their environment (von Lossau and Qingsong, 2011). Indigenous knowledge held by farmers and communities is studied and documented through ethnobotanical surveys and studies (Brush, 2000; Getachew Addis, 2009).

Ethnobotany is derived from the term ethno and botany. Ethno refers to race, people, cultural group, and nation, whereas botany is the science of plants. Thus, ethnobotany is the scientific discipline that studies the indigenous /traditional knowledge relating to plants (Albuquerque *et al.*, 2008). People know different farming techniques and

numerous ways of using wild plants and animals, for example as food, medicine and dyes (von Lossau and Qingsong, 2011).

Under *Article 8j* the CBD contracting parties have pledged to recognize traditional lifestyles relevant for the conservation and sustainable use of biological diversity. Access to TK must be based on the consent of the knowledge holders and their equitable participation in the benefits arising from the use of such knowledge (CBD, 1992).

Biological resources and TK are defined in the CBD as a collective asset. This contrasts with WTO usage, since the TRIPS Agreement (WTO, 1994) defines private and individual rights to knowledge and intellectual property. It grants protection for plant varieties either through patents or by an effective *sui generis* (unique) system or by any combination thereof (Hansen and VanFleet, 2003). TRIPS of the WTO (1994) puts standard and scope for intellectual property right and member states agreed on patentable subject matters. Article 27.3 (b) of the agreement excludes patentability of plants, animals, and processes for their production. The TRIPS Agreement of the WTO provisions guarantee ownership rights to products made in the laboratories of the north from the bio-materials and knowledge from the local communities of the south. These intergovernmental obliteration of community rights, knowledge, and traditional systems will ultimately lead to the ruin of biodiversity (IDRC, 1994). The contradiction between the CBD and TRIPS is as yet unresolved (von Lossau and Qingsong, 2011) because IPRS systems do not reward local communities for their custodian role (Laird, 2002).

The African Model Legislation for the Protection of Rights of Local Communities, Farmers, and Breeders and for the Regulation of Access to Biological Resources was

finally adopted in 2000 after a period of consultations and negotiations (Biber-Klemm and Cottier, 2006). In recognition of this convention and failure of Article 27.3 (b), the Joint Communication from the African Group (WTO, 2003) has forwarded a review of the article. The African Group stated “Traditional knowledge is a category of intellectual property rights...” and local communities have the right to be respected for their will and decisions and obtain remuneration for sharing their knowledge. Similarly, ethnobotanists recommend remuneration to local study participants for the time they spent with the researcher and release information (Martin, 1995).

Ethiopia has passed a law regarding access to genetic resources, community knowledge and right (Proclamation No. 482/2006, Federal Negarit Gazeta of the Federal Democratic Republic of Ethiopia). It stipulates the necessity to recognize and protect the knowledge of Ethiopian communities, and promote for wider application with approval and sharing of benefits by the communities. Article 6 of the proclamation stipulates that local communities have the right to use their knowledge, regulate access to and share from the benefit of utilizing community knowledge. Article 9 also stipulates that local communities have the right to obtain 50% of the benefit shared by the state which shall be put to the common advantage of the local community.

2. 5. DETERMINANTS OF AGROBIODIVERSITY

Agricultural biodiversity is affected by many factors, both from within the farm and household and from external forces (Mwalukasa *et al.*, 2003). Farmers grow diversity for many reasons such as agronomic (soil diversity and topography); seasonal (time of seeding, maturity, temperature and precipitation); cultivation system (monoculture,

mixed cropping) and pest control; economic (access to market, access and affordability of inputs, marketable traits); culinary traits and end use; storage quality (Maxted *et al.*, 1997; Lenné and Wood, 2011b); indigenous and religious beliefs; social functions, and sentimentality. These include both Socioeconomic and physical environmental factors.

2.5.1. Socioeconomic factors influencing agrobiodiversity

Studies showed that family size of the HH, number of oxen ownership, and land characteristics have promoted AB richness (Chalachew Temesgen, 2007; Di Falco *et al.*, 2010), livestock ownership and labour power being the major determining factors (Benin *et al.*, 2006). For instance, in Bangladesh smallholders with large family size cultivated larger numbers of species (Ali, 2005). On the other hand, agricultural diversification provides a mechanism to alleviate labour stress, e.g., intercropping is a labour-saving strategy, as land preparation efforts serve simultaneously for different crops.

Livestock holding, may act as an insurance against crop production risk, bearing a negative relationship with diversity (Rana *et al.*, 2000). Similarly, Sinafikeh Asrat *et al.* (2009) found that HH resource endowments, contact with extension services, and years of farming experience influence HH crop variety preferences. HGs age influences the diversity of perennial fruit trees, MPs, and trees for construction (Coomes and Ban, 2004), as well as species compositions (Wezel and Ohl, 2005).

Education positively influences cereal crop (Benin *et al.*, 2003) and MP diversity (Haile Yineger *et al.*, 2008b). The wealth status was found to influence species diversity for instance, HGs of poor are dominated by annual crops while those of the wealthy are dominated by perennials (Boncodin *et al.*, 2000). In another study, resource-rich farming

HHs maintained higher levels of varietal diversity (Sthapit *et al.*, 2005) but low-income HHs with their smaller gardens tend to have more diversity (Piniero, 2003).

Diversity seems to decrease with large share of cash crops and woodlots, high population density, and access to off-farm activities (Tesfaye Abebe, 2005). In addition, poor agricultural policy, conflicts and environmental degradation have been reported to influence agrobiodiversity (Cavatassi *et al.*, 2006). As to Mwalukasa *et al.* (2003) the accessibility and use of capital, and off-farm opportunities are factors for creating opportunities to diversify AB, by imposing the constraints on farm investments, and forcing farmers into strategies that minimize HH risk.

Physical features of the farm have large and significant effects on both the diversity among and within crops grown (Benin *et al.*, 2006). As to Chalachew Temesgen (2007), access to road infrastructure as well as access to market services correlated negatively with sorghum genetic diversity. The species abundance decreases as garden distance to market increases (Fentahun Mengistu, 2008). Conversely, it was shown that the more distant the market, the greater the number of crop varieties (Van Dusen, 2000; Mwalukasa *et al.*, 2003). As to Di Falco *et al.* (2010) the distance of farm plots from homestead was negative associated with crop diversity.

The closer the farm to a road, the fewer the number of tree species, the more uneven abundance of the species and the lower the density of trees (Tesfaye Abebe *et al.*, 2006). Wezel and Ohl (2005) also showed that species diversity seemed low in case many plant products are available in the surrounding forests.

The size of farmland influences species richness and diversity (Mwalukasa *et al.*, 2003; Kumar, 2011) where the greatest species diversity was recorded in large gardens. Land tenure security also determine farm level diversity (Di Falco *et al.*, 2010). Wealth in land and kin-ship affiliation, as well as the exchange of plant materials also influence HG diversity (Coomes and Ban, 2004). But Tesfaye Abebe *et al.* (2006) claimed that increasingly smaller farms might lead to a reduction of the perennial crop and tree components as well as livestock. On the other hand, density increases as land size decreases although the average total number of plants per farm is still higher in the large farms (Ahmed and Rahman, 2004).

2.5.2. Biophysical environmental factors

Plant diversity decreases with altitude (Hoogerbrugge and Fresco, 1993) but altitude had a significant positive influence on landraces diversity on-farm (Rana *et al.*, 2005). On the other hand, species diversity increases with increased amount of rainfall and temperature (Tesfaye Abebe, 2005). Di Falco *et al.* (2010) indicated that the level of rainfall is positively correlated with the number of crops. Another study also indicated that natural factors such as climate, farmers' fields (e.g., distance from homestead), and soil (type, fertility, texture, and water holding capacity) mainly influence the inter- and intra-specific diversity of crop genetic resources on-farm (Awegechew Teshome, 2001).

2. 6. THREATS TO AGROBIODIVERSITY IN ETHIOPIA

Ethiopia is an agricultural country where most of its populations depend on agriculture for their livelihood (Djurfeldt *et al.*, 2011). It has been noted that the world's food production and agricultural activities rely on increasingly fragile AB (FAO, 1999b). The

conversion of natural habitats, including habitats surrounding agricultural areas into agricultural land (Thrupp, 2000; Tomich *et al.*, 2011), and the use of few crop groups were recognized to be sources of biodiversity decline (Di Falco and Perrings, 2003; IBC, 2007). Since the 1900s, 70% of plant genetic diversity has been lost (FAO, 1999b) and 30% of the livestock breeds became on the edge of extinction (FAO, 1999b; Drucker *et al.*, 2001). The patterns of industrial agriculture and the 'Green Revolution' have yielded significant biophysical and socio-economic costs on natural resources (Thrupp, 2000).

The available pool of crop genetic resources for breeding became vulnerable to losses from natural or man-made interventions (Di Falco and Chavas, 2006; Trivedi, 2009). Increasing population, climatic changes, overharvesting, introduction of alien species (Trivedi, 2009), pesticides (Trivedi, 2009; Tomich *et al.*, 2011), and social and economic change (Di Falco and Chavas, 2006) brought about AB loss. Natural disasters such as desertification, drought, floods (Putter, 1994; Di Falco and Chavas, 2006), quakes (Trivedi, 2009) also contributed to genetic erosion (Putter, 1994; Di Falco and Chavas, 2006). Genetic erosion may occur at three levels of integration: crop, variety and allele (van de Wouw *et al.*, 2009). A typical example in Ethiopia is the genetic erosion of indigenous durum wheat, *Triticum durum* (CBDC, 2009). Furthermore, land tenure policies have instilled a sense of tenure insecurity that caused resistance to any conservation investments (Regassa Feyissa, 2006; German *et al.*, 2012).

Moreover, heavy pesticide inputs (Thrupp, 2004), serious degradation of natural resources, including soils (Thrupp, 2000), and persistent drought (Hammer, 2004) can cause erosion of agrobiodiversity. Late maturing farmers' varieties such as diploid

durum wheat (IBC, 2009), impeding regeneration, overharvesting, logging, grazing, burning, tourism, road construction, fuel wood collection, and decline of local knowledge about plants (Hamilton and Hamilton, 2006) were threats to agricultural plant diversity.

Livestock is suffering genetic erosion. Many traditional strains have disappeared as farmers focus on new livestock breeds (Plucknett and Horne, 1992; Thrupp, 2000), which is initiated by government policy (Drucker *et al.*, 2001). It was estimated that at least one traditional breed of livestock dies out somewhere in the world every week (Thrupp, 2004). The livestock export due to increased market demand, and cross-breeding the livestock with foreign breeds (IBC, 2009) for example, Sheko cattle (trypanotolerant breeds) with zebu breed (*Bos indicus*) (FAO, 2007; IBC, 2009) also threatened livestock diversity. Rangeland degradation, overgrazing and overstocking; invasion of rangelands by exotic plants; expansion of crop cultivation; diseases such as Trypanosomiasis (Hall, 2004; IBC, 2009), predation and pests, and application of agro-chemicals (IBC, 2009) are among the chief threats to the livestock.

2.6.1. Effects of loss of agrobiodiversity

The loss of biodiversity in habitats surrounding agricultural areas results in the disruption of ecosystem services such as pollination, which in turn influences productivity (Thrupp, 2000). Ecosystem services (ESs) are the range of conditions and processes through which natural ecosystems help people get benefits (directly or indirectly) from nature (Daily, 1997; MEA, 2005). The concept of ESs encompasses the delivery, provision, production, protection or maintenance of a set of goods and services that people perceive to be important. These includes goods such as forage, timber, biomass fuels, natural fibre,

pharmaceuticals and industrial products and services like the maintenance of biodiversity and life-support functions e.g., waste assimilation, and recycling (Daily, 1997).

Crop pests and pathogens (fungal, bacterial and viral diseases) are examples of ecosystem dis-service that happen when agricultural diversity is lost, which in turn reduces agricultural productivity. Ecosystem disservice also include loss of biodiversity, agrochemical contamination and pesticide, poisoning of nontarget organisms, and emissions of greenhouse gases and pollutants (Zhang *et al.*, 2007). AB loss reduces the available pool of genetic materials for breeding (Sinafikeh Asrat *et al.*, 2009), and causes food insecurity (Thrupp, 2004). Furthermore, it increases vulnerability to climatic and other stresses (Thrupp, 2000; Sinafikeh Asrat *et al.*, 2009), and increases susceptibility to diseases and drought (Regassa Feyissa, 1999).

2. 7. APPROACHES TO AGROBIODIVERSITY CONSERVATION

There is a growing awareness of the accelerated loss of biodiversity and associated traditional knowledge (CBD, 1992; Engels *et al.*, 2006; IBC, 2007). Such a loss will jeopardize our future ability to adapt to changes in climate and farming conditions (Zhou, 2010). This leads to greater efforts to conserve biodiversity, particularly agrobiodiversity (IBC, 2007). Conservation is the management of human use of the biosphere so that it may yield the greatest sustainable benefit to current generations while maintaining its potential to meet the needs of future generations (Jarvis *et al.*, 2000). The scale and intensity of human interactions with the environment have led to progressive and wide scale habitat loss, and degradation and fragmentation, with subsequent loss of species and genetic variability.

Some of the structural constraints that influence conservation activities include, national policies (e.g., government land tenure), poor market opportunities and infrastructure, failure of research for development and organizations, and the demonization of indigenous beliefs (German *et al.*, 2012). Since Africa's greatest challenge is poverty, the conservation of AB remains a vital element (Rudebjer *et al.*, 2009).

Both the CBD and the ITPGR (International Treaty on Plant Genetic Resources) encourage signatory countries to promote on-farm conservation of AB (Brush, 1995). The CBD seeks to promote the conservation of biodiversity, the sustainable use of its components and the equitable sharing of benefits arising from the use of the resources (CBD, 1992). Raising awareness is the first step in promoting conservation. It adds value and encourages consumers, development workers, policy-makers and farming communities to conserve and make continued use of the resource. Various methods such as folk song competition, and conservation essay competition be employed to create awareness (Friis-Hansen and Sthapit, 2000). Conservation and management strategies of genetic resources may be grouped primarily into two domains: *in situ* and *ex situ* conservation (Putter, 1994). Since both conservation strategies have their own shortcoming, the incorporation of elements of both (integrated approach) is a must to conservation (Jarvis *et al.*, 2000).

2.7.1. *In-situ* conservation methods

In-situ conservation is the conservation of ecosystems and natural habitats and the maintenance and recovery of viable populations of species in their natural surroundings or in the agro-ecosystems (Bellon *et al.*, 1997; Jarvis *et al.*, 2000; Swanson and Goeschl,

2000; Andersen, 2008) where genetic diversity exists and where wild/weedy forms are present, often hybridizing with cultivated forms (Melaku Worede, 1991). It safeguards both dynamic, evolutionary genetic processes and the complexity of genetic interactions in the agricultural ecosystem (Melaku Worede, 1991; Brush, 1995). Further, *In situ* conservation has the potential to (1) conserve biodiversity at all levels, and (2) integrate farmers or informal sectors into the national Plant Genetic Resource system of conservation and use (Jarvis *et al.*, 1998). Respect for and identification of farmers' needs and objectives are essential when establishing crop genetic resources management on-farm (Friis-Hansen and Sthapit, 2000). *In situ* conservation consists of the continued cultivation of crop varieties by farmers, together with their practices of observation, selection, and use (Swanson and Goeschl, 2000). In cultivated plants, *in situ* conservation is best referred to as on-farm crop conservation (Brush, 2000), which also includes conservation in reserves, and in HGs (Maxted *et al.*, 1997).

2. 7.1.1. On-farm conservation (farmers field) methods

On-farm conservation is the sustainable management of genetic diversity of locally developed traditional crop varieties with associated wild and weedy species by farmers within traditional agricultural, horticultural or agri-silvicultural cultivation systems (Maxted *et al.*, 1997). It allows for the cultivation of the crops in heterogeneous populations, in varied agroecosystems, and with varied cultural practices that admits for the co-evolution of crops with diseases and pests. The species targets of on-farm genetic conservation include cultivated crop, including MPs, forage, and agroforestry species, as well as the wild relatives of cultivated species (Brush, 2000).

2. 7.1.2. Uses of on-farm conservation

- i. Conservation of indigenous knowledge - it maintains TK about the farming systems and agricultural practices that retain knowledge about direct uses of that diversity.
- ii. Continuing crop evolutionary processes- it conserves the crop evolutionary processes (through mutation, migration, recombination, and selection)
- iii. Maintains allelic richness and genotypic diversity - on-farm populations have the capacity to support a much greater number of rare alleles (Brush, 2000).

There are some challenges in effecting on-farm conservation such as policy issues in terms of the design of appropriate incentives (Benin *et al.*, 2003), individual farmers' decisions (Sinafikeh Asrat *et al.*, 2009), difficulty to identify and access the genetic material for researchers, genetic erosion due to natural disasters, etc (Jarvis *et al.*, 2000).

2.7.2. Ex-situ conservation methods

Ex situ conservation is defined as the conservation of plant genetic resources for food and agriculture outside their natural habitat (CBD, 1992; Atta-Krah *et al.*, 2004). This strategy is static (Swanson and Goeschl, 2000), and does not capture the dynamic process of genetic resource evolution in response to natural selection pressures (Cavatassi *et al.*, 2006; Rudebjer, 2009), and thus the existing sets of germplasm are frozen (Rudebjer, 2009). *Ex situ* conservation should serve as a back-up for on-farm conservation and they should be considered as complementary (Brush, 2000).

Although gene banks are central points where germplasm is conserved, they are always prone to calamities such as fires, earthquakes, floods and acts of war. Financial constraints limit gene bank activities such as collection. Moreover, limited expertise and

human resources (Putter, 1994), and high maintenance costs (Rudebjer *et al.*, 2009) can reduce the effectiveness of a gene bank (Putter, 1994). Ex situ conservation method includes (Hamilton and Hamilton, 2006).

- a. Field gene bank (e.g., botanical gardens) for conserving varieties of plants for which seed banks are inappropriate such as *Ensete ventricosum* (Putter, 1994).
- b. In-vitro (tissue culture, cryopreservation, and DNA/pollen storage) – it is a costly exercise and requires expensive equipments and skilled staff. Raising of aseptic cultures such as employing shoot tip, is a pre-requisite for this activity (Mandal *et al.*, 2000). Cryopreservation involves the conservation of germplasm at ultra low temperature of -196°C using liquid nitrogen. The recalcitrant seeds are preserved as whole seeds or as the excised embryonic axes.
- c. Seed gene banks for orthodox seed producing species (Hamilton and Hamilton, 2006). The seed for the base collections are stored in the long-term storage modules maintained at -20°C temperature (Ellis *et al.*, 1985).

2.7.3. Agrobiodiversity conservation practice in Ethiopia

The Ethiopian National Gene Bank established in 1976 through the support of the German government. The practice of integrating off-farm and on-farm crop genetic resources management approaches has been exercised since 1989 (CBDC, 2009). Since 2003, EOSA (Ethio-Organic Seed Action) is promoting an integrated agrobiodiversity management and seed security program in different agroecological regions.

On-farm conservation practices are linked to the traditional crop variety enhancement and seed multiplication activities (CBDC, 2009) through a novel approach of establishing

Community Gene Banks (CGBs) where large samples of various farmers' varieties of major food crops are being conserved, multiplied and distributed to smallholder farmers. The CGB involves both the *ex situ* and the *in situ* practices at community level as well as farms and fields inhabited by the cultivated, semi-cultivated or wild relatives of crops, field gene banks, HGs, botanical gardens, and other seed storage facilities as elements of CGB systems (CBDC, 2009). IBC has developed *in situ* landrace conservation and enhancement programs that involve breeders, farmers and others (IBC, 2007). Ethiopia is among the pioneer countries in *ex-situ* conservation. Crop genetic resources have been stored in cold room (Gene Bank) and field gene banks by IBC since 1976 (EPA, 2012). The IBC has been involved in the collection and preservation of the biological resources of the country. So far, the Institute has conserved 69,255 accessions in its cold rooms and field gene bank facilities, out of which 61,782 are plant and 1,268 are microbial accessions that are kept in the cold room, while 6,205 are plant accessions maintained in field gene banks. Table 1 shows the germplasm holdings of the Institute.

CGBs in Ethiopia were constructed with the objectives of safe seed storage, provision of seed loans; replacement of the lost landrace crops through reintroduction and restoration in their respective agroecosystems; and purchase of the local landrace seed and enhancement for further use. It involves expert's working with local farmers, enhancing local varieties conservation, particularly through farm-based participatory plant breeding using CGBs. This practice has linked *ex situ* conservation with *in-situ* in different agro-ecological farming systems (Thijssen *et al.*, 2008). At the different CGB sites, the activities pursued have reduced the rate of genetic erosion and restored the landraces in

Table 1. Germplasm holdings of the Ethiopian Institute of Biodiversity Conservation in Cold Rooms and Field Gene Banks

Germplasm Categories	Number of genera	Number of accessions
cold room(a)		
Cereals	9	45,873
Pulses	11	6,906
Industrial crops	5	501
Medicinal plants	24	239
Forage plants	43	658
Horticultural plants		1,501
Oil crops	7	5,928
Fiber plants		70
Wild plants used as food	4	18
Forestry	23	88
Sub total	126	61,782
Microbial*		1,268(548**)
Field bank(b)		
Forage and pasture	35	104
Coffee	1	5,446
Spices	4	71
Root crops	6	301
Medicinal plants	193	283
Subtotal	239	6,205
Grand total (a+b)		69,255

Note : * From the total microbial holdings, 14 fungal and 35 bacterial strains were isolated and identified **584 bacteria accessions/samples have been submitted by other organizations and kept under agreement. **Source:** IBC (2009).

regions (EPA, 2004). The CGB is comprised of two major components: 1) a seed store, which consists of largely of materials developed and multiplied contractually by farmers. It provides a backup to the local market networks where farmers traditionally exchange seeds and information, and 2) the seed reserve that the CGBs maintain becomes crucial to ensuring a sustained supply of adapted seeds, channeled through the informal market system.

Thus, CGBs and improved local seed storage practices support the in-situ conservation. For example, in Tigray, Ethiopia farmers have established a CGB that is linked to a Gene Bank, which involves small local seed storage systems such as clay pots, rock hewn mortars and underground pits (Melaku Worede *et al.*, 2000; Gemmill, 2001).

2.7.4. Methods to encourage agrobiodiversity conservation

There is a need to educate farmers and all extension agents of the need to conserve germplasm at farm level (Putter, 1994). The participation and empowerment of indigenous peoples, protection of their rights, respect and use of their knowledge on biodiversity (CBD, 1992; Thrupp, 2004), and developing markets and business opportunities for diverse products of AB (Thrupp, 2004) will enhance AB conservation.

Some methods that enhance AB conservation include, producing traditional speciality crops (Brush, 1991), payment for AB conservation services (Zhou, 2010), creating a supportive policy environment, ensuring secure tenure, prioritizing AB enhancement in research and development programs (Thrupp, 2000), applying multiple cropping and/or crop rotations, using certain plants as natural pesticides e.g., *Ricinus communis* leaves that contain a paralyzing agent are used to control a phytophagous tenebrionid beetle (Thrupp, 2004). Moreover, increasing farmers' access to landrace diversity through encouraging CGB, and tailoring formal crop-selection programs (Tuxill and Nabhan, 2001), and implementing agroforestry practice that shelters diverse plants and animals (Boshier, 2004) can assist in preserving varied agrobiodiversity.

CHAPTER THREE

3. MATERIALS AND METHODS

3.1. DESCRIPTION OF THE STUDY AREA

3.1.1. Geographic location

K T Zone is located at latitudes of 7.09° – 7.31° N and longitudes of 37.21° – 38.06° E (Fig.3).

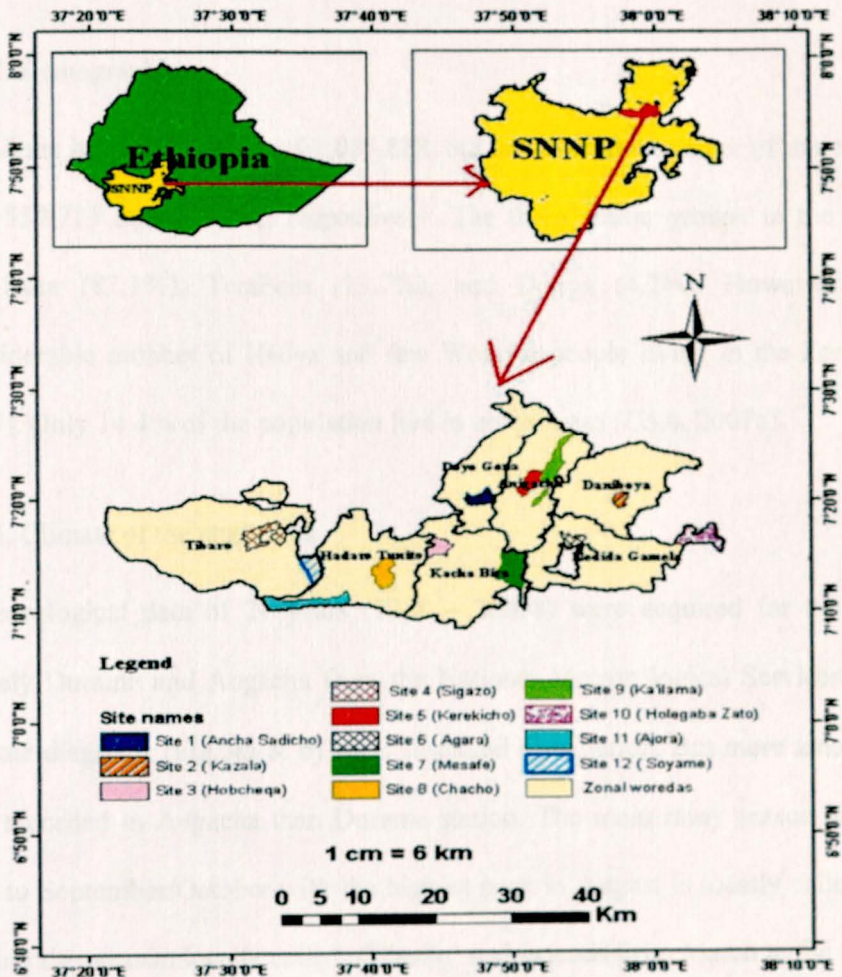


Figure 3. The Map of the study area

The altitudinal ranges of the study area is from 501 to 3080 m.a.s.l. (SNNPR, 2008). Durame is the Zonal town and located at a distance of about 350 kms south of Addis Ababa. The Zone covers a total area of 1523.6 sq. km and divided in to seven *Woredas*, namely Doyogana, Angacha, Hadero and Tunto Zuriya, Tembaro, Damboya, Kedida Gamella, and Kacha Bira. It is also bordered on the south by Wolayta, on the south west by Dawro, on the north west by Hadiya Zones, and on the east by the Alaba special *Woreda*, and on the south east by Badawacho (SNNPR, 2008; KTZARD, 2011).

3.1.2. Demographics

The Zone has a population of 1,055,828, out of which the number of males and females was 559,713 and 496, 11, respectively. The three ethnic groups in the Zone include Kambatta (82.1%), Tembaro (13.7%), and Donga (4.2%). However, there are a considerable number of Hadya and few Wolayta people living in the Zone (KTZARD, 2011). Only 14.4% of the population live in urban areas (CSA, 2007a).

3.1.3. Climate of the study area

Meteorological data of 21 years (1988 – 20008) were acquired for the two stations, namely Durame and Angacha from the National Meteorological Services Agency. The climate diagrams (Fig. 4a & b) show bi-modal distribution. But more amount of rainfall was recorded in Angacha than Durame station. The main rainy season stretching from July to September/October with the highest peak in August is locally called '*Ojaa*'. The minor rainy season locally called '*Gilaallo*' and extends from March to the beginning of June (Fig. 4a). In Durame station, the highest average montly rainfall was recorded in August (158.9 mm) and the lowest in December (24.1 mm). February to June are the

hottest months of the year. The maximum mean temperature was recorded in June (26.8°C). In general, the mean annual temperature and mean annual rainfall was 19.3°C and 1144mm, respectively (Fig. 4a). In Angacha station, the highest average monthly rainfall was recorded in August (202.1 mm) and the lowest in December (30.38 mm). November to February are the hottest months of the year. But the maximum mean temperature was recorded in December (25.03°C). The mean annual temperature and mean annual rainfall was 19.4°C and 1507mm, respectively (Fig.4b).

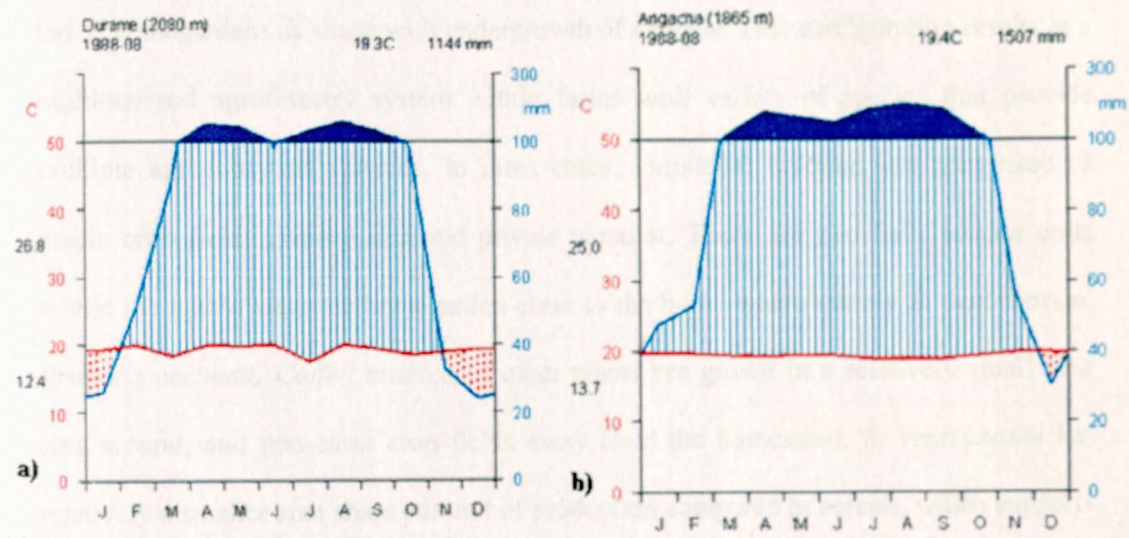


Figure 4. Climadiagram of the study area from 1988-2008
 a) Durame station, and b) Angacha station (Data from National Meteorological Service Agency, 2011) (drawn using R program)

3.1.4. Agroecological zones, land use and vegetation

KT Zone has three agroecological zones, 25% *Dega* (highland), 67% *Woyna Dega* (midland), and 8% *Kola* (lowland). Of the total 149,166.37 hectares of the land, 74.18 % is cultivated, 5.30 % is grazing land, 8.80 % is covered by bush and forest, 2.32%

cultivable, 3.10 % uncultivable land and the remaining 6.30 % is covered by others. Topographically, the plateau, plain and steep slope represent 28, 28 and 44%, respectively (KTZARD, 2011). Dry ever green afrotemperate forest and Grassland complex (DAF) and *Combretum-Terminalia* woodland and wooded grassland (CTW) are the characteristic vegetation types of the study area (Friis *et al.*, 2011).

Agroforestry tree species such as *Ehretia cymosa*, *Erythrina brucei*, and *Cordia africana*, and some fruit trees like *Mangifera indica* and *Persea americana* are planted in the enset based homegardens as shade with undergrowth of annuals. This configuration results in a multi-storied agroforestry system within farms with variety of species that provide multiple agroecosystem services. In most cases, individual holdings are comprised of arable crop field, grazing area and private woodlot. There are two farm section units within the arable area: the homegarden close to the home where mainly *E. ventricosum*, *Brassica carinata*, *Coffea arabica* or other plants are grown in a relatively small land area around, and non-enset crop fields away from the homestead. *E. ventricosum* has relatively a smaller area share per unit of production compared to cereals, which supports densely populated areas

3.1.5. Socioeconomic information

Kambaata are the people, and *Kambatissa* is the language. *Kambatissa* is a Highland East Cushitic language, a part of the Afro-Asiatic family spoken by more than 700,000 people. Local dialects include Donga, Kambatta and Tambaro (Raymond and Gordon, 2005). *Kambatissa* has a lexical similarity of 95% with the Tembaro dialect. Among the total

Kambatissa speakers 4% are of Donga dialect, 13% are of Tambaro dialect and 83% are of Kambata dialect (CSA, 2007a).

The average land holding per household is less than 1ha and there are about 708 people per sq.km. Overpopulation and poverty have pushed large groups of peasants to resettle in other parts of the country such as Wondo Tikka, Kaffa, Arsi, Metekel, and Gambella over the past forty years or so. Similarly, there is a large exodus of young men and women to areas such as Wonji, Matahara, Babaka, Wushwish, Finchaha, and Ziway seeking employment on seasonal and permanent basis (Yacob Arsano, 2002). About 11% of the zonal population was reported to be migrant (CSA, 2007b). Currently, youths are migrating to South Africa, Sudan and some Middle East Arab countries.

The economy of the local people is mainly based on subsistence agriculture where mixed farming is a common practice while off-farm labour, commerce and craftsmanship are supplementary activities. Although enset constitutes the staple crop to most people, other crop types such as cereals e.g. teff and wheat, oil crops, tubers, pulses, vegetables, fruits, condiments and spices, stimulants, and others like sugar cane are grown in enset cultivation systems. Moreover, they are engaged in rearing livestock including goats, sheep, donkeys, mules and chicken.

The waste from livestock and other household wastes serve as an organic fertilizer for homegardens. The soil of the enset ecology vary from sandy loam to heavy clay while the dominant soil types are red to reddish-brown nitisols, lateritic loams or clay loams of volcanic origin, which are mainly acidic (Eyasu Elias, 2003). In many cases the farming systems are characterized by a high degree of intra- and inter-species diversity where root

crops and tubers are important components of the overall enset based agricultural system that is supplemented by livestock rearing. In general, occupationally 90% are farmers but state employment and other off-farm careers represent 10% (KTZARD, 2011).

3.1.6. Education and health status

Fifty six percent of the population $\geq$ year five old was literate, of which 81.2% of all eligible children are enrolled in primary school, and 13.2% in secondary schools (CSA, 2007b). Seventy four per cent of the Zone is exposed to malaria (World Bank, 2004). Malaria, intestinal parasitic infections, respiratory tract infections, and skin diseases are major public health problems afflicting the people in the Zone (KTZHO, 2011). Conversely, abdominal parasites, infectious diseases, anthrax, black leg and external parasites are diseases of the highest veterinary importance (KTZARD, 2011).

Table 2. Some physical features of the farmscapes: traditional climatic zone, farmscapes number and name, elevation, coordinates and farmscapes distance from the main zonal town (Durame)

Traditional Zone	Farmscapes number	Farmscape Name	Average elevation in (M)	Latitude(N)	Longitude(E)	Distance from Durame (≈Km)
<i>Dega</i>	1	A/Sadicho	2619	7.34 ⁰ N	37.78-37.81 ⁰ E	15.7
	2	Kazala	2350	7.34 ⁰ N	37.95-37.97 ⁰ E	13.6
	3	Hobichaqa	2407	7.26 ⁰ N	37.73-37.76 ⁰ E	16.8
	4	Sigazo	2310	7.28 ⁰ N	37.5-37.66 ⁰ E	40.4
<i>Woyna Dega</i>	5	Kerekicho	2259	7.34-7.38 ⁰ N	37.84- 37.87 ⁰ E	14.5
	6	Agara	2120	7.18-7.19 ⁰ N	37.54-37.64 ⁰ E	3.9
	7	Mesafe	2126	7.22-7.26 ⁰ N	37.81-37.85 ⁰ E	7
	8	Chacho	1892	7.22 ⁰ N	37.67-37.69 ⁰ E	23.3
<i>Kola</i>	9	Kai'llama	1790	7.35 ⁰ N	37.84-37.9 ⁰ E	18
	10	H/Zato	1745	7.27 ⁰ N	38.02-38.08 ⁰ E	19
	11	Ajora	1557	7.18-7.19 ⁰ N	37.54-37.64 ⁰ E	35
	12	Soyame	1677	7.23 ⁰ N	37.59-37.61 ⁰ E	32.7

Source: Current study assisted by GIS distance estimation tool

3.2. SELECTION OF STUDY SITES

A reconnaissance survey was made between October and December, 2009, and data collection was carried out between October, 2010 and February, 2012 in KT Zone. Agroclimate was the main factor in selecting the study sites (here after farmscapes). Farmscape is a landscape in which farming has largely played and does play a large role. We emphasize that role by calling our landscape a farmscape. The ultimate goal is to encourage the sympathetic, holistic understanding of our landscape and the active consideration of how human and non-human ecology can best be configured on that landscape so as to provide healthy, economically feasible (for consumer and producer) human sustenance while also providing a livelihood for the other species that share this land with us. The three traditional agroclimatic zones were determined as *Dega*, *Weyna-Dega*, and *Kola* following CBDC (2009) and Daniel Gamachu (1977) (Table 3).

Table 3. Traditional climatic zones and their characteristics

Traditional zone	Climate	Altitude (m)	Average Annual Temperature (0C)	Average Annual Rainfall (mm)
<i>Bereha</i>	Hot arid	< 500	> 27	<200
<i>Kola</i>	Warm Semi-arid	500-1500/1800	27-20	200-800
<i>Weyna-dega</i>	Cool Semi-humid	1500/1800-2400	20-16	800-1200
<i>Dega</i>	Cool & Humid	2400-3200	16-11	1200-2200
<i>Wurch</i>	Cold & Moist	Above 3200	<11	above 2200

In total, 12 farmscapes were selected from the study area. These are: Ancha Sadicho (A/Sadicho), Ka'illama, Kerekicho, Taza Agara, Kazala, Hologaba Zato (H/Zato), Ajora, Hobichaqa, Masafe, Chacho, Sigazo, and Soyame (Figure 3). At each farmscape, 15 sampling sites (farmlands owned by HHs) were sampled, making the total sampling sites 180 (see Table 4). Among the selected 180 HHs, 156 (87%) were male headed and 24

(13%) were female headed. In order to substantiate the proportion of female respondents, 60 women from male headed HHs were included for interview, raising the number of female participants to 84 (47%) of the total respondents. The sizes of the farmlands are different because this is determined by the wealth status (poor, medium and rich) of the farmers. The wealth status of the farmers was determined with the help of *kebele* or peasant association development agents, community leaders and elders based on the context of the local farmland size, livestock holding, amount of crop production and the engagement of some off-farm activities.

Table 4. The number of farmscapes selected and the respective wealth groups sampled based on traditional agroclimatic zones

Farmscape Number	Major Traditional agroclimate zones	Name of farmscape	No of sampling sites			Total
			Poor	Medium	Rich	
1	<i>Dega</i>	A/Sadicho	5	5	5	15
2		Kazala	5	5	5	15
3		Hobichaqa	5	5	5	15
4		Sigazo	5	5	5	15
5	<i>Woyna Dega</i>	Kerekicho	5	5	5	15
6		Agara	5	5	5	15
7		Mesafe	5	5	5	15
8		Chacho	5	5	5	15
9	<i>Kola</i>	Kai'llama	5	5	5	15
10		H/Zata	5	5	5	15
11		Ajora	5	5	5	15
12		Soyame	5	5	5	15
			60	60	60	180

3.3. METHODS OF DATA COLLECTION

3.3.1. Plant data collection

At each sampling site, common trees/shrub species were identified on-site and other native flora were collected following standard herbarium techniques and identified at

ETH (The National Herbarium of Ethiopia) by comparing with herbarium specimens and the Flora of Ethiopia and Eritrea. The identified specimens were deposited in the National Herbarium of Ethiopia.

At each sampling site, trees and shrubs were recorded from all farm fields and woodlots (if any) that were at the disposal of the household: homegarden, crop fields, hedgerows/boundary, and woodlot (Fig. 5). The total area of the farmland as well as area of each unit was measured and the different woody species grown were counted and listed using local and botanical names. All tree and shrub species in the farmlands were considered to account the abundance, frequency, and density. DBH (Diameter at Breast Height, 1.3M) was measured for woody species with a diameter > 2 cm, while those smaller than this minimum value were counted and included in the abundance and frequency data.

Data collection on crop plants

The configuration of cropping patterns outside of and around HGs varies across the agroclimatic zones in the study area (Fig 5 a & b) but some plant species tend to overlap across the farmscapes of the three agroclimate zones. At farmland level (HG and crop field), the total area was measured in square metre (later converted into hectare), and the different crop units were identified (separate plots with specific crop species composition), and classified by dominant crop. Depending on the number and size of the different plots and similarities of component species, within each plot quadrats of 50 – 400 m² were laid out for detailed crop species inventory but five quadrats of 400 m² were considered systematically and the average was considered for large farm holdings. The

Data collection on enset landraces

The total enset landrace composition was determined by making a presence-or-absence record of landrace in farms of each sampled HH. At the end, the total landrace density per HH was converted into hectares. In order to investigate the pattern of diversity that exists in the area, the identification of enset landrace and recording of basic information such as uses of landraces, farmers' preferences, criterion for landraces identification, and the maintenance and cultural practices were recorded with the help of farmers to name enset landrace. There is no standard descriptor relevant for the identification of enset landraces (Kefale Alemu and Sandford, 1996; Eyasu Elias, 2003). Thus, farmers' identification and the response was complemented by identifying landraces using the color of (pseudostem, midrib and leaf petiole) the plant at adult stage, otherwise at lower stage. Finally, field notes and photographs of plants representing the different landraces were taken, and the identification of landraces and listing of the names was conducted by consulting scientific literatures following previous scholars (Del Greco *et al.*, 2007).

The characters of enset landraces that were used to evaluate the knowledge of farmers on use values were based on qualities of *bullaa*, *hamicho*, *kocho*, taste, storability, yield, earliness, fiber, fodder and medicinal values. Additional characters used were the resistance to enset diseases like the destructive bacterial wilt (locally called *Ganshoo/alloya*) as well as the resistance to drought. To study the perception of 80 informants on the end uses of the enset landraces, 38 recognized enset landraces were ranked by farmers (1= poor, 2 = intermediate, 3 = best) and converted to binary data (1 best or 0 poor). The summarized data were subjected to multidimensional preference

analysis (MDPRE) to assess the possible association between enset landraces and the various attributes mentioned following Yemane Tsehaye and Fassil Kebebew (2006).

Environmental and socioeconomic data

Data on farm characteristics (slope, altitude, aspect, location and the farm size), HH characteristics (age, education, family size, off-farm activities, and the TLU) and market characteristics (access to road, and access to town), the area share of crops and woody species of each farm, respectively were collected following previous researchers (Coomes and Ban, 2004; Berhanu Gebremedhin *et al.*, 2006; Tesfaye Abebe *et al.*, 2006; Winters *et al.*, 2006a). The data on aspect, slope, and elevation of the farms were recorded using Suunto Compass, Clino Master Clinometers, and Garmin 12 channel GPS, respectively. Aspect, linked to total solar energy, was codified following earlier workers (Zerihun Woldu *et al.*, 1989), with the following modifications: N = 0, E = 2, S = 4, W = 2.5, NE = 1, SE = 3, SW = 3.3, NW = 1.3, Ridge top = 4. A tape measure was used to measure DBH at 1.3m. Owners of each farm participated in the fieldwork by showing their farm boundaries when measuring the farm areas and explaining about overall farming system.

Finally, the data on annual income, criterion for area allocation for different agroforestry species, and the associated challenges of crop production and agroforestry woody species management were collected through structured and semi-structured questionnaire by interviewing HH heads, and through Focus Group Discussion/FGD (Appendix IX).

3.3.2. Plant uses

In order to substantiate medicinal plant use and the practice of individual practitioners, 51 healers (34 Males and 17 females) were selected from the community, making a total of 231 HHs (age >25 years). Ethical clearances were made with the local authorities, local peoples and traditional healers of the communities following Martin (1995) before the start of interviews to share their knowledge only for the purpose of this academic reason. Lastly, 15 key informants were selected purposefully on recommendations from the local leaders, elder people, and development agents.

The methods used for ethnobotanical data collection were semi-structured interviews, field observation, and various ranking methods following earlier scholars (Alexiades, 1996; Cotton, 1996). During interview the respondents' background, health problems treated, diagnosis and treatment methods, local name & habitat of medicinal plants, management of MPs, plant parts used (fresh/ dried), methods of remedy preparation and application, indigenous knowledge transfer, other uses of the ethnomedicinal plants, threats to MPs and traditional conservation practices of respondents were cautiously recorded. Healers were contacted two times for the same ideas in order to confirm the information he/she has given is correct.

Furthermore, factors that influence the diversity of medicinal plants were short listed by traditional healers, and the preference ranking was conducted by the informants. Fifteen key informants ranked plants species based on the ailment treated. Each rank was given an integer number with the most preferred item being assigned the highest number. Further, FGD was held on the status of medicinal plants and the knowledge transfer in the

study Zone. The informants were compensated for their time. Medicinally useful plants were collected from crop fields, woodlots, woodlands, field margins with linear features located adjacent to the field, water shed areas, homegardens, and hedgerows.

3.4. DATA ANALYSIS

3.4.1. Plant ecological data analysis

Species diversity is determined by means of species richness and species evenness. Species richness (S) is the oldest and most intuitive measure of biological diversity (Magurran, 2004), which in the current study represents the total number of crops species, enset landraces or trees and shrubs species on the farmland. Total species richness is calculated just by counting the number of species in a given sampling unit. This index doesn't indicate the relative proportion or abundance of a particular species. Hence, other indices particularly Shannon Index (H') and Shannon evenness (E) are used to estimate both crop and woody species diversity in the farmlands, respectively. H' is calculated using the formula, $H' = - \sum p_i \ln p_i$ (Magurran, 2004), where p_i is the proportion of crop, enset landraces, and tree and shrub area, respectively composed of species i . An additional measure of diversity is the measure of Evenness (E) that is a measure of how similar the abundance of different species are. It is calculated as the ratio of observed diversity (H') to maximum diversity (H_{max}) (Pielou, 1969) using the formula, $E = H'/H_{max} = H' / \ln S$, Where S = number of species, and $\ln$ is a natural log. E has values between 0 and 1.0, where 1.0 represents a situation in which all species are equally abundant. H' is high when the relative abundance of the different species in the sample is even, and is low when few species are more abundant than the others. The values usually fall between 1.5 and 3.5 only rarely surpasses 4.5 (Magurran, 2004).

One- way ANOVA was carried out using the values on Evenness and Shannon diversity indices to test whether there were significant differences among farms. Post Hoc tests mainly, Duncan multiple range test was used for mean separation of those properties that were found to be significantly different.

Plant species diversity across farmscapes

Shannon diversity and Evenness indices, which are generally referred as alpha diversity, indicate richness and evenness of species within a locality only. But the extent of differences in the composition of crop and tree/shrub species, respectively among different farmscapes was determined by computing beta diversity. Beta diversity (β) is a measure of the extent to which the diversity of two or more spatial units differs (Magurran, 2004), and is generally used to characterize the degree of spatial heterogeneity in diversity at the landscape scale, or to measure the change in diversity along environmental gradients. It is based on the use of presence-absence data, although quantitative abundance data can also be used (Newton, 2007). Beta diversity is usually expressed in terms of a similarity index between different habitats in the same geographical area. It was calculated using the formula following Magurran (2004).

$\beta = 1 - C_j$, where C_j is Jaccard's similarity index (presence /absence data),

$C_j = j/(a+b+ j)$, where j = the number of species shared by any two sites a and b ,

a = the number of species in site a , and b = the number of species in site b

Similarly, in order to examine the effects of biophysical and socioeconomic variables on agrobiodiversity the linear multiple regression was employed using Minitab ver 15 (Minitab Inc, 2003). Moreover, the strength of relation between crop species, and

physical and socioeconomic factors was determined. Multidimensional preference analysis (MDPRE) was conducted using SAS ver. 8.02 (SAS, 1999).

Vegetation classification

Cluster analysis was used to identify groups of sites (vegetation Samples) that are similar in terms of their woody species composition. The abundance data of a species were used for the analysis. R program Version 2.15.2 (The R Core Team, 2012) was used to perform a hierarchical cluster dendrogram, which depicted the vegetation community of woody species. The indicator values for each species in each group and tests for statistical significance ($P < 0.05$) were analyzed to name the vegetation community. The values are based only on the species abundance and frequency comparisons. In order to obtain an effective description of community types and their environmental relations, both classificatory and ordination techniques were employed.

Species - environmental relationship

Ordination is a multivariate method that expresses the relationships between samples, species and environmental variables in a low-dimensional space using ordination diagrams (Ter Braak, 1987). In order to determine the patterns and the relationships between agrobiodiversity (crop, and tree/shrub species) among farmlands (response variables) and environment (explanatory variables) (Leps and Smilauer, 2003), the data were summarized using CCA (Canonical Correspondence Analysis) using CANOCO for Windows version 4.52 (Ter Braak and Smilauer, 2003). CCA was applied to recognize crop-environmental and tree/shrub- environmental relationships, respectively. The Crop group types were identified on the ordination axis (DCA) on the basis of indicator species

(Dufréne and Legendre, 1997) obtained from the classification. DCA is distinctive in its effectiveness and robustness for complex and heterogeneous data sets (Gauch, 1982).

Structural analysis

The structure of the woody species in the agroforestry systems was described based on the analysis of species density, DBH, basal area, frequency and Importance Value Index (IVI). DBH was classified into DBH classes for woody species.

The frequency of each of the identified crop, enset landrace, and tree and shrub species, respectively was determined to identify the most commonly grown species of the area.

- **The frequency (%)** = number of sampled HHs in which species A occurred/Total no of HHs sampled x100
- **Relative frequency** = number of plots sp A occurred/ total number of plots x 100.
- **Density:** the number of individuals of size class in the stand, determined by counting the number of individuals of each size class of each sample plot. Tree density was computed by converting the count from the total quadrates into the hectare basis.
- **Relative density** = Number of stems (individuals of species A) per ha of the i^{th} species / Total number of stems per ha of all species x 100;
- **Relative dominance or Basal area (BA)** = Sum of basal area of individuals of i^{th} species / total basal area of all species x 100.

Basal area (BA) is the cross-sectional area of the tree at point 1.3m above the ground. It can be calculated from measurements of stem diameter by using the following equation,

$BA = \pi d^2/4$, where d = diameter at breast height. Thus, Importance Value Index (IVI) = Relative density + Relative frequency + Relative basal area (Curtis, 1959). IVI is used to compare ecological significance or it is used for a comparison of species in a given area and depicts the sociological structure of a population in its totality in the community (Kent and Coker, 1992).

3.4.2. Ethnobotanical data analysis

Descriptive statistics was calculated on Ms Excel spreadsheet. The Informant Consensus Factor (ICF) was calculated to see the agreement of informants for a plant species in treating a particular disease. It shows the distribution and incidences of disease categories in the study area. $ICF = (nuc - ns)/(nuc - 1)$, where nuc = number of use citations, ns = number of species used for each use citation (Heinrich *et al.*, 1998).

Similarity in medicinal plant with other areas

Jaccard's similarity coefficient was estimated for comparing MP species composition in thirteen randomly selected areas in Ethiopia studied by different workers following Kent and Coker (1992)

Preference, direct matrix, and Priority ranking

Preference ranking involves asking each of the 15 selected key informants to arrange the items. In our case informants were requested to arrange seven MPs used to treat human ailment (ascariasis) and the other seven MPs used to treat livestock ailment (blackleg) following Martin (1995). Priority ranking of factors perceived as threats to medicinal plants based on their level of destructive effects (values 1- 6 were given: 1 was the least

destructive threat, and 6 was the most destructive threat) and direct matrix ranking on uses perceived as threats to six medicinal plants were conducted for multipurpose medicinal plants that were commonly reported by healers following Cotton (1996).

Fidelity Level (FL) values were used to estimate the relative healing potential of each MP based on the proportion of informants who agreed on its use against a given ailment category (Friedman *et al.*, 1986). This method enables to recommend a particular traditionally used MP species for the future bioactivity and therapeutic tests (Ankli *et al.*, 1999). FL is calculated using $FL (\%) = SF/TF(100)$, where SF = frequency of citation of a species for a specific ailment and TF = total number of citations of that species. The Spearman Rank Correlation Test was employed to evaluate whether there was significant ($p < 0.05$) correlation between i) the age of traditional healers and the number of ethnomedicinal plant species reported, and ii) the educational level of healers and the number of species reported.

CHAPTER FOUR

4. RESULTS

4.1. SOCIO-DEMOGRAPHIC CHARACTERISTICS OF THE HOUSEHOLDS

4.1.1. Social characteristics

The age range was between 28 and 83 years where the modal age class (33.3%) falls in the 39-48 years age (Fig. 6). There was extremely significant difference ($P < 0.001$) in age among the wealth classes. The mean age of the wealth classes indicated that the rich had greater age (mean = 54) than the other categories.

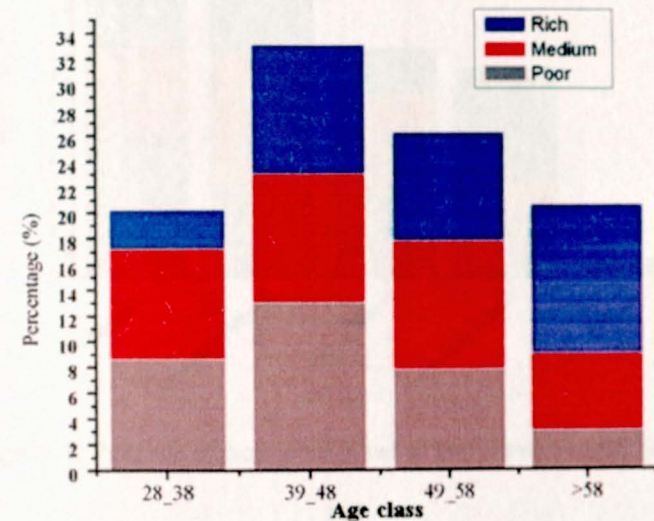


Figure 6. Age class distribution based on wealth status

There was extremely significant difference ($P < 0.001$) between family sizes among wealth groups. Accordingly, medium and rich HHs had higher family size than poor HHs. High family size can be seen as a labour force for agricultural activity or for off farm activities. Christianity is the dominant religion in the study

(97.2%). Protestant constitute 85.6 %, followed by orthodox (7.2) and Catholic (4.4)), followed by Muslim (2.8).

There was a significant difference ($P < 0.05$) in educational level among wealth groups (Fig 7). The proportion of illiterate was 26.6%, of which 51% belongs to poor wealth group. However, about 3/4th of the study HH heads were literate, ranging from elementary to tertiary levels. More than 40% of the HH heads had junior and above levels although the dominant educational level was elementary (33%).

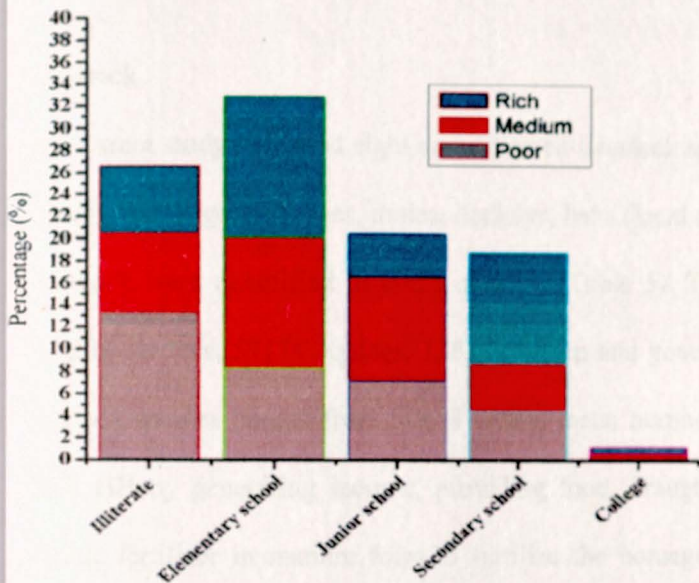


Figure 7. Percent educational level of the three wealth groups

4.1.2. Socio-economic characteristics of the study households

ANOVA result showed that the socioeconomic factors of the HHs were statistically significant ($p < 0.05$) among wealth groups. However, only family size and livestock number showed significant difference among the agroclimatic zones. Dega agroclimatic area is characterized by relatively large family size and livestock species number. The number of family size ranged from 2 to 21 with mean of 8.2 ± 2.7 (Table 5).

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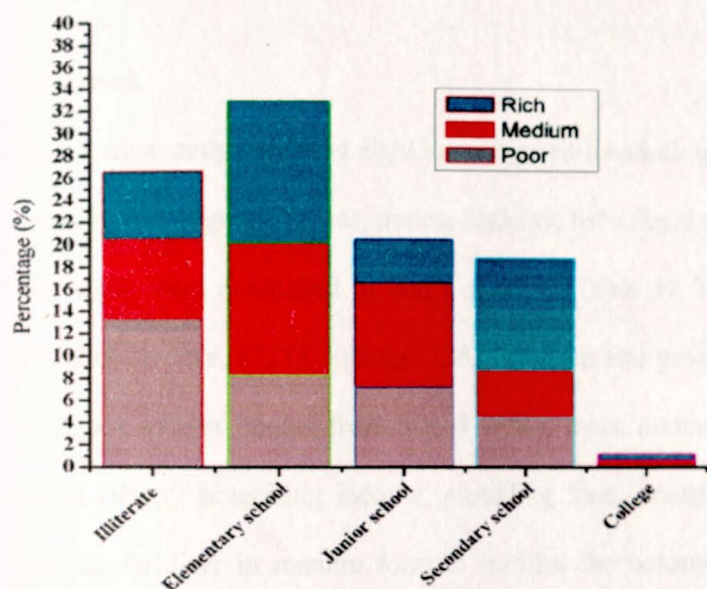


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Farmland size

The farm size varied from 0.04 to 21.3 hectares (ha) with mean value of 1.9 ± 0.2 ha/HH (Table 5). The mean farm size for poor, medium and rich wealth groups was 0.8, 1.9, and 3.3 ha, respectively. Thirty six percent of HHs had landholding less than 1 ha, and only 27% of the HHs had land holding > 2 hectares. Similarly, the mean wood lot size per HH was 0.46 ± 0.1 ha. However, 34% of HHs don't have woodlots, while 43% had woodlots < 0.5 ha, and 23% had woodlots > 0.5 ha.

Livestock

The current study indicated eight domesticated livestock species, namely cattle (local and hybrid breeds), sheep, goats, horses, mules, donkeys, hens (local and hybrid breeds), and domestic bees. Livestock were quantified in terms of TLU (Table 5). The livestock population comprised of 772,203 bovines, 57114 equines, 138,672 sheep and goats, and 150000 poultry. The number of livestock species ranged from 0 to 8 with a mean number of 3.2 ± 1.5 species/HH. Livestock assist HH by generating income, providing food, draught operation, transport, and providing organic fertilizer in manure form to fertilize the homegarden, mainly enset field. In order to compare the livestock population, TLU was used as a conversion factor of species. The livestock unit (TLU) ranged from 0 to 81.6 with a mean value of 6.3 ± 0.71 per household.

The mean annual income of HH was $12,995 \pm 2208$ Ethiopian birr (ETB) at zonal level where the highest annual income of the rich wealth group was 28,563.9 ETB and that of the poor groups was 1723.6 ETB (Table 5).

Table 5. Mean values of some HH resources on the basis of wealth category of the households

<i>Agroclimatic zones</i>	Wealth group	HHs	Family size	Farm size	TLU	No of livestock spp.	No of Oxen	Woodlot area	Annual income
<i>Dega</i>	M	20	9.4	2.5	4.6	3.8	1.2	.71	8333.2
	P	20	7.5	0.7	1.9	2.4	.7	.03	2150.0
	R	20	9.8	2.9	13.4	4.7	2.7	1.08	22302.9
	average		8.9 ± 3	2.03 ± 0.4	6.6 ± 1.5	3.6 ± 1.5	1.5 ± 0.3	.61 ± 0.2	10928.7 ± 20136
<i>Woyyna Dega</i>	M	20	7.8	1.4	5.0	2.9	1.6	.2	8270.3
	P	20	6.3	0.6	1.5	2.0	.5	.1	1428.2
	R	20	8.8	3.4	10.6	3.4	2.8	.4	41358.4
	average		7.6 ± 2.1	1.8 ± 1	5.7 ± 0.8	2.7 ± 1	1.6 ± 0.2	.2 ± 0.03	17018.9 ± 5859
<i>Kola</i>	M	20	9.2	2	4.4	3.2	1.5	.6	9493.9
	P	20	6.6	0.9	2.2	2.5	.8	.3	1592.6
	R	20	8.7	3.5	13.4	4.1	3.6	1.1	22030.6
	average		8.1 ± 2.7	2.1 ± 1.7	6.7 ± 1.2	3.3 ± 1.4	2.0 ± 0.3	.7 ± 0.2	11039.0 ± 1700
Total	M	60	8.78	1.9	4.64	3.3	1.4	0.5	8699.1
	P	60	6.78	0.8	1.86	2.3	0.7	0.1	1723.6
	R	60	9.05	3.3	12.5	4.1	3	0.8	28563.9
	average		8.2 ± 2.7	1.9 ± 0.2	6.3 ± 0.71	3.2 ± 1.5	1.7 ± 0.14	0.46 ± 0.1	12995 ± 2208

Abbreviations: P= poor, M= medium, and R= rich wealth class.

Note: The tropical livestock unit (TLU)) is commonly taken to be an animal of 250 kg liveweight. TLU conversion factors constitute a compromise between different common practices. 1 TLU= 250kg. Accordingly Bull = 1.1, calves = 0.2, Chickens = 0.01, Cows (cross) = 1.2, Cows (local) = 0.8, Donkeys = 0.5, Goats/ sheep = 0.1, Heifers = 0.5, Horses/mule = 0.8, and Immature males 0.6. **Source:**(Jahnke, 1982)

4.2. DIVERSITY AND COMPOSITION OF CROP PLANTS

4.2.1. The Richness of crop species

A total of 92 cultivated crop species (see lists of crops in Figure 9 and Appendix I) belonging to 73 genera and 37 families were recorded in the study area. The most species rich family is Poaceae (12 species) and it is followed by Solanaceae (10 species) (Table 6).

Table 6. Families of crop plant species of the study area

S.No	Family	Number of genera	species	%	S.No	Family	Number of genera	species	%
1	Poaceae	8	12	12.8	20	Bromeliaceae	1	1	1.1
2	Solanaceae	6	10	10.6	21	Cactaceae	1	1	1.1
3	Fabaceae	9	10	9.6	22	Caricaceae	1	1	1.1
4	Brassicaceae	3	7	7.4	23	Celastraceae	1	1	1.1
5	Lamiaceae	5	5	5.3	24	Chenopodiaceae	1	1	1.1
6	Rosaceae	3	5	5.3	25	Convolvulaceae	1	1	1.1
7	Rutaceae	3	4	4.3	26	Cucurbitaceae	1	1	1.1
8	Alliaceae	1	3	3.2	27	Lauraceae	1	1	1.1
9	Asteraceae	3	3	3.2	28	Malvaceae	1	1	1.1
10	Amaranthaceae	1	2	2.1	29	Moraceae	1	1	1.1
11	Apiaceae	2	2	2.1	30	Moringaceae	1	1	1.1
12	Dioscoriaceae	1	2	2.1	31	Myrtaceae	1	1	1.1
13	Euphorbiaceae	2	2	2.1	32	Passifloraceae	1	1	1.1
14	Musaceae	2	2	2.1	33	Punicaceae	1	1	1.1
15	Piperaceae	1	2	2.1	34	Ranunculaceae	1	1	1.1
16	Zingiberaceae	2	2	2.1	35	Rhanmaceae	1	1	1.1
17	Anacardiaceae	1	1	1.1	36	Rubiaceae	1	1	1.1
18	Annonaceae	1	1	1.1	37	Verbenaceae	1	1	1.1
19	Araceae	1	1	1.1		Total	73	92	100

The number of crop plants examined was mainly based on the importance for food (Appendix I) but the useful cultivated medicinal crop plants were dealt independently in this thesis. Moreover, six useful forage crop species were identified, namely, *Avena sativa*, *Chloris gayana*, *Desmodium uncinatum*, *Medicago sativa*, *Sorghum dochna*, and *Pennisetum purpureum*. Three crops, namely *Ensete ventricosum*, *Coffea arabica* and *Eragrostis tef* are commonly cultivated

and are present in almost all farms. Eight species occurred in more than 50% of the farms, namely *Brassica carinata*, *Persea americana*, *Musa paradisiaca*, *Colocasia esculenta*, *Saccharum officinarum*, *Triticum aestivum*, *Vicia faba*, and *Zea mays*. Furthermore, 17 different crop plant species were found to have from 2 – 111 farmers' varieties (Fig. 8).

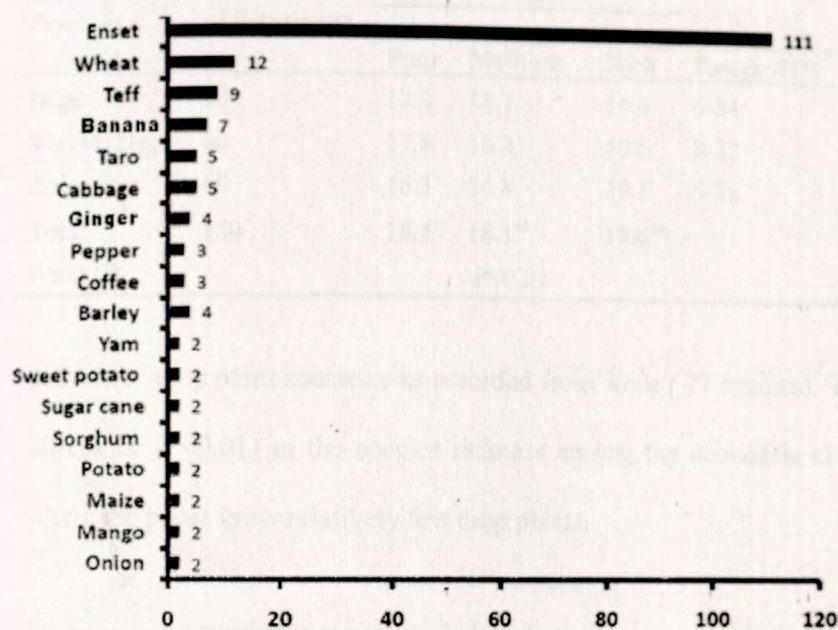


Figure 8. The number of farmers varieties of different crop plant species (N= 180)

Farmers' varieties or landraces are crop populations selected by farmers over many generations and adapted to different agro-climate zones. Landraces have agro-morphological characters that farmers use for distinction. The distinction between farmer's varieties are made based on color, height, produce, taste, tolerance to drought, fodder use, etc. The conservation of crop genetic diversity (e.g., landraces) is entirely based on the decision of household heads (97%, N=175).

Table 7 indicates the number of cultivated crops in individual farmlands, which ranged from 5 to 35, with a mean value of 17.4 ± 5.5 . The number of crop species varies across the agroclimatic zones of the study area. There was a significant difference ($P<0.05$) in crop species richness

among the agroclimatic zones. *Woyna Dega* had the highest number of crops species (81), accounting for 86.2 % of the total number of crop species in the study area. The minimum

Table 7. Total and mean number of crops within the three agroclimatic Zones (N =180)

Agroclimatic Zone	Number of farmlands	Mean crop species per economic classes				Crop species			
		Poor	Medium	Rich	Range /HH	Total	Mean	F	Sig.
Dega	60	12.3	18.7	16.4	6-34	79	15.8 ^a	5	0.01
Woyna Dega	60	17.8	18.2	19.6	8-32	81	19 ^b	0.8	0.4
Kola	60	16.3	16.8	19.1	5-35	77	17.4 ^{ab}	1.4	0.2
Total	180	15.4^a	18.1^{ab}	18.6^{ab}		94	17.4	3.9	0.01
F-test (P)		P<0.01							

number of crop plant species was recorded from *Kola* (77 species). There was a high significant difference ($P<0.01$) in the species richness among the economic classes across the study area where the poors grew relatively few crop plants.

Frequency of crop plants across the study area

The most frequent crop plants in the study area is *Ensete ventricosum* (97%, N= 175) (Fig. 9).

Other relatively more frequent crop plants include *Coffea arabica* (81%, N= 145), *Eragrostis tef* (75%), *Brassica carinata* (71%), *Persea americana* (70%), *Musa paradisiaca* (66%) and *Colocasia esculenta* (63%). *E. ventricosum* is the main staple food crop for many households and fodder for livestock. Accordingly, enset based homegardens integrate crop-livestock farming. The crop area share and abundance is higher for enset in highland and midland areas where the mean area share for enset in highland, midland and lowland areas is 0.32, 0.26 and 0.14, respectively. *Coffea arabica* is the second most frequent crop type , and it is a main cash crop for most farm families. It grows in all agroclimatic areas of the Zone though it is more abundant at altitude below 2000m asl e.g., farmscapes 11 (Ajora) and 12 (Soyame).

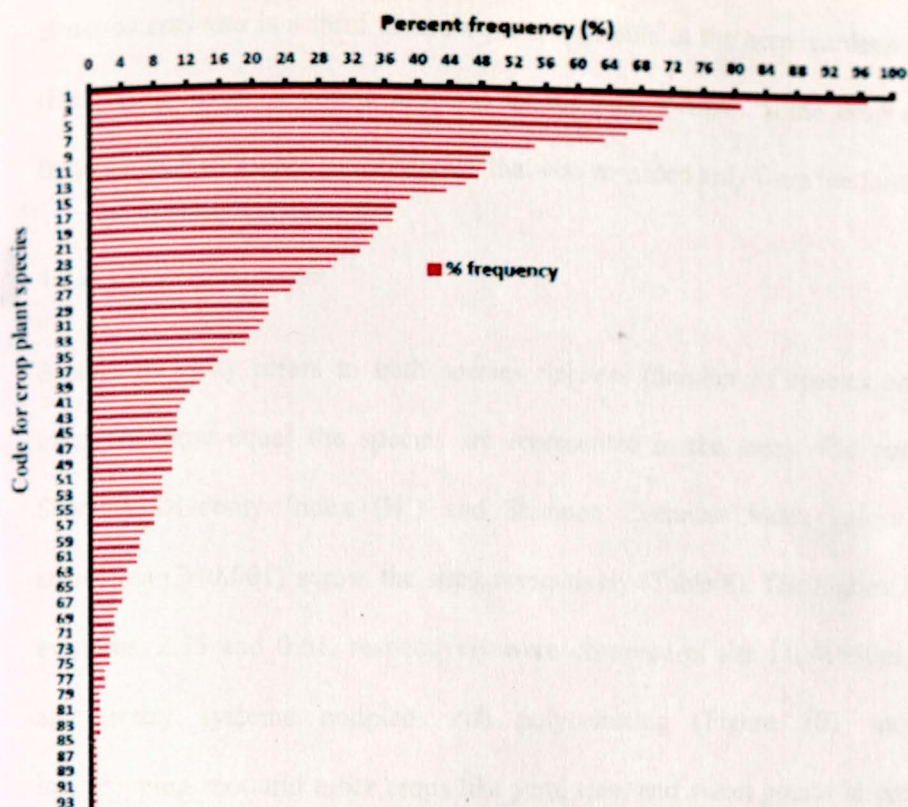


Figure 9. Frequency of crop species across the farmlands (N=180) in KT Zone

Key:

Code	Spp name	Code	Spp name	Code	Spp name	Code	Spp name
1	<i>Ensete ventricosum</i>	25	<i>Solanum macrocarpon</i>	49	<i>Citrus aurantifolia</i>	73	<i>Dioscorea bulbifera</i>
2	<i>Coffea arabica</i>	26	<i>Cymbopogon citratus</i>	50	<i>Lycopersicon esculentum</i>	74	<i>Morus alba</i>
3	<i>Eragrostis tef</i>	27	<i>Coriandrum sativum</i>	51	<i>Eleusine coracana</i>	75	<i>Mentha spicata</i>
4	<i>Brassica carinata</i>	28	<i>Zingiber officinale</i>	52	<i>Psidium guajava</i>	76	<i>Guizotia abyssinica</i>
5	<i>Persea americana</i>	29	<i>Pisum sativum</i>	53	<i>Manihot esculenta</i>	77	<i>Lagenaria siceraria</i>
6	<i>Musa paradisiaca</i>	30	<i>Citrus sinensis</i>	54	<i>Capsicum frutescens</i>	78	<i>Vigna unguiculata</i>
7	<i>Colocasia esculenta</i>	31	<i>Hoardeum vulgare</i>	55	<i>Beta vulgaris</i>	79	<i>Punica granatum</i>
8	<i>Saccharum officinarum</i>	32	<i>Brassica integrifolia</i>	56	<i>Brassica nigra</i>	80	<i>Lens culinaris</i>
9	<i>Zea mays</i>	33	<i>Erucastrum arabicum</i> *	58	<i>Daucus carota</i>	81	<i>Arachis hypogea</i>
10	<i>Vicia faba</i>	34	<i>Carica papaya</i>	59	<i>Plectranthus punctatus</i>	82	<i>Piper capense</i>
11	<i>Ocimum basilicum</i>	35	<i>Catha edulis</i>	60	<i>Cyphomandra betacea</i>	83	<i>Trigonella foenumgraecum</i>
12	<i>Lippia adoensis</i> var <i>koseret</i>	36	<i>Malus Xdomestica</i> **	61	<i>Prunus persica</i>	84	<i>Nigella sativa</i>
13	<i>Ipomoea batatas</i>	37	<i>Solanum nigrum</i> *	62	<i>Foeniculum vulgare</i>	85	<i>Triticum aethiopicum</i>
14	<i>Sorghum bicolor</i>	38	<i>Nicotiana tabacum</i>	63	<i>Triticum dicocoon</i>	86	<i>Brassica rapa</i>
15	<i>Mangifera indica</i>	39	<i>Rosmarinus officinalis</i>	64	<i>Ananas comosus</i>	87	<i>Triticum turgidum</i>
16	<i>Triticum aestivum</i>	40	<i>Glycine max</i>	65	<i>Allium sativum</i>	88	<i>Triticum durum</i>
17	<i>Cucurbita pepa</i>	41	<i>Amaranthus caudatus</i> *	66	<i>Allium porrum</i>	89	<i>Opuntia ficus-indica</i>
18	<i>Phaseolus vulgaris</i>	42	<i>Dioscorea alata</i>	67	<i>Solanum muricatum</i>	90	<i>Cicer arietinum</i>
19	<i>Phaseolus lunatus</i>	43	<i>Thymus schimperi</i>	68	<i>Lepidium sativum</i>	91	<i>Citrus medica</i>
20	<i>Solanum tuberosum</i>	44	<i>Brassica oleracea</i>	69	<i>Aframomum corrorima</i>	92	<i>Linum usitatissimum</i>
21	<i>Capsicum annuum</i>	45	<i>Allium cepa</i>	70	<i>Moringa stenopetala</i>		
22	<i>Rhamnus prinoides</i>	46	<i>Amaranthus graecicus</i> *	71	<i>Ricinus communis</i>		
23	<i>Ruta chalepensis</i>	47	<i>Artemisia absinthium</i>	72	<i>Gossypium barbadense</i>		
24	<i>Casimiroa edulis</i>	48	<i>Annona reticulata</i>	73	<i>Passiflora edulis</i>		

Note : * wild growing plants being taken up into agriculture
 ** *Malus x domestica* (hybrids where *M. sylvestris* , and others locally called *Yuuaana*, *Pumtilaa*, *Pratti* and *redlish* are involved)

Brassica carinata is a third most frequent vegetable in the homegardens that is fed with *Kocho* (Flat bread made of ensete product) by the local people. Some crop species were the least frequent such as *Linum usitatissimum* that was recorded only from the farmscape 1.

4.2.2. Diversity of crops

Species diversity refers to both species richness (number of species on the area) as well as evenness (how equal the species are represented in the area). The number of crop species, Shannon Diversity Index (H') and Shannon Evenness Index values (E) were extremely significant ($P < 0.001$) across the sites, respectively (Table 8). The highest Shannon diversity and evenness, 2.35 and 0.61, respectively were observed at site 11 (<1650m asl) where multistory agroforestry systems coupled with polyculturing (Figure 10), including intercropping. Intercropping root and tuber crops like yam, taro, and sweet potato in coffee, banana and enset fields reduced the dominance of cereals like teff.

The mean evenness value of 0.61 for farmlands in this site indicates that evenness in abundance of the species is 61% of what would have been under uniform distribution. The least diversity and evenness, 2.06 and 0.55, respectively were seen at site 1 (Ancha Sadich) at altitude > 2400m asl where wheat and enset alone shared about 60% of the crop areas. The H' values were between 2.06 and 2.35 for the groups of crops studied, which is within the theoretical ranges of H' values. On the whole, the population of crop species had a relative evenness of 57%. In most cases the diversity of particular location will be higher if the species are distributed, which was depicted in the farmscape 11 (Ajora) with Shannon diversity value equals 2.35 (Table 8).

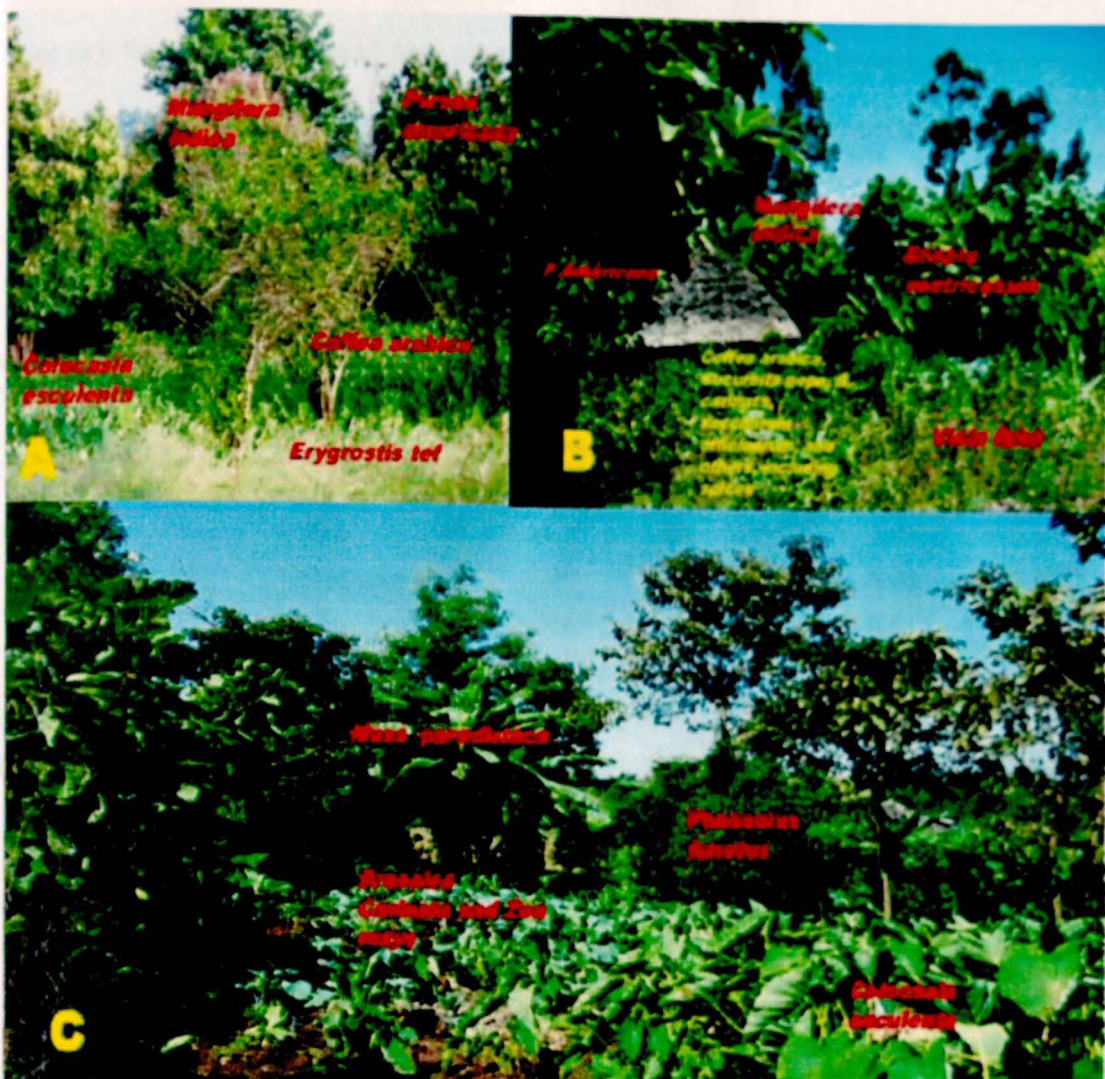


Figure 10. Polyculture farming

(A-teff, coffee and taro intercropped inside mango and avocado trees, B & C many crop species are intercropped)

Table 8 shows that the highest number of crop species (61) was recorded in farmscape 7 (Mesafe) of *Woyna Dega* agroclimate. It represents 65% of the crop species grown in the whole study area. The average number of 21.5 crop species per farmland in this site pointed that each farm represented only 21.5% of the species in that site. The small number of crop species was recorded in *Kola*, and the lowest number (44) was recorded in farmscape 10 (H/Zato). The crop

species rich farmscape 7 (Mesafe) had lower farm level species richness compared to farmscape 10 (H/Zato) where the mean of 16 species represented 36.4% of the total crops in the PA.

Table 8.Total and average number of crop species, mean values of the Shannon (H') and the Evenness (E) indices at the research sites

Agr.cl Zone	Farmscape number	Farmscape name	Number of crop species			Shannon Index H'	Standard deviation SD	Evenness Index E
			(N= 12)	Total	mean	SD		
<i>Dega</i>	1	A/Sadicho	50	12.5 ^a	6.6	2.06 ^a	0.02	0.54 ^a
	2	kazala	49	14.7 ^{ab}	5.6	2.23 ^{bc}	0.01	0.57 ^{bcd}
	3	Hobichaka	58	15 ^{ab}	7	2.14 ^{ab}	0.02	0.55 ^{ab}
	4	Sigazo	58	20.8 ^{de}	6	2.3 ^c	0.01	0.57 ^{bcd}
<i>Woyna Dega</i>	5	Kerakicho	57	18 ^{bcd}	5.8	2.27 ^c	0.01	0.56 ^{bc}
	6	Agara	56	19.6 ^{cde}	4	2.34 ^c	0.01	0.58 ^{cde}
	7	Mesafe	61	21.5 ^e	4.7	2.34 ^c	0.01	0.57 ^{bcd}
	8	Chacho	50	16.7 ^{abcd}	5	2.28 ^c	0.01	0.58 ^{cde}
<i>Kola</i>	9	Kaelama	59	21.1 ^{de}	5.6	2.32 ^c	0.01	0.57 ^{bcd}
	10	H/Zato	44	16 ^{abc}	5	2.27 ^c	0.01	0.6 ^{de}
	11	Ajora	47	15.5 ^{abc}	2.9	2.35 ^e	0.05	0.61 ^e
	12	Soyame	47	17 ^{bcd}	5	2.28 ^c	0.01	0.59 ^{cde}
		Mean	53	17.4	5.5	2.27	0.011	0.57

Note: Means in a column with different superscripts are extremely significant at F- test (P < 0.001), according to Duncan's multiple range test. Evenness was significant at P<0.001.

Crops also vary in the amount of crop area allocated for production based on the households' preferences. The percent area share (in hectare) for crops grown in the study area is shown in Figure 11. Accordingly, teff is the most widely cultivated crop with a total crop area share of 21%. A total of seven crops, i.e., teff, wheat, maize, enset, taro, coffee and ginger occupied about 75% of the total crop area share in the Zone.

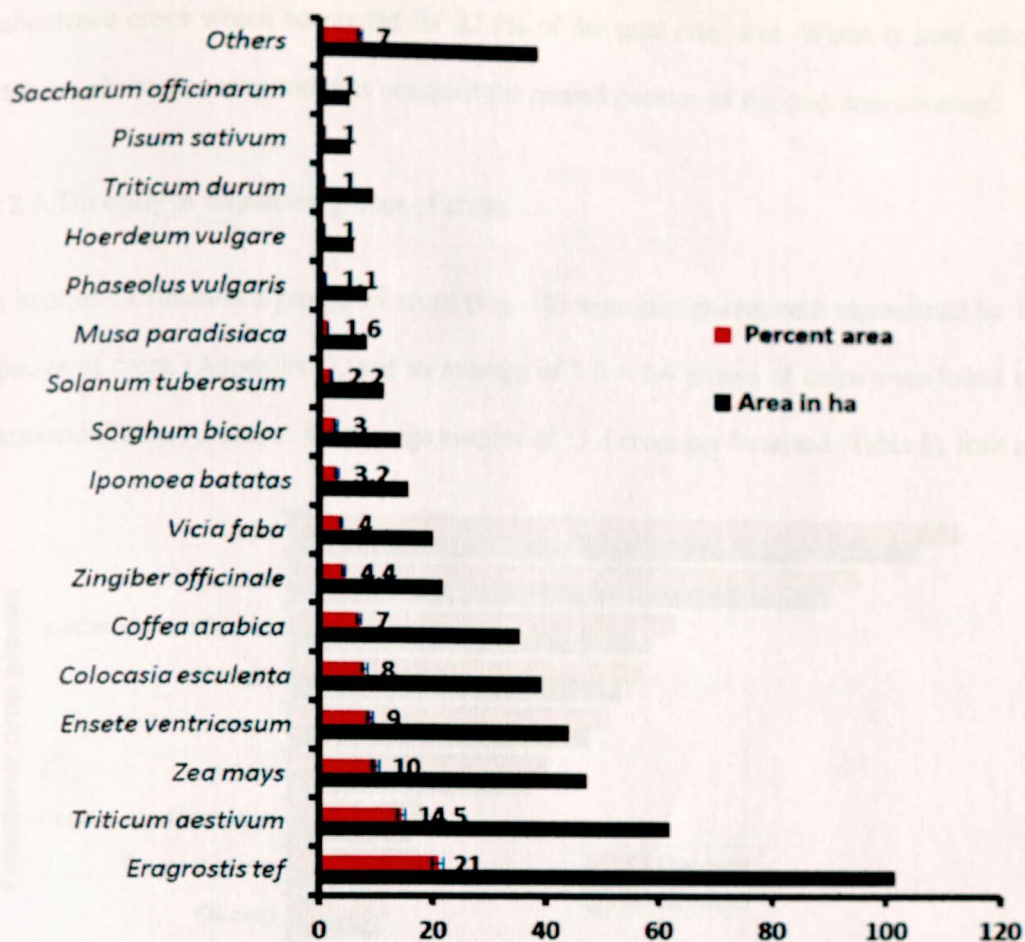


Figure 11. Mean crop area share of the major crops in the study area

(Black represents area in hectare and red percentage in ha) (Error Bars show Mean $\pm$ 1.0 SD)

Fifty one percent (N= 92) of the farmers confirmed that the first priority criterion they employ to allocate a land for diverse crop species was the income gain, followed by food value (24%), contribution to soil fertility (15%), and the season and the climate condition of the area (10%).

Teff, wheat, maize and enset are the key crop species of the study area. Although teff and maize are favorably grown in low altitude areas, enset and wheat are better grown at highland areas.

Teff, coffee and ginger are important cash crops, which accounted for 32.4% of the total crop area share whereas wheat, enset, taro, sweet potato, potato, banana and common bean are mainly

subsistence crops which accounted for 42.5% of the total crop area. Wheat is used either as a cash or subsistence crop and thus occupied the second position of the crop area coverage.

4.2.3. Diversity in functional groups of crops

A total of 12 functional groups of crops (Fig. 12) were recognised, each represented by 1 to 17 species of crops (Appendix I), and an average of 7.6 ± 1.6 groups of crops were found in each farmland (Table 9). Out of the average number of 17.4 crops per farmland (Table 8), fruit crops

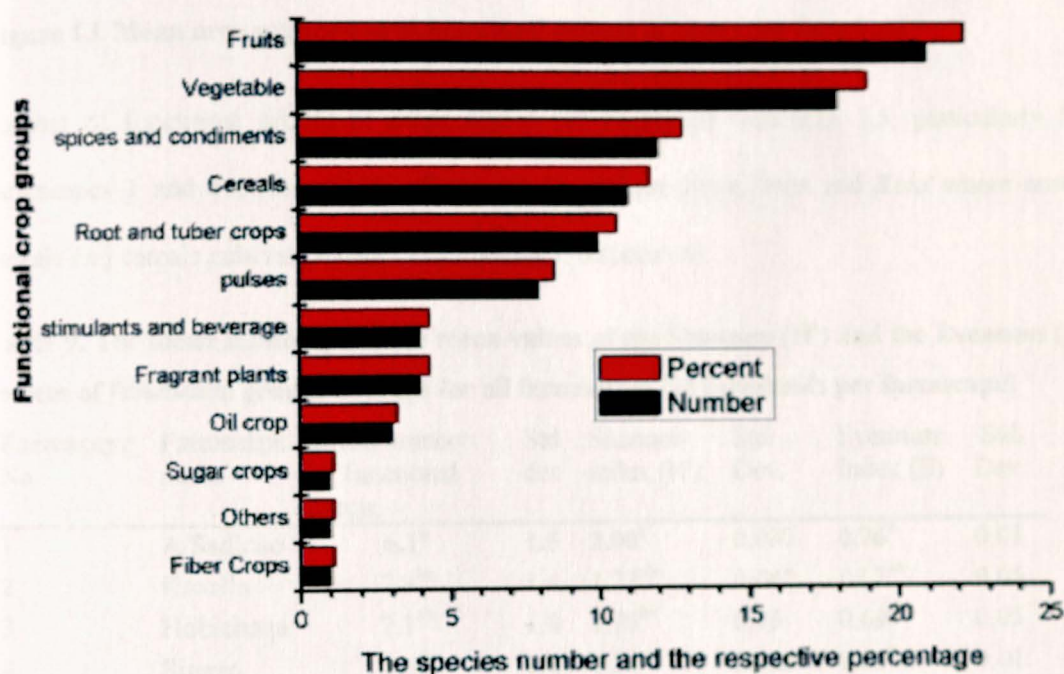


Figure 12 . The number and the proportion of Function groups of crops

accounts for 22% ($n= 21$ species) and vegetables 19% (Fig. 12). This percentage indicates the proportion of crop species in the crop category, which doesn't explain the area coverage. For instance, fruit crops constituted 22% of the average number of crop species, but they covered only 3.4 % of the farmland areas (Fig.13). There was extremely significant difference ($P<0.001$) in the number of functional groups of crops among farmscapes (Table 9). The minimum average

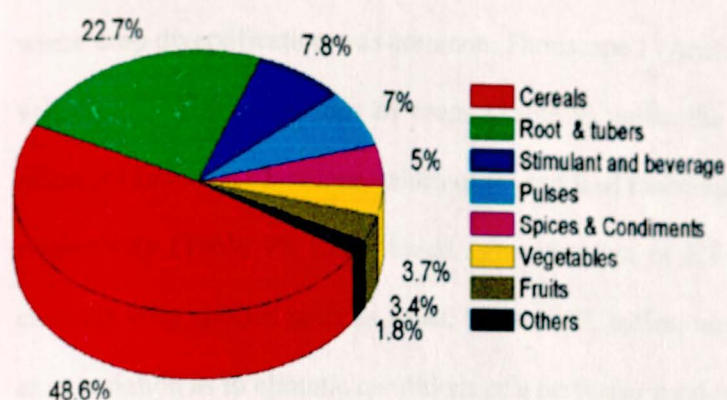


Figure 13. Mean area proportion of functional groups of crops per farmland

number of functional groups of crops record per farmscape was 6.1 ± 1.5 , particularly for farmscapes 1 and 10, respectively. These are farmscapes from *Dega* and *Kola* where enset-cereals and cereals cultivations are more dominant, respectively.

Table 9. The mean number, and the mean values of the Shannon (H') and the Evenness (E) indices of functional groups of crops for all farmscapes (15 farmlands per farmscape)

Farmscape No	Farmscape name	Mean number of functional crops	Std dev	Shannon index (H')	Std. Dev.	Evenness Index (E)	Std. Dev.
1	A/Sadicho	6.1 ^a	1.5	2.00 ^c	0.037	0.76 ^b	0.01
2	Kazalla	7.4 ^{bc}	1.4	1.73 ^{abc}	0.042	0.67 ^{ab}	0.05
3	Hobichaqa	7.1 ^{ab}	1.8	1.76 ^{bc}	0.03	0.69 ^{ab}	0.05
4	Sigazo	8.6 ^{cd}	1.1	1.53 ^{ab}	0.028	0.59 ^a	0.01
5	Kerekicho	7.4 ^{bc}	1	1.70 ^{abc}	0.03	0.66 ^{ab}	0.04
6	Agara	7.9 ^{bcd}	1.6	1.33 ^a	0.036	0.52 ^a	0.01
7	Mesafe	8.8 ^e	1.3	1.38 ^{ab}	0.035	0.54 ^a	0.01
8	Chacho	7.7 ^{bcd}	1.5	1.79 ^{bc}	0.029	0.68 ^{ab}	0.01
9	Ka'illama	8.5 ^{cde}	0.9	1.46 ^{ab}	0.025	0.57 ^a	0.01
10	H/Zato	6.1 ^a	1.5	1.56 ^{ab}	0.044	0.63 ^{ab}	0.02
11	Ajora	7.5 ^{bcd}	1.5	1.80 ^{bc}	0.024	0.68 ^{ab}	0.01
12	Soyame	7.8 ^{abcde}	1.6	1.46 ^{ab}	0.035	0.58 ^a	0.01
	Average	7.6	1.6	1.63	0.032	0.63	0.02
	F-test (P)	<0.01		<0.01	0.03	<0.05	0.02

Note: *Dega* agroclimate =farmscape (site) 1-4; *Woyna Dega* = 5-8 and *Kola* = 9-12

The maximum record of functional groups of crops was 8.8 ± 1.3 from farmscape 7 (Mesafe) where crop diversification was common. Farmscape 1 (Ancha Sadicho) had the highest H' and E values for functional groups of crops (Table 9) unlike the results obtained from crop species richness (Table 8). The mean values of H' and E of functional groups of crops are 1.63 and 0.63, respectively (Table 9). Enset based agroecosystem of KT Zone is characterized by growing common crop species such as enset, wheat, teff, coffee, taro, and banana. However, there may exist variation as to climatic conditions of a particular locality.

There were variations in crop species composition among the farmscapes 2 and 6 (Kazala and Agara, respectively) (Table 10). The two are about 11Km apart and are located in *Dega* and *woyna Dega* climatic zones, respectively. These farmscapes had the least dissimilarity of only 16% (i.e., they shared 84% of the crop species).

On the other hand, farmscapes 1 and 12 (A/Sadicho and Soyame) about 26 Km apart are located in *Dega* and *Kola* agoclimatic areas, respectively were 44% dissimilar in species composition. This was followed by farmscapes 1 and 12 (A/ Sadicho and H/Zato) with 39% dissimilarity. A/Sadicho had relatively the highest dissimilarity to others, and this may be due to its location at higher altitude (>2400m asl).

4.2.4. Similarity of farmscapes in composition of crop Species

The correlation result shows that there was a weak relation (Spearman correlation test, $r = 0.06$, $p > 0.05$) between distance between farmscapes with respect to the composition of crop species. However, altitude between farmscapes partly explains the differences among the farmscapes with respect to the composition of crop species ($r = 0.65$, $p < 0.001$) which shows good correlation between crop species and altitude. Altitude also has effects on the dissimilarity of crop species across the farmscapes. Dissimilarity in the composition of crop species increased with increasing

Table 10. Beta diversity: Dissimilarity values for crop species composition of the farmscapes (sites)

Farmscape number	Farmscape name	Ancha Sadicho	Kazala	Hobicho	Sigazo	Kerekicho	Agara	Masafe	Chacho	Kai'llama	Zato	Ajora	Soyame
1	A/Sadicho	-	0.24	0.37	0.38	0.34	0.29	0.32	0.31	0.32	0.39	0.36	0.44
2	Kazala		-	0.31	0.26	0.29	0.16	0.27	0.3	0.2	0.29	0.28	0.31
3	Hobicho			-	0.3	0.27	0.26	0.28	0.38	0.28	0.3	0.3	0.36
4	Sigazo				-	0.23	0.18	0.25	0.31	0.19	0.32	0.28	0.27
5	Kerekicho					-	0.21	0.28	0.33	0.21	0.38	0.3	0.34
6	Agara						-	0.24	0.26	0.21	0.25	0.2	0.27
7	Masafe							-	0.29	0.22	0.35	0.3	0.3
8	Chacho								-	0.27	0.33	0.21	0.26
9	Kai'llama									-	0.35	0.29	0.33
10	H/Zato										-	0.2	0.29
11	Ajora											-	0.19
12	Soyame												

Note: The value of Beta diversity ranges from 0 to 1. A value of 0 means the two farmscapes are similar in composition of species, and 1 is when no species is shared among two farmscapes

➤ *Dega* agroclimate = farmscapes (site) 1-4; *Woyna Dega* = 5-8 and *Kola* = 9-12.

altitudinal difference (Figure 14).

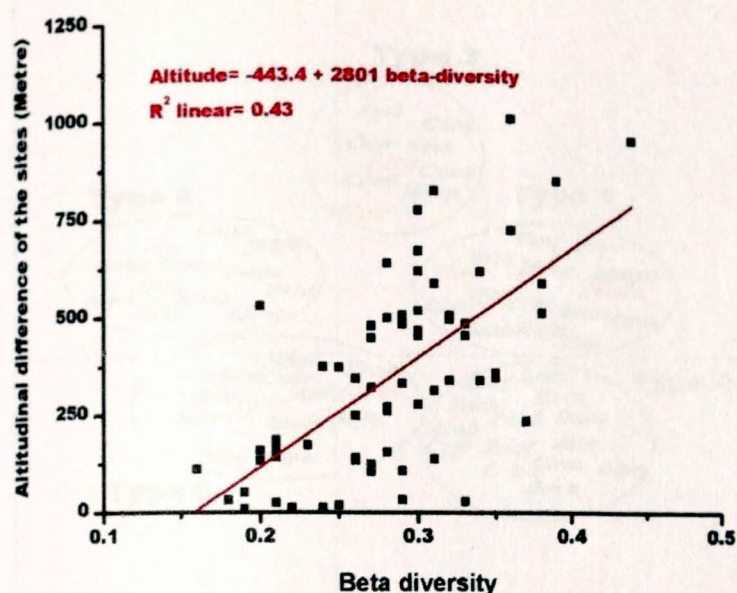


Figure 14. The relationship between altitudinal differences of the famscape and their Beta diversity values (n=66) (data are derived from Table 10)

4.2.5. Ordination

Since there is a general agreement between the classification and ordination results, indicator (%) and P-values used in classification were used to name the crop cluster groups on the ordination graph. The ordination outputs show a pattern that agrees in general with the results of the classification. They are therefore used both for classification and for explaining the relations with environmental factors. The five crop group types were identified (Figure 15). These are

1. *The Ensete ventricosum –Triticum aestivum* type: The crop aggregation in this group comprises 50 plots of which 27 are in *Dega* and 17 plots are *Woyna Dega*, and other 6 are in *Kola* agroclimatic areas. This crop type grew at the altitudinal range of 1502-2669m asl. It constitutes 30.4% of the total crop area share in the Zone. But the two indicator species

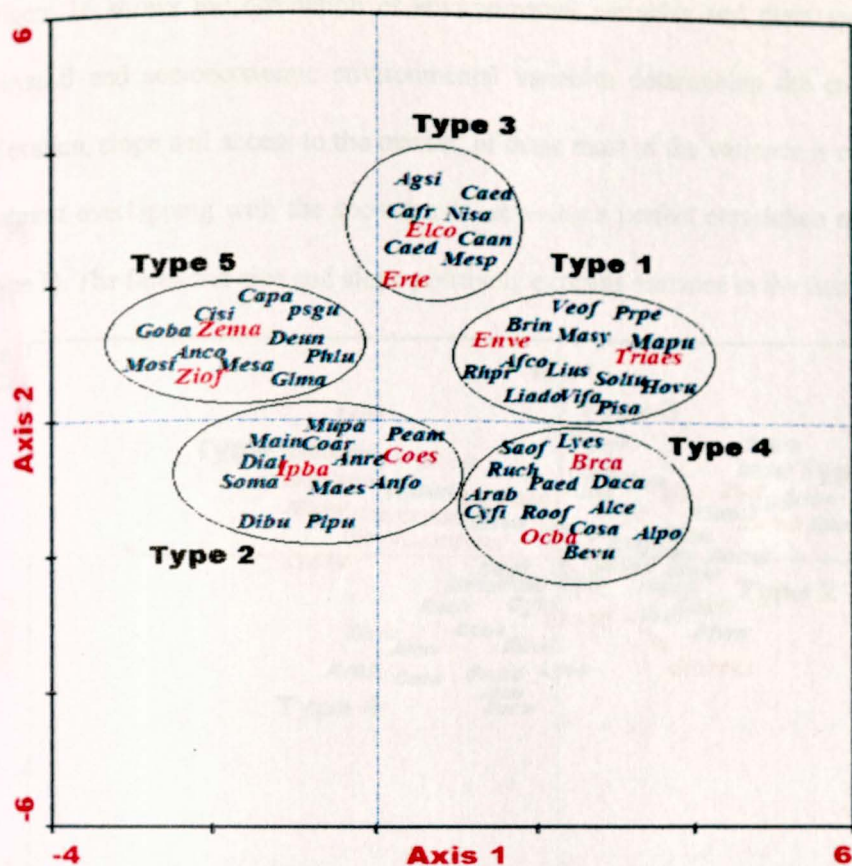


Figure 15. DCA plot ordination overlaid with crop group types

The plots in each crop group are indicated as follows:

T1:1,8,11,3,5,7,12,12,14,13,15,23,27,30,73,91,93,28,167,173,175,178,2,17,16,24,146,21,165,66,160,163,62,70,68,71,72,74,96,10,92,172,25,76,99,102,36,157,65,153,105; T2:4,80,140,87,6,88,9,86,89,81,19,20,2,2,59,64,144,145,151,155,26,142,137,154,82,94,158,141,79,100,84,90,161,76,98,77,78,32,52,83,46,43,48,85,147,49,54,52,61,97,156,162,104,138,149,150,95,101,103,109; T3:18,63,64,127,135,41,59,33,133,128,131,121,129,130,132,122,125,124; T4:166,174,168,177,170,169,171,176,179,180; T5:31,33,35,50,40,55,60,111,120,34,33,44,45,47,48,58,108,109,36,139,36,39,107,113,38,119,51,116,37,112,106,117,42,114,43,57,115,56,118,110, T= crop group type

92 Species found in 180 plots in the study area were grouped into five group types. The first two letters from genus and another two letters from species scientific names were used to abbreviate the species name (see Appendix XIV for indicator and P-values, too). Only few dominant species are indicated in each cluster of crop groups

represent 60% of the group. The group includes *Hordeum vulgare*, *Prunus persica*, *Rhamnus prinoides*, *Solanum tuberosum*, and *Vicia faba*.

Figure 16 shows the ordination of environmental variables and plant species. The important physical and socioeconomic environmental variables determining the crop group types were elevation, slope and access to the market, of these most of the variance is explained by elevation (almost overlapping with the second axis, showing a perfect correlation of elevation with crop type 1). The farmland size and slope positively explains variance in the first axis.

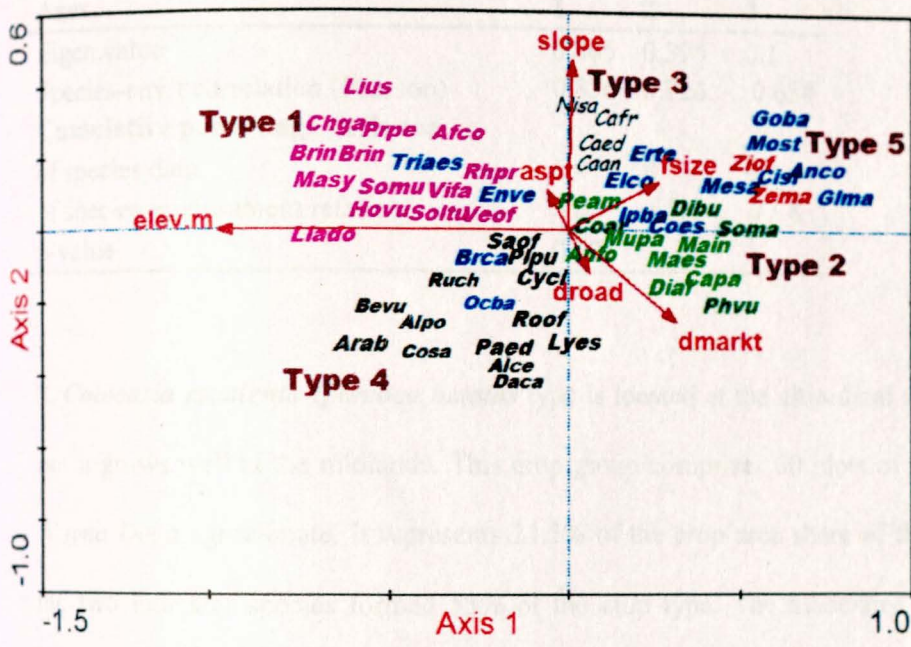


Figure 16. Canonical Correspondence Analysis for crop species and environmental factors

- Key
1. *Ensete ventricosum*-*Triticum aestivum* type
 2. *Colocasia esculenta*-*Ipomoea batatas* type
 3. *Eleusine coracana*-*Eragrostis tef*- type
 4. *Brassica carinata*-*Ocimum basilicum* type
 5. *Ginger officinale*- *Zea mays* type

But, the result of Pearson correlation coefficient shows that slope and altitude are negatively correlated to the species richness (Table 12). Yet, CCA result agrees with the Pearson correlation of crop species with the access to market. The length and orientation of environmental variables reflect their relative importance and their approximate correlation to the ordination axis. The first

and second CCA axes displayed in the ordination diagram (Eigen values 0.465 and 0.394, respectively) (Table 11), explained 8% of the variance in plant species data, and 65.4% of the variance in the plant species–environment relation.

Table 11. Eigen values and variation explained by CCA for crop types and environmental factors

Axes	1	2	3
Eigen value	0.465	0.394	0.1
Species-env't correlation (Pearson)	0.836	0.726	0.634
Cumulative percentage variance			
of species data	6.4	8	9.2
of species-environment relation:	50.5	65.4	77.8
p-value	0.001		

2. *Colocasia esculenta-Ipomoea batatas* type is located at the altitudinal range of 1502 to 2662 but it grows well at the midlands. This crop group comprises 60 plots of which 30 plots are of *Woyna Dega* agroclimate. It represents 21.5% of the crop area share of the samples. However, the two indicator species formed 53% of the crop type. The associated crop species include *Coffea arabica*, *Plectranthus punctatus*, *Cymbopogon citrates*, *Dioscorea bulbifera*, *Persea americana*, *Casimora edulis*, *Psidium guajava*, *Rosmarinus officinalis*, *Musa paradisiaca* and *Mangifera indica*. This crop group hosted familiar subsistence as well as cash crops, mainly *C. esculenta* and *C. arabica*, respectively.

3. *Eleusine coracana-Eragrostis tef* type consists of 19 plots, of which 14 occupy *Kola* , and the rest *Dega* and *Woyna Dega* agroclimatic zones. It constituted about 25.1% of the total crop area in the Zone, but the two dominant crop species, *Eleusine coracana* and *Eragrostis tef*, form 88% of this crop type. They constitute a subsistence as well as cash crop species, respectively. The group includes crop species like *Capsicum annum*, *C. frutescens*, *Carica papaya*, *Catha edulis*,

and *Nigella sativa*. Teff was given larger area share than other crops (Figure 11). It is cultivated widely, especially at the altitudinal range between 1502-2501m asl. Crop type 1 and 3 constituted the most dominant crop species in the Zone where both comprised more than 55% of the total crop area share in KT agroecosystems.

4. ***Brassica carinata* -*Ocimum basilicum*** type commonly grows in the homegardens of the study area. The group is comprised of 10 plots forming 8% of the total crop area share. It is dominant in Dega agroclimate where 78% of this crop types grow. This crop group is a typical representative of the HGs where vegetables, spices, fragrant plants as well as some MPs such as *Ruta chalepensis* grow luxuriously. The group also includes *Daucus carota*, *Rosmarinus officinalis*, *Beta vulgaris*, *Artemisia absinthium*, *Phaseolus lunatus*, and *Cymbopogon citrates*.
5. ***Zea mays*-*Zingiber officinale*** type is found mainly at the altitudinal range of 1502-2407m asl. It comprised of 41 plots, of which 28 plots are in Kola, 11 in Woyna Dega, and the rest in Dega agroclimatic zones. This group type makes up 15.3% of the total crop share of the study area. It includes *Sorghum bicolor*, *Carica papaya*, *Solanum macrocarpon*, *Phaseolus vulgaris*, *Phaseolus lunatus*, *Ananas comosus*, and *Citrus aurantifolia*. *Z. officinale* is highly important cash crop of the study area where it grows mainly in red vertisols. The crop group types 2 and 5 are negatively influenced by rise in elevation (Figure, 15).

4.2.6. Determinants of crop diversity

Crop species were not distributed uniformly throughout the study area (see section 4.2.4.). Table 12 indicates the influence of some physical and socioeconomic variables on the crop diversity (both species richness and diversity indices are dependant variables) in the study area.

1. **Distance to market and Distance to major road** positively influenced crop species richness, diversity (heterogeneity) as well as the evenness (distribution of crop species). With increasing distance to market, the number of crop species increased. As indicated in Figure 11, crop species like *Z. mays*, *C. arabica*, and *Z. officinale* tend to increase in the area share with increase in distance to market but with decrease in distance, *E. ventricosum* and *T. aestivum* took the share of others.
 2. **Farmland size:** It significantly influenced the number of crop species grown as well as the evenness of crops. With increase in farmland size, the crop species increased accordingly. The owners of large farmland tend to allocate large proportion of cereals like *E. tef* and *T. aestivum* besides growing root crops, coffee and fruit crops.
 3. **Livestock holding (TLU):** the number of livestock influenced the number and evenness of crop species positively and significantly.
 4. **Family size** do not have any significant influence on crop species richness and crop functional groups.
- Age:** The number of years that HH heads farmed influenced both the crop species number and the crop functional groups positively and significantly. Older farmers had mature HGs as well as other arable land since they have adopted different crop varieties through time in response to climate and other stresses of the agroecosystem.
6. **Education** is negatively related to crop species richness, crop functional groups, heterogeneity and evenness with no significant influence on them.

Table 12. Result of multiple linear regressions of diversity indices on biophysical and socioeconomic environments

Factors/explanatory variables	Crop species			Functional groups of crop		
	Richness (S)	Shannon's index (H')	Evenness Index (E)	Richness (S)	Shannon's index (H')	Evenness Index(E)
Adjusted R ²	.163***	.167**	0.205***	.153**	0.129*	0.126*
Physical environment						
Elevation of the farm (1502-2669m)	1.2 (-0.081)	13.4**	23.5***	NS (-0.102)	NS	NS
Slope of the farmland (2-26)	7**(-0.195)	NS	NS	NS (-0.071)	NS	NS
Aspect of the farmland (0-4)	NS (0.043)	NS	NS	NS (0.24)	NS	NS
Socio-economic environment						
Distance to markets (0.5-33 km)	8.8** (0.217)	2.61*	2.6*	NS (0.143)	NS	NS
Distance to major roads (0.01-14km)	9.2** (0.222)	4.54*	5.2*	NS (.225)	NS	NS
Farmland size (0.04-21.2ha/HH)	6.67*(0.19)	7.5*	1.8*	NS (0.138)	NS	NS
Number of livestock (0-86.6 TLU)	7** (0.195)	NS	NS	5.9* (0.18)	8.2**	8.2**
Off-farm activity (Yes/No)	NS (-0.047)	NS	NS	NS (-0.038)	NS	NS
Family size (2-21 people/HH)	NS(0.094)	NS	NS	NS (0.138)	NS	NS
Age (28-82)	9.5** (0.225)	NS	NS	2.46*(0.241)	NS	NS
Education (0- 12+3)	NS (-0.106)	NS	NS	NS (-0.114)	NS	NS

The parenthetical values indicate Pearson correlation (r) that predicts the strength of the relation whereas the parenthetical values under “factors” denote the range for each parameter. * = F values at $p < 0.05$; ** = at $p < 0.01$; *** = at $p < 0.001$.

Note: The explanatory variable such as education refers to the proportion of literate HHs in 2010; Distance to markets is the walking distance in Kilo metres to the nearest market; Distance to the major roads is the walking distance in Kilo metres to the nearest all-weather road; Altitude describes range of altitude of topography in metres, and farmland size is the area of farmland in hectare owned by the HH.

Multiple regression equation:

Crop species richness = $14 + 0.059 \text{ age} - 0.045 \text{educ} + 0.04 \text{ family size} - 1.15 \text{ off farm} + 0.045 \text{ TLU} + 0.287 \text{ fam size} + 0.103 \text{ aspect} - 0.19 \text{ slope} - 0.00024 \text{ altitude} + 0.276 \text{dmarket} + 0.195 \text{ distance to market}$. But the model explains only 16% of the variation in the number of crop species that is maintained at HH level (it has low prediction power).

4.2.7. Threats to crop agrobiodiversity

The agroecosystem of KT Zone with its multistory homegardens, intercropping and growing trees both in HGs as well as cropland gave a configuration that resembles a forest. However, planting fast growing and income generating exotic trees inside crop fields e.g., eucalyptus (Figure 17), over grazing, cultivating woodlands and focus on few crop species, are among the factors that threaten the biodiversity in particular and the agroecosystems in general.

Informants reported on the frequency of crop failure with hybrid crop varieties in the extension program, particularly that of maize and teff. On the other hand, the agroecosystem of the study area is receiving ecosystem disservices mainly from crop pests and diseases. Eventhough pests like monkeys, mole rat and others were recorded, the crested porcupine was found to be the



Figure 17. Eucalyptus plantation inside the crop fields (highland areas)

most serious pest disturbing crops in the study area. The six most affected subsistence food crops by wild animal pests are shown in Table 13.

Table 13. The relative impact of various wild pests on subsistence crops in KT Zone as indicated by the percentage of respondents

S.No	Crop type	Crop pests		
		Porcupine	Mole rat	Monkeys
1	<i>Zea mays</i>	45		9
2	<i>Solanum tuberosum</i>	41		
3	<i>Ensete ventricosum</i>	37	6	
4	<i>Vicia faba</i>	37		
5	<i>Brassica carinata</i>	16	6	4
6	<i>Colocasia esculenta</i>	15	13	

Note: blackened box shows no report on pests' impact

Forty five percent of the farmers affirmed that *Z. mays* is the number one crop damaged by porcupine, followed by *S. tuberosum* and *E. ventricosum*. These crop species are typical subsistence crops in the Zone. Similarly, the mole rat and monkeys damage mostly *C. esculenta* and *Z. mays*, respectively.

Informants also confirmed that porcupine caused a great loss of various enset varieties, which are highly preferred for their edible corm (e.g., *Astra*, *Aganne*, *Leqqaqa*, and *Oniya*), medicinal values, quality of *bull*a and *kocho*. Many farmers abandoned cultivating locally preferred varieties for they are easily damaged by porcupine. However, indigenous people have developed methods to protect crops from porcupine. These include repelling by smoking bones in the crop fields, building stone bench terraces around crop field, filling porcupine holes, deep digging around its den, and adding manure around the victim enset varieties. Farmers also suggested the significance of cooperation of local communities, including neighbor peasant association in the protection of this pest.

4.3. THE DIVERSITY AND COMPOSITION OF ENSET LANDRACES

4.3.1. The number and characterization of enset landraces

This study used farmers' characterization as the means of detecting enset varieties though it is unclear and very subjective. A total of 111 named enset landraces were recognized in this study (see Appendix II.), and the enset plantation covers 9% of the total crop land in the study Zone.

The indigenous people grouped enset landraces into two based on sex. The classification into "male" and "female" does not represent the biological reproductive parts of the plant, but rather a set of qualities desired by local people. The female groups are recognized by ease of scrapping, early fermentation, low yield, low quality fiber, susceptibility to disease, small size, and corm edibility while the male group contrasts to these traits.

Enset farmers differentiate two variants or may be mutants of the same landrace differing in their color as well as use value, using words *Waju* and *Gambella*, the white and dark green landraces, for instance, *Waju Sorphe* (means white landrace *Sorphe*) and *Gambella Sorphe* (means black landrace *sorphe*), respectively. The white one is recognized as male and the dark green as female. Other three farmer varieties that follow such naming pattern include, *Quina*, *Sisqella*, and *Qeqille* (*wojuta* and *kashalata*, meaning white and red respectively). *Waju* is to refer to maleness. When *ta* added, it becomes *Wojuta* that is to refer to femaleness. If such varieties were considered as a different group, the total landrace number would be raised to 115. Moreover, some enset landrace names have sub names, e.g. Merza has two types (*Dego merza* and *Abat merza*), and *Dirbo* has 3 types (*Belaka*, *Danxxa* and *Disho*).

Enset landraces are named by indigenous people of the study area based on attributes such as colour and shape. For example, enset names are given on the basis of

- a. **Colour**, e.g., *Aganne* is a name given to a landrace which means moon. It is to indicate that the landrace is as white as the moon;
- b. **Shape** for instance, *Fachache* means fattened or big sized. This variety is known with its wide gird whereas some names:
- c. Are **synonym**, and used interchangeably such as *Gambella Sisqella* in one locality is named as *Wachiso* in other areas. Similarly, *Aganne* is named as *Wojille*, and *Qeqille* is named as *Dinke*, respectively in other areas, and
- d. Have **similar naming** pattern to different ethnic groups with minor modification, which may indicate the exchange of enset landraces among different groups. For instance *Agiiniia* in Wolaita is named as *Aganne* by people in KT Zone.

4.3.2. Diversity and uses of enset landraces

There was high significant difference ($P < 0.01$) in enset landraces among the 3 economic classes, and there was also extremely significant difference among the 3 agroclimatic zones ($P < 0.001$). The mean number of enset landraces in the Zone was 7.2/HH. *Dega* agroclimatic areas cultivate large number of enset landraces (mean = 11.5/HH) but *Kola* areas cultivate the number equals only 50% of *Dega*. Poor farmer grows few number of landraces compared to other economic groups (Table 14). Table 14 shows that the number of enset landraces is related to the farmland size, area allocated to enset, and the size of livestock. Enset landraces also vary in their frequency across the Zone (See Appendix II).

Table 14. Average number of farm size, onset landrace area, and the number cultivated by 3 economic classes across the 3 agroclimatic zones of the study area (N= 180)

Wealth category	Farmland Size (ha)	Onset area (ha)	No of livestock	Onset in agroclimatic zones			Total	Std. Dev
				Dega	WD*	Kola		
Poor	0.8	0.11	1.86	9.2	7.9	3.5	6.9 ^a	3.9
Medium	1.9	0.23	4.6	11.4	11.2	6.3	9.7 ^{ab}	5
Rich	3.3	0.39	12.5	13.8	10	7.5	10.4 ^b	6
Average	2	0.24	6.3 ± 0.7	11.5 ^a	9.7 ^b	5.8 ^c	9	5

WD* = Woyna Dega; letters with different superscripts are significant (P<0.05)

The top 10 most frequent onset varieties are shown in Table 15. The top three most frequent onset varieties were *Sisqella*, *Dirbo*, and *Gishra* with frequency of 57.2, 53.5, and 47.5%, respectively. But there were 15 different onset landraces with the least frequency such as *Amareeta*, *Beneja*, *Indelible*, and *Shododona* (Appendix II).

Table 15. Frequency of the 10 most widely grown landraces in KT Zone

Local name of Onset landrace	<i>Sisqella</i>	<i>Dirbo</i>	<i>Gishira</i>	<i>Gimbo</i>	<i>Unjamo</i>	<i>Laqqaga</i>	<i>Sebera</i>	<i>Abat merza</i>	<i>Sheleqe</i>	<i>Xororre</i>
Frequency (%)	57.2	53.7	47.5	43.1	39.6	32.9	30.2	23.1	19.8	19.6

The onset plantation area that was confined in the HGs of the study area ranged from 0.01 to 1.25 ha with a mean of 0.24 ± 0.02 ha (Table 16). The number of onset landraces per farmscapes ranged from 8 to 61 with an average of 27.3, whereas the mean Shannon diversity index (H') and evenness (E) indices were 1.84 and 0.64, respectively, in the Zone. Similarly, the mean number of onset landraces at farmland level was 9 ± 3.9 .

The number of onset landraces showed extremely significant difference ($P<0.001$) across the farmscapes. Table 16 shows that onset landrace diversity tend to decrease down the elevation.

The highest number of enset landraces 61(55%) was recorded from famscape 1 (A/Sadicho) where the altitude is above 2500m asl. It also had the highest average number of enset landraces, 15.1 per farmland indicating that each farmland represents about 15% of the enset varieties in that famscape. Furthermore, there was the highest evenness (0.88), showing that the famscape is characterized by large number of landraces which are better distributed equally in most sample HHs of the famscape. However, the highest landrace diversity ($H' = 2.35$) was recorded from famscape 5 in *Woyna Dega* agroclimate.

Nonetheless, the least number of enset varieties was recorded from famscape 10 (H/Zato), at site and farmland level was 8 and 0.93, respectively. This famscape falls under *Kola* agroclimate (< 1800m asl) where cereals are the main staple food. Due to the prevalence of sandy soils, few farmers grow enset for uses other than staple food. This resulted in a very low E and H' , 0.20 and 0.7, respectively (Table 16). The H' value is below the theoretical ranges which may signal few number of landraces in the sample as well as the absence of landraces in other samples.

There was high significant difference ($P < 0.01$) in the mean density across famscapes. The density of enset per hectare was 445, 1037, and 3081 for *Dega*, *Woyna Dega* and *Kola*, respectively. The mean density of enset landrace was 1520 (Table 16). Enset is widely spaced in *Dega* and *Woyna Dega* agroclimatic areas to avoid competition, and enhance leaf spreading out for fodder use and thickness of pseudostem for *kocho* processing.

Table 16. Total and mean number of enset landraces, mean values of the Shannon (H') and the Evenness (E) indices, and enset density across the farmscapes

Farmscape number	Farmscape name	Altitude (m)	Area share (ha)	Total Landraces	Mean	Std. Dev	Shannon Index, H'	Std. Dev	Evenness Index, E	Enset density (indvls/ha)
1	A/Sadicho	2619	0.39	61	15.1 ^g	7.9	2.26 ^a	0.03	0.88^a	435
2	Kazalla	2350	0.35	20	14 ^{fg}	5.1	2.18 ^a	0.03	0.83 ^a	236
3	Hobicho	2407	0.29	58	13.6 ^{fg}	5.8	2.22 ^a	0.02	0.85 ^a	324
4	Sigazo	2310	0.30	18	2.7 ^b	3.8	0.89 ^b	0.08	0.31 ^b	784
5	Kerekicho	2259	0.25	42	11.6 ^{ef}	3.8	2.36^a	0.01	0.65 ^a	768
6	Agara	2120	0.21	22	8.7 ^{de}	4.6	2.0 ^a	0.03	0.64 ^a	543
7	Mesafe	2126	0.37	24	7.1 ^{cd}	3.1	2.16 ^a	0.03	0.68 ^a	476
8	Chacho	1892	0.19	25	4.2 ^{abc}	1.8	1.80 ^a	0.04	0.57 ^a	2358
9	Kaillama	1790	0.18	15	6.2 ^{bcd}	2.9	1.86 ^a	0.03	0.76 ^a	2535
10	H/Zato	1745	0.04	8	0.93 ^a	2.3	0.7^b	1.67	0.20^b	4508
11	Ajora	1557	0.21	24	5 ^{bc}	4.4	1.64 ^a	0.05	0.52 ^a	533
12	Soyame	1677	0.15	10	3.5 ^b	1.4	1.90 ^a	0.02	0.70 ^a	4747
	Average	2071	0.24	27.3	9	3.9	1.84	0.31	0.64	1520

Note: Dega agroclimate = farmscape (site) 1-4; Woyna Dega = 5-8 and Kola = 9-12.

Beta diversity

Enset plant varies in its landrace composition, abundance, and area coverage among different farmscapes. Beta diversity was used to characterize the degree of spatial heterogeneity in the composition of enset landraces across the farmscapes (Table 17).

The farmscapes 1 and 3 (Ancha Sadicho and Hobichaqa) about 10 Km distant had the least dissimilarities of 40% (they shared 60% of the enset landraces). Enset area cover is relatively large in these farmscapes, and enset is the main staple food. But farmscapes 1 and 12 (A/Sadicho and Soyame) about 26 Km apart are located in *Dega* and *Kola* agroclimatic areas, respectively were 97% dissimilar in the composition of enset landrace, which was followed by farmscapes 2 and 12 (Kazala and Soyame), and farmscapes 7 and 12 (Mesafe and Soyame), each with 96% dissimilarity. Farmscapes 4 and 12 (Sigazo and Soyame) had relatively the highest dissimilarity to others which is more associated with the system of farming where cereals and root/tuber crops other than enset are major staple foods.

The use values of enset

The results of the ordination analysis performed to identify the relationships among 38 landraces in 12 farmscapes revealed that 84.5% of the total variation to have been accounted by the two dimensions or Axes (1 and 2) (Figure 18). The use values with long vectors (*amicho*, storability, fiber, high yield, and earliness) were most preferred by the individual judge, useful in discriminating enset landraces. The enset landraces investigated showed a high significant variability ($P < 0.01$) in their use value, and there was some sort of clustering of landraces, especially towards *amicho*, *bullu*, taste, and earliness. Multidimensional preference ranking analysis (Figure 18) separated the landraces locally distinguished as 'males' towards negative

Table 17. Beta diversity: Dissimilarity values for enset landraces composition between famscapes

Farmscape number	Farmscape name	Ancha Sadicho	Kazala	Hob.	Sigazo	kerekicho	Agara	Mesafe	Chacho	Kai'llama	Zato	Ajora	Soyame
1	A/Sadicho	-											
2	Kazala	0.71	-										
3	Hobichaqa	0.40	0.75	-									
4	Sigazo	0.89	0.88	0.83	-								
5	kerekicho	0.56	0.8	0.57	0.89	-							
6	Agara	0.79	0.54	0.77	0.92	0.81	-						
7	Mesafe	0.85	0.78	0.80	0.92	0.82	0.71	-					
8	Chacho	0.75	0.85	0.75	0.83	0.89	0.83	0.83	-				
9	Kai'llama	0.81	0.70	0.83	0.90	0.83	0.71	0.85	0.79	-			
10	H/Zato	0.92	0.67	0.85	0.92	0.83	0.74	0.86	0.90	0.81	-		
11	Ajora	0.82	0.81	0.82	0.93	0.86	0.78	0.88	0.68	0.78	0.86	-	
12	Soyame	0.97	0.96	0.92	0.88	0.96	0.93	0.96	0.83	0.91	0.94	0.87	-

Note: *Dega* agroclimate = Farmscape (site) 1-4; *Woyna Dega* = 5-8 and *Kola* = 9-12.

highly useful in discriminating enset landraces. *Amicho*, taste, and earliness point in roughly the same direction may show similar preference patterns. This shows that landraces preferred for *amicho* are tasty, which also ferment early if desired to process *kocho*.

Bulla and *amicho* contributed more to the positive axis of the first dimension where varieties of the 'female' category dominated. The varieties under this dimension also overlap with their uses. For example, *Itine*, *Woa*, *Woshameda*, *Goemorsa*, and *Usquruzu* are known in their quality for processing *bull*a, and also preferred for their tasty *amicho*. The short length of arrow for *bull*a shows its relatively low significance in grouping enset landraces. In general, most of the studied enset landraces were used for preparing *amicho* (about 51%), followed by *bull*a (50), making *kocho* (41%), and medicine (19%). It can be said that names given to different landraces on the basis of their use values by the enset-growing farmers seem consistent.

Medicinal use of enset

Table 18 shows that twenty one enset landraces were identified for their medicinal use. Out of these, 13 enset landraces were known to have medicinal significance to cure problems of broken bone fractures and joint displacement of both human as well as livestock. For instance, *Laqaqqa* is used to heal the boil (a painful infected swelling). The watery liquid squeezed from the pseudostem of some varieties is boiled and the skin is washed to heal the skin fungal disease called *ulama* (*Tinea corporis*), e.g., *Hargama* and *Moche*. *Qeqille* is uniquely a red colored variant with abortifacient action, used to expel placenta. The management of such medicinal enset landraces differs in that they are planted closer to home in order to take care by supplying adequate manure, and to protect them from pests. Moreover, the processed food, called '*kocho*' is used against dysentery.

Table 18. Medicinally useful enset landraces used to treat various ailments of both human and livestock

Ailment type	Name of enset variety	Part used	Used for	
			Human	Livestock
Bone setting	<i>Aganche</i>	Corm	The corm is cooked and fed with milk or it is ground , cooked and butter is added	fed raw
	<i>Astra</i>			
	<i>Charquwa</i>			
	<i>Fello</i>			
	<i>Gimbuwa</i>			
	<i>Gishira</i>			
	<i>Ketanne</i>			
	<i>Qeniware</i>			
	<i>Sebera</i>			
	<i>Sheleqoma</i>			
	<i>Xebare</i>			
Boil	<i>Zessa</i>	Corm	Cooked and fed with milk	Not common
	<i>Zinke</i>			
Skin fungal problems	<i>Laqqqa</i>	Pseudostem	Watery liquid squeezed, boiled	x
	<i>Teressega</i>			
	<i>Oniya</i>			
	<i>Hargama</i>			
Afterbirth	<i>Moche</i>	Corm	Cooked and fed with milk	fed raw
	<i>Wolagella</i>			
	<i>Qeqille</i>			
Hepatitis	<i>Unjamo</i>	Corm	Cooked and fed with milk	x

Note: X mark indicates not used

Apart from the above medicinal values, enset also has *non-medicinal* uses. Table 19 shows non-medicinal multipurpose role of enset as a human food, livestock fodder and non food uses for growers. Varieties like *Gishira*, *woju Sorphe*, *woju Qeqille*, *Aganne*, and *Wolanche* are used to fatten cattle, mainly oxen. But all landraces are not given to cattle because families believe that if some landraces (e.g., *Qeqille*) are given to a pregnant cow, it results in abortion. Many of the female varieties have large amount of *bulla* or starch, which may deter digestion and can cause death to cattle, e.g., *Buqane* is not recommended.

Some landraces are highly recognized by the local people. For example *Bishato*, *Bunache* and *Usquruzo* have high quality *kocho* from which injera (thin, and flat Ethiopia bread made from teff) can be made. Varieties like *Abat merza*, *Gimbo* and *Sebera* are used to process a high quality *qocho* from which a traditional food called *atakana* is made. *Atakana* is made mainly during the Ethiopian religious *Meskel* holiday, which commemorates the finding of the true Cross. *Kocho* is dried for a month to allow it loose its moisture. Then, it is powdered, roasted on flat clay material, cooled, and spiced. Then, it is softened by adding purified butter and milk until it is made to be taken with spoon.

Table 19. Some of the non-medicinal uses of enset

S.no	Products of enset	Uses	Remark
1	<i>Waasa</i> (Kocho)	food	surplus for sale
2	<i>Hamicho</i> (Amicho)	food	
3	<i>Bu'ula</i> (Bulla)	Food	mainly for income generation
4	<i>Qancha</i> (fiber)	for making rope and sieves, material for construction, bondage, mats.	mainly for sale
5	<i>Habara</i> (leaves)	bread wrappers, serving plates, and pit liners to store kocho	
6	<i>Hofcho</i> (Dried leaf/pseudostem sheaths)	wrappers for butter and kocho	
7	<i>Halana</i> (The pulp from the dried petioles and midribs)	diapers for baby, brusher	
8	<i>Wesse</i> (all fresh parts of adult enset)	fodder for cattle	some female named bulla rich and abortifacient landraces are excluded

4.3.3. Determinants of enset landrace diversity

Enset based homegardens of the study Zone varied in the number and types of enset landraces they held (Table 16). Table 20 shows that the socioeconomic factor primarily off-farm activity and the physical environmental factors (i.e., elevation, access to main road and access to market) have significantly influenced the diversity of enset landraces.

Elevation was the only variable that positively related to the enset diversity. Thus, there was a strong and positive correlation of the number of enset landraces with altitude (Figure 19), whereas with increase in off farm activity the diversity decreases. Similarly, enset diversity increased with decrease in distance to major road as well as distance to market. Other factors such as age of HH, TLU, family size (labour force), and cultivated crops diversity did not show any significance though they were positively correlated to enset diversity.

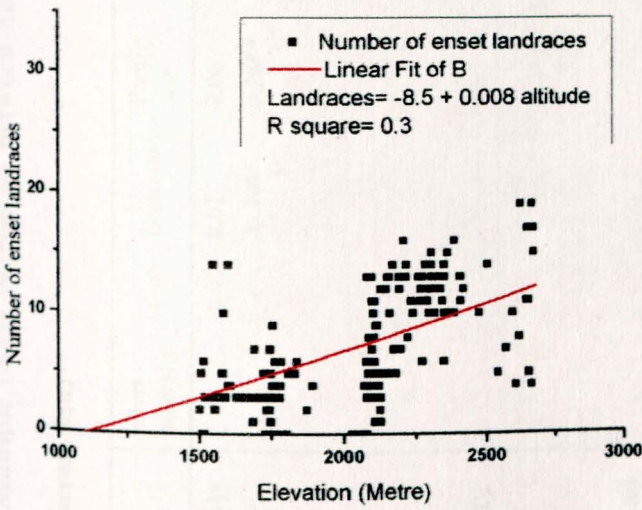


Figure 19. The relationship between elevation and number of enset landraces in KT Zone

Table 20. Multiple linear regression between number of enset landraces, socio-economic and biophysical factors (N=180)
(Pearson correlation)

Variables	Enset diversity	Age	Education	Family size	off farm activity	TLU	Crop diversity	Aspect	Slope	Elevation	Access to road	Access to market	Farm l Size
Enset diversity	—	0.05	0.01	0.06	-0.18*	0.02	0.07	0.1	0.18	0.68**	-0.15**	-0.45**	0.1
Age		—	-0.39**	0.28**	-0.09	0.31**	0.24**	0.04	-0.17*	0.04	0.02	0.11	0.3**
Education			—	0.04	0.27**	0.1	-0.09	0.07	0.1	0.05	-0.14	-0.05	0.04
Family size				—	-0.04	0.37**	0.16*	0.07	-0.01	-0.03	0.01	0.01	0.43**
Off farm activity					—	0.19**	-0.03	0.12	0.03	-0.01	-0.08	0.08	-0.1
TLU						—	0.38**	0.1	-0.2**	-0.09	0.07	0.14	0.71**
Crop diversity							—	0.06	-0.2**	-0.11	0.2**	0.22**	0.31**
Aspect								—	0.08	0.07	0.04	0.02	0.05
Slope									—	0.13	-0.20**	-0.17**	-0.15*
Elevation										—	-0.16**	-0.53**	-0.07
Access to road											—	0.45**	0.05
Access to market												—	0
Farmland size													—

*. Correlation is significant at the 0.05 level (2-tailed).

**. Correlation is significant at the 0.01 level (2-tailed).

TLU = Tropical Livestock Unit

4.3.4. Threats to enset landraces and indigenous management systems

The enset plant growing in small areas of the HGs is a renowned food security crop. However, respondents confirmed that the shortage of farmland, the influences of vertebrate pests and enset diseases (Figure 20) are challenging the diversity and production of enset. The focus on fast growing cash crops by young generation is also another emergent challenge.

There is a prudent interaction between enset and livestock in enset farming areas particularly in the highlands where enset serves as a source of fodder, and livestock provide manure to fertilize enset fields.



Figure 20. Commonly observed enset diseases (Photos by Melesse Maryo, 2010)

A) *Zi'ira* (unidentified species) forms a freckle like spots that coalesce to form a big one, the leaf sheaths of the pseudostem dries up. A plant has an opportunity to recover), B) *Aloyaa/Ganshua* (enset bacterial wilt) kills a plant

Eighty six percent of farmers stated that there is a shortage of grazing land as well as arable land, which in turn tend to limit livestock number. In the absence of livestock, the sustainability of enset production can be disadvantaged. In addition, about 52% of the farmers described that enset landraces faced difficulties from wild animal pests and diseases, mainly porcupine (79%) (See section 4.2.7), *Aloya/Gansho* (bacterial disease) (9%) (Fig. 20B), the disease caused by unknown agent called *Zi'ira* (8%) (Fig. 20A), and the mole rat (4%).

Traditional methods that are used to prevent the mole rat include the removal of large grassy crop field margins, trapping, and flooding the mixture of cow and horse dung into its hole. Furthermore, enset varieties that are highly recognized in their use are planted very close to the home meant to protect from pests and diseases.

Informants also discussed that though not regularly practiced by all, traditionally knowledgeable people 1). Grow some plants like *Pycnostachys abyssinica* & *Canna indica* near the enset plant that is infected by bacteria. During the field work, some recovered landraces were observed after planting this species; 2). Plant healthy, disease-free enset suckers, and use clean farm tools, and 3). Remove infected enset from the area and rotate cereal crops to avoid bacterial recycling. Very few farmers use the combination of these methods.

4.4. DIVERSITY AND COMPOSITION OF WOODY SPECIES IN AF SYSTEMS

4.4.1. Tree and shrub species diversity

A total of 186 tree and shrub species belonging to 135 Genera and 63 Families were recorded in the current study (Appendix V). Among these Fabaceae had the highest number of species with 24 (13%), followed by Euphorbiaceae 14 spp. (8%), and Rubiaceae 7 spp (4%) (Appendix V).

The genera, which had the highest number of species, were *Acacia*, *Euphorbia* and *Senna* (each six spp.). From the identified woody species eight of them were endemic to Ethiopia. These are *Acanthus sennii*, *Boswellia pirottae*, *Erythrina brucei*, *Millettia ferruginea*, *Pittosporum abyssinicum*, *Pycnostachys abyssinica*, *Vernonia filigera*, and *Vepris dainellii*. (Appendix IV).

Tree and shrub species vary in their frequency of occurrence across the farmscapes (see Appendix VI) along altitudinal gradients but only five species occurred in over 50% of the studied HHs (sampling sites). *Cordia africana* and *Croton macrostachyus* were the most frequent species occurring in 70% of the studied HHs farmlands. These were followed by *Brucea antidysenterica* (61%), *Cupressus lusitanica* (58%), and *Senna petersiana* (54%). On the other hand, 21 tree species, including *Securidaca longipedunculata*, *Boswellia pirottae*, *Acacia tortilis*, and *Salix subserrata* were very rare, each occurring only in one farmland. Out of the total identified woody species, 85% were indigenous which may show the maintenance of ecologically well adapted species by the local people.

There was statistically significant difference ($p < 0.05$) in the number of woody species among the farmscapes across the agroclimatic zones (Table 21). Table 21 shows that the diversity of tree species varied across the farmscapes. The highest number of tree and shrub species (90) was recorded from farmscape 11 (Ajora) of *Kola* agroclimatic zones, which contributed to 48% of the total woody species record in the Zone. The maximum number of species from a single farmland in this farmscape was 44. Nonetheless, a farmland with the highest number of species (52) was recorded from farmscape 6 (Chacho) of the *Woyna Dega* area, which accounted about 28% of the total species recorded in the Zone. Farmscape 10 (Holegeba Zato) of the study area had the

lowest average number of species per farmland (13.9) from where the minimum number of tree and shrub species was recorded (53).

The mean value of Shannon's index of diversity (H') was 2.19, and there was no significant difference in the mean values of H' among farmscapes. On the other hand, there was high significant difference ($P < 0.01$) in the evenness values among farmscapes. The average evenness (E) value was 0.51, which indicates that the relative homogeneity of the species in the farmscapes to be 51% of the maximum possible even population. This also depicts that some species are more abundant than others. In most cases there was high correlation between the values of H' and E ($r = 0.75$, $p < 0.01$), for example farmscape 7 (Mesafe) with the highest H'

Table 21. Woody species diversity of farmlands at the farmscape level where 15 farmlands were investigated at each farmscape (N= 180)

Farmscape number	Farmscape name	woody species		Std. Dev	Shannon Index		Evenness Index	
		Total	Mean		H'	Std.	E	Std. D
1	A/Sadicho	65	19.8 ^{abc}	8.81	2.18 ^{abc}	0.01	0.52 ^c	0.003
2	Kazala	72	23.3 ^{bc}	7.71	2.26 ^{bc}	0.01	0.53 ^c	0.003
3	Hobichaka	71	19.8 ^{abc}	8.19	2.17 ^{abc}	0.02	0.51 ^{ab}	0.005
4	Sigazo	68	17 ^{ab}	6.16	2.16 ^{abc}	0.01	0.51 ^{ab}	0.004
5	Kerekicho	67	21.6 ^{bc}	7.42	2.26 ^{abc}	0.01	0.54^c	0.002
6	Agara	68	19.5 ^{abc}	6.97	2.22 ^{abc}	0.01	0.53 ^c	0.003
7	Mesafe	81	26.2^c	6.18	2.32^c	0.01	0.53 ^c	0.003
8	Chacho	76	21.4 ^{bc}	12.6	2.06 ^a	0.02	0.47 ^a	0.004
9	kaillama	67	17.7 ^{ab}	7.96	2.12 ^{abc}	0.02	0.50 ^{ab}	0.005
10	H/Zato	53	13.9^a	5.55	2.16 ^{abc}	0.02	0.54^c	0.005
11	Ajora	90	22.4 ^{bc}	9.84	2.11 ^{ab}	0.02	0.47 ^a	0.004
12	Soyame	73	19.6 ^{abc}	6.57	2.21 ^{abc}	0.01	0.51 ^{ab}	0.003
	Average	186	20.19	7.8	2.19	0.014	0.51	0.004
		(total)						
	F test (P)		P<0.05				P<0.01	

Means with different letters are significant at the 0.05 and 0.01 level

Note: Dega agroclimate = farmscape (site) 1-4; Woyna Dega = 5-8 and Kola = 9-12.

(2.32) had higher evenness values. Farms in this farmscape had the highest farm level species richness of woody species, and the mean total number of species was also maximum (26.2) showing that commonly occurring species are characterized by many individuals. Farmscape 10 (Holegaba Zato) with the lowest average species richness had the maximum evenness value (0.54), which could be due a fair representation of few species. Moreover, the mean number of trees and shrubs was 20 at each farmland level (Table 21).

Table 22 shows that the total number of woody species per *Dega*, *Woyna Dega*, and *Kola* agroclimatic zones was 124, 130 and 132, respectively. There was a high significant difference in the number of woody species across the agroclimatic areas. *Woyna Dega* areas had the highest mean total number of the woody species (22.2) in the Zone. There is a significant difference in the number of woody species among the wealth classes, and the medium and the rich grow large mean number of species than the poor classes. Out of the total investigated species, shrubs and trees constituted 65% and 32.6% respectively, while other species contributed to 2.4% of the total species composition (Appendix IV).

Table 22. Total and mean number of woody species within the 3 agroclimatic zones
(N=180)

Agroclimate Zone	Number of farmlands	Mean woody species per economic classes			Woody species				
		Poor	Medium	Rich	Range /HH	Total	Mean	F	Sig.
<i>Dega</i>	60	14.5	22.8	22.9	7- 38	124	19.9 ^{ab}	11	0.000
<i>Woyna Dega</i>	60	17.7	20.9	27.9	7- 52	132	22.2 ^b	1.3	0.278
<i>Kola</i>	60	14.2	20.9	20.2	4- 44	130	18.04 ^a	4.7	0.013
Total	180	15.3^a	21.6^b	23.7^b		186	20.19	3.2	0.04
F-test (P)		P<0.05							

Due to high population pressure, the original wooded lands and remnant natural forest cover are scant. This compelled the local people to depend on traditional agroforestry systems. Home gardens, woodlots, scattered trees on the farmland including coffee shade based, and farm boundary trees are common traditional agroforestry practices in the study area (Figure 21).



Figure 21. Some of the agroforestry systems in KT Zone

(A- Coffee agroforestry, B-homegarden agroforestry C- small scale woodlot, and D-fruit tree crops (mango and avocado) as agroforestry trees) (Photos by Melesse Maryo, 2010)

Figure 22 shows the four major land use types in the study area where tree and shrub species are established. Tree and shrub species richness was the highest in homegardens (33%), followed by boundary plantings (24%), small scale woodlots (23%), and crop fields and their margins (20%).

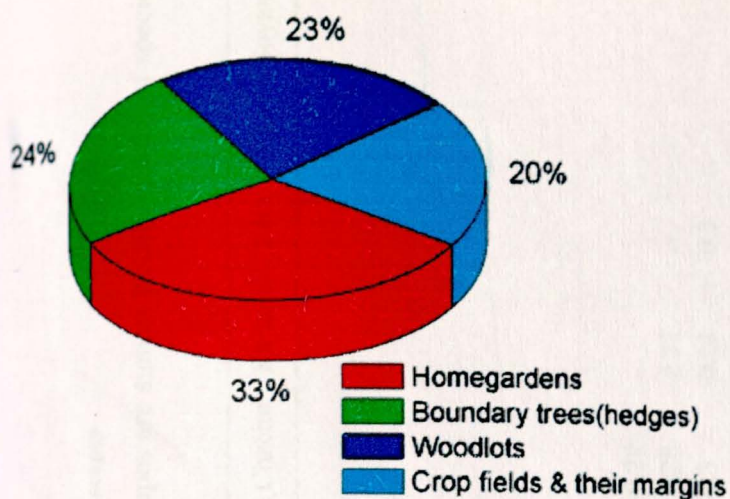


Figure 22. Percentage of the four major land use types for woody species establishment

4.4.2. Beta diversity: composition of tree/shrub species across farmscape

Significant variation was observed in the tree and shrub species composition between the farmscapes ranging between 13 to 36% (Table 23). The highest difference in species composition (36%) was observed between farmscape 10 (H/Zato) and farmscape 3 (Hobichaka) of the *Kola* and *Dega* agroclimatic areas, respectively, which are about 35 Kms apart. Farmscape 3 is located at altitude >2300 m asl whereas farmscape 10 is located at altitude < 1800 m asl. Although there was statistically extremely significant difference ($P < 0.001$) in elevation among the farmscapes, altitude and β -diversity had a weak correlation ($r = 0.03$).

On the other hand, the composition of trees and shrubs in farmscape 5 (Kerekicho) and farmscape 3 (Hobichaka) differs only by 13%. These farmscapes are located at altitude above 2200m asl (Table 2), and the geographical distance between them is 13 kms, showing the overlap of limiting factors that influence woody species composition.

Table 23. Beta diversity: Dissimilarity values for woody species composition of the farmscapes

(**Note:** The value of Beta diversity ranges from 0 to 1. A value of 0 means the two farmscapes are similar in composition of species, and 1 is when no species is shared among two farmscapes.

Farmscape number	Farmscape name	A/Sadicho	Kazala	Hobichaqa	Sigazo	Kere-kicho	Agara	Mesafe	Chacho	Ka'lama	Zato	Ajora	Soyame
1	A/Sadicho	-											
2	Kazala	0.25	-										
3	Hobichaqa	0.28	0.25	-									
4	Sigazo	0.25	0.24	0.23	-								
5	Kerekicho	0.23	0.14	0.13	0.22	-							
6	Agara	0.18	0.17	0.26	0.21	0.19	-						
7	Mesafe	0.24	0.16	0.18	0.25	0.28	0.22	-					
8	Chacho	0.26	0.23	0.33	0.25	0.33	0.25	0.26	-				
9	Ka'lama	0.2	0.23	0.28	0.22	0.27	0.24	0.27	0.29	-			
10	H/Zato	0.24	0.26	0.36	0.24	0.31	0.2	0.33	0.26	0.22	-		
11	Ajora	0.23	0.25	0.24	0.26	0.24	0.2	0.21	0.3	0.28	0.3	-	
12	Soyame	0.23	0.19	0.15	0.28	0.12	0.2	0.18	0.29	0.23	0.26	0.27	-

Note: *Dega agroclimate* = farmscape 1-4; *Woyna Dega* = 5-8 and *Kola* = 9-12.

4.4.3. Vegetation Analysis

Woody vegetations in the agroecosystems of KT Zone were classified in to five major communities (Fig. 23), representing the major woody flora of KT Zone. The species with the highest indicator value (%) and the level of significance (P-value) (Appendix VIII) were used to name the community. Indicator values were obtained by combining the relative abundances and relative frequencies of each species. The communities differ from each other on the basis of difference in effects of various environmental attributes.

The five communities are:

1. *Justicia schimperiana*- *Vernonia auriculifera* community is comprised of 56 plots of which 28, 18 and 11 are in *Dega*, *Woyna Dega* and *Kola* agroclimatic areas, respectively. It includes vegetations of the field margin, most commonly found as boundary or hedgerow plants. Most are used as live fences such as *Pycnostachys abyssinica*, *Rubus steudneri*, *Senna obtusifolia* and *Caesalpinia decapetala*;
2. *Acacia abyssinica*-*Prunus africana* community comprises 49 plots of which 28, 11 and 10 are in *Woyna Dega*, *Dega* and *Kola* agroclimatic areas. It harbours vegetation typical of moist highland areas (montane forests), which include *Millettia ferruginea*, *Brucea antidysentrica*, *Vernonia amygdalina*, *Erythrina brucei*, *Celtis africana*, *Olea europaea*, and *Podocarpus falcatus*. The community also includes on-farm plants growing mainly in the coffee and enset fields in the Zone. The local people manage such species with high biomass that decompose easily to add fertility to the soil, and shade the coffee and enset;

Cluster Dendrogram

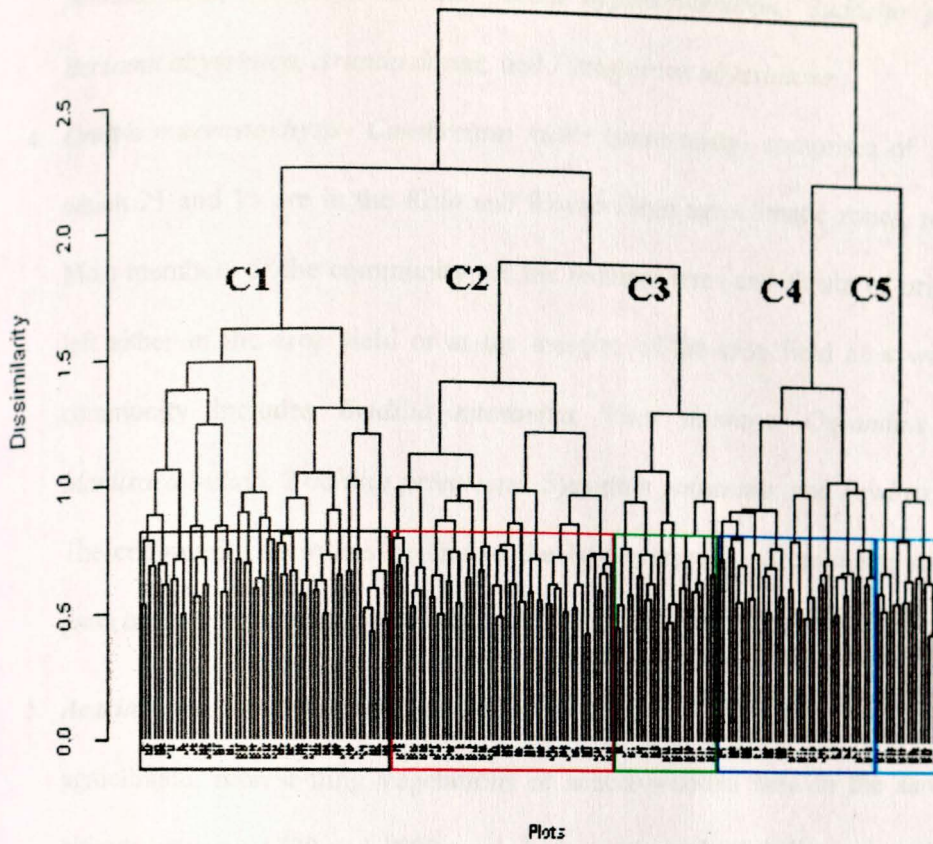


Figure 23. Dendrogram of the cluster analysis results of species abundance of 186 woody species found in 180 plots in 12 farmscapes of KT Zone. The plot code and the arrangement of the plots along the dendrogram from left to right are as follows:

C1: 1, 16, 87, 90, 68, 95, 102, 2, 4, 3, 16, 5, 18, 25, 62, 173, 19, 20, 21, 74, 70, 109, 152, 161, 165, 110, 64, 179, 136, 157, 34, 79, 83, 84, 85, 98, 103, 101, 78, 86, 80, 80, 96, 88, 92, 104, 38, 31, 44, 162, 47, 77, 81, 53, 52, 7; C2: 6, 105, 146, 144, 151, 159, 156, 153, 29, 42, 139, 141, 56, 137, 143, 145, 148, 163, 150, 155, 154, 22, 63, 69, 28, 26, 64, 61, 75, 23, 71, 66, 67, 24, 138, 72, 73, 93, 147, 94, 97, 98, 27, 30, 100, 91, 141, 140, 160; C3: 7, 8, 14, 11, 17, 9, 10, 13, 15, 89, 172, 166, 167, 170, 168, 175, 169, 171, 176, 174, 178, 177, 180; C4: 31, 42, 35, 56, 54, 59, 58, 36, 45, 41, 33, 51, 57, 37, 39, 60, 106, 117, 114, 115, 107, 116, 119, 32, 108, 40, 43, 46, 50, 49, 55, 48, 111, 112, 113, 118; C5: 121, 124, 126, 123, 122, 126, 127, 134, 135, 128, 130, 129, 132, 100. **Note:** C1= community 1; C2= community 2, etc.

3. *Arundinaria alpina*- *Eucalyptus globulus* community is located at highland areas in the study Zone. This community comprises 24 plots of which 23 belong to Dega agroclimatic zone. The species belonging to this community include *Discopodium*

penninervium, *Dombeya torrida*, *Urera hyposelodendron*, *Buddelja polystachya*, *Bersama abyssinica*, *Arundo donax*, and *Pittosporum abyssinicum*;

4. ***Croton macrostachyus*- *Combretum molle* community**- comprises of 36 plots, of which 21 and 15 are in the *Kola* and *Woyna Dega* agroclimatic zones, respectively. Most members of the community are the remnant trees and shrubs of original forest left either in the crop field or at the margins of the crop field as a woodlot. The community includes *Bridilia micrantha*, *Vitex doniana*, *Oxyanthus speciosus*, *Manilkara butugi*, *Trichilia prieuriana*, *Syzygium guineense*, and *Psydrax parviflora*. The community members belong to the Dry evergreen Afromontane and Wooded grass land (DAF/WG) vegetations, and
5. ***Acacia seyal* - *Balanites aegyptiaca* community** comprises 15 plots of *Kola* agroclimate, representing vegetations of acacia wooded land in the sandy soils at altitude between 1700 and 1800m asl. It also includes both indigenous and exotic tree species found in the crop field as a shade including *Cordia africana*, *Melia azedarach*, and *Schinus molle*.

The environmental variables that influence the communities are depicted in Figure 24. The most important biophysical and socioeconomic environmental variables determining the communities are elevation and slope, and Tropical Livestock Unit (TLU), respectively. The CCA result also agrees with the results of Pearson correlation where these factors are positively related to woody species richness. The slope has positive influence both in CCA as well as in Pearson correlation (see Table 25). Elevation is the most important variable in determining variation in species composition along axis 2. It is

positively correlated to the slope. Species richness (species abundance) in community 3 was influenced by elevation, especially *Urera hyposelodendron*, *Solanum giganteum*, and *Arundinaria alpina* along axis 2 ($r = -0.78$, $P = 0.002$). They occurred in high altitude areas. Elevation was negatively correlated with Community 4 and 5 whose species are species growing in low elevated areas.

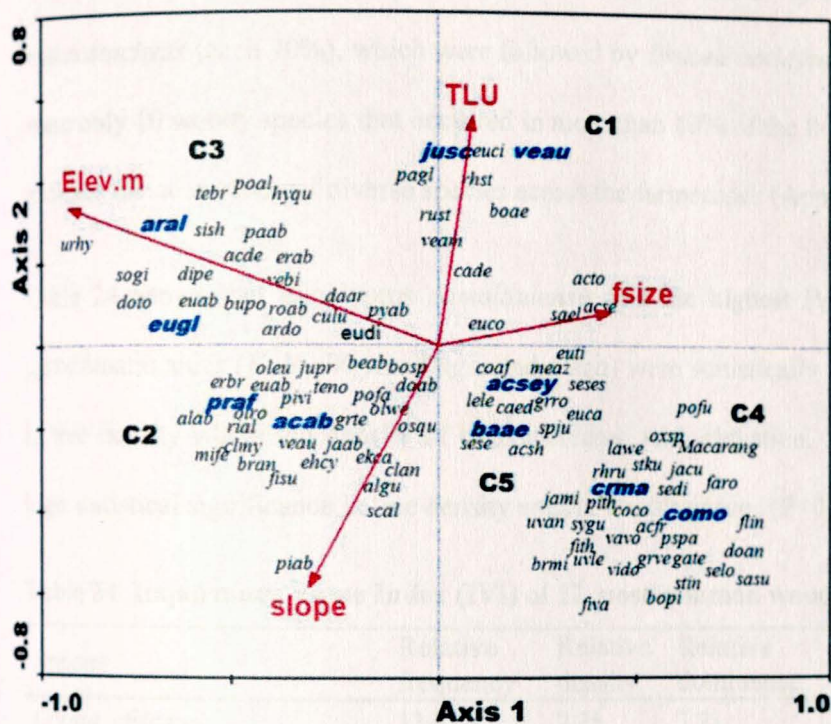


Figure 24. CCA ordination of species and environmental factors (arrows)

Pittosporum abyssinicum was highly influenced by slope. The highly correlated socioeconomic environmental variables, namely farmland size (fsize) had positive correlation to species on the first axis ($r = 0.37$), particularly to *Acacia senegal* positively correlated to a farmland size, whereas *Justicia schimperiana* was positively influenced by the TLU. This could be because peasants with large TLU may grow *Justicia schimperiana* since it can be used as a fodder. In general, the environmental variables attributed to 82% of the variation in the species composition as explained by the first

three axes. Axis 1 and 2 explain 66% of the variation but axis 1 alone explains 46% of the environmental variation on the species composition. Additionally, the species – environment correlation for the first axis was 0.83.

4.4.4. Vegetation structure

The most frequently encountered species were *Cordia africana* and *Croton macrostachyus* (each 70%), which were followed by *Brucea antidysentrica* (61%). There were only 10 woody species that occurred in more than 40% of the farmlands, which may indicate the occurrence of diverse species across the farmscapes (Appendix IV).

Table 24 shows that *Eucalyptus camaldulensis* had the highest IVI (60.2). The three agroclimatic areas (*Kola*, *Woyna Dega*, and *Dega*) were statistically significant ($P < 0.05$) in tree density where the density of trees increased with elevation. Similarly, there was high statistical significance in tree density among wealth groups ($P < 0.01$). The mean

Table 24. Importance Value Index (IVI) of 12 most common woody species

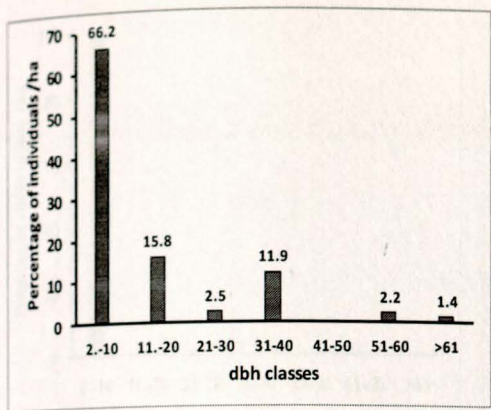
Species	Relative frequency	Relative density	Relative dominance	IVI
<i>Cordia africana</i>	13.07	2.25	7.23	22.55
<i>Croton macrostachyus</i>	12.77	2.78	5.77	21.32
<i>Cupressus lucitanica</i>	10.11	8.05	3.45	21.61
<i>Erythrina brucei</i>	8.31	2.69	3.56	14.56
<i>Eucalyptus camaldulensis</i>	9.13	21.03	31.03	60.19
<i>Eucalyptus citriodora</i>	4.15	9.06	10.37	23.58
<i>Eucalyptus globulus</i>	6.35	19.05	12.16	37.56
<i>Grevillea robusta</i>	8.18	3.33	1.3	12.81
<i>Justicia schimperiana</i>	7.91	12.06	1.08	21.05
<i>Podocarpus falcatus</i>	5.09	1.35	3.01	9.45
<i>Syzygium guineense</i>	2.11	0.52	2.35	4.98
<i>Vernonia amygdalina</i>	6.15	1.4	2.08	9.63
Other species	6.67	16.43	16.61	40.71
Total	100	100	100	300

density of woody species in rich, medium and poor HHs was 135, 167 and 391/ha, respectively. A total of 42, 895 individuals of woody species (trees/shrubs), with a corresponding average density of 71 trees/shrubs at farmland level, and 231 individuals per hectare were encountered in all the farmscapes. Eucalyptus species contributed to 42% of the total individuals. The species that contributed most to both basal area and density across all the study area were *Eucalyptus species*.

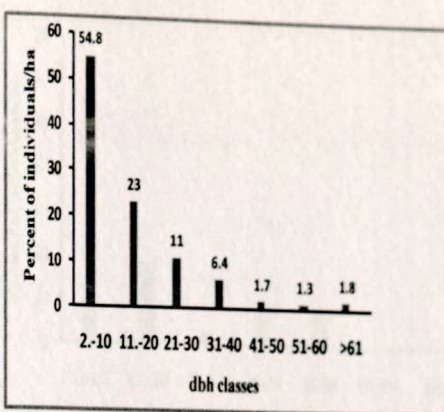
4.4.5. Population structure: DBH class size distributions

The population structure differed among the woody species recorded in the farmscapes (Fig 26 a_i). About 75% of the individual plants had DBH < 10 cm. As the DBH class increases, the percentage of individuals gradually showed a decreasing trend starting from 75% in the first class down to the last class (3%). In general, the DBH class appears to be a regular distribution (resembles the inverted J-shape) of individuals in the different DBH classes although the third class showed an irregular decrease (Fig. 25j).

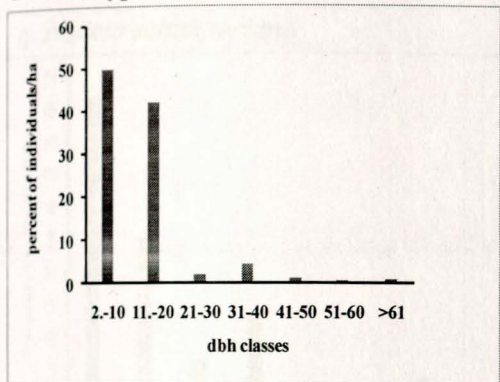
However, the frequency distribution of DBH classes of some selected important tree species indicated almost three different types of population structures (Fig. 25): (i) inverted J-shaped distribution, e.g. *E. camaldulensis*, and *J. schimperiana* (Fig. 25b and g respectively); (ii) irregular distribution with the highest peak at the highest DBH class, e.g. *E. brucei* (Fig. 25f), and (iii) broken inverted J- shaped distribution with missing individuals in the middle DBH classes, e.g. *E. globulus*, *G. robusta*, and *V. amygdalina* (Fig. 25a, h and i) that may indicate the removal of certain DBH classes for construction purposes.



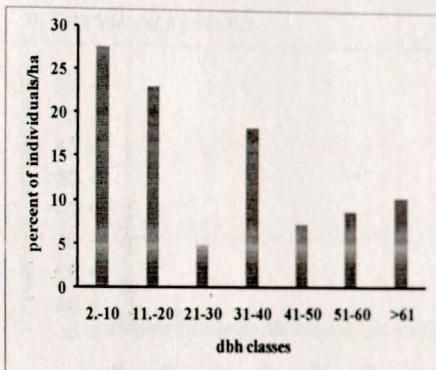
a. *Eucalyptus globulus*



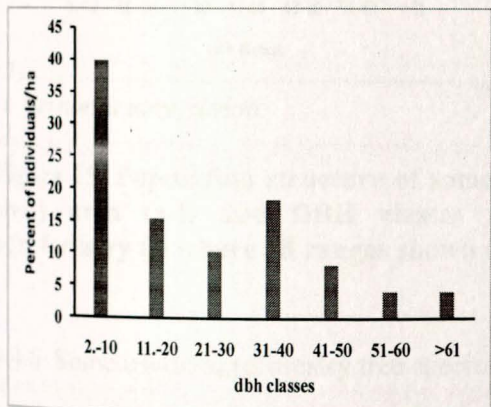
b. *Eucalyptus camaldulensis*



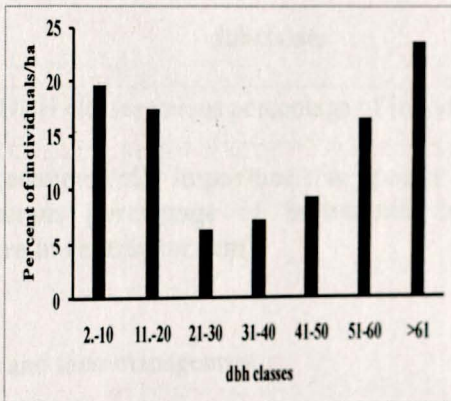
c. *Eucalyptus citriodora*



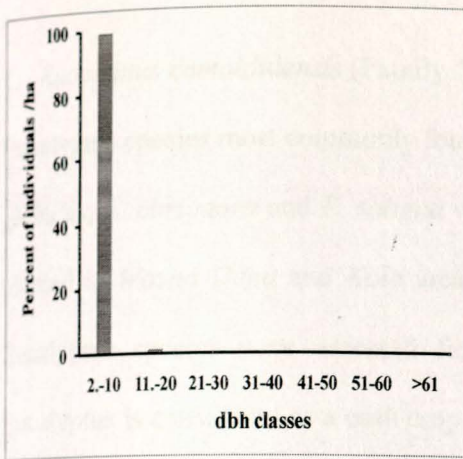
d. *Cordia africana*



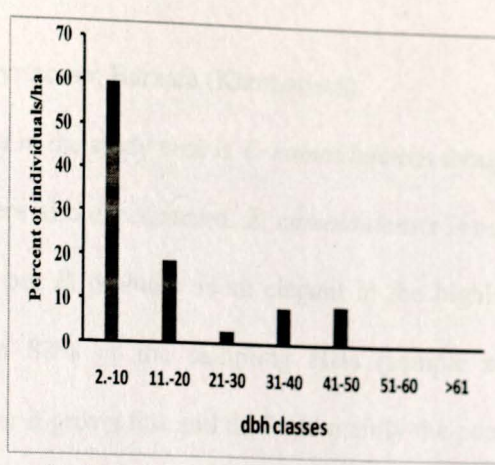
e. *Croton macrostachyus*



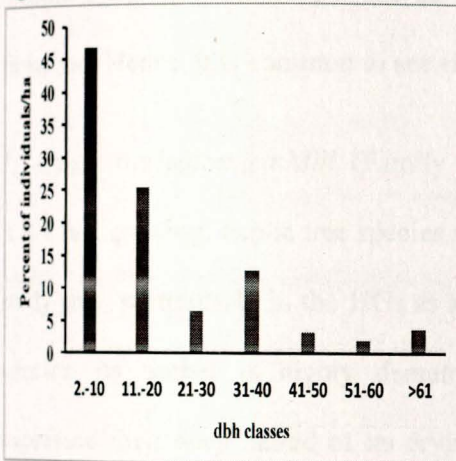
f. *Erythrina brucei*



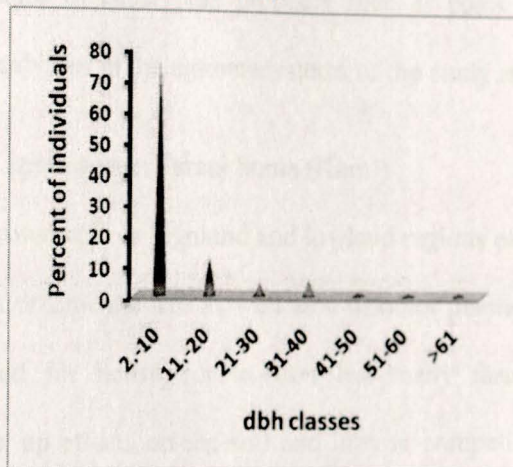
g. *Justicia schimperiana*



h. *Grevillea robusta*



i. *Vernonia amygdalina*



j. DBH classes versus percentage of individuals

Figure 25. Population structure of some economically important tree species in the study area (a-i) and DBH classes versus percentage of individuals in KT agroforestry (j) where all ranges shown are in centimeter (cm)

4.4.6. Some useful agroforestry tree species and their management

IVI often reflects the extent of the dominance, occurrence and abundance of a given species in relation to other associated species in an area. This index depicts ecologically very important key species of the study area. These include

1. *Eucalyptus camaldulensis* (Family-Myrtaceae; Barzafa (Kambatissa))

Eucalyptus species most commonly found in the study area is *E. camaldulensis* though *E. globulus*, *E. citriodora* and *E. saligna* were also encountered. *E. camaldulensis* is mainly planted in *Woyna Dega* and *Kola* areas but *E. globulus* is an elegant in the highlands. *Eucalyptus* species were assessed from 88% of the sampling HHs (sample sites). *Eucalyptus* is considered as a cash crop for it grows fast and the HHs mainly the poor get income for their livelihood from the sales of *eucalyptus* products such as poles and firewood. Hence, it is common to see *eucalyptus* in the agroecosystems of the study area.

2. *Cupressus lusitanica* Mill. (Family-Cupressaceae; Faranj homa (Kam))

It is a fast growing, exotic tree species grown both in highland and lowland regions of the study area, particularly in the HGs as an ornamental tree as well as a woodlot plantation species. Its timber is highly demanded for house construction but many farmers expressed their deep hatred of its drying up effects on the soil and intense competition with crops.

3. *Croton macrostachyus* Del- Euphorbiaceae; Masanna (kam.)

This species was found in all the study areas (1502-2669m asl). It is grown as a scattered tree on croplands, and is very common in enset plantation (Fig. 26B) besides *Erythrina brucei* (Fig. 26A). Farmers believe that it has no negative effect on growing crops since the large amount of its leaf biomass decomposes easily and adds soil fertility. It is used as a source of fire wood, medicine, live fence, and bee keeping. It is also compatible with cereal crops. Currently, some farmers are making compost from its leaves.

4. *Cordia africana* Lam. -F. Boraginaceae: Waanja (Kam)

It was found growing well in midland agroclimatic regions of the study area. It is scattered in crop lands as a shade tree for coffee, enset and some other crops. It also grows as a living fence, and boundary hedgerow around homestead. *C. africana* is a source of HH tools, fruits are eaten during famine periods, useful for bee keeping and adding soil fertility.



Figure 26. Agroforestry trees in enset plantation areas

A = *Erythrina brucei*, B = *Croton macrostachys*, and C = *Eucalyptus globulus* is away from enset (Photos by Melesse Maryo, 2010)

5. *Justicia schimperiana* (Hochst.ex Nees) T. Anders: Family: Acanthaceae; *Gulbana*

This shrub is commonly grown as a hedge around homegardens as well as crop field margins. It propagates vegetatively in a short period. It is a fodder, medicinal, and boundary demarcating species, which is also used for rural house construction as well as for making farm tools. The respondent farmers confirmed that various methods of tree

management are used depending on the nature of tree species. For example, they prune *Cordia africana* whereas they pollard *Erythrina species*, and lay *Justicia schimperiana*. Farmers manage trees on their farmland in order to prevent the negative effects of trees on crops and other biodiversity. The common practices were pruning (79%), followed by Pollarding (47%) and laying (45%).

4.4.7. Factors influencing the diversity and density of woody species

The influence of some physical and socioeconomic factors on farmland level diversity and density of trees is indicated in Table 25. The number of trees and their heterogeneity (diversity) including their distribution varied with increase in elevation, within the altitudinal limits of 1502-2669 m a.s.l. Tree species richness was found to increase with slope, woodlot area, crop species number, age of the farmland as well as labour force. These were positively correlated with tree species richness with Spearman's correlation, $r > 0.2$ in each case. This study found that farmers had awareness and willingness to grow woody species. However, only 67% of the studied HHs had woodlots ranged from 0.1 to 10 hectares, with an average of 0.5 ha.

The sizes of woodlots vary among the three economic classes where the rich, medium and poor had 0.8, 0.5 and 0.1 hectare in average, respectively. The woodlot size is mainly associated with the size of farmlandholding. The mean labour force was 5 where the corresponding values for poor, medium and rich peasants were 3.8, 5.8 and 6, respectively. There was a significant variation in labour resource among economic classes, which has influenced the tree species richness as well as diversity. Twenty five percent of the studied HHs were involved in off-farm activities. The off-farm activity has influenced the tree density positively and significantly. In addition, the density was

higher with the decrease in farmland size that is associated with the compensation of small farmland size, particularly true in the case of poor farmers.

Distance to road, and distance to market were insignificant but negatively correlated to tree species richness. Distance to a major road has negatively and significantly influenced the evenness of the woody species, which could be related to growing few and equally abundant tree species as access to market increases. The age of a farmland has influenced the woody species richness and the diversity positively and significantly. Moreover, crop diversity has influenced the woody species richness strongly and significantly.

Table 25. Multiple stepwise linear regression of tree diversity and density indices with physical and socioeconomic factors (Values indicate standardized Beta coefficients)

Factors	Species richness (S)	Nr. of trees per farmland	Density of trees	Shannon's index (H')	Shannon's Evenness (E)
Adjusted R ²	0.27*	0.146**	0.18***	0.18*	0.18*
Physical environment					
Altitude of the farm	ns	0.30***	0.17*	0.14*	0.18**
Slope of the farm	0.23**	ns	ns(-0.01)	ns	ns
Aspect	ns	ns	ns	ns	ns
Socio-economic environment					
Distance to markets	ns(-0.02)	ns (-0.13)	ns(-0.1)	ns(-0.02)	ns(-0.04)
Distance to major roads	ns (-0.04)	ns (-0.12)	ns(-0.1)	-0.17*	-0.17*
Farmland size	ns	ns	-0.23***	ns	ns
Woodlot area	0.17*	ns	ns(-0.1)	ns	ns
Farm labour force	0.22**	ns	ns(-0.16)	0.19**	0.19**
Off-farm activities	ns	ns	0.27***	ns	ns(-0.1)
TLU	ns	ns	ns(-0.04)	ns	ns
Age of the farmland	0.26**	ns	ns	ns	ns
Education	ns	ns(-0.03)	ns(-0.1)	ns	ns
Number of crop species	0.38***	ns	ns	0.38	0.35

Note: ns = not significant; *, **, *** = Significant (F-test) at $p < 0.05$, $p < 0.01$, $p < 0.001$, respectively. Values inside the bracket indicate insignificant but negatively correlated factors only. Multiple regression estimation indicated that the model explains 27% the variation in the number of trees species is maintained at HH level.

4.5. PLANT USES IN FARMING SYSTEMS

4.5.1. Traditional healers background

In addition to 180 HHs survey made for MPs used by the community, 51 traditional healers (67% males and 33% females) were involved who were married with the ages ranging between 28 and 95. Sixty three percent are educated (23% elementary and 40% junior and above) and the rest 37% illiterate. This formal education may help healers in recording and maintaining indigenous knowledge on useful plants. Ninety four percent were Christians, of whom 84% were Protestants, and 6% were Muslims.

4.5.2. The diversity of medicinal plant species

A total of 170 useful medicinal plant species of 148 Genera and 69 families were recorded. The most species rich family is Asteraceae (19 species, 11%) and it is followed by Fabaceae (15 spp) and Lamiaceae (14 spp) (Table 26). Out of the total MP species identified 13 were endemic (*Acanthus sennii*, *Ceropegia microgaster*, *Clematis longicaudata*, *Echinops kebericho*, *Ensete ventricosum*, *Euphorbia dumalis*, *Kniphofia foliosa*, *Leucas stachydiformis*, *Mikaniopsis clematoides*, *Millettia ferruginea*, *Pittosporum abyssinicum*, *Pycnostachys abyssinica*, and *Urtica simensis*) (see Appendix VII, species are bolded).

There was a significant positive correlation (Spearman correlation test, $r = 0.28$, at $\alpha = 0.05$, $p = 0.04$) between the age of healers and number of species reported by healers where the elderly people reported more than youngsters. On the other hand, highly significant negative correlation ($r = -0.34$, at $\alpha = 0.05$, $p < 0.001$) was observed between

Table 26. Botanical Families of medicinal plants with number of species and genera in KT Zone

S.no	Family	No of Genera	Spp no	% of spp	S.no	Family	No of Genera	Spp no	% of spp
1	Acanthaceae	3	3	1.8	37	Malvaceae	2	4	2.3
2	Alliaceae	1	2	1.2	38	Meliaceae	3	3	1.8
3	Aloaceae	1	1	0.6	39	Melanthaceae	1	1	0.6
4	Amaranthaceae	3	4	2.3	40	Menispermaceae	1	1	0.6
5	Apiaceae	3	3	1.8	41	Musaceae	1	1	0.6
6	Apocynaceae	2	3	1.8	42	Myrsinaceae	1	1	0.6
7	Araceae	1	1	0.6	43	Myrtaceae	1	1	0.6
8	Araliaceae	1	1	0.6	44	Oleaceae	3	3	1.8
9	Asclepiadaceae	1	1	0.6	45	Oliniaceae	1	1	0.6
10	Asparagaceae	1	1	0.6	46	Oxalidaceae	1	1	0.6
11	Asphodelaceae	1	1	0.6	47	Phytolaccaceae	1	1	0.6
12	Asteraceae	15	19	11	48	Piperaceae	1	1	0.6
13	Boraginaceae	1	1	0.6	49	Pittosporaceae	1	2	1.2
14	Brassicaceae	2	2	1.2	50	Plantaginaceae	1	2	1.2
15	Caricaceae	1	1	0.6	51	poaceae	6	6	3.3
16	Celastraceae	1	1	0.6	52	Podocarpceae	1	1	0.6
17	Chenopodiaceae	1	1	0.6	53	Polygalaceae	1	1	0.6
18	Combretaceae	1	1	0.6	54	Polygonaceae	2	3	1.8
19	Commelinaceae	1	1	0.6	55	Primulaceae	1	1	0.6
20	Crassulaceae	1	1	0.6	56	Proteaceae	2	2	1.2
21	Cucurbitaceae	3	3	1.8	57	Punicaceae	1	1	0.6
22	Cupressaceae	2	2	1.2	58	Ranunculaceae	4	4	2.3
23	Cyperaceae	1	1	0.6	59	Rosaceae	2	2	1.2
24	Dioscoreaceae	1	1	0.6	60	Rubiaceae	3	3	1.8
25	Dracaenaceae	1	1	0.6	61	Rutaceae	4	4	2.3
26	Euphorbiaceae	3	4	2.3	62	Santalaceae	1	1	0.6
27	Fabaceae	11	15	8.8	63	Sapindaceae	1	1	0.6
28	Flacourtiaceae	1	1	0.6	64	Simaroubaceae	1	1	0.6
29	Hypericaceae	1	2	1.2	65	Smilacaceae	1	1	0.6
30	Icacinaeae	1	1	0.6	66	Solanaceae	7	9	5.5
31	Lamiaceae	12	14	8.2	67	Urticaceae	2	2	1.2
32	Liliaceae	2	1	0.6	65	Tiliaceae	1	1	0.6
33	Linaceae	1	1	0.6	68	Vitaceae	2	2	1.2
34	Lobeliaceae	1	1	0.6	69	Zingeberaceae	2	2	1.2
35	Loganiaceae	1	1	0.6	69		148	170	100
36	Loranthaceae	2	2	1.2					

the number of medicinal plant species reported and healers' educational level. This may show that with increase in educational level, there will be a decrease in knowledge and use practice of traditional medicines where illiterates reported large number of MP species.

Life form classes and the proportion of cultivated and noncultivated MPs

Most of the recorded ethnomedicinal plant species were herbs (52%) and shrubs (27%), followed by 13% trees, 6% liana, and 2% grasses (Fig. 27).

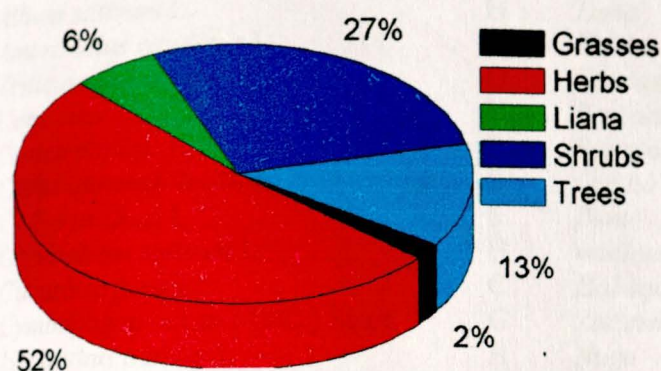


Figure 27. The growth forms of the ethnomedicinal plant species

As shown in Table 27, the majority, 63% (108 species) of the MP species are of wild origin but only 28% of the total MPs were cultivated and about 9% of them were collected both from the wild and cultivated fields.

Table 27. Life form classes and the proportion of cultivated, semi cultivated and wild MP species

Habit	Cultivated	Wild	Semi-cultivated	Total
Climber	2	7	2	11
Grasses	3			3
Herbs	33	46	10	89
Shrubs	4	38	4	46
Trees	6	15		21
Total	48	106	16	170
Proportion	28	63	9	100

Of the total medicinal plants identified, 26 species (15%) of them were marketed along with other spices (Table 28 and Fig. 28).

Table 28. Marketable cultivated MPs in the study area

Medicinal plant species	habit	Local name	Habitat
<i>Aframomum corrorima</i> (Braun) Jansen	H	Wokash	HG
<i>Allium porrum</i> L	H	Sunkutata	HG (Gatita)
<i>Allium sativum</i> L.	H	Tuma	HG (Gatita)
<i>Amaranthus caudatus</i> L.	H	Halibe	HG (Gatita)
<i>Triticum polonicum</i> L.	G	Gardaamu	CL
<i>Capsicum annuum</i> L.	H	Barbaru	HG/ Crop land
<i>Carica papaya</i> L.	S	Papaya	HG (Gatita)
<i>Citrus aurantifolia</i> (Christm.) Swingle	S	Lomita	HG (Gatita)
<i>Coffea arabica</i> L.	S	Buna	HG (Gatita)
<i>Coriandrum sativum</i> L.	H	wodimamu	HG (Gatita)
<i>Cucurbita pepa</i> L.	C	Dabaqula	HG/ CL
<i>Cymbopogon citratus</i> (DC.) Stapf.	G	Zazancho hixxita	HG (Gatita)
<i>Helianthus annuus</i> L	H	Nuga	HG (Gatita)
<i>Hordeum vulgare</i> L.	G	Soa'	CL
<i>Lepidium sativum</i> L.	H	sunfa	CL
<i>Linum usitatissimum</i> L	H	Talba	CL
<i>Nicotiana tabacum</i> L.	H	Tumbe-oo/koshuta	HG (Gatita)
<i>Nigelia sativa</i> L.	H	Gambelata Xagutta	HG/ Crop land
<i>Phaseolus vulgaris</i> L.	H	Wokitta (Gambelata)	CL
<i>Piper capense</i> L.	H	Ximzi	HG (Gatita)
<i>Ruta chalepensis</i> L.	H	Xelachuta	HG (Gatita)
<i>Securidaca longipedunculata</i> Fresen*	T	Sanganna	WL/WdL
<i>Trigonella foenum-graecum</i> L.	H	shu'oota	HG/ Crop land
<i>Vicia faba</i> L.	T	Baqeela	CL /HG
<i>Zingiber officinale</i> Rosc.	H	Jangibelu	HG/ Crop land

Note : where *= wild species , H= herb, T= tree, S= shrub, G= grass, HG= homegarden, CL= crop land, WL= woodlot, and WdL= woodland. Gatita = is a backyard of HG

Medicinal plants examined in this study were found to treat 76 various ailments of both human and livestock (AppendixVII). Of the total MP species, 105 species (62%) were used to treat 52% of the total identified human ailments. Fourty four species (26%) were used to treat problems common to human and livestock, whereas 12% of them were found to treat 9 various ailments (12%) found only in livestock (Fig. 29).



Figure 28. Some of the marketable medicinal plants (A) fresh and B) dried forms)

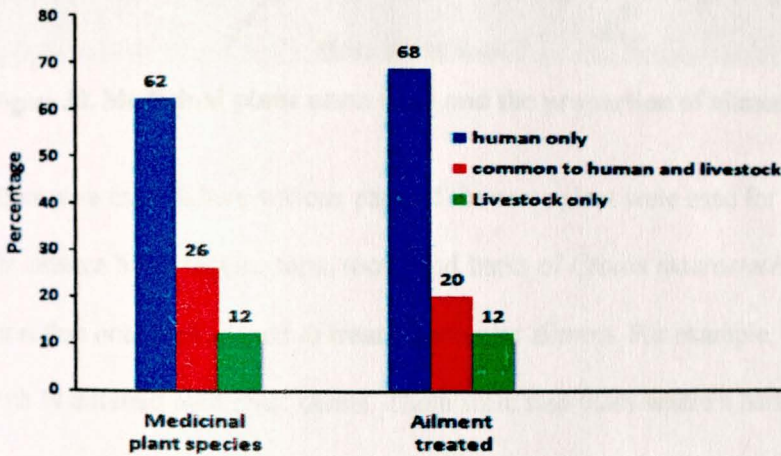


Figure 29. The percentage of medicinal plants used to treat ailments of human (only), both human and livestock, and livestock (only)

4.5.3. Plant parts used and the proportion of ailments treated

Leaves were the first most harvested medicinal plants parts in the current study. Forty eight percent of the MPs were harvested for their leaves to treat 72% of the total ailments, and 27% of them were harvested for their roots. Roots were the second most harvested plant parts showing a threat to the MPs since root harvesting may kill a plant. Other plant

parts sought included: seed (13%), shoot (10%), barks (9%), buds (8%), whole plants (7%), fruits (5%), inflorescence (2%), and others like roots and pseudostems, gum, sap, stems, rhizomes, and roots and inflorescence constituted (10%) (Figure 30).

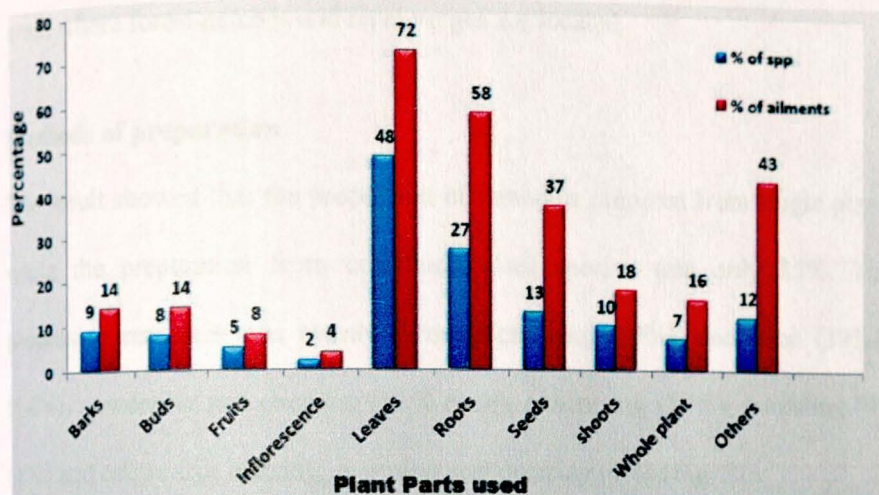


Figure 30. Medicinal plant parts used and the proportion of ailments treated

There were cases where various parts of the same plant were used for different purposes, for instance buds, leaves, saps, roots, and barks of *Croton macrostachyus*. In some cases more than one plant is used to treat a particular ailment. For example, tonsillitis is treated with 14 different medicinal plants. There were also cases where a particular plant is used to treat many ailments. For example, *Echinops kebericho* and *Momordica foetida* are used to treat seven ailments each (Appendix VII). Accordingly, 60% of the investigated plant species were involved in the cure of more than one disease.

4.5.4. Medicinal plant processing and administration methods

Most Kambatta Tembaro remedial plant species (86%) were processed in fresh, others in either fresh or dried forms (6%) while some (8%) were prepared and applied after immediate drying (Appendix VII). Mr. Jemal Wochamo (95 years old), Mrs. Ashure

Lafamo (70 yrs old) and Mrs. Gatisse Yoeyo (55 yrs) were senior healers who narrated that they used to travel more than 3 hrs on bare foot to collect the fresh material from areas where forest patches and river verges are located.

Methods of preparation

The result showed that the proportion of remedies prepared from single plant to be 75% while the preparation from combined plant species was only 25%. The mode of processing remedies was mainly through crushing (30%), decoction (19%), squeezing (14%), powdering and chewing (11% each), concocting (10%), pounding (3%), exudate (1%) and others like burning, warming and dressing (4%) (Fig. 31).

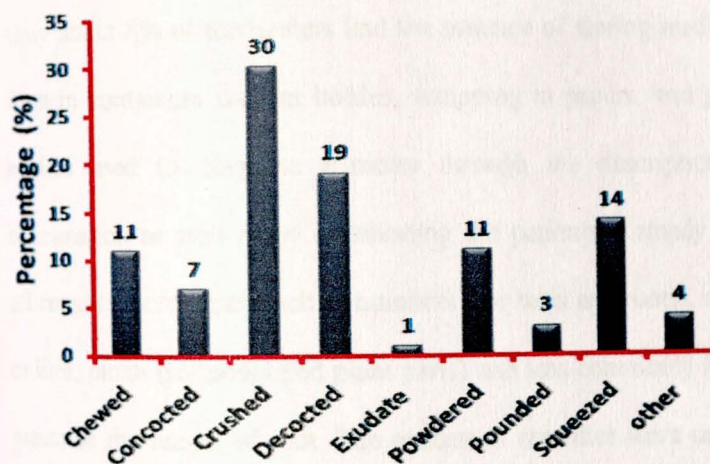


Figure 31. Mode of preparation of remedies by Kambatta Tembaro People

Mortar and pestle were the main tools used during processing. Substances like cold water, whey, coffee, butter, salt, or local alcoholic beverages like 'aragee' and 'tella', as well as honey and milk were reported to be mixed with the plant materials during the preparation of remedies (Appendix VII).

Fifty nine percent of the remedies were prepared and administered undiluted while the rest were diluted with water (22%), butter (8%), whey (4%), coffee (4%), and others (3%), which represent tea, milk, honey and local alcoholic beverages (Figure 32a).

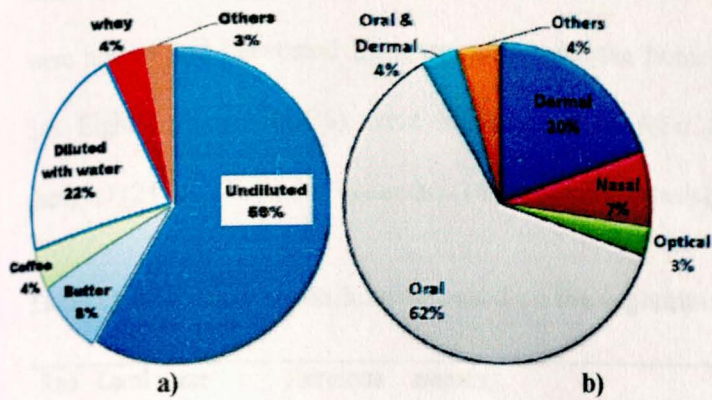


Figure 32. a) The nature of dilution of remedies by different materials b) The percentage of different Routes of administration

Only about 8% of the healers had the practice of storing medicines usually in powdered form in containers such as bottles, wrapping in papers, and pieces of cloth. Traditional healers used to diagnose ailments through the descriptions of a patient, physical examination as well as by questioning the patients. Remedy prescriptions were mostly affirmed to have doses such as numbers (for buds and roots), drops, cups, spoons, glasses or litre, pinch (for powdered plant parts) and less commonly little finger index is used to prescribe the length of root. The processed remedies were mostly administered through oral (62%) and dermal (20%) routes. These were followed by nasal (7%), oral & dermal (4%), and optical (3%) administrations. The others constitute 4% (Figure 32b).

5.5.5. Traditional land classification and medicinal plant taxonomy

Table 29 shows that indigenous people of KT Zone classify the land into 16 categories based on vegetation cover. *Gatee*, *Wesse ulataa* and *Witarra* are components of the homegarden, which is locally termed as *Minni heegeego*. The common land cover in the

agroecosystem of Kambatta Tembaro is *Minni hegeego* and *Wixaa ulla* (homegarden). Landless peasants in the study area have only mini heeggeego which consists of yard (*witarra*), back yard (*gate*) and enset plantation (*Wesse ulla*) (Fig. 5). Most of the MPs were hosted and harvested from in and around the homegarden (*Mini heeggeego*) (Fig 5a). Eighty species (47%) were harvested from *Mini heeggeego* followed by *Zana* (hedges) (24%), *Carra* (woodlands) (10%), and the others (19%) (Fig. 33).

Table 29. KT Land classification based on the vegetation cover

S.no	Local name	Acronym	meaning
1	<i>Badaa</i>	UGL	small uncultivated grazing land e.g., grasses like <i>Cynodon dactylon</i>
2	<i>Barraa</i>	FL	forestland e.g., dry evergreen montane forest vegetation
3	<i>Bonatta</i>	SUL	very small uncultivated area at the margin of the crop land, containing grass species and shrubs
4	<i>Boqotta</i>	GA	a graveyard may act as a meeting site for some local issues e.g., species of <i>Juniperus</i> , <i>Podocarpus</i> , <i>Eucalyptus</i> and <i>Euphorbia</i>
5	<i>Caffa</i>	WtL	wet land e.g., <i>Cyperus</i> and <i>Typha sp</i>
6	<i>Carra</i>	WL	wood land e.g. <i>Podocarpus sp</i> , <i>Juniperus sp</i> and others
7	<i>Daqaya</i>	WGL	a wide grazing land, may include some wetlands e.g., grass species
8	<i>Gatee</i>	BK	Backyard of the HG very close to home, mainly dominated by species of fruits, vegetables and spices
9	<i>Wesse ulla</i>	EP	enset plantation area of the homegarden where <i>Ensete ventricosum</i> is a dominant species
10	<i>Witarra</i>	FHG	front of the homegarden where shade tree species like <i>Podocarpus sp</i> , <i>Olea sp</i> and <i>Linocera giordani</i>
11	<i>Haaqi ulla</i>	WdL	woodlot (Plantation), mainly <i>Eucalyptus spp</i> , <i>Cupressus sp</i> , <i>Juniperus procera</i> and others
12	<i>Kallo</i>	PGL	preserved land for grazing, mainly grass species dominated
13	<i>Lagaa</i>	RV	riverine vegetation e.g., <i>Ficus spp</i>
14	<i>Uduuma</i>	DA	desertified areas where there is a scarcity of plant species
15	<i>Wixaa ulla</i>	CL	crop land dominated by cereals like <i>Triticum spp</i> and <i>Eragrostis tef</i> or root plants like <i>Ipomoea batatas</i> and <i>Colocasia esculenta</i>
16	<i>Zana</i>	Hed	hedges e.g., <i>Erythrina brucei</i> , <i>Croton sp</i> , <i>Vernonia spp</i> , <i>Cupressus sp</i> and other shrubs

The study indicated that 85% of MPs have one to one matching between the local name and botanical name. The plant naming system is mainly at species level. There are a few cases where one local name is used for two and more species (4%), and a single species

with two local names (11%). The local people name medicinal plants on the basis of various characteristic features. Some examples of plant naming are indicated below:

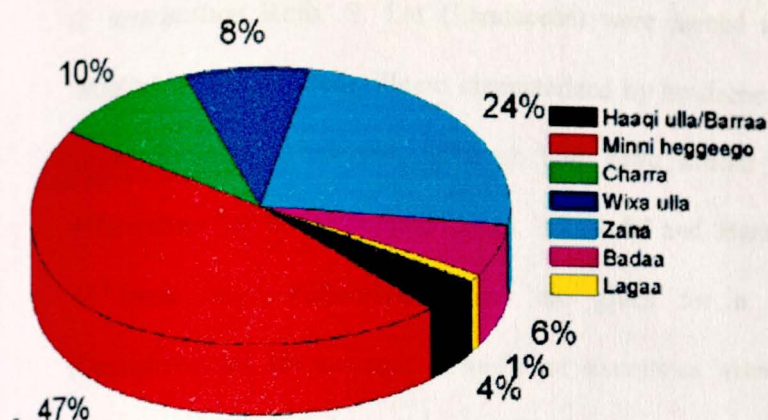


Figure 33. The percentage of the distribution of medicinal plants in KT Zone

1. **Sound**, for example 'Chachayeenaa' is a name given to *Crotalaria incana* L. (Fabaceae) since it produces rattling sound when the seeds inside the dry pod are shaken. 'Chachaa' means rattling and 'chachayeenaa' means something that rattles.
2. **Colors** like 'Gamballa Soa' and 'Wojuu Soa' to differentiate *Hordeum vulgare* (Poaceae) of different varieties, respectively. In this case 'Gamballa Soa' means black barley, and 'Wojuu Soa' means the white barely.
3. **Morphology of a plant**, for example 'Boqqee' is a name given to *Plantago lanceolata* L. (Plantaginaceae). 'Boqqoo' means head and 'Boqqee' refers to the tufted inflorescence on the head of a plant.
4. **Morphological and color similarity**, for instance 'Beshinqa' normally refers to Sorghum. 'Beshinqa' is a name given to *Trichilia prieuriana* A. Juss (Meliaceae) and *Lysimachia ruhmeriana* Vatke (Primulaceae), respectively since their seeds are red colored, and resemble that of sorghum. But to differentiate one from another 'wosha beshinqa' is given to *Lysimachia ruhmeriana*, means dog's sorghum.

5. Names are given on the basis of the **ailment treated** which is followed by 'Zebu' that means medicine. Example, two species, *Ocimum lamiifolium* Hochst. Ex Benth and *O. urticifolium* Roth. S. Lat (Lamiaceae) were named as 'Michi Zebuu', where 'Micha' means a febrile illness characterized by headache, fever, etc, and 'Zebuu', means medicine. However, although both have similar medicinal role, they are differentiated by their alternate names, 'Minatofa' and 'Barxulaa', respectively.
6. In some cases **collective names** are given for a group of plant species (Genus/Genera), for example 'Chee'a' or sometimes 'seennaa' is a name given for Genus *Senna* such as *Senna occidentalis*, *S. obtusifolia* and *S. petersiana*.
7. In some cases **collective names** are given for a group of plant species (Genus/Genera), for example 'Chee'a' or sometimes 'seennaa' is a name given for Genus *Senna* such as *Senna occidentalis*, *S. obtusifolia* and *S. petersiana*.

Names are given based on the **use value**. Sometimes a prefix is used to differentiate diverse plant species such as *Fugi malaata* to refer to *Solanecio mannii* (Hook.f.) C. Jeffrey (Asteraceae), and *Fugi ojomoko* refers to *Arisaema enneaphyllum* Hochst. ex A.Rich (Araceae). To name these two plants a prefix *Fugi* is used. *Fuga* is a clan in KT Zone who are highly skilled people making utensils from clay, pottery. Here *malaata* is a dry hollow material made of *Solanecio mannii* by *Fuga* people and used to produce a sound during the traditional musical dancing, called *giffaata* that is demonstrated at the start of a new year. *Ojomoko* is a root plant used as a medicine as well as famine food by this clan only, thus called *Fugi Ojomoko*.

4.5.6. Ranking and scoring

As shown in Table 30 *Ajuga integrifolia*, scored the highest mark and ranked first for effective treatment of ascariasis, followed by *Leucas stachydiformis*, and *Teclea nobilis*.

Table 30. Preference ranking of medicinal plants used for treating Ascariasis

Species	Respondents (A-O)															Total	Rank
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O		
<i>Teclea nobilis</i>	3	1	5	1	4	1	0	1	5	0	5	5	1	5	5	42	3
<i>Ajuga integrifolia</i>	2	2	2	1	3	5	5	5	4	1	4	5	5	3	3	48	1
<i>Clausena anisata</i>	1	0	1	4	2	3	1	4	2	0	2	2	3	1	5	31	5
<i>Vernonia amygdalina</i>	1	4	1	5	1	1	4	3	3	1	3	1	2	5	2	37	4
<i>Leucas stachydiformis</i>	0	5	4	2	1	4	2	5	5	0	5	4	4	2	4	47	2
<i>Achyroserpnum shimperi</i>	2	1	0	0	0	0	3	2	1	0	1	3	1	1	1	16	7
<i>Pycnostachys abyssinica</i>	0	3	3	5	0	2	1	2	3	0	2	1	0	4	1	27	6

Likewise, black leg was the livestock disease most often reported by healers and is the fourth top livestock disease at the zonal level. A preference ranking of medicinal plants used for treating blackleg is shown in Table 31. *Cyphostemma adenantum* scored the highest mark and ranked first for effective treatment of blackleg, followed by *Thalictrum rhynchocarpum*, and *Tanacetum parthenium*, respectively.

Table 31. Preference ranking of medicinal plants used for treating blackleg

Medicinal plants	Respondents (A-O)															Total	Rank
	A	B	C	D	E	F	G	H	I	J	K	L	N	M	O		
<i>Cyphostemma adenantum</i>	1	4	3	4	2	3	2	2	2	3	4	2	4	4	5	45	1
<i>Commelina benghalensis</i>	1	3	4	2	2	3	2	1	3	2	2	3	3	1	2	34	7
<i>Cyathula cylindrica</i>	3	2	4	2	3	2	2	2	2	2	2	2	4	2	2	36	6
<i>Pittosporum viridiflorum</i>	1	3	3	5	3	0	4	2	0	0	5	4	3	4	4	41	4
<i>Solanum incanum</i>	1	4	2	4	3	2	3	1	2	2	4	1	4	1	4	38	5
<i>Tanacetum parthenium</i>	3	1	4	5	3	1	4	2	2	1	4	3	4	2	3	42	3
<i>Thalictrum rhynchocarpum</i>	3	3	1	5	1	3	4	2	5	3	2	1	5	2	3	43	2

Direct matrix ranking of six multipurpose medicinal plant species

The people in KT Zone use plants for various purposes such as food, charcoal making, construction, forage, fire wood, and fodder. Of the total MPs examined seventy (64%) of them were found to have uses other than medicinal value. Table 32 shows the result of direct matrix ranking where *H. abyssinica* was ranked first, followed by *A. abyssinica*,

and *P. falcatus*, respectively. These were highly exploited species, particularly *P. falcatus* and *H. abyssinica* for their timber, and *A. abyssinica* for charcoal making other than their medicinal uses.

Table 32. Direct matrix ranking of six medicinal plants with different uses other than medicinal value (total score of fifteen informants) in the study area

Uses	<i>Croton macrostachyus</i>	<i>Vernonia amygdalina</i>	<i>Pavetta abyssinica</i>	<i>Acacia abyssinica</i>	<i>Hagenia abyssinica</i>	<i>Podocarpus falcatus</i>
Farm tools	53	23	42	51	63	24
Construction	60	35	22	53	70	75
Income generation	63	35	17	51	68	72
Charcoal	39	47	27	66	42	39
Fuel wood	26	51	24	60	47	48
Fodder	17	36	31	34	30	32
Total	258	227	163	315	320	290
Rank	4 th	5 th	6 th	2 nd	1 st	3 rd

Similarly, in priority ranking based on the extent of impact on MP resources, deforestation, agricultural expansion, and overgrazing were found to be the first three top factors perceived as threats to medicinal plants in the study area (Table 33). This seems to be associated with the high density of both human as well as the livestock population.

Table 33. Priority ranking of factors perceived as threats to MP resources based on their level of destructive effects

Factors	Respondents (A-J)										Total	Percent	Rank
	A	B	C	D	E	F	G	H	I	J			
Agricultural expansion	3	6	3	2	5	5	5	5	3	3	40	19	2
Climate Change	5	4	4	3	2	2	2	2	2	6	32	14	5
Deforestation	1	3	6	4	4	6	6	6	4	4	44	21	1
Firewood	6	5	1	6	3	1	4	1	1	1	29	13	6
Over grazing	4	1	5	5	6	4	1	3	5	2	36	18	3
Over harvesting	3	2	3	1	1	3	3	4	6	5	31	15	4

Note : values 1-6 were given: 1 is the least destructive threat and 6 is the most destructive

From the study it was confirmed that there are various driving forces, which lead to the deforestation of the existing vegetation and the expansion of agriculture. These include the division of a few existing grazing lands, woodlands as well as steep sloppy areas hosting MPs to ex-military returnees and youth. Furthermore, uncultivated community grazing lands were found used for the establishment of infrastructures such as elementary schools, churches and mosques, cemetery, and farmer training centers.

4.5.7. Traditional medical practices and knowledge transfer

Some healers were specialist in treating a particular ailment. Many acquired MP knowledge from their families or relatives (Figure 34). But few gained the knowledge through contact with “spirit”, yet few acquired through exchange, learning from others and through trial and error. Like any other indigenous communities in Ethiopia, people in the study Zone give priority for their health status. They say “*Fayimat faduu wimma laliicii abbata*” that means “health is better than a pen full of cattle.” Most indigenous



Figure 34. The healer (woman in the middle) has already passed her knowledge to the daughter (right side). A woman collected various medicinal plants from different habitat and sharing her knowledge to a researcher, assisted by her daughter

people used to treat ailments like head ache, abdominal pains, cough, and febrile associated with other diseases at their home level. They use some common MPs such as *Ajuga integrifolia*, *Allium sativum*, *Coriandrum sativum*, *Eucalyptus globulus*, *Ocimum lamiifolium*, *Rumex nepalensis*, *Ruta chalepensis*, *Verbena officinalis*, *Vernonia amygdalina*, *Zingiber officinale* and others, which are obtained at household level or in case they can be collected freely from neighbors. Many of the studied HHs have some common knowledge on MPs of both human and livestock. However, about 26% of the studied HHs have knowledge derived either from friends, relatives or family, and they have knowledge on MPs in a similar way to some healers. They give medicines freely for a person in need. Traditional healers transfer traditional medicinal knowledge to the family members whom they believe keeps the secrecy.

Currently, modern medicine is becoming the first choice during an episode of illness, particularly among young people if not the cases have to do with bone dislocation, breakage, and delivery. Traditional healers claimed that the health extension agents at *kebele* level instruct people not to use medicinal plants from healers. Similarly, religious teaching that associates the healers practice with witchery discourages the use of traditional medicines. Again as youngsters progress in education they tend to use modern medicines. As a result, most young generation tends to use traditional plants medicines only when 1) during emergency cases before reaching health centers, 2) if they lacked cash to purchase drugs from pharmacy, and 3) if modern medication fails to heal.

CHAPTER FIVE

5. DISCUSSION, CONCLUSION, AND RECOMMENDATIONS

5.1. DISCUSSION

5.1.1. Crop species diversity

The diversity of crop plants cultivated in KT was investigated in the current study. A total of 92 different cultivated crop species with an average of 17.4 crops species per farmland were reported. This result indicates that the crops were diverse though there was a large difference among farmscapes and between farmlands within a farmscape. The multi-story agroforestry systems, intercropping (e.g., coffee shade tree crops, root plants, pulses, and vegetables), and cultivation of different annuals more than once in a year gave rise to the diversity of crops in the study area. These practices also enable farmers to produce more yields from the small plot of farmland. Moreover, the farmscapes studied were located at relatively wide altitudinal range (1502-2669m asl). This has perhaps privileged the growth of diverse crop species.

Cultivating traditional crop landraces and maintaining high levels of genetic and crop species diversity is critical for promoting stabilized production and for minimizing risks due to environmental changes (Eyasu Elias, 2003; Altieri and Nicholls, 2005). Crop diversity also has multiple use needs (Bellon, 1996) as well as the potential to enhance pollination services. One recent study (Ratnadass *et al.*, 2012) showed that with an increase in crop species richness, the severity of non-insect-transmitted host-specific diseases will decrease. In addition, the higher diversity systems give greater yields than lower ones (Tilman *et al.*, 2005). Furthermore, farmers in enset based agroecosystem

maintain landraces that ensure the household food and income security. CBDC (2009) stated that growing several genetically distinct varieties of crops in a single field or small area acts as a risk-aversion strategy against crop failure. Diversifying and planting different crops are also among many common adaptation measures to climate change (Nhemachena and Hassan, 2008). That means crop diversifications, including landraces that tolerate drought perhaps encourage income generation and asset holding for the households, both of which provide households with a financial buffer against sporadic climatic events.

While over 100 plant species had been identified as food crops in Ethiopia (Edwards, 1991), Westphal (1975) had indicated that 94 crop species are grown within the enset-coffee systems alone. Different workers have reported different numbers of crop species being used in Ethiopia. For example, Tesfaye Abebe *et al.* (2010) and Berhanu Mengesha (2010) have reported 78 and 44 crop species, from Sidama homegardens and Arsi agroecosystems, respectively. Hence, enset-based farming systems of the current study area supported larger crop plants diversity. This may depict the significance of adopting the practice to non-enset farming areas in the country.

The enset culture in Ethiopia is said to be polyculture where large numbers of crops are grown along with trees (fruit and forest trees) and livestock rearing. In the current study the largest proportion of crop species, 70.6% ($n = 66$) was recorded from homegardens, which was followed by crops described both from homegardens and crop fields 19.3 % ($n = 18$), and the least was recorded in the crop fields only, 10.1 % ($n = 9$). This study showed that HGs harbored a total of 81 % ($n = 76$) of the studied crop species. Similarly, Zemedu Asfaw (2002) reported 112 crop species (including non- edible crops) both from

the homegardens as well as crop fields of the southern and southwestern parts of Ethiopia. Of these 69 (62%) were recorded in HGs, 26 (23%) both in HGs and crop fields and 17(15%) in fields only. This shows that although homegardens are limited in area proportion, they are key centers of *in situ* crop and other agrobiodiversity conservation. Hence, their sustainability requires due attention. Some of the characteristic species of homegardens in KT Zone include *Ensete ventricosum*, *Coffea arabica*, *Brassica carinata*, *Colocasia esculenta*, *Persea Americana*, *Ocimum basilicum*, *Artemisia absinthium*, *Cymbopogon citrates*, and *Lippia adoensis*.

Farmers of the study area have developed crop diversity by traditional methods, particularly through selecting adequate amount of propagules, buying seed from the nearby markets, and farmer to farmer seed exchange as described by Girma Balcha and Tesema Tanto (2008). This also calls for expert's working with local farmers and enhancing recognized local varieties conservation.

5.1.1.1. Dominant crops

The diversity of the functions of the crops is significant in satisfying nutritional needs as well as other income sources for the farm family. Therefore, farmlands should contain at least minimal supplies of balanced diet as well as cash crops. Cereal crops are good sources of energy, while legumes supply proteins, and fruit and leafy vegetable crops are excellent sources of micronutrients. Overall, maintaining crop diversity ensures adequate supplies for nutritionally balanced and healthy diets (Garí, 2003). Cereals were found to occupy nearly 50% of the total cultivated cropland in the current study area. It followed the trend of crop cultivation in Ethiopia where 73.4% of the total cultivated land was occupied by cereals (Alemayehu Seyoum *et al.*, 2011). This could be associated with

cereals being best adapted to *Dega and Woyna Dega* agroclimatic zones where the largest proportion of the study Zone falls under.

The most dominant cereal crop with the largest crop areas share was teff, followed by wheat and maize. The three cereals constituted 45.5% of the total cultivated crop land in KT Zone. But the study from Arsi highlands showed that wheat had the highest percentage of area share, followed by barley and teff (Berhanu Mengesha, 2010). The disparity could be related with the difference in agroclimate and the culture of crop cultivation. A large area share was given to teff in the current study area that could be attributed to its high market price and the hay utility (as a fodder as well as income source since its hay is sold for mud house construction). Edilegnaw Wale (2004) that large area share is given to teff among cereals in Ethiopia. Teff doesn't require much moisture as well as labour force once weed killer is applied. Thus, most farm families with large farmland size and small labour force prefer to grow teff. Previous studies have also drawn similar explanation on teff demand (Tsige-Yohannes Habte, 1998; Awegechew Teshome, 2001; Berhanu Gebremedhin *et al.*, 2009).

The study Zone is a part of Hadiya-Kambatta Cereal and Enset Livelihood Zone in SNNPR where wheat is the main crop sold for cash. Here, a livelihood refers to the sum of ways in which households make ends meet from year to year, and how they survive (or fail to survive) through difficult times (USAID FEWS NET project and DPPC of the Ethiopian Government, 2006). Thus, *Ensete ventricosum* – *Triticum aestivum* crop type had the largest crop area share, which constitutes more than 30% of the total crop area share in the Zone. Wheat, along with maize, is also used as a subsistence crop supplementing enset, mainly in *Dega* agroclimatic zones. The stalk and leaves of wheat

and maize straw are among major items used for animal feed (Girma Balcha and Tesema Tanto, 2008). Therefore, the crops' dominance is associated with their economic significance too.

Root and tuber crops are the second largest crop functional groups which include enset, taro, yam, and sweet potato. Enset is the most frequent root crop in the study area. Zemedu Asfaw and Zerihun Woldu (1997) reported a similar observation from Welayta and Gurage homegardens. Enset is the main cultural subsistence crop besides to its other uses as discussed by Brandt *et al.*, (1997) and Eyasu Elias (2003). Enset occupied 9% of the total cultivated land in KT, whereas its total share over the whole country is 2.5% (Alemayehu Seyoum *et al.*, 2011). A study conducted in cereal farming system of Arsi, southeaster Ethiopia by Berhanu Mengesha (2010) showed that about 50% of the income of the agricultural production of the households comes from wheat production. Unlike, enset based farming systems this system depends mainly on external agricultural inputs (inorganic fertilizers and other chemicals). This has resulted in poor crop diversity and low production, including environmental problems and poverty. However, the enset based farming system of the study area forms a farmscape with a mosaic of patches of high crop diversity, which tend to minimize the environmental deterioration connected with monocultural production systems.

5.1.1.2. Crop diversity among farmscapes

In enset based agroecosystems of KT Zone crops like enset, teff, wheat, and coffee are common. However, due to some biophysical, socioeconomic and agroclimatic factors crop plants like ginger, taro and yam are not grown evenly among the farmscapes. As the access to market increased, farmers tended to execute different off-farm activities such as

trading so that they give little attention to on-farm activities. Accordingly, they grow restricted crop species either for subsistence or cash generation. This is particularly true in Holegeba Zato of *Kola* agroclimatic zone. More than 50% of the cultivated crop land in this farmscape was occupied by maize, whereas more emphasis was given for ginger in Ajora, which is a major source of income for HHs. Ajora is a part of Hadero Ginger Livelihood Zone (one of the 41 rural livelihood zone of SNNPR) known for its ginger cultivation (USAID FEWS NET project and DPPC of the Ethiopian Government, 2006).

On the other hand, Mesafe farmscape had the highest crop species composition (Table 8). This farmscape shares the characteristic species of both highland and lowland areas. Moreover, farmers in this farmscape also have a good perception to adopt crop varieties such *Malus species*. Such adoption has also raised the crop diversity of the farmscape. Obviously, the introduction of relevant new crops and varieties increases agrobiodiversity in general (Garí, 2003). The highest average number of crop species in *Woyna Dega* agrees with the concept of a mid-altitudinal bulge in species richness (Rahbek, 2005). Mid-elevations offer optimal environmental conditions, which favors the growth of different plant species (Hawkins and Diniz-Filho, 2004; Kluge *et al.*, 2006).

A study done in Southwest Ethiopian highlands indicated that plant species richness tended to show a pattern with an increase that peaks at around 2000m a.s.l. but then starts to decline and level off at higher altitudes above 2500 m (Desalegn Wana, 2009). The geometric limits such as the bottom of a valley and the top of a mountain may affect altitudinal diversity pattern (Jetz and Rahbek, 2002). This phenomenon is called the mid-domain effect (MDE), which suggested a hump-shaped altitudinal richness pattern that arises due to the increasing overlap of species ranges towards the centre of the domain, as

the altitudinal ranges of species are limited by the spatial constraints in lower and higher elevations (Colwell and Lees, 2000).

5.1.1.3. Factors influencing crop species diversity

Altitude had a negative correlation with crop species number, although it had direct correlation with beta diversity (Figure 14). Similarly, a decrease in plant species diversity with increasing altitude was reported from the study on Javanese homegardens (Soemarwoto and Conway, 1991). The slope of the farmland has negatively influenced the crop species richness where crop species number decreased across the slope that could be associated with the maturity and fertility of soil. Consequently, as slope increases, the soils decrease in their fertility and hence tend to support very few perennial crops than the annuals.

The number of crop species increased with increase in distance from a market and decreased with increase of access to the market. For instance, farmscapes of H/Zato and Ajora were at close access to the market that had lower number of crop species than the average (Table 8). This could be attributed to either the farmers focus on the production of few marketable crops or they concentrated on some off-farm activities such as trading. This finding is in agreement with preceding studies (Jensen, 1993; Kehlenbeck and Maass, 2004; Tesfaye Abebe *et al.*, 2006).

As farm size increases, the species richness boosted accordingly. Farmers with a large farm had large TLU and adequate labour force (Table 5). This, in turn, gives them an opportunity to grow a large number of crop species valuable as food, fodder, and income generation. Similarly, larger farms were reported to be linked with greater diversity within as well as among crops in Ethiopian highlands (Benin *et al.*, 2003). The number of

livestock significantly influenced crop species richness, which could be associated with the need of livestock owners to grow diverse fodder species, and the role of livestock in adding nutrients to the agroecosystem and maintaining its sustainability. Crop-livestock integration is a major agricultural activity in the highlands of Ethiopia (Berhanu Gebremedhin *et al.*, 2006; CBDC, 2009). Growing diverse crops can function as a source of feed to livestock, in addition to providing primarily the human need. Livestock in turn can provide enriching nutrient to farms (Kaihura and Stocking, 2003), which shows a positive interaction between crop species and the livestock. Thus, livestock can enhance the overall agricultural systems, food production and income of many farmers across Africa (Gari, 2003).

5.1.2. Diversity and distribution of enset landraces in KT Zone

5.1.2.1. Diversity of enset landraces

Although folk botanical nomenclature is not guided by a set of written rules, there are prominent similarities in the way that plants are named by indigenous people around the world as described by Martin (1995). The classification of enset varieties into male and female based on certain farmer based characterizing qualities such as fiber quality and drought tolerance is in agreement with traditional knowledge from Bonga (Yemane Tsehaye and Fassil Kebebew, 2006) and Kaffa Shaka (Almaz Negash, 2001). This may show either independent development of similar cultures or the diffusion of cultures or both for the management of agrobiodiversity over years. The local people, mainly women provide great care and treatment to female landraces because 1). The varieties are more susceptible to drought, pest and bacterial wilt, 2). They are early maturing and can be harvested any time for the household consumption among poor families, and 3). Their

products are tasty and have high price. This agrees with earlier study on enset in Ethiopia (Asnakech Woldetensaye, 1997).

Farmers of the study area tend to sustain diverse range of enset landraces on their farmlands for the landraces could vary in their uses. This agrees with the report of Eyasu Elias (2003) from Ethiopia. The most frequently dominant enset types were male landraces. Similar observation was reported from Sidama by Bizuayehu Tesfaye (2008). The dominance of male enset landraces such as *Sisqella*, *Dirbo* and *Gishira* across the studied agroclimatic zones may be associated with the ability of landraces to drought conditions, low preference by wild pest animals and low susceptibility to diseases, and their uses both for human and livestock. Zippel (2005) also stated that farmers in Ethiopia always grow some less favoured landraces that withstand severe weather conditions.

More than 3 decades ago, Taye Bezuneh and Asrat Feleke (1966) reported 70 landraces of enset from the whole Ethiopia. Our finding showed 111 enset landraces, which is one of the highest records documented so far. Such deviation could be attributed due to the evolution of landraces or the method of sampling or both. Other previous reports on enset landrace diversity in the country include, 78 from Ari (Shigeta, 1990), 54 from Gurage (Worku Nida, 1996), 65 from Kaffa Shaka (Almaz Negash, 2001), 55 from Wolaita and 59 from Hadiya (Admasu Tsegaye, 2002), 42 from Sidama (Tesfaye Abebe *et al.*, 2010), 26 from Basketo, 70 from Kafa (Feleke Woldeyes, 2011), 105 from Gamo Gofa (Sabura Shara and Mulugeta Diro, 2012), and a list of 110 different enset names from Wolaita (Kefale Alemu and Sandford, 1993).

The mean number of enset landraces identified at farm level in the present study is 9, and the corresponding figure from Sidama (Tesfaye Abebe *et al.*, 2010) and Gamo Gofa (Sabura Shara and Mulugeta Diro, 2012) was 6 and 7.4, respectively. Our finding also showed that the highest number of named landraces per homegarden was 32 at Ancha Sadicho and the lowest was zero at Holegeba Zato. The equivalent report from Sidama was 24 and 2, respectively (Bizuyeyhu Tesfaye, 2008). This shows that farmers of the study area maintain fairly considerable number of enset landraces at individual farmland level.

The deviation of enset landrace richness from the previous studies may be due to the nature of the agroclimate where 92% of study area comprises midland and highland, and suitable for enset cultivation. Additionally, the study Zone is bordered by Wolayita, Hadiya, and Dawro Zones. The improved infrastructure might have allowed the transport of sprouts over long distances. This might have enabled the local people to exchange landraces. The exchange of enset landraces from the neighboring ethnic groups such as Wolaita, Hadiya, Gurage, and Sidama probably makes the area to be one of the richest in enset landrace diversity in Ethiopia. Enset landraces are exchanged mostly at *sima* stage (one-year-old suckers) since it is more portable to transport, or if the distance to be transported is close, the user takes mother corm pieces through family relation or friendship even from distant places.

The similarity in enset landrace names among different enset cultivating ethnic groups of southern Ethiopia is shown in Table 34. The similarity in names with or without slight modification may indicate the landrace exchange between different ethnic groups. Enset landrace exchange was reported from Sidama by Bizuyeyhu Tesfaye and Lüdders (2003).

Table 34. Number of enset landraces maintained by various ethnic groups of Southern Ethiopia and their similarity to those in the present study

Zone	No of landraces examined	No of similarity in landrace names	Examples	Corresponding Kambatissa names	References
Hadiya	59	26	<i>Bedadede, disho, Oniya, Unjamo, Zobra, woshameja</i>	<i>Badade, disho, Oniya, Unjamo, Zobro, woshamede</i>	Admasu Tsegaye and Struik, 2002
Wolaita	55	19	<i>Agiiniia, Alagena, Arrkiia, Bedadiya, Suiitiia, Tuzuma, separa</i>	<i>Aganne, allagena, Arke, badade, Suteta, Tuzuma, Sabara</i>	Admasu Tsegaye and Struik, 2002
Sidama	52	7	<i>Ado, Gena, Astara Wanikore, argicha</i>	<i>Addo, gena, Astra wanqorotte, Derga</i>	Admasu Tsegaye and Struik, 2002
Sidama	79	8	<i>Agana, Tororo</i>	<i>Aganne, Xorore</i>	Bizuayehu Tesfaye & Lüdders, 2003
Gurage	54	7	<i>Amarat, Astara, Baddadet, Marya, Sapara</i>	<i>Amareeta, Astra, badade, Marya, sabara</i>	(Worku Nida, 1996)

New landraces can also be obtained through trade (Zippel, 2005). Furthermore, the stratified sampling method that involved different agroclimatic zones as well as different wealth categories probably has contributed to the high landrace diversity record of the current study.

This survey can offer information about the level of existing enset landrace diversity and their distribution in KT Zone. It also may serve as a baseline data to allow monitoring of future genetic erosion. However, further study on morphological as well as molecular level (using molecular techniques) is needed to attain better insight into the degree of variation among landraces. A molecular technique involves studying the genetic diversity using molecular markers (e.g., Amplified Fragment Length Polymorphism/AFLP) and assists to assess genetic relationships among enset landraces, identification of duplicates and allows the selection of germplasm for effective conservation of genetic resources.

The study area differs both in the number and type of landraces across the agroclimatic zones. Farmers in lowland areas mostly cultivate landraces tolerant to drought and disease. However, in highland areas highly diverse enset landraces over relatively wider areas are grown. This finding is in agreement with the work of Asnakech Woldetensaye (1997) in Ethiopia. Since highlanders grow diverse enset landraces, they use to feed various enset products or the products of enset-cereal mix. This may show the maintenance of enset diversity through use.

The density of enset in lowland areas was higher than in highland areas. The narrow spacing of enset in a small area of the garden, and preferring to grow very limited number of enset landraces (resistant to drought and diseases) seems a means of coping with uncertain environmental conditions. It was explained by Admasu Tsegaye and Struik, (2002) that in a relatively dense enset plantation the leaf canopy conserves soil moisture, suppresses weed growth and reduces organic matter decomposition by reducing soil temperature besides full use of the land.

5.1.2.2. *Uses of enset*

Over the course of time, indigenous people in and around the study area had made enset production a part of their life activity. It is a food to humans, fodder to cattle, medicine to humans and livestock, a source of income, a source of useful materials (e.g., sacks, bags, mats, sieves), material for construction, ornamental crop around the homegarden, and its ability to reduce soil erosion are some of the important uses of enset, among others. Hence, enset is everything to them. They describe this in their proverb “*mini xawaha wesse wassaha lamenoba*” meaning family issues and *kocho* of enset are never bored of. They should be always refreshed and considered as something new. That means although

kocho is fed often, any one never loses interest to eating it. This shows the strong attachment of the indigenous people to enset plant. Enset also has landraces that tolerate considerable drought conditions, once established. According to Dessalegn Rahmato (1996), during environmental hazards and famine, enset can be harvested and consumed before it is fully mature, though the quality of food may be poor. These qualities of enset plant allowed enset growing regions to suffer less during famine periods in the past.

Enset farmers were aware of the variation among different landraces based on their end uses. The multidimensional preference ranking analysis also depicted that landraces recognized as “female” are having the best qualities for making *bulla* and *amicho*, and their *kocho* is tasty to eat. They also ferment early and can be processed and feed within one week’s time (especially by the poor families). However, landraces recognized as male have more yield and produce better quality fiber. They are also tolerant to drought/disease and preferred as animal feed.

Twenty one enset landraces were identified as medicinally helpful in treating human and livestock ailments such as bone fracture, among other ailments. Eyasu Elias (2003) identified 7 medicinal landraces from Woilata. Similarly, Admasu Tsegaye (2002) reported 3 medicinal landraces from Kaffa-Shaka Zone and 12 medicinal landraces from Hadiya Zones. In another study conducted in Gurage (Worku Nida, 1996), 11 medicinal varieties were identified for their medicinal values. This reflects on the knowledge that people of KT Zone had developed over the course of time towards the efficient exploitation of the diverse enset landraces for the various purposes.

Studies on mineral nutrients confirmed that enset is rich in calcium, magnesium, potassium, and iron. The concentration of calcium is 36,100 – 39,100 µg/g on dry weight

basis (Ayalew Debebe, 2006). Similar study showed that enset products are rich in calcium, and are free of heavy metals (Cd and Pb) (Minaleshewa Atlabachew, 2007). Presumably, the high calcium content, common among certain enset types, must be the quality that contributes to the preference of enset in healing fractured bones. Furthermore, a chemical substance called phenylphenalenone, which has antitumour, antibacterial, nematicidic and antifungal activity has been reported from some enset landraces (Hölscher and Schneider, 1998). This indicates that more has to be done on the analysis of nutrient contents as well as bioactive ingredients of various landraces that may help for the development of food quality as well as modern medicinal treatment.

5.1.2.3. Enset landraces diversity and determinants across farmscapes

Our finding shows that there was higher dissimilarity in enset landraces among the farmscapes, which indicates uneven distribution of enset landraces (Table 17). This could be associated with the extent to which enset is used as a staple crop and the tolerance to disease and drought. Furthermore, there was high diversity of enset in *Dega* agroclimatic areas (e.g., Ancha Sadicho and Hobichaqa) where enset serves as the main staple crop. But low diversity was recorded from *Kola* areas (e.g., farmscapes in Holegeba Zato and Soyame) where cereals, root and tuber crops prevail and enset remains co-staple. Westphal (1975) claimed that the extent to which people depend on the enset crop varies among enset farming systems in Ethiopia, is based upon environmental, agronomic, and cultural criteria. Enset varies in its use from being the main staple crop to being a crop that is consumed during famine periods (Million Tadesse *et al.*, 2003). Bizuayehu Tesfaye and Lüdders (2003) stated that unequal distribution and abundance of enset landraces reflects their relative importance to farmers.

In our finding enset landrace diversity was highly influenced by elevation. The finding is consistent with study in Sidama (Bizuyeyhu Tesfaye and Lüdders, 2003). This could be due to relatively optimum temperature and moisture (see Fig. 4), as well as fertile loamy soils in highland areas. For optimum growth, enset plant requires an annual average rainfall of 1100-1500 mm, and a mean temperature of 16-20°C (Taye Bezuneh and Asrat Feleke, 1966). They also described that *E. ventricosum* occurs at altitude from 1500-3100m asl, but scattered at lower altitude areas. Enset grows well in moist, fertile and well-drained soil types (pH 5.6 to 7.3).

Our result shows an increase in enset landrace diversity with increase in the access to market. This could be related to the benefit that the local people gain by selling various enset products including enset leaves to urban areas. The finding contrasts with the hypothesis that associates market isolation with higher levels of crop diversity (Van Dusen and Taylor, 2005; Winters *et al.*, 2006b). But other studies reported that farmers cultivating in close proximity to major market centers maintain relatively high levels of crop diversity (Perales *et al.*, 2003; Sthapit and Shrestha, 2006). But enset diversity decreases with increase in exogenous income (e.g., trading). This finding is consistent with the report by Brandt *et al.* (1997) from Ethiopia. Enset cultivation is basically an incessant labour seeking activity. Any interruption in enset growing activities may affect its production including the diversity. Another worker also affirmed that exogenous income could contribute to significant losses in crop genetic resources (Isakson, 2007). It was shown that the growing prevalence of exogenous income undermined the cultivation of maize genetic diversity in Mexico (Fitting, 2006). Van Dusen and Taylor (2005) also discussed that households located in communities where a greater percentage of agricultural tasks are performed by hired labour tend to plant fewer crop varieties.

There was a remarkable correlation between on-farm diversity of enset landraces and the HH characteristics of the better off (Table 14). Wealthy farmers grow more enset landraces which is in accord with an earlier finding in south western Ethiopia (Almaz Negash and Niehof, 2004). This could be attributed to the possession of large landholding. They also have an aptitude to manage environmental risks that might affect enset production as described by Isakson (2007). That means the status of these HHs to maintain the sanitary measures as a means to control enset disease plus methods used to protect enset pests might be significantly higher.

5.1.3. Agroforestry species diversity and composition

5.1.3.1. *Diversity and density of agroforestry tree and shrub species*

A total of 211 agroforestry tree and shrub species were identified from KT Zone. Out of this, 25 species were edible trees and shrubs. The figure presented here exceeds previous reports in Ethiopia: 120 species from Sidama (Tesfaye Abebe, 2005); 70 species from Arsi Negelle (Motuma Tolera *et al.*, 2008); 20 species from Northern Wello (Yigardu Mulatu, 2005); 60 species from Tigray agroecosystems (Kiros Hadegu *et al.*, 2004); and 90 woody tree and shrub species from Arsi highlands (Berhanu Mengesha, 2010). The mean number of tree and shrub species at farm level was 20 which is consistent with the findings of Tesfaye Abebe (2005).

Some of the factors which might have contributed to the woody species diversity in the study area include, the traditional practice of the people to establish trees on farmlands, around homesteads, crop field margins, in woodlots, and in areas inapt for cultivation. Moreover, the presence of remnant forest species on the farmlands, willingness to adopt

useful exotic species, support provided by extension agents and the like along with wide altitudinal range of the study area could contribute to the woody species diversity. The presence of diverse tree and shrub species provide a wide variety of different uses such as environmental/ecological (e.g., increase soil fertility and prevent wind erosion) and socioeconomic (e.g., they are sources of food, fodder, medicine and firewood) (see Appendix IV). These uses of woody species could contribute to the diversification of tree/shrub as described by Menfese Tadesse (2010).

However, woody species were unevenly distributed across the farmscapes. Even farmscapes from the same agroclimatic zones, for instance H/Zato and Ajora had the lowest and the highest woody species record, respectively. The species richness in Ajora can be explained by the proximity of old forest patches as well as the occurrence of remnant forest tree species on the crop fields is in accord with an earlier study (Zobel, 1997). He stated that species richness in an area may be determined by the species available at a larger scale, the proximity of forests, old-fields, and the new build-up areas. On the other hand, the least species number in H/Zato seems to be due to a narrow range of altitude (1729-1769m asl) as well as the aridity of the environment, with mostly sandy soils that harbour few species including, acacia and other seasonal species, whereas Ajora has red vertisol which is rich in nutrient and can retain moisture. In addition, there were over twenty locally rare species that were recorded from a single farm of different study farmscapes, e.g., *Securidaca longipedunculata*. Their rarity may be associated with over exploitation due to their economic significance to the local people.

Studies in southwestern Uganda (Boffa *et al.*, 2005) and in SE Ethiopia (Berhanu Mengesha, 2010) showed that 69% and 23 % of woody species on agricultural land are

exotic, respectively. However, most of the investigated woody species in this study were indigenous (85%), of which 35% are cultivated. This may indicate healthier on-farm maintenance of ecologically adapted local species although the current trend inclines to the dominance of the exotic species like eucalyptus.

The land use type most common for establishing woody species in our study was the homegarden. Similar observations were reported by Motuma Tolera *et al.* (2008) from south central highlands of Ethiopia. Homegarden agroforestry tree establishment is associated with ease of management. This includes keeping farmlands from the attack of wild animal pests, protection from thievery, getting benefits from various services in the close proximity (e.g., shade for human and livestock), acquiring fodder to cattle and ease of collection of firewood. HGs contained high diversity of trees and shrubs including the spatial arrangement of these components (Mergen, 1987). In the current study homegardens hosted some rare tree species which are totally absent in the adjacent local woody patches of the study area such as *Chionanthus mildbraedii*. This shows the knowledge of indigenous people in selective maintenance and experimentation of valuable biodiversity and the significance of homegardens in the preservation of agrobiodiversity. The previous study on the homegardens support this finding (Watson and Eyzaguirre, 2002).

Homegardens of the study area belong to the agrosilvopastoral agroforestry system that combines agronomic crops with trees/shrubs on the same unit of land meant for better-sustained production of annual crops, fodder for livestock, and wood. Tree growing on the boundary of farmlands was the second common practice observed in the study area. However, Lalisa Alemayehu (2010) reported that boundary tree growing to be the most

common in Menagesha Suba. The disparity could be linked with the nature of AF species, traditional practice, and agroclimate of the study area.

The density of woody species per hectare ranged from 11 to 3828 with an average of 239 individuals per hectare. This finding deviates from the previous report of 13 individuals/ha in North Wello (Yigardu Mulatu, 2005), 475 individuals from Sidama (Tesfaye Abebe, 2005), 1053 ± 114 individuals from old farm in Honduras (Pauli *et al.*, 2005) and 85 individuals/ha from Kerala (Peyre *et al.*, 2006). Unlike a study by Tesfaye Abebe (2005) in Sidama where the coffee plant requires relatively more shade trees, the current study showed lower tree density that could be due to the fact that the study area has dominant cereal and enset cultivation that require low shade trees. Additionally, both study areas also vary in agroclimatic conditions. Yet, the current tree density is higher than the report from the northern Ethiopia (Wello). Unlike Wello, the tree density in KT Zone may be attributed to the agroforestry practice in enset farming systems that involves multiple trees species, among other factors. Moreover, the tree density increased with decrease in wealth status, that means poors grow densier trees to compensate for the land scarcity and to gain economic benefit.

5.1.3.2. Variation in the composition of agroforestry species among farmscapes

Although some trees like *Eucalyptus spp* and *C. macrostachyus* are common to most farmscapes. Other species like *Combretum molle* are located in Kola agroclimatic zones only whereas tree species like *Buddelja polystachya* are restricted to upper highland areas. These variations reveal ecological adaptations of the species to particular agroecological areas. The highest beta diversity (36%) was recorded between Hobichaqa and H/Zato, which were situated at elevation >2300m asl and < 1800m asl, respectively.

The large altitudinal difference (1502 to 2669 m a.s.l.) of the farmscapes can explain the dissimilarity in the composition of natural vegetation in this study. It seems that elevational difference along with climatic factors, soil type and tree growing practice of the people could influence the beta diversity of the study area. The patterns in β -diversity are to a great extent associated with environmental heterogeneity (topographic gradients, and soil nutrients) and anthropogenic disturbances (Mwavu, 2007). Furthermore, climate, differences in landscape context, including various habitat and land use types and different species pools were found to cause beta diversity (Gabriel *et al.*, 2006).

5.1.3.3. Population structure and socio-economic importance of some woody species

The inverted J-shaped frequency distribution was exhibited by *Eucalyptus camaldulensis*. It had the highest IVI and its density (>95% of the individuals) was distributed between DBH of 2 and 40 cm (Figure 25b). Other frequency distributions indicate certain impacts during one or several phases of their life cycles as a result of selective cutting of desirable sizes of trees for different purposes, e.g., pole, fuel wood and clearing for agriculture or a combination of these factors as explained by previous workers (Tamrat

Bekele, 1994; Getachew Tesfaye *et al.*, 2002; Feyera Senbeta and Demel Teketay, 2003).

But there is a limitation in our work with regards to population structure analysis because a very large number of individuals of different species would have been required for such a study. Moreover, the regeneration ecology of the valuable woody species, including rare indigenous species of the agroecosystems should be done to reach on the general conclusion about the population structure of the woody species in the study Zone.

Woody species examined in this study provide socioeconomic benefits for the communities. Among the total examined woody species 9% of them are used as wild edibles whereas 25% ($n = 46$ species) are useful fodder for livestock (see Appendix IV). They also provide valuable ecosystem services such as soil erosion control and improving soil fertility (supporting services), educational and recreational (cultural), food and fuel (provision), sources of pollination, and carbon sequestration (regulating services). The following part summarizes three woody species that are with high IVI in KT Zone.

Cordia africana Lam is a fast-growing tree, grown mainly scattered in the crop fields and as boundary tree in the study area for various purposes. In the current study area the tree is highly valued for its timber and for making various household and farm tools as it can be shaped easily into different forms. *C. africana* is the source of bees forage, its leaf litters maintain soil moisture, and add soil fertility, and its fruits are eaten by children, and its wood is sold to generate income. Similar explanations have been described on the socioeconomic significance of *C. africana* by different authors (ICRAF, 1998; Tesfaye Abebe, 2005; Demel Teketay *et al.*, 2010; Habtamu Hailu and Asfaw, 2011).

Croton macrostachyus Del. is grown as a scattered and boundary tree on farms and at the crop field margins with its demand for uses such as source of firewood and charcoal, the flowers are used for bee keeping, source of farm tools and provides a live fence service. Currently, some farmers use its leaf to produce compost since it has large biomass and high nutrient recycling potential to improve the soil fertility. The indigenous people use its sap, leaves, roots and bark as a remedy for the treatment of various ailments such as hemorrhoid, wounds, snake bite, ascariasis, and diarrhea (see Appendix VII). It is one of the characteristic species in *Woyna Dega* and *Kola* agroclimatic areas of the study Zone where it forms the *Croton macrostachyus*- *Combretum molle* community type. Many other workers also reviewed the socioeconomic role of *C. macrostachyus*, including medicinal uses and ecological values (Young, 1997).

Eucalyptus: the dominant tree species with the highest IVI in this study was *Eucalyptus camandulensis*. This could be due to its abundance and wide range of its agroecological adaptation, including successful regeneration and lower preference by herbivores within the existing environmental circumstances. However, *E. globulus* was the top indicator species which formed *Arundinaria alpina*- *Eucalyptus globulus* community type at highland areas of the study area. Eucalyptus was encountered from 88% of the sampling sites (HHs) but Tesfaye Abebe (2005) from Sidama and Berhanu Mengesha (2010) from Arsi reported that 95% and 63 % of the study HHs planted eucalyptus. The disparity could be attributed to the availability of alternative woody species, agroclimatic conditions of the areas, and the AF practices in the study Zone. The local people ranked eucalypts the first among agroforestry tree species due to its fast growth and the highest economic benefits. Other studies also showed that the maximum scores per use criterion were given to eucalypts (Berhan Kidane *et al.*, 2006; Berhanu Mengesha, 2010; Gil *et*

al., 2010; Habtamu Hailu and Asfaw, 2011). Many authors also described the socioeconomic significance of eucalyptus (Selamyihun Kidanu *et al.*, 2004; Jiregna Gindaba, 2006; Edwards, 2010; Zerihun Kebebew and Gezehagn Ayele, 2010).

The benefit gained from eucalyptus forced its integration into tree-crop production systems despite a view that the practice unfavorably affects undergrowth plant species (Selamyihun Kidanu *et al.*, 2004). Despite the potential for eucalyptus to improve rural livelihoods in northern Ethiopia in 1997, the regional government of Tigray imposed a ban on eucalyptus tree planting on farmlands, to reserve productive farmland for crop production. But private planting of eucalyptus on community wasteland and steep hillsides as well as community woodlots was promoted (Jagger and Pender, 2000). Similarly, the people of KT Zone valued enset plantation so that eucalypts are banned from growing with enset, which may signal their knowledge on the side effects of the tree. Therefore, careful analysis of the community needs and cautious matching of the potential site are critical prerequisites for the promotion of on-farm tree plantings as reported before (Demel Teketay, 2000). In general, because of its fast growth and adaptation to varied agroclimatic zones, people planted eucalyptus as a cash crop even in crop fields of the study zone. However, it seems appropriate to employ management practices that are beneficiary to the indigenous people without harming other AB.

5.1.3.4. *Determinants of agroforestry species diversity*

Studies showed that the regional patterns of species richness are a result of many interrelating factors, such as environmental variables, regional species pool, geographical area, regional species dynamics, competition, plant productivity, evolutionary development, and human activity (Woodward, 1988; Zobel, 1997; Criddle *et al.*, 2003).

In the current study, the woody species richness increased with increase in slope that is in agreement with previous workers (Pattanayak *et al.*, 2002; Tesfaye Abebe, 2005; Fentahun Mengistu, 2008). This could be associated with the presence of bottomlands, steep slopes, marshy areas and riversides that require certain woody species for soil and water management activity. The slope influences the distribution of individual plants and communities by indirectly regulating the distribution of moisture, nutrients and through the influence of micro-climatic conditions in the site (Parker and Bendix, 1996).

As shown from ordination output *Arundinaria alpina-Eucalyptus globulus* community was found to be highly influenced by elevation. Elevation is a complex environmental factor influencing the distribution patterns of plant species (Zhao and Fang, 2006). In the current study, *Dega* agroclimatic area hosted lesser number of woody species than other areas. Hence, elevation influences both species richness and abundance significantly (Hoogerbrugge and Fresco, 1993; Fentahun Mengistu, 2008).

Some of the factors that may influence species number along altitude include climatic factors mainly rainfall and temperature; temperature decreases with increasing altitude while rainfall increases non-linearly with altitude in the tropics and affects the abundance and diversity of species (Brown and Lomolino, 1998). The decrease in species richness at higher elevations may be due to the decrease in temperature (Rahbek, 1995). The other factor, which was thought to affect the pattern of species diversity along altitudinal gradient, is the effect of area. Area within an elevational band may have a strong effect on species richness patterns along elevational gradients even when a constant plot size and standardized sampling is used (Romdal and Grytnes, 2007). As the altitude increases, the total area decreases towards the top of altitude. This small area effect with increasing

isolation of habitats at higher altitudes would result in lower number of species at the upper end of the gradient (Lomolino, 2001).

Our result showed that with increasing areas of woodlots, the number of tree species also increased that agrees with Tesfaye Abebe (2005). This is linked to the fact that some of the small scale woodlots were situated in areas where small patches of old forest are located. Additionally, the regeneration and secondary succession in mature woodlots, and the adoption of some woody species can contribute to the tree species richness.

Furthermore, with increasing wealth status of the HHs, the tree and shrub species richness increased, which is consistent with the study in the central highlands of Ethiopia (Lalisa Alemayehu, 2010). This could be due to the presence of large farmland size and the available labour force among the wealth classes. The labour force (mean = 5 men per HH) positively influenced the woody species richness. This means that households with large labour force invest their time for tree establishment and management activity and hence have diverse woody species. Previous studies reported similar explanations (FAO, 1995; Pattanayak *et al.*, 2002; Ali, 2005). Likewise, studies showed that the number of people who contribute to farm work are significant variables in determining the adoption of tree growing (Badege Bishaw, 1993; Thangataa and Alavalapatib, 2003).

Farmland size has negatively and significantly influenced the density of trees, which is consistent with some studies (Biggelaar and Gold., 1996; Degrande *et al.*, 2006; Fentahun Mengistu, 2008; Muneer, 2008; Kumar, 2011). This might be to compensate the small farmland size, particularly among economically poor farmers. Moreover, the farm size was reported as a significant determinant in the adoption of agroforestry (Michael and

Holm, 2007; Zenebe Gebreegziabher *et al.*, 2010). Similarly, older farmlands had more woody species richness which is consistent with the previous findings (Degrande *et al.*, 2006; Motuma Tolera *et al.*, 2008) that might be linked with the long term buildup of the experience and history of trialing with different valuable species. Furthermore, it is believed that experience decreases the uncertainty associated with an investment with unpredictable returns when adopting on-farm tree planting (Pattanayak *et al.*, 2002).

5.1.4. Plant uses in agroecosystems

5.1.4.1. *The diversity of medicinal plant species and indigenous knowledge*

A total of 170 MP species were examined in the current study. Out of these 13 species were endemic, which calls for the enhancement of the conservation of such species through use. Older people knew more MPs than young people and the knowledge about MPs declined with increase in education. This result is in accord with earlier workers (Debela Hunde *et al.*, 2006; Tesfaye Awas and Sebsebe Demissew, 2009). This may depict the occurrence of quick loss of ethnobotanical knowledge as the young generation attends school, and become accustomed with modern health services, including the teachings of health extension agents who discourage traditional medicinal uses.

Medicinal plant knowledge in the study area is mainly passed through family relation like everywhere else in Ethiopia as described by previous scholars (Fisseha Mesfin *et al.*, 2009). Social relations (friendship, neighborhood, etc.) also assisted in the diffusion of plant knowledge. On the other hand, there are few who claimed to have gained their plant use knowledge from the ghosts. These people are reserved in sharing their knowledge with others, and doing so will be considered like breaking a covenant. Eventhough the

local people realize particular MPs used by a known healer, many are reserved from using it. Because of the widely held belief that MP's are given to the selected healers alone, use by other ordinary people will result in the loss of its healing power. Such taboos may assist for the conservation of MP species since taboos and social restrictions serve to limit MP harvesting (Trivedi, 2009).

Medicinal plants and ailments treated

The ICF values ranged from 0.65 to 0.95, which probably indicate that MPs are either kept in a less secretive way or ailments among the society were wide spread. ICF is a good measure of assessing efficacy of MPs for categorical disease in the context of the local community. MPs supposed to be effective for a certain category of disease treatment will have high ICF. Large proportions of disease categories were represented by high ICF value ($ICF > 0.85$), for instance, ailments with the highest ICF were emaciation, trypsis and head ache with ICF values, 0.95, 0.93 and 0.92 (Appendix VII), respectively, which may indicate the prevalence of diseases. Among the MPs used against human ailments, the highest proportions were used to treat abdominal complaints (16%), followed by lung and skin related problems (11% each), liver and kidney problems (10%), and 6% is used to treat livestock diseases called anthrax, black leg and trypsis (Appendix VII). Intestinal parasites and black leg were the second and the fourth among the ten top diseases of human and livestock, respectively in the study Zone (Zonal Health Office, 2011; Zonal Agriculture Office, 2011). This may show the traditional knowledge of the MPs and their management in the area is related to the abundance of the ailment type.

Medicinal plant parts used to treat ailments

Herbs were the most frequently used ethnomedicinal plant species, followed by shrubs and trees. The highest proportion of MP species was harvested for their leaves. Similar practice was reported from other ethnic groups in Ethiopia (Haile Yineger *et al.*, 2008a; Tesfaye Hailemariam *et al.*, 2009; Mirutse Giday *et al.*, 2010). The preference of leaves to other plant parts seems profitable from conservation point of view since leaf removal may not cause the death of a plant. Leaf harvesting is a non-destructive strategy. Similarly, the ease of preparation and the presence of more bioactive ingredients in the leaf probably made it worthy (Bhattarai *et al.*, 2006).

5.1.4.2. Medicinal plants processing and administration methods

The current finding showed that the largest proportion of the remedy is processed in a fresh form, which is consistent with previous reports (Mirutse Giday *et al.*, 2007; Haile Yineger *et al.*, 2008b; Mirutse Giday *et al.*, 2010; Nigussie Amsalu, 2010). Many healers believe that fresh preparations are effective in healing the supposed ailments. Because of the loss of some MP species in their vicinity, some traditional healers were forced to go long distance for the collection of fresh remedies. Such wearisomeness for the collection of remedies may lead healers to abandon easily unreachable MP species, which in turn results in the loss of a particular plant and its knowledge in the long-run.

This may call for the need for a technology or practice of using herbals in a dried form or there should be reliable methods of preserving medicinal extracts for extended shelf life. In this study only about 8% of the healers had the practice of storing medicines usually in powdered form in containers such as bottles, papers, and pieces of cloth. Furthermore,

healers should be encouraged to grow medicinal plants in their HGs. The targeted conservation measures can be achieved by encouraging people to grow MPs in their homegardens, live fences, farmlands (Rao *et al.*, 2004; Trivedi, 2009), and agroforestry.

Medicinal principles are present in different parts of the plant like root, stem, bark, leaf, flower, fruit or plant exudates. These medicinal principles are separated by different processes (Joy *et al.*, 2001). Seventy five percent of the remedies were prepared from a single plant. This study also agrees with the previous reports (Macía *et al.*, 2005), which may show the efficacy of MPs in healing the ailment. The oral route of remedies administration was the highest. This result is in accord with Mirutse Giday *et al.* (2007), which could be attributed to the prevalence of internal ailments in the study area.

Jaccard's Coefficient of Similarity index(JCS) for comparing MP species in eight randomly selected areas in Ethiopia disclosed that the present study area with 0.3 JCS has the highest similarity with Eastern Shoa Zone (Alemayehu Kefyalew, 2010) (Table 35). The variation in climatic conditions, the sample size, topography and type of flora can influence the similarity. Yet, these JCS values could not strongly depict that the study area has similarity with other areas rather the values may describe there are differences in vegetation as well as cultures with the study area.

Table 35. Similarity in medicinal plant knowledge with previous works

Sample Zone/country	JCS	Sources
Agew-Awi Zone	0.15	(Mirutse Giday <i>et al.</i> , 2007)
Bale Mountains NP	0.08	(Haile Yineger <i>et al.</i> , 2008b)
Benchi Maji Zone(Sheko)	0.17	(Mirutse Giday <i>et al.</i> , 2010)
Eastern Shoa Zone	0.30	(Alemayehu Kefyalew, 2010)
Benchi Maji Zone, Meinit	0.18	(Mirutse Giday <i>et al.</i> , 2009)
Gedeo Zone	0.15	(Fisseha Mesfin <i>et al.</i> , 2009)
Kaffa Zone	0.26	(Tsfaye Awas & Sebsebe Demissew, 2009)
Konta special district	0.11	(Tsfaye Hailemariam <i>et al.</i> , 2009)

5.1.4.3. Distribution and folk taxonomy of medicinal plants

Medicinal plants are distributed across various bio-geographic regions, vegetation types and landscape elements (Rijal, 2011). A large proportion of MPs was collected both from *mini heeggeego* and *Zana*/hedgerows, constituted over 70% of the medicinal plants source. Hedgerows are one of the most valuable sites for biodiversity in the farmed landscape, supporting a number of species (Thompson, 2004). But other workers such as Fisseha Mesfin *et al.* (2009) from Gedeo Zone and Belachew Wassihun *et al.* (2003) from north Omo Zone claimed that homegardens contributed 29% and 13.5% of medicinal plants, respectively. The disparity may be attributed to factors like difference in cultural practice of MP use, agroclimate of the area, and the background of the informants. The homegardens contain diverse life forms, species and varieties (Zemedu Asfaw and Ayele Nigatu, 1995). Moreover, 72% of the marketable MPs in the current study were of the homegarden origin.

In Ethiopia, the reported MPs distribution by their state of existence for wild and for cultivated species is 40.2 and 5.9%, respectively (IBC, 2009). The corresponding figures for the current study are 64% and 28%, respectively. This indicates that MPs of wild origin of the study area become more susceptible as human population pressure increases on the environment. However, the majority of the MPs of the wild origin were associated with the multistory agroforestry systems of the homegardens.

Folk Taxonomy: naming of medicinal plants

The local people have classified vegetation cover in to 16 categories which relies on the vegetation type, abundance and cover. Similar indigenous classifications in Ethiopia were reported on vegetation classification (Fisseha Mesfin *et al.*, 2009), and landscape

categorization (Feleke Woldeyes, 2011). These classifications indicate close relation of natives with not only to medicinal plants but also to their environment at large. Further, they have their own way of taxonomic classification based on various attributes of plants mainly morphological ones, such as colour, size, shape, and use values. This is also in accord with the folk taxonomy described by Kafficho people (Tesfaye Awas and Sebsebe Demissew, 2009). The folk taxonomy gives us insights into the local perception about local resources, for instance, in the current study *Arisaema enneaphyllum* was given a name *Fugi ojomoko* where the local people perceived the plant as it was made to serve only *Fuga* people in the study area.

5.1.4.4. Ranking and scoring medicinal Plants

Helminthic problem is a major public health and economic importance to human, especially in Sub-Saharan Africa (Peter and Deogracious, 2006). The preference ranking exercise of the seven medicinal plants for their efficacy against ascariasis showed that *A. integrifolia*, *L. stachydiformis* and *T. nobilis* were ranked as the top three in decreasing order. These species were previously reported as remedies against ascariasis, namely *A. integrifolia* (Mirutse Giday *et al.*, 2009; Mirutse Giday *et al.*, 2010), and *Leucas stachydiformis* and *Teclea nobilis* (Peter and Deogracious, 2006; Tesfaye Awas and Sebsebe Demissew, 2009). *Ajuga integrifolia* was reported to contain bioactive compounds such as terpenoids, glycosides and phenolics, iridoid glycosides, terpenoids glycosides and ajugarins (Pascaline *et al.*, 2011). Likewise, the species of *Leucas* were known to contain bioactive chemicals like oleanolic acid, ursolic acid and beta-sitosterol, a triterpenoid, leucolactone, and the sterols, sitosterol, stigmasterol and campesterol. Substances in these compounds were reported to have a vermifuge action (Khare, 2007).

The presence of these compounds in *A. integrifolia* and *Leucas sp* corroborates with the medicinal use by the Kambatta Tembaro people.

Similarly, *Cyphostemma adenanthum*, *Thalictrum rhynchocarpum* and *Tanacetum parthenium* were ranked by informants as the top three medicinal plants against blackleg. Previous authors (Mirutse Giday *et al.*, 2007; Kamatenesi *et al.*, 2011) reported the role of *C. adenanthum* against blackleg. The study done on subtropical *Cyphostemma* species indicated that it contains phenolics (a high antioxidant) and other chemical compounds (Al-Duais, 2009), which might have given its medicinal property. Berberine (antibacterial alkaloid) is a bioactive chemical reported in *Thalictrum species*, which acted against *Clostridium sp.* (Erdemgil *et al.*, 2004; Hota, 2007). *Clostridium chauvaei* is a blackleg causative bacterium. Yet, further bioactive chemical analysis of *C. adenanthum*, *L. stachydiformis*, and the others need to be conducted.

5.1.5. The future trend in KT agroecosystems: challenges and opportunities

Challenges

It is believed that enset growing regions do not suffer much during famine and drought periods as compared to non- enset growing areas (Almaz Negash, 2001). However, this study showed that agricultural land fragmentation due to population pressure, crop diseases, focus on improved crops and the failure of viability and adaptability of the improved seeds, wild animal pests and decrease in the size of livestock, which provide manure to fertilize enset are challenging the agrobiodiversity of KT Zone.

Wild mammalian pests are causing a great loss of both production as well as crop diversity in this study, among which porcupine is a serious one. As deforestation of

woodland and forest lands increased, porcupine made its habitat (den) in graveyards, woodlots as well as hedges in the agricultural lands. Similarly, monkeys also made their habitat in the agroforests of the HG and damaging the agricultural crops. Many workers reported the impact of porcupine (*Hystrix cristata* Linnaeus) on agrobiodiversity (Kebu Balemie *et al.*, 2004; Quirin, 2005; German *et al.*, 2006; Waga Mazengia and Mowo, 2012). In the current study area, porcupine was found to damage enset crop seriously, particularly those landraces well recognized for their *amicho* and *bulla* qualities. As a result, many farmers abandoned planting such varieties. Many previous studies indicated the threats of wild animal pests and enset bacterial wilt disease on enset landrace diversity (Shiferaw Tesfaye, 1996; Million Tadesse *et al.*, 2003; Zippel, 2005; Bizuayehu Tesfaye, 2008; Solomon Tekalign and Suneetha, 2012).

Our finding showed that enset bacterial wilt is more frequent in highlands, which agrees with Shiferaw Tesfaye (1996) and Brandt *et al.* (1997). This could be attributed to the difference in climatic condition as well as the cultivation of diverse varieties, including those susceptible landraces of desired qualities in highland areas.

The scarcities of pastureland as well as cropland (caused by the family land division) became challenges to enset production. German *et al.* (2012) also expressed that the scarcity of pastureland influenced the livestock size. Limiting the livestock number per HH also limits the availability of manure to fertilize the enset plant, which in turn affects enset farming system. Similarly, Brandt *et al.* (1997) stated that decreases in livestock manure causes reductions in the long-term sustainability of enset systems. One recent study also identified the land shortage as the first major challenges for enset production in southern Ethiopia (Abrham Shumbulo *et al.*, 2012). Moreover, land shortage is pushing

young farmers to produce short growing food crops since enset production requires more labour as well as series of time to get the product. Almaz Negash (2001) also described the impacts of a shift to cash crop farming on enset crop diversity.

Obviously, enset is a multipurpose, drought tolerant and food security crop. The loss of ecological integrity of livestock and enset can interrupt sustainability of the system. All informants confirmed that they had an access to extension service. However, the extension agents who assist farmers ought to get appropriate training in the areas of AB management, including enset. Additionally, the government should encourage research centres in searching remedies against enset disease.

This study found that disseminating improved crop varieties that are unfit to a particular environmental condition put farmers into debt and loss of their landraces. Other studies showed that the focus on marketable crops (Brush, 2004), and the government's ambition to achieve food security through disseminating improved varieties of crops brought the replacement of traditional varieties (Edilegnaw Wale *et al.*, 2011) as well as the loss of associated knowledge to the landraces.

There was an expansion of fast growing tree, eucalyptus in mid and highlands of the study area which became threat to the existing agrobiodiversity. Some farmers were found to grow eucalyptus at the boundary very close to crops or inside the crop field. An early report from the study area expressed the complaint from peasants about the land infertility due to eucalypt (Barthès and Boquien, 2005). The rapid expansion of eucalyptus in an integrated land use in Ethiopian highlands has been a subject of concern for its competitive effect with crops (Selamyihun Kidanu *et al.*, 2004). Therefore, selection of the suitable sites and management options are significant as to eucalyptus

plantation in agroecosystems. Hence, for the management of agroecosystem services the coordinated effort of the local people, researchers and governmental bodies is an obligatory.

This study showed that lack of access to the desired planting material influenced onfarm tree growing. This agrees with the previous studies (Zenebe Gebreegziabher *et al.*, 2010). This may call for the active involvement of KTZARD in the development and distribution of seedlings of the desired tree species such as *Chionanthus mildbraedii* and *Podocarpus falcatus*. To this effect, the germination ecology of the species should be examined first.

Another challenge to onfarm tree growing include farmland scarcity, fear of crop pest and land tenure insecurity (23% of the informants do not feel the sense of long term security to grow trees on their farms). In the current study the shortage of landholding was ranked as a major constraint to tree growing where 33% of the studied HHs did not have land to grow trees. The size of farmland influenced tree growing on farm lands (Badege Bishaw, 1993; Michael and Holm, 2006; Daniel Ayalew *et al.*, 2007; Zenebe Gebreegziabher *et al.*, 2010). To limit the scarcity of woodland, many local people of the study area were found planting trees on the road and river sides, crop field margins and crop fields. Such practices are appropriate but the compatibility of the growing tree species need to be checked first by experts. The animal pests hosted on trees can constraint tree growing on farmlands (Boffa *et al.*, 2005). But the side effects would be minimized by employing the appropriate traditional tree management practices.

Improper use of the resources like harvesting the root part of useful MPs, e.g., *Securidaca longipedunculata* is a significant threat to plant diversity. The root harvesting may end up

with species extinction. It is a destructive practice, which poses more threat than collecting other plant parts (Emiru Birhane *et al.*, 2011). Deforestation and agricultural expansion were reported as the leading threatening factors for the MPs in the study area, which is in agreement with other researchers (Emiru Birhane *et al.*, 2011). As to Rijal (2011), deforestation and agricultural expansion are major ways of habitat destruction.

The poor perception of some local people to traditional healers and the teaching of health extension workers who discourages users not to consult healers are threats to MPs. This finding agrees with other researchers (German *et al.*, 2012). Hence, this requires awareness raising on the significance of herbal medicines in the primary healthcare.

Furthermore, during the field study we observed only one vendor in Hadero town. Sellers of traditional medicines were coming from Addis Ababa and other place during market day to Mudulla and Doyogana towns of KT Zone. More recently unlicensed practitioners were prohibited by Districts' Health Offices (Pers. communication). Ethiopian government definitely recognizes the traditional medicine, mainly herbal medicine (Solomon Mequanente, 2009). Thus, the responsible governmental body and the public at large should collaborate in the implementation of the policy through developing rules and regulations on the integration of herbal medicine.

Opportunities: indigenous knowledge on agrobiodiversity management

Enset management: As to the management of enset landraces, for instance, some farmers use healthy plant materials, clean farm tools at work, and rotate crops in areas where enset was infected by enset bacterial wilt disease. Since so far there is no considerable chemical remedy against enset bacterial wilt (Abebe Kirub, 2003), the use of such integrated methods seem meaningful. Sanitary measure is the first control

measure, which has been recommended for enset bacterial wilt (Welde -Micheal *et al.*, 2008). It includes uprooting and burying of diseased plants, and cleaning and flaming of equipments (Brandt *et al.*, 1997). Some traditional practices of growing plants such as *Pychnostachis abyssinica* near the infected enset showed positive outcome against enset bacterial wilt in the current study. As to Kidist Bobosha (2003), the crude extracts from the leaf of *P. abyssinica* showed better inhibition. This is an indication of the need for scientific investigation of indigenous knowledge and their practices.

Furthermore, the indigenous people use traditional management methods to protect enset pests (wild animals) individually or in group (section 4.2.7). Brandt *et al.*(1997) also described that the use of traps, and ditch making around enset field against porcupine. Similarly, fencing, trapping, shooting during activity periods, and using repellants were suggested for porcupine management (Olson and Lewis, 1999). Therefore, indigenous practices should be incorporated into scientific methods for effective control measures.

Agroforestry management: farmers design tree management practices to get the tree products for various reasons, namely to create positive interaction between trees and crops, and to minimize a negative influence of some animals on crops. However, most farmland level tree management is chiefly to meet HH needs for fruit, fuel, fodder, building materials, etc (Arnold and Dewees, 1995).

In the current study, pruning was the most common tree management practices, followed by pollarding and layering, respectively. The practice of the tree management methods depend on the type of tree managed, crop species grown as well as the culture of the people. To reduce the competition between the field crops and the tree, regular tree pruning, coppicing, lopping, and pollarding are undertaken during cropping seasons

(Gyasi *et al.*, 2004). The native tree management of the study area relates to scientific agroforestry management that encourages periodic tree pruning and pollarding to maintain proper light levels (Kumar, 2008; Idol *et al.*, 2011), and to return nutrients to the soil in the case of tree legumes (Idol *et al.*, 2011). In addition, farmers in the current study area do not grow eucalyptus with enset plant recognizing its negative impact. Hence, such useful practices should be strengthened among farmers.

Medicinal plants management: it was believed that the future role of HGs in supplementing farm production, including medicinal plants will grow (Kathe, 2006) particularly with increasing the shortage of farmland. This indicates the significance of maintaining HGs and the associated hedges for the management of MPs among small holder farmers. In this study some knowledgeable community members and traditional practitioners were found to cultivate MPs of rare abundance such as *Clausena anistata*. They use HGs, hedgerows and crop fields to grow the desired medicinal species. Similar trend was reported from south eastern Ethiopia (Ermias Lulekal *et al.*, 2008). Likewise, the significance of hedgerows for the maintenance of ecological diversity and the sustainability of agricultural productivity was highly emphasized (de Blois *et al.*, 2002).

5.2. CONCLUSION AND RECOMMENDATIONS

5.2.1. Conclusion

The enset farming systems in the homegardens of south and southwestern Ethiopia preserve a large number of species with a diverse mixture of annual and perennial crops than other types of agricultural production systems. The farmscapes (study sites) were characterized by a wide range of altitudinal variation of the farmlands (1502-2669m asl). Along this altitudinal gradient diverse crop, woody species and useful MP were recorded.

The crop species diversity tends to increase with increase in woody species diversity. Both the mean agricultural crop plants and woody species diversity was higher in *Woyna Dega* (midlands), where nearly 90 and 78% of the crop and woody species grow, respectively in the study Zone. This is attributed to the optimum environmental conditions for the growth of diverse species of both *Dega* and *Kola* agroclimatic zones. *Woyna Dega* agroclimatic areas are characterized by multistory agroforestry systems, intercropping the root and tuber crop plants, and successive cropping (as many as three crops per year) that gave rise to high crop diversity.

This finding showed that enset landrace diversity was highly correlated with elevation where the diversity was high at highland areas. This is associated with the optimum climatic and edaphic conditions for its growth, the type of farming system where enset is staple or co-staple food crop, labour force to carry out enset farming activities, and the presence of relatively large livestock (sources of manure) number in highland areas. However, *Kola* agroclimatic areas cultivated very few common enset landraces that are recognized by their tolerance to drought and diseases. Furthermore, KT Zone hosted highly diverse medicinal plant species most of which are associated within and around the multistory homegardens. As forests, woodlands, and pasture lands are dwindling, many indigenous people were found growing common MPs in their homegardens.

In general, the diversity of agricultural crops, including enset landraces and the agroforestry woody species was associated with the wealth status of the households (e.g., farm holdings), environmental and climatic conditions of the study area. Households with large farmland size in any of the three studied agroclimatic zones grew highly varied agricultural diversity. Moreover, the study shows that the high diversity of enset,

agroforestry species as well as other plant diversity is associated with their use by indigenous people, which satisfies the principle of conservation through use.

There were considerable variations in the diversity of crops, enset landraces and agroforestry woody species among the farmscapes. Most of these variations are associated with the climatic conditions along the altitudinal gradients. Crop species diversity in farmscapes from *Kola* varies greatly from *Dega* than *Woyna Dega* areas. This is due to intensive multicropping of root and tuber crops as well as crop rotation that are common in *Kola* and *Woyna Dega* while enset and cereal dominance is frequent in *Dega* agroclimatic areas. Enset diversity increases along elevational gradient while the woody species diversity tends to increase down to elevation.

The variation in agroforestry woody species diversity is attributed to the proximity of remnant forest patches and the presence of forest species on the farmlands, particularly in *Kola* or *Woyna Dega* agroclimatic areas. The dominant land use type for growing woody species was homegarden. Every economic class owns homegardens where people with out woodlots were found to grow multipurpose woody species in and around the homegarden in order to compensate the farmland scarcity.

This finding showed that crop diversity increased with farmland size as well as livestock size. Farmers with large farmland grew diverse crop varieties, including fodder species. However, crop diversity decreased as access to market increases. Farmers at close access to market cultivate few crops mainly cash crops and engaged themselves on off farm activities and hence get other needs from the market. But farmers distant to market are likely to avail needs on their farmlands and hence grow diverse crop species.

In contrast, farmers at close access to market cultivated higher enset landraces which can be related to the income farmers get from the sales of various enset products such as *bulla*, *kocho* and enset leaves to the urban people. Those farmers with off farm activity grew few enset varieties. They do not invest enough time for growing enset since enset requires intense labour for its production. Enset production was highly influenced by elevation because enset growing conditions are optimum at highland areas. Similarly, the woody species diversity was highly influenced by woodlot size, available labour force and age of the farmland. Those farmers with long experience and large and mature woodlot grew diverse woody species provided that they have sufficient labour force.

Enset farming areas have the potential to endure famine conditions due to the productivity of enset, polyculturing diverse crops, and integrating crop-tree-livestock (agrosilvopastoral) systems. These systems have been interacting and remain sustained for years. However, the current human population increase and the scarcity of pasture and crop land, emphasis on cash crops, the impact of some wild animal pests and crop disease are challenging the agrobiodiversity in particular and enset based farming systems in general. Moreover, the shortage of woodlot forced many households to grow eucalyptus on their crop fields since eucalyptus is recognized as a cash crop by the local people.

The scarcity of pastureland has limited the number of livestock, which are sources of organic fertilizer (manure) and human diet. It is difficult to maintain the diversity of homegardens in the absence of organic fertilizer, particularly in *Dega* and *Woyna Dega* areas. The trend is to replace enset and other garden crops by either cash crop or annuals that require chemical fertilizers. Furthermore, the impacts of wild animal pests like porcupine and enset disease are common problems in highland areas. As a result, many

people abandoned growing enset landraces, particularly sweet female varieties that are easily damaged by pests and disease, which is causing the genetic erosion of economically useful varieties.

This study showed that about 75% of the study informants were educated, which suggests the ease of access to transfer the desired agricultural knowledge to the farm family. Therefore, in order to safeguard enset based farming system of KT Zone, it is helpful to integrate various measures. These include enhancing family planning programs, using the best practices of indigenous people in protecting crop pests and disease, and creating awareness on sanitary measures against bacterial wilt. Furthermore, the *Woreda* Agriculture and Rural Development (ARD) Offices have to enhance polyculturing in the densely populated areas to maintain crop diversity and ensure food security.

5.2.2. Recommendations

Based on the above discussion the following recommendations were suggested:

1. The study Zone has rich agrobiodiversity, including enset landraces. Thus, farmers require experts' assistance on the maintenance of local landraces. This demands capacitating ARD extension agents on the issues of AB conservation. Extension agents also need to have a mandate to facilitate the exchange of desired landraces among farmers. Furthermore, there should be cooperation of scholars in fields such as ethnobotany, genetics and microbiology for a practical solution of AB conservation.
2. Farmers' classification of agro-morphological diversity of enset does not fully depict variations among landraces. Thus, genetic variations need to be assessed using molecular techniques in order to develop a strategy to protect the existing landraces.

3. Disease tolerant enset landraces need to be examined, and adopted to areas where bacterial wilt is more frequent. Additionally, the traditional MPs found valuable against enset bacterial wilt such as *Canna indica* need to be evaluated.
4. The viability and adaptability of improved crop seeds need to be assessed before dissemination.
5. In order to lessen the shortage of crop land, the government sponsored resettlement programs currently being implemented should be continued.
6. The rich trees/shrubs diversity in the agroforestry of the study area is believed to harbor many agriculturally beneficial animal diversity, e.g., birds and insects. Thus, the ecological role of these animals for the sustainability of diverse crop and woody species needs to be examined.
7. Zonal Agriculture and Rural Development should enhance suitable eucalypts tree management practices in order to maximize gain from eucalypts, and to assure the maintenance of ecological integrity.
8. Farmers should be encouraged to adopt both indigenous and exotic fruit, fodder and woody species meant to ensure food security, and protect the environment.
9. Ethiopia should have a clear policy of using both modern as well as traditional medicines. Hence, the concerned bodies in the Zone should raise awareness of various social groups such as influential religious and community leaders, and health workers at various levels on the role of herbal medicines on primary health care. Finally, pharmacological research on the identified indigenous medicinal plants, including varieties of enset needs to be carried out.

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APPENDICES

Appendix I. List of Crop species in Functional Groups

Group of crops (Species)	Family	local name	Functional
<i>Amaranthus caudatus</i> L.	Amaranthaceae	Halibe	Cereal
<i>Eleusine coracana</i> (L.) Gaertn.	Poaceae	Fagajita	Cereals
<i>Eragrostis tef</i> (Zucc.) Trotter	Poaceae	Xaafa	Cereals
<i>Hordeum vulgare</i> L.	Poaceae	Soa	Cereals
<i>Sorghum bicolor</i> (L.) Moench	Poaceae	Bashinqa	Cereals
<i>Triticum dicocoon</i> Schrank	Poaceae	Gardamu	Cereals
<i>Triticum durum</i> Desf.	Poaceae	Alasu/legamo	Cereals
<i>Triticum aethiopicum</i> Jakubz	Poaceae	Alasu	Cereals
<i>Triticum turgidum</i> L.	Poaceae	Alasu	Cereals
<i>Triticum aestivum</i> L.	Poaceae	Alasu	Cereals
<i>Zea mays</i> L.	Poaceae	Boqolla	Cereals
Fiber Crops			
<i>Gossypium barbadense</i> L.	Malvaceae	Futa	Fiber Crops
Fragrant plants			
<i>Artemisia absinthium</i> L.	Asteraceae	Natra	Fragrant plants
<i>Cymbopogon citratus</i> (DC.) Stapf.	poaceae	Hixxichu	Fragrant plants
<i>Lippia adoensis</i> Hochst. Ex Walp	Lamiaceae	kosorotita	Fragrant plants
<i>Mentha spicata</i> L.	Lamiaceae	shaye bonxa	Fragrant plants
Fruits			
<i>Ananas comosus</i> (L.) Merr	Bromeliaceae	ananasa	Fruits
<i>Annona reticulata</i> L.	Annonaceae	Gishxxa	Fruits
<i>Casimiroa edulis</i> La Llave and Lex.	Rutaceae	casimira	Fruits
<i>Carica papaya</i> L.	Caricaceae	pappaya	Fruits
<i>Citrus aurantifolia</i> (Christm) Swingle	Rutaceae	Lomita	Fruits
<i>Citrus sinensis</i> (L.) Osb.	Rutaceae	burutukana	Fruits
<i>Cyphomandra betacea</i> (Cav.) Sendtner	Solanaceae	Daxxe	Fruits
<i>Malus x domestica</i> *	Rosaceae	Apla	Fruits
<i>Mangifera indica</i> L.	Anacardiaceae	Manguta	Fruits
<i>Morus alba</i> L.	Moraceae	Hamaro'oo	Fruits
<i>Musa paradisiaca</i> L.-Abasha	Musaceae	Muza	Fruits
<i>Opuntia ficus-indica</i> (L.) Miller	Cactaceae		Fruits
<i>Passiflora edulis</i> Sims	Passifloraceae	Hopita	Fruits
<i>Persea americana</i> Mill.	Lauraceae	Abokaduta	Fruits
<i>Prunus persica</i> (L.) Batsch	Rosaceae	Koka	Fruits

*Hybrids where *Malus sylvestris*, and others locally called *yunaana*, *pumiilaa*, and *redlish* are involved,

Group of crops (Species)	Family	local name	Functional
<i>Psidium guajava</i> L.	Myrtaceae	Zaytuna	Fruits
<i>Punica granatum</i> L.	Punicaceae	Romana	Fruits
<i>Solanum muricatum</i> Ait	Solanaceae	Mogn apple	Fruits
<i>Citrus medica</i> L.	Rutaceae	Tringo	Fruits
Oil crop			
<i>Guizotia abyssinica</i> (L. f.) Cass.	Asteraceae	(shuqqo- wol)	oil crop
<i>Linum usitatissimum</i> L.	Linaceae	Talba	oil crop
<i>Ricinus communis</i>	Euphorbiaceae	Cheena	oil crop
Pulses			
<i>Cicer arietinum</i> L.	Fabaceae	Shubura	pulses
<i>Glycine max</i> (L.) Merr.	Fabaceae	Akuri atara	pulses
<i>Lens culinaris</i> Medik.,	fabaceae	mishira	pulses
<i>Phaseolus lunatus</i> L.	Fabaceae	haqi wokita	pulses
<i>Phaseolus vulgaris</i> L.	Fabaceae	Lokemu	pulses
<i>Pisum sativum</i> L.	Fabaceae	Atara	pulses
<i>Vicia faba</i> L.	Fabaceae	Baqeela	pulses
<i>Vigna unguiculata</i> (L.)Walp.	Fabaceae	Hixxita	Pulses
<i>Arachis hypogeal</i> L.	Fabaceae		Pulses
Root and tuber crops			
<i>Beta vulgaris</i> L.	Chenopodiaceae	key sira	root and tuber crops
<i>Colocasia esculenta</i> (L.) Schoot.	Araceae	Gabiza	root and tuber crops
<i>Daucus carota</i> L.	Apiaceae	karota	root and tuber crops
<i>Dioscorea alata</i> L.	Dioscoriaceae	Boye	root and tuber crops
<i>Dioscorea bulbifera</i> L	Dioscoriaceae	Harekonchia	root and tuber crops
<i>Ensete ventricosum</i> (Welw) Cheesman	Musaceae	Wesse	root and tuber crops
<i>Ipomoea batatas</i> (L.) Lam.	Convolvulaceae	matatisho	root and tuber crops
<i>Manihot esculenta</i> Cranz.	Euphorbiaceae	haqiqotinit/ Aseba (wol)	root and tuber crops
<i>Plectranthus punctatus</i> L.	Lamiaceae	Sheshe dinikata	root and tuber crops
<i>Solanum tuberosum</i> L.	Solanaceae	dinikata	root and tuber crops
Others			
<i>Lagenaria siceraria</i> (Molina) Stand***	Cucurbitaceae	Komu	Others

*** provides the role of farm tool and income generation other than its use as a wild edible plant (whose young fruits are eaten cooked) by some people..

Contd...

Group of crops (Species)	Family	local name	Functional
<i>Aframomum corrorima</i> (Braun) Jansen	Zingiberaceae	<i>Wokasha</i>	spices and condiments
<i>Foeniculum vulgare</i> Mill	Apiaceae	<i>xumunga</i>	spices and condiments
<i>Coriandrum sativum</i> L.	Apiaceae	<i>wodimamu/xumunga</i>	spices and condiments
<i>Lepidium sativum</i> L.	Brassicaceae	<i>sunfa</i>	Medicinal
<i>Nigella sativa</i> L.	Ranunculaceae	<i>shu'oota (gamb)</i>	spices and condiments
<i>Ocimum basilicum</i> L.	Lamiaceae	<i>basobila/kefuta</i>	spices and condiments
<i>Ocimum basilicum</i> L. var <i>thrysiflorum</i>	Lamiaceae	<i>yanata</i>	spices and condiments
<i>Piper capense</i> L.	Piperaceae	<i>Ximzi</i>	spices and condiments
<i>Rosmarinus officinalis</i> L.	Lamiaceae	<i>Mexibesha</i>	Spices and condiments
<i>Ruta chalepensis</i> L.	Rutaceae	<i>Xalachuta</i>	spices and condiments
<i>Thymus schimperi</i> Ronniger	Lamiaceae	<i>Zazanchuta/tosina</i>	spices and condiments
<i>Trigonella foenumgraecum</i> L.	Fabaceae	<i>shuota (wojuta)</i>	spices and condiments
<i>Zingiber officinale</i>	Zingiberaceae	<i>Jangibelu</i>	spices and condiments
Stimulants and beverage			
<i>Catha edulis</i> (Vahl)			
Forssk.ex Endl.	Celastraceae	<i>chata</i>	stimulants
<i>Rhammus prinoides</i> L' Herit	Rhanmaceae	<i>Gesha</i>	stimulants
<i>Coffea arabica</i> L.	Rutaceae	<i>Buna</i>	stimulants
<i>Nicotiana tabacum</i> L.	Solanaceae	<i>Tumbe'oo</i>	stimulants
Sugar crops			
<i>Saccharum officinarum</i> L.	Poaceae	<i>Shonqora</i>	Sugar crops
Vegetables			
<i>Allium cepa</i>	Alliaceae	<i>Sunkutata</i>	Vegetables
<i>Allium porrum</i> L	Alliaceae	<i>baro</i>	Vegetables
<i>Allium sativum</i> L.	Alliaceae	<i>Tuma</i>	Vegetables
<i>Amaranthus graecizens</i> (L.)	Amaranthaceae	<i>Rasuta</i>	Vegetable
<i>Brassica carinata</i> A. Br.	Brassicaceae	<i>Asusa hamilu</i>	Vegetables
<i>Brassica integrifolia</i> var. <i>carinata</i> (A. Br.) O.E. Schulz	Brassicaceae	<i>hamilu</i>	Vegetables
<i>Brassica rapa</i> L	Brassicaceae	<i>Qosta</i>	Vegetables
<i>Brassica nigra</i> (L.) Koch.	Brassicaceae	<i>Dankalehamlu</i>	Vegetables
<i>Brassica oleracea</i> L.	Brassicaceae	<i>Xiqila</i>	Vegetables
<i>Capsicum annuum</i> L.	Solanaceae	<i>barnaru miximita</i>	Vegetables
<i>Capsicum frutescens</i> L.	Solanaceae	<i>barnaru</i>	Vegetables
<i>Cucurbita pepo</i> L.	Cucurbitaceae	<i>Dabaqula</i>	Vegetables
<i>Erucastrum arbicum</i> Fisch.and Mey.	Brassicaceae	<i>Fesereka/Dankale</i>	Vegetables
<i>Lycopersicon esculentum</i> Mill.	Solanaceae	<i>Timatima</i>	Vegetables
<i>Moringa stenopetala</i> (Bak.)Cuf.	Moringaceae	<i>Halako</i>	Vegetables
<i>Solanum macrocarpon</i> poir.	Solanaceae	<i>Buluta</i>	Vegetables
<i>Solanum nigrum</i> L.	Solanaceae	<i>Migluta</i>	Vegetable
<i>Lactuca sativa</i>	Asteraceae	<i>Selata</i>	Vegetable

Appendix II. The diversity of enset land races identified in the study area

	Name of landrace	sex	Pseudostem color	midrib color	petiole colour	frequency
1	<i>Abatemerza</i>	f	red	reddish green	red with green lines	23.1
2	<i>Aganche/aganne</i>	f	whitish	white	white	5.5
3	<i>Alagenna</i>	m	yellowish green	greenish	greenish black	3.5
4	<i>Ankogenna</i>	f	white-green	yellow green	green with black streaks	1.6
5	<i>Arke</i>	f	green with black dots	yellow green	reddish with green lines	4.7
6	<i>Astra</i>	f	red	red with green lines	red with green lines	7.8
7	<i>Addo</i>	f	green with black spots	green with tinged black streaks	green with tinged black streaks	2.4
8	<i>Awonaada</i>	f	green with black patches	reddish with green lines	reddish with green lines	0.4
9	<i>Belaka</i>	f	red	reddish green		5.9
10	<i>Baddadde</i>	f	green	light greenish red	deep red with green lines	2.4
11	<i>Bambo/lembo</i>	m	dark black	yellow green	black	0.8
12	<i>Bishato</i>	m	white-red	red with green lines	red with green lines	16.5
13	<i>Buqanne</i>	?f	Green	green	greenish red	0.8
14	<i>Bosiye/bossie</i>	f	white-red	green with tinged red	greenish red	0.8
15	<i>Bunache</i>	f	red	red with green lines	red with green lines	3.5
16	<i>Charquwa</i>	f	red with black patches	red with green lines	red	9.4
17	<i>Dirbo</i>	m	reddish green	reddish green	green	53.7
18	<i>Dirbo disho</i>	m	reddish brown	green tinged with red	reddish green	16.9
19	<i>Dirso</i>	f	green	green	green	1.2
20	<i>Dego/dego merza</i>	f	Greenish black	light green tinged with red	light green tinged with black	9.8
21	<i>Fachache</i>	f	red with black streaks	red with green lines	red with green lines	8.2
22	<i>Fello/feluwa</i>	f	orange red	dark red	reddish green	0.4
23	<i>Gegabo/Gegebuwa</i>	m	reddish	reddish with tinged black	reddish with tinged black	0.4
24	<i>Ginuwa</i>	f	purplish green	reddish green	black patched green	2.4
25	<i>Gimbo/Gimbuwa</i>	f	red	red with green lines	black patched green	43.1
26	<i>Gishira</i>	m	black spotted Green	Green	black spotted Green	47.5
27	<i>Ginjona</i>	f	black green	reddish green with black patches	reddish black	3.9

Contd....

	Name landrace	of sex	Pseudostem color	midrib color	petiole colour	frequency
28	<i>Genna</i>	f	yellowish green	faint red	redish green	7.1
29	<i>Gulfe</i>	f	reedish	reddish green	reddish green	0.8
30	<i>Gutte</i>	f	reddish black	green with black spots	green with black spots	1.2
31	<i>Godorote</i>	f	Greenish black	reddish with green lines streaked black	reddish green	2.4
32	<i>Goemorsa</i>	f?	light green	reddish green	reddish green	3.1
33	<i>Gormoro, gonimoro</i>	f	white-green	green	deep green	2.4
34	<i>Hashura/ashura</i>	f	white-green	light green	green black patches	0.4
35	<i>Hargama/Argama</i>	m	purple	red green patched	red green patched	6.7
36	<i>Heilla</i>	m	reddish with black spots	black with green lines	reddish green	13.7
37	<i>Hinuwa</i>	f	light red	green lined red	green lined red	2.4
38	<i>Helo/halla</i>	m	black	yellow green	green	2
39	<i>Inedellibe</i>	f	green	green	green	0.4
40	<i>Etinne</i>	f	red	red with green lines	red with green lines	17.6
41	<i>Kassettee</i>	f	yellowish red	reddish green	green with tinged red	3.5
42	<i>Ketanne</i>	f	deep red	deep red	deep red	1.2
43	<i>Kerqerre</i>	f	red	red	black red	0.8
44	<i>Korbe</i>	?m	Green streaked with red	greenish with black patches	greenish with black patches	0.8
45	<i>Leqqqa</i>	f	yellowish green	yellowish green	green	32.9
46	<i>Lukanda</i>	f	dark green	Green		4.3
47	<i>Mariya</i>	f	light red	red with green lines tinged with black	red with green lines	10.6
48	<i>Merza</i>	f	whitish red brown	red	red	19.6
49	<i>Mesmessa</i>	f	light red	green with tinged red	green with tinged red	14.1
50	<i>Moche</i>	f	green	green	green	11.4
51	<i>Maxxe</i>	m	red with brown spots	brown	brown with green lines	0.4
52	<i>Manirra</i>	m	green with tinged red	reddish green with black patches	white-black	2.4
53	<i>Manduluqqa</i>	f	red	red with green lines	red with green lines	4.3

	Name landrace	of sex	Pseudostem color	midrib color	petiole colour	frequency
54	<i>Nejabuura</i>	m	deep red	deep red with black patches		1.2
55	<i>Odolle</i>	m	reddish green	green with black patches	green with black patches	3.1
56	<i>Oniya</i>	f	green	green	green	16.1
57	<i>Qeberbuya</i>	f	green dark spotted	light green with tinged red	black patched green	2
58	<i>Qeniwaree</i>	f	green with black spots	green	Green	1.2
59	<i>Quenna (gambella)</i>	f	green black	green black		12.5
	<i>Quenna (wojuta)</i>	m	Green with red spots	red with green lines	red with green lines	5.5
60	<i>Qeqilleta</i> (<i>kashalata</i>)	f	dark red	red		8.2
	<i>Qeqille (wojuta)</i>	m	green	greenish		0.8
61	<i>Qorate</i>	f	light red	red lined with green	red	0.8
62	<i>Sebera</i>	f	reddish green	red with green lines	reddish green black patches	with 30.2
63	<i>Sessa</i>	f	reddish green	green with tinged red	green with tinged red	0.4
64	<i>Shaleqoma</i>	f	green dark spotted	Green black spot	green	5.9
65	<i>Sheleqe</i>	m	green with black spots	green	green	19.8
66	<i>Shoddodona</i>	m	light green	green with tinged red	black patched green	0.4
67	<i>Sisqella (gambella)</i>	f	green with black patches	light green	light green	33.7
	<i>Sisqella (woju)</i>	m	light green	green	light green	23.5
68	<i>Suteta, sutalle</i>	f	greenish red	greenish red with black patches		1.2
69	<i>Suwandia</i>	f	white-black	green		5.1
70	<i>Sorphe (gembella)</i>	m	greenish black	black	green with reddish lines	12.9
	<i>Sorphe (woju)</i>	f	white-green	green		1.2
71	<i>Teresseqa</i>	f	light green with black patches	green tinged red	green	16.1
72	<i>teena</i>	??	purple	purple	greenish purple	1.6

	Name of landrace	sex	Pseudostem color	midrib color	petiole colour	frequency
73	<i>Tuzuma</i>	m	yellowish green	green	black patched green	9.8
74	<i>oosquruzu</i>	m	Purple	purple	greenish purple	18
75	<i>Unjamo</i>	m	red with black spots	green with tinged red	green with tinged red	39.6
76	<i>Xororre</i>	f	light red	red with green lines tinged with black	red with green lines tinged with black	19.6
77	<i>Xebare</i>	f	green with black spots	green	green with black patches	12.2
78	<i>Xessa</i>	f	Black patched green	green	green with tinged black	12.2
79	<i>Xixra</i>	f?	greenish black	green with black spots	black spotted Green	3.5
80	<i>Woa,wokta</i>	f	reddish green	Green	red with green lines	3.1
81	<i>Woshemeda</i>	f	green	green	green	15.7
82	<i>Wolanche</i>	m	reddish green	red with green lines	red with green lines	13.7
83	<i>Wanqebare</i>	f	white-green			2.7
84	<i>Wachiso</i>	m	reddish brown			5.1
85	<i>Walama</i>	f	red	reddish green	reddish green	2
86	<i>Wonqorotte,</i>	m	Green with black streaks	green	green	2.7
87	<i>Wolagella</i>	m	light green	Green		1.2
88	<i>Zinketa</i>	f	purple	light purple	light purple	1.2
89	<i>Zobiro</i>	f	red	red with green lines	red	0.4
90	<i>Alo/halla</i>	m?				0.4
91	<i>Amareeta</i>	M?				0.4
92	<i>Amoche</i>	f				0.8
93	<i>Ayasse</i>	f	black			0.8
94	<i>Abodego</i>	?m				0.4
95	<i>Beneja</i>	f	white-red			0.4
96	<i>Bellelee</i>	f	red			0.8

contd....

	Name landrace	of sex	Pseudostem color	midrib color	petiole colour	frequency
97	<i>Bifabello</i>	f	black red			0.8
98	<i>Boshasha</i>	?m				0.8
99	<i>Chicha</i>	f	red			3.5
100	<i>Dagicho</i>	m				0.4
101	<i>Derqetta</i>	f	white			2.7
102	<i>Derga</i>	f	red with black spots			0.4
103	<i>Defaleqqa</i>	?m	white			0.8
104	<i>Ferchasse</i>	m	white			3.1
105	<i>Gaari, garree</i>	?f	white-red			0.8
106	<i>Geimisso</i>	m				1.6
107	<i>Lemosse</i>	?f	red			0.4
108	<i>Mergagambella</i>	?m	black			0.8
109	<i>Metinche</i>	f	white			2
110	<i>Manasisqella</i>	?m				0.8
111	<i>Sennera</i>					0.4
	<i>danxxi disho</i>	m	orange with tingled red	orange with tingled red	orange with tingled red	

Note : Question mark (?) in front of the sex of a landrace shows a lack of agreement among informants on the sex of the landrace, the indicated sex has been reported by many.

Appendix III. Enset landraces on the basis of farmer preference for various use values

<i>Amicho</i>	<i>bullā</i>	<i>Kocho</i> quality	better taste of <i>kocho</i>	storability	medicine	drought stress	earliness in fermentation	fiber
<i>Abatemerza</i>	<i>Abatemerza</i>	<i>Abatemerza</i>	<i>Ankogenna</i>	<i>Aganne</i>	<i>Aganne/aganche</i>	<i>Ankogenna</i>	<i>Arke</i>	<i>Dirbol</i>
<i>Aganne</i>	<i>Aganne</i>	<i>Amoche</i>	<i>Amareeta</i>	<i>Alo</i>	<i>Astra</i>	<i>Amareeta</i>	<i>Godorote</i>	<i>Gishira</i>
<i>Amoche</i>	<i>Amoche</i>	<i>Astra</i>	<i>Arke</i>	<i>Arke</i>	<i>Charquwa</i>	<i>Bishato</i>	<i>Goemorsa</i>	<i>Hargama</i>
<i>Addo</i>	<i>Addo</i>	<i>Addo</i>	<i>Bishato</i>	<i>Abodego</i>	<i>Fello</i>	<i>Belaka</i>	<i>Inedellibe</i>	<i>Sisqella</i>
<i>Bambo</i>	<i>Bambo</i>	<i>Ayasse</i>	<i>Bifabello</i>	<i>Baddadde</i>	<i>Gimbuwa</i>	<i>Baddadde</i>	<i>Itinne</i>	
<i>Beneja</i>	<i>Beneja</i>	<i>Bambo</i>	<i>Buqanne</i>	<i>Chicha</i>	<i>Gishira</i>	<i>Bishato</i>	<i>Quinna</i>	
<i>Baddaada</i> <i>gena</i>	<i>Baddaada</i> <i>gena</i>	<i>Belaka</i>	<i>Bunache</i>	<i>Dirbol</i>	<i>Hargama</i>	<i>Dirbol</i>	<i>Suwandia</i>	
<i>Bellelee</i>	<i>Bellelee</i>	<i>Bellelee</i>	<i>Chicha</i>	<i>Defaleqqa</i>	<i>Ketanne</i>	<i>Fachache</i>	<i>Xororre</i>	
<i>Bishato</i>	<i>Bishato</i>	<i>Baddadde</i>	<i>Defaleqqa</i>	<i>Fello</i>	<i>Laqqqa</i>	<i>Gishira</i>	<i>Wanqebare</i>	
<i>Boshasha</i>	<i>Boshasha</i>	<i>Bishato</i>	<i>Gimbo</i>	<i>Garree</i>	<i>Moche</i>	<i>Gulfe</i>		
<i>Bosiye</i>	<i>Bosiye</i>	<i>Bunache</i>	<i>Ginjona</i>	<i>Gimbuwa</i>	<i>Oniya</i>	<i>Godorote</i>		
<i>Charquwa</i>	<i>Charquwa</i>	<i>Dagicho</i>	<i>Gutte</i>	<i>Gishira</i>	<i>Qeniware</i>	<i>Inedellibe</i>		
<i>Dagicho</i>	<i>Dagicho</i>	<i>balakichu</i>	<i>Godorote</i>	<i>Gembo</i>	<i>Qeqille</i>	<i>Korbe</i>		
		<i>balakichu</i>						
<i>Dirbo</i> <i>balakichu</i>	<i>Dirbo</i> <i>balakichu</i>	<i>Derqetta</i>	<i>Goemorsa</i>	<i>Gena</i>	<i>Sebera</i>	<i>Oniya</i>		
<i>Dirso</i>	<i>Dirso</i>	<i>Derga</i>	<i>Heilla</i>	<i>Gutte</i>	<i>Sheleqoma</i>	<i>Ogina</i>		
<i>Derqetta</i>	<i>Derqetta</i>	<i>Fachache</i>	<i>Kettenne</i>	<i>Heilla</i>	<i>Unjamo</i>	<i>Quenna,woju</i>		
<i>Dego</i>	<i>Dego</i>	<i>Ferchasse</i>	<i>Lemosse</i>	<i>Leqqqa</i>	<i>Wolagella</i>	<i>Sheleqeta</i>		
<i>Geimisso</i>	<i>Geimisso</i>	<i>Geimisso</i>	<i>Mariya</i>	<i>Mesmesa</i>	<i>Xebare</i>	<i>Sisqella</i>		
<i>Gimbuwa</i> <i>Ginuwa</i>	<i>Gimbuwa</i> <i>Ginuwa</i>	<i>Ginjona</i> <i>Gegabo</i>	<i>Mesmesa</i> <i>Maxxe</i>	<i>Moche</i> <i>Ogina</i>	<i>Xessa</i> <i>Zinke</i>	<i>Suteta/sutalle</i> <i>Suwandia</i>		
<i>Gembo</i>	<i>Gembo</i>	<i>Gulfe</i>	<i>Manduluqqa</i>	<i>Qebarre</i>	<i>Teresseqa</i>	<i>Unjamo</i>		

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<i>Amicho</i>	<i>bullā</i>	<i>Kocho</i>	<i>better taste</i>	<i>storability</i>	<i>medicine</i>	<i>drought</i>	<i>earlinss in</i>	<i>fiber</i>
<i>Gena</i>	<i>Gena</i>	<i>Godorote</i>	<i>Nejabuura</i>	<i>Shaleqoma</i>		<i>Xessa</i>		
<i>Gutte</i>	<i>Gutte</i>	<i>Hargama</i>	<i>Qeqillewojuta</i>	<i>S/gambella</i>		<i>Woshemeda</i>		
<i>Godorote</i>	<i>Godorote</i>	<i>Hinuwa</i>	<i>Sebera</i>	<i>Sorphegembella</i>		<i>Wanqebare</i>		
<i>Goemorsa</i>	<i>Goemorsa</i>	<i>Itinne</i>	<i>Shaleqoma</i>	<i>Tuzuma</i>		<i>Wachiso</i>		
<i>Gormoro/gonimoro</i>	<i>Gormoro</i>	<i>Iniya</i>	<i>Teresseqa</i>	<i>Unjamo</i>		<i>Walama</i>		
	<i>gonimoro</i>							
<i>Hashura</i>	<i>Hashura</i>	<i>Kassettee</i>	<i>Usquruzu</i>	<i>Wolanche</i>				
<i>Hargama</i>	<i>Hargama</i>	<i>Lukanda</i>	<i>Xebare</i>	<i>Walama</i>				
<i>Hinuwa</i>	<i>Hinuwa</i>	<i>Mariya</i>	<i>Wolanche</i>					
<i>Inedellibe</i>	<i>Inedellibe</i>	<i>Merzadego</i>	<i>Walama</i>					
<i>Itinne</i>	<i>Itinne</i>	<i>Mergagambella</i>	<i>Wonqorotte,</i>					
<i>Kassettee</i>	<i>Kassettee</i>	<i>Mesmessā</i>	<i>Wolagella</i>					
<i>Kerqerre</i>	<i>Kerqerre</i>	<i>Odolle</i>	<i>Zinketa</i>					
<i>Leqqaqa</i>	<i>Leqqaqa</i>	<i>Oniya</i>						
<i>Lukanda</i>	<i>Lukanda</i>	<i>Qeberbuya</i>						
<i>Mergagambella</i>	<i>Mergagambella</i>	<i>Sebera</i>						
<i>Moche</i>	<i>Moche</i>	<i>Shoddodona</i>						
<i>Manirra</i>	<i>Manirra</i>	<i>Suwandia</i>						
<i>Manduluqqa</i>	<i>Manduluqqa</i>	<i>Teresseqa</i>						
<i>Oniya</i>	<i>Oniya</i>	<i>Usquruzu</i>						
<i>Qeberbuya</i>	<i>Qeberbuya</i>	<i>Unjamo</i>						
<i>Qorate</i>	<i>Qorate</i>	<i>Xororre</i>						
<i>Sebera</i>	<i>Sebera</i>	<i>Woa, wokta</i>						

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<i>Amicho</i>	<i>bullā</i>	<i>Kocho</i>	better taste	storability	medicine	drought	earlinss in	<i>fiber</i>
<i>Sheleqeta</i>	<i>Sheleqeta</i>	<i>Woshemeda</i>						
<i>Shoddodona</i>	<i>Shoddodona</i>	<i>Wogille</i>						
<i>Suteta, sutalle</i>	<i>Suteta, sutalle</i>	<i>Zobiro</i>						
<i>Suwandia</i>	<i>Suwandia</i>							
<i>Usquruzu</i>	<i>Usquruzu</i>							
<i>Woa,wokta</i>	<i>Woa,wokta</i>							
<i>Woshemeda</i>	<i>Woshemeda</i>							
<i>Wanqebare</i>	<i>Wanqebare</i>							
<i>Walama</i>	<i>Walama</i>							
<i>Wogille</i>	<i>Wogille</i>							
<i>Wolagella</i>	<i>Wolagella</i>							
<i>Zobiro</i>	<i>Zobiro</i>							

Appendix IV. The list of woody species found in KT Zone, their family names, local names, habit, Land use types woody species grown, percent frequency and uses.

S.no	Botanical name	Origin	Family	Local Name	Habit	LU type	Percent frequency	Uses
1	<i>Acacia abyssinica</i> Hochst. Ex Benth	I	Fabaceae	<i>Odorra</i>	T	CF	23.3	Md,Fd,Bk, Po,Fw,Sf,Ft,Sh,Lf
2	<i>Acacia decurrens</i> Willd.	I	Fabaceae	<i>Odorra</i>	T	HG	15.6	Fd,Po,Fw,Sf,Sh, Co
3	<i>Acacia melanoxylon</i> R. Br.	I	Fabaceae	<i>Omedilla</i>	T	HG	3.3	Fw, Co
4	<i>Acacia senegal</i> (L.) Willd.	I	Fabaceae	<i>Odorra</i>	T	CF	8.3	Fw
5	<i>Acacia seyal</i> Del.	I	Fabaceae	<i>Wacho</i>	T	CFM	10.6	Fw, Fd
6	<i>Acacia tortilis</i> (Forssk.)Bayne	I	Fabaceae	<i>Odorra</i>	T	CF	0.6	Fw, Fd, Ch
7	<i>Acalypha fruticosa</i> Forssk.	I	Euphorbiaceae		S	CFM	2.2	Fw, Lf
8	<i>Acanthus eminens</i> C. B. Clarke	I	Acanthaceae	<i>Chocha</i>	S	Hd	7.2	Lf, BK
9	<i>Acanthus sennii</i> Chiovi	I	Acanthaceae	<i>Chocha</i>	S	Hd	8.2	Lf, BK
10	<i>Acokanthera schimperi</i> Schwein	I	Apocynaceae	<i>Hulkuba</i>	S	HG	0.6	BK,Md, Fo, Sh, Or
11	<i>Albizia gummifera</i> C.A.Sm.	I	Fabaceae	<i>Ma'ata</i>	T	CF	32.2	Md,Bk,Po,Fw,Sh
12	<i>Allophylus abyssinicus</i> (Hochst.) Radlkofer	I	Sapindaceae	<i>Aberra</i>	T	WL/Hd	13.9	Fw, Lf, Co
13	<i>Apodytes dimidiata</i> E.Mey Ex Am.	I	Icacinaceae	<i>Mewa</i>	T/S	CF	3.9	Md, Fw
14	<i>Arundinaria alpina</i> K.Schum	I	Poaceae	<i>Lema</i>	G	HG	17.8	Fd,Po,Ft,Tb, Co
15	<i>Arundo donax</i> L.	I	Poaceae	<i>Shombogo</i>	G	HG	20	Fd Ft,,Po, Co
16	<i>Asparagus africana</i> Lam.	I	Asparagaceae	<i>Seratiita</i>	S	HG	2.2	Md, Fe, Fd
17	<i>Balanites aegyptiaca</i> (L.) Del.	I	Balanitaceae	<i>Bedena</i>	T	CF	2.8	Fw, Fd, Co, Ft, Bk
18	<i>Bersama abyssinica</i> Fresen.	I	Meliastaceae	<i>Bitansa</i>	T	CF	36.1	Fw,Ft
19	<i>Blighia unijugata</i> Bak.	I	Sapindaceae	<i>Reqqet</i>	S	WL/Hd	4.4	Fw, BK
20	<i>Borassus aethiopum</i> Mart.	I	Arecaceae	<i>Zembata</i>	T	HG	0.6	Or
21	<i>Boscia salicifolia</i> Olive	I	Cappardiaceae	<i>Hesbeta</i>	S	CFM	1.1	Fw
22	<i>Buxwellia piroetae</i> Chiov.	I	Burseraceae	<i>ye ixan zaf</i>	T	WL	0.6	incense
23	<i>Bougainvillea spectabilis</i> Willd.	Ex	Nyctaginaceae		S	HG	12.8	Sh,Or
24	<i>Bridelia micrantha</i> Baill	I	Euphorbiaceae	<i>kane kassiya</i>	S	HG	11.7	Ft, Co, Po, Ch, Fw
25	<i>Bridelia scleroneura</i> Muell. Arg.	I	Euphorbiaceae	<i>Xemama</i>	S	HG	2.8	Ft, Co, Po,Fw

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S.no	Botanical name	Origin	Family	Local Name	Habit	LU type	% freq.	Uses
26	<i>Brucea antidysentrica</i> J.F. Miller	I	Simaroubaceae	<i>Duget</i>	S	Hd	61.1	Md,Fw,So, Bk, Lf
27	<i>Buddelja polystachya</i> Fresen.	I	Loganiaceae	<i>Hanfara</i>	T	HG	10	Md,Fd,Fw,Sh,Bk, Lf
28	<i>Caesalpinia decapetala</i> (Roth) Alston	I	Fabaceae	<i>Amarqapa'</i>	S	Hd	41.1	Lf, Fw, Bk
29	<i>Callistemon citrinus</i> (Curtis) Stapf.	Ex	Myrtaceae		S	HG	0.6	Or, Sh
30	<i>Canthium oligocarpum</i> Hiern subsp. <i>oligocarpum</i>	I	Rubiaceae	<i>Kimbecha</i>	S	WL	1.1	FW,Po,LF
31	<i>Carissa spinarum</i> (Forssk.) Vahl.	I	Apocynaceae	<i>Atula</i>	S	WL	5	Fd,Fw,Lf, Fo, BK
32	<i>Carissa edulis</i> (Vahl) Endl.	I	Apocynaceae	<i>Atula</i>	S	WL	12.8	Fo,Fd,Fw,Lf, Bk
33	<i>Cassipourea malosana</i> (Bak.) Alston	I	Rhizophoraceae	<i>Ximra/Kmbacha</i>	T	CF	3.3	Ft,Fw,Ti, po
34	<i>Casuarina equisetifolia</i> L.	I	Casuarinaceae	<i>Shuwashuwe</i>	T	HG	1.1	Po,Fw,Lf
35	<i>Celtis africana</i> Burm. f.	I	Ulmaceae	<i>Sutat</i>	T	HG	18.3	Fw, Lf, Co, Fd, Sh
36	<i>C. gomphophylla</i> Bak.	I	Ulmaceae	<i>Roqqona</i>	T/S	HG	1.1	Fw, Lf, Co, Fd
37	<i>Cestrum purpureum</i> (Lindl.) Standl.	I	Bignoniaceae		S	HG	1.7	Or, Lf
38	<i>Chionanthus mildbraedii</i> (Gilg & Schellenb.) Stearn	I	Oleaceae	<i>Sigazu</i>	T	HG/WL	2.2	Ft, Co, Sh, Ti, Fw
39	<i>Clausena anistata</i> (Willd.) Benth.	I	Rutaceae	<i>Bayxaqa</i>	S	HG	8.9	Md,Fd,Tb, Co, Bk
40	<i>Clerodendrum myricoides</i> Vatke	I	Lamiaceae	<i>Marsesa</i>	S	HG	5	Md,Fd,Ft
41	<i>Combretum adengonium</i> Steud. Ex A. Rich.	I	Combretaceae	<i>Burchana</i>	T	WL	1.1	Fd,Po,Sh
42	<i>Combretum collinum</i> Fresen	I	Combretaceae	<i>Digisuta/danshe</i>	T	CF	2.8	Co,Ft,Fw
43	<i>Combretum molle</i> G. Don	I	Combretaceae	<i>Abella/Debeqa</i>	T	CF	16.7	Co,Ft,Fw
44	<i>Cordia africana</i> Lam	I	Boraginaceae	<i>Wamja</i>	T	CF	70	Ti,Ft,Sh,Sf,Fd,Bk, Fo, Ch
45	<i>Croton macrostachyus</i> Del.	I	Euphorbiaceae	<i>Mesana</i>	T	CF	70	Md,Bk,Po, Ft,Lf,Shade
46	<i>Cupressus lucitanica</i> Mill.	Ex	Cupressaceae	<i>farangi Homa</i>	T	HG	57.8	Po,Lf, Ti
47	<i>Datura arborea</i> (Wild) Bercht. & Presch	I	Solanaceae	<i>ababaqa</i>	S	HG	21.1	Bk,Or, Lf
48	<i>Delonix regia</i> (Bojer ex Hook.) Raf	Ex	Fabaceae		T	HG	0.6	Or, Bf, Sh
49	<i>Diospyros abyssinica</i> (Heim) F. White	I	Ebenaceae	<i>Legbella</i>	T	WL	22.2	Po, Ft, Fw
50	<i>Discopodium penninervium</i> Hochst.	I	Solanaceae	<i>Chochinga</i>	S	HG	16.1	Lf, Bk
51	<i>Dodonaea angustifolia</i> L.F.	I	Sapindaceae	<i>kitkita</i>	S	WL	1.7	Md,Fw,
52	<i>Dombeya torrida</i> (J. F. Gmel.) P. Bamps	I	Sterculiaceae	<i>Da'ina</i>	S	HG	7.8	Fd,Bk,Fw,Lf, Sf

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S.no	Botanical name	Origin	Family	Local Name	Habit	LU type	% freq.	Uses
53	<i>Dovyalis abyssinica</i> (A. Rich.) Warb.	I	Flacourtiaceae	<i>Koshma</i>	S	Hd	15	Md,Lf, Bk, Fo
54	<i>Dracaena steudneri</i> Engl	I	Dracaenaceae	<i>Fishgalla</i>	T	WL	8.3	Md,Or,
55	<i>Ehretia cymosa</i> Thonn.	I	Boraginaceae	<i>Ulag</i>	T/S	HG	24.4	Md,Fw,Ft, ti, Sf, Lf, Bk
56	<i>Ekebergia capensis</i> Sparrm.	I	Meliaceae	<i>Olonchuta</i>	T	HG/WL	26.7	Ft, Sh, Po, Fw, Bk
57	<i>Erica arborea</i> L.	I	Ericaceae	<i>Satita</i>	S	WL	1.7	Fw, Fd, Bf, Lf, Ch
58	<i>Erythrina abyssinica</i> Lam. exDC.	I	Fabaceae	<i>Wella</i>	T	HG	18.3	Md,Bk,Sf,Fw,Ft,Lf
59	<i>Erythrina brucei</i> Schweinf.	I	Fabaceae	<i>Wella</i>	T	HG	42.2	Md,Bk,Sf,Fw,Ft,Lf
60	<i>Erythrococca tricogene</i> Prain	I	Euphorbiaceae		S	Hd	2.2	Fw, Lf
61	<i>Eucalyptus camaldulensis</i> Dehnh	Ex	Myrtaceae	<i>Barzafa</i>	T	WL/Hd	46.7	Po,Fw, Co, Bk
62	<i>Eucalyptus citriodora</i> Hook	Ex	Myrtaceae	<i>Barzafa</i>	T	WL/Hd	21.1	Po,Fw, Co, Bk
63	<i>Eucalyptus globulus</i> Labill.	Ex	Myrtaceae	<i>Barzafa</i>	T	WL/Hd	32.8	Po,Fw, Co, Bk
64	<i>Eucalyptus saligna</i> sam.	Ex	Myrtaceae	<i>Barzafa</i>	T	WL/Hd	5	Po,Fw, Co, Bk
65	<i>Euclea divinorum</i> Hiern	I	Ebenaceae		S	Hd	1.1	Po,Fw,Ft,Lf Md
66	<i>Euphorbia abyssinica</i> Pax	I	Euphorbiaceae	<i>Charata</i>	T	Hd	20.6	Po,Ft,Lf, Bk
67	<i>Euphorbia candelabrum</i> Kotschy	I	Euphorbiaceae	<i>Charata</i>	T	Hd	1.1	Po,Ft,Lf, Bk
68	<i>Euphorbia compacta</i>	Ex	Euphorbiaceae	<i>Ababa haqqa</i>	S	HG	2.8	Or, Sh, Lf
69	<i>Euphorbia cotinifolia</i> L.	Ex	Euphorbiaceae	<i>Ababa haqqa</i>	S	HG	18.9	Or, Lf
70	<i>Euphorbia pulcherrima</i> Klotzsch.	Ex	Euphorbiaceae	<i>Ababa haqqa</i>	S	HG	13.3	Lf,Or
71	<i>Euphorbia tirucalli</i> L.	I	Euphorbiaceae	<i>Hinchibeta</i>	S	Hd	22.2	Lf, Md
72	<i>Faurea rochetiana</i> Serm	I	Proteaceae	<i>Futeta</i>	S	WL	1.1	Fw, Ft, Lf, Bk, Fd
73	<i>Ficus sur</i> Forssk.	I	Moraceae	<i>Odeta</i>	T	HG/WL	11.1	Fo,Fd,Sf
74	<i>Ficus sycomorus</i> L.	I	Moraceae	<i>Odeta</i>	T	WL	8.9	Fo,Fd,Sf, Sh
75	<i>Ficus thonniigii</i> Blume	I	Moraceae	<i>Dongita</i>	T	HG	1.1	Fo,Fd,Sf, Sh
76	<i>Ficus vasta</i> Forssk.	I	Moraceae	<i>Odeta</i>	T	HG	2.2	Fd,Sf
77	<i>Flacourtia inidca</i> Merrill	I	Flacourtiaceae	<i>Hagla</i>	S	CFM	0.6	Fw, Fd, Ft

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S.no	Botanical name	Origin	Family	Local Name	Habit	LU type	% freq.	Uses
78	<i>Gardenia ternifolia</i> K. Schumach & Thon	I	Rubiaceae	<i>Saga/Gambeleqa</i>	S	CF	3.3	Ft, Fw, Fe
79	<i>Gouania longispicata</i> Engl.	I	Rhamnaceae		C	Hd	3.3	Fw, Lf, Bk
80	<i>Grevillea robusta</i> A. Cunn.Ex.R.Br.	Ex	Proteaceae	<i>Gravila</i>	T	CFM	46.7	Fd, Sf, Ti
81	<i>Grewia tenax</i> (Forssk) Fiori	I	Tiliaceae		S	WL	0.6	Fw, Ft, Tb
82	<i>Grewia velutina</i> (Fork.) Valh	I	Tiliaceae	<i>Haruresha</i>	T/S	Hd	1.1	Fw, Ft, Fd, Co, Bk
83	<i>Halleria lucida</i> L	I	Schrophulariaceae		S	WL	0.6	Fw
84	<i>Helinus mystacinus</i> Steud	I	Rhamnaceae	<i>Wetechua</i>	S	WL	1.7	Co,Fw, utensils
85	<i>Hibiscus berberidifolius</i> A. Rich	I	Malvaceae	<i>Shanda</i>	S	Hd	6.7	Fw, Lf
86	<i>Hibiscus dongolensis</i> Del.	I	Malvaceae	<i>qixiqitta</i>	S	Hd	1.7	Fw, Lf
87	<i>Hibiscus rosa-sinensis</i> L.,	I	Malvaceae		S	HG	2.2	Lf, Or
88	<i>Hagenia abyssinica</i> (Bruce) J. F. Gmel.		Rosaceae	<i>Xenchuta</i>	T/S	HG	2.2	Co, Fi, Md, Sh, Ti,
89	<i>Hymenodictyon floribundum</i> Robinson	I	Rubiaceae		S	WL	1.1	Fw,
90	<i>Hypericum quartinianum</i> A. Rich.	I	Hypericaceae	<i>wobaxi haqa</i>	S	WL	0.6	Fw, Ch, Bk
91	<i>Hypericum revolutum</i> vahl	I	Hypericaceae	<i>wobaxi haqa</i>	T/S	WL	1.1	Bk, Fw
92	<i>Jacaranda minosifolia</i> D. Don.	Ex	Bignoniaceae	<i>jakaranda</i>	T	HG	7.8	Bk,Fw, Or
93	<i>Jasminum abyssinicum</i> DC.	I	Oleaceae	<i>Xosha</i>	C	Hd	3.9	Co, Lf
94	<i>Jatropha curcas</i> L.	Ex	Euphorbiaceae	<i>Chena</i>	S	Hd	7.2	Lf, fuel
95	<i>Juniperus procera</i> L.	I	Cupressaceae	<i>Abash homa</i>	T	HG/WL	32.2	Md,Po,Ft,Lf
96	<i>Justicia schimperiana</i> T. Anders	I	Acanthaceae	<i>Gulbana</i>	S	Hd	40.6	Md,Fd,Bk,Po, Fw,Ft,Lf
97	<i>Lannea welwitschia</i> (Hiem) Engl.	I	Anacardiaceae	<i>Qilxuta</i>	T	WL	2.2	Ft, Co, Fw
98	<i>Lantana camara</i> L.	Ex	Lamiaceae		S	Hd	3.9	Lf
99	<i>Leucaena leucocephala</i> (Lam.) De Wit.	Ex	Fabaceae	<i>Lukana</i>	S	CFM	5.6	Fd,Sf,Lf
100	<i>Macaranga capensis</i> (Baill.) Sim	I	Euphorbiaceae	<i>Bilatena/bararaqa</i>	T	HG	2.2	Fd,Fw,Hb, Lf, Fo
101	<i>Muesia lanceolata</i> Forssk.	I	Myrsinaceae	<i>Gowada</i>	T	WL/Hd	28.3	Fd,Fo,Fw,Ft,LF

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S.no	Botanical name	Origin	Family	Local Name	Habit	LU type	% freq.	Uses
102	<i>Manilkara butugi</i> Chiov.	I	Sapotaceae	<i>Gilta/Lega</i>	T	WL/Hd	7.2	Ft, Co,Ti, Fo
103	<i>Maytenus arbutifolia</i> (A.Rich) Wilczek	I	Celestraceae	<i>kombolla</i>	T/S	Hd	22.2	Ft,Fw,Lf
104	<i>Maytenus arguta</i> (Loes) Robson	I	Celestraceae	<i>Atula</i>	S	Hd	2.2	Fd,Fw,Ft,Lf
105	<i>Maytenus gracilipes</i> (Welw. Ex Oliv.) Exell <i>suspp. Arguta</i> (Leos) sebsibe	I	Celestraceae	<i>Atula</i>	S	Hd	0.6	Fd, Lf
106	<i>Maytenus senegalensis</i> (Lam.) Exell	I	Celestraceae	<i>Atula</i>	T/S	Hd	3.3	Md, Fw,LF
107	<i>Melia azedarach</i> L.	Ex	Meliaceae	<i>Mila</i>	T	HG	15.6	Md,Po,Fw,Sh,
108	<i>Millettia ferruginea</i> (Hochst.) Baker	I	Fabaceae	Hengezenna	S	HG	18.3	Md,Fd,Bk,Fw,Sf,Ft,Sh
109	<i>Myrsine africana</i> L.	I	Myrsinaceae	<i>Gettemmuta</i>	S	Hd	1.1	Po,Lf
110	<i>Nerium oleander</i> L.	Ex	Apocynaceae		S	HG	2.2	Or, Lf
111	<i>Olea europaea</i> L. <i>ssp. cuspidata</i> (Wall. ex C. Don) Cif.	I	Oleaceae	<i>Weira</i>	T	HG/WL	33.3	Md,Fd,Bk,Ft,Sh,Co, Tb
112	<i>Olea welwitschii</i> Gilg.& Schellenb	I	Oleaceae	<i>Onema</i>	T	HG/WL	2.8	Ti, Fw
113	<i>Olinia rochetiana</i> A. Juss.	I	Oliniaceae	<i>Shoimoluta</i>	S	WL	5.6	Md,Co,Fw,
114	<i>Osyris quadripartita</i> Decn.	I	Santalaceae	<i>Ka'rruta</i>	S	WL	3.3	Md,Fw
115	<i>Oxyanthus speciosus</i> DC.	I	Rubiaceae	<i>Zizambetta</i>	S	CFM	16.1	Lf, Fw
116	<i>Pavetta abyssinica</i> Fresen	I	Rubiaceae	<i>Fugi miketta</i>	S	HG/WL	23.3	Med,Bk, Lf, Fw
117	<i>Pavonia glechomifolia</i> (A. Rich.) Garcke	I	Malvaceae		S	Hd	1.1	Fw, Lf
118	<i>Pavonia urens</i> Cav.	I			S	WL	5.6	Fw,Md, Lf
119	<i>Pentas lanceolata</i> (Forssk)Defl.	I	Rubiaceae	<i>Gonawasa</i>	S	Hd	9.4	Fw, Lf, Bk
120	<i>Phoenix reclinata</i> Jacq.	I	Arecaceae	<i>Zambatta</i>	T	HG	3.9	Or, Sh, Fd
121	<i>Phytolacca dodecandra</i> L. Herit.	I	Phytolaccaceae	<i>haranja</i>	S	Hd	2.8	Lf, Bk
122	<i>Piliostigma thorningii</i> (Schumach.) Milne-Redh.	I	Fabaceae	<i>Qelqelaga</i>	T	CF	1.1	Md,Fd,Fw, Bk
123	<i>Pinus patula</i> L.	Ex	Pinaceae		T	HG	0.6	Or, Fw, Co, Ti
124	<i>Pinus radiata</i> D. Don.	Ex	Pinaceae		T	HG	0.6	Or, Fw, Co, Ti
125	<i>Pittosporum abyssinicum</i> Hochst. ex Del.	I	Pittosporaceae	<i>Bunega</i>	T	HG/WL	7.8	Fd,Fw, Lf, Sf

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S.no	Botanical name	Origin	Family	Local Name	Habit	LU type	% freq.	Uses
126	<i>Pittosporum viridiflorum</i> Sims.	I	Pittosporaceae	<i>Bobanaqa</i>	T	HG	3.3	Md, Fw, Ft
127	<i>Podocarpus falcatus</i> (Thunb.) Mirb.	I	Podocarpaceae	<i>Zegba</i>	T	HG	36.1	Md, Ti, Fw, Sh, Or
128	<i>Polyscia fulva</i> (Heirn)	I	Araliaceae	<i>Getame</i>	T	WL	2.2	Ft,Fw,
129	<i>Populus alba</i> L.	Ex	Salicaceae		T	HG	0.6	Or, Lf
130	<i>Pouteria adolfi-friederici</i> (Engl.) Baehni	I	Sapotaceae	<i>Shoa'</i>	T	HG	2.2	Ti,Cons,
131	<i>Premna schimperi</i> Engl.	I	Lamiaceae	<i>Xoxanqeta/wesesita</i>	S	Hd	8.9	Md,Fd,Co,
132	<i>Protea gagued</i> J. F. Gmel.	I	Proteaceae	<i>Xa'yt</i>	S	CFM	2.2	Or
133	<i>Prunus africana</i> (Hook. f.) Kalkm	I	Rosaceae	<i>Gerba</i>	T	HG	36.1	Md,Co, Fw,Ft
134	<i>Psydrax parviflora</i> Bridson	I	Rubiaceae	<i>Ga'yt</i>	T	CFM	4.4	Fw
135	<i>Pycnostachys abyssinica</i> Fresen	I	Lamiaceae	<i>Tontona</i>	S	Hd	25	Md,Sf, Lf
136	<i>Rhamnus staddo</i> A. Rich	I	Rhamnaceae	<i>Wetechua</i>	S/T	Hd	1.1	FW, fumigation
137	<i>Rhus glutinosa</i> A.Rich	I	Anacardiaceae	<i>Shilale/Qemo</i>	S	Hd	5.6	Fo,
138	<i>Rhus ruspoli</i> Engl.	I	Anacardiaceae		S	Hd	0.6	Lf
139	<i>Ritchiea albersii</i> Gilg	I	Capparidaceae	<i>Qoroqonda</i>	S	CFM	0.6	FW,Fd,LF, Fo
140	<i>Rosa abyssinica</i> Lindley	I	Rosaceae	<i>Seguta</i>	S	WL/Hd	2.8	Fo, Bk, Lf
141	<i>Rosa x richardii</i> Rehd.	I	Rosaceae	<i>ababa</i>	S	HG	12.8	Or, Ft
142	<i>Rubus steudneri</i> Schweinf.	I	Rosaceae	<i>Hamarou'</i>	S	Hd	8.3	Fd,Lf
143	<i>Salix subserrata</i> Willd	I	Salicaceae		T	Hd	0.6	Lf, Fw, Tb
144	<i>Sapium ellipticum</i> (Hochst) Pax	I	Euphorbiaceae	<i>Magera</i>	S	WL/Hd	10	Sh, Fw, Co, Ft
145	<i>Schefflera abyssinica</i> Harms	I	Araliaceae	<i>Getame</i>	T	HG/WL	1.7	Bk, Sf, Ft, Ti
146	<i>Schrebera alata</i> Welw	I	Oleaceae	<i>qebelaqa</i>	S	CFM	1.7	Fe, Fw,Or, Md
147	<i>Schinus molle</i> L.	Ex	Anacardiaceae	<i>Qondoerber</i>	T	HG	0.6	Lf, Or, Sh, Ir
148	<i>Securidaca longipedunculata</i> Fresen	I	Polygalaceae	<i>Sangana</i>	S	WL	0.6	Md, Fw, Bk, , Po
149	<i>Senna didymobotrya</i> (Fresen.) Irwin & Bameby	I	Fabaceae	<i>Sena/zemaka</i>	S	Hd	18.9	Fw,Lf
150	<i>Senna obtusifolia</i> (L.) Irwin & Bameby	I	Fabaceae	<i>Chachayena</i>	S	Hd	5.6	Fw,Md

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S.no	Botanical name	Origin	Family	Local Name	Habit	LU type	% freq.	Uses
151	<i>Senna occidentalis</i> (L.) Link	I	Fabaceae	<i>Sena/semaka</i>	S	Hd	1.1	Md,Fw,
152	<i>Senna petersiana</i> (Bolle) Lock	I	Fabaceae	<i>Sena/semaka</i>	S	WL/Hd	53.9	Md, Ft, Lf
153	<i>Senna septemtrionalis</i> (Viv.) Irwin & Bameby	Ex	Fabaceae	<i>Sena/semaka</i>	S	Hd	11.7	Fw,Lf
154	<i>Senna singueana</i> (Del.) Lock	I	Fabaceae	<i>Sena/semaka</i>	S	Hd	2.2	Fw
155	<i>Sesbania sesban</i> (L.) Merr.	I	Fabaceae	<i>Sesbana</i>	S	CFM	15	Fw,Fd, BK, Lf, Sf
156	<i>Sesbania quadrata</i> Gillett	I	Fabaceae	<i>Sesbana</i>	S	Hd	2.2	Fw,Fd, BK, Lf
157	<i>Sida schimperiana</i> Hochst. Ex Rich.	I	Malvaceae	<i>Xurazu</i>	S	WL	2.2	Md,Fw
158	<i>Sida tenuicarpa</i> Vollesen	I	Malvaceae	<i>Xurazu</i>	S	WL	1.7	Fw
159	<i>Smilax aspera</i> L.	I	Smilacaceae	<i>Gesargaja</i>	C	WL	1.1	Co,Md, Fd
160	<i>Solanecio gigas</i> (Vatke) C. Jeffrey	I	Asteraceae	<i>wocho haqa</i>	S	HG	5.6	Md, Sf
161	<i>Solanecio mannii</i> (Hook.f) C. Jeffrey	I	Asteraceae	<i>Fugi malaata</i>	S	HG	2.2	Md, Sf, Lf
162	<i>Solanum incanum</i> L.	I	Solanaceae	<i>Hombororita</i>	S	Hd	30.6	Md, Lf, Bk
163	<i>Solanum giganteum</i> Jacq,	I	Solanaceae	<i>Ziza</i>	S/T	Hd	6.7	Md, Lf, Bk
164	<i>Spartium junceum</i> L.	Ex	Fabaceae		S	CFM	1.1	Or, Lf
165	<i>Spathodea nilotica</i> Seem	Ex	Bignoniaceae	<i>Spatoda</i>	T	HG	5.6	Or, Sh, Ti, Fw, Ch
166	<i>Stereospermum kunthianum</i> Cham	I	Bignoniaceae	<i>Gambella</i>	T	CFM	2.8	Fw, Fd, Or,
167	<i>Strychnos innocua</i> Del.	I	Loganiaceae		S	WL	0.6	Fw, Ft
168	<i>Syzygium guineense</i> (Willd.) DC.	I	Myrtaceae	<i>Yumeta</i>	T	CFM	11.1	Fo,Fd,Bk,Fw,Ft,Sh, Ch, Co
169	<i>Teclea nobilis</i> Del.	I	Rutaceae	<i>Adera/</i>	S	WL/Hd	22.2	Bk,Ft,Lf, Tb, Md, Co, Fw
170	<i>Terminalia browni</i> Fresen	I	Combretaceae		T	WL	1.1	Fw,Ft
171	<i>T. brevipes</i> pampan	I	Combretaceae		T	HG	1.1	Sh, Or, Fw, Ft
172	<i>Trichilia dregeana</i> Sond	I	Meliaceae	<i>Dimut/Megaweta</i>	T	CFM	5	Sh, Fw, Ti, Fw, Bk
173	<i>Trichilia prieuriana</i> A. Juss	I	Meliaceae	<i>Beshinga</i>	T	CFM	8.9	Co, Fw, Lf
174	<i>Trichocladus ellipticus</i> Eckl. & Zeyh. Ex Sond	I	Hamamelidaceae	<i>Gomora</i>	T	HG	1.1	Bk, Co
175	<i>Urera hyposelodendron</i> (A. Rich.) Wedd.	I	Urticaceae	<i>Halila</i>	C/L	Hd	3.3	Bk, Lf

S.no	Botanical name	Origin	Family	Local Name	Habit	LU type	% freq.	Uses
176	<i>Uvaria angolensis</i> Oliv.	I	Annonaceae	Boyna	S	WL/Hd	2.2	Fo, Fe, Fw
177	<i>Uvaria leptocladon</i> Oliv.	I	Annonaceae	chechileta	S	Hd	2.2	Fw, Fo
178	<i>Vangueria volkensii</i> K. Schum.,	I	Rubiaceae	murxanqeta	S	WL	0.6	Bk
179	<i>Vernonia amygdalina</i> Del	I	Asteraceae	Heba'	T	CFM	33.3	Md, Fd, Fw, Sf, Ft, Lf, Ch
180	<i>Vernonia auriculifera</i> Hiern	I	Asteraceae	Reja/barawa	S	Hd	32.8	Md, Fw, Lf, Sf
181	<i>Vernonia bipontini</i> Vatke	I	Asteraceae	Hamaka	S	WL/Hd	17.2	Fw, Co, Bk
182	<i>Vernonia filigera</i> Olive & Heirn	I	Asteraceae	Hamaka	S	Hd	29.4	Md, Bk, Sf, Ch
183	<i>Vitex doniana</i> Sweet	I	Verbenaceae	Duli'chuta	T	CFM	6.1	Fo, Fw, Ch, Bk, Co, Ft
184	<i>Withania somnifera</i> (L.) Dunal	Ex	Solanaceae	Gizawa	S	HG	2.2	Md
185	<i>Ximenia americana</i> L.	I	Olacaceae	Hui'la	S	CFM	1.1	FW, Fo, Md, Fd, Bk, Lf, Ft
186	<i>Vepris dainellii</i> (Pichi-Serm.) Kokwaro	I	Rutaceae	Lala	S	WL		FW,

Key: Bk-bee keeping, Ch-Charcoal, Co-construction, Fd- fodder, Fw- firewood, Fo- food, Ft-farm tool & handle, Fu- Fumigant, Lf-live fence, Md-medicine, IR- Insect repellent, Po-poles for construction, Sf- soil fertility, Sh- Shade, and Tb-tooth brush.

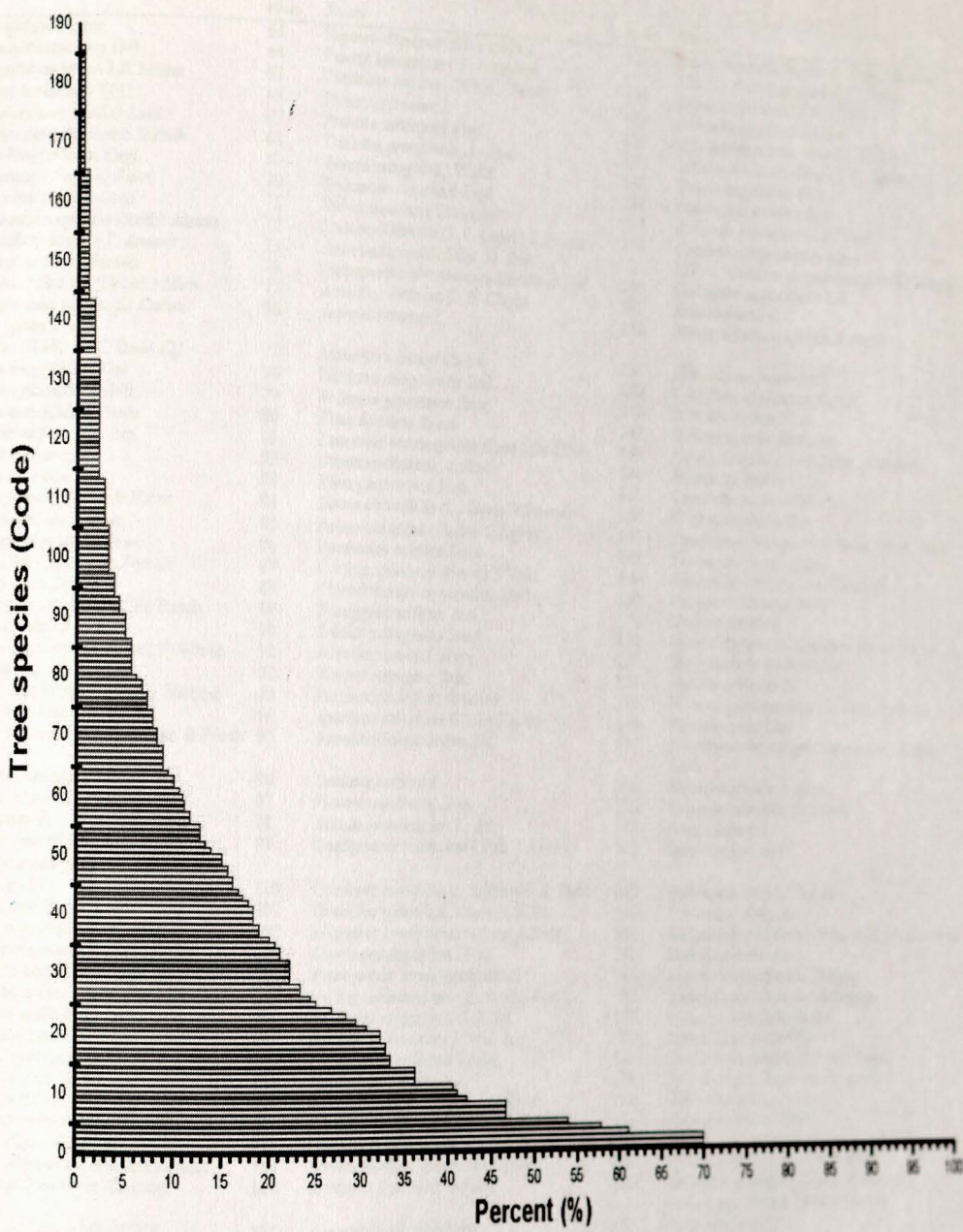
Habit: S = Shrub, T = Tree, T/S= tree/shrub, and WC= Woody Climbers/lianoids

Land Use types (LU type): Hd = Hedge, HG = Home garden, WL= Woodlot, WL/Hd = woodlot/Hedge, HG/WL= Homegarden/woodlot, CF = Crop field, and CFM= Crop field margin.

Appendix V. The number of Families, Genera and species of woody species in KT Zone.

Family	Genera	Species	%	Family	Genera	Species	%
Acanthaceae	2	3	1.6	Myrsinaceae	2	2	1.1
Anacardiaceae	3	4	2.2	Myrtaceae	3	6	3.2
Annonaceae	1	2	1.1	Nyctaginaceae	1	1	0.5
Apocynaceae	3	4	2.2	Olacaceae	2	2	1.1
Araliaceae	2	2	1.1	Oleaceae	3	4	2.2
Arecaceae	2	2	1.1	Oliniaceae	1	1	0.5
Asparagaceae	1	1	0.5	Phytolaccaceae	1	1	0.5
Asteraceae	2	6	3.2	Pinaceae	1	2	1.1
Balanitaceae	1	1	0.5	Pittosporaceae	1	2	1.1
Bignoniaceae	4	4	2.2	Poaceae	2	2	1.1
Boraginaceae	2	2	1.1	Podocarpaceae	1	1	0.5
Burseraceae	1	1	0.5	Polygalaceae	1	1	0.5
Capparidaceae	2	2	1.1	Proteaceae	3	3	1.6
Casuarinaceae	1	1	0.5	Rhamnaceae	3	3	1.6
Celestraceae	1	4	2.2	Rhizophoraceae	1	1	0.5
Combretaceae	2	5	2.7	Rosaceae	4	5	2.7
Cupressaceae	2	2	1.1	Rubiaceae	7	7	3.8
Dracaenaceae	1	1	0.5	Rutaceae	4	4	1.6
Ebenaceae	2	2	1.1	Salicaceae	2	2	1.1
Ericaceae	1	1	0.5	Santalaceae	1	1	0.5
Euphorbiaceae	8	14	7.5	Sapindaceae	3	3	1.6
Fabaceae	11	23	12.4	Sapotaceae	2	2	1.1
Flacourtiaceae	2	2	1.1	Schrophulariaceae	1	1	0.5
Hamamelidaceae	1	1	0.5	Simaroubaceae	1	1	0.5
Hypericaceae	1	2	1.1	Smilacaceae	1	1	0.5
Icacinaeae	1	1	0.5	Solanaceae	4	5	2.7
Lamiaceae	4	4	2.2	Sterculariaceae	1	1	0.5
Loganiaceae	2	2	1.1	Tiliaceae	1	2	1.1
Malvaceae	3	7	3.8	Ulmaceae	1	2	1.1
Meliaceae	3	4	2.2	Urticaceae	1	1	0.5
Meliantaceae	1	1	0.5	Verbenaceae	1	1	0.5
Moraceae	1	4	2.7				
Total			63		135	186	100

Appendix VI. Percent frequency of woody species in KT zone



Refer keys for tree/shrub species code on next page

Keys:

code	Name	code	Name	code	Name
1	<i>Cordia africana</i> Lam	63	<i>Saphum ellipticum</i> (Hochst) Pax	125	<i>Pouteria adolphi-friderici</i> (Engl.) Baillon
2	<i>Croton macrostachyus</i> Del.	64	<i>Pentas lanceolata</i> (Forssk) Deff.	126	<i>Protea giquad</i> J. F. Gmel
3	<i>Brucea antidysentrica</i> J.F. Miller	65	<i>Clauseria anistata</i> (Willd.) Benth.		<i>Senna singuana</i> (Del.) Lock
4	<i>Cupressus lucitanica</i> Mill.	66	<i>Ficus sycamoris</i> L.	127	<i>Sesbania quadrata</i> Gillen
5	<i>Senna petersiana</i> (Bolte) Lock	67	<i>Premna schimperi</i> Engl.	128	<i>Sida schimperiana</i> Hochst. Ex Rich
6	<i>Eucalyptus camaldulensis</i> Dehnh	68	<i>Trichilia prisurtiana</i> A. Juss	129	<i>Solanecio mannii</i> (Hook f.) C. Jeffrey
7	<i>Gouania longispicata</i> Engl.	69	<i>Acacia senegal</i> (L.) Willd.	130	<i>Uvaria angolensis</i> Oliv.
8	<i>Grewia tenax</i> (Forssk) Fiori	70	<i>Dracaena steudneri</i> Engl.	131	<i>Uvaria leptoclados</i> Oliv.
9	<i>Erythrina brucei</i> Schweinf.	71	<i>Rubus steudneri</i> Schweinf.	132	<i>Withania somnifera</i> (L.) Dunal
10	<i>Caesalpinia decapetala</i> (Roth) Alston	72	<i>Dombeya torrida</i> (J. F. Gmel.) P. Bamps	133	<i>Canthium oligocarpum</i> Hiern
11	<i>Justicia schimperiana</i> T. Anders	73	<i>Jacaranda mimosifolia</i> D. Don.	134	<i>Cestrum purpureum</i> (Lindl.) Standl.
12	<i>Bersama abyssinica</i> Fresen.	74	<i>Pittosporum abyssinicum</i> Hochst. ex Del.	135	<i>Dodonaea angustifolia</i> L.F
13	<i>Podocarpus falcatus</i> (Thunb.) Mirb.	75	<i>Acanthus eminens</i> C. B. Clarke	136	<i>Erica arborea</i> L.
14	<i>Prunus africana</i> (Hook. f.) Kalkm	76	<i>Jatropha curcas</i> L.	137	<i>Hibiscus berberidifolius</i> A. Rich
15	<i>Olea europaea</i> L. ssp.			138	<i>Hibiscus rosa-sinensis</i> L.
	<i>Cuspidate</i> (Wall. ex C. Don) Cif.	77	<i>Manilkara bunigi</i> Chiov.	139	<i>Schefflera abyssinica</i> Harms
16	<i>Vernonia amygdalina</i> Del.	78	<i>Hibiscus dongolensis</i> Del.	140	<i>Schreberia alata</i> Webb
17	<i>Eucalyptus globulus</i> Labill.	79	<i>Solanum giganteum</i> Jacq.	141	<i>Sida tenuicarpa</i> Vollsan
18	<i>Vernonia auriculifera</i> Hiern	80	<i>Vitex doniana</i> Sweet	142	<i>Vepris dainelli</i> (Pick.-Serm.) Kolwara
19	<i>Albizia gummifera</i> C.A. Sm.	81	<i>Leucaena leucocephala</i> (Lam.) De Wit.	143	<i>Boscia salicifolia</i> Olive
20	<i>Juniperus procera</i> L.	82	<i>Olinia rocheiana</i> A. Juss.	144	<i>Casuarina acutisensifolia</i> L.
21	<i>Solanum incanum</i> L.	83	<i>Rhus glutinosa</i> A. Rich	145	<i>C. gomphophylla</i> Bak.
22	<i>Vernonia filigera</i> Olive & Heim	84	<i>Senna obtusifolia</i> (L.) Irwin & Bameby	146	<i>Combretum adenogonum</i> Steud. Ex A. Rich.
23	<i>Maesa lanceolata</i> Forssk.	85	<i>Solanecio gigas</i> (Vatke) C. Jeffrey	147	<i>Euclea divinatorum</i> Hiern
24	<i>Ekebergia capensis</i> Sparrm.	86	<i>Spathodea nilotica</i> Seem	148	<i>Euphorbia candelabrum</i> Kotschy
25	<i>Pycnostachys abyssinica</i> Fresen	87	<i>Carissa spinarum</i> (Forssk.) Vahl.	149	<i>Fauria rocheiana</i> Serm
26	<i>Ehretia cymosa</i> Thonn.	88	<i>Clerodendrum myricoides</i> Vatke	150	<i>Halleria lucida</i> L.
27	<i>Acacia abyssinica</i> Hochst. Ex Benth	89	<i>Eucalyptus saligna</i> sam.	151	<i>Hymenodictyon floribundum</i> Robinson
28	<i>Pavetta abyssinica</i> Fresen	90	<i>Trichilia dregeana</i> Sond	152	<i>Hypericum revolutum</i> Vahl
29	<i>Diospyros abyssinica</i> (Heim) F. White	91	<i>Acanthus semiti</i> Chiov	153	<i>Myrsine africana</i> L.
30	<i>Euphorbia tirucalli</i> L.	92	<i>Blighia unijugata</i> Bak.	154	<i>Pavonia glechonifolia</i> (A. Rich.) Garcia
31	<i>Maytenus arbutifolia</i> (A. Rich.) Wileczek	93	<i>Psdrax parviflora</i> Bridson	155	<i>Pavonia urens</i> Cav.
32	<i>Teclea nobilis</i> Del.	94	<i>Apodytes dimidiata</i> E. Mey Ex Am.	156	<i>Philostigma thomningii</i> (Schumach.) Milne
33	<i>Datura arboreum</i> (Willd) Bercht. & Presl	95	<i>Jasminum abyssinicum</i> DC.	157	<i>Rodh.</i>
				158	<i>Rhamnus staddo</i> A. Rich
34	<i>Eucalyptus citriodora</i> Hook	96	<i>Lantana camara</i> L.	159	<i>Senna occidentalis</i> (L.) Link
35	<i>Euphorbia abyssinica</i> Pax	97	<i>Phoenix reclinata</i> Jacq.	160	<i>Smilax aspera</i> L.
36	<i>Arundo donax</i> L.	98	<i>Acacia melanoxylon</i> R. Br.	161	<i>Spartium junceum</i> L.
37	<i>Euphorbia cotinifolia</i> L.	99	<i>Cassipourea malosana</i> (Bak.) Alston		
38	<i>Senna didymobotrya</i> (Fresen.)			162	<i>Terminalia brownii</i> Fresen
	Irwin & Bameby	100	<i>Gardenia ternifolia</i> K. Schumach. & Thon	163	<i>T. brevipes</i> pampam
39	<i>Celtis africana</i> Burm. f.	101	<i>Grevillea robusta</i> A. Cunn. Ex R. Br.	164	<i>Trichoclada elliptica</i> Eckl. & Zeyh. Ex Sond
40	<i>Erythrina abyssinica</i> Lam. ex DC.	102	<i>Maytenus senegalensis</i> (Lam.) Exell	165	<i>Ximenia americana</i> L.
41	<i>Milletia ferruginea</i> (Hochst.) Baker	103	<i>Oxyris quadripartita</i> Decn.	166	<i>Acacia tortilis</i> (Forssk.) Bayne
42	<i>Arundinaria alpina</i> K. Schum.	104	<i>Pittosporum viridiflorum</i> Sims.	167	<i>Acokanthera schimperi</i> Schweinf.
43	<i>Vernonia bipontini</i> Vatke	105	<i>Urea hypselodendron</i> (A. Rich.) Wedd.	168	<i>Borassus aethiopicum</i> Mart.
44	<i>Combretum molle</i> G. Don	106	<i>Balanites aegyptiaca</i> (L.) Del.	169	<i>Boswellia pirotae</i> Chiov.
45	<i>Discopodium penninervium</i> Hochst.	107	<i>Bridelia scleroneura</i> Muell. Arg.	170	<i>Callistemon citrinus</i> (Curtis) Stapf
46	<i>Oxyanthus speciosus</i> DC.	108	<i>Combretum collinum</i> Fresen	171	<i>Delonix regia</i> (Bojer ex Hook.) Raf
47	<i>Acacia decurrens</i> Willd.	109	<i>Euphorbia compacta</i>	172	<i>Flacourtia indica</i> Merrill
48	<i>Melia azedarach</i> L.	110	<i>Olea welwitschii</i> Gilg. & Schellenb	173	<i>Grewia velutina</i> (Fork.) Vahl
49	<i>Dovyalis abyssinica</i> (A. Rich.) Warb.	111	<i>Phytolacca dodecandra</i> L. Herit.	174	<i>Helinus mystacinus</i> Steud
50	<i>Sesbania sesban</i> (L.) Merr.	112	<i>Rosa abyssinica</i> Lindley	175	<i>Hypericum quarantianum</i> A. Rich
51	<i>Allophylus abyssinica</i> (Hochst.) Radlk	113	<i>Stereospermum kunthianum</i> Cham	176	<i>Maytenus gracilipes</i> (Wels. Ex Oliv.)
52	<i>Euphorbia pulcherrima</i> Klotzsch.	114	<i>Acalypha fruticosa</i> Forssk.		Exell supp. <i>Arguta</i> (Loes) Seebibe
				177	<i>Pinus patula</i> L.
53	<i>Bougainvillea spectabilis</i> Willd.	115	<i>Asparagus africana</i> Lam.	178	<i>Pinus radiata</i> D. Don.
54	<i>Carissa edulis</i> (Vahl) Endl.	116	<i>Erythrococca tricogena</i> Prain	179	<i>Populus alba</i> L.
55	<i>Rosa x richardii</i> Rehd.	117	<i>Ficus vasta</i> Forssk.	180	<i>Rhus ruspoli</i> Engl.
56	<i>Bridelia micrantha</i> Baill	118	<i>Hagenia abyssinica</i> (Bruce) J. F. Gmel.	181	<i>Rickia albertii</i> Gilg
57	<i>Senna septemtrionalis</i> (Triv.) Irwin & Bameby	119	<i>Lanea welwitschii</i> (Hiern) Engl.	182	<i>Salix subcervata</i> Willd
58	<i>Ficus sur</i> Forssk.	120	<i>Linociera giordani</i> Chiov.	183	<i>Schinus molle</i> L.
59	<i>Syzygium guineense</i> (Willd.) DC.	121	<i>Macaranga capensis</i> (Baill.) Sim	184	<i>Securidaca longipedunculata</i> Fresen
60	<i>Ficus thonningii</i> Blume	122	<i>Maytenus arguta</i> (Loes) Robson	185	<i>Strychnos imbecilis</i> Del.
61	<i>Acacia seyal</i> Del.	123	<i>Nerium oleander</i> L.	186	<i>Vangueria volkensii</i> K. Schum.
62	<i>Buddleja polystachya</i> Fresen.	124	<i>Polyscia fulva</i> (Heim)		

Appendix VII. List of medicinal plants used by Kambatta Tembaro people: ailments treated, Botanical names, family names; Kambattissa/Tembarissa names, FL(Fidelity Level), Habit, Part used, Form used, methods of preparation, administration route and voucher number. ICF and the average preference rank of each medicinal plant were given in parenthesis following the ailment treated and scientific names, respectively. The highest number under ailment category indicates the best one. Abbreviations: Habit- H(Herb), T(tree), S (Shrub), P(perennial); Form used D (Dried), and F(Fresh).

a. Medicinal Plants list for human ailments Only

Scientific name	Family	Local names	FL	Habit	part used	Form used	Methods of preparation	Route	Ailment treated (ICF)	voucher no
<i>Acacia abyssinica</i> Hochst. ex Benth.	Fabaceae	Odooraa	33	T	Gum	D	Decocted, mixed with honey	Oral	Pertussis (Qakkita) (0.87)	313
<i>Acanthus sennii</i> Chiov.	Acanthaceae	Chocha	67	S	Shoots	F/D	Ashed, mixed with butter	Dermal	Eczema (wichiba)(0.88)	291
<i>Achyranthes aspera</i> L.	Amaranthaceae	Ambuta	20	H	Roots	F	Crushed, mixed with water, filtered	Oral	Abdominal complaints (0.90)	185
<i>Achyrospermum shimper</i> (Hochst ex Briq.) perkins	Lamiaceae	Zamzameta	67..	S	leaves	F	Crushed, mixed with water, filtered	Oral	Ascariasis (Hamas Xidatta) (0.93)	146
<i>Acmella caulirhiza</i> Del.(1)	Asteraceae	Bishibisha /Ka'losanchuta	73	H	Root & inflorescence	F	Chewed	Oral	Odontalgia (Inqqo Xiddata) (0.93)	9
	Asteraceae	Bishibisha	47	H	leaves	F	Squeezed	Oral	Emaciation (Middadiqqa) (0.95)	9
	Asteraceae	Bishibisha	33	H	Root & inflorescence	F	Chewed	Oral	Tonsillitis (qoqpera) (0.81)	9
	Asteraceae	Bishibisha	40	H	Leaves	F	Crushed	Dermal	Herpes zoster (qisona xidata) (0.92)	9
<i>Aframomum corrorima</i> (Braun) Jansen	Zingiberaceae	Wokash	100	H	Seeds	D	Chewed	Oral	Abdominal complaints (0.90)	314
	Zingiberaceae	Wokash	100	H	Seeds	D	Chewed with <i>Catha edulis</i>	Oral	Tonsillitis (qoqpera) (0.81)	314
<i>Ajuga integrifolia</i> D Don	Lamiaceae	Anamura	40	H	Leaves	F	Crushed along with <i>B. antidysentrica</i> , and mixed with water	Dermal	Evil eye (Manni ilita) (0.87)	142
	Lamiaceae	Anamura	100	H	Leaves	F	Concocted with <i>R. chalepensis</i> and <i>V. amygdalina</i>	Oral	Ascariasis (Hamas Xidatta) (0.93)	142
	Lamiaceae	Anamura	100	H	Leaves	D	Powdered, mixed with 'arake' or local ethanol	Oral	Rheumatism(allii ixuuu) (0.91)	142
<i>Albizia schimperiana</i> Oliv	Fabaceae	Ma'ta	67	T	Barks	F	Chewed with <i>P. abyssinicum</i>	Oral	Singultus (kushanata) (0.92)	47
	Fabaceae	Ma'ta	27	T	Barks	F	Concocted with <i>C. macrostachyus</i> , mixed with whey	Oral	Abdominal complaints (0.90)	47

<i>Allium porrum</i> L.	Aliaceae	Sunkutata	40	H	Bulbs	F	Chopped, milled and mixed with whey. Then, concocted with <i>R. abyssinicus</i> and <i>C. macrostachyus</i> .	Oral	Nephropathy (Muli Xidatta) (0.89)	335
<i>Allium sativum</i> L.	Aliaceae	Tuma	73	H	Bulbs	F	Crushed along with <i>A. porrum</i> , and mixed whey	Oral	Diarrhea (Muggitta) (0.88)	206
	Aliaceae	Tuma	60	H	Bulbs	F	crushed along with <i>A. porrum</i> L., mixed with whey, and filtered	Oral	Hypertension (0.81) (Qeegi mossu)	206
<i>Aloe spp</i>	Aloaceae	Goti Moquta	53		Leaves	F	Crushed, Squeezed		Cold (gid mo'ssu) (0.81)	317
<i>Amaranthus caudatus</i> L.	Amaranthaceae	Halibe	35	H	Seeds	D	powdered, mixed with coffee	Oral	Sunburn (Nifazuta) (0.93)	318
<i>Amaranthus dubius</i> Theil.	Amaranthaceae	Rasulta	33	H	Seeds	D	Powdered, mixed with coffee	Oral	Micha (siriais) (0.91)	310
<i>Anethum foeniculum</i> L.	Apiaceae	Wolenga	87	H	Roots	F	crushed, mixed with whey, and filtered.	Oral	Intestinal worms (Godebi huchcha) (0.91)	207
	Apiaceae	Wolenga	93	H	Roots	F	Crushed, mixed with water, filtered	Oral	Abdominal complaints (0.90)	207
<i>Artemisia absinthium</i> L.	Asteraceae	Aguffa/natra	27	H	leaves	F	chewed or powdered and drink with tea.	Oral	Hypertension (0.81) (Qeegi mossu)	147
	Asteraceae	Aguffa	53	H	leaves	F	crushed, rubbed	Dermal	Dandruff (Bulalimata) (0.93)	147
	Asteraceae	Aguffa/natra	53	H	Leaves	F/D	Concocted with <i>Ruta chalepensis</i>	Oral	Epilepsy (Zabberra) (0.86)	147
	Asteraceae	Aguffa/natra	87	H	Leaves	F	Decocted	Oral	Febrile (ibbaa) (0.92)	147
	Asteraceae	Aguffa/natra	67	H	leaves	F	Decocted, mixed with coffee	Oral	Cough (Ganshu) (0.93)	147
<i>Artemisia afra</i> Jacq. Ex Willd	Asteraceae	Artimsa, Natra	40	H	Leaves	D	powdered, decocted	Oral	Malaria (shekerita) (0.90)	256
<i>Asparagus africana</i> Lam.	Asparagaceae	serati	60	S	Roots	F	Crushed, Squeezed	Oral	Hemorrhoid (Kintarota) (0.87)	225
	Asparagaceae	serati	40	S	Roots	F/D	Ashed, mixed with butter	Dermal	Eczema (wichiba) (0.88)	225
	Asparagaceae	serati	73	S	Roots	F	Crushed, mixed with water, filtered	Oral	Atrophy (Banichu) (0.92)	225
	Asparagaceae	serati	80	S	Roots	F	Crushed, mixed with water, filtered	Oral	Breast pain (unuuni xidata) (0.92)	225
<i>Bersama abyssinica</i> Fresen.	Melanthaceae	Bitarssa	53	T	Buds	F	Concocted with seeds of <i>B. antidysenterica</i> and <i>B. abyssinica</i> .	Oral	Snake bite (wori karu) (0.88)	321
	Melanthaceae	Bitarssa	60	T	Buds	F	decocted mixed with <i>B. antidysenterica</i> seeds	Oral	Devil sickness (0.91)	321
<i>Bruccea antidysenterica</i> J F. Müller	Simaroubaceae	Daqetta	80	H	Leaves	F	Chewed	Oral	Abdominal complaints (0.90)	273
	Simaroubaceae	Daqetta	73	H	Leaves & seeds	F	Squeezed	Oral	Diarrhea (Muggitta) (0.88)	273
	Simaroubaceae	Daqetta	50	H	Leaves	F	Crushed, inhaled	Nasal	Evil eye (Manni ilita) (0.87)	273

<i>Centella</i>	Loganiaceae	Hanfarra	73	S	leaves	F	Decocted, buttered	Oral	Uterine pain (Uuna) (0.93)	322
<i>Budbalepa polytachya</i> Fresen	Asteraceae	Chua'	87	H	Roots	F	Crushed, mixed with water, filtered	Oral	Abdominal complaints (0.90)	227
<i>Carduus camaecephalus</i> (Vatke) Oliv. And Hiern	Asteraceae	Chua'	87	H	Roots	F	Powdered, mixed with coffee	Oral	Micha (siriais) (0.91)	227
<i>Carica papaya</i> L.	Caricaceae	Papaya	40	T	Leaves		powdered, decocted	Oral	Amoebiasis/Giardiasis (Emmema/Jarda) (0.88)	325
	Caricaceae	Papaya	73	T	Seeds	F/D	Chewed	Oral	Intestinal worms (Godebi huchcha) (0.91)	325
	Caricaceae	Papaya	27	T	Leaves	F	Decocted	Oral	Malaria (shekerita) (0.90)	325
	Caricaceae	Pappaaya	60	S	Fruits	F	Crushed	Oral	stomachache (Kuuchchaamnee Xidatta) (0.93)	325
<i>Carissa spinarum</i> L.	Apocynaceae	Atulla	27	S	Roots	F	Crushed, squeezed	Oral	Snake bite (wori karu) (0.88)	241
	Apocynaceae	Atulla	53	S	Roots	F	Crushed, mixed with water, filtered	Oral	Abdominal complaints (0.90)	241
<i>Ceropegia microgaster</i> M. G. G. Gilbert	Asclepiadaceae	Tudichu/gidi zebu	33	L(H)	Leaves	F	pounded, mixed with water	Oral & Dermal	Cold (gid mo'ssu) (0.81)	135
<i>Chenopodium ambrsioides</i> L.	Chenopodiaceae	Gonsidida	53	H	Leaves	F	Squeezed	Oral	Odontalgia	98
	Chenopodiaceae	Gonsidida	40	H	Leaves	F	Squeezed	Optical	Eye ache (ille xiddata) (0.90)	98
<i>Citrus aurantifolia</i> (Christm) Swingle	Rutaceae	Lomita	93	T	Fruits	F	Chewed	Oral	Cough (Ganshu) (0.93)	
<i>Clausena onisata</i> (Willd.) Benth.	Rutaceae	Bayxaqqa	47	S	leaves	F	Crushed, mixed with water, filtered	Oral	Pertussis (Qakkita) (0.87)	330
	Rutaceae	Bayxaqqa	73	S	leaves	F	Crushed, squeezed	Oral	Sunburn (Nifazuta) (0.93)	330
	Rutaceae	Gembaleka/B ayxaqqa	80	S	leaves	F	Concocted with Ocimum lamiifolium, and buttered.	Oral	Ascariasis (Hamas Xidatta) (0.93)	330
	Rutaceae	Gembaleka/B ayxaqqa	93	S	Buds	F	mixed with C. anistata, V. amygdalina, & E. tef	Oral	Rheumatism(allii icxuu) (0.91)	330
	Rutaceae	Gembaleka/B ayxaqqa	80	S	Leaves	F	Crushed, mixed with water, filtered	Oral	Evil eye (Manni iliita) (0.87)	330
<i>Clematis longicauda</i> Steud. ex A. Rich.	Ranunculaceae	Shishuta	20	L(H)	Roots	F	Salted, chewed	Oral	Odontalgia	92
	Ranunculaceae	Shishuta	27	L(H)	Roots	F	Chewed with salt	Oral	Tonsillitis (qoqquera) (0.81)	92
<i>Clusia abyssinica</i> Jaub. & Spach.	Euphorbiaceae	shumtigesha	60	S	Leaves	F	Squeezed	Dermal	Eczema (wichiba)(0.88)	333
	Euphorbiaceae	shumtigesha/Hurumassa	25	S	Roots	F	Mixed with L. stachydiformis, squeezed.	Oral	Rheumatism(allii icxuu) (0.91)	333
<i>Coffea arabica</i> L.	Rubiaceae	Buna	67	T/S	Seeds	D	Roasted, powdered	Dermal	Bleeding (Cut) (0.90)	247
	Rubiaceae	Buna	80	T/S	Seeds	D	Roasted, powdered, mixed with A. sativum	Oral	Diarrhea (Muggitta) (0.88)	247
	Rubiaceae	Buna	75	T/S	Seeds	D	Roasted, powdered, mixed with coffee & buttered	Dermal	Eczema (wichiba)(0.88)	247
<i>Commelina benghalensis</i> L.	Commelinaceae	Laaluncha	80	H	Latex	F	Exudate collected	Dermal	Vitiligo (Becharut) (0.94)	334
<i>Conyza achampuri</i> Sch. Bip. Ex A. Rich.	Asteraceae	Natra	73	H	Shoots	F/D	Crushed, mixed with whey, filtered	Oral & dermal	Evil eye (Manni iliita) (0.87)	88

<i>Coriandrum sativum</i>	Apiaceae	wodimamu	100	H	Inflorescence	F/D	Chewed	Oral	Abdominal complaints (0.90)	308
<i>Coronopus didymus</i> (L.) Smith	Brassicaceae	faranji sunfa	100	H	Leaves	F	Chewed	Oral	Abdominal complaints (0.90)	166
<i>Crotalaria incana</i> L.	Fabaceae	Chachayena	47	H	Roots	F	Crushed	Oral	Diarrhea (Muggitta) (0.88)	
<i>Crotalaria plowdenii</i> Bak.	Fabaceae	Chachayena	47	H	Shoots	F	Crushed, mixed with water	Dermal	Jaundice /Gaqichi mossu (0.88)	301
<i>Croton macrostachyus</i> Del.	Euphorbiaceae	mesana	53	T	buds	F	sap smeared on	Dermal	Vitiligo (Becharut) (0.94)	49
	Euphorbiaceae	mesana	93	T	Roots	F	Crushed, mixed with water, filtered	Oral	Obesity	316
	Euphorbiaceae	Mesana	93	T	Sap	F	Exudated	Dermal	Bleeding (Cut) (0.90)	49
	Euphorbiaceae	Mesana	100	T	Barks	D/F	mixed with A. sativum, N. sativa, R. chalepensis, and whey	Oral	Intestinal worms (Godebi huchcha) (0.91)	49
	Euphorbiaceae	mesana	87	T	Leaves	F	Crushed, squeezed	Oral	Snake bite (wori karu) (0.88)	49
<i>Cucumis melo</i> L.	Cucurbitaceae		27	L(H)	Fruits	F	Decocted	Oral	Nephropathy (Muli Xidatta) (0.89)	335
<i>Cucurbita pepa</i> L.	Cucurbitaceae	Dabaqula	27	H	Fruits	D	mixed with whey	Oral	Nephropathy (Muli Xidatta) (0.89)	336
<i>Cupressus lusitanica</i> Mill.	Cupressaceae	Faranji Homa	67	T	Leaves	F	Squeezed	Oral	Typhoid (Taayfoodaa) (0.95)	337
<i>Cymbopogon citratus</i> (DC.) Stapf.	poaceae	Hitichuta	27	H	leaves	F	Crushed, squeezed	Oral	Hypertension (0.81) (Qeegi mossu)	338
	poaceae	Hitichu	87	G	Roots	F	Crushed, mixed with whey, filtered	Oral	Abortifacient (Fo'oli fa-issi) (0.92)	338
<i>Cynodon dactylon</i> L.	Poaceae	Qorixxu/haruffa	60	G	whole plant	F	Crushed, squeezed	Dermal	Snake bite (wori karu) (0.88)	339
<i>Cynoglossum coeruleum</i> Steud. ex DC.	Boraginaceae	Kacheba/Baxxaturssa	67	H	Leaves	F	Heated, squeezed	Dermal	Hemorrhoid (Kintarota) (0.87)	165
<i>Cyperus fischerianus</i> A. Rich.	Cyperaceae	Na'qqa	93	H	Roots	F	Chewed	Oral	Dingategna (Sudden sickness) (0.91)	141
<i>Datura stramonium</i> L.	Solanaceae	Machareqqa	100	H	Leaves	F	Crushed, Squeezed	Oral	Dog bite	339
	Solanaceae	Machareqqa	80	H	Seeds	D	burnt for smoke bath	Oral	Odontalgia	339
<i>Dichrocephala integrifolia</i> (L.f.O) Kuntze	Asteraceae	Higme	33	H	Inflorescence	F	Squeezed, rubbed on	Dermal	Hemorrhoid (Kintarota) (0.87)	74
<i>Dodonaea angustifolia</i> L.F.	Sapindaceae	kitkita	47	S	Leaves	D	Powdered with H. abyssinica, mixed with water	Oral	Intestinal worms (Godebi huchcha) (0.91)	41/02
<i>Dovyalis abyssinica</i> (A. Rich.) Warb	Flacourtiaceae	Koshima	73	S	Leaves	F	Chewed	Oral	Tonsillitis (qoqpera) (0.81)	343
<i>Echinops kebericho</i> Mesfin	Asteraceae	Tossa	60	H	Roots	F/D	Concocted with 'bulla'	Oral	Abortifacient (Fo'oli fa-issi) (0.92)	205
	Asteraceae	Tossa	73	H	Roots	F	Squeezed	Nasal	Epilepsy (Zabbera) (0.86)	205
	Asteraceae	Tossa	53	H	Roots	F	Crushed, squeezed	Nasal	Epistaxis (Sangguga) (0.78)	205
	Asteraceae	Tossa	73	H	Roots	F/D	Concocted with 'bulla' keeping small twigs of the root inside somebody's pocket	Oral	Atrophy (Banichu) (0.92)	205
	Asteraceae	Tossa		H	Roots	F/D		external	Devil sickness (0.91)	205

<i>Echinops kebericho</i> Mesfin	Asteraceae	To'ossa	53	H	Roots	F/D	Chewed	Oral	Dingategna (Sudden sickness) (0.91)	205
	Asteraceae	Tossa	67	H	Roots	F	Chewed	Oral	Tonsillitis (qoqqera) (0.81)	205
<i>Elusine coracana</i> (L.) Gaertn.	Poaceae	Fagajit	73	H	Seeds	D	Decocted, mixed with butter	Oral	bone setting (Bixxamo ali) (0.83)	320
<i>Ekebergia capensis</i> Sparrm	Meliaceae	Olonchuta	93	T	Barks	F	mixed with A. africana, held in mouth	Oral	Odontalgia	377
Ensete ventricosum (Welw) Cheesman	Musaceae	Wesse	87	H (P)	Corm	F	Chopped	Oral	Abortifacient (Fo'oli fa-issi) (0.92)	244
	Musaceae	wesse	80	H (P)	root & pseudostem	F	Powdered, heated, spiced	Oral	Amoebiasis/Giardiasis (Emmema/Jarda) (0.88)	244
	Musaceae	Helagana/Oniya	80	H (P)	Sap / pseudostem	F	Squeezed	Dermal	Tinea corporis (Ulamaaha) (0.94)	244
<i>Eucalyptus globulus</i> Labill.	Myrtaceae	Waju barzafa	73	T	Leaves & seeds	F/D	Decocted for steam bath	Oral & Nasal	Epilepsy (Zabbera) (0.86)	346
	Myrtaceae	wojjuu baarzaffa	87	T	Leaves & seeds	F/D	Decocted, steam inhaled	Oral & Nasal	Cough (Ganshu) (0.93)	344
<i>Euphorbia dumalis</i> S. Carter	Euphorbiaceae	Gendele'illata	67	H	whole plant	F	Concocted with C. macrostachyus	Oral & Dermal	Anorexia (kurma) (0.93)	347
<i>Euphorbia tirucalli</i> L.	Euphorbiaceae	Hinchibeta/Ch arata	40	S	Latex	F	latex is mixed with squeezed coffee leaves	Dermal	Hemorrhoid (Kintarota) (0.87)	245
<i>Faurea rochetiana</i> Serm	Proteaceae	Futeta	27	T	leaves	F	Chewed	Dermal	Snake bite (wori karu) (0.88)	31
<i>Girardinia bulbosa</i> Wedd	Urticaceae	Dobita	27	S	Roots	F	Squeezed	Oral	Singultus (kushanata) (0.92)	72
<i>Gloriosa superba</i> L.	Liliaceae	Sidita	27	H	Roots	F	Chewed	Oral	Abdominal complaints (0.90)	196
<i>Guizotia scabra</i> (Vis.) Chiov.	Asteraceae	Shesha-a		H	leaves	F	Squeezed	Dermal	wound /cut(Maazatta) (0.91)	348
<i>Hagenia abyssinica</i> (Bruce) J. F. Gmel.	Rosaceae	Xenchuta	100	T	Inflorescence	D	Powdered with Dodonaea angustifolia, mixed with water	Oral	Intestinal worms (Godebi huchcha) (0.91)	376
<i>Helianthus annuus</i> L.	Asteraceae	Nuga	73	H	Seeds	D	powdered, mixed with tea	Oral	Anorexia (kurma) (0.93)	251
<i>Hordeum vulgare</i> L.	Poaceae	Soa'	60	G	Seeds	D	powdered, mixed with Pavonia urens root filerate, concocted	Oral	Cold (gid mo'ssu) (0.81)	349
<i>Hypericum peplidifolium</i>	Hypericaceae	Wosha babbaru		H	Roots	F	Chewed	Oral	Pertussis (Qakkita) (0.87)	
<i>Hypericum revolutum</i> Vahl	Guttiferae	Wobexi haqqa		S	Leaves	F	Squeezed, mixed with water	dermal	Washing woman after delivery S leaves F Squeezed, mixed with water Dermal	381
<i>Hypoestes forsskaolii</i> (Vahl) R. Br.	Acanthaceae	Omorutta	93	H	Leaves	F	Squeezed, dropped	Auricular	Ear ache (Mecha xiddata) (0.94)	3
	Acanthaceae	Omorutta	100	H	Leaves	F	Crushed, squeezed	Oral	Sunburn (Nifazuta) (0.93)	3
	Acanthaceae	Omorutta	80	H	Leaves	F	Squeezed	Nasal	Cough (Ganahu) (0.93)	3
	Acanthaceae	Omorutta	100	H	Leaves	F	Squeezed	Optical	Eye ache (ille xiddata) (0.90)	3
	Acanthaceae	Omorutta	100	H	Leaves	F	squeezed	Nasal	Febrile (ibbaa) (0.92)	3
	Acanthaceae	Omorutta	100	H	Leaves	F	Squeezed	Nasal	Mecha (sirias) (0.91)	3

<i>Hyposestes forskaholii</i> (Vahl) R. Seh	Acanthaceae	Umbaata	23	H	Leaves	F	Squeezed	Oral	Jaundice / Gaqichi mossu (0.88)	135
<i>Indigofera schimperii</i> Jaub. & Spach var. <i>schimperii</i>	Fabaceae		47	S	Leaves	D	powdered	Dermal	Eczema (wichiba) (0.88)	298
<i>Jasminum abyssinicum</i> Hochst. ex DC.	Oleaceae	Hagichu (Toshichu)	40	L	Shoots	D	Powdered	Dermal	Eczema (wichiba) (0.88)	161
	Oleaceae	Hagichu, Toshichu	47	L	Leaves	F	Crushed, inhaled	Nasal	Epilepsy (Zabbera) (0.86)	161
<i>Juniperus procera</i> Hochst (	Cupressaceae	Abash Homa	80	T	leaves	F	Decocted	Oral	Typhoid (Taayfoodaa) (0.95)	287
	Cupressaceae	Abash Homa	73	T	leaves	F	Decocted	Oral	Uterine pain (Uuna) (0.93)	287
	Cupressaceae	Abash Homa	93	T	Barks	F	Chewed	Oral	Tonsillitis (qoqgera) (0.81)	287
<i>Justitia schimperana</i> (Hochst ex Nees) T. Anders	Acanthaceae	Gulbanna	13	S	Leaves	F	Chewed	Oral	Abdominal complaints (0.90)	243
	Acanthaceae	Gulbanna	33	S	Leaves	F	Squeezed	Oral	Jaundice /Gaqichi mossu (0.88)	243
	Acanthaceae	Gulbanna	33	S	Leaves	F	Crushed, mixed with water, squeezed	Oral	Malaria (shekerita) (0.90)	243
	Acanthaceae	Gulbanna	80	S	Buds	F	Crushed, squeezed, mixed with milk	Oral	Rabies (Woshaa mossuu)	243
<i>Kalanchoe petitiiana</i> A. Rich	Crassulaceae	Hanchura	73	H	Seeds	D	Roasted, powdered	Oral & Dermal	labour facilitation	289
	Crassulaceae	Hanchura	87	S	leaves	F	warmed, touched with	Dermal	Rheumatism (allii ixuu) (0.91)	289
<i>Kniphofia foliosa</i> Hochst.	Asphodelaceae	Onshololuta/ula Tuma	27	H	Roots	F	Decocted	Oral	Pertussis (Qakkita) (0.87)	69
	Asphodelaceae	Ula Tuma		H	Roots	F	Decocted, buttered	Oral	Goiter	69
<i>Lepidium sativum</i> L.	Brassicaceae	sunfa	33	H	Seeds	D	Roasted, powdered, mixed with coffee	Oral	Pertussis (Qakkita) (0.87)	234
	Brassicaceae	Sunfa	60	H	Seeds	D	Roasted, powdered, mixed with coffee	Oral	Sunburn (Nifazuta) (0.93)	234
	Brassicaceae	sunfa /feto	93	H	Seeds	D	Roasted, powdered & mixed with coffe	Oral	Abdominal complaints (0.90)	234
	Brassicaceae	Sunfa	87	H	Seeds	D	Powdered, mixed with coffee	Oral	Heart failure	234
	Brassicaceae	sunfa /feto	87	H	Seeds	F	Roasted, Powdered, mixed with coffee	Oral	Micha (siriais) (0.91)	120
<i>Leucas Calostachys</i> Oliv	Lamiaceae	Qibbatora	47	H	Leaves	F	Decocted	Oral	Abdominal comp,aints (0.90)	186
<i>Leucas stachydiformis</i> (Hochst. ex Benth.) Briq	Lamiaceae	Xinbebela/kibato ra	67	H (P)	Leaves	F	Decocted for steam bath	external	Eye ache (ille xiddata) (0.90)	13
	Lamiaceae	Xinbebela/kibato ra	87	H (P)	Leaves	F/D	Decocted	Oral	Abdominal comp,aints (0.90)	13
	Lamiaceae	Xinbebela/kibato ra	87	H (P)	Leaves	F	Decocted	Oral	Ascariasis (Hamas Xidatta) (0.93)	13
<i>Linum catharticum</i> L.	Linaceae	Talbu	27	H	Seeds	D	Decocted (uncrushed seeds)	Oral	Breast pain (unusu xidata) (0.92)	248

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<i>Linum usitatissimum</i> L.	Linaceae	Talba	100	H	Seeds	D	Decocted	Oral	stomachache (Kuuchchaammee Xidatta) (0.93)	248
	Linaceae	Talba	100	H	Seeds	D	Decocted	Oral	Constipation (Godabii mollimatta) (0.90)	248
	Linaceae	Talba		H	Seeds	D	Decocted	Oral	Uterine pain (Uuna) (0.93)	248
	Linaceae	Talba	87	H	Seeds	D	Decocted (uncrushed seeds)	Oral	Amoebiasis/Giardiasis (Emmema/Jarda) (0.88)	248
<i>Lysimachia ruhmeriana</i> Vatke (4)	Primulaceae	Wosha bashinga	80	H	Roots	F	Chewed	Oral	Cough (Ganshu) (0.93)	2
<i>Lysimachia ruhmeriana</i> Vatke	Primulaceae	Wosha bashinga	67	H	Roots	F	Crushed, squeezed	Oral	Tonsillitis (qoqpera) (0.81)	2
<i>Melia azedarach</i> L.	Meliaceae	Milla	27	T	Barks	F	Crushed, mixed with water, filtered	Oral	Intestinal worms (Godebi huchcha) (0.91)	290
<i>Mentha spicata</i> L.	Lamiaceae	Naanna	47	H	Leaves	F	concocted along with C. edulis & C. limon	Oral	Hypertension (0.81) (Qeegi mossu)	350
<i>Mikaniopsis clematoides</i> (A.Rich) M.Redh.	Asteraceae	Bukukuta	60	L(H)	Roots	F	salted & chewd		Glandular disease (kichuta) (0.89)	303
<i>Milletia ferruginea</i> (Hochst.) Bak.	Fabaceae	Hengezena/Bil ewi haga	47	T	Barks	F	Decocted, mixed with butter	Oral	Pertussis (Qakkita) (0.87)	
<i>Momordica foetida</i> Schumach.	Cucurbitaceae	Wori rebuta	27	L(H)	Buds	F	Squeezed	Oral	Tonsillitis (qoqpera) (0.81)	1
	Cucurbitaceae	Wori rebuta	47	L(H)	Leaves	D	Powdered	Dermal	wound /cut(Maazatta) (0.91)	1
	Cucurbitaceae	Wori rebuta	60	L(H)	Roots	F	Concocted with Momordica foetida & Justicia shimperian	Oral	Atrophy (Banichu) (0.92)	1
	Cucurbitaceae	Wori rebuta	47	L(H)	Shoots	F	Crushed, squeezed	Dermal	Herpes zoster (qisona xidata) (0.92)	1
<i>Monopsis stellariodes</i> (Presl) Urb.	Lobeliaceae	Dukuchita	87	H	Leaves	F	Squeezed, dropped	Auricular	Ear ache (Mecha xiddata) (0.94)	299
<i>Nicotiana tabacum</i> L.	Solanaceae	Tumbe-oo	93	H	leaves	F	concocted with buds of B. antidyentrica & C. macrostachyus, salted	Oral	Herpes zoster (qisona xidata) (0.92)	207
<i>Nigella sativa</i> L.	Ranunculaceae	Gambelata Xagutta	100	H	Seeds	D	Powdered, mixed with water	Oral	Abdominal complaints (0.90)	239
	Ranunculaceae	Gambelata Xagutta	100	H	Seeds	D	Powdered, mixed with honey & butter, fermented	Oral	Cough (Ganshu) (0.93)	239
<i>Ocimum urticifolium</i> Roth S Lat	Lamiaceae	xu-muuta/ Barxcula/Mic-hi Zebuu	53	S	shoots	F	Decocted	Oral	Febrile (ibbaa) (0.92)	120
	Lamiaceae	xu-muuta	53	S	whole plant	F	Squeezed	Nasal	Micha (siriais) (0.91)	352
	Lamiaceae	xu-muuta	47	S	Leaves	F	Squeezed	Oral	Abdominal complaints (0.90)	120
<i>Ocimum lamifolium</i> Hochst. Ex Benth.	Lamiaceae	Minatofa	100	H	leaves	F	Squeezed	Nasal	Headache (Boqgo xidata) (0.92)	352
	Lamiaceae	Minatofa	87	H	leaves	F	Decocted	Oral	Febrile (ibbaa) (0.92)	352
	Lamiaceae	Minatofa	93	H	leaves	F	Squeezed	Nasal	Micha (siriais) (0.91)	191

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<i>Olea europaea</i> L. ssp. <i>cuspidata</i> (Wall. ex DC.) Cifferri	Oleaceae	Weirra	80	T	Leaves	F	decocted with Clausena anistata and Premna schimperii	Oral	Odontalgia	353
<i>Olinia rochetiana</i> A. Juss.	Oliniaceae	shoo'emolutta	47	S	Barks	F	Pounded, decocted	Oral	Pertussis (Qakkita) (0.87)	131
	Oliniaceae	shoo'emolutta	27	S	Barks	F	Decocted, held in mouth	Oral	Odontalgia	131
	Oliniaceae	shoo'emolutta	20	S	Barks	F	Decocted	Oral	Abdominal complaints (0.90)	131
	Oliniaceae	sho'emolutta	60	S	buds	F	Decocted	Optical	Eye ache (ille xiddata) (0.90)	131
<i>Oncocalyx glabratus</i> (Engl.) M. Gilbert	Loranthaceae	chati kurumu	67	S	Shoots	F	Crush along A. porrum, mix with "Tella"	Oral	Gonorrhea	354
<i>Orthosiphon suffrutescens</i> J. K	Lamiaceae	Anganbisha	80	H (P)	Leaves	F	Squeezed	Nasal	Micha (siriais) (0.91)	89
<i>Osyris quadripartita</i> Decne	Santalaceae	Ka'arruta	33	S	Barks	F	Decocted	Oral	Jaundice /Gaqichi mossu (0.88)	355
<i>Oxalis corniculata</i> L.	Oxalidaceae	Shimale /Chichile	27	H	Shoots	F	Squeezed	Dermal	Eczema (wichiba)(0.88)	170
	Oxalidaceae	Shimale	40	H	Shoots	F	Squeezed	Dermal	Scabies (Hangaruu) (0.75)	170
	Oxalidaceae	Shimale	27	H	Shoots	F	Heated, squeezed	Dermal	Hemorrhoid (Kintarota) (0.87)	170
	Oxalidaceae	Shimale	47	H	Roots	F	Squeezed	Oral	Sore throat (Samanga) (0.90)	170
	Oxalidaceae	Shimale	27	H	Shoots	F	Squeezed	Dermal	wound /cut(Maazatta) (0.91)	170
	Oxalidaceae	Shimale	87	H	leaves	F	Squeezed	Oral	Tonsillitis (qoqera) (0.81)	170
<i>Pavetta abyssinica</i> Fresen	Rubiaceae	Fugi Miqichuta	27	S	Buds and Seeds	F	squeezed	Nasal	Epilepsy (Zabbera) (0.86)	253
	Rubiaceae	Miqichuta	40	S	Leaves	F	Crushed, squeezed	Nasal	Epistaxis (Sangguga) (0.78)	253
	Rubiaceae	Miqichuta	73	S	Seeds	D	Powdered, decocted	Oral	Malaria (shekerita) (0.90)	253
	Rubiaceae	Miqichuta	53	S	Buds & Seeds	D	Powdered, mixed with water	Oral & Dermal	Evil eye (Manni iliita) (0.87)	253
	Rubiaceae	Miqichuta	60	S	Buds and Seeds	F	Powdered, mixed with water	Oral & Dermal	Rheumatism(allii ixuu) (0.91)	253
<i>Pavonia urens</i> cav	Malvaceae	Merqeqena/ Kurmi zebbu	53	H	Roots	F	Crushed, mixed with water, filtered	Oral	Abdominal complaints (0.90)	206
	Malvaceae	Merqeqena	66	H	Roots	F	Crushed, mixed with water, filtered	Oral	Constipation (Godabii mollimatta) (0.90)	206
<i>Persicaria senegalensis</i> (Meisn) Sojak Preslia	Polygoniaceae	Olaqaa	27	H	whole plant	F	Crushed, decocted mixed with H. vulgare	Oral	Abortifacient (Fo'oli fa-issi) (0.92)	294
<i>Phaseolus vulgaris</i> L.	Fabaceae	Wokitta (Gambelata)	80	H		D	decocted	Oral	Jaundice /Gaqichi mossu (0.88)	356
<i>Phytolacca dodecandra</i> L. Herit.	Phytolaccaceae	Harraanja	60	S	Roots	F	Squeezed	Dermal	Scabies (Hangaruu) (0.75)	357
<i>Piper capense</i> L.	Piperaceae	Ximzi	47	H	Fruits	F	Concocted with Capsicum annum	Oral	Sore throat (Samanga) (0.90)	173

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<i>Plantago africana</i> Verdc.	Plantaginaceae	Boqqe	53	H	Roots	F	Chewed	Oral	Sore throat (Samanga) (0.90)	359
<i>Plantago lanceolata</i> L.	Plantaginaceae	Boqqe	27	H	whole plant	F	heated, squeezed & mixed with salt	Dermal	Hemorrhoid (Kintarota) (0.87)	360
	Plantaginaceae	Boqqe	47	H	Roots	F	Chewed	Oral	Tonsillitis (qoqpera) (0.81)	360
	Plantaginaceae	Boqqe	27	H	whole plant	F	Squeezed, buttered	Nasal & dermal	Jaundice /Gaqichi mossu (0.88)	360
<i>Plectranthus punctatus</i> subsp. <i>edulis</i> (Vatke) Morton	Lamiaceae	Sheshe dinikata	67	H	Leaves	F	Crushed, Squeezed	Oral	Malaria (shekerita) (0.90)	297
<i>Podocarpus falcatus</i> (Thunb.) Mirb.	Podocarpaceae	Zagib aqomaada	80	T	Gum	D	decocted	Oral	Pertussis (Qakkita) (0.87)	361
	Podocarpaceae	Zagib aqommada	53	T	Gum	D	Decocted	Oral	Anorexia (kurma) (0.93)	361
	Podocarpaceae	Zagba	67	T	Gum	D	decocted	Dermal	Atrophy (Banichu) (0.92)	361
	Podocarpaceae	Zagibba	53	T	Gum	D	Decocted	Dermal	Eczema (wichiba) (0.88)	
<i>Premna schimperi</i> Engl.	Lamiaceae	Xoxxanqetta	47	T	Leaves	F	Decocted for steam bath	Dermal	Eye ache (ille xiddata) (0.90)	99/02
<i>Prunus africana</i> (Hook. f.) Kalkm	Rosaceae	Gerbbaa	73	H	Barks	F	Decocted	Oral	Nephropathy (Muli Xidatta) (0.89)	101/02
<i>Punica granatum</i> L.	Punicaceae	Romana	27	S	Seeds	D	powered, mixed with the leaf squeezes of <i>O. grandisimum</i> & <i>Hypoestes forskaolii</i>	Optical	Eye ache (ille xiddata) (0.90)	375
Pycnostachys abyssinica Fresen	Lamiaceae	Tontona	67	S	whole plant	F	Crushed, mixed with water, filtered	Oral	Antiemetic (ho'itta)	176
	Lamiaceae	Tontonna	80	S	whole plant	F	Smoked	External	Cholera	176
	Lamiaceae	Tontonna	87	S	Leaves	F	Crushed, mixed with water	External	Insectifuge	176
	Lamiaceae	Tontona	73	S	Leaves	F	concocted with <i>P. abyssinica</i> , <i>V. amygdalina</i> & <i>L. stachydiformis</i>	Oral	Ascariasis (Hamas Xidatta) (0.93)	176
	Lamiaceae	Tontonna	87	S	Roots	F	Crushed, Squeezed	Oral	Malaria (shekerita) (0.90)	176
	Lamiaceae	Tontona	67	S	Leaves	F	Squeezed	Oral	Micha (siriais) (0.91)	29
	Lamiaceae	Tontona	73	S	Leaves	F	Concocted, mixed with <i>V. amygdalina</i> & <i>Leucas stachydiformis</i>	Oral	Diarrhea (Muggitta) (0.88)	176
	Lamiaceae	Tontonna	87	S	Leaves	F	Squeezed	Optical	Eye ache (ille xiddata) (0.90)	176
	Lamiaceae	Tontona	60	S	Leaves	F	Decocted, salted	Oral	Abdominal complaints (0.90)	176
<i>Ranunculus murifidus</i> Forssk.	Ranunculaceae	Anshichuta'	47	H	Leaves	F	Squeezed	Dermal	Glandular disease (kichuta) (0.89)	17
	Ranunculaceae	Anshichuta'	67	H	Shoots	D	Roasted, powdered, and buttered	Dermal	Eczema (wichiba) (0.88)	17

Contd....

<i>Rubia cordifolia</i> L.	Rubiaceae	Ha'ruta	67	L/H	Roots	F	Crushed, mixed with water, squeezed	Oral	Micha (siriais) (0.91)	364
<i>Rumex abyssinicus</i> Jacq.	Polygoniaceae	Shishonda	60	H	Roots	F	Crushed, mixed with water, filtered	Oral	Nephropathy (Muli Xidatta) (0.89)	362
	Polygoniaceae	Shishonda	73	H	Roots	F	Crushed, mixed with water, filtered	Oral	Jaundice /Gaqichi mossu (0.88)	362
<i>Rumex nepalensis</i> Spreng	Polygoniaceae	Kashala Go'echu	73	H	Roots	F	Crushed	dermal	Dandruff (Bulalimata) (0.93)	18
	Polygoniaceae	Kashala Go'echu	73	H	Roots	F	Crushed, mixed with water, filtered	Oral	Anorexia (kurma) (0.93)	18
	Polygoniaceae	Kashala Go'echu	93	H	whole plant	F	Decocted & buttered.	Dermal	Hemorrhoid (Kintarota) (0.87)	18
	Polygoniaceae	Kashala Go'echu	73	H	Roots	F	Concocted, mixed with <i>R. nepalensis</i> and <i>Carduus camaecephalus</i>	Dermal	wound /cut (Maazatta) (0.91)	18
	Polygoniaceae	Kashala Go'echu	87	H	whole plant	F	Crushed, mixed with water, filtered	Oral	Nephropathy (Muli Xidatta) (0.89)	18
	Polygoniaceae	Kashala Go'echu	87	H	Roots	F	Chewed	Oral	Tonsillitis (qoqpera) (0.81)	18
<i>Ruta chalepensis</i> L.	Rutaceae	Xelachuta	100	S	Leaves	F	Crushed, inhaled	Nasal	Evil eye (Manni iliita) (0.87)	250
	Rutaceae	Xalachuta	80	H	Leaves	F	Decocted	Oral	Febrile (ibbaa) (0.92)	250
	Rutaceae	Xalachuta	100	H	leaves	F	Chewed	Oral	Abdominal complaints (0.90)	250
<i>Saccharum officinarum</i> L.	Poaceae	Shonkora	53	G	Stems	F	chewd	Oral	Gastritis	363
<i>Salvia nilotica</i> Jacq (8)	Lamiaceae	Okota/Gambel a Go-ichu	80	H	Roots	F	Crushed, mixed with water, filtered	Oral	Abdominal complaints (0.90)	15
<i>Santolina chamacyparis</i> L.	Asteraceae	Faranje Agufa	40	H	Leaves	F	mixed with "bulla", false banana product	Oral	Uterine pain (Uuna) (0.93)	148
	Asteraceae	Faranje Agufa	60	H	Leaves	F	Decocted	Oral	Febrile (ibbaa) (0.92)	148
<i>Schefflera abyssinica</i> (Hochst. ex A.Rich.) Harms	Araliaceae	Gatame	27	H	Barks	F	Decocted	Oral	Tonsillitis (qoqpera) (0.81)	108/02
	Araliaceae	Gatame	80	H	Barks	F	Decocted	Oral	Odontalgia	108/02
<i>Schrebera alata</i> Welw	Oleaceae	Kebala'qa	80	T	Root bark	F	Pounding, chewing	Oral	Odontalgia and Febrile	180
<i>Securidaca longipedunculata</i> Fresen	Polygalaceae	Sanganna	67	S	Roots	F/D	Chewed	Oral	Dingategna (Sudden sickness) (0.91)	167
	Polygalaceae	Sanganna	47	S	Roots	F/D	Chewed	Oral	Febrile (ibbaa) (0.92)	167
	Polygalaceae	Sanganna	60	S	Roots	F/D	Chewed	Oral	Headache (Boggo xidatta) (0.92)	167
	Polygalaceae	Sanganna	73	S	Roots	F/D	Chewed	Oral	Abdominal complaints (0.90)	167
<i>Senna obtusifolia</i> (L.) Irwin & Barneby	Fabaceae	Che'aa/Senna	27	S	Leaves	F	Squeezed	Oral	Amoebiasis/Giardiasis (Emmema/Jarda) (0.88)	14

Contd....

<i>Senna obtusifolia</i> (L.) Irwin & Bameby	Fabaceae	Chachayen Hengezena	80	S	Leaves	F	Pounded, decocted	Dermal	Dandruff (Bulalimata) (0.93)	14
	Fabaceae	Che'aa/Senna	60	S	Leaves	F	Crushed, squeezed	Oral	Diarrhea (Muggitta) (0.88)	14
<i>Senna occidentalis</i> (L.) Link	Fabaceae	Che'aa/Senna	53	S	Seeds	D	Roasted with <i>T. foenumgraecum</i> , powdered & butter.	Dermal	Eczema (wichiba) (0.88)	280
<i>Senna occidentalis</i> (L.) Link	Fabaceae	Che'aa/Senna	40	S	Seeds	D	Roasted with <i>T. foenum-graecum</i> , powdered, mixed with coffee.	Oral	Diarrhea (Muggitta) (0.88)	280
<i>Senna petersiana</i> (Bolle) Lock	Fabaceae	Che'aa	27	S	Roots	F	Concocted mixed with Croton macrostachyus	Oral & Dermal	Freckle (Madiat)	364
	Fabaceae	Sena (Kem.)/Che'aa (Had.)	27	S	Roots	F	Crushed with <i>C. macrostachyus</i> buds, concocted, filtered	Oral & Dermal	Micha (siriais) (0.91)	133
<i>Senna septemtrionalis</i> (Viv.) Irwin & Bameby	Fabaceae	Samammaka (senna)	27	S	Seeds	D	Powdered, mixed with coffee	Oral	Burn (Girat buusito'i) (0.80)	365
	Fabaceae	sena(Kem)	21	S	Seeds	F	Roasted, decocted	Oral	Abdominal complaints (0.90)	365
	Fabaceae	sena(Kem)	53	S	Seeds	D	Roasted, decocted	Oral	Headache (Boqo xidata) (0.92)	365
<i>Sida schimperiana</i> Hochst. Ex Rich. (	Malvaceae		27	S	Stems	D	Small pieces Wrapped, tied on a neck	Dermal	Glandular disease (kichuta) (0.89)	70
	Malvaceae	Xurazoo	37	S	Roots	F	Pounded, mixed with water, filtered	Oral	Diarrhea (Muggitta) (0.88)	372
<i>Solanecio mannii</i> (Hook.f.) C. Jeffrey	Asteraceae	Fugi malaata		S	leaves	D	Powdered, mixed with water	Oral	Intestinal worms (Godebi huchcha) (0.91)	366
<i>Solanum giganteum</i> Jacq	Solanaceae	Ziza	87	S	Leaves	F	Heated with kalanchoe sp & Senecio hadiensis	Dermal	Breast pain (unuuni xidata) (0.92)	208
<i>Solanum incanum</i> L.	Solanaceae	Maahe'ta	67	H	Leaves	F	Crushed, squeezed	Nasal	Epistaxis (Sangguga) (0.78)	278
	Solanaceae	Maahe'ta	73	H	Roots	F	Crushed, mixed with water, filtered	Oral	Abdominal complaints (0.90)	278
	Solanaceae	Maahe'ta	60	S	Roots	F	Crushed, Squeezed	Nasal	Headache (Boqo xidata) (0.92)	278
	Solanaceae	Maahe'ta	53	S	Seeds	D	Chewed	Oral	Tonsillitis (qoqquera) (0.81)	278
<i>Solanum macrocarpon</i> Poir.	Solanaceae	Buluta	100	H(P)	Leaves	F	Decocted, mixed with butter	Oral	Chest pain (Hammo xidata)	168
	Solanaceae	Buluta	53	H(P)	Leaves	F	Crushed, decocted, and buttered	Oral	Emaciation (Middadiqqa) (0.95)	168
	Solanaceae	Buluta	60	H(P)	Leaves	F	Decocted, buttered	Oral	Pertussis (Qakkita) (0.87)	168
	Solanaceae	Buluta	30	H(P)	Leaves	F	Decocted, buttered	Oral	Jaundice /Gaqichi mossu (0.88)	168
	Solanaceae	Buluta	30	H(P)	Leaves	F	Decocted, buttered	Oral	Jaundice /Gaqichi mossu (0.88)	168
<i>Stephania abyssinica</i> (dell ex A. rich) Walp	Menispermaceae	Ma'ira	27	L(H)	Leaves	F	Squeezed	Dermal	Burn (Girat buusito'i) (0.80)	63
	Menispermaceae	Kalalata	33	L(H)	Roots	F	Squeezed, mixed with whey	Oral	Pneumonia (79)	63

<i>Teclea nobilis</i> Del.	Rutaceae	Adarchchu	73	S	Leaves	F	Crushed, mixed with water, filtered	Oral	Anorexia (kurma) (0.93)	367
	Rutaceae	Adarchchu	87	S	Leaves	F	Crushed, mixed with water, filtered	Oral	Ascariasis (Hamas Xidatta) (0.93)	367
<i>Thalictrum rhynchocarpum</i> Dillon & A. Rich	Ranunculaceae	Filitita		H	Roots	F	Chewed	Oral	Pertussis (Qakkita) (0.87)	328
	Ranunculaceae	Filitita	33	H	Roots	F	Decocted	Oral	Evil eye (Manni ilita) (0.87)	5
	Ranunculaceae	Filitita	40	H	Roots	F	Decocted	Oral	Febrile (ibbaa) (0.92)	5
	Ranunculaceae	Filitita/Beshb esha, Kushana zebu	33	H	Roots	F	pounded with <i>Acmella caulirhiza</i> , mixed with whey, and filtered.	Oral	Jaundice /Gaqichi mossu (0.88)	5
	Ranunculaceae	Filitita	78	H	Roots	F	Decocted	Oral	Herpes zoster (qisona xidata) (0.92)	5
	Ranunculaceae	Filitita	40	H	Roots	D	Concocted with N. sativa seeds, A. sativum & A. porrum, powdered, and mixed with whey	Oral	Snake bite (wori karu) (0.88)	328
<i>Thymus schimperi</i> Roninger	Lamiaceae	Zazanchut	65	H	leaves	F	Decocted	Oral	Hypertension (0.81) (Qeegi mossu)	369
<i>Trichilia prieuriana</i> A. Juss	Meliaceae	Beshinqa	47	T	whole plant	F	Pounded, mixed with water, decocted, buttered	Oral & Dermal	Jaundice /Gaqichi mossu (0.88)	370
<i>Trifolium rueppellianum</i> Fresen	Fabaceae	Godoro-oo'	53	H	Leaves	F	Squeezed, dropped	Auricular	Ear ache (Mecha xiddata) (0.94)	371
	Fabaceae	Godoro-oo'	53	H	Leaves	F	Decocted	Oral	Constipation (Godabii mollimatta) (0.90)	371
	Fabaceae	shu'oota	73	H	Seeds	F	Powdered, mixed with water	Oral	Nephropathy (Muli Xidatta) (0.89)	254
<i>Trigonella foenum-graecum</i> L.	Fabaceae	shu'oota	73	H	Seeds	D	Powdered, mixed with water	Oral	Abdominal complaints (0.90)	254
<i>Triticum polonicum</i> L.	Poace	gardamu	80	H	Seeds	D	Concocted with Sorghum bicolor L., buttered	Oral	bone setting (Bixxamo ali) (0.83)	345
<i>Urtica simensis</i> Steudel	Urticaceae	Dobita	60	H	Roots	F	Concocted with Bu'ulla'	Oral	Cold (gid mo'ssu) (0.81)	373
<i>Venonia urticifolia</i> A. Rich.	Asteraceae	Germoti Xudichu		S	Leaves	F	Warmed along with <i>C. macrostachyus</i> & roots of <i>C. camaecephalus</i> to touched with.	Dermal	Mumps (Anku'l'i'chu)	49
<i>Verbena officinalis</i> L.	Lamiaceae	Modolita	87	H	Leaves	F	Chewed	Oral	stomachache (Kuuchchaammee Xidatta) (0.93)	133
	Lamiaceae	Modolita	87	H	Leaves	F	Squeezed	Optical	Eye ache (ille xiddata) (0.90)	133
	Lamiaceae	Modolita	87	H	Leaves	F	Concocted with <i>C. macrostachyus</i>	Oral	Anorexia (kurma) (0.93)	133

Contd....

<i>Verbena officinalis</i> L.	Lamiaceae	Modolita	87	H	Leaves	F	Decocted	Oral	Febrile (ibbaa) (0.92)	133
	Lamiaceae	Modolita	60	H	Leaves	F	Squeezed	Oral	Bleeding (Cut) (0.90)	133
	Lamiaceae	Modolita	47	H	Leaves	F	Squeezed, dropped	Nasal	Epistaxis (Sangguga) (0.78)	133
	Lamiaceae	Modolita	60	H	Leaves	F	Squeezed	Oral	Cough (Ganshu) (0.93)	133
	Lamiaceae	Modolita	80	H	Leaves	F	Squeezed	Nasal	Micha (siriais) (0.91)	139
<i>Vernonia amygdalina</i> Del	Asteraceae	He'ba	93	S	Buds	F	Crushed, and squeezed with <i>Clausena anistata</i> , and mixed with E. tef powder, concocted.	Oral	Rheumatism(allii ixuuu) (0.91)	374
	Asteraceae	He'ba	100	S	Buds	F	Concocted with C. anistata and J. schimperana, mixed with coffee	Oral	Cold (gid mo'ssu) (0.81)	374
	Asteraceae	He'ba	100	S	leaves	F	Decocted, buttered	Oral	Plancetal expeller (Zakkiirra uujjisaanchu)	374
	Asteraceae	He'ba	73	S	leaves	F	Crushed, Squeezed	Oral	Malaria (shekerita) (0.90)	374
	Asteraceae	He'ba	73	S	leaves	F	Concocted with <i>Hordeum vulgare</i>	Oral	Bleeding (Cut) (0.90)	374
	Asteraceae	He'ba	67	S	Leaves	F	Squeezed	Dermal	wound /cut(Maazatta) (0.91)	374
	Asteraceae	He'ba	100	S	leaves	F	Crushed, mixed with water, filtered	Oral	Ascariasis (Hamas Xidatta) (0.93)	374
<i>Vernonia auriculifera</i> Hiern	Asteraceae	Rejja/barawa	80	S	Leaves	F	Squeezed	dermal	wound /cut(Maazatta) (0.91)	177
<i>Vicia faba</i> L.	Fabaceae	Bakela	80	H	Seeds	D	Decocted	Dermal	Tinea corporis (Ulamaaha) (0.94)	307
<i>Withania somnifera</i> Dunal	Solanaceae	Gizawa	27	H	Roots	F	Decocted	Oral	Evil eye (Manni iliita) (0.87)	139
	Solanaceae	Gizawa	27	H	Roots	F	Crushed, Decocted	Oral	Micha (siriais) (0.91)	176
<i>Ximenia americana</i> L.	Oleaceae	Hue'la	27	S	whole plant	F	Pounded, mixed with water	Dermal	Rheumatism(allii ixuuu) (0.91)	87
<i>Zingiber officinale</i> Rosc.	Zingiberaceae	Jangibelu	93	H	Rhizomes	F/D	Chewed	Oral	Abdominal complaints (0.90)	
	Zingiberaceae	Jangibelu	100	H	Rhizomes	F	Chewed	Oral	Tonsillitis (qoqquera) (0.81)	

b. Medicinal plants used for Livestock only

Scientific name	Family	local	FL	Habit	Part used	Form used	Methods of preparation	Route	Ailment treated	voucher no
<i>Acokanthera schimperi</i> Benth	Apocynaceae	Hulqubba	40	S	Leaves	F	Pounded, mixed with water	Dermal	Eczema (Chachaarsaa) (0.88)	137
<i>Albizia schimperiana</i> Oliv	Fabaceae	Ma'ta	47	T	Barks	F	Chewed with <i>Pittosporum abyssinicum</i>	Oral	Singultus (kushanat) (0.92)	47
<i>Anethum foeniculum</i> L.	Apiaceae	Wolenga	80	H	Roots	F	Crushed, mixed with water, filtered	Oral	Cold (gid mo'ssu) (0.81)	207
<i>Apodytes dimidiata</i> E.Key Ex Arn	Icacinaeae	Me'wa	27	S	Barks	F	Crushed, mixed with water, filtered	Oral	abdominal complaints (0.90)	101
<i>Arisaema enneaphyllum</i> Hochst. ex A.Rich	Araceae	Fugi Ojomoko	73	H	Roots	F	Crushed, mixed with water, filtered	Oral	Edema (karshuta) (0.91)	377
<i>Asparagus africana</i> Lam.	Asparagaceae	serati	47	S	Roots	F	Crushed, mixed with water, filtered	Oral	Cold (gid mo'ssu) (0.81)	225
	Asparagaceae	serati		S	Roots	F	Crushed, mixed with water, filtered	Oral & Dermal	Devil sickness (Shaxxaani mossu) (0.90)	225
	Asparagaceae	serati	60	S	Roots	F	Crushed, mixed with water, filtered	Oral	Evil eye (Manni iliita) (0.87)	225
<i>Bothriocline tomentosa</i> (S.more) Wild & Pope	Asteraceae	Soyama	33	H	Shoots	F	Pounded, mixed with water	Oral	Constipation (Godabii mollimatta) (0.90)	119
	Asteraceae	Soyama	25	H	Leaves	F	Squeezed	Nasal	Singultus (kushanata) (0.92)	119
<i>Capsicum annuum</i> L.	Solanaceae	Barbaru	27	H	Fruits	F	Salted, powdered, mixed with 'mocha' (watery extract from <i>kocho</i> processing)	Oral	Constipation (Godabii mollimatta) (0.90)	382
<i>Carissa edulis</i>	Apocynaceae	Atulla	33	S	Root	F	Pounded, mixed with water	Oral	Mastitis	326
<i>Cissus ruspolii</i> Gilgi	Vitaceae	Haniga	47	L	Roots	F	Decocted mixed with salted powders of <i>Cissus ruspolii</i> , coffee & corn flour.	Oral	Evil eye (Manni iliita)(0.87)	200
<i>Commelina benghalensis</i> L.	Commelinaceae	Laaluncha	40	H	Shoots	F	Crushed, mixed with water, filtered	Oral	Black leg (<i>bobira</i>) (0.87)	334
<i>Cyathula cylindrica</i> Moq	Amaranthaceae	Gonjeta	60	H	Roots	F	Crushed, mixed with water, filtered	Oral	Black leg (<i>bobira</i>) (0.87)	295
<i>Cynoglossum coeruleum</i> Steud. ex DC.	Boraginaceae	Kacheba/ Baxxaturssa	87	H	Shoots	F	Crushed, mixed with water, filtered	Oral	Cold (gid mo'ssu) (0.81)	165
<i>Cyphostemma adenanthum</i> Descouings	Vitaceae	karsho zabbu	67	H	Shoots	F	Crushed, mixed with water, filtered	Oral	Black leg (<i>bobira</i>) (0.87)	127
	Vitaceae	karsho zabbu	27	H	Shoots	F	Crushed, mixed with water,	Oral	Trypsis (<i>muratnuta</i>) (0.93)	127
<i>Dioscorea bulbifera</i> L. var. <i>bulbifera</i>	Dioscoreaceae	Qotinita	40	L	fruit	F	Decocted	oral	Leech (0.88)	95
<i>Discopodium penninervium</i> Hochst.	Solanaceae	Abba'baqaa'	27	S	Leaves	F	Crushed, mixed with water, filtered	Oral	Rheumatism(allii oxuuu) (0.79)	309
<i>Dracaena steudneri</i> Engl	Dracaenaceae	Fishagaala	23	T	leaves	F	Crushed, squeezed	Nasal	Leech (0.88)	344
<i>Emsete ventricosum</i> (Welw) Choisiman	Musaceae	Weise (e.g. Gishira)	100	H	Corn	F	Chopped, decocted , and mixed with butter	Oral	bone setting (0.83)	244
<i>Erythrina brucei</i> Schweinf.	Fabaceae	Wellaa	47	T	Buds	F	Concocted mixed with <i>C. macrostachyus</i>	Oral	Constipation (Godabii mollimatta) (0.90)	305
<i>Mama lanceolata</i> Forsk.	Myrsinaceae	Gewada		T	Fruits	F	Pounded, mixed with water	Oral	Intestinal worms (0.65)	304

<i>Maytenus senegalensis</i> (Lam.) Exell	Celastraceae	kombolla	33	S	leaves	F	chewed	Oral	Snake bite (wori karu) (0.88)	85
<i>Milletia ferruginea</i> (Hochst.) Bak.	Fabaceae	Hengezena	27	T	leaves	F/D	Crushed, powdered	Nasal	Evil eye (Manni iliita) (0.87)	351
<i>Momordica foetida</i> Schumach.	Cucurbitaceae	Wori rebuta	81	L	Leaves	F	Concocted with <i>N. sativa</i>	Oral	Abdominal complaint (0.90)	1
	Cucurbitaceae	Wori rebuta	80	L	Leaves	F	Crushed, squeezed	Oral	Bloat (buussanata) (0.87)	1
<i>Nicotiana tabacum</i> L.	Solanaceae	Tumbe-u/koshuta	100	H	leaves	F	concocted, mixed with <i>B. antidysentrica</i> & <i>C. macrostachyus</i>	Oral	Snake bite (wori karu) (0.88)	207
<i>Pavetta abyssinica</i> Fresen	Rubiaceae	Miqichuta (Fugi)	33	S	Roots	F	Chewed with salt	Oral	Pneumonia (0.79)	253
	Rubiaceae	Miqichuta (Fugi)	60	S	Buds and Seeds	F	Squeezed	Nasal	Devil sickness (Shaxxaani mossu) (0.90)	253
	Rubiaceae	Miqichuta (Fugi)	87	S	Buds and Seeds	F	Powdered	Oral & Dermal	Emaciation (0.95)	253
<i>Pavonia glechomifolia</i> (A. Rich.) Garcke	Malvaceae	Lagana	87	S	Roots	F	Concocted mixed with <i>Lysimachia ruhmeriana</i>	Oral	Plancetal expeller	300
<i>Phragmanthera regularis</i> (Sprague) M. Gilbert	Loranthaceae	Masani kurumu	60	S	Leaves	F	Crushed, mixed with water, filtered	Oral	Evil eye (Manni iliita) (0.87)	285
<i>Physalis peruviana</i> L.	Solanaceae	Daaxxe	60	H	Roots	F	Crushed, mixed with water,	Oral	Anthrax (Hixichuu) (0.91)	277
	Solanaceae	Daaxxe	73	H	Roots	F	Crushed, mixed with water	Oral	Dingategna (Sudden illness) (0.91)	277
<i>Pimpinella hirtella</i> A. Rich	Apiaceae	Fitetta	27	H	whole plant	F	Pounded, mixed with water	Oral	Constipation (0.90)	121
<i>Pittosporum abyssinicum</i> Hochst. ex Del.	Pittosporaceae	Buneqqa	47	S	Barks	F	Crushed, squeezed	Nasal	Singultus (kushanata) (0.92)	358
<i>Pittosporum viridiflorum</i> Sims.	Pittosporaceae	Bobanqa	67	T	leaves	F	Crushed, mixed with water	Oral	Black leg (bobira) (0.87)	131
<i>Protea gagued</i> J. F. Gmel	Proteaceae	Habuyamme	33	S	Barks	F	Crushed, mixed with water	Oral	Anthrax (Hixichuu) (0.91)	100/02
<i>Ricinus communis</i> L.	Euphorbiaceae	Cheenna	40	S	Buds	F	Concocted with <i>C. anistata</i> , <i>C. macrostachyus</i> , <i>C. sativum</i> , and <i>A. sativum</i>	Oral	Black leg (bobira) (0.87)	380
<i>Senecio hadiensis</i> Forssk.	Asteraceae	Bushbusha/Arbaba	60	L	Leaves	F	Crushed, mixed with water	Oral	Diarrhea (Muggitta) (0.88)	5
<i>Senna septemtrionalis</i> (Viv.) Irwin & Bameby	Fabaceae	Samammaka (senna)	40	S	Seeds	D	powdered with <i>E. kebericho</i> , and mixed with coffee	Dermal	Snake bite (wori karu) (0.88)	365
	Fabaceae	Sena (Kem)	53	S	Seeds	D	Burnt for smoke	external	Snake repellent	365
<i>Smilax aspera</i> L.	Smilacaceae	Gasargaja	40	H	whole plant	F	Concocted mixed with <i>S. incum</i> , <i>C. macrostachyus</i> , <i>M. yfoetida</i> , <i>C. camaecephalus</i>	Dermal	Evil eye (Manni iliita) (0.87)	128
<i>Solanecio mannii</i> (Hook. f.) C. Jeffrey	Asteraceae	Fugi malaata	47	S	leaves	D	Powdered	Oral	Devil sickness (Shaxxaani mossu) (0.90)	366
<i>Tanacetum parthenium</i> (L.)	Asteraceae	Bobri zebu (Leli)	40	H	Leaves	F	Crushed, mixed with water	Oral	Black leg (bobira) (0.87)	203
	Asteraceae	bobri zebu (Leli)	27	H	Leaves	F	Crushed, mixed with water	Oral	Pneumonia (0.79)	203
<i>Terminalia brownii</i> Fresen	Combretaceae	Kechichichuu		T	leaves	F	Crushed, mixed with water	Oral	Trypsis (<i>muratonta</i>) (0.93)	368
<i>Vernonia urticifolia</i> A. Rich	Asteraceae	Germoti Xadichu	33	H	Buds	F	concocted mixed with <i>C. macrostachyus</i> and <i>C. camaecephalus</i>	Oral	Evil eye (Manni iliita) (0.87)	29
<i>Withania somnifera</i> Dunal	Solanaceae	Gizawa		H	Roots	F	Decocted	Oral	Evil eye (Manni iliita) (0.87)	139
<i>Zehneria microphylla</i> (Cogn.) C. Jeffrey	Asteraceae	Kushana zebu	60	H	Leaves	F	Crushed, mixed with water, filtered	Oral	Singultus (kushanata) (0.92)	129

Scientific name	Family	Local	FL	Habit	part used	Form used	Methods of preparation	Route	Ailment treated	voucher no
<i>Arisaema enneaphyllum</i> Hochst. ex A. Rich	Araceae	Ojomukuta	73	H	Roots	F	Crushed, mixed with water, filtered	Oral	Edema (karshuta) (0.91)	377
<i>Clausena anistata</i> (Wild)	Rutaceae	Gembaleka/Bayxaqqa	80	S	leaves	F	Crushed, mixed with water	Oral	Bloat (buussanata) (0.87)	330
<i>Crotalaria incana</i> L.	Fabaceae	Chachayena		H	leaves	F	Decocted	Dermal	Eczema (Hanggaarru) (0.88)	23
<i>Croton macrostachyus</i> Del.	Euphorbiaceae	Mesana	40	S	leaves	F	Wrapped by shamma cloth to put in to	Vaginal	Antifertility (livestock) (0.90)	49
	uphorbiaceae	Massana	25	T	leaves	F	Crushed	Dermal	Ectoparasites (0.75)	49
<i>Cyperus fischerianus</i> A. Rich	Cyperaceae	Na'qqa	87	H	Roots	F	Concocted, mixed with <i>S. abyssinica</i>	Oral	Bloat (buussanata) (0.87)	141
<i>Echinops kebericho</i> Mesfin	Asteraceae	Tossa	80	H	Roots	F	mixed with <i>A. sativum</i> and <i>A. enneaphyllum</i>	Oral	Trypsis (Muratuuta) (0.93)	205
<i>Justitia schimperana</i> (Hochst. ex Nees) T. Anders	Acanthaceae	Gulbanna	40	S	Leaves	F	Crushed	Dermal	Ectoparasites (Chchibitta) (0.75)	243
<i>Kniphofia foliosa</i> Hochst.	Asphodelaceae	Onshololuta	53	H	Roots	F	Crushed, mixed with water	Oral	Bloat (buussanata) (0.87)	69
<i>Mikaniopsis clematoides</i> (A. Rich) M. Redh.	Asteraceae	Bukukuta	65	L	roots	F	Crushed, mixed with water, filtered	Oral	Trypsis (Muratuuta) (0.93)	303
<i>Momordica foetida</i> Schumach.	Cucurbitaceae	Wori rebuta	73	L	Roots	F	Crushed, mixed with water	Oral	Anthrax (Hixichuu) (0.91)	1
	Cucurbitaceae	Wori rebuta	73	L	Roots	F	Crushed, mixed with water	Oral	Edema (karshuuta) (0.76)	1
<i>Nicotiana tabacum</i> L.	Solanaceae	Tumbe-oo	25	H	leaves	F	Crushed	Dermal	Ectoparasites (0.75)	207
	Solanaceae	Tumbe-oo (Koshuta)	80	H	leaves	F	Squeezed	Nasal	Leech (mulluu-illat) (0.88)	207
<i>Olinia rochetiana</i> A. Juss.	Oliniaceae	shoo'emolutta	27	S	Barks	F	Decocted, held in mouth	Oral	Edema (karshuuta) (0.76)	131
<i>Pavetta abyssinica</i> Fresen	Rubiaceae	Miqichuta	40	S	Leaves	F	Squeezed	Nasal	Leech (mulluu-illat) (0.88)	253
<i>Rubia cordifolia</i> L.	Rubiaceae	Ha'ruta	80	L	Roots	F	mixed with <i>C. anistata</i>	Oral	Mastitis	89
<i>Securidaca longipedunculata</i> Fresen	Polygalaceae	Sanganna	73	S	Roots	F	Crushed, mixed with water		Bloat (buussanata) (0.87)	167
<i>Senecio hadiensis</i> Forssk.	Asteraceae	Bushbusha/Arbaba	53	L	Leaves	F	Crushed, mixed with water	Oral	Anthrax (Hixichuu)	5
<i>Senna occidentalis</i> (L.) Link	Fabaceae	Che'aa/Senna	33	S	Leaves	F	Crushed	Dermal	Ectoparasites (0.75)	M280
<i>Senna septentrionalis</i> (Viv.) Irwin & Bameby	Fabaceae	sammamaka (senna)	33	S	Buds	F	concocted mixed with <i>C. macrostachys</i>	Oral	Anthrax (Hixichuu)	365
<i>Solanecio mannii</i> (Hook. f.) C.	Asteraceae	Fugi malata	53	S	leaf	F	Crushed, mixed with water	Oral	Trypsis (Muratuuta) (0.93)	366
<i>Solanum incanum</i> L.	Solanaceae	Maheta	40	S	Root	F	concocted mixed with <i>B. antidysenterica</i> and <i>T. nobilis</i>	Oral	Black leg (Hitichu) (0.87)	278
<i>Stephania abyssinica</i> Quart.-Dill. & A. Rich. Walp.	Menispermaceae	Kalalata	67	L	Roots	F	Crushed, mixed with water	Oral	Abdominal complaint	9 63
<i>Thalicttrum rhynchocarpum</i> Dillon & A. Rich	Ranunculaceae	Filita/Kushana zebu/Bekbeshu	47	H	Roots	D	Concocted mixed with <i>Eragrostis tef</i> , buttered.	Oral	Black leg (bobiru) (0.87)	5
	Ranunculaceae	Filita	47	H	Roots	D	Concocted mixed with <i>E. tef</i> , buttered.	Oral	Singultra (Kushana) (0.92)	5
<i>Verbena officinalis</i> L.	Lamiaceae	Modolita	87	H	Leaves	F	Crushed, mixed with water	Oral	Bloat (buussanata) (0.87)	133
<i>Veronica anagallifolia</i> Hurn	Asteraceae	Rega/burawa	93	S	Leaves	F	Decocted, the buttered leaf juice is given to chickens	Oral	Coccidiosis	177

Appendix VIII. Indicator values (%) of each tree/shrub of each community (1-5) and the test of significance observed for each species is shown below. Indicator values were obtained by combining the relative abundances and relative frequencies of each species

Species name	Indicator and significance value						
	abbrev	I	II	III	IV	V	P value
<i>Acacia abyssinica</i> Hochst. Ex Benth	Acab	2	41	0	0	4	0
<i>Acacia decurrens</i> Willd.	acde	2	3	35	0	0	0
<i>Acacia melanoxylon</i> R. Br.	acme	0	4	0	0	3	0.35
<i>Acacia senegal</i> (L.) Willd.	acse	0	0	0	0	9	0
<i>Acacia seyal</i> Del.	acsey	0	4	0	0	50	0
<i>Acacia tortilis</i> (Forssk.) Bayne	acto	0	0	0	0	7	0.08
<i>Acalypha fruticosa</i> Forssk.	acfr	0	0	0	11	0	0.02
<i>Acanthus eminens</i> C. B. Clarke	acem	1	15	0	0	0	0.01
<i>Acanthus sennii</i> Chiovi	Acse	4	2	1	0	0	0.23
<i>Acokanthera schimperi</i> Schwein	acsh	0	0	0	0	7	0.09
<i>Albizia gummifera</i> C.A.Sm.	algu	7	19	0	18	0	0.02
<i>Allophylus abyssinicus</i> (Hochst.) Radlkofer	alab	2	6	13	0	0	0.04
<i>Apodytes dimidiata</i> E.Mey Ex Am.	apdi	0	0	3	3	0	0.46
<i>Arundinaria alpina</i> K.Schum	aral	0	5	50	0	0	0
<i>Arundo donax</i> L.	ardo	2	9	22	0	0	0
<i>Asparagus africana</i> Lam.	asaf	0	0	6	0	0	0.1
<i>Balanites aegyptiaca</i> (L.) Del.	baae	0	0	0	0	37	0
<i>Bersama abyssinica</i> Fresen.	beab	1	19	20	9	0	0.02
<i>Blighia unijugata</i> Bak.	blun	0	16	0	0	0	0.01
<i>Borassus aethiopum</i> Mart.	boae	2	0	0	0	0	1
<i>Boscia salicifolia</i> Olive	bosa	0	0	0	0	14	0.01
<i>Boswellia pirottae</i> Chiov.	bopi	0	0	0	3	0	0.4
<i>Bougainvillea spectabilis</i> Willd.	bosp	0	8	0	4	7	0.24
<i>Bridelia micrantha</i> Baill	brmi	0	0	0	5	0	0
<i>Bridelia scleroneura</i> Muell. Arg.	brsc	1	0	0	6	0	0.11
<i>Bucea antidysentrica</i> J.F. Miller	bran	8	24	25	15	0	0.01
<i>Buddelja polystachya</i> Fresen.	bupo	0	1	31	0	0	0
<i>Caesalpinia decapetala</i> (Roth) Alston	cade	20	10	2	10	2	0.03
<i>Callistemon citrinus</i> (Curtis) Stapf.	caci	0	0	4	0	0	0.18
<i>Canthium oligocarpum</i> Hiern	caol	0	0	0	3	0	0.51
<i>Carissa spinarum</i> (Forssk.) Vahl.	casp	0	11	0	0	0	0.03
<i>Carissa edulis</i> (Vahl) Endl.	caed	0	8	0	2	11	0.06
<i>Cassipourea malosana</i> (Bak.) Alston	cama	0	0	0	12	0	0.01
<i>Casuarina equisetifolia</i> L.	caeq	0	0	3	0	0	0.51
<i>Celtis africana</i> Burm. f.	ceaf	0	25	0	3	0	0
<i>C. gomphophylla</i> Bak.	cego	0	10	0	0	0	0.01
<i>Cestrum purpureum</i> (Lindl.) Standl.	cepu	0	0	7	0	0	0.04
<i>Clausena anistata</i> (Willd.) Benth.	clan	0	14	0	0	0	0.02
<i>Clerodendrum myricoides</i> Vatke	clmy	0	4	0	0	2	0.42
<i>Combretum adengonium</i> Steud. Ex A. Rich.	coad	0	0	3	1	0	0.6
<i>Combretum collinum</i> Fresen	coco	0	0	0	14	0	0

Contd...

Combretum Molle G. Don
Cordia africana Lam
Croton macrostachyus Del.
Cupressus lucitanica Mill.
Datura arboreum (Wild) Bercht. & Presh
Delonix regia (Bojer ex Hook.) Raf
Diospyros abyssinica (Heirn) F. White
Discopodium penninervium Hochst.
Dodonaea angustifolia L.F.
Dombeya torrida (J. F. Gmel.) P. Bamps
Dovyalis abyssinica (A. Rich.) Warb.
Dracaena steudneri Engl
Ehretia cymosa Thonn.
Ekebergia capensis Sparrm.
Erica arborea L.
Erythrina abyssinica Lam. exDC.
Erythrina brucei Schweinf.
Erythrococca tricogene Prain
Eucalyptus camaldulensis Dehnh
Eucalyptus citriodora Hook
Eucalyptus globulus Labill.
Eucalyptus saligna sam.
Euclea divinorum Hiern
Euphorbia abyssinica Pax
Euphorbia candelabrum Kotschy
Euphorbia compacta
Euphorbia cotinifolia L.
Euphorbia pulcherrima Klotzsch.
Euphorbia tirucalli L.
Faurea rochetiana Serm
Ficus sur Forssk.
Ficus sycomorus L.
Ficus thonnigii Blume
Ficus vasta Forssk.
Flacourtia inidca Merrill
Gardenia ternifolia K. Schumach & Thon
Gouania longispicata Engl.
Grevillea robusta A. Cunn.Ex.R.Br.
Grewia tenax (Forssk) Fiori
Grewia velutina (Fork.) Valh
Halleria lucida L
Helinus mystacinus Steud
Hibiscus berberidifolius A. Rich
Hibiscus dongolensis Del.
Hibiscus rosa-sinensis L.,
Hagenia abyssinica (Bruce) J. F. Gmel.
Hymenodictyon floribundum Robinson

como	0	0	0	48	8	0
coaf	14	17	3	19	21	0.07
crma	15	14	12	42	6	0.02
culu	14	14	19	10	2	0.15
daar	6	4	9	3	0	0.39
dere	0	2	0	0	0	0.69
diab	0	12	16	3	0	0.03
dipe	0	8	40	0	0	0
doan	0	0	0	8	0	0.02
doto	0	2	24	0	0	0
doab	1	8	0	0	10	0.12
drst	1	2	0	8	0	0.14
ehcy	0	12	0	6	19	0.01
ekca	2	16	0	18	0	0.02
erar	0	0	13	0	0	0.01
erab	0	20	2	5	0	0
erbr	17	27	12	0	0	0
ertr	9	0	0	0	0	0.08
euca	7	7	1	16	29	0
euci	3	5	13	0	4	0.07
eugl	6	13	44	0	0	0
eusa	0	1	11	0	0	0.04
eudi	0	0	8	0	0	0.02
euab	4	13	15	0	0	0.04
eucan	0	0	0	6	0	0.14
euco	0	1	1	0	0	1
eucot	16	2	0	2	2	0.04
eupu	2	12	0	1	0	0.03
euti	0	0	0	25	41	0
faro	0	0	0	6	0	0.15
fisu	0	3	5	14	0	0.02
fisy	0	0	0	14	1	0.03
fith	0	0	0	2	0	0.81
fiva	0	2	0	3	0	0.57
flin	0	0	0	3	0	0.38
gate	0	0	0	12	0	0.02
golo	0	0	0	11	0	0.03
grro	8	7	9	19	6	0.07
grte	0	2	0	0	0	0.69
grve	0	0	0	6	0	0.16
halu	0	0	0	7	0	0.06
hemy	0	6	0	0	0	0.09
hibe	1	1	2	6	0	0.17
hido	0	6	0	0	0	0.1
hisi	0	4	0	1	0	0.18
haab	0	0	0	0.1	0	0.15
hyfl	0	0	0	6	0	0.15

Contd...

<i>Hypericum revolutum</i> vahl	hyre	0	1	3	0	0	0.53
<i>Hypericum quartinianum</i> A. Rich.	hyqu	0	2	0	0	0	0.67
<i>Jacaranda mimosifolia</i> D. Don.	jami	0	2	0	15	0	0.02
<i>Jasminum abyssinicum</i> DC.	jaab	0	1	4	2	0	0.44
<i>Jatropha curcas</i> L.	jacu	0	0	0	27	0	0
<i>Juniperus procera</i> L.	jupr	1	32	10	3	0	0
<i>Justicia schimperiana</i> T. Anders	jusc	28	12	9	0	4	0
<i>Lannea welwitchia</i> (Hiem) Engl.	lawe	0	0	0	11	0	0.02
<i>Lantana camara</i> L.	laca	0	0	1	1	7	0.11
<i>Leucaena leucocephala</i> (Lam.) De Wit.	lele	1	1	1	1	2	1
<i>Chionanthus mildbraedii</i> (Gilg & Schellenb.) Stearn	ligi	0	0	10	0	0	0.03
<i>Macaranga capensis</i> (Baill.) Sim	Maca	0	0	1	3	0	0.63
<i>Maesa lanceolata</i> Forssk. (Gilg & Schellenb.) Stearn	mala	1	6	12	27	0	0
<i>Mamilkara butugi</i> Chiov.	mabu	0	0	0	31	0	0
<i>Maytenus arbutifolia</i> (A. Rich) Wilczek	maar	3	8	0	13	0	0.1
<i>Maytenus arguta</i> (Loes) Robson	maarg	0	1	1	0	3	0.48
<i>Maytenus gracilipes</i> Exell suspp. Arguta (Leos) sebsibe	magr	0	0	4	0	0	0.21
<i>Maytenus senegalensis</i> (Lam.) Exell	mase	0	1	0	5	0	0.18
<i>Melia azedarach</i> L.	meaz	0	2	0	1	27	0
<i>Millettia ferruginea</i> (Hochst.) Baker	mife	1	15	3	5	0	0.03
<i>Myrsine africana</i> L.	myaf	0	0	8	0	0	0.02
<i>Nerium oleander</i> L.	Neol	0	0	3	0	0	0.05
<i>Olea europaea</i> L. ssp. Cuspidate (Wall. ex C. Don) Cif.	oleu	2	33	8	3	0	0
<i>Olea welwitschii</i> Gilg. & Schellenb	olwe	0	0	1	5	0	0.17
<i>Olinia rochetiana</i> A. Juss.	olro	0	6	3	0	0	0.21
<i>Osyris quadripartita</i> Decn.	osqu	0	6	0	2	0	0.19
<i>Oxyanthus speciosus</i> DC.	oxsp	0	0	0	69	0	0
<i>Pavetta abyssinica</i> Fresen	paab	0	19	21	0	0	0
<i>Pavonia glechomifolia</i> (A. Rich.) Garcke	pagl	1	0	3	0	0	0.46
<i>Pavonia urens</i> cav.	paur	1	0	5	0	0	0.54
<i>Pentas lanceolata</i> (Forssk) Defl.	pela	0	2	36	0	0	0
<i>Phoenix reclinata</i> Jacq.	phre	0	2	3	2	0	0.48
<i>Phytolacca dodecandra</i> L Herit.	phdo	1	0	1	1	0	0.96
<i>Ptilostigma thonningii</i> (Schumach.) Milne-Redh.	pith	0	0	0	6	0	0.16
<i>Pinus raidata</i>	pira	0	2	0	0	0	0.68
<i>Pinus patula</i> L.	pipa	0	1	4	2	0	1
<i>Piptosporum abyssinicum</i> Hochst. ex Del.	piab	0	2	15	1	0	0.01
<i>Piptosporum viridiflorum</i> Sims.	pivi	0	9	0	0	0	0.05
<i>Podocarpus falcatus</i> (Thunb.) Mirb.	pofa	5	30	10	3	0	0
<i>Polyscia fulva</i> (Heirn)	pofu	0	0	0	3	0	0.51
<i>Populus alba</i>	poal	0	0	4	0	0	0.22
<i>Porteria adolfi-friederici</i> (Engl.) Baehni	poad	0	0	1	3	0	0.61
<i>Remna schimper</i> Engl.	prsc	0	6	0	8	0	0.19
<i>Rotea gagued</i> J. F. Gmel.	proga	0	8	0	0	0	0.06
<i>Rumex africana</i> (Hook. f.) Kalkm	praf	19	37	27	0	0	0
<i>Sydrax parviflora</i> Bridson	pspa	0	0	0	22	0	0
<i>Tenostachys abyssinica</i> Fresen	pyab	8	14	13	0	0	0.06

	rhst	0	4	0	0	0	0.28
	rhgl	0	3	1	0	6	0.22
	rhru	0	0	0	0	7	0.08
	rial	0	2	0	0	0	0.7
	roab	0	0	9	0	0	0.07
	rori	0	3	21	1	0	0
	rust	11	1	0	2	0	0.03
	sasu	0	0	0	3	0	0.41
ax	sacl	0	1	0	32	0	0
	scab	1	3	0	0	0	0.48
	scal	0	2	0	1	0	0.52
	scmo	0	0	0	0	36	0
a Fresen	selo	0	0	0	3	0	0.41
Jeffrey	sogi	0	0	24	0	0	0
) Irwin& Bameby	sedi	0	1	0	16	33	0
& Bameby	seob	8	2	0	0	0	0.09
	seoc	0	0	3	1	0	0.58
k	sepe	8	29	7	9	2	0
Irwin& Bameby	sese	0	11	0	4	1	0.08
	sesi	0	0	0	7	0	0.06
	seses	0	6	0	4	15	0.02
	sequ	0	1	1	0	3	0.48
	siten	0	0	0	8	0	0.02
x Rich.	sisc	0	0	2	0	0	0.91
	smas	0	0	8	0	0	0.02
Jeffrey	soma	0	1	6	0	0	0.09
	soin	8	6	0	10	9	0.54
	sogig	0	8	8	0	0	0.09
	spju	0	0	0	1	5	0.18
	spni	3	2	0	0	7	0.1
Tham	stku	0	0	0	14	0	0.01
	stin	0	0	0	3	0	0.41
DC.	sygu	0	0	0	22	0	0
	teno	1	30	1	3	0	0
	tebr	0	1	3	0	0	0.54
	tebre	0	0	0	12	1	0
	trdr	0	0	25	1	0	0
	trpr	0	0	0	44	0	0
& Zeyh. Ex Sond	trel	0	4	0	0	0	0.28
ich.) Wedd.	urhy	0	0	25	0	0	0
	uvan	0	0	0	11	0	0.02
	uvle	0	0	0	11	0	0.01
	vavo	0	0	0	3	0	0.41
	veam	2	19	5	4	11	0.02
	veau	22	5	0	18	0	0.01
	vebi	2	2	8	2	8	0.37
	vefl	3	7	18	2	8	0.03
irn	vido	0	0	0	17	1	0.01
	Wiso	0	0	0	0	36	0
l	xiam	0	0	3	1	0	0.59
	Veda	0	8	0	0	0	0.04

Kokwaro

Appendix IX. Medicinal plant data collection format

Informant's Name _____ Age _____ Sex _____ Woreda _____ Locality _____

Occupation _____ Marital Status _____ Religion _____

S.no.	Medicinal plants local Name	Bot. Name	1. habit	2. Part used	3. Ailment (human, livestock/ both)	4. preparation	5. Prep. form	6. Status of use	7.dose	8. Side effect	9. Forbidden for or taboos	10. Its status ; Other uses

Appendix X. Format for tree/shrub data collection

Background of HH	
1. HH Name	_____
2. Age	_____
3. Gender/Sex	_____
4. education	_____

Socioeconomic aspects	
6. Total farm size owned	_____
7. No of livestock owned	_____
8. Off farm activity e.g., trading/ carpentry	_____
9. Farm labour (no of indls work in the farm)	_____

Area share of d/t components	
10. Crop total	_____ ha/ _____ M ²
11. Grazing	_____ ha/ _____ M ²
12. Woodlot	_____ ha/ _____ M ²
13. HG	_____ ha/ _____ M ²
14. any other	_____ ha/ _____ M ²

S. no.	Tree/shrubs' local name	Bot. Name	1. Location	2. aspect	3. slope	4. Altitude	5. dist to m.road)	6. dist to market	7. area share	No of DBH classes in each quadrat (refer foot note) ; A= 20mx20m or direct count					8. total number	9. density	Other Uses : Bk-bee keeping; Charcoal; Co- construction; Fd-fodder; fence; Fo-food; FT- Farm tool making; firewood; md- medicinal; Po-poles construction; Sf-soil fertility; Shade;swc- soil /water conservation; tooth brush;Ti- timber ;Ut-Utensils; V veterinary use
										Q1	Q2	Q3	Q4	Q5			

1. Dbh classes ; a = 2-15 cm, b= 15-25cm; c= 25-35cm; d= 35-45cm ; e= 45-55cm; f= 55-65 cm, g> 65 cm
2. Location- Agroforestry /in field; F- fence ; FS- field strip/margin; HG- home garden; H- Hedgerow; R- riparian, O- other
3. A= 20mx20m for tree/shrubs in the wood lot or direct counting available ,in field margin, hedges, boundary,etc

Appendix XI. Checklist of questions or items used as a basis for discussion and interview for ethnomedicinal data collection

1. What are the main human health problems?
2. What do you diagnose each disease/ health problems?
3. Symptoms of each disease?
4. How do you control diseases?
5. How do you treat human diseases?
6. Which plant/s do you use for treating those particular health problems/diseases? Location/GPS
7. Habitat of the plant-where it grows in the study area & its size, flower, seed, stem or other attributes
8. Preparation of remedy: detailed account.
9. Does the dose differ among males, females, children, and elders?
10. Is/are there antidotes for adverse effects?
11. How is the medicinal plant (s) preserved (if any)?
12. Are there members of the community who frequently use the medicinal plant
13. Are there economic groups who mostly or occasionally use these medicinal plants?
14. Is there regimen in the use of medicinal plants?
15. Is (are) the medicinal plants(s) marketable?
 - a. Which age group? B) Which plant species? C) Source? D) Benefits?
16. How is the knowledge passed from elders to younger in the study area?
17. Does modernization interfere with traditional medicinal system?
18. Any threats to the medicinal plants?
19. Are there traditional medicinal plants conservation methods in the area?
20. Include the management practices by indigenous people.
21. Is the plant currently cultivated in the study area?
22. Information on edibility and other uses of the plant besides its medicinal uses/value.
23. Interaction of human being and ecosystem services

ions to collect woody species data based on focus group discussion and interview
conomic importance of the following tree species which had higher IVI: *Cordia*
on macrostachyus, *Cupressus lucitanica*, *Erythrina brucei*, *Eucalyptus species*, and
sta

manage trees/shrubs in your crop field? Which technique you use most?

ment or pruning by balancing the trunk and the crown

major constraints of tree growing in the agroecosystems?

the effect of growing trees on agricultural land? If yes, discuss.

II. Questionnaire on Socioeconomic aspect filled by each HH

name _____

of the area (*Woreda* in the zone) _____

Peasant Association _____ site _____

Agro-ecological category _____ Altitude _____ slope _____

Latitude _____ Longitude _____ Aspect _____

from the nearest town (in minutes/Km) _____

distance from the nearest all weather road (in minutes/Km) _____

Personal information

age	marital status	No of Family members	Labour force	education	religion	Describe any off farm activity & income

How many years have you been farming? _____

Have you got extension services? _____

What training did you get from the training for your livelihood activities? _____

Do you have additional skill other than farming (e.g. traditional healing, carpentry)? If yes, how do you use this skill to support your life? _____

Land resources

Do you have your own land? 1. Yes 2. No, and /or if any rent land, _____ ha

What is the size of your land in *Borra' hosh*a (1 Bh = 1/4ha)?; i.e., 1 pair of oxen can plough _____ ha

Type of land	Farm size in <i>Hosha'</i>			
	2001/2 E.C	2002/3 E.C.	2003/4 E.C	
Arable land				
Forest				
Barren land				
Water				
Other				
Wood lot				

Is there a shortage of land in this village? If you have shortage of land, how do you ensure that your land produces enough food?

own livestock? 1. Yes 2. No; If yes, mention the number and uses of
k?

	Number	Purpose/use
cow with		
of hives)		

have a practice of livestock fattening? If yes, how & from where you get the
stock fodder?

n disservice

any prevalence of crop pests and diseases?

, what kind of crop pests, weeds, diseases, and climatic problems are
ent? What control Measures do you use?

Crop type	Pests	Weeds	Diseases	Climatic adaptations	Control measures

ystem

he following soil & water management methods do you use most often,

rst top six

nanuring

ck waste manure

ic fertilizers

ting

g crop residues

tillage

stry

ure (inter cropping)

ation

i field strips

ed protection

2. What are the soil fertilizing methods
in this area?

& Management

What do you take when the productivity of your farmland declines?
 Do you take fodder into crop Land?
 What benefits do you get?
 What do you use crop residues?
 Do you take water conservation and water harvesting in your farmland?

Question

	Yes (1)	No (2)	Any reason for your choice of yes or not

What are the major sources of feed for animals?
 Does the carrying capacity of the grazing area fit with the number of livestock? If no,
 What measures do you take to alleviate feed shortages?

	Yes (1)	No (2)	any possible reason , if any.
Farmland			
Straw			
From other farmers			
From other places			

Income

What is the source of income? _____
 How much does it add to the household income. Annual income _____ birr
 How much do you get from the sale of different products last year?
 From sale of grains _____
 From sale of pulses _____
 From sale of animals _____
 From sale of vegetables _____
 From sale of animal products (eggs, milk, butter) _____
 How much does it come from the sale of fuel wood or charcoal?
 What is the total amount of income generated (in birr) _____ birr.
 How much does it come from the sale of fuel wood or charcoal for sale?
 How much does it come from the sale of crop residues or dung?
 How much do you get from the sale? Crop residues (straw, hay, etc)

number /members of the HH is engaged in off farm income generating activities? monthly
 received any other income (remittance, gift or other transfers) in the last 12 months?

penditure

end on any of the following activities in the last 12 months?	
ults and Children?	How much is the total expender ?(Birr)
ipment or other HH goods?	
ouse construction?	
or religious (church/mosque)	
? (e.g., Wedding and idir)	
ev't contributions to your PA	
or any member of the HH?	
materials etc...)	
inputs?	
repayment?	
el-wood (charcoal) and water?	
ment measures?	
enses	

ny of your household assets in the last 2 years? If yes, would you please mention the
 ou sold the household assets?

e- expense of the family

household farms
 ive grown during the last three years what is the yield kg/ha and utilization?

ivated in 1/2 ha)		Production kg/ha			Consumed at home kg			Sold in market Kg		
2002/3E.C.	2003/4E.C	2001/2 E.C	2002/3E.C.	2003/4E.C	2001/2 E.C	2002/3E.C.	2003/4E.C	2001/2 E.C	2002/3E.C.	2003/4E.C

iversity

Change in the diversity of	Yes	No	reasons
...s (kinds and species)			
...cies			
...h			
...stureland			
...ces			
...size and number			
...the land/productivity			
...ange			
...ial /governmental/aid			
...ctors are responsible for the above			
...nges			
...ogical/regional effects you recognized?			
(crop varieties, livestock, etc any			
...tatus of the following whether increasing			What did each look like
...h reasons			some 20-30 years before
			(abundant, scare, rare,
			endangered, etc)
...vity			
...cies			
.../soil erosions, etc			

...r occupation of each household members?

...sions about which landrace to plant in each farmland? _____

...ifferent parcels/plots of land for different varieties?

...ria do you use for such allocation? _____

Indicator and P-values for crops forming crop cluster groups
(C1 –crop cluster 1...C5-crop cluster 5)

	abb.	C1	C2	C3	C4	C5	P- Value
<i>tus</i>	Amca	1	2	7	1	22	0.001
<i>izens</i>	Amgr	8	15	0	5	0	0.04
<i>rima</i>	Afco	1	2	0	0	0	0.73
	Alce	9	7	0	0	0	0.1
	Alpo	10	0	0	0	0	0.01
	Alsa	4	0	0	0	3	0.22
	Anco	0	0	0	14	0	0.02
<i>e</i>	Anfo	2	6	2	2	0	0.47
	Anre	0	10	2	1	0	0.06
<i>im</i>	Arab	0	7	0	2	1	0.28
	Bevu	3	4	0	0	8	0.11
	Brea	3	19	20	43	14	0.001
<i>a var.</i>	Brin	27	1	0	0	0	0.001
	Brra	0	0	0	0	5	0.27
	Brni	0	2	4	1	0	0.43
	Brol	13	0	3	3	0	0.03
	Caan	6	8	4	0	40	0.001
<i>is</i>	Cafr	2	0	1	2	13	0.02
	Caed	2	10	4	3	7	0.25
	Capa	0	3	0	6	48	0.001
	Cated	0	4	12	0	5	0.08
	Ciar	0	0	1	0	0	0.77
	Ciau	0	1	0	9	8	0.07
	Cime	4	1	1	0	0	0.01
	Cisi	0	5	4	19	2	0.02
	Coar	4	23	20	18	19	0.06
<i>t</i>	Coes	5	36	3	26	3	0.001
<i>n</i>	Cosa	5	22	3	0	2	0.01
	Cupe	0	16	6	6	15	0.09

ea	Cybe	2	0	3	0	0	
	Daca	1	2	2	0	0	0.55
	Dial	0	2	0	0	2	0.78
	Dibu	0	0	0	20	0	0.001
	Elco	0	0	0	3	0	0.79
	Enve	0	0	49	0	3	0.001
	Erte	36	20	20	20	20	0.04
	Erar	0	13	28	21	22	0.04
t	Erar	0	21	3	4	11	0.02
	Glma	0	3	4	8	0	0.15
ise	Goba	0	0	0	0	10	0.02
	Helan	0	0	0	2	0	0.81
	Hovu	20	6	0	0	0	0.001
	Ipba	0	39	7	16	0	0.001
	Lasa	1	0	0	0	0	0.9
	Lecu	1	0	1	0	0	0.65
	Lius	1	0	3	0	0	0.5
	Lesä	0	5	0	0	0	0.21
	Liado	11	14	6	5	6	0.09
utum	Lyes	0	6	0	1	1	0.26
	Mado	25	1	6	0	0	0.001
	Main	0	19	1	18	17	0.03
	Maes	0	1	0	9	1	0.06
	Mesp	0	0	0	3	0	0.76
	Moal	2	5	0	0	0	0.36
	Most	0	0	0	10	0	0.04
	Mupa	0	26	10	20	23	0.001
	Nisa	0	1	2	0	0	0.77
	Nita	4	5	7	0	0	0.35
	Ocba	11	4	0	29	0	0.001
	Opfi	0	0	0	0	7	0.06

	Paed	0	7	0	0	0	0.68
	Peam	7	24	13	21	4	0.01
	Phlu	1	8	6	18	3	0.03
	Phvu	3	18	3	0	26	0.001
	Pica	0	0	0	2	0	0.67
	Prpe	10	0	3	0	0	0.04
	Pisa	9	17	1	0	2	0.02
tus	Plpu	1	4	1	0	0	0.38
	psgu	0	9	0	2	3	0.03
	Pugr	0	0	0	1	0	0.92
	Rico	6	16	0	3	0	0.01
	Rhpr	21	5	12	0	0	0.61
lis	Roof	7	9	0	1	0	0.19
	Ruch	10	3	3	19	0	0.02
um	Saof	1	19	11	27	0	0.001
on	Soma	0	7	0	0	40	0.001
	Lasi	0	0	2	0	0	0.65
	Somu	6	0	2	0	0	0.09
	Soni	8	6	0	0	3	0.26
	Soltu	29	18	5	0	0	0.001
	Sobi	0	15	9	5	23	0.01
	Thsc	4	11	0	0	0	0.05
aecum	Trfo	2	0	0	0	0	0.48
	Trdi	2	0	0	0	0	0.5
	Trdu	11	6	0	0	0	0.04
1	Traet	4	0	0	0	0	0.28
	Trtu	3	0	0	0	0	0.26
	Triaes	41	20	16	0	0	0.001
	Veof	0	0	2	0	0	0.73
	Vifa	26	23	18	0	0	0.001
	Viun	0	2	0	1	0	0.6
	Zema	2	15	3	6	41	0.001
	Ziof	0	0	0	0	73	0.001