Local Crop Genetic Resource Utilization and Management in Gindeberet, west central Ethiopia

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Declaration

I, Teshome Hunduma, hereby declare to the senate of Norwegian University of Life Sciences that this thesis is product of my original research work, and all other sources are dully acknowledged. This work has not been submitted to any other university for award of academic degree.

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Dedication

To the Oromo farmers in Gindeberet

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Abstract

Understanding farmers' knowledge and innovation as well as factors affecting their decisions and preferences in the process of crop genetic conservation is indispensable. This study was conducted to understand farmers' traditional knowledge and practices in the conservation of crop genetic resources managed by Oromo communities in Gindeberet district, west central Ethiopia. Household survey was conducted using a semi-structured questionnaire and group discussion with key informants and direct field observation were held for the study.

A wide range of inter-specific and infra-specific diversity of crops was grown in communities and on individual farms. A checklist of crops found in the study area included: cereals (8), oil crops (9), pulses (7), and industrial crops (2), summing up to 26 species of field crops. One hundred two farmer-identified landraces distributed among 14 crop species and 12 other species represented by one variety each were recorded. Few improved varieties of wheat, maize, and linseed were also encountered. A total of 15 wild relatives of 5 crop species were recorded on managed farmlands (homegardens, nearby farms and main fields) that also occurred in the adjacent natural ecosystem, and disturbed wild habitats

Not only crops and varieties grown in lowland and midland areas were different, but also the distribution of crops on managed farms and vernacular names of varieties vary in the study area. The spatial layout in managed farms presents a complex pattern of crop distribution. Vernacular names of farmers' varieties were reflections of breeders' names, culinary attributes, geographic origin, habitats, field performance, agro-morphology, varietal seed sources .Diversity was reflected from array of the vernacular names. Ethiopian mustard and maize were strictly homegarden crops except few fields that were covered by maize in the lowland areas. Tef, wheat, and noug were major field crops in the midland, while maize and sorghum dominate in the lowland main fields. Farmers also practiced simple form of inter-cropping in field crops. The purpose of intercropping was to secure better harvest, efficiently utilize the land, improve soil fertility, adjust to crop and variety requirements, and reduce potential damages due to pests and diseases. Combination of factors related to farm and household characteristics significantly affected crop diversity on household farms. Greater number of farm plots and education were associated with cultivation of richer and more evenly distributed crop combinations ($p \leq 0.001$). Availability of production assets such as human labour was associated with lower diversity and specialization of few crops ($p \leq 0.001$). Older farmers who have accumulated farming experience, maintained greater number of crops on their farms ($p \leq 0.001$). Different varieties of tef, wheat, and, maize were associated with several agro-morphological, field performances, culinary and use value traits. To identify varieties of crops farmers used such traits, though; these were not strictly used to discriminate the varieties for maintenance.

The values of diversity were expressed using customary proverbs, folksongs, and poems that reflected in food and livelihood security, culinary attributes, field performance, agro-morphological features, selection pressure, agro-ecological adaptation and risk management. Generally, five traditional working parties namely fulbaasii/qaboo, kadhaa, daboo/wanfala, jigii, and kadhaachisa were used to mobilize labour and capital for agricultural production in the study area.

Local seed supply contributed about 93 % of seed sources in the study area in the form of own seed sources (62 %), those obtained from local communities (21 %), friends or relatives (6 %), and those purchased from local markets (4 %). Improved seeds, which constitute about 5 % of the total seed supply, were obtained from Agricultural Research Centres i.e. the formal seed supply scheme. The majority of farmers (73 %) practiced seed selection in which most of them (78 %) selected before harvesting, while the rest selected at the threshing ground during winnowing and from store prior to planting. About 92 % of the respondents' base their seed selection criteria on the appearance of individual crops such as grain filling capacity and size of seeds, which are yield oriented. Their concerns about diseases, pests, and consumptive values were also resolved through seed selection. Most often selected seeds were stored in locally made containers, while in some cases hung on roof in order to reduce pest damage through smoking. Plant species such as Vernonia amagadylina (Eebichaa), Maesa lanceolata (abbayyii), Acokanthera schimperi (qaraaruu) were used as insect repellents and insecticidal plants during seed storage in some villages.

Threats of genetic erosion were observed in most crops/varieties because of selection pressure and agro-ecological constraints. However, there was a danger of genetic replacement in maize and wheat. On average, each farmer allocated only 0.25 hectares of land to farmers' varieties of wheat (durum and bread wheat), while only 2 out of 37 farmers had grown farmers' varieties, suggesting that there is danger of genetic displacement. Farmers' practices and innovation that was associated with local seed system and knowledge underlying farmers naming of varieties and customary proverbs, folksongs and poems show communities self-contained managements of genetic resources. It is worthwhile to make rescue collection especially to capture rare types, those species of crops represented by few varieties.

CHAPTER I: INTRODUCTION

1.1 BACKGROUND

1.1.1 Origin and centres of diversity

Genetic diversity is one of the three pillars of biodiversity, which was defined at the Rio de Janeiro Earth Summit as the variability among living organisms from all sources including, *inter alia*, marine and other aquatic ecosystems and the ecological complexes of which they are part. It includes diversity within species, between species and of ecosystems (CBD, Article 2). Crop genetic diversity can be viewed at different geographical scales or levels of analysis. Variation manifests itself both among the crops and varieties grown by individual farmers and at a community level (Almekinders & Struik, 2000). Today it is a common phenomenon to encounter both farmers' varieties and improved varieties in rural parts of developing countries. The relationship between variety names and genetic variation is not well defined (Benin *et al.*, 2003). Within crops, "variety" is simply understood as crop population recognized by farmers. Farmers' varieties are defined as varieties that have been grown and selected by farmers for many years and modern varieties are varieties that meet International Union for the Protection of New Varieties of Plants (UPOV) definition. UPOV's definition of improved varieties states that the varieties should be of distinct, uniform and stable as well as "rusticated" or "creolized" types that are the product of deliberate or natural mixing of the two (Bellon & Risopoulos, 2001). Usually "name" by farmers, varieties have agro-morphological characters that farmers use to distinguish among them and that are an expression of their genetic diversity.

Seed has both private and public attributes (Smale *et al.*, 2001), and for cross-pollinating species especially, the structure of genetic variation may most closely reflect the combined practices of farmers in a community rather than that of any single household farm (Berthaud *et al.*, 2002; van Brocke, 2001). The combination of private seed choices made by individual farmers each cropping season generates the spatial distribution of distinct types and genetic diversity across the community and higher levels of aggregation. A community is the smallest social unit that has the capacity to govern the utilization and conservation of genetic resources. The scale of genetic analysis, therefore, encompasses assessment of genetic structure at a few sites at a single point in time to assessment at regional scale and/or over times.

Centre of origin is defined as the primary centre of *in situ* diversity for a given crop and continued gene flow between crops and their wild relatives can occur. Centre of diversity is defined as geographical area where a wide genetic diversity is found for particular crops and related species (Almekinders & Louwaars, 1999; FAO, 1996; UNEP, 1992). This definition is, however, difficult to rely on. In some cases, different species of the same crop might have been domesticated in different places, for example yams were domesticated in West Africa, Southeast Asia, and in Tropical America (Harlan, 1976). Furthermore, since evolution outside the centres of origin has resulted in different genetic constitution of the materials, it can be argued that these materials originate from the farms where they were further shaped and maintained. With present sophisticated methods of looking at genetic diversity, such as isozyme and molecular analysis, it has become clear that most genetic diversity in a crop is not necessarily found in its centre of origin. It is generally accepted that Ethiopia is an important domestication and genetic diversification centres of crop species and their wild relatives (Hancock, 1992; Mooney, 1979; Purseglove, 1968; Vavilov, 1951; Zeven & de Wet, 1982). Local cultivars/farmers' varieties of several major crops, e.g. durum wheat, bread wheat, barley, sorghum, field pea, faba bean, chick pea, cowpea, linseed, castor bean and wild relatives of some of the world's important crops are abundant in Ethiopia.

In Ethiopia the main cereal staples include durum wheat, bread wheat, barley, *tef*, finger millet, maize and sorghum grown in varying proportions according to soils, altitude and the prevailing climatic and market conditions during planting seasons. Cereal production comprises about 82 % of the total cultivated land area, and pulse a further 12 % (FAO, 2004a). The continued interaction of cultivated crop plants with their wild relatives under diverse ecological, social, and economic conditions has made the country one of the most heterogeneous areas of the world in terms of genetic diversity of farmers' varieties. For instance, crops that were originally domesticated outside of the East African highlands exhibit extreme secondary diversification in Ethiopia (Harlan, 1969; Vavilov, 1951). Vavilov (1951) and Harlan (1969) regarded Ethiopia as a centre of origin of many cultivated species such as *Eragrostis tef* (xaafii), *Guizotia abyssinica* (nuugii), *Rhamnus prinoides* (geeshoo), *Hygenia abyssinica* (heexoo), *Ensete ventricosum* (worqee), *Catha edulis* (jimaa/caatii) and *Coffea arabica* (buna)[1]. All of these cultivated species

[1] Brackets: Local names in *afaan* Oromo (the Oromo language)

are found in the current study area. According to Harlan (ibid), sorghum, finger millet, okra, castor bean, and sesame could be of Ethiopian origin. Numerous useful genetic variations of global significance have evolved at the local farm and farming community in the country. These diverse genetic resources are used and managed in various ways by communities.

1.1.2 Use and management of genetic diversity

For centuries, traditional farmers have developed diverse and locally adapted varieties of crops, managing them with ingenious practices that often result in both community food security, industrial agriculture and the conservation of agrobiodiversity. Farmers maintain a complex population of landraces of crops because no single variety could satisfy their main concerns like environmental heterogeneity effects, pest and pathogen problems, risk management, and demands of landraces for its cultural, ritual and dietary values. This strategy of minimizing risk stabilizes yields, promotes dietary diversity, and maximizes returns using low levels of technology and limited resources (Altieri, 2004).Diversity is the only defence against the unknown (Browning, 1988).

Crop species and their landraces are consciously fitted into three distinct farm types spread across the heterogeneous cultivated landscape in different parts of Ethiopia (Deribe *et al.*, 2002; Pretty & Smith, 2004). These are home-gardens, the nearby farm and the main crop field. Farmers consciously allocate species and landraces to these farm types in concurrence with compatibility, preference, and use values. The heterogeneous environmental conditions and the diverse cultural history of tropical and subtropical African people made the continent rich in crop diversity (Anishetty, 1994). However, the distribution of crops/landraces in traditional farms is determined by environmental conditions and farmers' objectives (Longley and Richards 1993). The pattern of species distribution within and towards home gardens follows increasing diversity (Asfaw, 2001; Okigbo, 1994).

Farmers have been the generators and curators of the rich assemblage of crop biodiversity under their custodianship. Farming communities in grain producing areas of Ethiopia manage their cropping systems employing a range of indigenous skills. Study of the dispersion of this diversity across the cultivated landscape along with associated local knowledge base is central for understanding the scientific basis of *in situ* conservation of crop biodiversity on-farm. Perspectives in this direction would provide a platform for studying the nature of crop genetic resources and relevance of ethno-agriculture in farming communities. Agricultural system that allows crops and wild species to thrive together within agro-ecosystem are viewed in the context of eco-agriculture, a concept with a promising future for biodiversity (McNeely & Scherr, 2001). The grains of sustainable biodiversity conservation are rooted in indigenous practice and they are best explained through the application of modern ethno-botanical methodology.

The genetic diversity of traditional varieties of crops is the most economically valuable part of global biodiversity and is of paramount importance for future crop production. Therefore, conservation and the improvement of plant genetic resources are central to their evolving strategies to promote their potential in meeting this demand. There is a direct relationship between genetic heterogeneity in crop plants and stable production particularly for resource-poor farmers in marginal environments. However, there is no well documented evidence to show that farmers' decisions regarding the choice of varieties is based on the level of genetic biodiversity within and between varieties (Ceccarelli, 1994). The enormous biological wealth of species, varieties, and local knowledge associated with crop genetic resources of Ethiopia is linked to the livelihood of the traditional farming community. Across the globe, genetic resources form the basis for commodities, consumer goods, and innovative products in numerous major industries. Farmers value intercropping and various other cropping systems for benefits ranging from economic, nutritional, risk minimizing, potential social value to conservation, efficient resource use or combination of these (Benin *et al.*, 2003; Deribe *et al.*, 2002). Although there are encouraging examples of farmers in many regions retaining old varieties for special needs (Qualset *et al.*, 1997), usually farmers have a logical preference for cultivars that produce higher yield and better quality and ensure stable production under seasonal fluctuations in crop growing conditions. For example, 78 sorghum landraces that are grown over 100 plots are appreciated for their nutritional value by the farmers in different agro-ecological sites, in north Shewa and south Welo regions of Ethiopia (Abdi, 2000). Similarly, 34 sorghum, 16 *tef*, 13 small rain season (*belg*) barley, 16 main rain season (*kiremt*)[2] and 20 main rain season wheat landraces have been identified for a range of agro-morphological and socio-economic uses in north Shewa (Mengist,

[2] Brackets: Local names of main and small rainy seasons in Amharic

1999). Traditional management of crop genetic resources that are based on use and preference values could be useful for choosing conservation strategies pertinent to target crop species in a given ago-ecological conditions.

1.2 RESEARCH MOTIVATIONS AND JUSTIFICATION FOR THE STUDY

Agriculture is the single most important sector of Ethiopia's economy and plays a vital role in terms of food security and economic growth. It accounts for 45 % of the GDP, employs 85 % of the labour force, generates over 90 % of the foreign exchange earnings, and supplies the bulk of the raw material inputs to the industrial sector (Anon, 2005; FAO, 2004a). However, growth rate in agriculture is much less than population growth rate. For instance during the period 1992-2002 annual average population growth rate was 2.7 % while the annual average growth rate for agriculture was 0.67 % (MOFED, 2002).

Rapid population growth has brought about several changes in the traditional cereal farming systems in Ethiopia. Fast changes are taking place in landscapes, farming systems and individual crops as well as peoples' lifestyles. That means actual and potential threats are progressing from different directions thereby affecting the sustainability of traditional farming systems. The changes are in the forms of expansion of agricultural land to more marginal and fragile lowlands as well as steep slopes which were previously used as pasture and forest lands; shrinkage and fragmentation of farm holdings, reduced farmers' ability to practice crop rotation and fallowing; replacement of local seed system by formal seed system, expansion of use of improved varieties, shifting from organic to inorganic fertilization of farms as crop residues became major animal feed and animal manure is becoming important sources of fuel by the farming communities (Anon, 2003). Moreover, the Ethiopian agricultural sector comprises heterogeneous environmental conditions with diverse agro-ecological settings representing different farming systems with different potentials and constraints. The crops grown are diverse and reflect the complicated mosaic of agro-ecologies derived from soil types ranging from vertisol to sand and cropping altitudes ranging from more than 3000 meters to less than 600 meters above sea level (FAO, 2004a). However, a checklist of crop diversity is not made for all regions of the country.

Despite changes in traditional farming system, however, little attention has been paid to understanding how traditional farming systems function. Very few studies have examined the significance of traditional farming system. This, for example, contrasts considerably with the extensive studies going on concerning improved varieties and formal seed system in modern agricultural system. The current sustainability debates highlights this lack of knowledge and recommend that field studies of traditional system should be undertaken to fill the gap (Cromwell, 1996).

In connection with the current displacement of landraces by improved varieties of crops, the claim that improved varieties of few crops feed the world should be critically reviewed. Subsistence farmers increase their options by diversifying the small plots of land instead of homogenizing their fields with high external inputs and uniform varieties. Factors explaining this diversification in communities and on household farms vary among regions and need to be studied. The negative lesson learnt from the Green Revolution is that it has accelerated genetic erosion and undermined farmers' efforts to conserve, improve and utilize their traditional varieties, endangering long term food security (UN-ECA, 2004). For many years government agricultural policy did not adequately address the role and contribution that farmers' varieties could play. This is partly due to lack of information regarding the traditional ways of life using farmers' varieties and partly because of the ambition to fill gaps in food security. However, farmers have a wealth of knowledge on seed selection, storage and farm management. They know how to reduce risk and contribute to resilience, food security, and income generation under the subsistence farming systems. On the other hand, information on traditional farming system is scanty. It is also unclear as to how these farmers' practices within the farming system influence agricultural development. Specifically, the flow of seeds and information both within and between the local and formal systems is not well understood. Seed selection and storage practices of local communities are factors that are directly associated with agrobiodiversity conservation. A thorough understanding of farmers' knowledge in traditional farming and their management skills and the effect of these on the rural economy is specifically necessary for the designing of appropriate agricultural and rural development policies and strategies.

Biodiversity is fundamental to the growth of agricultural production and food security as well as to environmental conservation in Ethiopia. Equally important as genetic erosion of farmers' varieties is the loss of biodiversity in natural habitats due to the expansion of commercial agricultural production that are based on few improved varieties into the remote and virgin areas. Genetic erosion of crops and their wild relatives is accelerating at a high rate because of human activities in Ethiopia (Worede, 1997). The recurrent drought in the past decades has eroded considerable amount of biodiversity in the country. Furthermore, less is known about the causes and the degree of genetic erosion on local varieties of crop plant species or list of varieties/species lost in various parts of the country. Knowing the causes of genetic erosion is equally important for devising conservation measures. Likewise, identifying local crop varieties and associated wild relatives that are lost or are on the verge of extinction, play crucial role in designing and implementation of conservation policies.

The findings from the research and recommendations to be made will hopefully be of use to planners, policy makers, researchers, and enable them to formulate appropriate policies, to coordinate further research efforts and focus those efforts on research geared towards improving critical problems of farmers. In particular, the research on traditional management of crop genetic resources in such marginal areas will recommend on-farm conservation and further development of farmers' varieties.

The objectives of the study were to identify inter-specific and infra-specific diversity of crops and study farmers' traditional knowledge, innovations and practices related to conservation and management of crop genetic resources in communities and on household farms in Gindeberet district, west central Ethiopia. The study attempted to examine factors explaining crop diversity by applying a choice model in which the farm and household characteristics determine area shares planted to diverse crops by farm households. Furthermore, the association between varieties of crops and factors influencing their maintenance were investigated.

1.3 RESEARCH QUESTIONS

With the above justification and objectives in mind, this study was carried out to answer the following questions.

a) What are the inter-specific and infra-specific diversity of crops as well as their wild relative species found in Gindeberet?
b) How are crop diversity and their wild relative species distributed across landscape and agro-ecological zones?
c) What are the factors explaining crop diversity on household farms?
d) What are the relationships between maintained varieties and variables governing their maintenance?
e) What are the available seed supply systems? What are the associated knowledge, innovations, and practices?
f) What are the threats to genetic erosion of crop species/landraces and their wild relative species in the area?

1.4 THESIS STRUCTURE

The first chapter of the thesis introduced genetic diversity in agriculture. It highlighted on the origin and centres of diversity. It also presented the research motivation and justification for the study. In connection with this, objectives of the study and research questions were given. The remaining chapters cover a range of topics on the study. Chapter 2 presents issues related to the current studies that have been dealt within different literature. It broadly describes formal and local seed supply systems. Specifically, detailed feature of seed acquisition, flow, selection and storage are presented. The chapter took upon concepts and causes of genetic erosion at the end. Chapter 3 begins by providing description of the study area, including general information with respect to its geographical location, soil, climate, vegetation, demographics, patterns of land use and agricultural system. The chapter presents the methodology employed in the research. Details of procedure on selection and sampling of both study sites and respondents are provided. Data collection techniques, data entry, and analysis are described.

The fifth chapter deals with the core result of the study and discussion of results. Checklists of crop diversity and wild relative species of crops are provided. Crop lay out across landscape and agro-ecological zones are described for the area. The chapter covered local uses of crop diversity from farmers' perspective and farmers' reasons for the maintenance of diverse crops on their farms. Factors explaining crop diversity maintained on household farms is also discussed. The association between maintained varieties and important agro-morphological, socio-economic, and culinary attributes is presented. In connection with conservation of crop diversity, vernacular names of varieties, proverbs, folksongs, and poems are presented. Farmers' seed sourcing, selection, storage, and diffusion in the area are illustrated. Socially defined institutions that existed in the area for inter-household cooperation is outlined. The chapter finally discusses genetic erosion from the point of view of spatial displacement of farmers' varieties and number of farmers growing landraces of crops that have competent improved varieties in the area. Targeted selection pressure by farmers and heterogeneity of farming system are discussed as underlying concepts of genetic erosion. The last chapter concludes how local knowledge related to the use and managements of crop genetic resources affected the maintenance of diverse populations of varieties. It also revel research gaps and gives recommendations towards conservation and developments of farmers' varieties in order to ensure food security in the area.

CHAPTER II: LITRATURE REVIEW

2.1 SEED SUPPLY SYSTEMS

In all kinds of agriculture, seeds and vegetative planting materials are basic inputs. The seed system is composed of organizations, individuals and institutions involved in the development, multiplication, processing, storage, distribution and marketing of seeds (Maredia & Howard, 1998). Use of seed system at farm level may be flawed; rather it explains the different ways that farmers access seed at the farm level. Seed and the accompanying knowledge systems are valued in all farming communities as a major cultural element. There are two basic seed supply systems among farming communities. These are formal and informal seed systems.

2.1.1 Formal seed supply system

The formal seed supply system is the chain of activities from breeding to marketing/distribution that are operated by specialized public and private organizations and supported by well-defined rules and procedures supplying seeds to farmers with some level of quality assurance. It only covers 10 % of the seed requirement in developing countries (Almekinders & Louwaars, 1999; Louwaars & Tripp, 1998). That means 90 % of the seed requirement is covered by the local seed system. The formal seed system is designed along the industrialized country's organizational patterns of seed supply and has replaced the age-old local seed supply systems in some regions and crops. The formal seed supply system has highly centralized organizations dealing with only one or few (homogenous) varieties of crops.

The formal seed system is vertically organized in which activities follow each other. There are links between plant breeding, seed multiplication, and seed distribution activities. In Ethiopia the development of the seed industry involves different institutions (Tadesse, 1998). The farmers' varieties that are collected, characterized, and conserved by the Institute of Biodiversity Conservation (IBC) with their passport data are accessible to plant breeders at the Ethiopian Agricultural Research Organization (EARO) and researchers at universities. The National Committee for release of crop varieties approves the release of improved varieties. Improved varieties that are proved promising are given to Ethiopian Seed Enterprise (ESE) for multiplication/production, processing, and storage. The National Seed Industry Agency (NSIA) of Ethiopia deals with seed legislation on sale and distribution. Before it started to operate independently, the Ethiopian Pioneer Hybrid Incorporated (EPHI) was working as a joint venture with ESE to produce basic seed of hybrid maize and sunflower. Despite the involvement of those institutions in the Ethiopian formal seed supply system there is no facilitated cooperative linkage and coordination between the various participants in the seed industry.

In this regard farmers in the study area have obtained few varieties of crops such as wheat, maize, lentil and faba bean through the established channel in the past two decades. Even then, only few farmers used the source and the supply was not on regular basis.

The formal seed system is important for a very limited number of crops in developing countries (Louwaars & Tripp, 1998). Louwaars and Tripp (ibid), indicated that public formal systems commonly deal with the most important crops such as rice, wheat, maize, and cowpeas (Louwaars & Tripp, 1998). Similarly commercial formal seed systems concentrate on high value seeds such as hybrid maize, pearl millet and vegetable seeds. The formal seed sector serves part of agricultural production system, but is poorly equipped to meet the diverse need of small-scale farmers like the ones in Gindeberet. Farmer's access to seed from the formal seed sector depends on the community proximity to market places and wealth status. Rather, these farmers derive their seed from local seed sources. The integration of local and formal seed systems at the point where the systems meet can significantly contribute to the functioning of both systems (Louwaars and Tripp, 1998).

2.1.2 Local seed supply system

Local seed supply systems, also called 'informal seed supply system' or farmers' seed system is defined as systems in which selection, seed production and seed exchange are integrated into crop production and socio-economic processes of farming communities (Almekinders & Louwaars, 1999). It is largely composed of individual farm households, which are heterogeneous in space and flexible in time. It comprises the practices, knowledge and social relations which farmers use to promote the usefulness of crop genetic resources. Specifically, it deals with the processes, which farmers use to produce, obtain, maintain, develop, and distribute seed resources, both from one growing season to the next and in the long-term. The processes, therefore, combines social and technical perspectives, and the dynamic ways in which these two perspectives interact. It is only in the last two decades that farmers' seed systems have begun to be recognized as a valuable resource in agricultural development. Now a day it mainly deals with seed security, quality, and availability in the local situation.

In centres of diversity, the local seed system remains important as source of valuable genes in crop improvement. The repeated production, selection, and conservation under local conditions, allowing for the effects of mutations, hybridization and selection pressure, represents a dynamic evolutionary process. The local seed system provides over 80 % of the total amount of seed planted in both developed and developing countries (Cromwell, 1996; Louwaars & Tripp, 1998). For centuries, the smallholder Ethiopian farmers have used own saved landraces for agricultural production. Even today, most (85 %) of the Ethiopian farmers are believed to be depending upon these seeds (Tadesse, 1998; Tafesse, 1998). Not all crop species are developed into improved varieties in the country. Besides, the distribution of improved varieties is limited by diversity of agro-ecological zones and poor infrastructure. Consequently, farmers' demand for seed is met from local seed sources using farmers' varieties. A typical aspect of local seed systems is that they may maintain a wide diversity within and among varieties or landraces as a response to diverse ecosystems and local markets. Despite the extreme severities of difficult conditions like drought and war there is an apparent resilience of farmer seed systems where farmers retain their seed stocks or obtain seed from sources within their communities (FAO, 2004a). The social ties and networks play a crucial role during seed emergencies and contribute to resilience of local seed supply. Understanding the local seed supply system is important in implementing site-specific crop genetic resource conservation program.

2.1.2.1 Seed acquisition and seed flow

Acquisition of seeds by farmers forms one of the most important aspects of local seed systems. Seeds are acquired in several ways depending on the social networks and economic situation of the farmer in a community. Much of the seed planted by farmers (50-80 %) is seed that farmers have kept from the previous harvest (Longley & Richards, 1998; Teshome *et al.*, 1997) and most of these seeds have high quality (Wright *et al.*, 1995). Farmers prefer their own seed because it is the cheapest, most available, and of variety that the farmer is familiar with (Almekinders &

Louwaars, 1999). However, those who are unable to retain part of their harvested output, or farmers who decide to plant a different seed variety, acquire seed from within the local community or within the farmer's wider social network. They also agree that farmers who do not have their own saved seeds prefer seeds from relative, friend, or neighbour because it is of known quality and inexpensive compared to seed from market, intermediaries, and commercial seed enterprises. A national seed programme is often useful because it serves as sources of seeds of new varieties. Different scholars described many different ways of acquiring seed in the local system (e.g. Almekinders & Louwaars, 1999; Louwaars & Tripp, 1998; Teshome *et al.*, 1997). These are by saving seed from the previous harvest; as loans, gifts, or other forms of reciprocal assistance (including seed-for-seed exchanges between farmers); and by purchasing seed (either for cash or in exchange for other commodities) through markets or localized trade networks. Seeds can also be acquired by merely asking or begging, and this does not oblige one to give something in return (FAO, 2004b) .

The acquisition of new crop species/varieties depends on the proper functioning of traditional forms of gift-giving, the availability and affordability of transport services and an economic infrastructure to support the marketing of goods and services (Louwaars & Tripp, 1998). In this regard, the wealth category to which farmers belong determines farmers' ability to access seed from different seed sources. In fact, money and social networks in a community is what plays a great role in traditional seed exchange practices. Money is important in transactions exchanging seed resources, which makes it a key asset in seed security. Longley & Richards (1998), agree that those who are least able to access seed in normal times (usually the poor) are the ones who suffer the most in terms of reduced seed access in times of crisis. Despite the penetration of markets in the local economy, traditional coping strategies based on local processes of seed exchange are still important.

Seed acquisition systems, therefore, are social systems and their vulnerability and resilience depends on how the social basis for seed exchange is affected by social and economic changes (Longley & Richards, 1998). Different livelihood strategies and household responsibilities of different farmers (e.g. according to age and gender) may also partly determine how seed is acquired. For example, variations in seed sources for male and female rice cultivators from two neighbouring ethnic groups (Susu and Limba) in northern Sierra Leone reflect that Susu women have greater involvement in trade activities (Longley & Richards, 1998). In this study it was indicated that for both ethnic groups, women tend to rely more than men on acquiring seed through loans, gifts and reciprocal assistance.

An investigation of the seed exchange system focusing on the local crop diversity would also be important in the assessment of plant genetic resources conservation. The role of village grain traders as sources of credit in kind, and of older more established farmers (women as well as men) as agents of informal inter-seasonal seed, exchange is often vital to the proper functioning of a community seed system.

Farmers have different reasons for using seed from other sources and for using seed from sources of own preference. The later mainly depends on the quality and price of the seed (Almekinders & Louwaars, 1999). Furthermore, the need to get a new variety, inability to save seed, the need to replace farmers' own diseased or 'degenerated' seed, unfavourable seed production conditions, inability to produce a variety, inability to store quality seed for long period, the need to specialize own production for market are reasons why farmers use seed from other sources. Such reasons as quality and price of seed seem to affect farmer's sources of seed preference and seed flow within farmers in a community. Moreover, the impact of formal seed programme and social networking in local seed system seem to affect the diffusion and flow of seed in a farming community. In North central Ethiopia, for example, community social organization, local markets and church saint celebration holydays are ways by which landrace seed and associated knowledge diffuse (Mengist, 1999). Even if such social network exists for the continuity of local seed system to function, modernization of agriculture seems to affect its long-term sustainability.

2.1.2.2 Seed selection and storage

Seed selection has emerged with the domestication of cultivated plant species. The local farming communities have played a key role in maintaining the diverse crop resources in the form of farmers' varieties by way of selection over generations. In addition to being affected by population structure and natural selection from the surrounding environment, crop diversity in agricultural systems is also affected by farmer selection of agro-morphological traits and management (Jarvis & Lallemand, 1998). The farmer's choice to grow certain crops and particular varieties of these crops is based on a complex set of decisions. These are based on needs and expectations of individuals, farm household, and community. In many cases, farmer’s selection criterion to maintain a particular landrace at any given time depends on the ecological factors as well as on the cultural and socio-economic factors. For some crops (e.g. *Guzotia abyssinica*, *Sorghum bicolor* and *Eragrostis tef*) farmers’ varieties are found along with their wild relatives in the agro-ecological environments of Ethiopia. The continued interaction of cultivated crop types with their wild relatives under diverse ecological conditions, climatic factors, and socio-cultural evolution is often given as explanation for Ethiopia’s Vavilovian centre of origin/diversity for several cultivated crop species. In fact, the existence of wild relatives of crops in the agro-ecological system has contributed to the heterogeneity and diversity of these crop species.

The traditional criterion for selection of farmers’ varieties among Ethiopian farmers include adaptability, high yield, reliable and stable yield, cooking quality, taste, colour, disease and pest resistance, grain size and texture (Worede & Mekbeb, 1993). The criteria of seed selection are often associated with morphological features of the plant by farmers. Farmers’ varieties are normally distinguished by farmers in terms of their agro-morphological characters (Teshome *et al.*, 1997) which are the results of many years of activities of isolation, selection and hybridization (Harlan, 1975). Farmers’ criteria of seed selection and varietal identification are often integrated with the culture of the community. As the result farmers’ indigenous knowledge about local cultivars could be expressed in terms of popular sayings, songs and poems (Abdi, 2000; Mengist, 1999; Tsehaye, 2004).

Traditional seed selection by farmers improve the vigour of the seed and adaptation to changing growing conditions in a way enabling farmers to get better seed interims of yield and yield stability, resistance to pest and drought tolerance, nutritional quality, market preference and straw quality. Farmers’ selections to attain these goals follow different methods (pure line and mass selection) that are realized during different phases of seed production. Seed selection practices include selection during planting, selection after harvest (before threshing and storage), marking during maturity period, picking before the harvest and selection of field for seed production separate from crop production field (Almekinders & Louwaars, 1999). Most farmers practice pre-harvest selection. This timing of seed selection could be related to farmers' reasons for seed selection. All members of the household are involved at different levels of seed selection practices. Specifically, children are always involved, and transmission of skills to the next generation is emphasized (Berg, 1994).

Lack of standardized storage facility affect the health of saved seeds and food grains in many ways. In fact, the major post harvest loss by small-scale farmers is attributed to poor storage facility. The main factors affecting the health of seed and food grain under local storage condition is high temperature and moisture. High temperature and moisture favour the development of insects and fungi. Moreover, damage caused by rats and termites is due to poor storage structures and practices. Hence, understanding local storage systems, which are critical in the maintenance of crop genetic resources, is crucial.

Some farmers store both planting seeds and food grains in bulk. Others store seed and food grains separately. In practice, seed storage methods depend on crop types, farmer's preference, and storage practices and vary between different households. For instance, both planting seeds and food grains are stored in bulk for *Eragrostis tef* (*tef*) because of its long-term storability (Worede & Mekbeb, 1993). Crops (e.g. maize, barley, and sorghum) that are easily damaged by insect pests are stored separately as planting seeds and food grains. In most cases Ethiopian farmers store planting seeds either in containers (earthen pots and jute bags) or hung on the roof whereas food grains are stored in traditional storage spaces such as conventional storage containers like *gotooraa*[3] , warehouses and outdoor silos (Worede & Mekbeb, 1993). The techniques used in storage are embedded in custom and has passed down through generations.

Before storing the seeds are first dried, sometimes smoked, and treated with chemicals. The primary concern of storage is to prevent deterioration of quality of the seed. Many researchers have studied diverse storage facilities that are available in different parts of the country. For example, some farmers hang maize cobs on the walls inside the house in order to reduce pest

[3] Name in *afaan* Oromo for medium and large sized cylindrical or rectangular bamboo/shrub stick made structures and built on a bed having four forked support poles as an integral part of it (Figure 8c). It is plastered with mud and dung and dried before use for storage.

damage (Mengist, 1999; Worede & Mekbeb, 1993) and keep in air-tight underground pit storage (Teshome, 2001). In these literature it seems that seed storage materials and storage techniques vary from one agro-ecological zone to another depending on the temperature of the area. Factors affecting seed storage for the next planting season influence the availability of seed and seed exchange among farmers. As part of traditional farming local storage practices mentioned above by the local communities, however, can improve the shelf life of the seed and its availability.

2.2 GENETIC EROSION

The number of different species on which we rely for food, fibre, medicine, timber and other natural products is extremely limited. Of an estimated 265,000 species of plants, only about 7000 have ever been cultivated or collected for food. Of these, 20 species currently supply 90 % of the world's food and just three (wheat, maize and rice) supply more than half (Zedan, 1995). Another analysis of data on a country-by-country basis indicated that 103 species of plants contribute 90 % of the world plant food supply (Prescott-Allen & Prescott-Allen, 1990). Today world's biological wealth is being depleted at an ever-increasing rate and this will adversely affect the well-being of people in both industrialized and developing nations. It was pointed out that while loss of genes is of particular concern, loss of gene complexes and unique combinations of genes (as in different landraces) could also have important consequences. Genetic erosion, therefore, may be defined as a permanent reduction in richness or evenness of common localized alleles or the loss of combination of alleles over time in a defined area (Guarino, 1998).

Genetic diversity is always changing, but the Report on the State of the World's Plant Genetic Resources (FAO, 1996), summarizing country reports, suggests that "recent losses of diversity have been large, and that the process of 'erosion' continues". It is said that, of the 10,000 varieties of wheat, which were in use in China in 1949, only 1,000 remained in 1970. In United States of America, 95 % of cabbage, 91 % of field maize, 94 % of pea, 86 % of apple and 81 % of tomato varieties of last century have been lost (Arunachalam, 1998). From this, it is clear that the trend of genetic erosion is worrisome. Nevertheless, monitoring genetic erosion of crop species/varieties at any scale requires understanding of the concepts and causes of genetic erosion.

2.2.1 Concepts of genetic erosion

Genetic erosion is a process acting both on wild and domesticated species. It is also both natural and manmade process. Naturally, it occurs when there is inbreeding between members of small population that will reveal deleterious recessive alleles. It causes a population "bottleneck" by shrinking gene pool or narrowing the genetic diversity available. This natural process could be the causes for the losses of heterozygosity that reduces the adaptive potential of every population (Caro & Laurenson, 1999). In cultivated plants, genetic erosion is the loss of variability from the population i.e. the loss of heterogeneity of alleles and genotypes with their attendant morphotypes and phenotypes. The American plant explorers are credited for first recognizing the problem of genetic erosion in crops (Harlan & Martini, 1936). A striking thing about Harlan and Martini's observation is that it occurred relatively early in the deployment of crop science to improve and distribute modern varieties and relatively early in the science of crop population biology. The concept emerged forcefully late in the 20^{th} century, in a period when crop improvement had clearly demonstrated its power to transform local crop populations in industrialized countries and in some less developed regions.

The concept of genetic erosion of farmers' varieties was elaborated based on a model of crop population structure in centres of diversity (Frankel, 1970). Frankel's definition rests on five principles. These are diversity in crops exists because of adaptation by localized populations; pre-modern agriculture in centres of diversity is stable; introduction of modern (exotic) agricultural technology, including modern varieties, is a recent phenomenon and leads to instability; competition between farmers varieties' and introduced varieties results in displacement of local varieties; displacement of local varieties reduces the genetic variability of the local crop population. Frankel's principles to understand genetic erosion mainly signify the fact that introduction of agricultural modernization, intensification of production, commercialization and habitat destruction are causes of loss of crop genetic resources.

The observation of genetic erosion was largely subjective and only rarely because of a focused research effort. On top of this, time series data on biological variability for crops and on agriculture (for example on the extent of modern varieties in centres of diversity) is not available. This has resulted in difficulties for the formal assessment levels of genetic erosion at all scales.

Longitudinal instead of direct observation and formulation of the theoretical base for the concept of genetic erosion has been suggested as a solutions for solving the difficulties of this assessment (Brush, 1999).

2.2.2 Causes of genetic erosion

Agenda 21 of the Rio declaration on environment and development states that, 'the current decline in biodiversity is largely the result of human activity and represents a serious threat to human development'. Generally, habitat loss or modification, over-exploitation, introduction of exotic species, disturbance, disease and limited distributions are quoted as factors currently endangering biodiversity (Muchiru, 1985; WCWC, 1992). Threats endangering the genetic diversity of cultivated plants could be seen from global environmental change and international economic pressure to crop specific problems. In view of this, fragmentation of farm holdings, allowing farmers to maintain landraces in at least one field; increasing cultivation of marginal land, where landraces tend to have an advantage over modern varieties; economic isolation, creating market distortions which give landraces a competitive advantage; and cultural values and preferences for diversity are important factors in preserving crop diversity. Any process that counter-balances this situation could cause genetic erosion of crops (Brush, 1993). Similarly farmers' local knowledge of crops associated crop diversity lost as the result of such causes (Kebebew, 1997).

Ethiopia has economically important plant resources and rich wild gene pools of cultivated species. It is acknowledged that these are an important source of genetic variation for the plant breeding of commercial crops. The Ethiopian crop wild relatives are increasingly threatened by genetic erosion and extinction mainly due to habitat fragmentation and over-exploitation. Currently, farmers and their systems of production face new challenges from genetic erosion, ecological degradation, and pressures to produce more from the land. The most crucial factors for genetic erosion in the country include displacement of farmers' varieties by new, genetically uniform crop cultivars, changes and development in agriculture or land use, destruction of habitats and ecosystems, and drought (Worede, 1997). Moreover, the famine that persisted in some parts of Ethiopia has forced farmers to consume their own seed in order to survive or to sell the seed as a food commodity. This often resulted in massive displacement of native seed stock (mostly sorghum, wheat, and maize) by exotic seeds provided by relief agencies in the form of food grains in the country. The extent to which the displacement of farmers' varieties by exotic/improved materials occurs has not yet been fully studied. This would also vary between regions and crops. In response to such erosion, various genetic resource conservations are adopted today. In the next section crop genetic resource conservation strategies are discussed.

2.3 GENETIC RESOURCE CONSERVATION STRATEGIES

2.3.1 Ex situ conservation

Ex situ conservation of plant genetic resources is mainly based in genebanks. It aims to conserve as much as possible of existing genetic diversity of cultivated species with their infra-specific *taxa* and wild species of potential use outside agro-ecosystems (Alvarez *et al.*, 2005). *Ex situ* conservation, strategy is limited in that there could be loss of genes or materials in case of failing infrastructure and low level of knowledge regarding optimum storage conditions and seed biology. Furthermore, an important characteristic of genebanks is that they 'freeze' the evolution of the stored genetic materials. It arrests the most complex interaction of genetically diverse farmers' varieties with the associated pests, diseases, climatic factors and wild and weedy relatives. It also fails to retain traditional knowledge associated with landraces, which can be instrumental in the management of genetic resources (Kebebew, 1997) . The Institute of Biodiversity Conservation (IBC) in Ethiopia is actively implementing conservation of crop species, largely in *ex situ* gene banks. So far the Institute holds about 61,000 accessions of plant genetic resources of which 90 % consist of germplasm of field crops (IBCR, 2001). However, not all farmers' varieties from all regions and wild relatives of these crop species, which are also of socio-economic value as gene donors to crop species (Cooper *et al.*, 2001; Hoyt, 1998), are sufficiently collected and conserved.

2.3.2 In situ conservation

In situ conservation is an ecosystem and habitat-based conservation strategy, which allows the maintenance of organisms in their natural habitat. Maintaining genetic variation *in situ* as a complementary strategy to conservation in genebanks has re-emerged as a scientific question in recent years (Bretting & Duvick, 1997; Brush, 2000; Maxted *et al.*, 1997; Sutherland, 2000). For cultivated crops, conservation of genetic resources *in situ* refers to the continued cultivation and management by farmers of crop populations in the open, genetically dynamic systems where the crop has evolved (see on-farm conservation below). Under this system, crops co-evolve with diseases, pests, and weeds by developing mechanisms of co-existence through time. The diversity of crops maintained on farms has both inter-specific and infra-specific components. Inter-specific diversity is the diversity among crop species, while infra-specific diversity is the repertoire of varieties of a crop that farmers grow simultaneously (Bellon, 1996). For conservation of wild relatives of crop species, *in situ* method is given priority and community seed conservation practice on-farm has been taken as a tool for agrobiodiversity rural development projects in many countries around the world. However, *in situ* conservation is facing challenge from the expanding human population with irreversible influence on native environment. In Ethiopia the Institute of Biodiversity Conservation is mandated to conserve biodiversity in general and has established various *in situ* sites (field genebanks) for conservation of coffee and other horticultural crop genetic resources in particular (IBCR, 2001). Understanding the population management processes involved to ensure inter-specific and infra-specific components of genetic conservation *in situ* and the attempt to develop practical techniques to achieve this goal is useful for plant conservationists. For cultivated plant species, this concept is being used in on-farm seed conservation practices.

2.3.3 On-farm conservation

On-farm conservation involves farmers' continued cultivation and management of a diverse set of crop populations and accompanied *taxa* in the agro-ecosystem where the crop evolved, or in secondary centres of diversity (Almekinders & Louwaars, 1999; Bellon *et al.*, 1997). *In situ* conservation of genetic resources can also specifically target the conservation of local varieties or landraces (Alvarez *et al.*, 2005). In this case, the farm or agro-ecosystem is considered the habitat where the genetic diversity developed or originated. Conservation at farm level allows continuing farmer selection, interaction with environment and gene exchange with wild species so that evolution of the landraces may continue. On-farm conservation practices by farmers, therefore, influence evolutionary forces acting on crop plant populations. Farmers' criteria in seed selection and the goals of selection, choices among varieties, and spatial arrangement of planting in ways that encourage hybridization between varieties that are associated with on-farm activities maintain continuous evolutionary genetics of crop plants in traditional agro-ecosystems (Alvarez *et al.*, 2005; Bellon *et al.*, 1997). By default, this conservation practice still exists in marginal areas of most developing countries.

Ethiopia is one of the world's richest regions of crop diversity and its genetic resources are of considerable value both within and outside Africa. Among numerous examples are the yellow dwarf virus (BYDV) resistance gene found in Ethiopian barley, on which California's US $160 million annual barley crop depends, as well as the high lysine gene in sorghum. Much of this diversity is still in the hands of the farmers, despite the depletion of some. The recognition of the situation has served as a basis for the inception of on-farm farmers' varieties maintenance and enhancement strategy, in the year 1989 through the project entitled "A dynamic Farmer Based Approach to the Conservation of Ethiopia's Plant Genetic Resources" funded by the Global Environmental Facility (GEF). With this project it was possible to establish 12 on-farm conservation sites and community genebanks to link farming communities and their varieties with the existing formal genetic resource conservation undertaken by the IBC in six agro-ecological regions (IBCR, 2001). A consortium of Canadian NGO's headed by the Unitarian Service Committee of Canada (USC/C) also supported on-farm conservation of farmers' varieties in drought-prone areas of Ethiopia. However, such projects seem to loose their long-term sustainability because of lack of connection to the socio-cultural basis of on-farm conservation in project implementation sites. Generally, on-farm conservation program encourages smallholder farmers in selected areas to continue growing landraces of several staple crops, which are in danger of being displaced by high yielding varieties. Nevertheless, intensification and mechanization of agriculture accompanied with the fast changing land use system have affected the success of *in situ* conservation. As the result in today's conservation and practical development of crop genetic resource *ex situ* and *in situ* conservation strategies are used complementarily.

2.3.4 Ex situ and in situ/on-farm as complementary conservation strategy

Dynamic (*in situ*) and static (*ex situ*) conservation strategies have a complementary function in genetic resource management and utilization (Worede, 1997). Many genebanks were created to provide the material to breeders and other potential users. Now a day, the need to ensure the availability of genetic material with information for future generation is gaining importance.

Therefore, *ex situ* conservation could play a buffering role and could be a back up against some unpredictable evolution (Berthaud, 1997) and could also be involved in the availability and use of germplasm for the improvement of a variety of crops. For sustainable genetic resource development, part of *ex situ* conservation should be envisaged as connected with dynamic, *in situ*/on-farm conservation. In some cases, short or medium term established *ex situ* conservation might serve restoration of crop varieties on-farm beyond its role to maintain valuable genes for future use.

In situ conservation is particularly useful for conserving semi-wild species or wild relatives of crop species (Almekinders & Louwaars, 1999). It is particularly relevant for habitats where crops and their wild relatives occur together, and which are under such pressure that the wild relatives might disappear. *In situ* conservation could help preserve and maintain knowledge, innovation and practices of indigenous and local communities embodying traditional lifestyles relevant for conservation and sustainable use of crop genetic resources (Kebebew, 1997; UNEP, 1992).

The combination of these dynamic and static conservation strategies, therefore, maintains evolution of materials conserved and associated traditional knowledge. Local plant development with integration of plant breeding and seed system is the basis for such conservation strategies maintaining, stimulating, and enhancing the dynamics of the community management of plant genetic resources.

CHAPTER III: METHODOLOGY

3.1 DESCRIPTION OF THE STUDY AREA

Since there are no published resources on Gindeberet, description of the study area is based on the information obtained from the district offices and personal observations during the fieldwork. The Zonal Atlas of west Shewa and some unpublished sources were also used for background information to describe the study areas.

3.1.1 Geographical location

The study was carried out in Gindeberet district, West Shewa Zone of Oromiya National Regional State, Ethiopia, between astronomical grids of $9^0 21'$ to $9^0 50'$ N and $37^0 37'$ to $38^0 08'$ E (PEDOWS, 1997) (Figure 1). The district town, Kachisi ($9^0 32'$ N and $37^0 49'$ E) is geographically located approximately at the centre of the district 193 Km west of Addis Ababa and 138 Km north of Ambo (Anon, 2005). The total area is 2417.82 Km^2. Elevation varies from 1000 to 2604 m meters above sea level (EMA, 1988; PEDOWS, 1997). The boundaries separating the district from other region/zones/districts in most cases have natural features, mainly rivers. For instance, Blue Nile River is the boundary between Amhara National Regional State and Gindeberet district.

Gindeberet is a district bounded by lowland gorges and rivers and it has only one access road recently constructed in the south leading to Addis Ababa. It is bounded by different scale of administrative units that varies from districts to a region. According to the current demarcation Gindeberet is bounded by Amhara National Regional State in the north, East Wellega Zone in the west, Jeldu, Ambo and Mida Kagni (not shown on the map) districts in the south and Meta Robi district and North Shewa Zone in the east (PEDOWS, 1997)(Figure 1).

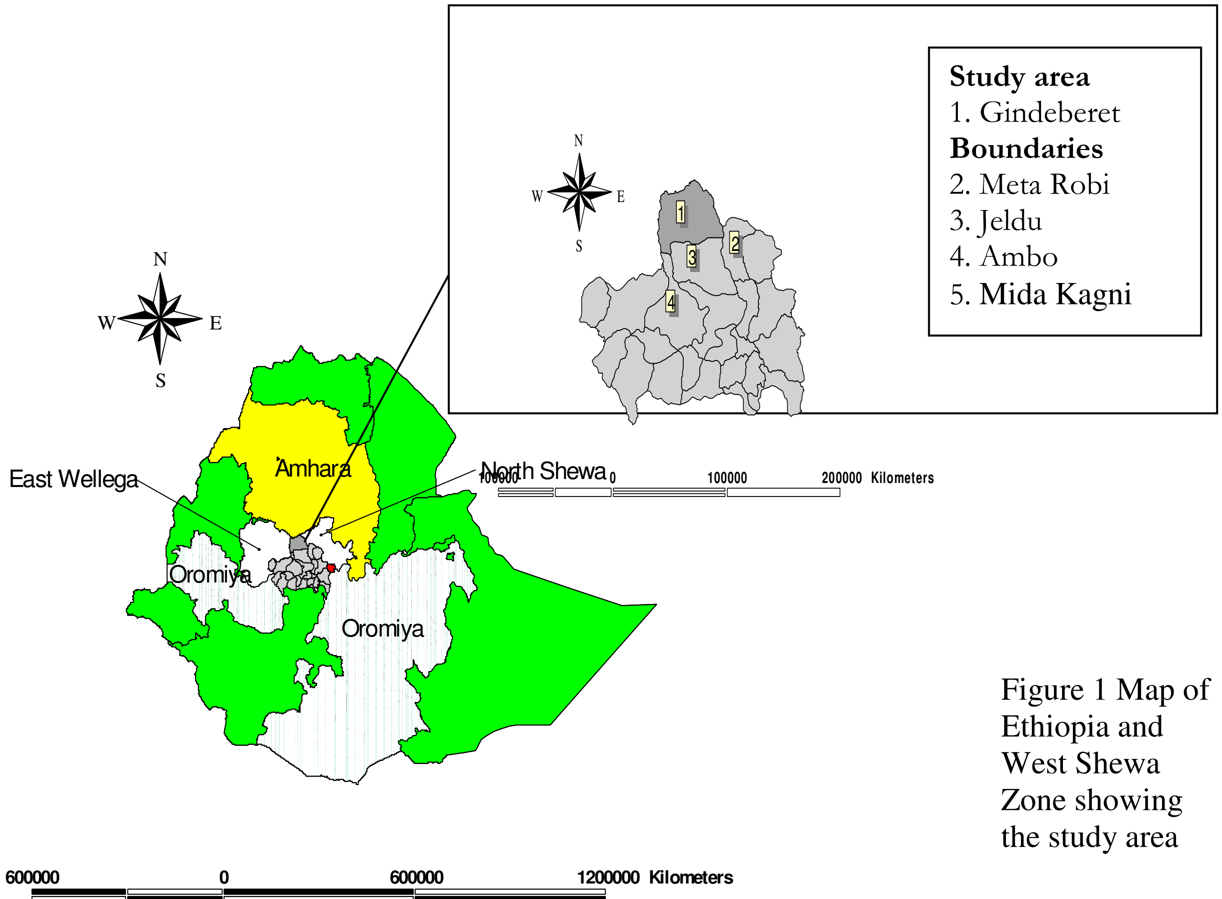


Figure 1 Map of Ethiopia and West Shewa Zone showing the study area

3.1.2 Soil

In Gindeberet, soils are predominantly developed on Trap series of volcanic and *felic* and metamorphic Precambrian material (PEDOWS, 1997). The Precambrian rocks are common in the western and northwestern extreme points of Gindeberet. Lower *Antalo* limestone and *Adigrat* sandstone occurs in the central plateau sediments of Gindeberet. The district is also rich in Marble. The range of parent materials in the high plateau is not strongly reflected in soil development because of high rainfall (PEDOWS, 1997). The physical and chemical compositions of soil have a considerable influence on the distribution of crop plant species. The soils in Gindeberet are mainly *Rendzinas* (20 %) and *Haplic Phaeozems* (20 %) that occur on the highland and *Dystric Nitosols* (60 %) occurring on almost flat to sloping terrain of highland rainfall areas (PEDOWS, 1997; WMQBAG, 2004). *Rendzinas* and *Haplic Phaeozems* soil depth is often limited by hard rock at shallow depth. They have limited agricultural value, because generally, they occur on the steep slopes, rooting depth is small, and there are many stones and rock outcrops. They also have high base saturation, which limits its value for agriculture. Conversely, *Dystric Nitosols* have low base saturation ($P^H < 5.5$) and low phosphorus content (PEDOWS, 1997). They have good potentialities for agriculture, because of its physical properties such as its uniform profile, porosity, stable structure, deep rooting volume, and high moisture storage capacity.

3.1.3 Climate and vegetation

The study area is characterized by tropical and warm temperate climates. The north and northwest valley floors of the lowland areas, such as Blue Nile gorge surrounding the high plateau have tropical climate. These areas are characterized by high average temperature (20-25 ^{0}C) and minimum rainfall (300-600 mm) that supports grass and woody savannah of dominant *Hyparhenia* and *Filipendula* species (PEDOWS, 1997).

The major portion of the high plateau of the district has warm temperate climate. It is characterized by moderate average temperature (10-15 ^{0}C) and abundant rainfall (700-1400 mm) used to support high forest species that survives as relics in less accessible and protected localities. The typical vegetation type in the high plateau of the district is open woodland with discontinuous canopy and larger trees [e.g. *Afrocarpus falcatus* (*birbirsa*), *Cordia africana* (*wodeessa*), *Ficus spp.* (e.*g. harbuu*, *qilxuu*), *croton macrostachyus* (*bakkanisa*), *Ekebergia capensis* (*soombo*), *Olea europaea subspp. caspidata* (*ejersa*) *and Prunus africana (gurraa)*[4]] limited in spatial cover. Most parts of the woodland are interspersed with cultivated land. The cultivated landscape includes home gardens in the living quarters, small-scale nearby farms and distant farm that stretch out from the residential sites. The spatial layout in home gardens, crop fields, and adjacent areas presents a complex pattern of crop distribution. Only a small proportion (10.2 %) of the land is under patches of woody vegetation and shrubs (Table 3). Bush, shrub, and grassland are often intermixed with intensively and moderately cultivated land in the buffer zone between the highland and lowlands especially in northeast part of the district. Grazing land is limited mostly to extreme outskirts of farming zones (patchy vegetation, marshes, wetlands and

[4] Brackets: Local names in *afaan* Oromo

adjacent areas). The climate of a year is divisible into a warm dry period (October–May) and warm rainy season (June–September) (PEDOWS, 1997). Unimodal rainfall pattern prevails.

The district is divided into two agro-ecological zones, locally called *badda-daree* (40 %) and *gammojjii* (60 %), which means midland and lowland respectively (Table 1). There is wide variation in altitude, temperature, and rainfall across the agro-ecological zones. It is also characterized by diverse landscape that ranges from steep slope (20 %), plateau (60 %) to mountainous (20 %) areas (WMQBAG, 2004). The slope gradient of the district varies from valley floors (0-1.5 %) through high plateau (1-5 %) to mountainous and steep slope (>15 %) (PEDOWS, 1997).

The mean monthly minimum and maximum temperature and rainfall for the agro-ecological zones of the study area are shown along with altitudinal variations in Table 1. The district is characterized by variable rainfall pattern. Seasonal variation in pressure systems and air circulation seems to determine the seasonal distribution of rainfall in Ethiopia (Gamechu, 1977). The variability of the rainfall regime of the study areas affects cultivation, planting and harvesting activities. The unpredictability of rainfall for this primarily rain-fed agricultural system leads farmers to employ a range of strategies, including stagger planting and/or diversification of cropping system, to minimize the risk of crop failure.

Table 1 Agro-climatic description of the study areas

Agro-climatic zone	Temperature range (^{0}C)		Altitudinal range (m)		Annual rainfall (mm)	
	Min	Max	Min	Max	Min	Max
Badda-daree	5	25	1501	2604	700	1400
Gammojjii	10	30	1000	1500	300	850

Source: Gindeberet District Agricultural Office (WMQBAG, 2004).

3.1.4 Population

The Oromo people mainly inhabited Gindeberet. The population distribution of the district is based on the population and housing census, which was conducted in October 1994 by Ethiopian Central Statistical Authority. According to this census, the population of the district was 147,437. The rural population was 96.3 % and the urban population was 3.7 % (see Table 2). This shows the majority of the population lives in the rural areas, depending on crop farming which is profoundly influenced by environmental factors. A large number of people are settled, population is more evenly distributed on the plateau than in the rugged areas where widely dispersed and unevenly distributed settlement are common.

Table 2 Population description of the study areas

Description	Rural		Urban		Total	
	Number	Percent	Number	Percent	Number	Percent
Male	92733	46.57	3762	1.88	96495	*48.45*
Female	98975	49.70	3684	1.85	102659	*51.55*
Total	191708	*96.27*	7446	*3.73*	199154	100

Source: Central Statistical Authority (CSA, 1996; CSA, 2004)

According to the population and housing census made by CSA (1994), the average household size is 4.6 (approximately five persons). Currently, high population density (82.4 persons/Km^2), shortage of land, land degradation and periodic drought are major constraints limiting food security. According to the estimates made by CSA (2004) for the year 2005, population growth rate of the district is 2.23 % and 4.11 % in the rural and urban areas respectively. There are 40,158 household heads in the district. The current population structure shown in Table 2 is based on the estimate made for the year 2005 (CSA, 2004).

3.1.5 Land use and land cover

The term "land use" implies the way people allocate land for different purposes (Anon, 2002). Land use pattern is often influenced by population distribution and density as well as climate and topography. The study area covers a total of 2417.8 square kilometre (CSA, 2004). Land is exclusively used for agriculture, and the Oromo people of the study area categorize their surroundings into different systems: homegarden (*oddoo*), crop field (*lafa qonnaa/oyiruu*), grazing land (*lafa kaloo*), forestland (*bosonaa*), fallow land (*lafa bayii*) and shrub lands (*miciree*)[5]. The land under cultivation accounts for nearly 41 % of the district's total area (Table 3).

[5] Brackets: Local names of land use category in *afaan* Oromo

Table 3 Areas of land use and land cover type in Gindeberet district

Land use type	Hectare	Percent
Cultivated land	98746	40.8
• Annual	89801	37.2
• Perennial	8945	3.6
Pasture land	87179	36.1
Forest land	2982	1.3
Shrub land	21784	9.0
Potential arable land	4264	1.8
Residential area	626	0.2
Non-arable land	21321	8.8
Others (e.g. water body)	4880	2.0
Total	241782	100

Source: Gindeberet District Agricultural Office (WMQBAG, 2004).

Gindeberet has high potential for rain-fed and irrigable agriculture. The district has a wealth of drainage and water basin. For instance, Blue Nile basin is the largest in West Shewa Zone and drains the whole of Gindeberet. It has large area of irrigable land along riverbanks that are so far not utilized.

3.1.6 Agricultural systems

Elements of a farm that interact as a system include people, crops, livestock, vegetation, wildlife, socio-economic and ecological factors between them shaping the farming system (Friis-Hansen & Sthapit, 2000). The seed-farming complex is the most important agricultural system of the study areas. This agricultural system is part of a highly developed, mixed agriculture in which livestock are used as a source of draft, transportation, and animal produce. Fallowing, uses of plough, crop rotation, terracing, irrigation, and soil fertilization have been practiced by the farmers for years as part of their traditional farming system. However, most of the cultivated land is not properly utilized and the soil is highly subjected to deterioration. All crops are grown from seeds broadcasted over the prepared field and ploughed into the soil to facilitate germination and seedling emergence. In the lowland areas, farmers also put seeds of maize and sorghum in hand dug holes that are made with wooden arrow without tilling.

A wide variety of crops is components of the agricultural systems of the area and is grown by small-scale farmers to meet a variety of needs. Cereals, pulses, and oil crops are the most important crops in the agricultural system. Cereal crops occupy the largest area. For example, in 1994/95 the production of major crops were *tef* (40 %), sorghum (20 %), barley (12 %), wheat (10 %), maize (9 %), pulses (5 %) and oil seeds (4 %) (PEDOWS, 1997). Of the cereal crops *tef*, wheat, and barley are cool weather crops. They are grown predominantly on highlands over 1500 m above sea level when the average annual temperature ranges between 16 ^{0}C and 20 ^{0}C, and the annual rainfall varies from 700-1400 mm.

The warm weather cereals are sorghum and maize. They grow under conditions of temperature that ranges from 18 ^{0}C to 25 ^{0}C and minimum rainfall. These crops are hardy and drought resistant and therefore do well in areas where rainfall is low and unreliable. *Tef* is the most important food crop in the district and had the largest total production, which is attributed to the largest total cultivation area. Nevertheless, this crop is highly delicate and fragile and requires a lot of work and care. Even though the total production is high, it has the lowest yields of cereal crops (PEDOWS, 1997). Pulses are mostly used for making "*ittoo*" (Ethiopian stew) and other forms of supplementary and complementary food for household consumption. The people in the area compare their nutritional value and composition of protein, in many ways, to that of meat. They are locally called 'foon hiyyeessaa' meaning "poor man's meat". Therefore, consumption of food legumes in complementarily with cereals satisfies the protein requirement of the diet. Niger seed, linseed, and sesame are oil seeds produced in the district for cash.

Generally, the main crops of the study area include *Eragrostis tef* (*tef*), *Zea mays* (maize), *Triticum* spp. (durum and bread wheat), *Sorghum bicolor* (sorghum), *Guzotia abyssinica* (*noug*), *Linum usitatissimum* (linseed), *Brassica carinata* (Ethiopian mustard), *Vicia faba* (faba bean) and *Pisum sativum* (field pea). Root crops are commonly grown for consumption and local market. Especially *Ensete ventricosum* (Enset) is a common highland tuber crop contributing significantly to household food security. *Solanum tuberosum* (Irish potato) cultivation as mono-crop and intercrop with maize is a common phenomenon in the highland areas. *Capsicum annum* (green pepper), *Allium cepa* (onion) and *Allium sativum* (garlic) are also produced for home consumption and as cash crop largely in the lowland areas. Fruit trees and green vegetables are rarely cultivated. Wild and weedy species are adapted to agricultural habitat, which farmers continuously develop to grow crops. Some of these species are tolerable while others are undesirable and removed from the field to avoid their negative effect on the growth and reproduction of the crop plants.

The major farm activities include ploughing (*qototuu*), planting (*facaasuu*), weeding (*aramuu*), fertilization of soil (*kosessuu*), pest control (*ilbiisaa ittisuu*), seed selection (*sanyii filuu*), harvesting (*haamaa*), threshing (*dhayichaa*) and storage (*kuusuu*). Farmers prepare fields each year by tilling and fertilizing the soil. Traditionally, tilling the soil and preparation of for planting involves series of stages. These are first ploughing (*baqaqsaa*), second ploughing (*garagalchaa*), third and subsequent ploughing after the second ploughing (*beeshalaa*) and levelling and seedbed preparation (*meesii*)[6]. Based on the type of cropland and crop species/varieties to be planted, crop fields are ploughed 1-9 times. *Meesii* is an activity carried out after planting, for example, for crops like wheat and barley. However, for *tef barayii* (trampling and levelling the crop field by cattle and equines) follows *meesii* to make the plot ready for broadcasting seeds. It is believed that *barayii* reduces weed and soil erosion. Although, farmers plough their land along the contour in the area, the repeated ploughing (up to 9 times) exposes the soil to water and wind erosion.

Most farmers in Gindeberet who have enough land practice fallowing and crop rotation. Almost all farmers practice crop rotation. Both fallowing and crop rotation is practiced to increase soil fertility. Fallow land is used as a grazing land until ploughing. Manure is mostly used for home gardens and near by farms. Moreover, rotation of animal enclosure or kraal (*dallaa loonii*) is a common practice for fertilization of homegardens and nearby farms. Very recently, few farmers have started to use compost through training offered by the agricultural development agents in the locality.

Since rain-fed farming is typical in the study area, rainfall variability is crucial in the farmers' decisions as to when to plant the desired variety. Because rainfall is a factor beyond the control of farmers, it is difficult for them to decide when to plant the varieties. Farmers usually begin planting early enough to take advantage of a long growing season and harvest before damaging

[6] Brackets: Farming activities and stages in field preparation as named locally in *afaan* Oromo.

rainfalls may set in. Farmers also practice diversified cropping to avoid the risk of crop failure, due to unexpected prolonged dry spells that may require replanting partly or fully. If the rain arrives late, fast-maturing varieties and varieties that on the residual soil moisture reserve are planted. Having diverse crop species and varieties with variable maturity period enables farmers to secure harvest.

The major limitations to agricultural production in the area include pest (grasshoppers, striga, stem borers, birds, and armyworms), diseases (Downey mildew, smuts, bacterial wilt, and anthracnose), unreliable rainfall, and shortage of farmland and land degradation. Farmers use various indigenous and modern measures to mitigate these constraints. For instance, farmers make trenches and terraces to reduce soil erosion from runoff.

3.2 METHODS

3.2.1 Selection and sampling procedures of study sites and respondents

The study sites and sample respondents were drawn from the sampling frames. A combination of different sampling procedures was used to select the samples to successfully meet the objectives of this study. The sample size was determined largely by the financial and time constraints. However, effort was made to improve the reliability of the samples by taking care at each level of stratification of heterogeneous population to a homogeneous group.

3.2.1.1 Selection of study sites

The study was conducted in Gindeberet district, West Shewa Zone in Oromiya Regional State, Ethiopia (Figure 1). The district was purposefully selected based on several conditions. The first criterion considered was its wide range of agro-ecological conditions, which made the district to possess unique diversity of crop genetic resources. Secondly, that the district had no access road or the road was only passable during certain periods (dry season) of the year until recently and poor infrastructure development in general. Thirdly, that it had less government attention with regard agriculture and agricultural input supply. Fouthly, there were no known study of any kind that has been done before in the study area that could be used as a baseline reference. It was assumed that poor infrastructural facilities and less accessibility combined with diverse agro-ecological conditions of the district could contribute to the maintenance and conservation of rich local varieties of crop genetic resources. This assumption emanates from the fact that the prevailing networks in the farmers' seed system had been less influenced by the formal seed system. Therefore, it was expected that such inaccessible area could have unique wealth of local knowledge on the use and management of plant genetic resources.

To select representative study sites within the district, use of administrative units was necessary. The smallest administrative unit in the district is locally called *ganda*, which means Peasant Associations (PAs). Selection of the PAs was approached based on the agro-ecological zones of the district (Table 4). The sites considered for the study covered both midland (46 %) and lowland (54 %) agro-ecological zones (Annex 1a). Based on the information provided by farmers, agricultural officers and own personal experience, representative PAs were selected from the two agro-ecological zones to capture different farming systems of the district. Their proximity to each other, distance from the all weather road and the district town (Kachisi) were additional criteria to select the PAs. Finally 3 PAs from midland and 4 PAs from lowland areas were selected (Table 4). Generally, the stratification of the study sites was designed to capture diversity and livelihood system associated with moisture availability and temperature that affect agricultural productivity, population pressure and agricultural landscapes. The PAs chosen covered wide ranges of the district surface area since it extends from the border of Jeldu in the south to the Blue Nile valley in the north. In each PA, there are 4 to 8 villages. As a result, it was reasonable to use simple random sampling method to select two villages from each PA except Kalloo Badhassaa in the lowland, which was represented by one village due to inaccessibility.

Table 4 Study sites and respective agro-ecological zones

Ganda (PAs)	Villages	Agro-ecological zones
Haroo	Hagamsoo	Badda-daree (Midland)
	Qalaaxee	Badda-daree (Midland)
Irjaajoo	Mogoraa	Badda-daree (Midland)
	Lafa Gabaa	Badda-daree (Midland)
Gamadaa	Amdoo	Badda-daree (Midland)
	Soggodoo	Badda-daree (Midland)
Caffee Eerrerii	Dirree Gambeelaa	Gammojjii (Lowland)
	Simbirroo	Gammojjii (Lowland)
Bakkee Fayyina	Bakkee Ayyannoo	Gammojjii (Lowland)
	Waashaa	Gammojjii (Lowland)
Lagaa Macaa	Gonfii Qadidaa	Gammojjii (Lowland)
	Gonfii Galaan	Gammojjii (Lowland)
Kalloo Badhassaa	Bidaaruu	Gammojjii (Lowland)

3.2.1.2 Selection of respondents

One hundred eighteen household heads consisting 90 smallholder farmers and 7 key informants (4 farmers in each group) were selected for interview. Out of the 118 respondents, 83 % were men and 17 % were women (Annex 1a). The individual household heads were selected from the sampling frame using simple random sampling techniques by resorting to a table of random numbers whereas the key informants were intentionally selected. An average of seven farmers per village was selected. The key informants were selected in order to conduct in-depth interview and discussions. They were selected from household heads of both sexes and different age groups based on their availability, willingness, and practical knowledge on crop genetic resources of the area. The local administrators and development agents helped in identifying the names of the key informants.

3.2.2 Data collection

Individual households were interviewed to gather information both quantitatively and qualitatively. Quantitative research emphasizes measurement and analysis of causal relationships between variables, not processes, while qualitative research focuses on the socially constructed nature of facts (Denzin & Lincoln, 1994). In this study, qualitative data were collected to understand the perceptions and opinion of the farmers where as quantitative data were for the purpose of quantifying and clarifying information that would not be obtained by qualitative methods i.e. for the purpose of triangulation. The main targets for primary data collection were individual household heads and key informants interview. Field observation, discussion with agricultural experts and the key informants were used to strengthen the individual interviews. Secondary data were obtained mainly from various unpublished documentary sources of the respective zonal and district agricultural offices.

3.2.2.1 Primary data

Individual households were interviewed using semi-structured questionnaire (Annex 7) at the village level. The questionnaire covered different topics in order to capture relevant information related to study sites and household heads, crop biodiversity and cropping system, local knowledge on use and management of farmers' varieties and the status of crop genetic resource conservation. Questions that are more detailed were asked about farmers' use and preferences of varieties, farmers' knowledge on varieties, seed selection and storage, genetic erosion, farmers' reasons for maintenance of landraces and gender role in the management of crop genetic resources. The questionnaires were prepared as simple as possible, which was later translated to *afaan* Oromo (the local language) in order to channel answers by the respondents. Only some of the questions can be predetermined in semi-structured interview (Mikkelsen, 1995). However, it was not possible during this study to pre-test the questionnaire because of the limitations in time for the fieldwork and the political instability in the country. It was very difficult to stay for longer periods in the field because of series of violence in all regions of the country following the May 2005 election that created incongruity between the ruling party and opposing parties. Rather the questionnaire was made as comprehensive as possible and correction was made along the way considering its relevance to local conditions from everyday lesson learnt while interviewing the farmers. Three diploma graduates who are native to the study area and know the language were hired as interviewer and were trained for three days on the content of the questionnaire and interviewing procedure. Due to detailed nature of the study, interviews took 60-90 minutes per household.

A survey of individual households was carried out during the months of October to December 2005. The time was when crops were at maturity and that facilitated documentation of both inter-specific and infra-specific crop diversity in the study area. Data were collected by recording crop species and farmer identified distinct crop landraces known to grow in all farm types (home garden, nearby farms and main crop fields) in the study area. Species and farmers' varieties were identified by their local names in the field with assistance of the knowledgeable farmers. Wild relatives of the crop species were also recorded. Crops that are lost/endangered both at village and district level were recorded. Farmers were also asked about their perception of seed selection schemes, variety identification criteria, vernacular name, meanings, and area allotted for each crop/variety, to determine patterns of diversity using semi-structured interview. Farmers' were also asked about their knowledge and experience of seed selection, local seed treatment and storage practices for seed conservation. Varietal use and associated knowledge were assessed using farmers' preference ranking of varieties considering crops/varieties planted during the season and those not planted. Respondents were asked to give personal preference and rank three most important crops/varieties based on their use value and socio-economic importance. Farmers were also asked about labour use, which covered analysis of participation of each family member in local seed management with emphasis on the role of women in genetic resource conservation and management.

Regarding indigenous knowledge and crop management system in the area, the key informants from each village were interviewed on issues related to the effects of traditional farmers' knowledge in agricultural practices and management of crop genetic diversity. This facilitated to channel more qualitative information regarding use and management of crop genetic resources. More detailed, focused information on the local seed system were generated during the discussion to get larger body of knowledge of the farming community. Key informants were asked about meanings of local names of species and varieties in cases where special attributes are associated with the names. The same applied when listing traditional sayings, folksongs, and poems that are related to use and management of crops. Different approaches were used during the discussion to capture responses of key informants regarding varietal mobility (introduction, adoption, loss and diffusion) over time; existing local knowledge to maintain farmers' varieties, interaction of farmers' varieties and modern varieties and causes of genetic erosion (if any) in the area.

Digital camera was used to take photographs of selected varieties, storage facilities, and crop stand in the field. Photographs of the farm landscapes were also taken. Voice recorder was used to record the local knowledge recovered during group interview of key informants.

3.2.2.2 Secondary data

Generally it was quite hard to get literature on the farming system and plant genetic resources of the district. There has been not been any published information about the district. Secondary data such as demography, soil, mean annual temperature, and rainfall and crop production for the district were obtained from unpublished sources at the respective regional, zonal and district agricultural bureaus. Discussions were held with relevant experts in the district on issues like genetic erosion, crop biodiversity, land use, seed system, and indigenous knowledge in management of crop genetic resources.

3.2.3 Data coding, entry and transformation

Both close ended and open-ended questions were properly coded and entered into the computer using Microsoft excel. Quantitative data was organized to suit the different statistical packages used in the analysis. To ease the statistical analysis and better interpretation of results, some data sets were transformed into standard units. Qualitative data was organized in such a way that cumulative of the respondent's information is presented.

3.2.4 Data analyses

Te data were grouped in various ways depending on the agro-ecological zones i.e. midland and lowland. Each agroecological zone served as a stratum to accommodate diversity of crop genetic resources grown and cultural diversity of farmers in the study area. Different sets of analyses were employed to assess differences in crop genetic resources with respect to spatial diversity, maintenance, and cropping patterns between the different agro-ecological zones as well as different classes of farmlands (i.e. homegarden, nearby farms and main fields). The analysis of qualitative information was based on household survey, the opinion, and perceptions of key informant group interviews and field observation.

In the first set of analysis, the information gathered was synthesized and sifted and the final list of inter-specific and infra-specific diversities of crop plants and their wild relatives was produced in a tabular form. Descriptive statistics were used to present information on number of farmer growers and area allocated to farmers' varieties and improved varieties of wheat and maize. Descriptive statistics and qualitative analysis of farmers' seed selection scheme, seed source and storage was drawn upon Almekinders and Louwaars (1999) guide for development workers on farmers' seed productions in order to put the information gathered into context and enhance understanding.

In the second set, one-way analysis of variance was used to compare the means of variables within and between Peasant Associations interviewed. Margalef and Shannon indices were also used to measure field crops diversity on household basis (Table 5). In order to test the relationships, Tobit regression models were estimated using household survey data. Tobit regressions were estimated because of censored dependent variables i.e. the diversity indices are censored because many of its values cluster at the limit (zero for both Margalef and Shannon). Using land allocated to each crop for estimating the diversity index justifies the theoretical plausibility of Margalef and Shannon indices function estimated using Tobit. Of the available indices to represent diversity based on crops, the two indices were adapted from ecological indices of spatial diversity in species (Magurran, 1988) to represent inter-specific diversity. Regression was estimated to explain the inter-specific diversity of five field crops (wheat, maize, sorghum, *tef* and *noug*).

Table 5 Definition of spatial diversity indices used to measure inter-specific crop diversity at household level

Index	Concept	Mathematical construction	Explanation	Adaptation in this paper
Margalef	Richness	$D_i = (S-1)/\ln A_i$	S is number of species recorded, corrected for the total number of individual N summed over species	S = number of crops grown Ai = total area planted (proportion of land) per household in 2005
Shannon	Evenness or equitability (i.e. both richness and relative abundance)	$D_i = -\Sigma\alpha_i \ln \alpha_i$ $D_i \geq 0$	α_i is proportion, or relative abundances, of species	α_i = area share occupied by *i*th field crop per household in 2005

Both indices represent a distinct diversity concept. Richness or number of species encountered is measured by a Margalef index at household level. Both richness and relative abundance is measured by Shannon index. The proportion of area planted to a crop (or area share) is used as a substitute for the number of individual plants encountered in physical unit of the area. Area shares are not distributed spatially in the same way as plants; however, they combine plants of the same crop from several different locations on the farm. Thus, choice of area share emphasizes better intercrop diversity analysis.

In this analysis, specifications of variables and hypotheses were made. The main household and farm physical characteristics hypothesized to determine intercrop diversity maintained by household farms in study area were identified as dependent (D_i) and independent variables (X_i).

Tobit regression model assumed that the observed dependent variables (Margalef index of richness and Shannon index of evenness) D_i for observation i = 1, .., 18 satisfy $D_i = \max(D_i^*, 0)$ where D_i^*'s latent variables generated by the classical linear regression model $D_i^* = \beta X_i + e_i$ with X_i a vector of explanatory variables, possibly including 1 for the intercept and β corresponding parameter to be estimated. The model error e_i are assumed to be independent N $(0, \sigma^2)$ distributed, conditional on the X_i's.

For the independent variables (X_i), specifications were made in both categories of farm and household characteristics.

Farm characteristics

X_1- Number of plots run by household [Number of plots]

X_2- Agro-ecological category (1=lowland; 2=midland)

X_3- Walking distance to the nearest market (in minutes) [Distance to town]

X_4- Walking distance to the nearest all weather road (in minutes) [Distance to road]

X_5- Amount of farm operated by household (in hectare) [Total cultivated land]

Household characteristics

X_6- Sex of household heads (1=male; 2= female)

X_7- Age of household heads (years)

X_8- Number of household members [Family size]

X_9- Literacy level of household head (1=cannot read and write; 2=can read and write; 3=have formal education; 4=church school) [Education of household]

X_{10}- Religion of household head (1=*waaqefataa*/traditional; 2=protestant; 3=orthodox; 4=catholic; 5=Muslim)

X_{11}- Engagement in farming by household head (1=full time; 2=part-time) [Farming involvement]

X_{12}- Number of years of farming by household head [Year of farming by household heads]

X_{13}- Availability of credit to household head (1=yes; 0=no) [Credit availability]

X_{14}- Beneficiary of agricultural extension services (1=yes; 0=no) [Extension services]

X_{15-} Household income sources (1=crop sale; 2=livestock sale; 3=crop & livestock sale; 4=casual labour; 5=crop & livestock sale plus remittance; 5= crop & livestock sale plus casual labour) [Income sources]

X_{16}- Household land ownership (1=yes; 0=no) [Land ownership]

X_{17}- Household land titlement (1=yes; 0=no) [Land title]

X18- Total number of oxen owned by household [Number of oxen]

In the third set of analysis, data on farmers ranking (1=best and 2=poor) on all varieties of three major crops (*tef*, wheat and maize) grown in the area were subjected to Correspondence Analysis using MINITAB (1998). The data were generated based on farmers ranking of varieties using number of variables related to agro-morphology, field performance, and culinary attributes, as they perceived it in the varieties. The variables considered for preference ranking by farmers included seed colour, tallness, seed size, tillering, earliness, storability, yield, disease resistance, drought tolerance, frost tolerance, straw palatability, taste, religious use, market value, and suitability for beverage, bread, *budeena (flat pancake)*, *qiixxa* (unleavened thin bread) and porridge. Correspondence analysis considered frequency data of farmers' preferences of crop variety according to the attributes best or poorly defined the variables.

Finally, the information was analyzed in various ways, compared with previous studies and recommendations towards the conservation of the crop genetic resources and maintenance of local knowledge on these crops is given.

CHAPTER IV: RESULTS AND DISCUSSIONS

4.1 GENETIC DIVERSITY

4.1.1 Checklists of inter-specific and infra-specific crop diversity

A wide range of inter-specific and infra-specific diversity of crops was found to grow in communities and on individual farms in Gindeberet. A checklist of crop species found in the study area included cereals (8), oil crops (9), pulses (7), and industrial crops (2) that accounted for 26 species of field crops. Most of these species showed large infra-specific variation (Table 6). There were clear agro-morphological variations among farmers grown varieties. The respondent household heads identified a total of 102 farmers' varieties that belongs to 14 crop species and 12 others represented by one variety each (Table 6). In the midlands, farmers identified 62 landraces that belongs to 20 crop species and they identified 69 landraces that belongs to 23 crop species in the lowland areas. Only six improved varieties of three crop species (maize, wheat, and linseed) were encountered. Many of the varieties were common to both agro-ecological zones but with varied vernacular names. In terms of variety, cereals were the most diversified crop types. The number of sorghum landraces took the major proportion in the lowland and that of *tef* was the highest in the midland areas. The continued production of highly diversified cereal crops was crucial in food security of the people in the study area. The newly constructed access road facilitated the transportation of oil crops (mainly *noug* and sesame) and *tef* to the main market centre in Addis Ababa that in turn helped the farmers to get better price for their grain supplied to the local markets.

Table 6 List of crop inter-specific and infra-specific diversity in Gindeberet

Major Crop types	Common name	Scientific name	Local name	Varieties/species
Cereal crops	Barley	*Hordeum vulgare* L.	*Garbuu*	*Abbaa shawayyee, ballammii, biyya dhufee, buttujjii, garbuu adii, garbuu bira, garbuu gurraacha, mosnoo, qaxxee, samareta adii, samareta gurraacha, sanaf qoloo, shaggar baasaa, sidaamoo, worqiinaa.*
	Emmer wheat	*Triticum dicoccum* (Schrank) Schuebl.	*Mata-jaboo*	*Mata-jaboo*
	Finger millet	*Eleusine coracana* L.	*Dagussa/ dagujja*	*Dagussa/dagujja adii, dagussa/dagujja gurraacha*
	Maize	*Zea mays* L.	*Boqqolloo*	*Biyyaa dhufee, boqqolloo adii, boqqolloo diimaa, chaayinaa, fandishaa, feeshoo, filaatamaa, gordod, horroo, jilame/ji'a lame, qaxxee, wallaggee.*
	Oats	*Avena sativa* L.	*Sheebboo*	*Sheebboo*
	Sorghum	*Sorghum bicolor* (L.) Moench	*Mishingaa*	*Ayoo adii, ayoo diimaa, boobee, boroo abbaa xulluphe, boshee, catee, curqeeta/xurqeeta, dafaa, galagala, gedalloo, gubbatee, gurraacha, hacciroo adii, hacciroo diimaa, janfala, jilamee/ji'a lame, joboo adii, joboo diimaa, kuraree, lafcanee, shokofee, wagaree, wallaggee.*
	Tef	*Eragrostis tef* (Zucc.) Trotter.	*Xaafii*	*Baadee gala, baal dimessa, baalchaa adii, baalchaa diimaa, bashanaa, bunnusee adii, bunnusee diimaa, daaboo, daggalee, filatamaa, foqoree, minaaree adii, mojoo, muriyyii adii, muriyyii diimaa, qomixee, tuulamticha, xaafii adii, xaafii diimaa, Xaafii durbucoo*
	Wheat	*Triticum* spp.	*Qamadii*	*Abbaa biilaa, biyyaa dhufee, boondii, buttujjii, daashin, dasoo, filatamaa, gufooroo, gurraattii/gurree, inkoyyee, qamadii adii, qaxxee, roomaa, sallaattoo.*
Oil crops	Brassica	*Brassica rapa* L.	*Feecoo*	*Feecoo*
	Brassica	*Brassica carinata* A.Br.	*Goomanzara*	*Goomanzara diimaa, goomanzara gurraacha*
	Brassica	*Brassica nigra* var. *abyssinica* A.Br	*Sanaafica*	*Sanaafica*
	Castor bean	*Ricinus communis* L.	*Qobboo*	*Qobboo faranjii/diimaa, qobboo gurraacha buburree, qobboo simbiraa.*
	Linseed	*Linum ustitatissimum L.*	*Talbaa*	*Talbaa adii, talbaa diimaa, talbaa filatamaa.*

	Noug	*Guizotia abyssinica* (L.f.) Cass.	*Nuugii*	*Nuugii*
	Sesame	*Sesamum indicum* L.	*Salixii*	*Salixii adii, salixii diimaa*
	Safflower	*Carthamus tinctorius* L.	*Suufii*	*Suufii abbaa qorratti*
	Sunflower	*Helianthus annus* L.	*Suufii*	*Suufii faranjii*
Pulse	Chickpea	*Cicer arientinum* L.	*Shumburaa*	*Shumburaa adii, shumburaa diimaa, shumburaa gurraacha.*
	Grass pea	*Lathyrus sativus* L.	*Gaayyoo*	*Gaayyoo*
	Haricot bean	*Phaseolus vulgaris* L.	*Boloqqee*	*Boloqqee adii, boloqqee diimaa, boloqqee gurraacha.*
	Faba beans	*Vicia faba* (L.)	*Baqilaa*	*Baqilaa durii/xixxiqqa, baqilaa faranjii/gurgudda, baqilaa filatamaa.*
	Field peas	*Pisum sativum* L.	*Atara*	*Atara adii, atara burree/buburree, atara gurraattii.*
	Fenugreek	*Trigonella foenum-graecum* L.	*Sunqoo*	*Sunqoo*
	Lentil	*Lens esculenta* Moench.	*Missira*	*Missira gurraattii*
Industrial crops	Cotton	*Gossypium hirsutum* L.	*Jirbii*	*Jirbii*
	Tobacco	*Nicotiana tabacum* L.	*Tamboo*	*Tamboo*

Ethiopia has been regarded as centre of origin of many cultivated species (e.g. *noug*, *tef*, *enset*) and secondary diversification for many other crops (e.g. wheat) that originated outside East African region (Harlan, 1969; Vavilov, 1951). Vavilov (1951) indicated that Ethiopia is centre of origin for cultivated barley and take first place in botanical varieties of wheat. In fact, he expressed that "nowhere else does there exist in nature such a diversity of forms and genes of barley" (Vavilov 1951:38). Among cereal crops grown in the area, some genera are found only in Ethiopia. For example, the bread grain *Eragrostis tef* and oil bearing *Guizotia abyssinica*, which were the major crops in the area are found only in Ethiopia (Vavilov, 1951).

The crop diversity observed among villages was different. For instance, one of the villages (Bidaaruu) bordering the Blue Nile valley had minimum inter-specific and infra-specific diversity of crops. Bidaaruu lowland in its agro-ecological setting received very small annual rainfall and had sandy soils, hence less favourable for many of the crops. As the result, only few crops such as *tef*, maize, sorghum, sesame, safflower, and finger millet were grown. Sesame and finger millet were absent in all villages surveyed except Bidaaruu. The varieties, which were adapted to moisture stress and low nutrient conditions of the Bidaaruu's soil, were largely known to be early maturing. They were planted early enough to take advantages of available moisture following the occurrence of the rains. For instance, a *tef* variety known as *bunnusee* and sorghum varieties, *wallaggee* and *boobee* were identified as tolerant to moisture stress. The varieties were highly valued by the farmers in the area. Consequently, the production of *tef* and sorghum in the lowland areas was based on varieties known to tolerate moisture stress.

In the extreme lowland areas, the land was underutilized because of malaria prevalence and trypanosomiasis, a sleeping sickness in cattle and humans. During rainy season landless farmers and farmers who had shortage of land moved from their residential areas to these unutilized lowland areas for cultivation of sesame and sorghum. In the lowland areas (e.g. Bidaaruu and Dirree Gambeelaa villages), zero tillage was the common practice. In such practice, wooden arrow was used to make holes in the field for planting maize and sorghum seeds since they cannot keep oxen because of trypanosomiasis. However, for cultivation of other crops in the upper lowland areas they used hand tools such as hoe, axe, and spade as opposed to the highlanders who used oxen to cultivate land. It seemed that the prevalence of disease and high temperature has limited the diversity of crops in Bidaaruu and Dire Gambeellaa villages.

The district agricultural officers and farmers confirmed that most of the improved varieties of *tef,* wheat, and maize that were introduced during the last three decades failed. Most of the farmers identified improved varieties of all crops as *filaatamaa*[7]. However, agricultural experts and researchers knew the varieties grown in their locality with hybrid names such as *birmash* (sorghum); *CR 44* and *CR 01354* (*tef*); and *BH 140*, *kulanii* and *beletech* (maize). *Birmash* failed because of its short plant height, which attracted birds at maturity stage and all other varieties failed due to lower yield and adaptation to the agro-climatic conditions of the area. However, one of the varieties of linseed (*belay 96*), barley (*HB 42*), faba bean (*DK 20*); and two of the varieties of wheat (*HAR 1685* and *HAR 710*) and maize (*BH 660* and *BH 540*) were widely grown in the area. Most farmers had grown both landraces and improved varieties parallel on their fields. Farmers who grow both varieties were doing it in order to get better yield and minimize risk. Interaction of improved varieties with farmers' varieties is discussed in section 4.5.

[7] *Filaatamaa* means improved variety in *afaan* Oromo.

4.1.2 Crop wild relatives

Fifteen wild relatives of five crop species were recorded from farmlands (homegardens, nearby farms and main crop fields), adjacent natural ecosystems, and disturbed wild habitats (Table 7). These wild plants, which were identified using their local names, share many attributes with the cultivated species. The wild relatives were recorded for *brassica*, finger millet, *noug*, sorghum, and *tef*. The highest number of wild relatives was recorded for sorghum (Table 7). Of the recorded wild relatives of sorghum, three morphologically distinct plant types were all named *qeeloo* (Figure 2f). Sorghum wild relatives mainly existed in the field as weed with the crop. In the case of *tef,* the wild relatives were found mainly in adjacent areas near the farm fields. In the genera *Eragrostis* to which *tef* belongs, there are 44 species in Ethiopia (Phillips, 1995). Among the 44 species described as part of Ethiopian flora, some were considered wild progenitor of *tef*. Oat was a cultivated crop in other parts of the country (Mengist, 1999); however, it grew as weed in Gindeberet. Thus, it could be considered as wild crop genetic resource. It is a common phenomenon to find oat infested *tef* field (Figure 2c). The local communities commonly use oat as forage crop. Wild relatives of *noug* existed in both field and surrounding areas adjacent to main crop fields.

The majority of the farm fields including *noug* and *tef* as well as other crops were infested with weedy wild relatives of crops. Majority of the respondents (>67 %) complained that the wild relatives were troublesome weeds competing with cultivated crops in the farm fields. For example, *Guzotia scabra* (*hadaa*), wild relative of *Guzotia abyssinica* (*noug*) was a noxious weed in the study area (Figure 2a). It infested not only *noug* but also other crops (e.g. *tef*). *Qeeloo,* a wild relative of sorghum, was also a problem in maize and sorghum fields of the lowland areas (Figure 2b). In fact, the term *qeeloo* was borrowed from the Amharic version ‘‘kilo’’ meaning “the fool” implying that the plant grows tall and on its own without human interference. Farmers indicated that the sources of such infestation were contamination of seed during harvest and soil seed bank.

Unlike farmers in south Welo and north Shewa, who maintained wild relatives in the field for different uses such as livestock fodder, accumulation of organic matter, and to encourage gene flow (Teshome *et al.*, 1997), farmers in Gindeberet do not tolerate weedy wild relatives in their fields except in *noug* fields. They had removed the weeds in the field mechanically by hand and sometimes sprayed selective herbicides on monocot crop fields against dicot weeds. For instance, herbicide 2,4-D was sprayed in *tef* and wheat fields against *Guzotia scabra* (*hadaa*). However, it developed tolerance to this herbicide and remain undamaged in the field. From genetic point if view, removing the weedy wild relatives of crops from the field affect the interaction of the two related plant categories. However, the wild relatives were remained in association with the cultivated varieties of crops due to their tolerance to herbicide and labour constraint by farmers to remove all weeds from their fields.

The close contact between wild relatives and cultivated crops in the field would probably facilitate hybridization among open-pollinated species, but this was beyond farmers' understanding in the study area. For example, some cross pollination (5-50 %) was reported to occur even though the proportion is influenced by some factors such as wind direction and panicle type in sorghum (Doggett, 1988). In Ethiopia, sorghum comprises great variety of freely interfertile diploid (2n=20) forms of cultivated sorghum, wild progenitors and intermediate between the two arising from widespread hybridization and backcrossing (Phillips, 1995). This implies that there could be some biological interaction between the wild relatives and the cultivated crops. Biological interaction refers to gene exchange between cultivated crops and their wild relatives in managed farms and adjacent agro-ecological habitats. Unless there is sexual incompatibility, genes that evolve under natural and human-induced conditions are likely to mix in the farms and adjacent areas among open-pollinated species, because there is a two-way movement of genes from the wild habitats to the managed farms and vice versa by agents like insects, birds, and wind. Such process of gene exchange between the wild and cultivated species has significant influence on the dynamics of crop hetrozygosity. It either improves or negatively affects the desirable traits of cultivated crops that are of interest to the farmers. From this perspective, wild relatives of crops grown in the area could be potentially important in enhancing crop genetic resources. However, the usefulness of wild relatives is limited to knowledge and value of professionals rather than farmer's knowledge, which will have a great impact on its conservation in the area.

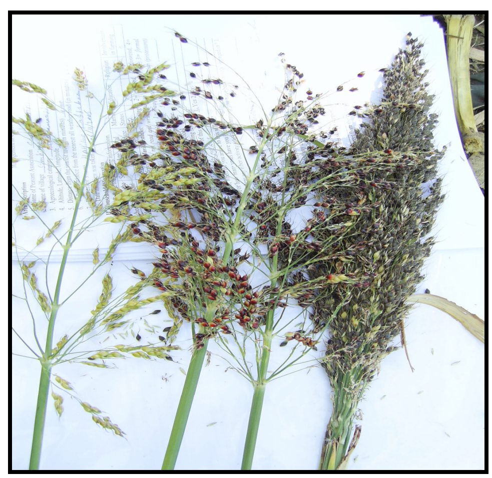
a) *Tef* infested by *hadaa* (wild relatives of *noug*)

b) *Sorghum* infested by its wild relative (*qeeloo*)

c) *Tef* infested by *sheebboo* (oats)

d) *Hadaa* (left) wild relative of *nugii* (right)

e) *Muriyyii* (left) wild relatives of *tef* (right)



f) Varieties of *qeeloo* (wild relatives of sorghum)

Figure 2 Current or potential wild relatives of crop genetic resources (Photo: Teshome Hunduma, 2005)

Cultural/socio-economic interactions were also observed for the wild relatives of crop genetic resources in the study area. The interactions could be illustrated by looking at how people use the wild relatives. For example, *muriyyii*, a wild relative species that resembles *tef*, was well remembered for its use for making *budeena* that was eaten in the old days. *Muriyyii* was also important for making household utensil such as broom, which people used, to clean house and crop threshing ground. Three different wild relatives (i.e. *luuccee, wajagsaa* and *xinqissaa*) of *sorghum* that were found both in managed farms and in the wild were seldom grown for their sweet juice[8]. Farmers clearly identified the wild relatives from cultivated sorghum based on their morphological traits. Such information could be the basis for investigation of molecular marker that is responsible for the production of juice in the plants.

Table 7 Lists of relatives of current or potentially important crop plants found in Gindeberet in the wild

Possible related crops	Crop wild relatives	Characteristics
Brassica	*Goommana simbiraa*	Weed
	Jaree	Weed
Finger millet	*Can-geeddara/coqorsa*	Weed
	Asaansara	Weed
Niger seed	*Hadaa*	Weed
Sorghum	*Qeeloo*	Weed
	Dolgommii	Weed
	Guumaa	Weed
	Luuccee	Weed, also planted for its juice
	Wajagsaa	Weed, also planted for its juice
	Xinqissaa	Weed, also planted for its juice
Tef	*Muriyyii*	Weed/grass
	Maccaaraa	Weed/grass
	Marga goggorrii	Weed/grass
	Migira saree	Weed/grass

The sweet stem of these plants had attracted farmers' attention and collection of their seeds and domestication is underway in the area. In the process of plant domestication, plants pass through stages of being restricted to wild habitats to a period of intensified use from the wild stands and gradual inclusion into cultivation and subsequent domestication to become fully dependent on

[8] Stem of sorghum varieties having sweet juicy stalk are chewed as delicacy.

human intervention. This was true in the study area since it seems *luuccee*, *wajagsaa* and *xinqissaa* will soon become cultivated crop species if the current domestication continues to large-scale cultivation. It is through such progressive domestication that Ethiopia became one of the major Vavilovian centres of origin/diversity for several domesticated crops and their wild and weedy relatives (Harlan, 1969). Checklists are already made for important the useful plants of Ethiopia that are found at different stages along the domestication scale (Edwards, 1991). According to Edwards (ibid), any crop improvement program would help to recruit some possible future crops from among the promising non-cultivated indigenous plant species, which can also be used as sources of genes to improve the cultivated taxa as some are relatives of crops. Indeed the country offers not only examples of useful plants but also environments where diversification is made possible.

4.2 CROPPING PATTERN

4.2.1 Distribution of field crops across landscapes and farming systems

The structure of cropping system or the physical arrangements of crops over space in the study area is presented in this section. Landscapes across agro-ecological zones present a wide range of inter-specific and infra-specific diversity of field crops in the study area. The major crops grown in the mid altitude were known to be cool weather crops such as *tef*, wheat, barley, *noug,* linseed, and faba bean. Warm weather crops such as maize, sorghum, sesame, and haricot bean were dominant in the lowland areas. It seemed that the distribution of crop genetic resources across the agro-ecological zones (midland and lowland) depend on the altitude, amount of rainfall, temperature and the soil conditions. The spatial distribution of crops on farmlands within the agro-ecological zones was governed by several other factors. Most farmers shared common reasons to assign crop species in their farmlands (homegardens, nearby farms and the main fields). Factors like risks of damage by pest wildlife, livestock, thefts, soil fertility, and size of farm plots played an important role in farmer's decision making for assigning crop species/varieties to their farmlands.

Field cropping and homegardening are established traditions in Gindeberet. Crops that were planted early enough during rainy season were grown in homegardens (e.g. *Zea mays*, *Brassica carinata*) are used as emergency food during autumn (Figure 3). According to Edwards (1991), there is an annual cycle of shortage of grain in some localities of Ethiopia, where families exhaust their grain supply before the next harvest and then heavily supplement their food intake by leafy vegetables such as *Brassica carinata, which* is grown by women in homegardens (Asfaw, 2001). Farmers had to protect these crops from damage by freely roaming livestock especially at seedling stage. The damage caused during crop maturity periods by pest wildlife such as monkeys, porcupines, birds, pigs, and human of theft particularly in bad years or periods of food shortage were also of serious concern. Some homegarden crops (e.g. bean and pea), do not give enough yields unless planted on fertile lands. As a result, farmers always used to replenish soil fertility of their homegarden by applying manure. Those farmers who have larger landholding had the opportunity to have both homegarden and field crops. Nevertheless, farmers who have smaller land size or who rented land only plant crops of high priority for their household food security.

Cereals, pulses, and oil crops were grown extensively in the main fields and showed relatively higher genetic diversity. Crops grown far from home (Figure 3) on the nearby farms and main fields were planted late after access of livestock population to the farmlands was restricted through guarding. Fortunately, pest wildlife usually has less preference for the crops planted on the main fields. The enabled farmers to save labour needed to guard the crops from pest wildlife. The potential risks of damage in the field guide farmers' allocation of crops to their farmlands. Farmers planted field crops in large scale on the main field using fertilizers since the fertility of the land is very low. Fertility level of the farm could determine the assignment of crops at variety level. For instance, *bunnusee* and *qamadii gurraattii* (*tef* and durum wheat varieties respectively) were planted on cleared forestland and farmlands that has high soil fertility. These circumstances seemed the governing factor for the creation of the present patterns of distributions in crop genetic resources within an agro-ecological system in the study area.

The difference in adaptation of crop genetic resources to the midland and lowland areas coupled with farmers' allocation of crops on their farmlands enabled the community to maintain useful crop biodiversity in a pattern of increased quantity towards the homestead. In Ethiopia, about 85 % of the cultivated crop species are grown in homegardens, but greater proportion of crops are found on the fields (Asfaw, 2001). Earlier research (e.g. Asfaw, 2001) identified three levels of crop diversity in the Ethiopian traditional farming system. These were:

1. Landscape level agrobiodiversity: farmlands (cultivated fields, margins, fallow lands, natural points), settlement areas (homegardens, fences, surrounding fields, open spaces), grazing areas (seedling sources for some crops, wild gene sources);
2. Farming systems level agrobiodiversity: permanent field cropping, home gardening, shifting cultivation, traditional agroforestry, cultivation under tree canopy; and
3. Individual crop species level agrobiodiversity: farmers' varieties.

The current study agrees with these three levels of agrobiodiversity where the diversity of field crops are found along with their wild relatives under management of community traditional farming systems in homegardens and fields distributed in the two agro-ecosystems. Social needs and cultural practices were strong factor that shaped the crop biodiversity in the farming systems and at home by the farming community. These socio-economic and cultural interactions have created huge amounts of diversity through combined effects of nature and humans. The rich diversity of crops was concentrated around homegardens while the maintenance of this diversity was mainly governed by use and preference values of farmers. Thus, homegardens were characterized by diversity and the main field accommodated large population of field crops. Five major crop species that were grown in the midlands, lowland homegardens, and main fields are shown in priority lists of their occurrence in Figure 3.

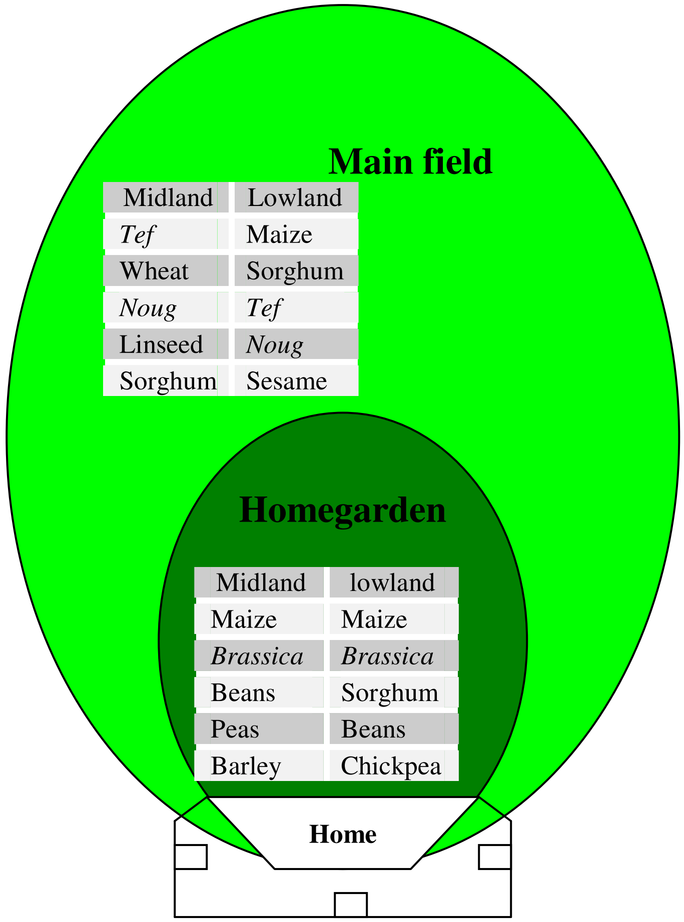


Figure 3 Spatial distributions of major field crops across farm landscapes and agro-ecological zones in Gindeberet traditional farming system

Collectively cereals and grain legumes created spatially complex seed cultivation in the area. The seed cultivation complex does not seem to conserve soil resources. Since the nutritious seed crops have, high demands of soil nutrients it could in the end mine the soils. Thus, with the shortage and intensified seed cultivation complex, soil fertility could readily go out of ecological equilibrium in the area. Farmers' efforts to maintain soil fertility by intercropping legumes with cereals are far from being adequate.

4.2.2 Intercropping in field crops

Intercropping in field crops was another important aspect of cropping pattern to be dealt with. Cereals were often cultivated in monocultures. Simple form of mixed cropping was also practiced in the study area. Traditionally farmers had grown many combinations of crop species/varieties on the same plots of land either in their homegardens or in fields. They considered seeding rates/plant density and maturity dates when planning intercropping of different species/varieties.

In both the midland and lowland areas, maize was intercropped with *brassica* and beans in homegardens whereas sunflower was intercropped with *tef* in the main fields. Beans and peas were intercropped in the highland areas in homegardens and nearby farms. In lowland areas, sorghum was intercropped with many other field crops either in homegardens or in main field. Usually, sorghum was intercropped with crops such as maize, haricot bean, and *brassica.* It is a common phenomenon to find several varieties of sorghum planted on a single plot of land. It seems that plant height also played a role in farmers' decision making of combining crops. In most cases, short and tall crops were planted together. Generally, intercropping of field crops with forest and horticultural species was more common than intercropping within field crops.

Farmers practiced intercropping of field crops to maximize yields, avoid lodging, improve soil fertility, efficiently utilize their farmlands, reduce risk, and make advantage of variations in times of maturity among individual crops helps to stagger harvesting. For instance, legumes were intercropped with cereals to improve soil fertility and maximize yield. Farmers explained that intercropping different species/varieties of field crops helped them to minimize damage caused by pest and diseases. The mix of species and varieties served as a buffer for certain pest and disease problems. Most of the respondents (>57 %) agreed that such constraints to crop production such as frost, weeds, insect pest and disease did not damage all varieties when planted as intercrop. Increasing diversity did not reduce all diseases and pests, but promoted diversity thereby reducing risks and resulting in yield stability. Intercropping was generally understood by farmers of the area as a way of maximizing an enterprise and creating a stable crop ecosystem thereby reducing risks related to production.

4.3 USES AND CONSERVATION OF CROP GENETIC RESOURCES

In addition to consumptive uses, the crops made considerable contribution to the welfare of communities in the study area through uses for medicinal purposes and source of cash income. In order to understand the maintenance and conservation aspects of farmers' varieties in the area crop spatial diversity and the association between varieties of crops and their important attributes were investigated.

4.3.1 Crop spatial diversity

This section of the paper presents household and farm characteristics that determine crop diversity maintained by households in the study area. Variables for analysis were selected based on previous studies (Benin *et al.*, 2003; Nagarajan & Smale, 2005). Data consistency was sought for the household farm analysis by omitting observations with missing data on relevant variables. Sixty-eight observations (households) were used for the analysis. Of the inter-specific diversity recorded in the study area (Table 6), 75.5 % of the households grow wheat, maize, sorghum, *tef* or *noug*. Households grew One to five of these crops. Sorghum was grown by most of the households (28.5 %), followed by maize (25 %), *tef* (20.2 %), *noug* (17.1 %) and wheat (9.2 %). All of these crops were main season crops and the diversity is distributed spatially across households rather than per household.

A one-way ANOVA showed that there were significant differences in distance to the nearest all weather road ($r^2 = 92213.33$, $p < 0.001$) and distance to the nearest market ($r^2 = 7125167.85$, $P < 0.001$) between the peasant associations interviewed. However, total number of household members ($r^2 = 34.98$, $p < 0.020$) farming involvement of farmers ($r^2 = 229.03$, $p < 0.032$), total cultivated lands ($r^2 = 42.40$, $p < 0.025$) and number of oxen owned by the household heads ($r^2 = 1.123$, $p < 0.749$) were not significantly different between peasant associations (also see Annex 3). To understand effect of these variables on crop diversity at household level, data were further treated using Tobit regression as discussed in the next section.

4.3.1.1 Inter-specific crop diversity

Household farm characteristics such as distance to all weather road, sex of the household head, engagement in farming, availability of extension services, number of oxen, endowment and titlement of land as well as amount of farmland operated by a households did not show positive and significant relationship with numbers of crops they grow. These variables were also not positively related to the evenness in the area shares, or specialization in any single crop (except farmer number of years of farming, which showed positive relationship), as the dependent variable (Table 8). Factors affecting production assets such as oxen, endowment and tiltlement of land seemed to have relationship with farmers' specialization on certain crops only. Distance to the nearest market centres, availability of formal credit, religion of the household head, and household income sources showed a positive relationship (though not significant) with the number of crops grown, the evenness in area share (except for household income sources, which showed negative relationship).

Table 8 Censored regression results, factors affecting inter-specific diversity of crops on household farms in Gindeberet

Variables	Shannon		Margalef	
	Coefficient	t-ratio	Coefficient	t-ratio
Number of plots	0.444349	22.01***	0.214699	409***
Agro-ecological category	-0.054926	-1.61*	0.000238	0.27
Distance to town	0.000018	0.12	0.000002	0.54
Distance to road	-0.000179	-0.89	-0.000006	-1.07
Sex of household heads	-0.060294	-1.14	-0.000708	-0.55
Age of household heads	0.008536	2.43***	0.000023	0.25
Family size	-0.015153	-2.91***	-0.000213	-1.6*
Education of household heads	0.052693	2.02**	0.001051	1.59*
Religion of household heads	0.012790	0.66	0.000268	0.54
Farming engagement by household heads	-0.005489	-0.14	-0.000540	-0.54
Year of farming by household heads	-0.005984	-1.83*	0.000020	0.24
Credit availability	0.014155	0.34	0.000116	0.11
Extension services	-0.015218	-0.36	0.000366	0.35
Income sources	0.010570	0.89	-0.000157	-0.51
Land ownership	-0.084303	-0.60	-0.004173	-1.19
Land title	-0.018836	-0.65	-0.000963	-1.33
Total cultivated land	-0.000753	-0.19	-0.000032	-0.32
Number of oxen	-0.003981	-0.32	-0.000016	-0.05
Constant	-0.362235	-2.04**	-0.208765	-46.00**
N	68		68	
Chi-square (22 *df*)	508.26***		167.55***	

* P < 0.1, ** P < 0.05, *** P < 0.001

Farm physical features such as large number of plots and education of the household heads was positively related and significant with the cultivation of richer and evenly distributed crop combination, perhaps reflecting farmers temporal smoothening in crop requirement through growing combinations with different planting, weeding and harvesting dates. With increasing farmland fragmentation the entire heterogeneity in cultivation environment is likely to be higher (Meng *et al.*, 1998). According to Brush (1993), fragmentation of farm holdings allows farmers to maintain landraces in at least one field. Positive relationship for education suggests that human capital and information are encouraging for growing a relatively greater number of crops. The number of family members showed significant relationship (in the negative direction) with number of crops grown and evenness of crop distribution, since the available household labour supply influences the amount of time that can be devoted to tasks affecting diversity outcomes (Meng *et al.*, 1998). Agro-ecological conditions and number of years of farming by household heads showed negative relationship with the number of crops grown, suggesting cultivation of greater number of crops were not influenced by biophysical factors, seasonality of climatic conditions and farmer experience in farming, rather socio-economic conditions might have enthused specialization. In fact, the two variables had positive relationship with evenness of crop distribution (though not significant). On the other hand, age of the household was positively associated with greater number of crops grown. The elder farmers and those who have greater farming experience are likely to grow large number of crop diversity as oppose to younger farmers who might specialize in certain crops.

Farmers interviewed reported that they had been growing wider diversity of crops for sound agronomic and economic reasons and they are still willing to continue crop diversification for strategic reasons to ensure survival and food security of the farm household. The obvious reason for such diversification is to reduce risks.

4.3.2 Crop varieties for multiple uses and preferences

In addition to the factors explaining maintenance of crop diversity by household farms, farmers have indicated reasons for growing landraces for number of years. Interviewed farmers had kept seeds of own varieties for a range of 1 to 32 years. Most of them maintained them for about 8-10 years. In case of loss of own varieties, farmers managed to get the same variety from other farmers through exchange and purchase from the local market. They believe that their own varieties are better adapted to the climate and soil conditions of the area. Lack of access to other types of varieties, the fear of inaccessibility once own seed is lost from their hand, and deep knowledge on their own variety made them stick to own varieties and maintain them for longer periods. Even if they maintain diverse varieties, farmers' preference varies between varieties for numerous attributes.

4.3.2.1 Tef varieties

The results of correspondence analysis for *tef* varieties are presented in Figure 4. The first axis contributed about 62.2 % of the total variation and the second contributed 15.2 % (Figure 4). Correspondence Analysis (MINITAB, 1998) on several attributes of 12 major *tef* varieties resulted in separation of *bunnuse, daaboo, minaaree adii, muriyyii adii* and *muriyyii diimaa* from other varieties*, bashanaa, xaafii durbucoo, xaafii adii, foqoree, qomixee,* and *baadee galaa,* and assigned them into the negative and positive direction of the first component (axis) respectively. Being a negative or positive direction has nothing to do with values, it does show their association i.e. contribution to the respective components (Figure 4, Annex 4a). Features such as drought tolerance, straw palatability, and earliness showed highest score in the negative direction of the first component showing their strong association with the red seeded variety *bunnusee*. Attributes such as use for religious purposes, local beverage, *budeena*, porridge, *qiixxa* (unleavened thin bread) and its yield and taste, was also associated with *bunnusee* and the other varieties, *minaaree adii*, *muriyyii adii* and *muriyyii diimaa*. Each of these varieties has an association with several traits. Farmers described *bunnusee* for its quality *budeena*, porridge, and *qiixxa*. They also mentioned that *bunnusee* grows commonly in the lowland areas and had better adaptation to moistures stress. Previous study by Ketema (1997) indicated that *local* cultivars of *tef* such as *gea-lamie*, *dabi*, *shewa-gimira*, *beten* and *bunign*, which are early maturing varieties (<85 days), are widely used in areas that have a short growing period due to low moisture stress or high temperature. *Bunnusee* is also called *Bunign* in Amharic name speaking areas.

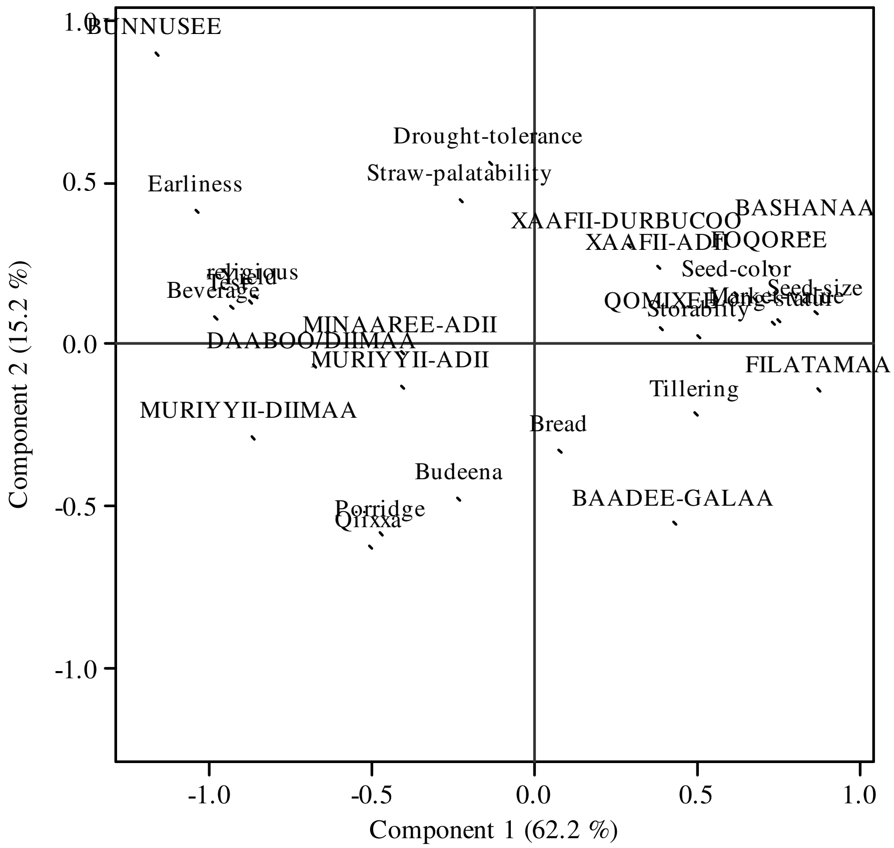


Figure 4 Biplot of local varieties of *tef* and associated attributes in Gindeberet (uppercase represent farmer' varieties and lowercase refers to attributes)

Of the *tef* varieties, *daaboo* (also red seeded) was highly appreciated for its consumptive and medicinal uses. Its roasted grain mixed with oil is used for treating diarrhoea. *Daaboo* was used for making *budeena*, porridge, *qiixxa* and local beverages. Moreover, farmers prefer *daaboo* for preparation of foods that are served during religious ceremonies and for traditional scarifies.

In the positive direction of the first component (axis), attributes such as seed colour, seed size, tallness, storability, tillering capacity, market value, and use for bread contributed more. An interesting association of these attributes were made with white seeded varieties. White seeded varieties (*bashanaa*, *xaafii adii*, *foqoree*, *qomixee* and *baadee gala*) were indicated by farmers for their better tillering capacity, tallness, seed size, seed colour and market value (Figure 4). Farmers, who had enough farmland, grew the variety called *xafii adii* (white seeded) for its high market price. End users appreciate white seeded varieties for their special uses during various ceremonies because of the good colour and quality *budeena* (flat pancake). People often used to serve guests with foods that were made from such varieties.

The second component (axis) separated varieties such as *muriyyii diimaa*, *muriyyii adii*, *daboo, minaaree adii* and *baadee gala* (in the negative direction) from *bunnusee*, *bashanaa*, *xaafii durbucoo*, *xaafii adii*, *foqoree* and *qomixee* (assigned in the positive direction). Attributes such as earliness, yield, drought tolerance, straw palatability, storability, seed colour, seed size, tallness, religious use, taste, market value, and use for local beverage contributed more to the positive direction. Whereas, tillering capacity; use for bread, porridge, *budeena* and *qiixxa* contributed more to the negative direction of the second component (axis). These associations also signified that *bunnusee* was preferred for its earliness and drought tolerance and at the same time white seed, varieties (*bashanaa*, *xaafii adii*, *foqoree* and *qomixee*) were preferred for their seed colour. Farmers stated that *daaboo* had multiple end uses in the area, thus the association of multiple attributes.

4.3.2.2 Wheat varieties

Correspondence Analysis generated the first axis, which contributed about 39.9 % and the second component contributed 31.1 % of the total variation. Correspondence Analysis of considered attributes of eight major wheat (durum and bread wheat) varieties (both improved and local) resulted separation of *daashin, filatamaa* and *gurree* from other varieties*, abbaa-biilaa, sallaattoo, roomaa, boondii and inkoyyee* and allocated them into the negative and positive direction of the first component (axis) respectively (Figure 5, Annex 4b). Features such as use for religious purpose, bread, *budeena*, *qiixxa*, porridge; and seed colour, market value, yield, and earliness showed highest score in the negative direction of the first component showing their strong association with the improved variety known as *filatamaa*. Attributes such as use for local beverage somehow contributed in the negative direction and showed strong association with a variety *gurree*. Farmers described *gurree* was mainly used for malt for preparation of local beverages. They also mentioned that *gurree* grows commonly as shade plant and had better adaptation to moistures stress since it is fast maturing. *Daashin* was most commonly encountered variety since it has multiple end uses including better market price compared to other varieties.

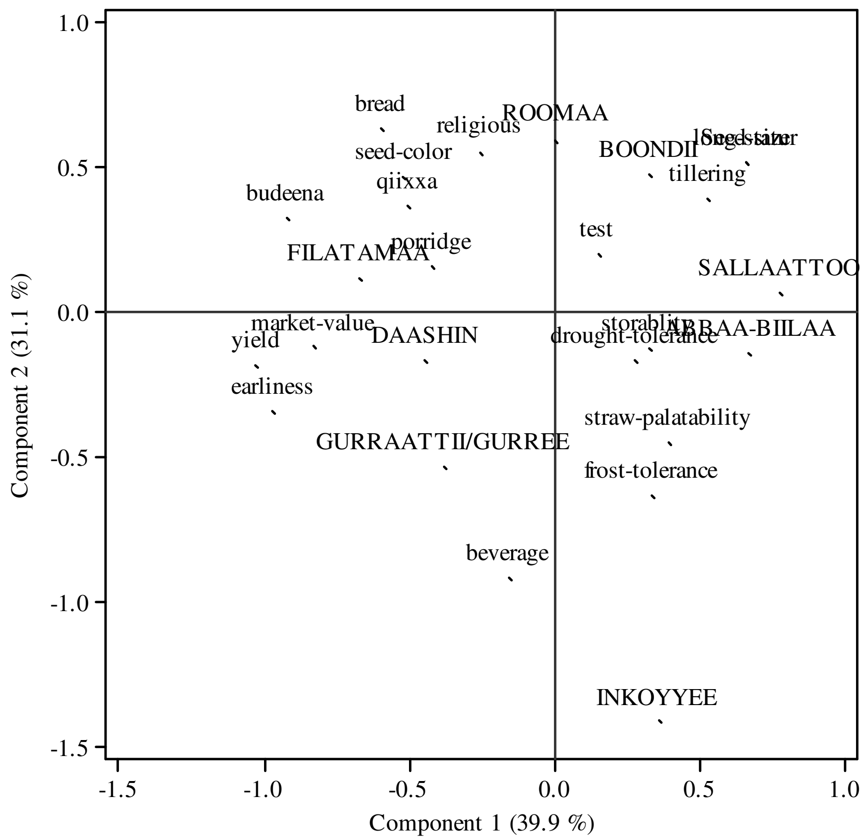


Figure 5 Biplot of varieties of wheat (both durum and bread wheat) and associated attributes in Gindeberet (uppercase represent farmer' varieties and lowercase refers to attributes)

In the positive direction of the first component (axis), attributes such as seed size, tallness, tillering capacity, taste, storability, drought tolerance, frost tolerance, and uses of straw contributed more. Varieties such as *roomaa*, *boondii*, *sallaattoo*, *abbaa-biilaa* and *inkoyyee* were associated with these attributes. Except *inkoyyee* the rest were farmers' varieties. Their association signified the farmers' description that landraces were better adapted to environmental constrains such as drought and frost, and preferred for their taste. These farmers' varieties were reported to have great importance for their straw because it is was used for roof thatching in the study area.

The second component (axis) separated varieties such as *filatamaa, roomaa*, *boondii*, and *sallaattoo* (positive direction) from *gurree, abba-biilaa, daashin* and *inkoyyee* (in the negative direction). Attributes such as taste, tillering capacity, seed size, tallness, seed colour; and use for religious purpose, bread, *budeena*, *qiixxa* and porridge contributed more to the positive direction. Market value, yield, storability, drought tolerance, earliness, straw palatability, frost tolerance, and uses for local beverage contributed more to the negative direction of the second component (axis). Farmers appreciated the improved variety (*filatamaa*) for its market value and yield. They stated that *inkoyyee* was very good for making *araaqii* (distilled local liquor). However, attributes such as seed colour, use for religious purposes, bread, poredge, *budeena,* and *qiixxa* are lossely associated with *inkoyyee*. *Boonii*, *roomaa* and *sallaattoo* were known for their tallness, thus, the straw was very important for roof cover (thatch roof).

4.3.2.3 Maize varieties

Correspondence Analysis generated the first axis, which contributed about 45.5 % of the total variation and the second component contributed 29.9 % (Figure 6). The analysis on farmers rating for several attributes of 8 varieties of maize (both improved and landraces) resulted in separation of *boondii*, *chaayinaa*, *filatamaa* and *gordod* from other variants, *feeshoo*, *wallaggee*, *biyyaa-dhufee* and *jiilame* and allocated them into negative and positive direction of the first component (axis) respectively (Figure 6, Annex 4c). Attributes such as market value, seed color, seed size, yield, tallness, disease and frost tolerance; and use for *budeena*, bread, *qiixxa* and porridge contributed in the negative direction of the first component (axis) showing their strong association with the varieties. Farmers stated that white seeded varieties such as *boondii*, *chaayinaa*, *filatamaa* and *gordod* were preferred for their seed colour and bigger seed size.

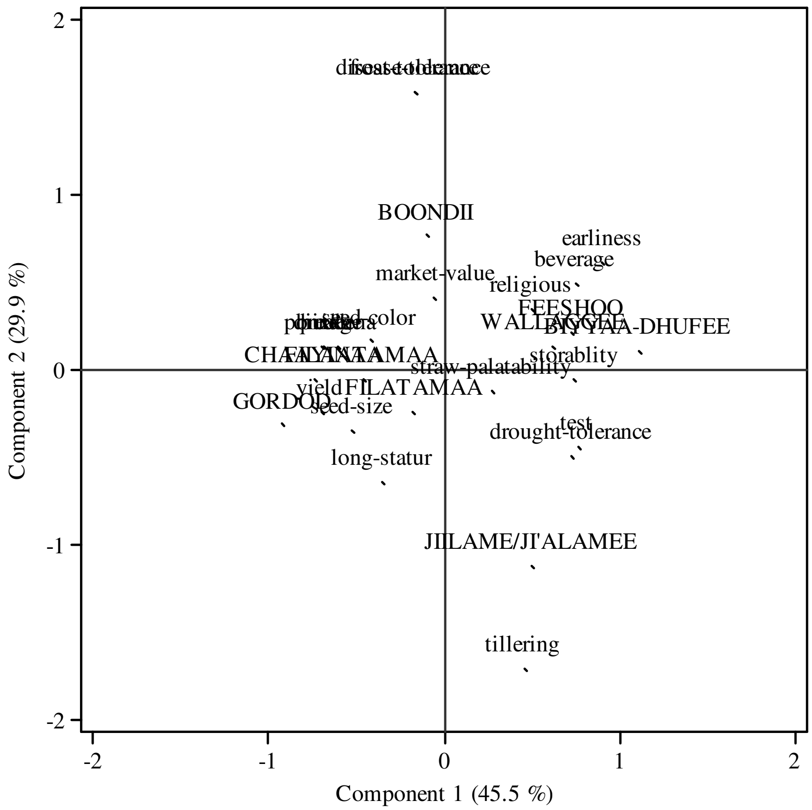


Figure 6 Biplot of varieties of maize and associated attributes in Gindeberet (uppercase represent farmer' varieties and lowercase refers to attributes)

The second component (axis) separated varieties *boondii*, *chaayinaa*, *feeshoo*, *wallaggee* and *biyyaa-dhufee* (positive direction) from *filatamaa*, *chaayinaa*, *gordod* and *jiilame* (in the negative direction). Features such as market value, seed colour, earliness, disease and frost tolerance; use for religious purpose, bread, *budeena*, *qiixxa*, porridge and local beverages contributed more to the positive direction while yield, seed size, taste, drought tolerance, tallness, storability, straw palatability and tillering capacity contributed more to the negative direction of the second component (axis). *Feeshoo*, which is equally competing with improved varieties in the area (Table 13), was reported to have multiple uses in the area. Farmers acknowledged its better market price and use for *asheeta* (fresh green), *muullu* (boiled dry), *akkawii* (roasted) and local beverages. They also indicated that *Jiilame* matures in two months, thus it escaped from effect of drought when rain was absent during flowering stage for other varieties. Farmers also indicated that *boondii* was resistant to frost and diseases.

The critera for classifying farmers' varieties used by Ethiopian farmers include: adaptability, high yield, reliable and stable yield, cooking quality, taste, colour, disease and pest resistance, grain size and texture (Worede & Mekbeb, 1993). Farmers in Gindeberet were using criterion, primarily those associated with varietal merit, agro-morphological and culinary features of the plants. Farmers' varieties of sorghum in south Welo are normally distinguished by farmers in terms of their agro-morphological characters (Teshome *et al.*, 1997), which are the results of many years of activities of isolation, selection and hybridization (Harlan, 1975). Moreover end uses, quality and tolerance to biotic and abiotic stress factors are also reported to be best criteria in varietal identification by farmers in Ethiopia (Kebede, 1991). Farmers in Gindeberet also consider end uses to classify varieties but it was not basic factor to discriminate crop varieties. Even if end uses are important in classifying finger millet in northern Ethiopia (Tigray), farmers don't use it for identifying varieties (Tsehaye, 2004).

Farmers in Gindeberet recognized all varieties with respect to preferred attributes. They maintained diverse varieties to derive several goods and services and as the same time to minimize production risks. Consequently, all farmers of the area failed to keep market-oriented production, thus, they retained subsistence mode of crop production. It is a general expectation for farmers to retain subsistence mode of production instead of specialization in crops due to market imperfection and the probabilistic nature of crop production. Landraces are still grown by farmers in centers of crop origin and diversity by many subsistence farmers to cope with the heterogeneous farming system (Bellon & Risopoulos, 2001).

4.3.3 Vernacular names

Like inter-specific and infra-specific diversity of crops, the naming of farmers' varieties differed markedly between and within agro-ecological zones. The naming also varied between villages. Vernacular names of farmers' varieties were recorded with their meanings for a range of crops grown in the area. All vernacular names were given in *afaan* Oromo (the language of the area). Vernacular names of farmers' varieties are often useful clues to charecteristics of crops and are needed in communicating back to the farmers and local people who use the crop. In fact, vernacular names do not always represent the botanical identity of the plants. However, in the study area, vernacular names of farmers' varieties were the reflections of breeders' names, culinary attributes, geographic origin, habitats, field performance, agro-morphology, and varietal seed sources (Table 9).

Most varieties were named based on their morphological attributes (Table 9). Vernacular names of farmers' varieties gave some indication of agronomic characteristics such as plant height, leaf colour, seed colour, head type, and seed size. For example, *diimaa,* meaning red referred to seed colour. Some of the vernacular names are associated with seed sources (e.g. *wallaggee, horroo and mojoo)* where the variety was brought from. Others imply earliness (e.g. *jilame/ji'a lame* means beauty of two months implying that the variety matures in two months), quality (e.g. *sanaf qoloo* and *qaxxee* eating quality of fried snacks). Some other varieties were named after the clan or the farmer breeder who developed it. For instance, *tuulamticha* and *bashanaa* were named after the clan *Tuulamaa* and farmer breeder *Bashanaa* respectively. Besides, farmers in the area named exotic varieties after the people who introduced it and the country of vareital origin. For example, *suufii faranjii* and *qamadii roomaa* meaning white man's safflower and Italian wheat respectively were referring to the people who introduced the variety and Italian origin. Vernacular names also dealt with varietal purity. For example, *ayoo adii* refers to original white seeded *tef* variety. It means that all other white seeded varieties had some degrees of contamination from other varieties.

Table 9 Vernacular names of some selected species/varieties of crops grouped according to attributes refered in the names

Referred attributes	Species/varieties	Meanings and implications
Breeders' name	*Abbaa shawayyee*	Shawayyee's father, name of farmer breeder
	Baalchaa adii	White seed of Baalchaa, name of a farmer breeder
	Bashanaa	Name of a person, farmer breeder
	Tuulamticha	Name of clan, variety brought by a clan called Tuulamaa
	Suufii faranjii	White man's, exotic sunflower
	Roomaa	Italian, variety introduced by Italians
Culinary attributes	*Qaxxee*	Pop barley, seeds explode upon roasting
	Sanaf qoloo	Weak fried snack, soft when eaten
	Shaggar baasaa	The brew can make one to walk to Addis Ababa (193 Km), good brewing quality
	Fandishaa	Pop maize, seeds explode upon roasting
Geographical origin	*Chaayinaa*	Country name, variety brought from China
	Horroo	Place name, variety brought from a place called Horroo
	Wallaggee	Place name, variety brought from a place called Wallaggaa
	Mojoo	Place name, variety brought from a place called Mojoo
	Dasoo	Place name, variety brought from a place called Dasoo
Habitat	*Goommana simbiraa**	Bird's cabbage, grow wild and seed is picked by birds
	*Qobboo simbiraa**	Bird's castor bean, wild type with smaller seeds
	*Marga goggorrii**	Partridge's grass, named after Partridge which picks its seeds in the wild
	Migira saree[*]	Dog's grass, is named because dogs smell and urinate on it
Merit (field performance)	*Mosnoo*	Irrigation; variety that grows with minimum soil moisture, usually planted on potato field immediately after its harvest
	Jilame/Ji'a lamee	Beauty of two months, that matures in two months
	Dafaa	Fast, fast maturing variety
	Janfala	The fool, fast growing and lodging variety
	Bunnusee	Dry fast, early maturing but shatters easily
Morphological description	*Ballammii*	Weed name, resembles a weed called *ballammii*
	Mata-jaboo	Hard spike, hard to thresh
	Baqilaa gurgudda	Big bean, big seeded
	Baqilaa xixxiqqa	Small bean, small seeded

[*]Wild relatives of crops

	Atara burree	Mixed, mixture of white and black seeds
	Feeshoo	Colourful; mixture of red, gray and white seeds on same ear
	Gordod	Big, bigger seeds
	Abbaa qorratti	Thorny, has thorns
	Ayoo adii	White seeded mother, original white seeded variety
	Gurraacha	Black, black seeded
	Baal dimessa	Red leafed, reddish leaf colour
	Daaboo/diimaa	Red, red seeded
	Daggalee	Weed name, long stem
	Muriyyii adii	White seeded *muriyyii*, its compact spike resemble its wild relative known as *muriyyii*
	Xaafii adii	White, white seeded
	Xaafii durbucoo	Mixed, mixture of white and red seeds
	Abbaa biilaa	Awned, have awns
	Buttujjii	Thick, short and compact spike usually with much rows
	Gufooroo	Hairy, variety possess prominent awns
	Gurraattii/gurree	Black; black seeded, femaleness is attached to show small seed size
	Sallaattoo	Good looking, have long spike
Seed source	*Baadee galaa*	Lost and returned; restored variety, variety that has been lost and reintroduced
	Filatamaa	Improved, variety with better performance
	Biyyaa dhufee	Introduced variety, variety introduced from other region

On the other hand, recognizing farmers' varieties was sometimes confusing. During the fieldwork, it was possible to come across a given variety bearing different vernacular names at different places. For example, same variety of *tef* was named as *daaboo* and *diimaa* in different villages as well as within villages. A single base name was also found to apply for two different varieties (e.g. *adii* meaning white seeded that applies to different varieties of wheat, *tef* and barley).

4.3.4 Traditional wisdom on agricultural practices and crop genetic resources

As much as vernacular names indicated uses of local knowledge on managements of crop biodiversity in the study area, socially constructed proverbs, folksongs, poems, and cultural practices were also found to have some cultural significance in the management of crop diversity. The Oromo communities in the study area had an intelligent way of expressing their wisdom and experiences using proverbs, folksongs, and poems. Thus, their knowledge highlighted the importance of farmers' varieties and the management practices of crop genetic resources. Specifically, they were the reflections of agricultural systems of the study area and certain attributes about the crop species/varieties grown. Most of the proverbs, folksongs, and poems were related to food security. In connection with food security issue, interviewed farmers described the significance of certain crop species (e.g. Irish potato and maize) as famine food. Farmers of the study area told that proverbs, folksongs, and poems related to famine were organized during the 1984/85 drought periods that affected wide geographical area in Ethiopia. By that time Irish potato, maize and leafy forms of Ethiopian mustard (*Brassica carinata*) were the ones that saved the lives of many people in the region. Those local narrations signify knowledge on food security, livelihood security; and crops culinary attributes, field performance, agro-morphological features as well as selection pressure, agro-ecological adaptation, and risk management through diversification of crops (Table 10). This also suggests that farmers had deliberate reasons rationalizing for maintaining farmers' varieties.

Culture is defined as accumulation of knowledge, rules, standards, skills and mental sets that humans utilise in order to survive, i.e. to adapt to the environments in which they live (Kebebew, 2001). From the proverbs, folksongs and poems learnt through this study, it was possible to understand that there existed accumulated local knowledge that had enabled the farming community to adapt to changing environmental conditions. For instance, in the following poem the local community narrated how diversification of crops over different agro-ecological zones helped to ensure food security.

Birraa maal jettee beellii jennaan, *Gammoojjiin qawwee bitate* *Saqni eeboo bitate* *Beena baddatii haa dachaanu* *isaantuu harca'aa harkaa fixate,* *jettee beellii jedhuu.*	Meaning	Translation: When asked what hunger said in *birraa* (September - October), it said lowlanders bought guns, midlanders bought spears, so let me go to the highland where they have nothing. Interpretation: Guns and spears here refer to the ripening of maize and barely. Therefore, it highlights linkage and importance of agro-ecological adaptation and seasonal variation of crops to household food security.

Figure 7 Traditional poem constructed by the local community to explain food security issue in Gindeberet

In this poem, the local people highlighted linkage and importance of agro-ecological adaptation and seasonal variation of crops to household food security. Customary proverbs, folksongs, and poems that are reflections of local knowledge on the use and management of crop genetic resources are summarized and presented in Table 10.

Table 10 Proverbs, folksongs and poems of Oromo communities in Gindeberet associated with uses and management of crop genetic resources

Attributes	Proverbs, folksongs, and poems in *afaan* Oromo	Meanings and implications
Agro-morphological	*Gurran raasa akka arbaa* *gannan baasaa akka abbaa, jedhe worqeen*	Translation: "I flap my ears like elephant, I take you through *ganna* like a father", said *worqee* (*Ensete ventricosum*). *Ganna* = rainy season (time of food shortage), ear refer to leaves. Interpretation: Morphological description and its role in food security
	Ani dhufee abbaan areeda bishii, *abbaan bareeda dinqii,* *abbaan kootii dirriibi, jedhee boqqolloon*	Translation: "I am coming with my tufted beard, admirable beauty, and thick coat", said maize. Interpretation: Morphological description and its role as famine crop during times of food shortage in autumn when it is ready for consumption as greens.
Culinary and/or quality	*Daaboo dhiiga dhiiraa, dhiirrii qoomafi,* *nadheen qoonqof si nyaattii*	Translation: *Daaboo* (red-seeded *tef* variety), you are part of men's blood, men eat you for body strength; women eat you when they are hungry. Interpretation: High iron content, nutritional quality
	Aqaaqiin bishaaniree *dheebonan dhugnee malee* *akkaawwiin midhaaniree* *beelofnaan nyaanne malee* *biyyii ormaa gaariidharee* *rakkannan deemnee malee*	Translation: Is Akaki water? – but we drink it when we are thirsty; Is roasted grain a meal? – but we eat it when we are hungry; Is foreign country good to live? – but we go there when we have to. Interpretation: Compared to the fresh green, roasted grain has low nutritional value.
	Midhaanis midhaani, *gaayyoonis midhaani,* *midhaan midhaaniin nyaatan*	Translation: Is crop (cereal) a crop? Is grass pea a crop? - a crop that is eaten with other crops. Interpretation: Grass pea is rated relatively lower in its nutritional quality compared to other pulses. Its consumption also causes

		paralysis of lower joints. It is consumed only as *ittoo* (Ethiopian stew) served with *budeena* because its toxic substance that cause lathyrism/neurological disorder (Kaul *et al*. 1986) need to be detoxified.
	Yaa boqqolloo seenaa isaa, *yommuun deemu bassoo isaa,* *yommuun galuu farsoo isaa.*	Translation: Wow! The story of maize, its *basoo* (roasted maize flour solidified with butter) is so good for journeys; its farsoo (local beer) is enjoyable at home. Interpretation: Its multiple end uses
	Nooruu yaa gurraa (loon) sin tiksuu galabaa *nuugii humadhaanan siin laba malee*	Translation: I will better keep you (my cattle) on poor pasture land than graze on *noug* residue in the field. Interpretation: Low feed value of *noug* residue or low straw palatability and inconveniencies to graze.
	Mishingaa yaa kombolosee *oton malakka tokko loosee*	Translation: Oh! Beautiful sorghum stand, I wish to have a glass (*malakka*) of *araqee* (local distilled liquor). Interpretation: Sorghum has good brewing quality.
	Adii yaa soorata cidhaa *daaboo soorata maati,* *jedhu xaafiidhan*	Translation: White *tef* is meant for wedding, whereas red *tef* is meant for family consumption. Interpretation: Food preferences for different occasions, based on colour, texture, and eating quality of *budeena*
	Daaboo dabeeti koo *amal qabeeti koo* *gumbiitu si yaadee* *aduutu si nyaatee, galii galii.*	Translation: The good mannered *daaboo* (red seeded *tef* variety), *gumbii* (locally made grain storage bin) is missing you and the sin is killing you, please come home. Interpretation: Appreciation of most of its traits and at the same time implying that *daaboo* shatters when left in the sun for longer period after maturity.
Ecological adaptations	*Ogdii keessatti kufurraa* *gannaa dhoqqee keessaattii kufuutu caala*	Translation: Rather than failing in the threshing ground, it is better to fall in the mud during rainy season. Interpretation: Strong commitment of farmers to carry out planting even during difficult seasons for the better yield they are looking.
	Heerumsissa durbba fi facaasa garbuu *eenyutu beekka baaranaa*	Translation: These days growing of barley and marriage age of girls are very difficult to predict. Interpretation: Because of the decline in soil fertility, barley has nearly lost its wide adaptation.
	Baddan kobortaan na bite *gammoojjiin moccorsan na fixe,* *jedhe boqqolloon*	Translation: "The highlanders sold me to buy a coat, the lowlanders exhausted me with repeated scratching", said maize. Interpretation: Explains the differences in the uses of maize in different agro-ecological zones
	Birraa maal jettee beellii jennaan, *Gammoojjiin qawwee bitate* *Saqni eeboo bitate* *Beena baddatii haa dachaanu* *isaantuu harca'aa harkaa fixate,* *jettee beellii jedhuu.*	Translation: When asked what hunger said in *birraa* (September - October), it said lowlanders bought guns, midlanders bought spears, so let me go to the highland where they have nothing. Interpretation: Guns and spears here refer to the ripening of maize and barely. Therefore, it highlights linkage and importance of agro-ecological adaptation and seasonal variation of crops to household food security.
Food security	*Dinnichaa koo yaa lotoo koo* *sin facaafadha boroo koo* *nyaanni kee akka gaarii* *finchaan kee garba baarii*	Translation: My potato, a crop of luxurious growth, I will plant you in my backyard, eating you is very good, although the urine produced is like a sea. Interpretation: High sugar and water content of Irish potato
	Yaa abbaa gammachuu *oton akkana se'ee qotee gotoraatti sin galchuu*	Translation: Oh! *Abbaa gammachu* (maize), have I known this kindness of yours from before I would have cultivated and stored you in my *gotoraa* (locally made storage bin). Interpretation: Maize is a famine crop. It helps household to be food secured.
	Bara boqqolloon badee *sareef ijoolleetu badee,* *bara mishingaan badee* *simbiraaf hadhaa hiyyeesaatu badee,* *jedha geraraan*	Translation: The year maize failed, it was dogs and children that suffered; the year sorghum failed, it was birds and the poor that are suffered, *geraraa* (said hero singer) Interpretation: Highlights importance of maize and sorghum in household food security; failure of these crops affects not only

		humans but also domestic animals.
	Dinnichaa koo yaa lolosoo *situ na baasee godoo koo* *gurgureen oolee qoloo koo* *sin qotadha boroo koo*	Translation: My Irish potato of big tuber, you made me survive the lean period in my hut, you saved me from selling my dress, I will plant you in my backyard. Interpretation: Irish potato plays a great role in food security.
	Boqqolloon birraa gahe *dhufe hinbaatuu yaa dinnichaa jennaan* *kan ganna baasee ana eessaa dhufte* *atoo daaraa keessaattan si argee* *akka wadala harree, jedhee dinnichii jedhu*	Translation: Maize, being mature in *birraa* (September - October), commands Irish potato: "leave the house!" Irish potato replied, "I took the family through *ganna* (rainy season/lean period). Where did you come from? I just saw you rolling in the ash like a donkey. Interpretation: Diversification for risk management, the two crops mature following each other and keep the household food secure.
	Gommana yaa waaroo koo *situ na baase haadhoo koo*	Translation: Ethiopian mustard, my dearest, my warmest cloth, you saved me. Interpretation: Cabbage comes into arena during the climax of seasonal food shortage; its nutritional value is highly appreciated as energy source.
Market	*Kan na dhaabdan qubaan* *kan na gafattaan lukan* *egeree baati gumaan, jedhee boqqolloon*	Translation: "You planted me with your finger, now you are asking me with your foot (in the market), you will see the revenge later", said maize. Interpretation: Low market price during harvest time
Merit	*Areeda bishii gotee* *ji'a shan duulaa taatee* *eessaan nu biraan baate,* *jedhu boqqolloo feeshoodhan*	Translation: "With your tufted beard, being away for five months, from where did you come for us?" said farmers to *feeshoo* (a local variety of maize). Interpretation: Longer maturity period
	Otoo maal gootuu yaa catee sammaan *si duuba ka'ee si fuldura ba'e*	Translation: "What have you been doing when *sammaa* (a weed) grows faster than you (*catee* - a local variety of highland sorghum)?", asked farmers. Interpretation: Poor weed tolerance capacity
Selection	*Yaa mishinga rasarrasa/jafajafa mataa daabee* *namni si qotuu didee mal yaadee,* *jedhu hacciroo adiidhan*	Translation: "*Hacciroo adii* (a local variety of sorghum), with your droopy panicles, people are banning your cultivation, what are they thinking?", ask some farmers. Interpretation: selection pressure is tending to remove certain genotypes of sorghum varieties from the domain.
Social	*Firaaf midhaanitti hin koorani*	Translation: You do not disregard your relatives and crops. Interpretation: Crop use values are given greatest respect as relatives, which is as strong as social ties in human life

There also existed a cultural practice, which the local community used to call *ayyana sanyii* and *ayyana midhaani*, which means "planting seed" and "crop ceremonies" respectively. These are ceremonies performed during planting and threshing (before the crop is stored at the threshing ground) to be blessed with plenty of harvest. During the ceremonies, *mugeraa* (big circular bread) and *marqaa* (porridge) were prepared from crops to be planted or threshed. The bread and porridge was enjoyed after the prayer for better yield. Specifically, at the threshing ground people cover the grain with a piece of cloth and phrase in *afaan* Oromo: *daara si baasee daara na baasii* meaning I should be dressed the way I dressed you/the grain.

Another cultural practice common to the study area was *ayyana arsaa* (smoke ceremony). Various food and drinks were made and taken to the crop field. After burning the dried weed and smoking the crop, people enjoy the food and drinks. This ritual sacrifice was held annually in October with prayer for better yields and for protection against crop disease and national disaster.

4.3.5 Farmers labour use system

Local institutions and a system of inter-household cooperation were central forces of the communities to mobilize labour and capital for agricultural production in the area. The main types of co-operation, which underpins farmers' responses to labour constraints in Gindeberet, for example, included sharing draught animals and working co-operatively through sharecropping and labour exchange groups or working parties known as *fulbaasii/qaboo, kadhaa, daboo/wanfala, jigii and kadhaachisa.* These institutional systems played a significant role focusing on effective solidarity by establishing social security.

For most of the months during a year, farmers are self sufficient in labour. However, during peak ploughing, weeding, harvesting and threshing seasons some farmers faced labour shortage. To overcome the shortage, it was common to hire working parties. In all of the villages surveyed, the different working parties had the same meanings. These working parties included:

1) *Fulbaasii/qaboo* involves a group of people working for one member for half a day. It was organized when a household experiences sudden problems like sickness or death of family members during peak times of agricultural activities. In most cases, food and drinks was not provided. Reciprocation was not expected;
2) *Kadhaa* is arranged when someone asks the assistance of others for ploughing, weeding, harvesting, house construction, cutting grass/straw for roof cover and firewood collection for longer hours by providing foods and local drinks. Reciprocation was expected but not paid back rapidly. *Kadhaa* was declining because of the costs of foods and drinks;
3) *Daboo/wanfala* involved people in a group working for one member for a day (food and drinks were provided). Reciprocation was expected. *Daboo* was also declining because of wage labour;
4) *Jigii* involved a group of people working for few members of the community who had problem due to sickness or death of family members or a group of organized people might

help each other during natural calamites, for example, during heavy rain at harvest periods. It may or may not be reciprocated; and,

5) *Kadhaachisa* was when relative of some one request the assistance of his/her friends to work for his relative (usually wife's parent) in various works. The person enjoying the support will not directly pay back the labour. Reciprocation was expected from the person asking the assistance who in turn expects from the person who benefited from the labour. The working parties were strengthened and existed for many years due to ties by kinship, neighbourhood, and networks of relations and intimacy.

Seasonality of demand for and supply of labour was an important issue in these social ties. Such social solidarity greatly contributed for agricultural production and management of crop genetic resources. These were through contribution to the timely operation of subsequent agricultural activities by households, which made farmers maintain their diverse production of crops. If there were no such social networking and ties among the farming communities in Gindeberet, it would have been very difficult for the resource poor farmers to accomplish their farm activities timely. Moreover, it would have been impractical to get such enormous varieties of crop genetic resources that are conserved in traditional ways on-farm in the area.

4.4 LOCAL SEED SUPPLY SYSTEM

This section of the paper presents information on seed supply system of the area. Since the use of own saved seeds as part of traditional seed supply system took the highest proportion (62 %) in seed supplies of the area, associated seed selection and storage practices are covered.

4.4.1 Seed source and diffusion

There were five major seed sources in the area. In Gindeberet, farmers source of seed material during planting included own saving, communities, friends or relatives, agricultural research centres, market and combinations of these sources. Traditional seed supply dominates. Most farmers (62 %) saved their own seeds for planting each year (Table 11). The dominance of traditional seed supply system was mainly due to the absence of formal seed suppliers in the area. Self-seed sourcing involved the actual selection of seed stock from the standing crops in the field and its maintenance under household condition until the planting seasons. In addition to seeds selected and stored from their own crops, farmers in some cases got seed from friends or relatives, or other farmers within or outside the community, and from agricultural research centres in the form of gift, exchange, purchase, or combination of these. Use of combinations of seed sources was common in the area. Farmers might use their own seeds for some crop species/varieties and exchange or buy from other farmers the varieties they did not have. Farmers exchanged seeds of one variety with another variety of the same crop species (infra-species), or a different crop species (inter-species) for the required attributes. Seed materials were also given as gifts among closely related farmers in the community.

Economically better off farmers (with no cash constraint) purchased desired seed from the local markets when they did not have the seed material. Nevertheless, the purchase of seed in the local market was from closely known farmers or other reliable sources. For example, some farmers in *Kalloo Badhassaa* marketed sesame from farmers in Gojam using trusted intermediaries following the boom of sesame price when they recently started its cultivation in large-scale. Since the production of some crops such as field pea, faba bean and emmer wheat was declining in the area; seed sources are mainly exchange from other farmers in the community or purchase from the local market. Crops for which production is declining in the area, seeds cannot be obtained from friends and relatives as gifts (Table 11). Moreover, faba bean and field peas were highly demanded for making "*ittoo*" (Ethiopian stew) since it was part of daily meal for most households.

Though the local seed system was the major seed source in the area, improved varieties were obtained from agricultural research centres following the formal seed supply procedures. Many of the varieties acquired through agricultural bureau failed to give good yields during the past two decades. As a result, farmers were not willing to use the source except for some varieties, which they think were rewarding. Recently, only improved varieties of maize and wheat were obtained from agricultural research centres and the use of these crops were common in the area (Table 11).

Table 11 Seed source and diffusion for major crops among farmers in Gindeberet

Crop	Own	Community	Friends or relatives	Agricultural research	Market	Aid
Tef	69	18	7		4	2
Linseed	72	14	14			
Sesame	100					
Faba bean	57	43				
Wheat	42	16	10	16	10	6
Field pea					100	
Maize	58	14	6	22		
Sorghum	64	32	2		2	
Emmer wheat		100				
Barley	100					
Noug	67	27	3		3	
Total	62	21	6	5	4	2

Most farmers (67 %), mainly the poor who did not have enough land for cultivation of crops, used other sources than own saved seeds. They usually got inadequate produce, which could not sustain the household all year round. As a result, they were forced to look for seeds from other sources during planting. All farmers in the area agreed that the rich household were recognized as seed farmers (i.e. seed source) in the community. This was because the rich had enough land to plant several varieties of crop species/landraces. They also reported that the rich normally save seeds in surplus than their needs because they also used other source of income for their living. It appears that diversity of enterprise owned by farmers is encouraging conservation of farmers' varieties. This is because the availability of resource including land encourages farmers to invest more on diversification within segment of each enterprise.

Like many other farming communities, combination of seed source were used by different farmers to enhance the seed material available first in type, then quantity, quality and diversity (Almekinders & Louwaars, 1999). The sequences of the seed source indicated the primary, secondary, and tertiary sources of availability for seeding during planting season. For example, the combination of seed sources of self, market, and gift indicated that the farmers had their own seed, but, to diversify the seed in type, quality, and quantity, they got additional seeds either from market as a secondary source and or as a gift from tertiary sources. In fact, the order of the seed sources varied from season to season based on the decisions of farmers.

Dissemination of seeds that originate from the small-scale farmers was facilitated by kinship and other social networks established within the community. Meeting places such as market, traditional group work, government meetings, wedding, and funeral ceremonies were very important for information exchange on agricultural practices in general and seed system in particular. Information that might be discussed during those gatherings include yield potential, disease resistance, market price, consumption preferences, and other attributes of varieties and these motivate farmers to arrange for its acquisition. Use and cultural values also determine the extent to which seeds diffuse within the community.

4.4.2 Seed selection practices

Since most farmers use own saved seeds, 73 % of the farmers interviewed reported that they practice seed selection for some crop species. Unlike some individuals in the northern Ethiopia who did not select seed because of the taboo in seed selection (Haddis, 1997), there was no taboo on seed selection in Gindeberet. All farmers expressed that seed selection was crucial in order to stabilize yield. However, some farmers did not select seed because of labour shortage and ignorance. Farmers practiced both pre- and post-harvest seed selection mainly in *tef*, maize, sorghum, barley, wheat, linseed, and faba bean. The majority of respondents (78 %) practiced seed selection before harvesting, while the rest selected at the threshing ground during winnowing and from store prior to planting. During pre-harvest selection, farmers walk through the fields select the best plants and bulk them for separate and storage until planting. Farmers had multiple concerns that were reflected in the criteria they used for selection. These included morphological traits (good looking, big and longer ears/spikes/panicles, and bigger seeds); agronomic traits (early maturity, good grain filling and tillering capacity); culinary attributes (e.g. taste in maize, use for malt in barley), and field performance (disease free). The majority of farmers (92 %), who practiced seed selection, based their selection criteria on plant's good looking, grain filling capacity, and bigger seed size. *Tef*, maize, sorghum, wheat, and barley were selected mainly based on the size of the head. In fact, disease free sorghum panicles and faba bean pods were also selected. During selection at threshing ground and storage, bigger and disease-free seeds were given priority by farmers. Other criteria such as non-lodging and seed colour of the plant were also mentioned. Most selection practices in the area focused on the yield potential of the crops. Moreover, farmers also liked to resolve their concerns about plant disease, maturity days, and other varietal qualities regarding market price and consumption needs via seed selection.

Generally, there was no difference between the midland and lowland areas, as well as among villages in terms of farmer's criteria in selection. Selection practices, however, differed by crop species. Farmers in the lowland areas commonly used to select sorghum and maize seed for the next planting season, while farmers in the midland areas exercised seed selection mainly in *tef*, wheat and barley. In fact, midland farmers also practiced selection in maize. Farmers intentionally exercised seed selection at maturity stage (pre-harvest) with careful observation of plant stands in the field. They harvested selected individual plants and kept them separately for the next planting season. Sometimes selection was made when farmers found good-looking plants by chance and mark them for separate harvest. Some farmers preferred seeds in the middle of maize ear for planting. They do so because they believed that the seeds at the middle of the ear were more productive and had better agronomic performance than the seeds at the top and base of the ear. They also claim that the seeds were resistant to weevils. Some others selected seed during post-harvest period and especially look for disease free plants/heads. Others used to select those seeds that were not taken by a current of air during separation of the seed from crop residue on threshing ground due to its weight. Thus, seed weight was an important criterion for seed selection. Farmer's effort to select better plants to obtain good quality seeds was a strategy followed towards stabilization of yield, maintaining varietal health and taste preferences.

Even though the level of participation was different, all family members participated in seed selection. Men took a leading role in seed selection in the area. At maturity, stage men used to select seed while walking in the field by picking good quality heads and the seeds were stored separately for planting. Women and children were also involved in seed selection. Women were usually involved in seed selection process during their free time, usually after they finished housework. Most women were instructed by their husbands to collect quality individual plants and keep them separately for planting seeds. Others were familiar with seed selection since they practiced selection by their own. Generally, decision on whether the identified seed had desired attributes or not was made by the husband. Selection of seed for planting from store and cleaning were mainly the duty of women. They took hours to separate desired seeds from unwanted seeds (diseased seeds and seeds belonging to different species/varieties) using their dextrous fingers. Young children (sons and daughters) were also active participant in the seed cleaning activity with their mothers. Some farmers reported that children were keen in identifying good quality seeds for selection. They usually used to inform their parents about those crops with good looking, longer panicle/ear/inflorescence, and bigger seeds. The participation of children was to enable them develop skills in seed selection and acquire the knowledge to do so in the future.

Generally, farmers select seeds based on the distinct observable plant morphology rather than the genes as such (Almekinders & Louwaars, 1999), and they observe them in the presence of environmental interactions. Thus, the maintenance of diverse crops and continuous selection was because a single landrace does not posses all the necessary attributes to meet the requirements of an individual farmer. A farm household used his/her selection criteria to meet those requirements in order to grow a variety of interest. The criteria represent complementary socio-economic, cultural, agronomic, ecological, biological, dietary, and nutritional needs derived from a range of crop species/varieties. However, those criteria could change from time to time due to seed sourcing, seasonality, market, and heterogeneity of agricultural fields. Seed selection, therefore, plays major role in the dynamic management of crop genetic diversity in the area. The dominant nature of men in seed selection signifies the intention for resource control. This might have an impact on the knowledge dissemination concerning seed selection in the community.

4.4.3 Seed storage practices

Seed storage practice was another important component of local seed system in Gindeberet. Small-scale farmers of the area stored seeds in order to save for planting, keep until market price rises and for consumption using various storage containers. The storage containers were cheap, affordable, locally available, and reliable for short-term seed storage. Containers such as *gaanii* (clay pots), *gotooraa* (bamboo/shrub sticks plastered with mud and dung), *guumbii* (made from *tef* straw and mud) and sacks were used for grain storage. Except g*otooraa* (Figure 8c), which was kept outside their houses to minimize damage caused by insect pests (usually weevils) on the stored grains (e.g. maize, sorghum, barley, wheat and legumes), the rest were kept inside their houses (Figure 8). Before storage, farmers usually check whether seeds were dried well. In some cases, seeds were smoked and treated with pesticide chemical tablets. Some farmers hung selected sorghum and maize heads on the wall or on roofs inside the hut and smoked to reduce pest damage. Farmers in the midland areas also hung selected wheat, barley, and linseed heads in order to maintain quality-planting seeds (Figure 8). There was no specific storage container for a particular crop species. Farmers stored seeds of any crop type in the available storage containers.

a) Selected barley spikes hung on the roof for smoking

c) *Gotooraa,* traditional store to kept seeds outside home

b) Selected durum wheat spikes hung on the roof for smoking

d) Selected linseed and bread wheat heads hung on the roof for smoking

Figure 8 Selected seeds and some traditional seed storage facilities in Gindeberet (Photo: Teshome Hunduma, 2005)

Similar to the findings in Worede & Mekbeb (1993), both grain and planting seeds of *tef* were stored together. At the same time, some farmers in lowland areas of Gindeberet mixed *tef* with beans and sorghum during storage to prevent damage caused by weevils and fungal parasites. Since, the seeds of *tef* were very small, there was little space between each seeds. This used to keep the temperature inside the store fairly cooler compared to when these crops were stored separately. The *tef* grains also fill the gap between the bigger seeds of beans and sorghum and suffocate the pests by reducing their movement and available fresh air. The cool storage condition and low fresh air in the store then reduces the number of pests in the containers.

However, farmers did not understand the mechanism by which pests were reduced. Farmers also used various plants to reduce the effect of pests. For instance, the leaves of *Vernonia amagadylina* (*eebichaa*), *Maesa lanceolata* (*abbayyii*), *Acokanthera schimperi* (*qaraaruu*)[9] were used for protection against weevil damage. Specifically *Vernonia amagadylina* and *Maesa lanceolata* leaves were pounded and used to wash sorghum seeds to avoid parasitic fungi from seeds before planting. Leaf of *qaraaruu* was kept with sorghum in the storage containers as insect repellents and insecticidal plants especially against weevils. Such uses of plants as repellents, insecticidal and fungicidal purpose have been important aspects of farmers' knowledge in genetic resource management on-farm.

4.5 THREATS OF GENETIC EROSSION

In this section threats to genetic erosion is approached from analysis of spatial competition among farmers' varieties and improved varieties in the study area. Changes in farmers' preference and agro-ecological environment are another aspect considered. Farmer respondents were categorized based on which varieties they grow of maize and wheat (both durum and bread wheat). The two crops were given attention because their improved varieties were part of crop diversity in the area. Farmers were asked to assign themselves as frequent growers of farmers' varieties, improved varieties or both, with respect to these two crop varieties. A comparison of the number of farmers growing improved and farmers' varieties as well as the mean area allocated to each of these varieties by individual farmer during 2004/2005 growing season were made.

Out of 90 respondents, 12.2 % were frequent growers of farmers' varieties, 35.6 % were frequent growers of improved varieties, and the rest (52.2 %) grew both improved and farmers' varieties (Table 12).

[9] Brackets: vernacular names in *afaan* Oromo

Table 12 Percent growers of local and improved varieties according to farmer groups

Farmer group	Number	Percent
Frequent growers of farmers' varieties	11	12.2
Frequent growers of improved variety	32	35.6
Growers of both farmers' varieties and improved varieties	47	52.2
Total	90	100

Number of farmers growing of farmers' varieties and improved varieties were also different during 2004/2005 growing season for maize and wheat. Out of 37 farmers who grow wheat, only 5.4 % farmers were found to grow farmers' varieties. The rest (94.6 %) grew improved varieties. Among 30 maize growing farmers, 53.3 % were growing farmers' varieties (mainly *feeshoo*). The remaining (46.7 %) had grown improved varieties of maize (Table 13). There were mean differences of area allocated to farmers' varieties and improved varieties of the two crops. On average, each farmer allocated 0.6 hectares of land to improved varieties and 0.25 hectares of land to farmers' varieties of wheat in the area. On the other hand, an average of 0.4 hectares of land is allocated to improved varieties and 0.54 hectares were allocated for farmers' varieties of maize (Table 13).

Table 13 Proportion of farmers growing and mean area allocated to farmers' varieties and improved varieties by individual farmer in Gindeberet for 2004/2005 growing season

Crop type	Varieties	Mean area (ha)	Proportion of farmer growers	Std. Deviation
Wheat	*Dasoo* (FV)	0.25	2.7	
	Roomaa (FV)	0.25	2.7	
	Improved varieties	0.60	94.6	0.42577
Maize	*Feeshoo* (FV)	0.58	50	0.70500
	Improved varieties	0.40	46.7	0.14015
	Wallaggee (FV)	0.50	3.3	
	Total	0.55	67	0.46026

FV= Farmers' variety

It appears that improved varieties of wheat were more frequently grown compared to the farmers' varieties. Both area allocated by individual farmer and the number of farmers who grow improved varieties of durum and bread wheat were much higher than for the farmers' varieties.

The later were restricted to marginal areas in wheat growing villages. On the other hand, farmers' variety of maize (*feeshoo*) was competing equally with improved varieties. Although, many farmers mentioned that the production of *feeshoo* was declining (Annex 5 and 6), the analysis of varietal spatial cover for the 2004/2005 growing season still showed equal-competence with improved varieties in the area (see coexistence in Brush, 1999). This was because of its better yield, adaptation, and field performance. Farmers also highly appreciate the taste and field performances (i.e. tolerance to drought and resistance to disease and pest) of *feeshoo*. The decline in area devoted to farmers' varieties of wheat and number of grower farmers made the improved varieties spatially competitive in the area. Thus, declining area reduces diversity of farmers' varieties (Brush, 1999). As improved varieties were increasingly adopted, there was a generally declining trend in the area allocated to farmers' varieties. However, heterogeneity and fragmentation of farming systems in centres of diversity limits the diffusion of improved varieties and maintains production space (Brush, 1999). In fact, Ethiopia has been cited as centres of diversity for durum wheat (Vavilov, 1951). The result of the present study supports the analysis made by Brush (1999) on genetic erosion of crop population in centres of diversity.

Interaction between social and environmental factors and the action of both natural and conscious selection affect the process of conservation and replacement of farmers' varieties (Brush, 1999). The other aspect of threats to genetic erosion of local crop genetic resources in the area seemed to complement this concept. Key informants and individual farmers confirmed that there had been a reduction in number of local varieties over the years. They provided a long list of crop species/varieties that were at risk (Annex 5 and 6). In this list, some were reported as lost while others were identified as rare. For example, finger millet was totally lost from most of the villages interviewed. Only farmers interviewed from Bidaaruu, bordering the Blue Nile valley witnessed the existence of this crop species. The production of other crops such as barley, lentil, chickpea, and faba bean were generally declining in the region. Among the rarely observed varieties in almost all villages were *qamadii guraatii* and *lafcanee,* farmers' varieties of durum wheat and sorghum respectively.

The losses of these crops were due to selection pressure driven by environmental factors and people's preference regarding consumption and market price. Most farmers (82 %) agreed that many varieties of barley, lentil, chickpea, and faba bean were lost due to the declining soil fertility. Few respondents mentioned that low level of disease and frost tolerance, productivity, and market price; and shortage of land as the major reasons for the decline in diversity of crops (Annex 5 and 6). Emmer wheat and *qamadii guraatii* (black seeded durum wheat) were important crop for dietary requirement and medicinal use in the area. Porridge made from emmer wheat was used to treat backache. Now a day, these crops were localized to few areas and habitats in the region. The decline in the production of emmer wheat and *qamadii guraatii* was attributed to deforestation. Both emmer wheat and *qamadii guraatii* were shade plants. They were normally planted under big trees with wider canopy. Deforestation of the high forest had resulted in the loss of suitable habitat for the cultivation of these crops. Only few farmers were growing emmer wheat and *qamadii guraatii* in their homegardens and as components of shifting cultivation. Some varieties were specifically declining because of the difficulty in their cultivation. For instance, harvesting *bunnusee* (red seeded variety of *tef*) was difficult because of its short stem. Some other crop varieties of sorghum were lost due to low resistance to bird damage (e.g. *hacciroo diimaa*). Striga[10] was another problem in sorghum cultivation in the lowland areas. It had affected all varieties of sorghum. No resistant varieties of sorghum were reported from the villages surveyed. As a result, the farmers tried to reduce the reservoir of striga in the soil by rotating kraal over their fields. Farmers switched to cultivation of maize because it is relatively less susceptible to striga. On the other hand, cultivation of highland varieties of sorghum (e.g. *lafcanee*) was almost discontinued due to low fertility of soil. Farmers had been continuously changing varieties that can positively respond to these constraints.

Localized loss and introduction of new crop species/varieties was a recurrent event in the area. Farmers reported that many crop species/varieties were lost repeatedly from their locality and restored from other villages through seed exchange. However, worries were there because these varieties, which are very rare, were unstable and might be subject to permanent losses. Loss of farmers' varieties could also be exacerbated by the ongoing diffusion of agricultural inputs. The finding of this study tend to support the idea that farmers' varieties are metapopulation whose extinction is possible as their habitat is degraded by modernization (Brush, 1999). In his metapopulation analysis, Brush (1999) indicated that individual farms experience local extinction

[10] Striga is a parasitic weed associated with sorghum and maize cultivation

of seed but local extinction is balanced by seed exchange (migration) among farmers. He further elucidated that habitat of seed production and exchange is degraded by adoption of improved varieties in that the number of sources of seed (patches, islands) of farmers' varieties is reduced and their connectivity is decreased.

Deforestation was very high in the region and agricultural land was highly fragmented. Farmers had no idea on the current and potential uses of crop wild relatives. They had been trying to eradicate wild relatives growing along with crops in their fields. There were high livestock numbers in the district that would probably contribute to environmental degradation. Combination of these factors could be threats of genetic erosion of the wild relatives. Losses of these genetic resources would have considerable influence on the current and potential uses, i.e. socio-economic values, cultural importance, aesthetics, and biological significances.

In general, in the era of modern agriculture more and more farmers depend on cash crops, which they think could be produced by using improved varieties and agricultural inputs (Almekinders & Louwaars, 1999). Furthermore, farmer's preference has also been changing rapidly. As informed by farmers disease prevalence is getting higher and higher from time to time. The fertility of land and habitat supporting wild relatives of crops has been declining. These needs and constraints have seriously affected the maintenance of farmers' varieties on-farm.

CHAPTER V: CONCLUSION AND RECOMENDATIONS

A wide inter-specific and infra-specific diversity of field crops were found growing in Gindeberet district. Most of these diversity existed in the forms of farmers' varieties. Few species of field crops existed in association with crop wild relatives on farmlands and the surrounding habitats. Consequently, there was continuous interaction between cultivated field crops and their wild relatives in both managed farms and surrounding natural habitats. This interaction could facilitate introgressions and gene flow between cultivated field crops and their wild relatives. Therefore, flow of genes could possibly be bidirectional and the effect of gene exchange could be either positive or negative. The cultivated populations might receive infusions of genes that confer survival advantage like disease and stress tolerance, or might receive some undesirable characters leading to the deterioration of agronomic and utility qualities of a particular crop.

The spatial patterns or lay out of crop species/varieties depended on soil fertility, maturity periods, theft, access to livestock, pest animals and size of farmlands in the area. Combination of these factors determined the composition of diversity in homegarden and main field species within field crops in the area. Maize and Ethiopian mustard were generally grown in the homegardens in Gindeberet. Crops such as *tef*, *noug*, wheat, linseed, and sesame were solely grown in the main field. Generally, homegardens were the richest in plant genetic diversity while the main fields comprised major crops with larger size of area allocation. Intercropping was another part of the system that created certain patterns of crop distribution in the area. Intercropping constituted combination of different species/varieties of crops on the same land by farmers and was practiced mainly for efficient use of available farmland and maximization of yields. The distribution of crops across agro-ecological zones follows the prevailing agro-climatic conditions of the area. Sorghum, finger millet, sesame, safflower and haricot bean were lowland crops where as linseed and wheat were midland crops. Some crops were adapted to both lowland and midland agro-climatic conditions (e.g. *tef*, maize, and castor bean). This showed that some crops had wider range of adaptation than others.

Farm physical characteristics and household characteristics were related in various ways to inter-specific diversity of crops. This would mean the diversity indices of related strategy for conservation as well as productivity are different and difficult to predict. The maintenance of a wide range of farmers' varieties of crops was a survival strategy and signified the value of diversity as risk management strategy by farmers. Farmers had grown and maintained diverse varieties in order to overcome risks associated with crop production, related to environmental conditions and other complex agricultural problems. Infra-specific diversity was maintained owing to environmental heterogeneity (soil conditions, rainfall), to cope with pest and pathogens, risk management (drought, lodging, frost), to meet cultural, ritual, and dietary needs. Traits governing maintenance of infra-specific diversity were used for identification, though; it was not strictly used to discriminate for maintenance. Even though, all farmers' varieties encountered were not reported to be high yielding, they survived because of their adaptation to different environmental limitations. Remoteness from market, multiple uses, farmers' preferences, and lack of access to modern technology were the reasons, which contributed to continued cultivation of landraces by the subsistence farmers of the area.

Seed selection, seed exchange, and storage could influence genetic processes in the landrace population that farmers' have managed in the area. Seed selection enabled the farmers to maintain stable yield through continued improvement in genetic adaptation of landraces within the production system. Quality traits including storage, cooking aspect, market and stability were identified as criteria that influence farmers' selection decisions besides grain and straw. The farm system in Gindeberet can be considered as an open system because seeds flow in multidirectional pattern among farmers. Localized loss and acquisitions of farmers' varieties was a recurrent phenomenon. Like many other groups, the Oromo community in Gindeberet had developed seed management and exchange schemes that remained functional over generations. Even though, there were some changes concerning storage containers, the traditional seed storage practices are still cost effective and seemed sustainable under the current production system. Understanding the consequences of these changes and the fundamental evolutionary process associated with seed selection would enable to set appropriate strategy for conservation of farmers' varieties.

Displacement of farmers' varieties had occurred in maize and wheat due to introduction of improved varieties in the area. Moreover, selection pressure has also removed many local varieties of other crops from the farming system. Both the number of farmers who had grown improved varieties of maize, wheat, and land covered by these varieties indicated gradual displacement of local varieties. Although, declining soil fertility and changing habitat had contributed to local extinction of some crop species/varieties environmental heterogeneity of farming systems (social and biophysical) has still contributed to the survival of the existing farmers' varieties. It is worthwhile to make rescue collection especially to capture rare types, those species of crops represented by few varieties.

In light of the existing diversity of crops and their wild relatives, Gindeberet is very important site for conservation of field crop genetic resources. However, conservation of this crop diversity requires enhancement of their productivity, which would add value to the already appreciated qualities of farmers' varieties within the subsistence mode of production in the study area. In this regard, development workers and conservationists can work cooperatively to ensure the sustenance of the subsistence farming. These important landraces, which took lion's share in traditional agriculture of the area, should not be far from the main stream of national scientific research. The local knowledge in seed selection and conservation could be used to backup crop genetic resource conservation and development projects such as participatory plant breeding programme to be designed. Therefore, concerted effort should be made to improve the food security situation in the area using these locally available, adaptable, and stable varieties of crops species. Strengthening on-farm conservation of farmers' varieties along with their wild relatives appears appropriate for sustainable use of these locally adapted varieties, which could buffer environmental constraints limiting agricultural production. Overall, increased attention needs to be focused nationally on traditional crop varieties through research, conservation, and promotion of use.

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APPENDICES

Annex 1Frequency data on Peasant Association surveyed including respective chi-square values

a) *Proportions interviewed farmers in gender category*

Peasant Association	Male	Female	
Haroo	64	36	
Irjaajoo	85	15	
Gamadaa	86	14	X^2=44.68**
Caffee Eererii	93	7	
Bakkee Fayyina	77	23	
Lagaa Macaa	93	7	
Kalloo Badhassaa	86	14	
Total	83	17	

b) *Proportions on respondents level of education*

Peasant Association	Cannot read and write	Can read and write	Have formal education	Church school	
Haroo	0	21	79	0	
Irjaajoo	0	23	77	0	
Gamadaa	7	0	93	0	x^2=223.74**
Caffee Eerrerii	33	7	53	7	
Bakkee Fayyina	15	0	85	0	
Lagaa Macaa	14	7	71	7	
Kalloo Badhassaa	43	0	57	0	
Total	14	9	74	2	

c) *Proportions on respondents religion*

Peasant Association	*Waaqefataa* (traditional)	Protestant Christian	Orthodox Christian	Catholic	
Haroo	14	29	57	0	
Irjaajoo	23	15	54	8	
Gamadaa	14	29	57	0	
Caffee Eerrerii	20	60	20	0	x^2=188.02**
Bakkee Fayyina	8	46	46	0	
Lagaa Macaa	0	29	71	0	
Kalloo Badhassaa	0	14	86	0	
Total	12	33	53	1	

d) Proportions on availability of formal credits and extension services to respondents

Extension services				Credit		
Peasant Association	Yes	No		Yes	No	
Haroo	79	21		14	86	
Irjaajoo	69	31		23	77	
Gamadaa	79	21		36	64	
Caffee Eerrerii	53	47	X^2=124.67**	7	93	x^2=67.78**
Bakkee Fayyina	77	23		8	92	
Lagaa Macaa	93	7		14	86	
Kalloo Badhassaa	29	71		0	100	
Total	71	29		16	84	

e) Proportions on respondents land ownership and engagement in farming

Engagement in farming				Have land		
	Full time	Part-time		Yes	No	
Haroo	71	29		100	0	
Irjaajoo	77	23		85	15	
Gamadaa	57	43		93	7	
Caffee Eerrerii	73	27	X^2=17.81**	80	20	x^2=74.82**
Bakkee Fayyina	62	38		100	0	
Lagaa Macaa	79	21		100	0	
Kalloo Badhassaa	71	29		100	0	
Total	70	30		93	7	

f) Proportions on respondents livestock ownership and land titlement

Have land title					Own livestock			
	Yes	No			Yes	No		
Haroo	79	21	0*		100	0	0*	
Irjaajoo	62	23	15*		100	0	0*	
Gamadaa	64	29	7*		100	0	0*	
Caffee Eerrerii	33	53	13*	x^2=63.79**	93	7	0*	x^2=63.13**
Bakkee Fayyina	54	46	0*		100	0	0*	
Lagaa Macaa	64	36	0*		79	14	7*	
Kalloo Badhassaa	86	14	0*		71	0	29*	
Total	61	33	6		93	3	4	

* The missing column is excluded from chi-square analysis

g) Proportions on respondents sources of income

	Crop sale	Crop and livestock sale	Crop-livestock sale and remittance	Crop-livestock sale and casual labour	
Haroo	7	86	7	0	
Irjaajoo	15	77	0	8	
Gamadaa	0	86	0	14	x^2=245.67**
Caffee Eerrerii	7	67	0	27	
Bakkee Fayyina	0	92	0	8	
Lagaa Macaa	7	93	0	0	
Kalloo Badhassaa	43	57	0	0	
Total	9	81	1	9	

Annex 2 descriptive statistics on farm and household characteristics

Variables	N	Mean	Std. Deviation	Mini	Max
Distance from the nearest town (in minutes)	90	146.0	97.2	15.0	420.0
Distance from nearest all weather road (in minutes)	90	97.1	85.6	0.0	420.0
Respondents age	90	37.6	11.5	20.0	70.0
Total household size	90	8.0	3.8	1.0	22.0
Number of children attending school	90	3.1	2.7	0.0	12.0
Number of children not attending school	90	2.8	1.7	0.0	10.0
Respondents engagement in farming (in Yrs)	90	18.1	10.1	2.0	54.0
Total cultivated land (ha)	90	6.3	4.3	0.0	18.8
Total grazing land (ha)	90	0.9	1.3	0.0	6.0
Total size of rented in land (ha)	90	0.6	1.5	0.0	10.0
Total size of rented out land (ha)	90	0.2	0.7	0.0	4.5
Total size of fallow land (ha)	90	0.3	0.8	0.0	3.8
Number of oxen	87	2.0	1.4	0.0	6.0

Annex 3 One way ANOVA between Peasant Associations

Variables	Comparison	Sum of Squares	df	Mean Square	F	Sig.
Distance from nearest all weather road (in minutes)	Between Groups	553279.996	6	92213.333	77.440	.000
	Within Groups	98833.681	83	1190.7		
	Total	652113.677	89			
Distance from the nearest town (in minutes)	Between Groups	751007.143	6	125167.86	115.045	.000
	Within Groups	98833.681	83	1190.767		
	Total	652113.677	89			
Respondents age	Between Groups	2496.836	6	416.139	3.707	.003
	Within Groups	9316.953	83	112.252		
	Total	11813.789	89			
Total household size	Between Groups	209.889	6	34.981	2.679	.020
	Within Groups	1083.933	83	13.059		
	Total	1293.822	89			
Respondents involvement in farming (in Yrs)	Between Groups	1374.196	6	229.033	2.446	.032
	Within Groups	7770.526	83	93.621		
	Total	9144.722	89			
Total Cultivated land	Between Groups	254.429	6	42.405	2.570	.025
	Within Groups	1369.357	83	16.498		
	Total	1623.785	89			
Number of oxen	Between Groups	6.739	6	1.123	.575	.749
	Within Groups	156.250	80	1.953		
	Total	162.989	86			

Annex 4: Correspondence Analysis (Analysis of Contingency Table) on attributes affecting variety identification by farmers

a) Tef varieties and associated attributes

Axis	Inertia	Proportion	Cumulative
1	0.4282	0.**6216**	0.6216
2	0.1048	0.**1522**	0.7737
3	0.0626	0.0908	0.8646
4	0.0534	0.0775	0.9421
5	0.0202	0.0293	0.9713
6	0.0092	0.0134	0.9847
7	0.0058	0.0085	0.9932
8	0.0027	0.0039	0.9971
9	0.0014	0.0020	0.9991
10	0.0004	0.0006	0.9996
11	0.0002	0.0004	1.0000
Total	0.6890		

Row Contributions

					Component 1		
ID	Name	Qual	Mass	Inert	Coord	Corr	Contr
1	XAAFII-ADII	0.806	0.065	0.024	0.380	0.578	0.022
2	BASHANAA	0.751	0.080	0.127	0.841	0.644	0.132
3	BUNNUSEE	0.952	0.046	0.151	-1.167	0.597	0.145
4	DAABOO/DIIMAA	0.950	0.116	0.083	-0.681	0.941	0.125
5	XAAFII-DURBUCOO	0.836	0.039	0.012	0.288	0.395	0.008
6	FOQOREE	0.583	0.080	0.118	0.730	0.525	0.099
7	MURIYYII-ADII	0.540	0.066	0.033	-0.412	0.493	0.026
8	MURIYYII-DIIMAA	0.835	0.103	0.151	-0.874	0.755	0.183
9	QOMIXEE	0.766	0.087	0.026	0.393	0.751	0.031
10	FILATAMAA	0.625	0.068	0.125	0.877	0.610	0.123
11	MINAAREE-ADII	0.561	0.137	0.061	-0.413	0.559	0.055
12	BAADEE-GALAA	0.911	0.114	0.090	0.436	0.349	0.051

		Component 2		
ID	Name	Coord	Corr	Contr
1	XAAFII-ADII	0.239	0.228	0.036
2	BASHANAA	0.343	0.107	0.090
3	BUNNUSEE	0.901	0.355	0.353
4	DAABOO/DIIMAA	-0.065	0.009	0.005
5	XAAFII-DURBUCOO	0.305	0.442	0.035
6	FOQOREE	0.243	0.058	0.045
7	MURIYYII-ADII	-0.126	0.046	0.010
8	MURIYYII-DIIMAA	-0.284	0.080	0.079
9	QOMIXEE	0.056	0.015	0.003
10	FILATAMAA	-0.138	0.015	0.012
11	MINAAREE-ADII	-0.020	0.001	0.001
12	BAADEE-GALAA	-0.553	0.562	0.332

Column Contributions

					Component 1		
ID	Name	Qual	Mass	Inert	Coord	Corr	Contr
1	Seed-color	0.598	0.064	0.064	0.624	0.562	0.058
2	Tillering	0.389	0.061	0.067	0.495	0.328	0.035
3	Earliness	0.890	0.050	0.103	-1.042	0.766	0.127
4	Long-statur	0.979	0.075	0.062	0.740	0.971	0.096
5	Storablity	0.864	0.088	0.038	0.509	0.862	0.053
6	Taste	0.883	0.041	0.060	-0.936	0.870	0.085
7	Yield	0.861	0.042	0.056	-0.877	0.842	0.076
8	Seed-size	0.925	0.069	0.083	0.872	0.912	0.122
9	Straw-palatability	0.425	0.056	0.048	-0.228	0.087	0.007

10	religious	0.937	0.045	0.054	-0.864	0.910	0.079
11	Market-value	0.971	0.075	0.063	0.749	0.962	0.098
12	Drought-tolerance	0.458	0.055	0.059	-0.137	0.026	0.002
13	Beverage	0.900	0.041	0.065	-0.985	0.893	0.093
14	Bread	0.350	0.080	0.037	0.079	0.019	0.001
15	Budeena	0.520	0.049	0.038	-0.233	0.101	0.006
16	Qiixxa	0.931	0.054	0.054	-0.511	0.376	0.033
17	Porridge	0.928	0.055	0.049	-0.474	0.368	0.029

		Component 2		
ID	Name	Coord	Corr	Contr
1	Seed-color	0.157	0.036	0.015
2	Tillering	-0.212	0.060	0.026
3	Earliness	0.419	0.124	0.084
4	Long-statur	0.068	0.008	0.003
5	Storablity	0.028	0.003	0.001
6	Taste	0.116	0.013	0.005
7	Yield	0.132	0.019	0.007
8	Seed-size	0.100	0.012	0.007
9	Straw-palatability	0.449	0.338	0.107
10	religious	0.150	0.027	0.010
11	Market-value	0.073	0.009	0.004
12	Drought-tolerance	0.563	0.432	0.166
13	Beverage	0.086	0.007	0.003
14	Bread	-0.325	0.331	0.080
15	Budeena	-0.473	0.418	0.105
16	Qiixxa	-0.622	0.556	0.197
17	Porridge	-0.584	0.560	0.179

b) Wheat varieties associated attributes

Axis	Inertia	Proportion	Cumulative
1	0.2856	0.**3991**	0.3991
2	0.2223	0.**3107**	0.7099
3	0.1126	0.1573	0.8672
4	0.0529	0.0739	0.9411
5	0.0200	0.0280	0.9691
6	0.0170	0.0238	0.9929
7	0.0051	0.0071	1.0000
Total	0.7156		

Row Contributions

					Component 1		
ID	Name	Qual	Mass	Inert	Coord	Corr	Contr
1	BOONDII	0.484	0.085	0.082	0.331	0.159	0.033
2	DAASHIN	0.688	0.141	0.064	-0.442	0.602	0.096
3	FILATAMAA	0.864	0.196	0.148	-0.674	0.839	0.312
4	GURRAATTII/GURREE	0.582	0.106	0.108	-0.382	0.199	0.054
5	INKOYYEE	0.725	0.053	0.216	0.357	0.044	0.024
6	ROOMAA	0.616	0.164	0.133	0.004	0.000	0.000
7	SALLAATTOO	0.772	0.141	0.156	0.780	0.766	0.300
8	ABBAA-BIILAA	0.820	0.115	0.092	0.673	0.785	0.182

		Component 2		
ID	Name	Coord	Corr	Contr
1	BOONDII	0.472	0.325	0.085
2	DAASHIN	-0.167	0.086	0.018
3	FILATAMAA	0.116	0.025	0.012
4	GURRAATTII/GURREE	-0.531	0.383	0.134
5	INKOYYEE	-1.413	0.682	0.475
6	ROOMAA	0.597	0.616	0.264
7	SALLAATTOO	0.069	0.006	0.003
8	ABBAA-BIILAA	-0.143	0.035	0.011

Column Contributions

					Component 1		
ID	Name	Qual	Mass	Inert	Coord	Corr	Contr
1	Seed-color	0.673	0.042	0.042	-0.518	0.369	0.039
2	Tillering	0.881	0.065	0.045	0.529	0.564	0.064
3	Earliness	0.808	0.039	0.072	-0.968	0.717	0.129
4	Long-statur	0.972	0.066	0.066	0.658	0.599	0.099
5	Storablity	0.178	0.055	0.053	0.326	0.154	0.020
6	Taste	0.291	0.066	0.020	0.150	0.103	0.005
7	Yield	0.816	0.035	0.066	-1.026	0.791	0.130
8	Seed-size	0.972	0.066	0.066	0.658	0.599	0.099
9	Straw-palatability	0.771	0.097	0.063	0.396	0.338	0.053
10	religious	0.463	0.050	0.056	-0.253	0.080	0.011
11	Market-value	0.715	0.038	0.051	-0.825	0.700	0.090
12	Drought-tolerance	0.225	0.067	0.045	0.280	0.165	0.019
13	Beverage	0.776	0.068	0.106	-0.159	0.023	0.006
14	Bread	0.615	0.038	0.065	-0.598	0.291	0.047
15	Budeena	0.699	0.029	0.056	-0.923	0.620	0.087
16	Qiixxa	0.779	0.042	0.029	-0.501	0.508	0.037
17	Porridge	0.584	0.042	0.020	-0.420	0.510	0.026
18	Frost-tolerance	0.880	0.096	0.079	0.336	0.193	0.038

		Component 2		
ID	Name	Coord	Corr	Contr
1	Seed-color	0.470	0.304	0.041
2	Tillering	0.397	0.317	0.046
3	Earliness	-0.344	0.091	0.021
4	Long-statur	0.519	0.372	0.079
5	Storablity	-0.128	0.024	0.004
6	Taste	0.203	0.189	0.012
7	Yield	-0.182	0.025	0.005
8	Seed-size	0.519	0.372	0.079
9	Straw-palatability	-0.448	0.433	0.087
10	religious	0.555	0.383	0.069
11	Market-value	-0.120	0.015	0.002
12	Drought-tolerance	-0.169	0.060	0.009
13	Beverage	-0.917	0.753	0.258
14	Bread	0.632	0.324	0.067
15	Budeena	0.329	0.079	0.014
16	Qiixxa	0.365	0.271	0.025
17	Porridge	0.161	0.075	0.005
18	Frost-tolerance	-0.634	0.687	0.174

c) Maize varieties associated attributes

Axis	Inertia	Proportion	Cumulative
1	0.3581	0.**4547**	0.4547
2	0.2354	0.**2989**	0.7536
3	0.1167	0.1482	0.9018
4	0.0347	0.0441	0.9458
5	0.0232	0.0295	0.9753
6	0.0116	0.0148	0.9901
7	0.0061	0.0078	0.9978
8	0.0017	0.0022	1.0000
Total	0.7876		

Row Contributions

					Component 1		
ID	Name	Qual	Mass	Inert	Coord	Corr	Contr
1	BIYYAA-DHUFEE	0.885	0.088	0.155	1.108	0.877	0.300
2	BOONDII	0.703	0.175	0.189	-0.101	0.012	0.005
3	FILATAMAA	0.595	0.175	0.033	-0.173	0.201	0.015

4	CHAAYINAA	0.818	0.125	0.107	-0.742	0.815	0.192
5	FEESHOO	0.666	0.071	0.076	0.720	0.614	0.102
6	FILAATAMAA	0.666	0.117	0.049	-0.465	0.657	0.070
7	GORDOD	0.776	0.063	0.097	-0.925	0.696	0.149
8	JIILAME/JI'ALAMEE	0.772	0.088	0.215	0.495	0.126	0.060
9	WALLAGGEE	0.654	0.100	0.078	0.617	0.622	0.107

		Component 2		
ID	Name	Coord	Corr	Contr
1	BIYYAA-DHUFEE	0.103	0.008	0.004
2	BOONDII	0.767	0.691	0.437
3	FILATAMAA	-0.243	0.395	0.044
4	CHAAYINAA	-0.047	0.003	0.001
5	FEESHOO	0.211	0.053	0.013
6	FILAATAMAA	-0.053	0.009	0.001
7	GORDOD	-0.312	0.079	0.026
8	JIILAME/JI'ALAMEE	-1.118	0.645	0.465
9	WALLAGGEE	0.140	0.032	0.008

Column Contributions

					Component 1		
ID	Name	Qual	Mass	Inert	Coord	Corr	Contr
1	seed-color	0.740	0.064	0.022	-0.420	0.639	0.031
2	tillering	0.659	0.019	0.112	0.455	0.044	0.011
3	earliness	0.890	0.049	0.083	0.896	0.609	0.111
4	long-statur	0.745	0.065	0.059	-0.348	0.170	0.022
5	storablity	0.877	0.063	0.051	0.741	0.872	0.097
6	taste	0.940	0.061	0.063	0.759	0.703	0.098
7	yield	0.661	0.048	0.050	-0.699	0.591	0.065
8	seed-size	0.741	0.074	0.051	-0.530	0.517	0.058
9	straw-palatability	0.491	0.083	0.018	0.268	0.412	0.017
10	religious	0.678	0.061	0.043	0.503	0.463	0.043
11	market-value	0.291	0.052	0.039	-0.054	0.005	0.000
12	drought-tolerance	0.951	0.057	0.059	0.729	0.655	0.085
13	beverage	0.889	0.052	0.060	0.745	0.613	0.080
14	bread	0.945	0.056	0.037	-0.695	0.912	0.075
15	budeena	0.910	0.060	0.032	-0.602	0.867	0.061
16	qiixxa	0.947	0.056	0.036	-0.681	0.911	0.072
17	porridge	0.951	0.055	0.035	-0.680	0.913	0.071
18	frost-tolerance	0.536	0.013	0.075	-0.169	0.006	0.001
19	disease-tolerance	0.536	0.013	0.075	-0.169	0.006	0.001

		Component 2		
ID	Name	Coord	Corr	Contr
1	seed-color	0.167	0.101	0.008
2	tillering	-1.703	0.615	0.231
3	earliness	0.609	0.281	0.078
4	long-statur	-0.641	0.576	0.114
5	storablity	-0.057	0.005	0.001
6	taste	-0.440	0.236	0.050
7	yield	-0.241	0.070	0.012
8	seed-size	-0.348	0.224	0.038
9	straw-palatability	-0.117	0.079	0.005
10	religious	0.343	0.215	0.031
11	market-value	0.412	0.287	0.037
12	drought-tolerance	-0.490	0.296	0.058
13	beverage	0.499	0.276	0.055
14	bread	0.132	0.033	0.004
15	budeena	0.134	0.043	0.005
16	qiixxa	0.135	0.036	0.004
17	porridge	0.139	0.038	0.004
18	frost-tolerance	1.581	0.530	0.133
19	disease-resistance	1.581	0.530	0.133

Annex 5: Crops species/varieties that are lost locally

PAs	Crop type	Species/varieties	Reasons for the losses
Bake Fayina	Maize	*Feeshoo*	Low yield, climate change, introduction of improved varieties
	Tef	*Muriyyii adii*	Low yield, hard straw
		Bursaa	Low yield
		Bunnusee	Rainfall variability
Cafee Eererii	Finger millet	*Daagujjaa*	Low soil fertility, less preference
	Maize	*Shallalaa*	Less preference, low yield, climate change
		Feeshoo	Low soil fertility, climate change
	Sorghum	*Lafcanee*	Low yield, low soil fertility
		Hacciroo diimaa	Low yield, climate change, bird damage, frost, striga
		Hacciroo adii	Low soil fertility, low frost tolerance, striga
	Wheat	*Sallattoo*	Low soil fertility
	Tef	*Tuulamticha*	Low disease resistance, low relative market price
Gamadda	Maize	*Feeshoo*	Rainfall variability, introduction of improved varieties, low yield
	Barley	*Gurraacha*	Low soil fertility, low preference
		Adii	Introduction of improved variety
	Emmer wheat	*Mataa jaboo*	Disease, deforestation of shade trees, low soil fertility
	Finger millet	*Daagujjaa*	Low disease resistance
	Wheat	*Sallattoo*	Low yield
		Boondii	Low disease resistance, low frost tolerance, low yield, use of improved varieties and fertilizer
		Gordod	Low yield
		Guraatii	Low soil fertility, loss of habitat
Haroo	Barley	*Gurraacha*	Climate change, introduction of improved variety of wheat
		Adii	Climate change
		Samareta	Low soil fertility
		Baallammii	Low soil fertility
	Emmer wheat	*Mataa jaboo*	Low soil fertility and deforestation of shade plant
	Linseed	*Talbaa durii*	Introduction of improved varieties, weed
	Maize	*Feeshoo*	Introduction of improved varieties
	Wheat	*Biyya dhufee*	Low yield
		Sallaatoo	Introduction of improved varieties, low yield, low frost tolerance
		Abbaa bilaa	Low frost tolerance, Introduction of improved varieties
		Goforoo	Low soil fertility
Kalloo Badhassaa	Finger millet	*Dagujjaa*	Low yield, low preference, climate change
	Maize	*Wallaggee*	Low yield
	Tef	*Adii haadha*	Low yield
Lagaa Macaa	Finger millet	*Dagujjaa*	Low yield, low preference, climate change
	Tef	*Muriiyyi diimaa*	Low relative market price
		Muriiyyi adii	Low yield, ignorance

Annex 6: Crops species/varieties that are rare locally

PAs	Crop species	Species/varieties	Reasons for the rarity as told by farmers
Bake Fayina	Maize	*Feeshoo*	Introduction of improved varieties
	Wheat	*Sallaatoo*	Introduction of improved varieties
	Tef	*Minaaree*	low yield
		Bunnusee adii	Climate change
		Qomixee	low yield
Cafee Eererii	Beans	*Baqilaa*	Low frost tolerance
	Chickpea	*Shumburaa*	Low soil fertility
	Finger millet	*Dagujjaa*	Less preference
	Lentil	*Missira*	Low soil fertility
	Maize	*Feeshoo*	Low soil fertility
	Sorghum	*Hacciroo adii*	Low yield, low soil fertility
		Hacciroo diimaa	Low yield, low soil fertility
	Wheat	*Guraatii*	Low soil fertility
		Roomaa	Low soil fertility
	Tef	*Diimaa*	Low relative market price
		Qomixee	Low soil fertility
		Daggalee	Low soil fertility
Gamadaa	Barley	*Gurraacha*	Low soil fertility, replacement by maize since maize is more preferred for local beer
	Beans	*Baqilaa durii*	Worm problem, low soil fertility
	Maize	*Feeshoo*	Low yield
	Peas	*Atara*	Worm problem, low soil fertility
	Wheat	*Boondii*	low yield, low frost tolerance, low wind tolerance/lodging, use of fertilizer and improved varieties
		Gurraatii	Low disease resistance, low soil fertility
		Boondii	Introduction of improved varieties
		Gosoroo	Introduction of improved varieties
Haroo	Barley	*Gurraacha*	Low frost tolerance
		Baalamii	Low soil fertility
		Adii	Low frost tolerance
		Samareta	low soil fertility
	Emmer wheat	*Maata-jaboo*	Deforestation of shade trees
	Linseed	*Talbaa durii*	Introduction of improved varieties, weed problem
	Maize	*Feeshoo*	Introduction of improved varieties
	Wheat	*Biyya dhufee*	Low yield
		Sallaatoo	Introduction of improved varieties, low yield, low frost tolerance, low bird resistant
		Abbaa biilaa	Introduction of improved varieties, low yield
		Roomaa	Low yield, low soil fertility, cause male infertility and stomach upset

		Gurree	low soil fertility
		Buttujjii	Introduction of improved varieties
	Tef	*Diimaa*	Low disease resistance, low yield, difficulty during harvest (short stem)
		Tuulamticha	Low yield
Irjajoo	Barley	*Gurraacha*	Low frost tolerance
		Adii	Low frost tolerance
		Samareta	low soil fertility
	Linseed	*Talbaa durii*	Introduction of improved varieties, weed problem
	Maize	*Feeshoo*	Introduction of improved varieties
	Wheat	*Sallaatoo*	Introduction of improved varieties, low yield, low frost tolerance, low bird resistant
		Abbaa biilaa	Introduction of improved varieties, low yield
		Roomaa	Low yield, low soil fertility, cause male infertility and stomach upset
		Gurree	low soil fertility
		Buttujjii	Introduction of improved varieties
	Tef	*Diimaa*	Low disease resistance, low yield, difficulty during harvest (short stem)

Appendix 7: Questionnaire

I. Area description

1. Name of Peasant Association ______
2. Name of village ______
3. Agro-ecological category ______
4. Altitude, Latitude, Longitude______
5. Distance from the nearest town (in minutes) ______
6. Walking distance from the nearest all weather road (in minutes) ______
7. Enumerator's name ______
8. Date interview was taken ______

II. Household information

1. Can you tell provide the following information?

Name of the HH	Sex	Age	THHS	Marital Status	Education	Religion	Engagement in farming

*Sex: 1= male, 2= female; Marital status: 1= single, 2= married, 3= divorced, 4= widowed; Education: 1= cannot read and write, 2= can read and write, 3= formal education in years, 4=church school; Religion: 1= Waaqefataa/*traditional *2=Christian (protestant) 3=Christian orthodox 4= Christian catholic 5=Muslim; Engagement in farming: 1=full time, 2= part-time*

2. Are you permanent resident of this village? 1. Yes 2. No
3. If yes, since when? ______
4. If no, when did you arrive to this village? ______
5. For how many years have you been farming? ______
6. Is there any other activity other than farming you have been mostly engaged in? 1. Yes 2. No
7. If yes, list them ______
8. Do you have access to credit for your livelihood activities? 1. Yes 2. No
9. If yes, what do you use for? ______
10. If no what is the reason? ______
11. Have you got extension services? 1. Yes 2. No
12. Have you attended any farmers training programme in relation to crop production? 1. Yes 2. No
13. If yes, what was the training all about? ______
14. What advantage did you get from the training for your livelihood activities? ______
15. Do you have additional skill other than farming (e.g. traditional healing, physiotherapy)? 1. Yes 2. No
16. If yes, how do you use this skill to support your life? ______
17. What are the sources of your overall household income? 1. Crop sale 2. Livestock sale 3. Both crop and livestock sale 4. Casual labour 5. Remittance 6. Other (specify)______
18. Who is contributing to the household income? 1. Husband 2. Wife 3.Children 4. Parents 5. All members of the household

III. Household resources

1. Do you have your own land? 1. Yes 2. No
2. If yes, ownership of the land: 1. Owner 2. Tenant 3. Tenant/owner
3. If yes, what is the size of your land in *cimdii*/*olmaa* (1 *cimdii* = ¼ ha)?

Type of land	Farm size in *ciimdii*		
	1995/96 E.C.	1996/97 E.C.	1997/98 E.C.
Cultivated			
Grazing			
Rented in			
Rented out			
Fallow			
Other			

4. Do you feel that there is shortage of land in this village? 1. Yes 2. No
5. If yes, what could be the possible reason? ____
6. If you have shortage of land, how do you ensure that your land produces enough food for your household?
7. What cash crops do you cultivate? ____
8. Do you own livestock? 1. Yes 2. No
9. If yes, can you mention the number and uses of livestock you own?

Type	Number	Purpose/use
Oxen /bulls		
Cows		
Bull calves		
Heifers		
Goats		
Sheep		
Horses		
Donkeys		
Mules		
Chicken		
Beekeeping (in hives)		

10. Do you practice livestock fattening practice? 1. Yes 2. No
11. If yes, how do you do it? ____
12. What are your farm implements? ____
13. What institutions or traditional working parties are available in the community? ___________________
14. How did the working parties helped in agricultural production and genetic resource management in this area?

IV. Cropping system

1. Can you tell how crop fields are distributed and possessed by farmers in this village? _______________
2. What are the soil fertilizing methods in this area? ____
3. Is there reliability in precipitation and is it sufficient for crop development? _______________________
4. Do you have incidence of pests and diseases? 1. Yes 2. No
5. If yes, what kind of crop pests, weeds, diseases, and climatic problems are prevalent? What control measures do you use?

	Pests	Weeds	Diseases	Climatic
Control measures (traditional/ modern)	. .	. .	. .	. .

6. How is the trend of this incidence? 1. Increasing 2. Decreasing 3. no change
7. If it is increasing, what do you think has led to the increase? ___________________________________
8. What causes depletion of soil fertility in this area? ____
9. Which one of the following farmer-based research/evaluation do you practice?
    a. productivity with and without chemical fertilizer
    b. productivity with and without manure
    c. productivity with chemical fertilizer and manure
    d. productivity, disease and pest resistance, and tolerance to drought and frost of modern and farmers' varieties
10. Do you practice crop rotation? ____
11. Why? ____
12. If no can you tell the reason? ____

13. Which crops grow in association and on which farmland?

Crops grown in association (a + b +…c)	Farm land (homegardens, nearby farm or main field)	Give reasons for or uses of intercropping

14. If there is any other plant species (tree, shrub, or herb) purposely grown in association with crops in crop fields or in vicinity, give the name of these species with the associated crops and its uses.

Tees or forage plants grown in association with crops	Use

15. Does distance from the home affect the distribution of crops/varieties on the farmland? 1. Yes 2. No
    a. If yes, tell me the first three crops grown on farmlands nearer to the home. ________________
    b. Why do you grow the aforementioned crops on nearer farms? __________________________
    c. Which crop/varieties are grown on distant farms? ______________________________________
16. What are the factors that determine the distribution of crops/varieties on these different farmland? _____

V. Crops/varieties grown on household farms

1. For the crops you have grown during the last three years what is the yield kg/ha and utilization?

Crop type	Area cultivated in *ciimdi* (1 *cimdii* = ¼ ha)			Production kg/ha			Consumed at home kg			Sold in market Kg		
	1995	1996	1997	1995	1996	1997	1995	1996	1997	1995	1996	1997

2. How many varieties of *tef* did you grow? ___________________________

Please compare your farmer varieties based on the following parameters

Parameter	Farmer variety name					Preference ranking				
						1	2	3	4	5
Meaning of the local name										
Original source										
Seed color										
Tillering capacity										
Earliness										
Tallness										
Storability										
Taste										
Yield										
Seed size										
Straw palatability										
Religious/cultural uses										
Market price										
Response to drought										
Local beverage										
Bread										
Budeena (flat pancake)										
Unleavened bread										
Porridge										

3. How many varieties of wheat did you grow? ___________________________

Please compare your farmer varieties based on the following parameters

Parameter	Farmer variety name					Preference ranking				
						1	2	3	4	5
Meaning of the local name										
Original source										
Earliness										
Seed color										
Tillering capacity										
Tallness										
Shelf life as grain										
Taste										
Yield										
Seed size										
Straw palatability										
Religious/cultural uses										
Market price										
Response to drought										

Frost tolerance										
Disease resistance										
Local beverage										
Bread										
Budeena (flat pancake)										
Unleavened bread										
Porridge										

4. How many varieties of maize did you grow? ____

Please compare your farmer varieties based on the following parameters

Parameter	Farmer variety name					Preference ranking				
						1	2	3	4	5
Meaning of the local name										
Original source										
Earliness										
Seed color										
Tillering capacity										
Tallness										
Storability										
Taste										
Yield										
Seed size										
Straw palatability										
Religious/cultural uses										
Market price										
Response to drought										
Local beverage										
Bread										
Budeena (flat pancake)										
Unleavened bread										
Porridge										

6. Let me ask you the following questions regarding crops grown during last harvest.

Land and production characteristics/Plots	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6
Plot names (by place where plots found)						
Plot size (in *cimdii*)						
Sloppiness (code a)						
Soil fertility (code b)						
The plot would give satisfactory yield with or without fertilizer (code c)						
Suitability for improved varieties vs. farmers' varieties (code d)						

Number of passes with Maarasha						
Crop planted (code z)						
Variety planted (code z)						
Seed rate per *cimdii*						
If fertilizer was used amount applied (in *madabaraa*)						
If manure was used amount applied (in *madabaraa*)						
Amount of output in *mdabaraa*						
Market price (in birr per kg)						
Straw bundle (in *tuullaa*)						
If straw would be used, what is it used for? (code g)						
Seed source in 1996 (code h)						
Grown since 19___						
Original seed source (code i)						

Code a*: 1. steep slope 2. gentle slope 3. hilltop (gaara) 4. flat plateau (goodaa) 5. Valley (boqoqqee) 6. Plain/flat land (lafa ciisaa);* ***Code b****: 1. highly fertile (qaljii/gabbataa) 2. medium fertility (gidduu galeessa) 3.low fertility 4. Infertile (diimolee/haphii);* ***Code c:*** *1. without fertilizer 2. with fertilizer;* ***Code d****: 1. suitable for farmers' variety 2. suitable for improved variety;* ***code g:*** *1. livestock feed 2. fuel 3. roof cover 4. bed making 5. fencing 6. harata, 7. other (specify)____;* ***code h:*** *1. farers' own 2. friend or relative 3. other farmer, 4. market 5. seed project/government 6. other(specify)____;* ***Code i:*** *A: 1. Friend or relative 2. other farmer 3. market 4. seed project/government 5. other (specify); B: 1. local 2. outside*

7. Do you know any wild relatives of cultivated plants in your area? 1. Yes 2. No
8. If yes, can you tell local names of the plants?

Plant name (local name)	Characteristics (e.g. weed)	Similarity (crops related)	Attributes shared

VI. Seed exchange

1. Do you use seed other than your own for planting? 1. Yes 2. No
2. How do you get seed for planting other than your own? 1. Exchange with other farmers 2. Gift 3. Purchase 4. Other (specify) ____
3. Which farmers are recognized as seed farmers or sources of seed in the community? 1. Rich: always has seed 2. Rich: has good quality 3. Poor: always has the variety 4. Poor has good quality 5. Other (Specify)
4. How frequent do you use seed from other sources? 1. Every year 2. Only in case of calamities 3. Other
5. If every year, what is the reason for regularly using seed from other source: 1. for seed quality other sources are better 2. Variety changes, degenerates, get tired 3. Sold out in years when grain price are high 4. Eating or selling the seed for cash needs 6. for yield other source are better
6. If you experiences calamities, what has exactly happened? 1. Crop loss because of climate (drought) 2. Crop loss because of crop pest or disease 3. Crop loss because of sickness family members/funeral/weeding/other social commitments 4. other (specify)___________________________

7. What was your source of seeds during the calamites? 1. Friends or relatives in the community 2. Other farmer in the community 3. Other farmer in other location 4. Market 5. Seed project/government 6. Other____
8. How new variety does diffuses among the people in this area? _________________________________

VII. Knowledge on crop plant species or varieties

Below are questions regarding any crop varieties that you might know? These varieties include those which used to be used by you, your neighbors, your parents, your relatives or other people in the locality. We would like you to list them. The questions concern your knowledge of the different desirable and undesirable characteristics associated with them.

1. Tell the variety you know. What characteristics do you know about it?

Crop species/ varieties (code z)	Desirable characteristics (code a)	Undesirable characteristics (code b)	Use value (code c)	Other features

***Code a**: **A) Agronomic Characteristics:** 1. disease resistant, 2. pest resistant, 3. frost resistant 4. other (specify) ______; **Other preferences**: 1. ease for cooking 2. long shelf life as grain 3.good shelf life as flour 4. taste preference 5. stability of flour/dough 6. stability of cooked food in the stomach 7. good straw quality 6. marketability 7. volume of flour per kg of grain 8. other (specify)_____; **B) Storage behavior**: 1. good germinating ability (low dormancy); 2. good seed quality 3. not susceptible to pest; **Code b**: 1. performs less with fertilizer compared to improved varieties and thus was substituted for by improved varieties 2. low disease resistance 3. low frost tolerance 4. low preference value (specify which); **Code c:** 1. sale 2. consumption 3. planting 4. repaying borrowed seed 5. other (specify) ____*

5. How do you maintain landrace varieties? ____
6. Why do you maintain landraces? ____
7. Do you know any newly introduced/cultivated varieties in this area? 1. Yes 2. No
8. Can you tell the newly introduced varieties?

Crop/variety names (code z)	Seed source or origin (code a)	Year introduced	Brought by (code b)	Reason for introduction (code c)

***Code a**: 1. other farmer in other location 2. seed project/government 3. other (specify) _____; **Code b**: 1. Agricultural research 2. NGOs 3.other _____ 4. **Code c**: 1. early maturing 2. better yield 3. pest resistance 4. disease resistant 5. drought tolerant 6.bird resistant 7. striga resistant 8. storable 9. other (specify) ____*

9. Have you encountered any problem following the introduction of new varieties? 1. Yes 2. No
10. If yes what? ____
11. How do you compare the use of crop residue of local varieties and improved varieties? ______________

VIII. Threats of genetic erosion

1. Do you know any crop/varieties that are lost in this area? 1. Yes 2. No
2. If yes, can you list them?

Crop species/varieties lost	Reason for the loss (code a)	Time it was lost (19--)

Code a: 1**.** climate change 2. low productivity 3. low disease resistance 4. low frost tolerance 5. low pest resistance 6. low bird resistance 7. low flour yield 8. less preferred for consumption 9. introduction of improved varieties 10. introduction of fertilizer 11. other (specify) ____

3. Do you think that the production of local varieties is increasing or decreasing?
   1. increasing 2. decreasing 3. no change
4. If it is increasing what is the possible reason? ____
5. If it is decreasing what is the reason behind it? ____
6. If it is not changing what is the reason? ____
7. How do you see in terms of diversity and vulnerability? ____
8. Do you think landraces are important to you & do you share concern for their loss? 1. Yes 2. No
9. What do you suggest about the conservation or maintenance of local varieties of crops? _____________

10. How many times have you faced problems or complete crop failure due to drought/pests and diseases in your farming experience? ____
11. When was this? ____
12. During those days, how did you manage to conserve seeds from disappearance? ____________
13. If you completely lost seeds of local varieties where do you get them? _______________
14. Do you think production practices of local varieties (such as ploughing, planting, threshing, and harvesting) compared to improved varieties is discouraging? 1. Yes 2. No
15. If yes how? ____
16. Do you think market price of local varieties is lower than that of improved varieties? 1. Yes 2. No

IX. Seed selection

1. Do you practice seed selection or use left over seeds for next planting season? 1. Yes, I do select 2. No I use left over seed
2. If yes why? ____
3. Who is responsible for seed selection? 1. husband 2.wife 3. children
4. Is the selection practice deliberate? 1. Yes 2. No
5. For which crop do you apply seed selection and when?

Crop (code z)	Pre-harvest (code a)	Post-harvest (code b)	Storage (code c)

Codes for selection criteria (agronomic, stresses, end-uses) during pre-harvest, post-harvest and storage times

Pre-harvest (code a)	√	Post-harvest (code b)	√	Storage (code c)	√
More grain/panicle/ears	1	Seed colour	1	Seed colour	1
Higher yield	2	Bigger seeds	2	Bread quality	2
Non lodging	3	Disease free seeds/pods/panicle	3	*Farsoo* and *hraqee* (distilled local liquor)	3
Good looking	4	Ease of threshing	4	Market value	4
High tiller	5	Other (specify)	5	Quality of *budeena* (pan cake)	5
Early maturing	6			Medicinal value	6
Straw quality	7			Fermentation quality	7
Less diseased	8			Disease free seeds	8
Less pest damage	9			Cooking quality	9
Tolerance to stress (e.g. drought)	10			Taste	10
Tall plant	11			Purity	11
Stability	12			Less damage by weevil	12
Other (specify)	13			Others (specify)	13

6. Do you multiply the selected seed? 1. Yes 2. No
7. For pre-harvest seed selection, which selection method do you apply? 1. pure selection 2. mass selection
8. What special activities do you use in the field during seed selection for selecting a plant or part of your crop?
9. How is the seed selection techniques/knowledge pass from parents to children? _______________

X. Seed storage

1. Do you store seed? 1. Yes 2. No
2. If yes, how and where do you store seed?

Crop type (code z)	Storage conditions (Code a)	Reasons

Code a: 1. separate in sacks 2. Ears smoked 3. In bulk with consumption grain 4. separately in other room or kitchen 5.outside house in special store (*gumbii* or vessel of clay pot) 6. In the ground 7. With its panicle outside (*tuulla*)

3. What special conservation treatments do you use before storage? 1. applying chemical 2. drying 3. smoking 4. removing diseased seed 5. using ash 6. using herbs 7. exposure to light 8. others (specify) __
4. Why do you practice this treatment? ____
5. What storage problem do you have? ____

XI. Gender division of labour

1. What is the major occupation of household members?

Activities	Husband	Wife	Children	Parents	Whole family
Ploughing/cultivation					
Clearing and levelling					
Planting					
Weeding					
Harvesting					
Transporting harvest to threshing site					
Threshing					
Storing					
Seed selection					
Fuel wood collection					
Herding					
Casual labour					
Other (specify)					

2. Who makes decision on the number of varieties/landraces to be planted? ______________________
3. Who makes decisions about which landrace to plant in each farmland?
4. Do you allocate different parcels/plots of land for different varieties? 1. Yes 2. No
5. If yes, what criteria do you use for such allocation? ____
6. Do you store seeds of different landraces separately from food grain/other types of seed? 1. Yes 2. No
7. If yes who makes decision? ____
8. Do you practice mixing seeds of different landraces either at planting or when storing? 1. Yes 2. No
9. Why? ____
10. If yes who makes the decision for this? ____
11. Do women have access to land through either land distribution or inheritance? 1. Yes 2. No
12. If no, why? ____
13. Can you mention the role of women in seed selection during pre-, post-harvest and storage? _________
14. What about men? ____

XII. Culture, songs, sayings, myths

1. What cultural use do you know of any landraces in this area? ___________________________________

Can you list folksongs, sayings, and/or poems you know in connection with crops/landraces in this area?

Crop type/ variety (code z)	Songs, sayings, poems	Local meanings

2. Can you tell any rituals in relation to crops/landraces in this area? ________________________________
3. How do you celebrate it and what is its interpretation all about? _________________________________