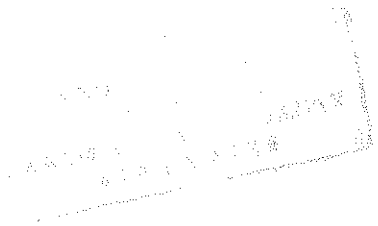
ADDIS ABABA UNIVERSITY

SCHOOL OF GRADUATE STUDIES

A STUDY ON THE AGRO-BIODIVERSITY WITH SPECIAL EMPHASIS ON THE RELATIONSHIP BETWEEN DISTANCE FROM HOMESTEAD AND CROP DIVERSITY ON -FARM IN FONTANINA, SOUTH WELO



By Shewaye Deribe

Addis Ababa, June, 2000

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A thesis submitted to the School of Graduate Studies in partial fulfillment of the requirements for the degree of Master of Science in Biology (Botanical Sciences)

By Shewaye Deribe

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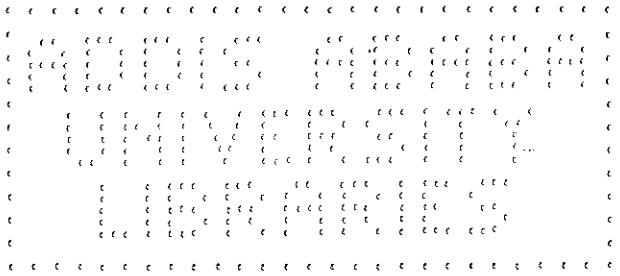

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Abstract

The distribution of crops with distance from the homestead was studied in 324 peasant farms in Fontanina village (South Welo). Edaphic, climatic and socio-cultural factors play important roles in the distribution of crop species. Farmers categorized their farms into three main classes and each class is located at different distance from the farm house- hold residence, and contains crops of different value.

The homegardens are characterized by perennial plants composed of construction and fruit trees. The nearby farms and main crop fields are fields of annual crops. The nearby farms are characterized by *Zea mays* L. and other crops planted for immediate use in preharvest periods. The main fields are dominated by *Sorghum bicolor* (L.) Moench and *Eragrostis tef* (Zucc.) Trotter.

Multivariate statistical analysis of presence/ absence data of species in a sample of 65 stands (farms) shows two distinct groups of farms. The fields of annual crops are categorized together and the homegardens formed a separate group. The variation among the homegardens is also detected. Clustering of 50 stands from annual crop fields based on quantitative data of 22 species resulted in three clusters (crop community types) and two plots.

Estimation of the frequency of sorghum intraspecific diversity in 123 fields indicated that the frequency of sorghum landraces decreased due to shortage of rainfall, while that of fast maturing, introduced varieties, of sorghum increased.

The discussion undertaken with the interviewed farmers revealed that traditional farmers have accumulated knowledge by which they classify their farms and crops, distribute crops in their fields and maintain or preserve landrace diversity. This knowledge can form the basis for scientific research activities in different branches of conservation and development. For example, it is vital to include farmers' knowledge in the efforts of strengthening the scientific basis of *insitu* conservation of crop genetic resources and in upbringing sustainable agricultural systems.

1. Introduction

1.1. Background of the study

There is a need to safeguard local varieties of crops and traditional farming systems in different parts of the world (Prance, 1997). Moreover, the primary strategy for the success of this activity should be surveying and documenting the traditional crop varieties, farming systems and the associated indigenous knowledge.

Currently, *in situ* (On-farm) and *ex situ* conservation strategies are radiating in centers of origin and primary diversity of different crop varieties. In this regard the undertakings of Ethiopian Biodiversity Conservation and Research Institute (IBCR/E) can be taken as a good example. These two strategies of conservation of crop genetic resources (farmers varieties) are complementary to each other (Maxted *et al.*, 1997).

However, more attention is given to in situ conservation, and it is encouraged to conserve plants in their natural home. This is due to the fact that on-farm conservation of crops has evolutionary and ecological significance. By realizing this truth, IBCR/E, by coordinating and in collaboration with different international projects, is actively engaged in conservation of crop genetic resources of Ethiopia.

The International plant Genetic Resource Institute (IPGRI) is also implementing a global project on strengthening the scientific basis of *in situ* conservation of agrobiodiversity. Kalu is a district in South Welo and it is one of the Ethiopian centers that have been selected by IPGRI in its global project to strengthen the scientific basis of *in situ* conservation of local crop varieties. The current study is part of this programme and it was initiated in 1998 by Dr Awegechew Teshome. And its focus is on the distribution of crop varieties with distance from the farmer's residence (homestead) in Fontenina village (Kalu). It also incorporates the indigenous knowledge of farmers, sorghum landrace frequency in the fields and soil sample analysis.

The area of this study is dominated by *Sorghum bicolor* (L.) Moench and other cereal crops such as *Eragrostis tef* (Zucc.) Trotter. Previous research works conducted in the surrounding have given due attention to the conservation of sorghum (Awegechew Teshome, 1996; Getahun Mulat, 1998).

To implement effective on farm conservation, detailed information regarding the distribution of diversity, the use of crop varieties, problems related to the conservation of each variety, etc., has to be gathered and documented.

This study gives emphasis on surveying the general crop biodiversity in the study area. It investigates the place of a crop variety in the holdings of a household and the farmer's objectives in determining the place of a variety in his/her farmlands. It also encompasses the pattern of intercropping (i.e. temporal and spatial crop association) and the agricultural system at large.

1.2. Study goal

1.2.1. General objectives

The objectives of this study are:

- To survey and document the pattern of crop distribution in the study area
- To identify factors that determine this distribution
- To gather and analyze the indigenous knowledge of farmers in relation to the distribution of crops, propagation and conservation of landrace varieties(farmers varieties).

1.2.2. Specific objectives

- To determine the relationship between soil characteristics and the distribution of crop varieties
- To identify the major factors that contribute to the decimation of landraces and introduction of new varieties
- To produce list of crop varieties cultivated at different distance from the home stead and classify the crop fields
- To estimate variation in the frequency of sorghum landrace diversity in the main crop fields
- To compare the pattern of intercropping in different farm lands and to document the objectives of farmers related to this intercropping pattern

- To study the farming system, conservation strategies, soil fertilizing methods and agricultural calendar of local farmers
- To document the crop categorization system and sorghum taxonomy of farmers

2. Literature Review

The human population is expanding and it has increasingly intensive demand for natural resources particularly plant species of different use (food, medicine, industry, etc). However, agricultural biodiversity faces uncertain future (Tuxill, 1999). As FAO estimates indicate, (Olasanta, 1999), there were much more species of cultivated plants at the beginning of the 20th century, but larger proportion of those species which were under cultivation have disappeared now. The major reason for this dwindling of local crop genetic diversity is the emergence and introduction of high yielding genetically uniform varieties (HYVs) as a means of alleviating food problems of the growing world population. Moreover, this condition will cause not only the disappearance of crop genetic resources but also the traditional agricultural systems that have produced and maintained this diversity. Tropical and subtropical Africa is rich in its crop diversity, and this diversity was maintained by diversified ecological conditions, farmers knowledge, cultural practices and traditional agricultural systems (Anishetty, 1994).

As noted by Hoben (1997), traditional agriculture is the major task of Ethiopian farmers living in the highlands above 1500m which comprises 43% of the country. In these highlands, the presence of favorable conditions for agriculture resulted in the development of different farming systems that have supported the inhabitants for generations. Ethiopia is one of the eight Vavilovian centers of origin and primary diversity of crop plants (Vavilov 1951). However, in this naturally well endowed East African country several obstacles such as recurrent drought, soil erosion and technological backwardness are hindering the efforts

of indigenous farmers to safeguard their resources and to achieve better living condition (Hoben, 1997).

In Ethiopia, traditional agriculture is based on the local varieties (landraces) (Harlan, 1975). Landraces, as described by Awegechew Teshome *et al.* (1997), are " variable plant populations adapted to local agroclimatic conditions, which are named, selected and maintained by the traditional farmers to meet their social, economic, cultural and ecological needs." They are the source of great genetic diversity because they are the results of natural and artificial selection in their centers of origin (Harlan, 1975); they exchanged genes with their wild and weedy relatives, and exposed to a multitude of environmental stress during the course of evolution (Qualset *et al.*, 1997). As suggested by Mengesha and Rao (1991), this exposure to environmental factors made landraces the "storehouse" of traits resistant to various biotic and abiotic stresses. Thus, they and their wild relatives have to be recognized, protected and conserved, at least for use in plant breeding activities before they are eliminated from the hands of subsistence peasants through the introduction of high yielding varieties.

Indigenous farmers are responsible for the development of traditional farming systems, that preserve the interaction of plants with their environment, and for retaining farmers varieties of crop plants (landraces) (Brush, 1995). Life styles of indigenous farmers, social ethos and traditional production systems in Ethiopia have played vital role in preservation of biodiversity of crop plants (Zemede Asfaw, 1996).

In the development of traditional agriculture and in preservation of landraces women also have contributed their part. It is stated in Kiplagat (1996) that rural women have direct contact with many species used as food, medicine, fuel, fodder, fiber, etc. in their routine household activities. As a result they have more accumulated knowledge than men in the patterns and uses of local biodiversity. Moreover, they rely on undisturbed and healthy ecosystems. As suggested by Guarino (1995), despite heavy work loads that resulted from socioeconomic and cultural reasons, African women are responsible for processing and storage of seeds of landraces. They are, thus, the main custodians of indigenous knowledge related to germ plasm performance and quality. In Ethiopia, women farmers participate in identification, characterization, cleaning and storing landrace seeds for the next sowing season (Bayush Tsegaye,1997). They also play important role in deciding the type and amount of crop that will be sown in the forthcoming season. The reason for this is that the women have better knowledge of nutritional value of crop varieties, family need and consumption and they are keen observers and evaluators of the local market condition.

There was certain form of ecological consciousness among the traditional African societies, before the introduction of the western knowledge, concerning their relationship to their living environment (Embola, 1996). In Ethiopia farmers have been well aware of the effects of soil erosion and traditionally they have created and applied different methods of controlling it. For example, they were controlling it by contour ridging, terracing, strip cropping, hedging and mulching (Hoben, 1997). Hajra and Hajra (1996) mentioned the presence of sacred patches of forests maintained by indigenous people in many tropical countries. By furthering their explanation,these authors added that these groves were

protected in association to some beliefs, but they are typical examples of ecosystem conservation and harbor a large number of economically and ecologically important plants.

Small farmers in rural areas of Ethiopia fertilize their farms with manure and crop residues. They also maintain their soil fertility by crop rotation, repeated deep tillage and other associated techniques. As indicated by Ghadim (1991), deep tillage is one of the factors that improve crop yield and profit farmers. In addition, the extent of yield improvement mainly depends on the timing of deep tillage, frequency of deep tillage and the size of tilling apparatus that determines the depth.

It is possible to increase productivity in peasant agricultural systems by using costly agrochemical but it is not a sustainable way (Altieri and Merrick, 1987). The sustainable way of increasing productivity is depending on diversity of crops and exploiting the natural resources found in the farm (Altieri and Merrick, 1987). According to Abenet Belete *et al.*, (1992), the proportion of farmers using chemical fertilizers is decreasing in the highlands of Ethiopia. These areas are the origins of Ethiopian indigenous system of agriculture and local landraces. They also mentioned some of the possible reasons for this decline of farmers' interest towards the use of chemical fertilizers. Some of the underlined reasons are high nominal cost of fertilizers, stringent credit systems, low cost benefit ratios due to low output prices and low fertilizer responses, and the over all risk aversion strategy of farmers.

As noted by Altieri (1991), crop biodiversity is vital for the survival of resource poor farmers of third world countries. These people usually live near hillsides and depend on

rainfed agriculture which is established on marginal lands. And also, severe soil erosion that resulted in reduced soil fertility, low seasonal rainfall and other environmental calamities are their major problems. Moreover, annual crop yields of these farmers are hampered by the above mentioned factors. However, they cannot purchase and apply expensive agrochemical to improve their yield, but they rely on their traditional farming practice, which is based on crop biodiversity.

As indicated in Francis (1986), intercropping (multiple cropping system), which is the first form of organized agriculture in the history of man, is most prevalent in East Africa. Furthermore, it has evolved to fit several geographic and climatic niches; and determined by the objectives of the farming family. According to Lynam *et al.,* (1986), crop cultivation system of small farmers is associated to ideas of home consumption, some monetary income and protection against natural risks. They, therefore, prefered intercropping systems due to the fact that it mainly reduces economic and environmental risks, and at the same time fulfills subsistence objectives.

Landrace diversity of crop plants is useful in ensuring yield stability because different genotypes found within the landrace populations vary in their resistance and response to environmental stress (Zeven, 1998; Olasanta, 1999). When diversity in agriculture increases,the magnitude of pest infestation, disease out breaks and other natural problems decrease (Qualset *et al.,* 1997; Tuxill, 1999).

According to Altieri (1987), uniform monoculture environments create favourable conditions for the multiplication and invasion of insect pests. The reason for this is that the vigour of predators decreases in the simplified environments due to the absence of adequate supply of food, shelter, breeding sites and other environmental requirements. Generally, crop diversity is advantageous in improving yield, efficient use of resources, nitrogen availability, reduction of diseases and pests, weed suppression, insurance against crop failure and soil protection.

In Africa the distribution of crops in the farmers village shows variation with distance from the dwellings (Ramaswamy, and Sanders,1992). Homegardens (compound farms) are the imitations of natural ecosystems and are established on a small plot of land near the residence of the farmers (Swift *et al.,* 1996). They are examples of living gene banks (Qualset *et al.,* 1997). They contain plants of different habits- herbs, shrubs, trees and vines that are used as fire wood, construction material, tool, medicine, food, spice, condiments and stimulants (Zemede Asfaw and Ayele Nigatu, 1995; Swift *et al.*, 1996). These homestead farms are rich in species diversity and established on soil well fertilized by animal waste (Okigbo and Greenland, 1976 cited in Francis, 1986). It is also regularly visited and treated by the family members, and provides different nutritional, medicinal,utility, etc services to the farming family (Zemede Asfaw and Ayele Nigatu, 1995). Primary cereal crops (major staple crops) are grown on permanent fields relatively far from the dwellings and intercropped with legumes (Ramaswamy and Sanders, 1992). As indicated by Okigbo (1994), the species diversity of crop plants decreases with increasing distance from the homestead.

According to Longley and Richards (1993), the distribution of crop varieties in the traditional farmers locality is determined by two major factors- environmental condition and farmers' objectives. For example, Mende upland rice farmers in Sierra Leone distribute their rice varieties (short-, medium-, and long duration rice varieties) on different soil conditions in a way that fits their needs. Early maturing (Short duration) rice varieties that reduce period of pre harvest hunger are planted on moisture retaining soils at the foot of the valley slopes. Slow maturing varieties however, are planted in water logged areas. Similarly, in Burkina Faso, maize that will be consumed in the hungry period before the harvest of sorghum and millet is planted on the compound land around the farm household (Ramaswany and Sanders, 1992).

Accordining to Berhane Gebrekidan (1979) and Francis (1986), in areas with more rainfall and fertile soil, cereals such as maize predominate, whereas in marginal environments with lower rainfall and poorer soil sorghum becomes dominant. Sorghum is the most important crop of rainfed agriculture in drought prone lowland areas of semi arid tropics including Ethiopia (Berhane Gebrekidan and Yilma Kebede, 1979; Wilson and Witcombe, 1985).

The indigenous crop varieties of Ethiopia are endangered due to the influence of unpredictable climatic conditions and by the introduction of high yielding genetically uniform varieties (Melaku Worede, 1992). According to Berhane G/K (1979), drought, striga infestation and the introduction of uniform sorghum cultivars are the major enemies of the slow maturing landrace varieties of sorghum in Ethiopia. Moreover, shortage of the rains

and increment of striga population forced farmers to shift from cultivating sorghum to cultivating teff.

South Welo (Ethiopia) is rich in crop landrace diversity particularly *Sorghum bicolor* (L.) Moench (Brhane G/K and Yilma Kebede, 1979; Awegechew Teshome, 1996). The farmers of South Welo have maintained their crop landraces for thousands of years by using their traditional preservation methods and farming practices (Awegechew Teshome , 1996). As suggested by Melaku Worede (1997), in drought prone parts of northern Ethiopia farmers always retain seeds of many different kind of crop species and intraspecific varieties for security. Moreover, these farmers, in the time of famine, migrate from their home lands, but before leaving their home they bury their landrace seeds in secured places to propagate when they return home after the drought is over.

Harlan (1975) stated that "An indigenous African agriculture was developed in Africa by Africans domesticating African plants. An agricultural system evolved with a farming village pattern and spread over much of the continent. This system was complete with cereals, pulses, root and tuber crops, oil crops, vegetables, stimulants and medicinal crops."

The indigenous Ethiopian agriculture system which is based on crops such as teff, niger seed, enset, finger millet, khat, coffee, etc is blended with the agricultural system introduced from Near East (Harlan, 1975). The introduced agricultural system was based on crops like wheat, grain legumes, flax and safflower.

3. The study area

3.1. General description

"Fontanina" or "ElaHaji":- These are the names given to the area in which this study has been conducted. Both names have similar meaning but different origin. They imply that the area is the source of spring water. The first name ("Fontanina") has foreign origin probably Italian, and the second name (" ElaHagi") was given by the local people.

Fontanina is a village of subsistence farmers and located at about 360 kms distance from Addis Ababa, in the northern direction along the road to Kombolcha town (South Welo). It is part of Chorisa 06 Kebele Farmers Association, in Kalu wereda, South Welo administrative region in Northern Ethiopia (see Figure 1).

The study site extends from Borkena river valley (its lower boundary) up to the top of Irgufet hill (its upper boundary)(Fig. 1). It includes crop fields and homegardens distributed in altitudinal range of 1490 m a.s.l. – 2030 m a.s.l. interrupted by grazing area and rocky, hilly areas with bushy vegetation.

The study area is geographically bounded in 10^0 56' – 11^0 00' N latitude and 39^0 45' – 39^0 48' E longitude. Dissected hills with shallow stony soils in the Eastern escarpment of Borkena valley is the characteristic feature of the study area.

According to the Ethiopian agroecological zonation the area of the current study is represented by two of the four major zones. These two agroceological zones that represent this area are kola: < 1600 m a.s.l and lower woina dega: 1600m a.s.l. – 2000 m a.s.l. (MOA, 1987) following the traditional classification. Using later agroecologic zones, the study area falls within the tepid arid mid altitude (1600 –2400 m a.s.l.) and hot to warm semi arid low land (1300 – 1600 m a.s.l.) (Ermias Bekele and Mengistu Negash, 1988).

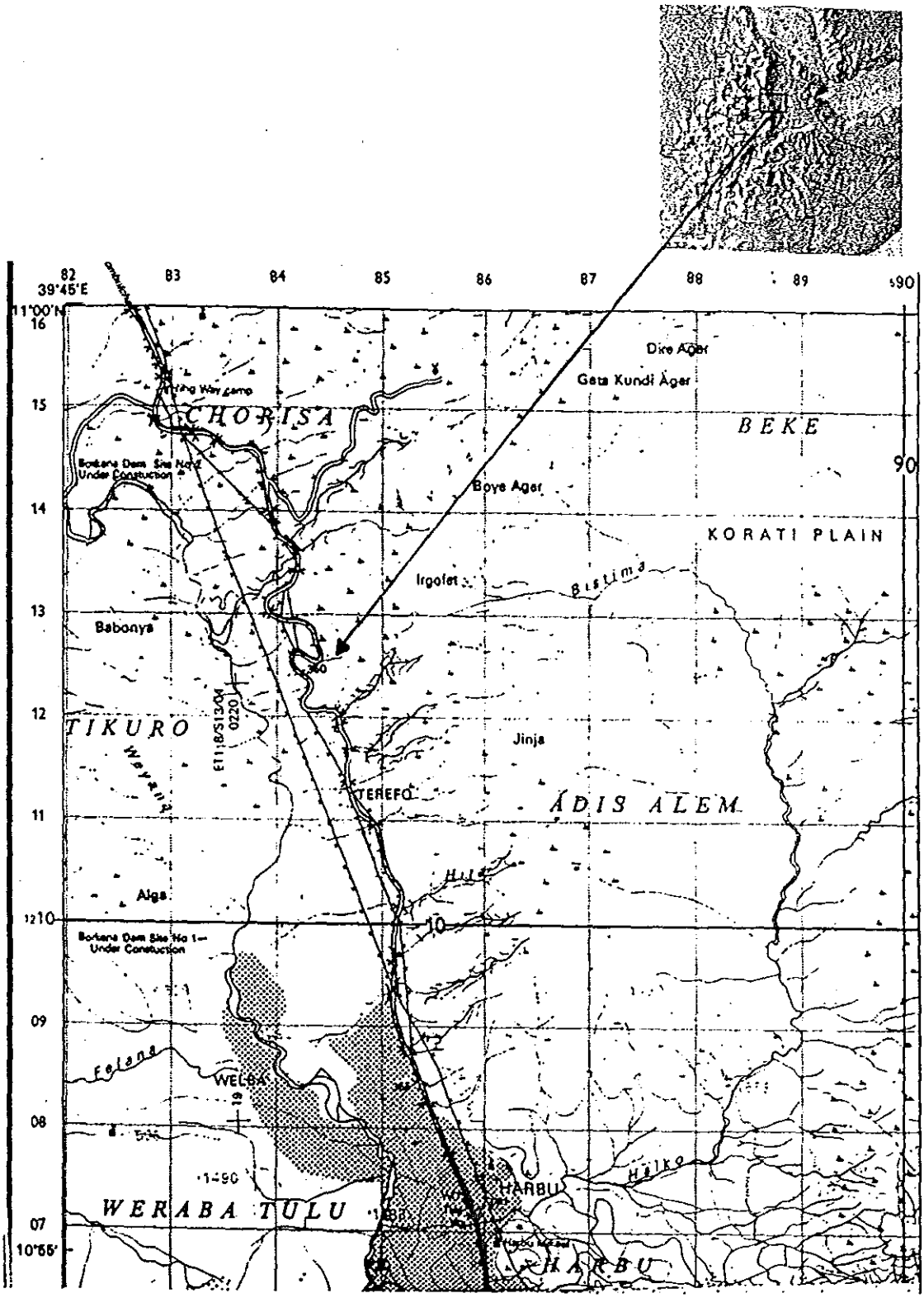


Figure 1. Map of the study area

3.2. Geology and Soil

The area is underlain by volcanic layers (basaltic rocks) of the Tertiary period (65-2 million years ago) similar to those found in most parts of the Ethiopian highlands (MOA, 1987). Major soil types of the escarpment are cambisols, lithosols and vertisols (MOA, 1987).

3.3. Rainfall and Temperature

It is highly drought prone area and rainfall reliability is very low. It has bimodal rainfall system (in "Belg" and "Kiremt"). "Belg" and "Kiremt" are the two Ethiopian rainy seasons that supply considerable amount of rain. In the study area "Belg" season lasts from February to May but it is small and much unreliable. Farmers in Fontanina produce (cultivate) cereals and pulses during favourable years of this season. "Kiremt" lasts from June to September and it is more reliable, and provides more water than "Belg".

Annual precipitation ranges from 1000-1300 mm and maximum rainfall is recorded in July andAugust(Table 1) (NMSA 2000). Temperature correlates with altitude (i.e. warmer low lands and colder higher altitudes). The mean annual temperature increases by 0.6^0 C for every 100m decrease in altitude. June is the hottest month of the year whereas December and January are the coldest months (NMSA 2000).

The growing period is around 180-210 days on average, i.e. from April to October. In some years when "Belg" and "Kiremt" rainy seasons merge the growing season will be longer. It

will extend from mid of February up to October, i.e. about 240 days (Personal comm. local farmer; MOA, 1987; NMSA, 2000).

Table 1: - **Rainfall and temperature data of seven consecutive years in the study area**

Month	January		February		March		April		May		June		July		August		September		October		November		December		
Year	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	R	T	Annual rainfall in mm
1993	46.2	22.6	83.0	22.4	37.1	26.4	239..9	24.4	181.0	25.8	4.7	29.2	256.8	28.2	155.3	27.1	226.6	26.1	41.8	25.2	0	25.1	7.6	29.5	1280
1994	0	25.4	0	26.6	53.9	26.6	51.0	28.6	86	28.9	30.7	30.7	436.6	26.5	331.6	25.6	154.4	25.9	2.2	25.4	36.8	24.5	1.9	24.3	1185.1
1995	0	24.8	29.5	25.7	48	26.3	209	25.6	79.4	27.8	30	30.2	284.2	27.2	260.5	26.6	80.5	26.3	30.3	25.7	0.0	25.8	44.6	24.5	1095.5
1996	48.4	23.2	3.4	26.7	139.7	25.8	133.4	26.5	124.8	26.7	61.8	28.8	164.4	28	346.9	26.6	37.3	26.7	8.3	26.4	57.2	24.3	1.9	24.1	1127.5
1997	33.6	23.5	0	25.9	51.4	27.0	69	26.8	13.6	30.0	104.2	29.0	234.8	28	216.3	27	52	27.4	154.6	25.7	87	24.8	0	24.7	1016.5
1998	95.4	23.7	91.5	24.5	36.3	25.9	124.6	28.5	49.2	28.4	2.9	31.7	4.80.2	27.4	248.2	26.0	114.5	26.6	76.5	25.8	0.0	25.2	0.0	25.0	1319.3
1999	54.4	24.4	3.8	27.6	22.7	26.6	19.0	29.3	5.4	30.6	10.8	31.3	374.3	27.0	328.4	26.6	109.1	26.0	121.8	24.2	1.7	24.3	2.0	23.5	1053.4
Average Monthly rainfall and temp.	39.14	23.9	30.17	25.6	55.58	26.4	120.84	27.1	77.05	28.3	35.01	30.1	318.75	27.5	269.6	26.5	110.62	26.4	62.21	25.5	26.1	24.9	58	25.1	1203.07

"Belg" "Kiremt"

R = Rainfall

T = Temperature ^{0}C

Source: National Meteorological Services Agency (NMSA), February 2000.

3.4. Vegetation

The vegetation of the study area is dry evergreen montane forest and grass land. Some of the characteristic species of plants in the study area are *Croton macrostachyus* Del., *Acacia seyal* Del., *Ziziphus mucronata* Willd. , *Ziziphus spina-christi* (L.) Desf., *Euphorbia candlabrum*Trem. ex Kotschy , *Cordia africana* Lam., *Olea europaea(L) subsp. cuspidata(*Wall. ex DC.) , *Diospyros abyssinica* (Heirn.) F.White, *Hyparrhenia spp., Euclea shimperi (AD.C.)* Dandy *and Carissa edulis* (Forssk.*)* Vahl . Increasing population density, extensive cropping and shortage of farmlands resulted in deforestation that destroyed the climax vegetation.

There are small patches of forest on community funeral places or traditional worship places. These vegetation patches are locally called "Hujiv" and they are strictly venerated. In addition, some tree species are domesticated in the live fences around the residential area of the farmers and some others are purposely left around the crop fields as shade trees.

3.5. Population and Land use

Fontanina is one of densely populated areas of the country (MOA, 1987; CSA, 1998). The inhabitants are subsistence farmers engaged in traditional mixed farming system (i.e ploughing the land and rearing draft animals). Land degradation, land shortage and climatic problems especially the recurrent drought are the major constraints of development. These

subsistence farmers are dependent on the field crops particularly sorghum [*Sorghum bicolor* (L.) Moench] for food and generating income. However, due to the above mentioned constraints most farmers couldn't produce sufficient yield even for their annual consumption.

Crop cultivation is based on rainfed agricultural system, but there is very small amount of production by irrigation around the riverbanks and irrigable localities. The land is ploughed by a traditional plough ("Maresha"- Amharic) which is pulled by two oxen joined together by a yoke. Ploughing the land is exclusively done by the male farmers.

Animals reared by the farmers include cattle, donkeys, sheep and goats. Recently, some young farmers, especially those who have partially engaged in non farming activities in their spare time, are introducing camels from the low land Afar regions. The aim of these farmers is to generate income by transporting agricultural products from the farmers villages to the nearby towns. However, the introduction of camels is not welcomed in the study area both by the inhabitants and by the environment. The reason for this is that when camels search for food they destroy the live fences, irrigated fruit trees and shrubs on steep slopes. This is resented by the farmers and the presence of the animal is aggravating soil erosion which is the major problem in the area.

3.6. Agricultural calendar

Farmers have their local agricultural calendar of ploughing, sowing and harvesting. This calendar is the result of experience accumulated for centuries. The agricultural system in the study area is rainfed, and the calendar is mainly determined by the rainfall cycle.

For the purpose of getting better yield in the forthcoming season and weed control, farmers have accustomed to ploughing their crop fields repeatedly. Under normal circumstances they start ploughing in January and continue upto the first week of July for various crops(Table 2). They get rest in May. May is dry and hot month, and they don't plough in May.

Table 2. Main seasonal agricultural activities concerning sorghum, teff and maize cultivation

Crop	Ploughing	Sowing	Harvesting	Threshing
Sorghum	1st round- January 2nd round – February 3rd round - March	-Zengada- March- April -Other late maturing sorghum varieties are sown in April	December (Tahisas)	December (Tahisas)
Teff	March,April, June,July	July	November (Hidar)	January (Tir)
Maize (Ginbote)	January, February, March, April	April	August-September	***

Traditionally, farmers believe that harvesting, threshing and storing sorghum in December makes the seeds resistant to weevil attack. The probable reason for this is that seeds are dry and suitable for storage in December.Thus, if it is not beyond their capacity they want to complete all these activities in the same month.

***Maize is grown in small amount in combination with other crops to be totally consumed by the farming family as green food (corn on the cob). Its threshing time, as a result, is not included in the agricultural calendar in the study area.

3.7. Major crop varieties grown in the two rainy seasons ("Belg" and "Kiremt")

3.7.1. Crops of "Belg"Season

Crops of this season are sown in February and March, and are harvested in June. This tradition is common in higher altitudes (i.e. above 2000m a.s.l) in the study area. Commonly cultivated crop varieties are maize, barley, teff, wheat, grass pea, emmer wheat, pea, niger seed and fenugreek. Slow maturing sorghum varieties sown during this time are-Zengada, Cherekit, Gorad, Tengelai, Mokake, Wegere, sweet stalk varieties and green food sorghum varieties.

3.7.2. Crops of "Kiremt"

Maize and teff are mainly planted during this period. And also fast maturing sorghum varieties such as Ismael, Wofaybelash, Abula gorad, Cherekit, Mokake, sweet stalk varieties and green food sorghum varieties are sown during this period. Here, we can understand that certain sorghum varieties such as Cherekit, Mokake, sweet stalk and green food sorghum varieties show flexibility. They can be planted in both seasons.

4. Materials and Methods

A reconnaissance survey was made in November,1998 and the study site was delimited. From October 1999 up to January 2000 four consecutive trips were made to the site for data acquisition. A total of 324 farms comprising 72 homegardens and 252 fields of annual crops were surveyed. The owners of each farm who were very cooperative assisted all the surveys. The farmers actively participated by sharing their experience and knowledge, by showing the boundary of their farms, by explaining the general condition of their farms and the crops they cultivate.

4.1 Crop data collection

To examine the crop diversity of each farm:

i. In the homegardens crop species in the whole garden were recorded

ii. In the fields of annual crops recording of crop species was carried out in a number of quadrats (4 m x 4m). The number of quadrats varies from 3 to 5 according to the size and species composition of the fields.

During data collection the researcher has observed crop fields with the same kind of intercropped species but different in the percentage of each species they contained. To include the detail of this information therefore, cover abundance of crop species in the same quadrats was estimated using a 1-9 modified Braun Blanquet (1932) scale (Vander Maarel, 1979 cited in Zerihun Woldu, 1985).

Recording diversity in a quadrat (stand) using presence/ absence method has its own weakness, i.e. it does not show the difference between abundant and rare species (Zerihun Woldu, 1985, Shaxson and Tauer, 1992).

A 1-9 modified Braun-Blanquet (1932) scale

1. rare, generally only one individual
2. sporadic with less than 5% cover of the total area
3. abundant with less than 5% cover of the total area
4. very abundant and less than 5% cover of the total area
5. 5-12% cover of the total area
6. 12.5 – 25% cover of the total area
7. 25 –50 % cover of the total area
8. 50- 75 % cover of the total area
9. 75-100 % cover of the total area

4.2 Estimating the frequency of Sorghum landraces

The intraspecific frequency of *Sorghum bicolor* (L.) Moench was estimated in 123 fields of different sizes using a line transect method. Transect lines spaced 10 meters apart from each other over the fields as used by Awegechew Teshome *et al.* (1999). By walking along the transect lines at every five steps (equivalent to five meters) the nearest sorghum plant was sampled and identified by the farmer expert on spot. For instance, it is possible to sample 10

sorghum plants from a 50 meter long line transect or a total of 200 sorghum plants from a typical one hectares farm.

4.3. Collection of plant specimen and Environmental data.

4.3.1. From farmers fields and their surrounding representative plant specimens were collected and authenticated in the National Herbarium AAU.

4.3.2. Soil samples were collected from 10-20 cores, according to Jackson (1958) and composited. About 1 kg of each composite sample was brought by polyethylene bags and air-dried. Some chemical and physical properties of top soil (0-10 cm) collected from farm lands located at different distance from the living place of the farm household were determined in the National Soil Laboratory.

4.3.3. Altitude of each farm was measured using Everest Altimeter.

4.3.4. Daily temperature and rainfall data of seven consecutive years (i.e from 1993-1999) were collected by formal request from National Meteorological Services Agency (NMSA 2000).

4.4. Interview with farmers

To document and analyze the indigenous knowledge of the traditional farmers, 30 farmers were selected based on their knowledge, and interviewed in the study site. The selected

farmers are from both sexes (male and female farmers) and age groups ranging from 33-85 years. Semi-structured questions in Amharic (local language) were used to gather information on various aspects of agrobiodiversity.

4.5. Data analysis

Multidimensional Scaling method of ordination was employed to see the relationship between sample stands using presence / absence data of crop species. Cluster analysis of sample stands from annual crop fields was performed with computer package SYNTAX.

Polynomial regression, one-way ANOVA, Pearson's correlation, Reliability analysis and Canonical discriminant analysis are some of the statistical methods employed to perform the analysis of different items indicated in the thesis.

a. Polynomial regression was used to analyse the relationship between farm size and sorghum landrace frequency.

b. One-way ANOVA was performed to see the variation among the farmland groups or crop communities with respect to environmental variables. It was tested by Tukey's multiple range test.

c. Reliability analysis performed to see the reliability of farmers' responses

d. Canonical discriminant analysis was used to classify soil samples into groups using soil analysis result.

e. Pearson's correlation coefficient was used to see the correlation between environmental variables.

Soil physical and chemical analysis was performed in the National Soil Research Laboratory according to the following methods of analysis.

a. Sample preparation: The soil samples were air dried at room temperature, grounded in a grinding machine and sieved through a 2 mm sieve.
b. Proportion of sand, silt, and clay were determined by Hydrometer method of mechanical analysis.
c. pH water was determined in 1:2.5 soil water ratio.
d. Electrical conductivity (EC) was determined in 1:2.5 soil water ratio.
e. The Kjeldahl procedure was employed for total nitrogen.
f. Walkley and Black method was employed for per cent organic carbon.
g. Olsen's method was employed for available phosphorus.

5. Results

5.1 Crop Communities of Fontanina

Sample of 65 stands comprising presence absence data of 52 crop species was subjected to Multidimentional Scaling method of Ordination. MDS of the data from these stands to summarize the relationship among stands in two dimensions resulted in two distinct clusters (Fig. 2). The scatter plot of axes 1 and 2 was used to obtain the relationship of the clusters.

Cluster1: is characterized by fruits and construction trees and other crops of Ye-gibi meret(homegardens).

Cluster 2: is characterized by annual crops such as *Zea mays* L., *Sorghum bicolor* (L.) Moench, *Eragrostis tef* (Zucc.) Trotter and other associated crops of Ye-guaro meret and Ye-dur meret.

Fifty stands of cluster 2 comprising quantitative data of 22 crop species were further classified using cluster analysis method. Clustering of these 50 stands resulted in three major groups of annual crop fields or crop communities and two plots (Figure 3).

A. Clusters

a. Fields of *Zea mays* L. (characterized by *Zea mays* L.). These fields are locally called "Ye- guaro Meret" (Nearby farm).

b. Fields of *Eragrostis tef* (Zucc.) Trotter

c. Fields of *Sorghum bicolor* (L.) Moench

B. Plots

d. Fields of *Triticium sativum* L.

e. Fields of *Vicia faba* (L)- *Guizotia abyssinica* (L.f) Cass.

Sample stands representing each group are: -

Cluster a- 1,6,9,15,43,49,17,7,12,16,8,10,11

Cluster b – 37,45,47,38,41,48,44,40,50,39

Cluster c - 2,3,28,26,13,14,18,23,22,4,21,27,20,5,32,30,19,25,29,33,31,24,34,35,36

Plot d – 46

Plot e-42

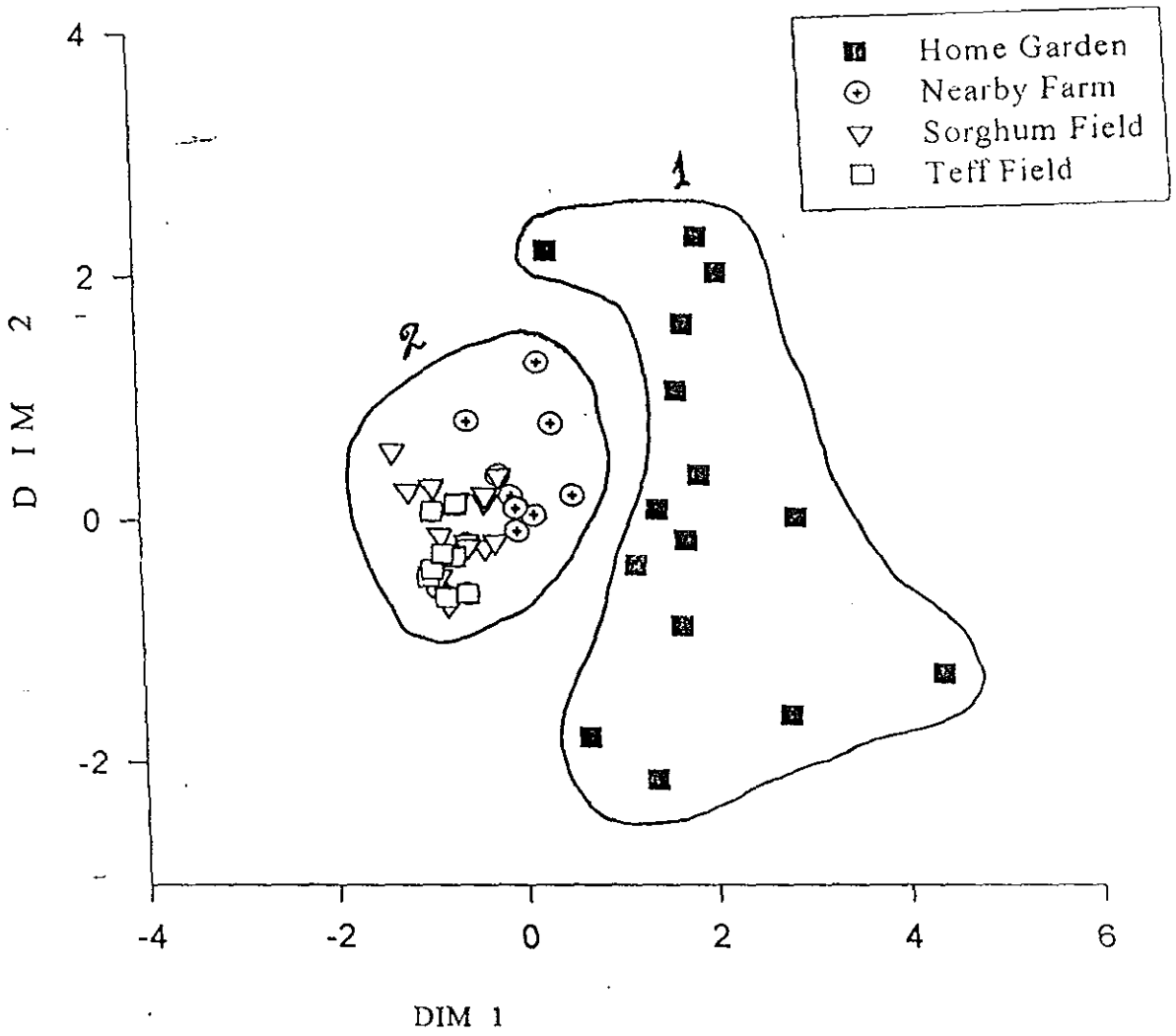


Figure. 2 Scatter diagram of presence/absence data set using MDS (Multidimensional Scaling)

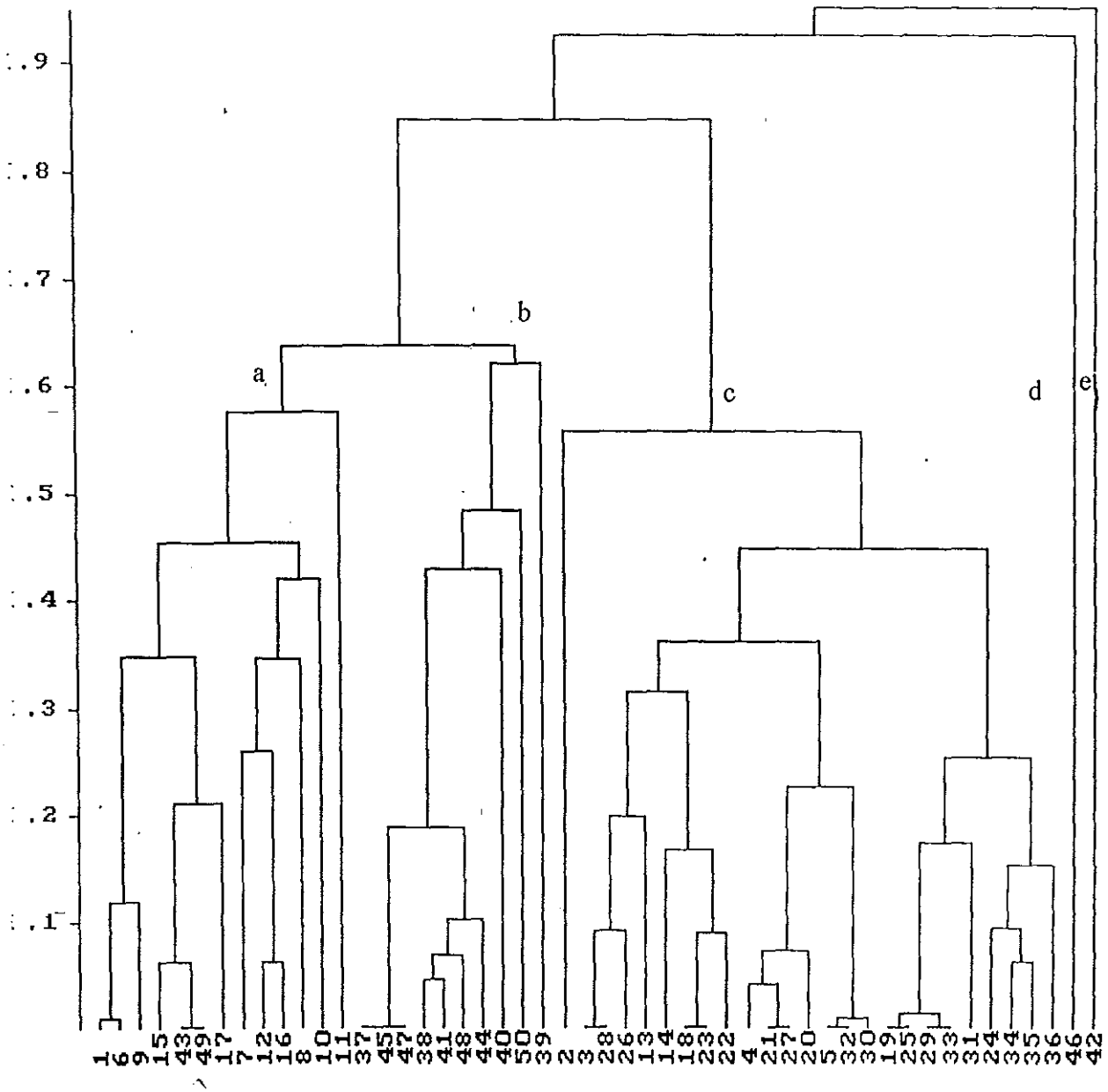


Figure 3. Dendrogram of quantitative data set of annual crop fields

5.2. Crop Data

Table 3. Total number and percentage of Crops recorded in "Ye-Gibi Meret" (homegarden)

Crop category	Number of species	Percentage
Food crop	44	51.16
Non food crop	42	48.83
Total	86	100

Table 4. Crops recorded in "Ye-Guaro Meret"(nearby farm)

Crop category	Number of species	Percent
Food crops	25	73.53
Non-Food crops	9	26.47
Total	34	100

Table 5. Crops recorded in the main crop fields (" Ye-Dur Meret")

Crop category	Number of species	Percent
Food crops	32	69.56
Non food crops	14	30.43
Total	46	100

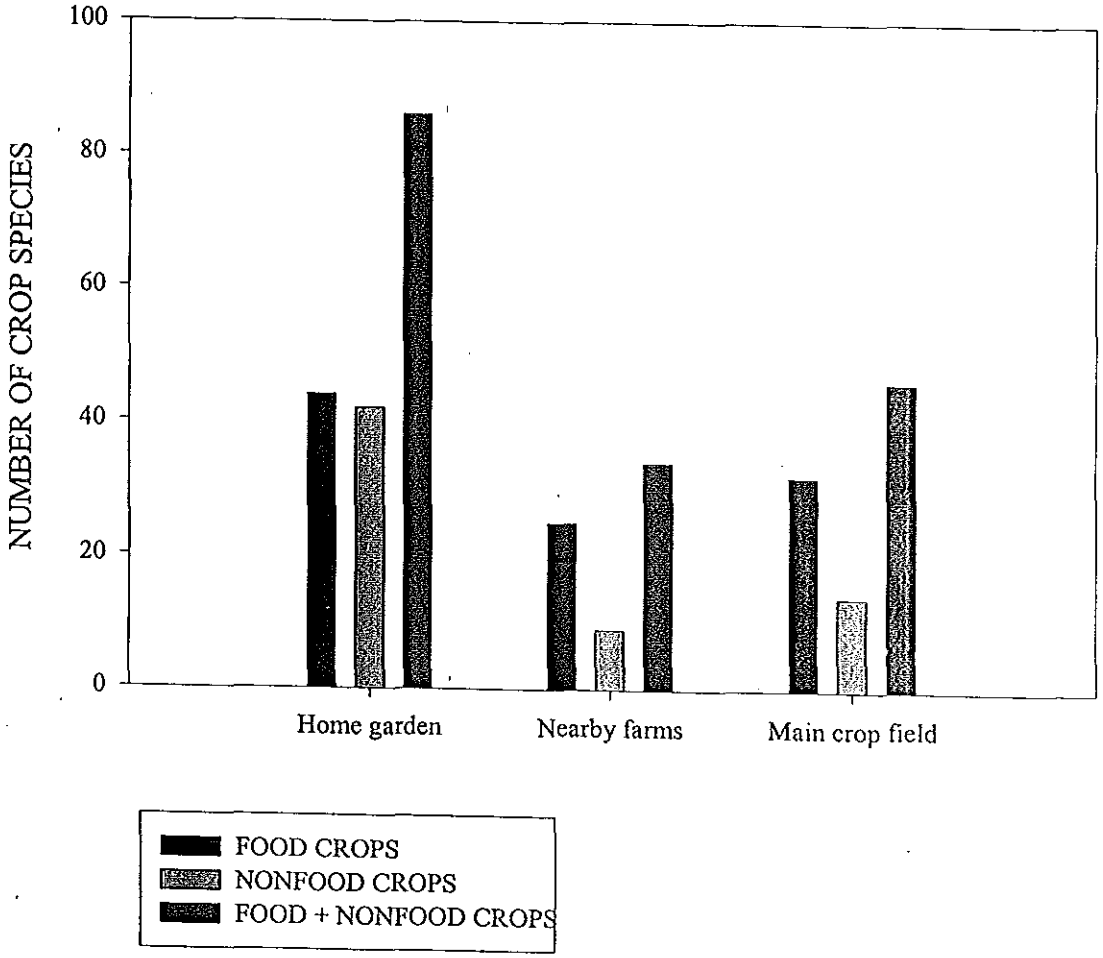


Figure 4. Number of crop species in the homegardens, nearby farms and main crop fields.

5.3. *Sorghum bicolor* (L.) Moench Landrace Frequency

There are many varieties of sorghum landraces in the study site, more than one variety being found intercropped in every sorghum field. In 1999 cropping season, absence of rain in March and April inhibited the germination and development of slow maturing long season landraces of sorghum. As a result farmers reploughed the seed sown fields in June and resown fast maturing introduced varieties and some fast maturing landraces of sorghum. Thus, in 1999 cropping season the fields of sorghum were unusually dominated by a uniform fast maturing variety, locally called Ismael. Farmers mentioned that this variety (Ismael) was introduced into the area some years back (10-15 years) as a means of alleviating farmers' problems in drought affected years.

The following table shows the varieties of sorghum and their respective frequency as obtained from 123 farmers' fields in November 1999. These fields are approximately equivalent to 65 hectares of land.

Table 6. The frequency of 58 sorghum varieties and 1 wild relative (kilo) of sorghum

No	Local name of Sorghum varieties	Frequency	No	Local name of sorghum varieties	Frequency
1	Ismael	6412	31	Ganseber	17
2	Gubete	124	32	Yikirmindaye tinkish	19
3	Abdoke	1613	33	Zergafe jiruh	45
4	Necho tinkish	402	34	Wanese	1
5	Keyo tinkish	338	35	Dewey	131
6	Mogne ayakish tinkish	357	36	Subhan	74
7	Mote tinkish	187	37	Tubah tinkish	7
8	Tengelai	272	38	Nech Jamo	43
9	Gorad	401	39	Watigela	34
10	Wof aibelash	910	40	Milte	8
11	Key Jamo	78	41	Irgo begunche(Barchuke)	49
12	Kilo	26	42	Welel eshet	3
13	Cherekit	496	43	Werebabo tinkish	2
14	Amelsi tinkish	147	44	Tubah	33
15	Mokake	147	45	Jibo tinkish	25
16	Minchiro	172	46	Abula gorad	5
17	Yikir solate tinkish	21	47	Jigrite (Jirgite)	17
18	Dikusie tinkish	26	48	Gilmite zengada	1
19	Zengada	71	49	Barchuke tinkish	1
20	Jofa tinkish	4	50	Dalecha tinkish	1
21	Gogobsa tinkish	9	51	Milte tinkish	2
22	Hadishe tinkish	1	52	Chibite tinkish	1
23	Wegere	10	53	Key gorad	6
24	Sererge tinkish	5	54	Guncho	2
25	Bekej tinkish	2	55	Yejibmurt tinkish	1
26	Mali tinkish	91	56	Zebit tinkish	2
27	Zengada tinkish	46	57	Gomzaze	3
28	Megale tinkish	3	58	Bitine tinkish	2
29	Goronjo	172	59	Gewle tinkish	1
30	Ajaive	43			

Table 7. Maximum and minimum number of sorghum landrace varieties intercropped per plot of land

	Number of sorghum landraces per plot	Fied size
Maximum number	24	9 "Timad"
Minimum number	3	1 "Timad"

- "Timad" is the amount of farm land that can be ploughed by an average Ethiopian farmer (peasant) in one working day. It is equivalent to one fourth of a hectare.

Table 8. The frequency of major landraces and introduced sorghum varieties in Fontanina village in 1999.

Sorghum landraces	%	Varieties introduced into Fontanina	%	Others	%
Gorad	3.05	Ismael	48.86		
Zengada	0.54	Abdoke	12.29		
Mokake	1.12	Cherekit	6.93		
Tubah	0.25	Wof aibelash	6.93		
Tengelai	2.07	Minchiro	1.31		
Total	7.03	Total	76.32	Total	16.65

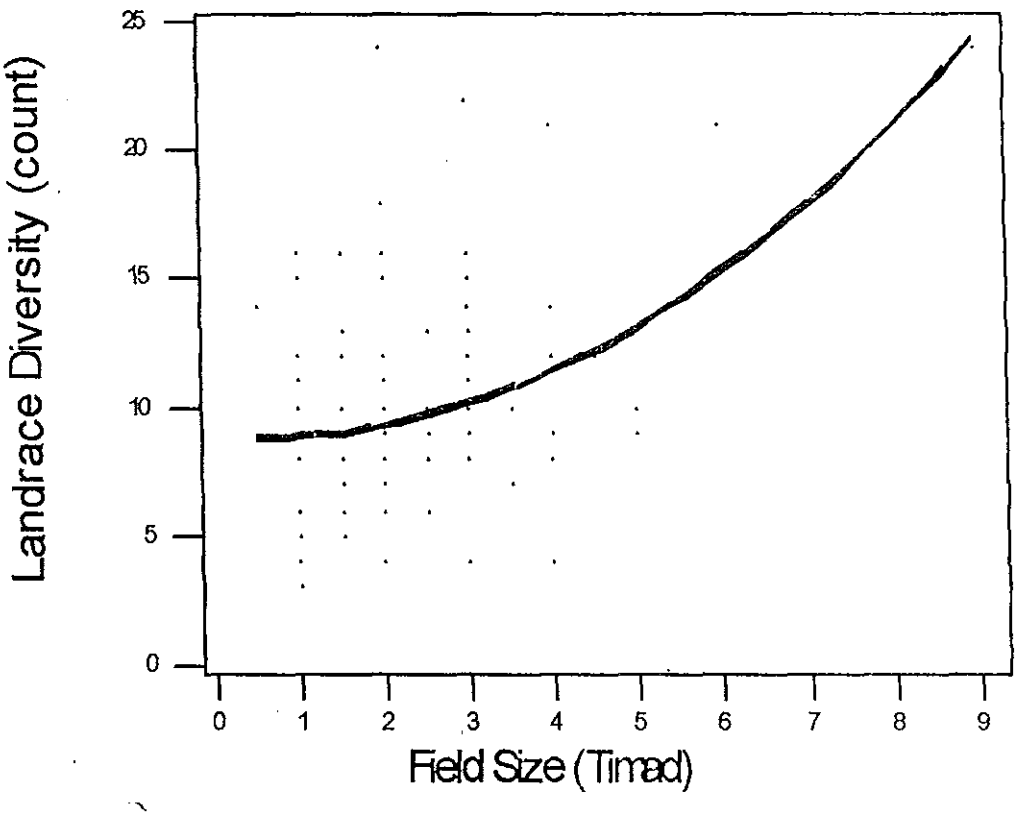


Figure 5. Relationship between land size and sorghum landrace diversity
(Polynomial regression $R^2 = 18.3\%$; $Y = 8.88393 - 0.234141 size + 0.218409 size^2$)

Comparison of Sorghum varieties

Farmers who were interviewed to distinguish between bird resistant and susceptible sorghum varieties mentioned that sorghum varieties called wofaiblash, cherekit and minchiro are bird resistant. Whereas, varieties called mokake, gorad and jamoye are most attacked by birds. They also indicated that cherekit is drought tolerant, striga resitant, but it is not storable in under ground pit. In contraty to this varieties of sorghum such as gorad and zengada are storable in underground pit but they are not striga resisitant.

5.4 Traditional Nomenclature and Taxonomy of Sorghum Landraces

Farmers in South Welo have their own traditional method of naming and classifying their crop varieties. The dominant crop in the area is Sorghum bicolor (L.) Moench. This crop has numerous intraspecific varieties (farmers varieties) and farmers distinguish one variety from the other variety using attributes related to morphology, adaptability, resistance and use values. Figure 6 shows the major sorghum varieties in the farmers fields, and also Table 9 shows the difference between sweet stalk and grain sorghum varietie

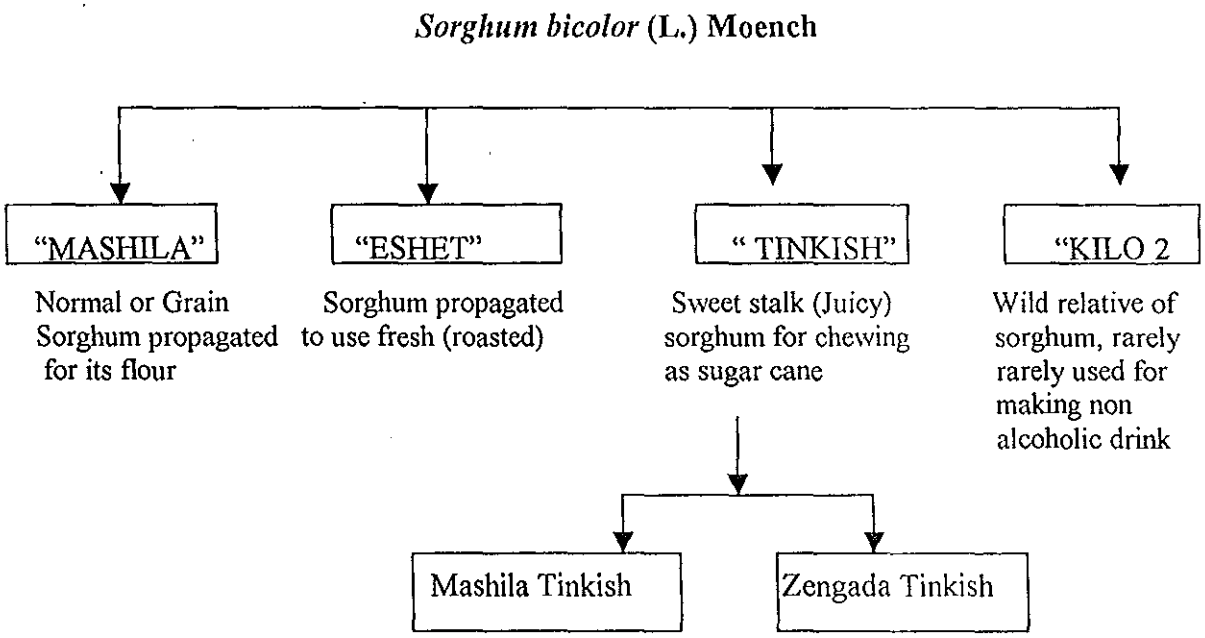


Figure 6.. Farmers' classification of Sorghum in their crop fields

Table 9 Difference between grain sorghum and sweet stalk soghum

Sweet stalk sorghum ("Tinkish")	Grain sorghum ("Mashila")
Hairy panicle (head)	Panicle is not hairy
Compact juicy stem	Pithy stem (less compact)
Mid rib has brown yellow colour	White midrib
Seeds are small in size	Seeds are bigger in size
Fast maturing	Slow maturing

The source of staple food for most of the farmers in the study area is grain sorghum that comprises more than 70% of the crop fields. Some examples of the sorghum landraces and taxonomic characters used by farmers are given below in Table 10.

Table 10. Some landraces of sorghum and characters used by farmers to classify them

Landrace Or Variety	Characters used by farmers				
	Seed colour	Panicle/head/ shape	Peduncle	Panicle compactness	Seed size
Gorad	White	Oval (cone) with 3 teats	Curved (goose neck)	Compact	Medium
Tengelai	Yellow	Oval (cone)	Curved (goose neck)	Compact	Medium
Zengada	Red		Not curved	Loose	Medium
Mokake	Yellowish	Oval (cone)	Curving	compact	big
Gubete	Greyish or dull liver colour	Small eleptical	Not curving	Less compact	Medium
Cherekit	White (chalk)		Not curving	Loose	Medium
Ismael	Pale red (orange)	Small elliptic	Not curving	Less compact	Medium
Goronjo	Pale (whitish)	Lanceolate	Erect	Less compact	Medium
Abdoke	Pinkish white	Elliptic	Not curving	Less compact	Medium
Wofaibelash	Redish	Oval (cone)	Curving	Compact	Medium
Yegenfoehil	White (marble)	Short	Not curved	Less compact	Medium
Minchiro	Red	Branching	Erect	Not compact	small

Traditional subsistence farmers in the study area also propagate sorghum varieties with high lysine content. The seeds of these varieties ("ESHET") are full of milky fluid and inflated when they are green. At maturity they shrink by losing their milky fluid. Then they attain dented shape.

There is one wild relative of sorghum which is locally called 'Kilo' [Sorghum bicolor subsp arundinaceum (Desr.) Stapt]. It has small flattened seeds completely covered with redish glumes. It has branching panicle, and at maturity it shades its seeds with slight contact. This is its natural seed dispersal mechanism. Farmers want to eradicate 'kilo' from their fields but it is not easily distinguishable at its younger stage. Some farmers (Ato Mohamed Hasen Anbesie) sow a variety called "Cherekit" (which is as white as chalk) in crop field infested by "kilo". This is a strategy to locate and up root the red headed "kilo" easily from a white background formed by "Cherekit".

An attempt was made to use farmers' morphological criteria and produce an identification key for the major categories and landraces of sorghum as shown below.

5.5. Identification key for *Sorghum bicolor* (L .) Moench.

a. For identification of main categories of sorghum

1. Seeds flat, completely covered with glumes, shaded easily; panicle branching (open)-----

---------- Wild relative of sorghum (**Kilo**).

Seeds round, partially covered with glumes, not shaded easily; panicle more or less compact----------2

2. Leaf midrib on the adaxial surface yellowish brown; panicle hairy; compact stem with sweet juice ----------**Sweet stalk varieties (Tinkish)**

Leaf midrib on the adaxial surface white; panicle not hairy; pithy, less compact stem without sweet juice----------3

3. Mature seeds dented----------Green food (**Eshet**)

Mature seeds not dented----------Normal grain (**Mashila**)

b. For identification of common landrace varieties of grain sorghum

1. Seeds red ----------2

Seeds paler or whitish ----------4

2. Panicle oval, compact----------**Wof-aibelash**

Panicle not oval, loose----------3

3. Panicle branching (open); glumes cover about 75% of seed part----------**Minchiro**

Panicle not branching; glumes cover <75% of seed of part----------**Zengada**

4. Panicle oval, compact----------5

Panicle elliptical, loose----------7

5. Seeds yellowish; panicle with or without three teats ----------6

Seeds white; panicle with three teats ----------**Gorad**

6. Seeds small; panicle with three teats----------**Tengelai**

Seeds big; panicle without teats----------**Mokake**

7. Panicle length <25cm long----------8

Panicle >25cm long--=----------**Goronjo**

8. Seeds pale or orange red ----------**Ismael**

Seds white ----------**Cherekit**

5.6. Crop category, Ranking and kinds of intercropping

Table 11. Crop category in the study site

CROP	
"Ye-Dirashot Ehil"	**"Ye-Tikmit Ehil"**
Pre-Harvest period crops used from August ("Buhe") upto September	Main Field Crops- harvested and used after October
Cabbage (*Brassica carinata* A.Br.) Maize (*Zea mays* L.) Potato (*Solanum tubersum* L.) Finger millet [*Eleusin coracana* (L.) Gaertn.] Tepary bean (*Phaseolus sp.*) Common bean (*Phaseolussp.*) Barley (*Hordeum vulgare* L.) Bunignteff [*Eragrostis tef* (Zucc.) Trotter.]	Sorghum [*Sorghum bicolor* (L.) Moench] Teff [*Eragrostis tef* (zucc) Trotter] Niger seed [*Guizotia abyssinica* (L.f) Cass] Sesame [*Seasmum indicum* L.]

Ranking crops

1st- Mashila [*Sorghum bicolor (L.)* Moench]

2nd- Zengada [*Sorghum bicolor* (L.) Moench]

3rd- Teff [*Eragrostis tef* (Zucc.) Trotter]

4th- Wheat(*Triticum spp.*), Barley(*Hordeum vulgarae*) Oats(*Titicum dicoccon*)---

- (Ye- Bireh Ehil) or (Bir- Ageda Ehil)

5th Broad bean, Pea, Lentil, Chick pea, Grass pea, Common bean,

Tepary bean, Cow pea ----------"Ye-Dibela Ehil" Pulses

6 th- Oils (Niger seed, Sesame, Flax) ------"Ye-kibat Ehil"

7th (cabbage seed, castor seed)---------- "Ye- Masesha Kibat"

Kinds of intercropping in the study site

- Maize +common beans + cabbage + pumpkin + cowpea + sorghum + tomato
- Teff + cabbage + Niger seed + Sorghum + Cress
- Sorghum + Seasame + Cabbage + Cowpea + Niger seed
- Broad bean + Niger seed + Pea
- Broad Bean + Niger seed
- Emmer wheat + Mustard
- Grass pea + Niger seed
- Maize + Tomato + Finger millet
- Sorghum + Sesame + Cowpea

Separately planted crops

- Wheat
- Grass pea
- Chick pea
- Barley
- Pepper

5.7. Result of interview data analysis

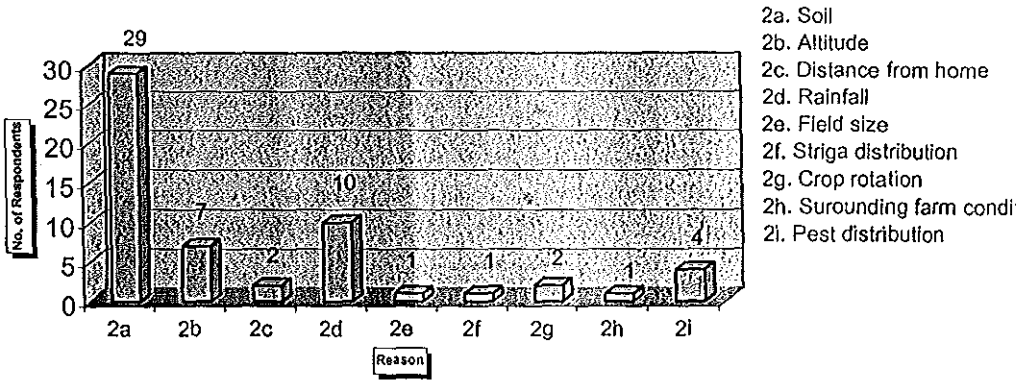


Figure 7 Factores determining the distribution of crops in Fontanina

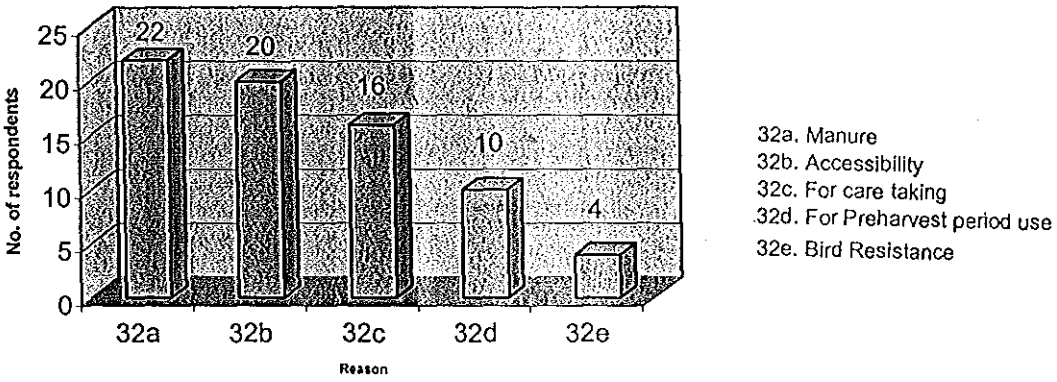


Figure 8 Reasons for sowing crops on nearby farms in Fontanina

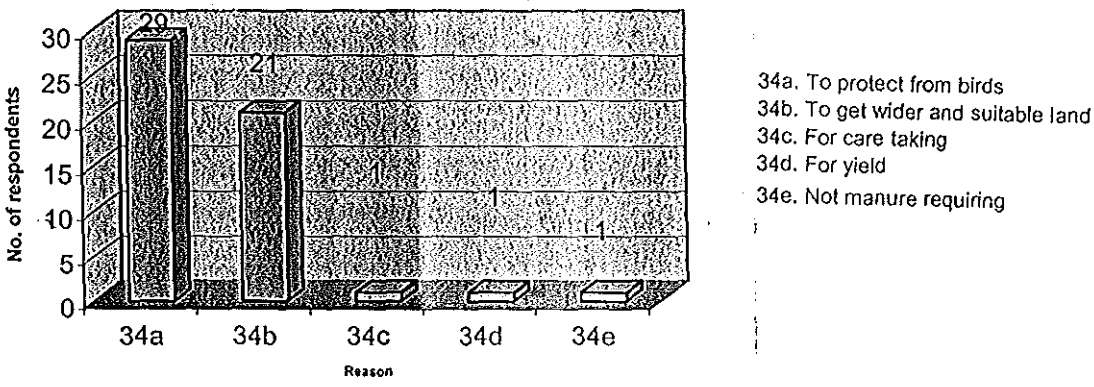


Figure 9 Reasons for sowing on main crop field far away from the dwelling

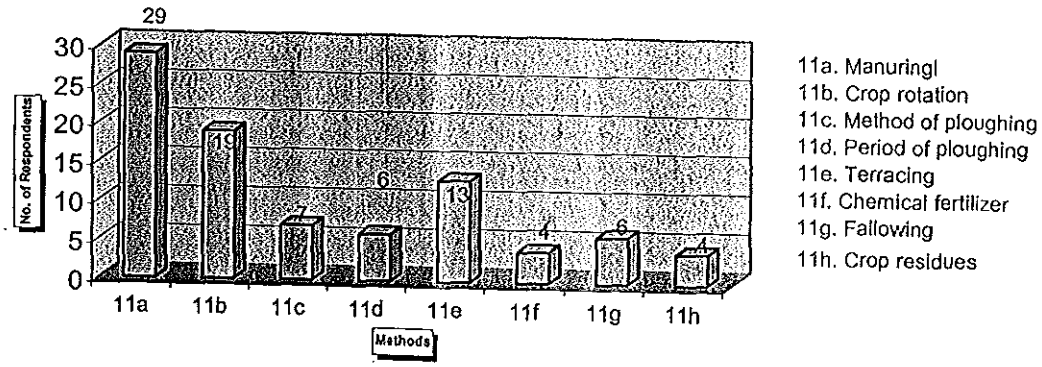


Figure 10 Soil fertilizing or soil fertility maintaining methods

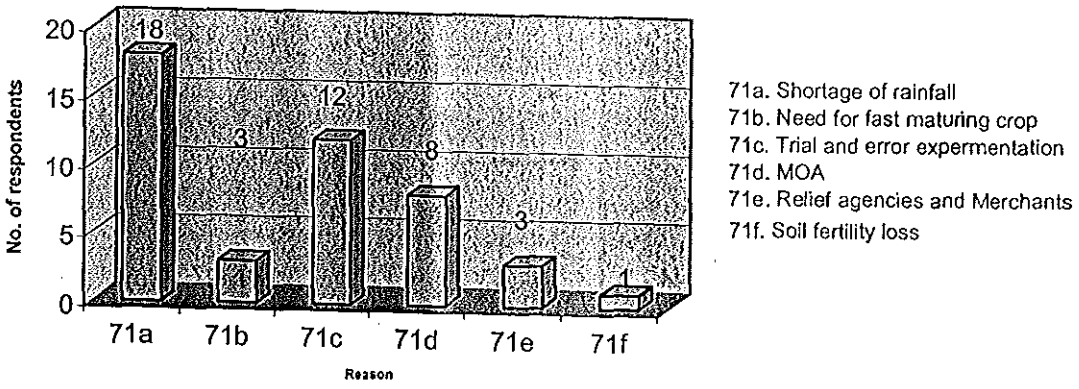
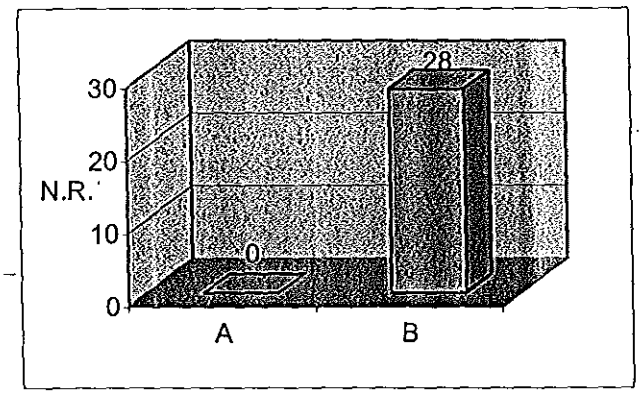


Figure 11 Reasons for the introduction of new crop varieties

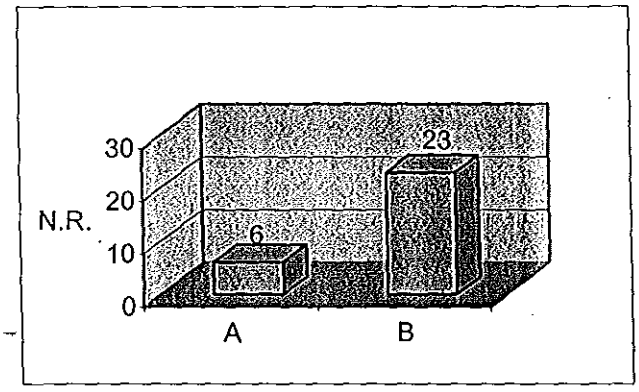


A. Reliable

B. Not Reliable

N.R. Number of respondents

Figure 12 Rainfall reliability

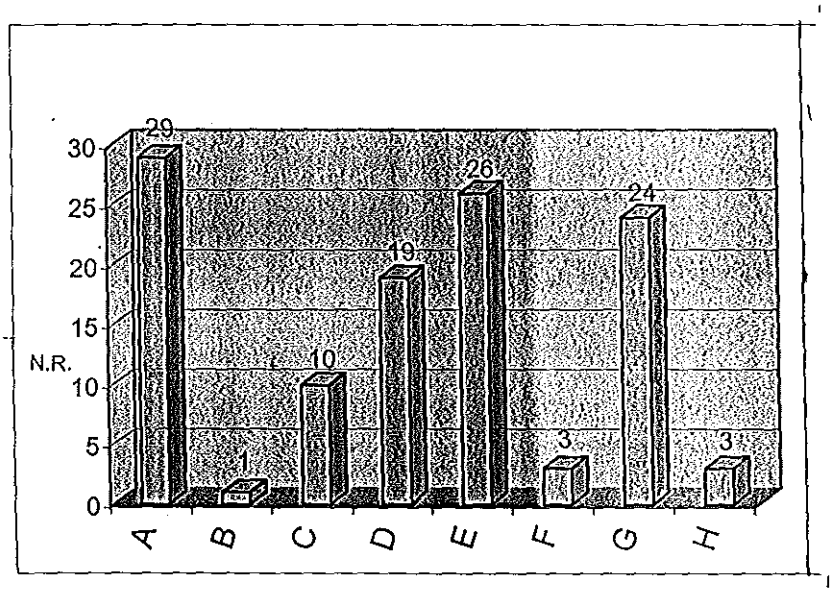


A. Disappeared

B. Decreased in frequency

N.R. Number of respondents

Figure 13 Status of landrace (farmers varieties)



A. Fast maturing
B. Slow maturing
C. Better yielding
D. Not better yielding
E. Pest Resistant
F. Not Pest Resistant
G. Drought Tolerant
H. Not Drought Tolerant

N.R. Number of respondents

Figure 14 comparison of sorghum varieties (Introduced vs Landrace)

5.8. Result of Soil Analysis

Table 12. Homegarden Soil ("Ye-gibi meret")

Profile 0-10 cm

Homegarden number / Soil parameters		1	2	3	4	5	6	7	8	9	10
TEXTURE (%)	sand	49	55	43	49	43	47	39	53	51	41
	silt	34	28	32	28	32	32	34	26	28	36
	clay	17	17	25	23	25	21	27	21	21	23
CLASS		L	SL	L	L	L	L	L	SCL	L	L
Electrical conductivity (ds/m)		0.207	0.129	1.232	0.174	0.096	0.086	0.057	0.089	0.043	0.679
pH water 1:2.5		7.33	7.06	7.20	7.69	7.34	7.48	7.34	7.54	7.30	7.32
Total Nitrogen %		0.448	0.357	0.644	0.357	0.203	0.252	0.196	0.224	0.133	0.826
Organic Carbon		3.630	3.471	6.264	4.069	1.955	2.254	1.516	1.596	0.877	7.700
Available %Phosphorus/ppm		139.58	95.02	34.50	135.40	70.16	118.44	47.56	77.32	16.50	145.60
C/N		8	10	10	11	10	9	8	7	7	9

Table 13. Nearby crop field soil ("Ye-guaro meret")

Profile 0-10 cm

Nearby Farm Land number Soil parameters	1	2	3	4	5	6	7	8	9	10
TEXTURE (%) sand	49	57	39	49	57	29	55	50	37	59
silt	32	20	36	30	26	38	22	24	38	22
clay	19	23	25	21	17	33	23	23	25	19
CLASS	L	SCL	L	L	SL	CL	SCL	SCL	L	SL
Electrical Conductivity (ds/m)	0.084	0.044	0.049	0.024	0.041	0.218	0.076	0.017	0.066	0.067
pH water 1:2.5	6.73	7.35	6.94	7.15	7.46	7.44	7.69	7.26	7.84	7.73
Total Nitrogen %	0.238	0.196	0.154	0.112	0.070	0.126	0.084	0.063	0.154	0.126
Organic Carbon %	2.693	2.094	1.257	0.818	0.559	0.858	0.658	0.419	1.037	0.778
Available Phosphorus/ppm	62.36	49.24	74.38	23.12	6.08	24.46	18.42	11.48	57.28	27.28
C/N	11	11	8	7	8	7	8	7	7	6

Table 14. Main crop field soil ("Ye-dur meret")

Profile 0-10cm

Main cropfield number	1	2	3	4	5	6	7	8	9	10
Soil parameters										
TEXTURE (%) sand	43	37	47	45	49	27	43	33	27	43
silt	30	36	28	28	26	40	30	32	36	28
clay	27	27	25	27	25	33	27	35	37	29
CLASS	L	L	L	L	SCL	CL	L	CL	CL	CL
Electrical Conductivity (ds/m)	0.036	0.031	0.072	0.024	0.019	0.086	0.072	0.038	0.185	0.031
PH water 1:2.5	7.23	6.84	7.31	6.46	6.98	7.26	7.50	7.38	7.74	7.62
Total Nitrogen %	0.147	0.140	0.168	0.084	0.084	0.119	0.058	0.112	0.126	0.084
Organic Carbon %	1.197	1.695	1.456	0.858	0.658	0.858	0.459	0.75	0.957	0.858
Available Phosphorus/ ppm	12.08	22.50	70.82	26.98	5.98	17.82	9.12	17.8	17.80	8.50
C/N	8	12	9	10	8	7	8	7	8	10

Table 15. Tukey's multiple range test used to compare the three farmland categories with the environmental variables; significant differences at $p < 0.05$ within the same row are indicated by different letters below each value.

Crop fields	Homegarden	Nearby farm	Main crop field
Sand	47 **a**	48.09 **a**	39.7 **a**
Silt	31.09 **a**	29.09 **a**	31.7 **a**
Clay	21.09 **a**	22.81 **a**	29 **b**
EC	0.274 **a**	0.065 **a**	0.055 **a**
PH	7.36 **a**	7.38 **a**	7.24 **a**
N	0.348 **a**	0.132 **b**	0.111 **b**
C	3.24 **a**	1.099 **b**	0.952 **b**
P	88.04 **a**	36.47 **b**	22.16 **b**

Table 16. Canonical discriminant analysis used to evaluate and classify crop fields based on soil properties

Actual group	Number of samples	Predicted group Membership		
		1	2	3
Group 1 (Homegarden)	10	7 70%	2 20%	1 10%
Group 2 (Nearby farm)	10	1 10%	8 80%	1 10%
Group 3 (Main crop field far away from the dwellings)	10	1 10%	1 10%	8 80%

Percent of "grouped" cases correctly classified: 76.67%

Table 17. Pearson's product-moment correlation Coefficients for correlations between environmental variables.

** P < 0.01; * P < 0.05 ; ns = not significant

sand									
Silt	-0.858**								
Clay	-0.857**	0.472**							
EC	-0.113 ns	0.152 ns	0.041 ns						
PH	-0.005 ns	-0.091 ns	0.099 ns	0.009 ns					
N	0.019 ns	0.236 ns	-0.270 ns	0.541**	-0.028 ns				
C	0.040 ns	0.200 ns	-0.270 ns	0.547**	-0.079 ns	0.986**			
P	0.135 ns	0.187 ns	-0.421*	0.059 ns	0.057 ns	0.709**	0.700**		
Distance	-0.423*	0.091 ns	0.638**	-0.246 ns	-0.189 ns	-0.504**	-0.474**	-0.574**	
	Sand	Silt	Clay	EC	pH	N	C	P	Distance

Tables 12,13and14 show the results of chemical and physical analysis of soil samples collected from homegardens, nearby farm and main crop fields, respectively. All the soil samples fall into the textural class of loam (pure loam, sandy loam, clay loam and sandy

clay loam). About 80% of the soil from the homegardens is pure loam soils. In all the soil samples the proportion of sand is about twice that of clay. Soil pH in all analyzed soil samples were marked by slightly acidic to weakly alkaline conditions (pH, 6.46-7.84). Organic carbon and total nitrogen are higher in concentration in the homegardens but their concentration is declining in annual crop fields (nearby farm and main crop fields far away from the dwellings).

Clay shows significant variation between the main crop fields and the other two groups of farms (Table 15). Phosphorus, Organic Carbon and total Nitrogen are similar in the fields of annual crops (nearby farm and main crop field) but they show significant variation with that of the homegardens (Table 15).

Soil samples were classified based on the results of chemical and physical analysis (Table 16). Classification results indicated that 20% of the homegarden soil samples are grouped with soils from the nearby crop fields and 10% with soils from the main crop fields. Similarly, 10% of soil samples from each group of annual crop fields are grouped with the homegarden soils.

Available Phosphorus, Organic Carbon, total Nitrogen and sand are negatively correlated with estimated average distance of farmlands from the homestead of the farmers (Table 17). Clay is positively correlated with distance from the homestead (Table 17).

Electrical conductivity is highly correlated with Carbon and Nitrogen, and also phosphorus is highly correlated with Carbon and Nitrogen. Sand is negatively correlated with clay and silt (Table 17).

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6. Discussion

6.1. Characteristic of Farmlands and pattern of crop distribution

6.1.1. Homegarden ("Ye Gibi Meret")

The homegardens of Fontanina are highly diverse; they are at different level of development and vary in their species composition. All are established on small plots of land around the household residence. Some homegardens are old and others are new. Older homegardens, and those which are established on relatively larger plots around the house are better structured and species rich. The number of food and non-food crop species in the surveyed homegardens shows great variation. Minimum number of species recorded is 4 and maximum is 29. The reasons that account for this variation are size of land and individual interest or preference.

The vertical and horizontal stratification is not systematically studied. However, in some of the homegardens of Fontanina it is possible to recognise three strata of vegetation. The upper stratum (4-20 m) is represented by tall fruit trees and eucalyptus; middle layer (1.5 – 4 m) is composed of shrubs and small trees, and the lower layer (0 - 1.5 m) includes herbs, annuals and seedlings. There is also a sort of horizontal stratification. Medicinal herbs, fragrance plants and *Capsicum sp.* are frequently planted near the house, separately. On the periphery of the garden *Eucalyptus camaldulensis* Dehnh., other trees and shrubs used as construction material, farm implement, fuel and part of live fence are planted. In between, annual, biennial and perennial food crops are grown.

Inroduced fruit trees and eucalyptus characterize most of the homegardens. Major fruit species recorded are *Carica papaya* L., *Casimiroa edulis* La Lave, and *Mangifera indica* L. Information obtained from elderly farmers clarified that propagating fruit trees in the area is recently accustomed, and at the present time the farmers attitude to propagate fruit trees is growing. It is due to the fact that fruit trees provide dietary complement, provide cool shade for calves, elderly people and children in dry warm months, and generate income for the family.

Eucalyptus camaldulensis is widely distributed around the residential houses. This species is all-purpose tree in the surrounding. It is source of material for construction, farm implement and fuel. Intensive cultivation and deforestation have destroyed the natural vegetation. Farmers cannot get trees from wild for construction and farm implement; as a result they rely on this tree, and are obliged to propagate it. It is nick named as "Wuletaw-Beza" (Amharic), which means, worthy of great favour. Farmers have realized that this tree has a devastating effect on other crops but they continued planting; it seems that its benefit is irreplaceable.

There are also some indigenous tree species brought from wild and planted near the dwellings. Some of the best examples are *Cordia africana* Lam., *Eheretia cymosa* Thonn, *Ziziphus mucronata* Willd. and *Ziziphus spina-christi* (L.) Desf. Annual crops widely distributed in the homegardens are *Lycopersicon esculanta* L., *Zea mays* L., *Sorghum bicolor* (L.) Moench (sweet stalk), *Capsicum frutescens, Phaseolus* sp. and *Brassica carinata* A.Br. In addition, *Ricinus communis* L. is also commonly encountered in the

homegardens. The oil from the seeds of this plant is used to polish baking plate while making "injera" (local bread). Young plants of *Coffea arabica* L. and *Ensete ventricosum* (Welw.) Cheesm. were seen in some gardens. Homegardens obtain the highest share of manure and other household residues. Since they are closest to the residence of people and pens domestic animals, farmers easily apply manure in these gardens without expending much energy to transport.

6.1.2.Nearby farm ("Ye- Guaro Irsha")

Nearby farms are located at different distances from the farmers' residence. In some cases they are found just next to the homegarden and in others they are located at about 200 meters distance from the house. In most cases they are fenced with live material and the gate is closed by pieces of wood. This protects the farm from attack by domestic animals and intrusion by other people. These farms are not established outside the settlement zone. Relatively, they are larger in size than the homegardens but smaller than the main crop fields. Next to the homegardens they get the higher share of manure and other organic residues. They are better managed and well protected from erosion. Unlike the main crop fields, they are nearer to trees grown in the homegardens.

Crops in the nearby farm and their role

Plants grown in this type of farm are fast maturing and consumed during the preharvest period of main crops (i.e. sorghum, teff). They ripen and become available for use when

there is shortage of food in the farming families (i.e. from mid of August up to the end of September). Farmers call these crop varieties- "Ye-dirashot ehil"- which means crops of transition period that save lives.These crops are *Brassica carinata* A.Br., *Zea mays* L., *Solanum tuberosum* L., *Eleusine coracana* (L.) Gaertn., *Phaseolus sp.*, *Hordeum vulgare* L., *Eragrostis tef* (Zucc.) Trotter,fast maturing variety called "Bunign", *Pisum sativum* L., *Vicia faba* L., *Lycopersicon esculanta* L., *Cucurbita pepo* L. and *Vigna unguiculata* (L.) Walp.

In some African countries maize is planted on small plots around the farm household to be consumed during the hunger periods before the harvest of sorghum and millet (Ramaswamy and Sanders, 1992).

Some sorghum varieties are also intercropped with the above mentioned crop varieties on the nearby farm. The main sorghum varieties cultivated in the nearby farm lands are sweet stalk (Juicy) varieties, bird resistant varieties and some that can be consumed as green food (roasted sorghum). Trees planted around the dwelling harbour many birds that destroy sorghum. This is the major reason why farmers cultivate bird resistant varieties of sorghum on the nearby farms.

Nearby farms are densely intercroppd. Crops are arranged in spatial and temporal sequence so as to exploit the resources efficiently. Through this method, farmers obtain good amount of yield composed of varieties from a small plot of land. In the spatial arrangement, tomato, cabbage and beans occupy the ground level together with pumpkin. Sorghum, maize and cowpea climbing over them occupy the upper space. In the temporal sequence fast maturing

varieties (i.e.maize, cabbage, phaseolus species) will be consumed earlier and leave more space for slow maturing varieties (i.e.sorghum and the climbing cowpea). In this densely intercropped area, legumes play important roles in feeding the family and enriching the soil with nitrogen. Moreover, the yield of cowpea increases when it gets solid material such as the stem of sorghum to climb. This is one of the objectives of farmers while intercropping cowpea with sorghum. On the average 6 species of crops are intercropped in nearby farms at Fontanina.

6.1.3 Main crop field environment (Ye-dur meret)

In Fontanina few trees are seen around the main crop fields. Crop fields are located at undulating open landscape surrounded by some herbs and shrubs grown at the margin of fields and on uncultivated slopes.

Some of the tree species growing near the crop fields are *Acacia seyal* Del., *Gardenia ternifolia* K. Schum. and Thonn. , *Ziziphus mucronata* Willd. and *Ziziphus spina-christi* (L.) Desf. Farmers get rest under these trees while ploughing the land during warm sunny days. However, these trees are not allowed to branch profusely. Farmers prune them regularly, especially when sorghum ripens, in order to prevent birds from settling on the branches. Bird watching posts ("Mama") are constructed on these trees to guard sorghum from birds. In this respect, *Ziziphus spina-christi* has additional contributions. It produces edible fruits, its stem is used to make "Mofer" (Farm implement) and the spiny pruning are used as temporary fence or cover for harvested and piled sorghum in the field.

Shrubs growing on uncultivated slopes are *Euclea shimperi* (A.DC.) Dandy, *Dicrostachys cinerea* (L.) Wight and Arn., *Carissa edulis* (Forssk.) Vahl, *Grewia villosa* Willd., and *Maytenus arbutifolia* (Hochst. ex A.Rich) R.Wilczek.

Shrubs and herbs purposely left at the margin of cultivated fields for their importance in soil conservation are: *Euphorbia tirucalli* L., *Rumex nervosus* Vahl, *Hyparrhenia anthistirioides* (A. Rich) Stapf, *Hyparrhenia hirta* (L.) Stapf, *Hyparrhennia dregeana* (Nees) Stapf and *Justicia shimperiana* (Hochst. ex Nees) T. Anders.

Farmers struggle against the eroding forces around the main crop fields of Fontanina. To protect their precious wealth, the soil, farmers are applying different indigenous methods of soil conservation. They level the land and compartment it using line of piled stones, terrace the slopes and sow the seeds of *Hyparrhenia spp.* on the margin of terraced land. The fields are stony, however, farmers on slopy areas do not want to make the fields completely free from stones. The reason they have given for this is that, the stones distributed in the fields play considerable role in reducing soil erosion.

Crops and cropping pattern in the main fields

Two major crops in the main fields at Fontanina are *Sorghum bicolor* (L.) Moench and *Eragrostis tef* (Zucc) Trotter. Other crops growing in association with these crops are *Sesamum indicum* L., *Guizotia abyssinica* (L.f.) Cass, *Brassica carinata* A. Br, *Vigna*

unguiculata (L.) Walp and *Lepidium sativum* L. In Fontenina (above 1800m) in the main fields sorghum is replaced by *Triticum spp.*, *Lathyrus sativus* L., *Pisum sativum* L and *Vicia faba* L. Due to the absence of rain in "Belg" season of 1999, high altitude adapted sorghum landrace ("Zengada") was not cultivated.

Teff fields

The pattern of intercropping in the main crop fields is relatively simple compared to that of the nearby farm. *Eragrostis tef* (Zucc) Trotter is intercropped with *Sorghum bicolor* (L.) Moench, *Brassic carinata* A. Br., *Lepidium sativum* L. and/or *Guizotia abyssinica* (L.f.) Cass. In the majority, other intercropped plants mentioned above cover 20 to 30% of teff field.

Guizotia abyssinica (L.f.) Cass is planted at the margin of teff fields in strip. It is not mixed with teff. Farmers have realized that *G. abyssinica* (L.f.) Cass has negative effect on teff plants growing in the vicinity. The under canopy of *G. abysinica* (L.f.) Cass is free from teff plants or covered by some poorly developed teff plants. Another objective of farmers when planting *G. abyssinica* at the boundary of teff field is to minimize or avoid the growth of weeds around the field. They know that the growth of weeds is also inhibited by *G. abyssinica*. Farmers also use this pattern to decorate their fields. When *G. abyssinica* (L.f.) Cass. flowers in October fields become attractive being decorated with its yellow flowers.

Nigusie Alemayhu and Yeshanew Ashagrie (1992) have indicated that *G. abyssinica* (L.f.) Cass. is used as a weed killer in crop rotation systems. In crop rotation system crops growing on the field following this plant grow freely without the effect of weeds.

Lepidium sativum L. is a medicinal herb and farmers use its seed to treat stomachache, and minor wounds. *Brassica carinata* A. Br. is used as vegetable and its oily seeds are used to polish baking plate. The sorghum intercropped with teff is a variety which is used as green food (eaten roasted) and its local name is "Abdoke". Teff is cultivated in the study area on smaller plots, and they plant it when they are unable to sow sorghum due to the shortage of rain (absence of "Belg" season rain). It is due to the fact that management of teff is difficult and expensive throughout i.e from preparing seed bed up to the stage of serving it as food.

Sorghum Fields

The sorghum fields are characterized by numerous landrace varieties, intercropped together. Farmers have many intraspecific varieties of sorghum planted in combination as risk minimizing. Farmers mentioned that intercropping different varieties is useful because if one variety fails to give yield the other variety will compensate. In addition to sorghum landraces, other speices of plants commonly intercropped with sorghum are *Sesamum indicum, Vigna unguiculata and Brassica carinata.*

The three main local lines of *Sorghum bicolor* (L.) Moench (Figure 6) are always intercropped together. From October -December farmers spend most of their time inside

their sorghum fields. They enjoy by chewing sweet stalk varieties of sorghum and eating roasted sorghum. In the mean time, they protect the crop from birds and monkeys. Farmers, especially, the adolescents use the roasted fresh sorghum and juice from sweet stalk as bodybuilding or energy compensating diet. There is high lysine containing sorghum variety ("Barchuke"), which is used as sweetener of other roasted sorghum varieties.

Dented high lysine containing sorghum varieties from Ethiopia are superior in their lysine content and they have sucrose content twice that of other sorghum grains (Singh and Axtell, 1973). The high lysine sorghum varieties collected from Welo have got international recognition, and are utilized as sweetener to other roasted sorghum traditionally, but they produce low yield compared to other grain sorghum varieties (Berhane G/K and Yilma Kebede, 1979).

Distant or main crop fields obtain the lowest manure treatment and more eroded than the nearby farms. Their distance from the farmers' residence and their big size are major factors for the above mentioned management problems. Larger farming families with better work force are efficient in transporting manure to the main crop fields and in protecting the land from erosion.

Fields of *Triticum spp.*, and *Vicia faba* L. -*Guizotia abyssinica* (L. f.) Cass.

These fields of annual crops are found above 1800 m. In the study area *Triticum spp.* were planted alone in most cases but in some cases they were intercropped with very few plants of *Brassica carinata* and very rarely with *Sorghum bicolor* and *Eleusine coracana.*

Vicia faba and *Guizoitia abyssinica* were intercropped in equal proportion. Although *G. abyssinica* inhibits the growth of cereals such as teff and weeds. Farmers in Fontanina realize that *Guizotia abyssincia* positively coexists with *Vicia faba.* This knowledge of farmers concerning the ability to distinguish between coexisting and non-coexisting crop species requires further ecophysiological investigations.

The general pattern of crop distribution in Fontanina is depicted in Figure 15.

Farm types	Homegarden ("Ye-Gibi Meret")	Nearby farm ("Ye Guaro Meret")	**Main crop Field ("Ye-Dur**
Crop features	Fruit trees Eucalyptus Vegetables Medicinal herbs Other trees and shrubs in live fence	Maize Cabbage Beans Sweet stalk sorghum Bird resistant sorghum Tomato Pumpkin	Sorghum, Sesame, Cowpea Teff, Sorghum, Cabbage, Niger seed Wheat, grass pea, Emmer
Distance from the dwelling	0 - 30m from the house	30 – 200m from the house	Beyond 200m from the house

Altitude	1690m-2030m	1690m-2030m	1490-1800m	1600-2030m	above 1800m

Figure: 15. Crop Distribution pattern in Fontanina

6.2 Factors that determine crop distribution

For farmers in South Welo crop distribution in the fields, pattern of intercropping system and crop biodiversity in the farms are key elements directly tied with their survival. Almost all farmers in the study site agree in similar pattern of crop distribution and intercropping system. As farmers explained, these patterns have been experimented and proved that they are useful by their parents and grand parents. Furthermore, except for some modifications made by the new generation in efforts to cope with the changing environment, the basic pattern of agriculture is similar to that of their parents.

The farmers' decision making to plant crop varieties where, when and how is influenced by several factors. Some of the major factors mentioned are soil property, altitude, distance from the homestead, distribution of animal pests (birds, monkeys, porcupine, etc), field size, presence of striga, the kind of crop cultivated in the surrounding, rainfall and crop rotation (Figure 7). Figures 8 and 9 also indicate the farmers' objectives for sowing crops on different fields in the study area.

6.2.1. Soil

The response of farmers interviewed (Figure 7) indicated that soil property in the crop fields is the main factor that determines crop distribution in Fontanina. Farmers in Fontanina village, before all other factors, study the property of the soil in their crop fields to decide crop distribution. Soil is one of the most important conditions for the development of plants.

The depth of soil, its mineral content, and water holding capacity are some of its properties that limit the development of crops. Farmers in the study site have satisfactory traditional knowledge about the nature of their soil and kind of crop species that best yields on a specific field. They closely follow, experiment and decide which crop variety gives better yield and which one fails on a given plot of land.

They classify their soil into two main classes. These are thick and shallow soils (plots). Thick-layered soil is also subdivided into manured and not manured. The manured thick-layered soil is found on farm lands nearer to the dwellings. Whereas, the non-manured thick layered soil is located in different areas and thickened as a result of silt accumulation.

Shallow layered soil is the result of severe soil erosion and it is a common problem in the area. In sloppy areas it is common to see two parts in the same farm, i.e. upper part eroded and shallow, lower part thickened by the accumulation of silt eroded from the upper portion.

On well-manured soil distinguished as "Cosi" they plant maize, cabbage, beans tomato and pumpkin. They do not usually cultivate teff or sorghum (long season crops) on "cosi"soil. The reasons for doing so are:

a. Teff planted on "Cosi"soil grows vegetatively at higher rate but fall down before giving yield, and decay when hailed by rain in September.
b. Farmers believe that the soil temperature of "Cosi" is higher than that of unmanured soil in dry and warm periods between May and June before the main rainy season

("Kiremt"). Seedlings of long season sorghum varieties (Landraces) resist the soil temperature of unmanured land but they collapse in manured land. Thus, farmers sow fast maturing crops in "Kiremt" on "Cosi", and slow maturing crops (long season sorghum) on thick layered soils of unmanured main fields in April. The moisture retained in this soil will be consumed by the slow maturing varieties after September (after the main rain is stopped).

c. They also reserve this manured land for maize and other preharvest period crops ("Ye- dirashot ehil")

Sorghum is drought tolerant crop because it has efficient root system that can absorb moisture from deep layers of soil unlike maize; and it can withstand periods of extreme drought by suspending growth and metabolic rates (Bassam *et al.*, 1990)

6.2.2. Altitude

In the study site altitudinal variation is low. Crops grown in the homegarden and the nearby farm are similar in the lower and higher altitudes. However, crops cultivated in the main crop fields show clear variation below and above 1900 m a.s.l. Below 1900 m a.s.l. *Sorghum bicolor* (L.) Moench is the dominant crop, whereas wheat, emmer wheat and pulses dominate above 1900 m a.s.l.

Wheat, barley and emmer wheat are cold resistant C_3 crops which are adapted to cooler condition whereas *Sorghum bicolor* (L.) Moench is a C_4 plant which is not adapted to cool

conditions in higher altitudes (Norman *et al.*,1984; Taiz and Zeiger, 1991 Cited in Awegechew Teshome et al.,1999). However, 'Zengada' (local sorghum landrace) is exceptionally cold adapted higher altitude variety of sorghum (Harlan, 1975).

6.2.3. Distance from the dwellings of farmers

Distance of the farm from the homestead is another important factor that influences the distribution of crops directly or indirectly. Women in the study area are responsible for different household activities including collecting food crops from their garden and preparing meal for the family members and it is difficult for those busy women to gather food crops daily from far places. Therefore, to avoid or minimize this problem, crops needed to prepare daily meal such as vegetables, maize and beans are planted on farmlands nearer to the residence. In addition, sweet stalk sorghum is also planted for children and women. On the other hand, major staple cereals, pulses and oils are intercropped on the main crop fields located far from the dwellings.

6.2.4. Distribution of pests

The distribution of pests (animal pests) that attack crops also affects the distribution of crops in the study area. For example, monkeys and porcupine mainly attack vegetables, fruit and maize and they are abundant in bushes and caves, respectively, far from the dwellings. Similarly, sorghum attacking birds are numerous around the dwellings because trees planted for different purposes around the residences harbor birds. As a result, fruits, vegetables and

maize are concentrated around the residential area. Together with these, bird resistant and sweet stalk sorghum varieties are also planted in nearby farms, whereas, major cereals (teff, wheat, sorghum) are planted in main fields located outside the village. In this regard, crops that require relatively higher care and close follow-up are cultivated on nearby farms. On the other hand, crops that need preharvest short period care are planted on main fields relatively far from the dwellings.

6.2.5. Field size

Farmers in the study area sow sorghum on their wider or bigger fields and teff on smaller fields. This is because teff requires more labour and time during land preparation, sowing, weeding, harvesting and threshing than sorghum. Managing teff requires either large family size for labour or money to hire laborers.

6.2.6. Presence of striga

Farmlands, which are known for their striga seed banks, are normally left for fast tillering striga tolerant sorghum varieties and teff. Striga is one of the major enemies of sorghum. Since striga is one of the main enemies of sorghum, farmers in Fontanina usually do not cultivate sorghum on striga-infested farms.

6.2.7. Neighboring crop field

Farmers in the study area discuss with their friends or study the surrounding of their farms to know the kind of crop sown or that will be sown on farms around their farms. After getting information about crops that will be planted around their farm they decide the kind of crop that they will sow on their own farm. The purpose of this discussion with others is to save their crops from pests. For example, if a farmer unknowingly sows sorghum in a field surround by teff fields he will harvest nothing because birds of the surrounding area will destroy the crop.

6.2.8. Rainfall

If rainfall is available in its normal cycle, farmers in Fontanina classify their farmlands purposefully and distribute the landraces appropriately according to their objectives. When the rainfall pattern is distorted the distribution of crops in the fields will differ from the usual pattern. This condition narrows the objectives and selection criteria of farmers and they will remain with only one objective, i.e. cultivating any crop variety that can solve their food problem by competing in the adverse environmental condition.

6.2.9. Crop rotation

Changing the type of crops to maintain the soil fertility is one factor that affects the distribution of crops in the study area. Farmers in Fontanina regularly change crop species growing in a field in order to improve productivity.

6.3 Factors related to the introduction of new crop varieties and causing erosion of the indigenous ones

It is obvious that new crop varieties are introduced into the study village. Different factors are mentioned as possible causes of introduction of new crops. However, most of them are directly or indirectly related to shortage of rainfall (Figure 12), which is unreliable in the area (Figure 13). As a result of shortage of rainfall and introduction of new crop varieties, the landrace frequency in the area is decreasing (Figure 14).

6.3.1. Rainfall unreliability/Drought

Genetic erosion of indigenous crop varieties is directly or indirectly related to drought. Most of the indigenous crop varieties (landraces) are slow maturing long season crops that require sufficient amount of rainfall. If these crops, especially sorghum, do not get water in April, they will not germinate or develop. This failure will deteriorate the seed stock in the hands of farmers. And seeds of landraces will be expensive in the next sowing season, which is unaffordable to poor farmers, then they start sowing any available seed.

6.3.2. Soil degradation

The information gathered from farmers indicated that long season landraces do not give better yield on degraded shallow layered soil. As the farms are further degraded, farmers are refraining from sowing landraces and diverting to cultivating fast maturing introduced varieties.

6.3.3. Experimentation by trial and error

New seeds come into the area via relief agencies, local markets, Ministry of Agriculture and immigrants. Farmers check the vigour and quality of these introduced seeds by sowing them on small plots of land. If they detect desirable qualities such as high yield, they will continue cultivating them on larger plots in the following years (for example some wheat varieties).

6.4 *Sorghum bicolor* (L.) Moench

6.4.1 Sorghum landrace frequency

Fontanina, like other parts of south Welo is rich in its sorghum intraspecific varieties. The landraces of sorghum are maintained for several generations by the preservation methods of the farming family and wisely designed farming systems. They have two common methods of preserving seeds of sorghum. They hang bunch of sorghum panicles in dry, cool part of the room in order not to get warmth. In this method they preserve the seeds only for one cropping season i.e. normally from December up to April for about five months. If they

want to preserve for longer period of time, they thresh the selected panicles of sorghum and keep the dried seeds in a gourd or jar after treating with ash or teff grains. Repeated drying at least once in a week, and treating with ash and keeping in tightly closed containers is to protect seeds from weevil.

Traditional intercropping of sorghum landraces is also vital in maintaining the genetic resources. For example, the largest portion of the field is always given to the variety most needed by the farming family and others will be sown in different smaller proportions. Through this traditional intercropping method, seeds of many sorghum varieties have evolved and preserved in their natural environment.

Most of sorghum landrace varieties are slow maturing long season crops that can give normal yield if the bimodal rainfall system is maintained. However, Fontanina and its surrounding was exposed to shortage of rain and climatic imbalance several times in the past and at present. This is causing farmers to refrain from cultivating long season sorghum varieties.

Farmers confirmed that this climatic imbalance or unpredictability of rainfall pattern resulted in the introduction of new varieties of sorghum and decrease in the abundance of landraces (Figure 11 and 13).

The introduced varieties of sorghum are fast maturing short season crops. Farmers cultivate them in drier years when they are unable to cultivate landraces due to absence of rain in "Belg" season (March, April).

Table 6 shows 59 varieties of sorghum (both landraces and introduced) and their respective frequency sampled from 123 fields of sorghum in Fontanina. Out of 59 varieites about 51 are landrace varieties but the rest are introduced into the study site. For example, older farmers indicated that a variety called Cherekit was introduced from low lands of Welo or Afar around 1974 and another variety called Ismael was introduced and widely cultivated in the last 10 to 15 years.

The diversity of sorghum in a field can be influenced by farmer's objectives, soil condition, altitude, field size, and availability of seeds during period of sowing, and rainfall seasonality. For instance, the maximum number of sorghum varieties per field was recorded in the largest field (Table 7) and (Figure5). According to Awegechew Teshome *et al.* (1999) diversity of sorghum landrace increases with increasing field size.

In Table 8 the frequency and percentage of main landrace and introduced sorghum varieties are shown. In dry weather (March, April, 1999) landraces failed to germinate, and as a result farmers cultivated introduced varieties on more than 75% of their cropping area of sorghum.

For instance, the percentage of five superior sorghum landrace varieties was less than 10% and that of only one introduced variety (Ismael) was about 50% in the surveyed fields (Table 8). This is an indication of genetic erosion of sorghum landraces. But, this may recover if the next season becomes favourable.

When farmers compare the introduced sorghum varieties with the landraces, they said that the introduced varieties are fast maturing. They are cultivated in the main rainy season ("Kiremt"), and as a result they escape periods of severe drought and insect pest invasion. However, they are inferior to the landraces in their milling quality and yield. The panicle of the introduced varieties is smaller than that of the major sorghum landraces. At the same time the stem (stalk) of introduced varieties such as Ismael is thinner and weaker than that of the landraces. Farmers use the stalk of landraces for construction and fuel, and thereby it reduces the dependence of farmers on wild and domesticated vegetation for fuel and construction. It also reduces the intensity of using dung for fuel. In this respect it was contributing its part in ecosystem conservation. On the other hand, Farmers in Fontanina are not interested in cultivating small headed, weak stemed sorghum varieties, but they have no alternative in drought affected years.

6.4.2. Comparison of sorghum varieties for four pair of attributes.

Farmers in Fontanina village clarified the presence of variation among the varieties of *Sorghum bicolor* (L.) Moench. Sorghum intraspecific varieites differ from each other by

resistance to insect pests, drought and birds. They also differ in yield, storability in under ground pits and tolerance to striga.

Farmers indicated that varieties called Wofaibelash, Cherekit and Minchiro are least attacked by birds. According to the explanation of farmers Wofaibelash has bitter taste, and Minchiro has branched panicle that cannot support birds settling on it. In contrary to this a variety called Mokake is most attacked by birds. This variety has bigger seeds and 75% of its grain is not covered by the glumes.

In Ethiopia including the study area of this project, farmers store different seeds in under ground pits for years. The landraces have different degree of storability and it is this property of storability that maintained them in the traditional societies for years. Cherekit is a variety of sorghum, which is as white as chalk and it is introduced into the study area from eastern drier lowlands. All the 30 respondents (100%) confirmed that Cherekit is not storable in under-ground pits.

Most farmers agree in the absence of a variety that resists extreme drought. However, Cherekit has better resistance to drought than other sorghum varieties in the village. Contrary to this, superior landraces such as Gorad are more susceptible to drought.

The major landraces (Gorad and Zengada) are easily attacked by *Striga hermontica*, whereas Cherekit tolerates the influence of striga. The varieites, which better resist striga, are those that tiller at faster rate (Personal communication-with farmers).

According to the explanation of farmers in Fontanina, sorghum landraces are better than the new varieties of sorghum in yield, milling quality and storability in underground pit. On the other hand, the introduced varieties of sorghum are less preferred or attacked by birds. And also they escape environmental problems related to shortage of rainfall because they are fast maturing. For example, the presence of rain in March and April enhances the development of striga. Shortage of rainfall in these months inhibits the development of both long season crops and striga. When the farmer ploughs the land again in June to sow fast maturing varieties he destroys the growing striga plants. Thus, fast maturing crops grow freely before striga resumes its development and attack.

Reliability analysis test (Appendix 7-11) indicate significant difference at $P < 0.001$ between each item mentioned under each title (Figures 7,8,9,10 and 11). Different factors or reasons or methods mentioned by farmers are significantly different in importance. On the other hand, there is no significant difference among the knowledge of the interviewed farmers. This may indicate that indigenous knowledge is uniformly shared among the farming community. This is due to the fact that agricultural security has survival value for farmers and their family.

6.5. Discussion of Soil analysis result

The difference in chemical properties (Nitrogen and Organic carbon) of soil samples (Table 12,13,and 14) can be attributable to variation in the amount of manure applied in different fields. For instance, farmers in Fontanina apply more manure in the homegardens and nearby farms. The concentration of available phosphorus is also higher in soil samples collected from the homegardens and nearby farms than that of the main crop fields.

Three homegarden soil samples (Table 15), which are grouped with soils from the fields of annual crops, may be sampled from the homegardens of poor farmers who do not have domestic animals that produce sufficient manure.

Some well-endowed farmers (who have many cattle and large family size) transport and distribute manure on their farmlands far from the living area. Thus, the soil samples grouped with the homegardens can be those that were collected from the annual crop fields of such farmers.

Crop plants cultivated in the above three types of soil (farms) (Tables 12,13 and 14) are included in (Appendix 1-6). The presence of more number of species of crop plants in the homegarden and in its surrounding can be attributed to the presence of relatively fertile soil in the homegardens.

Vegetation and soil are interdependent i.e., the improvement of one has positive effect on the development of the other. However, in agricultural environments the contribution of man in improving or reducing soil fertility is of considerable importance. For instance, the homegarden soil that receives more manure has greater amount of nitrogen and carbon than the main crop fields of annual crops. The main crop fields are continuously cropped but they are not supplied with sufficient amount of manure.

6.6. General trend of crop biodiversity distribution, farming system and reduction of diversity

6.6.1. Biodiversity distribution

Homegardens contain more number of species than other farms (Figure 4). Fields of annual crops contain less number of species. This indicates that species diversity in Fontanina decreases with increasing distance from the homestead. On the other hand, intraspecific diversity, particularly that of Sorghum bicolor (L.) Moench is very high in the main crop fields. For example, 58 sorghum varieties (Table 6), 5 teff varieties ('Abish lemine', 'Bursa', 'Atem bra', 'Asnake' and 'Bunign'), three wheat varieties ('Gunde', 'Tseguram' or 'Ye-agerewe sinde' and 'Tikure sinde') and three barley varieties ('Tebel', 'Enat gebse', and 'Ambediate') were recorded during the survey. The indication of this is that intraspecific diversity of crops increases with increasing distance from the dwelling .In general, in Fontanina village species diversity decreases and intraspecific diversity increases with increasing distance from the homestead. Fruit cultivation in the homegardens is growing in response to demand for fruits in the nearby urban areas.

The natural continuum of vegetation is replaced by man-made continuum. Annual crops cover the general area. Natural climax vegetation is totally destroyed. After annual crops are harvested, the remaining stony ground indicates that the environment is seriously degraded and erodable. The only green areas visible after harvest are the waterways and the homegardens.

Some indigenous tree and shrub species are brought from the wild and cultivated in the homegardens and live fence. These formed small artificial forests together with fruit trees and Eucalyptus around the dwellings. The dynamics had been such that the place of forests has changed from wild to domestic environment in Fontanina. The rapid invasion of *Eucalyptus camaldulensis,* which is getting wider acceptance in the area, could eliminate indigenous tree species from the homegardens also. And this is a menace for indigenous genetic resources of trees.

Eucalyptus camaldulensis is one of the most important alien tree species that cause majors problems as invaders of natural and semi-natural ecosystems (Richardson, 1998). It is used in commercial forestry and agro forestry systems but also included in the weed lists in different parts of the world.

6.6.2. Farming system

a. Intercropping

Mixed intercropping is a universal phenomenon in Fontanina village. It is advantageous in many respects. Farmers use this system to produce different varieties in a small plot of land. Thus, to fulfill their nutritional requirement by reducing the impact of land shortage, they rely on intercropping system. They maintain soil fertility, reduce erosion intensity, inhibit weed development and exploit above and below ground resources through this method. It is also a typical example of traditional *in situ* conservation of genetic resources. In order not to lose the seeds of their crop varieties farmers every year sow all available varieties of seeds in

different proportions. Preserving and proportionate seeds that will be intercropped is the responsibility of women. Intercropping is advantageous in the *in situ* conservation and maintenance of many traditional crop varieties without interrupting their evolution (Olasanta, 1999).

Intercropping between fast maturing and slow maturing crop varieties allows efficient use of resources for longer period. Furthermore, it reduces work burden by extending harvesting time (i.e. a farmer will get time to harvest crops that mature at different time intervals).

According to Olasanta (1999), mixed intercropping is biologically a more efficient method than sole cropping because the intercropped plants can use the resources found above and below the ground in greater amount through spatial and temporal complementarities. Moreover, in fields where crops of different lifespan are intercropped, the niche will be exploited sequentially. That is, once the early maturing varieties are harvested, the medium and late maturing ones can take over the niche before they too are harvested.

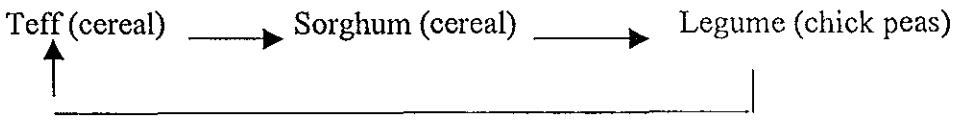
Since rainfall pattern of Fontanina is unpredictable, another purpose of intercropping is to minimize risk of crop failure. Farmers use the idea "Andu Bisit-Andu Aysit"- which means if one crop variety fails to produce the other variety will compensate.

According to Tivy (1990), mixed intercropping is chosen in tropical environments with unpredictable climate because it provides insurance against crop failure that can result from shortage of rainfall.

b. Soil management

The distribution of crops and maintenance of crop diversity is closely linked to the well being of soil. Continuous cropping and erosion are reducing the quality of soil in Fontanina. Crop residues are used for animal diet and fuel. Manure, except the droppings of donkeys, sheep and goats is partially used as fuel. Fallowing is almost impossible due to population growth and shortage of land. Farmers do not want to use chemical fertilizers. The lands are sloppy and shallow; as a result the applied fertilizer will be eroded into the rivers before the crops could utilize it. And also yield increment obtained from using chemical fertilizers cannot cover the credit. Crop rotation is the easiest and applicable method used to maintain the soil fertility in Fontanina. Two but similar crop rotation pattern are observed in the study area in lower and higher altitudes.

a. Crop rotation pattern in lower altitudes (Below 1900 m)



b. Crop rotation pattern in higher altitudes (above 1900 m)

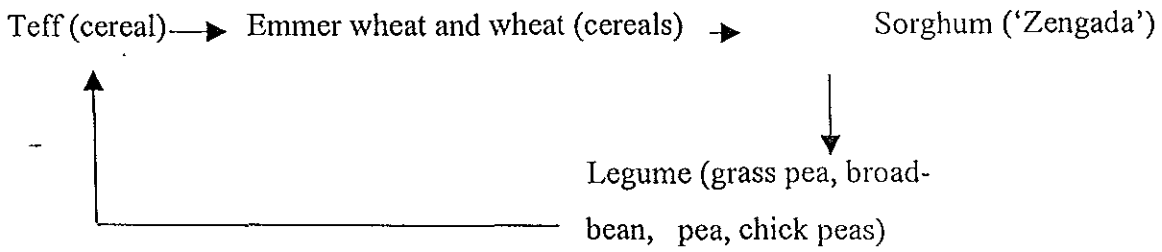


Figure 16 Pattern of crop rotation in Fontanina

Repeated deep tillage and early ploughing are also essential methods of maintaining soil fertility and improving crop yield. Farmers in Fontanina village plough their lands deeply step by step by increasing the length of the plough (blade). They realized that ploughing deeply improves the water retaining capacity of the soil and thereby causes increased crop yield. In addition, early ploughing in January and February encourages the germination of weeds such as *Datura stramonium* and *Ricinus communis*. These weeds decay rapidly and build up the soil organic matter content.

Soil fertility loss together with unreliable rainfall pattern is worsening the erosion of crop genetic resources. For farmers in Fontanina their traditional soil fertilizing methods are sustainable or profitable. The reason why they dislike chemical fertilizers requires further investigation.

6.6.3. Genetic erosion

Landrace diversity is insurance for farmers. It is also source of genetic material for domestic and international crop improvement programmes. However, the influences of unpredictable climatic changes are eliminating landrace diversity. Artificial selection in favour of fast maturing new varieties has also its share of contribution for the dwindling of landraces. The introduction of fast maturing crop varieties is reducing the dependence of farmers on the

long season landraces. Farmers in the study site mentioned that if climatic conditions are not supportive long season landraces could disappear in the long run. For example, sorghum landrace varieties such as 'Tubah,' 'Jamoye' and 'Gorad' are rapidly decreasing. Similarly, varieties of *Eragrostis tef* (Zucc.) Trotter such as 'Asnake' and Bursa are also decreasing. Teff varieties such as 'Guande', 'Magna', 'Jegar' and 'Agay' disappeared completely from the study site (Information from Sheh Yimam Mohamed Yasin- 80 years old farmer). These decreasing and disappeared landraces are replaced by new sorghum varieties mentioned in Table 8 and teff varieties called 'Atembra' and 'Abishlemine'.

6.7 Implications

This study revealed that traditional farmers are the custodians of both crop genetic resources and related indigenous knowledge. They are also generators of agro-biodiversity. Crops are distributed in Fontanina in a systematic way so as to fit the need of the family and the requirements of crops. The place of each variety is related to the physiological, morphological, ecological properties of the crop and its use value to the farmers. Seasonal land preparation for various crops, cropping season and pattern of intercropping coexisting varieties are parts of traditional agronomy filtered in the series of generations. Ranking crops, naming and classification are the results of traditional experiments; seed selection and preservation are also the expertise of traditional farming family.

In addition, avoidance of chemical fertilizers, using crop rotation system that involves legumes and domesticating rare indigenous trees and shrubs are experiences obtained from exposure to complicated natural and man made problems.

All these imply that traditional farming communities and their activities are basic sources of information for modern scientific research in the field of crop genetic resource conservation and the development of sustainable agriculture.

7. Conclusion

The survival of farmers is completely dependent on their crops that are of different qualities. The distribution of these crop species and varieties is more or less similar in the farmlands of different farmers. The efforts of farmers to increase productivity and maintain landraces are not supported by environmental and climatic conditions. Despite the impacts of climatic and environmental problems, hard working farmers of Fontainina still play decisive roles in maintaining crop genetic resources.

In situ conservation efforts of crop genetic resources can be fruitful if it includes the active participation of farmers. Farmers, in their close association to the landraces, have identified physical and biological factors that support the landraces. Crop plants cultivated at different level of abundance, distributed at different locations and given different ranks are all necessary for the farmers as well as for non-farmers. Therefore, *in situ* conservation strategy of crop plants should not concentrate only on the maintenance of major crop varieties of staple food. It should give weight for the conservation and maintenance of minor crop categories and wild relatives.

Due to rainfall unreliability, farmers lose certain amount of seeds from their seed stock in every drought-affected year. At the same time the price of seeds of landraces becomes expensive. These conditions are diverting the attention of farmers towards cultivating introduced crop varieties and forgetting the landraces. Farmers need assistance, seed

supplying body, in periods when their seed stocks are deteriorated by climatic-imbalances like that of year 1999 cropping season. Thus, establishing local seed stores that can distribute seeds at least by reasonable price in problematic years should be considered. It can be performed as part of *in situ* conservation of crops, and it can strengthen the process of *in situ* conservation. It is confirmed during the discussion with farmers that under normal circumstances if seeds are available they give priority to landraces.

In this study all the above points were explored, and the information compiled in this thesis can help related future research. Further investigations are necessary to get more information about each item mentioned above. When this happens, conservation of crop genetic resources and alleviating food problems will get strong base. Therefore, it is important to note that collecting, documenting and using farmers' knowledge and farming systems is useful. Moreover, improving this knowledge through modern scientific research and applying in appropriate environments seems indispensable for the development of countries like Ethiopia.

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Appendix

Appendix 1. Food crops recorded in Ye-gibi meret

Cereals			
Vernacular name	English name	Scientific name	Family
Bokolo	Maize	*Zea mays* L.	Poaceae
Mashila	Sorghum	*Sorghum bicolor* (L.) Moench	Poaceae
Dagussa	Finger millet	*Eleusine coracana* (L.) Gaertn.	Poaceae
Gebse	Barley	*Hordeum vulgare* L.	Poaceae
Pulses/Legumes			
Boloke	Tepary bean	*Phaseolus sp.*	Fabaceae
Adenguare/Arenguade	Common bean	*Phaseolus sp.*	Fabaceae
Bakela	Broad bean	*Vicia faba* L.	Fabaceae
Akuriater		*Glycin max* (L.) Merr.	Fabaceae
Fruits			
Kasmir /Casmir/	White sapota	*Casmiroa edulis* La Llave	Rutaceae
Papaye	Papaya	*Carica papaya* L.	Caricaceae
Birtukan	Sweet orange	*Citrus sinensis*(L.) Osbeck	Rutaceae
Lomi	Lime	*Citrus aurantifolia* L.	Rutaceae
Komtate	Sour orange	*Citrus sp .*	Rutaceae
Mango	Mango	*Mangifera indica* L.	Anacardiaceae
Zeytuni	Guava	*Psidium guajava* L.	Myrtaceae
Anino/Ye-berelib	Bullock's heart	*Annona cherimola* Mill.	Annonaceae
Suquar be-manka		*Annona reticulata* L.	Annonaceae

Tiringo	Citron	*Citurs medica* L.	Rutaceae
Abucado	Avocado	*Persea americana* Mill.	Lauraceae
Muz	Banana	*Musa paradisiaca* L.	Musaceae
Ananas	Pineapple	*Ananas comosus* (L.) Merr.	Bromeliaceae
Vegetables			
Timatim	Tomato	*Lycopersicon esculanta* L.	Solanaceae
Berbere/Karia	Peper	*Capsicum sp.*	Solanaceae
Mitmita/Belew	Chilly	*Capsicum sp.*	Solanaceae
Gomenzer	Cabbage	*Brassica carinata* A. Br.	Brassicaceae
Duba	Pumpkin	*Cucurbita pepo* L.	Cucurbitaceae
Key shinkurt	Onion	*Allium cepa* L.	Alliaceae
Nech shinkurt	Garlic	*Allium sativum* L.	Alliaceae
Senafich	Mustard	*Brassica nigra* (L.) Koch	Brassicaccae
Selata	Head lettuce	*Lactuca sativa* L.	Asteraceae
Root and Tuber			
Enset/Coba	False banana	*Ensete ventricosum* (Welw.) Cheesm.	Musaceae
Siquar dinich	Sweet potato	*Ipomea batatas* (L.) Lam.	Convolvulaceae
Dibulbul dinich	Potato	*Solamun tuberosum* L.	Solanaceae
Oils			
Selit	Sesame	*Sesamum indicum* L.	Pedaliaceae
Suf (Yeferenji)	Sun flower	*Helianthus annuus* L.	Asteraceae
Nug	Niger seed	*Guizotia abyssinica* (L.f.) Cass.	Asteraceae

Nuts			
Ocholoni/Lewz	Ground nut	*Arachis hypogea* L.	Fabaceae
Sugars			
Shenkora ageda	Sugar cane	*Saccharum officinarum* L.	Poaceae
Tinkish	Juicy (Sweet stalk) sorghum	*Sorghum bicolor* (L.) Moench	Poaceae
Spice, caffine and Flavour plants			
Dimbilal	Coriander	*Coriandrum sativum* L.	Apiacea
Besobila	Sweet basil	*Ocimum basilicum* L.	Lamiaceae
Gesho	Rhamnus	*Rhamnus prinoides* L'Herit.	Rhammaceae
Kese	-	*Lippia sp.*	Verbenaceae
Buna	Coffee	*Coffea arabica* L.	Rubiaceae
Abish	Fenugreek	*Trigonela foenum-graecum* L.	Fabaceae

Appendix 2. Non food crops recorded in Ye-gibi meret.

Construction and farm implements			
Ade –kurkura		*Ziziphus mucronata* Willd.	Rhamnaceae
Kurkura		*Ziziphus spina-christi* (L.) Desf.	Rhammaceae
Selewa		*Diospyros abyssinica* (Hiern.) White.	Ebenaceae
Wanza	Cordia	*Cordia africana* Lam.	Boraginaceae
Bahirzaf	Eucalyptus	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae
Wulaga		*Ehretia cymosa* Thonn	Boraginaceae
Nech Girar/Wacho/	Acacia	*Acacia seyal* Del.	Fabaceae
Woyra	Olea	*Olea europaea* (L.) *subsp cuspidate*(Wall.ex.DC.)	Oleaceae
Jacaranda	Jacaranda	*Jacaranda mimosifolia* D.Don	
Tsid		*Cupressus sp.*	Cupressaceae
Kundoberbere		*Schinus molle* L.	Anacardiaceae
Digita		*Calpurnia aurea* (Ait.) Benth	Fabaceae
Aroressa		*Grewia mollis* A.Juss	Tiliaceae
Shiwshiwe		*Casuarina equisetifolia* L.	Casuarinaceae
Shembeko	Bamboo	*Arundo donax* L.	Poaceae

Stimulants and Narcotics			
Chat	Khat	*Catha edulis* (Vahl) Forssk. Ex. Endl.	Celastraceae
Timbaho	Tobacco	*Nicotiana rustica* L.	Solanaceae

Medicinal			
Damakesse	Sage	*Ocimum gratissimum* L.	Lamiaceae
Telenze		*Acyranthus aspera* L.	Amaranthaceae
Senemeca		*Senna occidentalis* (L.) Link	Fabaceae
Kumen		*Foeniculum vulgare* Mill.	Apiaceae
Yefereszeng		*Leonotis neptifolia* (L.) R.Br.	Lamiaceae
Ede Buda /Gizawa/		*Withania somnifera* (L.) Dunal	Solanaceae
Tena adam	Rue	*Ruta chalepensis* L.	Rutaceae
Shiferaw	Cabbage tree	*Moringa oleifera* Lam.	Moringaceae
Chiguagot		*Trichodesma* zylanicum (L.) R.Br.	Boraginaceae
Eret	Aloe	*Aloe sp*	Aloeaceae
Crafts and utility			
Kil	Gourd	*Lagenaria sp.*	Cucurbitaceae
Halge		*Agave sp*	Agavaceae
Tit	Cotton	*Gossypium arboreum* L.	Malvaceae
Musbaha (Key)	Red flower	*Canna indica L.*	Cannaceae
Bicha Musbaha	Yellow flower	*Canna indica L.*	Cannaceae
Fragrance			
Tikur ariti/Ajuban/		*Ocimum basilicum* L.	Lamiaceae
Ariti		*Artemisia absinthium* L.	Astraceae
Woiba		*Combretum molle* R.Br.ex. G.Don	Combretaceae
Oil (non- edible)			
Gulo	Castor	*Ricinus communis* L.	Euphorbiaceae

Fodder and soil fertilizing			
Sesbania	Sesbania	*Sesbania sesban* (L.) Merr.	Fabaceae
Anja-granja (Lusena)		*Leucaena leucocephala* (Lam.) De. Wit	Fabaceae
Live fence			
Kulkual	Euphorbia	*Euphorbia candelabrum* Kotschy	Euphorbiaceae
Kinchib		*Euphorbia tirucalli* L.	Euphorbiaceae
Agam		*Carissa edulis* (Forssk.) Vahl	Apocynaceae
Dedeho		*Eculea shimperi* (AD.C.) Dandy	Ebenaceae
Kontir		*Pterolobium stellatum* (Forssk.) Brenan	Fabaceae

Appendix 3. Food crops recorded in Ye-guaro meret

Cereals			
Local name	**English name**	**Scientific name**	**Family**
Bokolo	Maize	*Zea mays* L.	Poaceae
Gebse	Barley	*Hordeum vulgare* L.	Poaceae
Mashila	Sorghum /Grain/	Sorghum bicolor (L.) Moench.	Poaceae
Teff	Tef	*Eragrostis tef* (zucc.) Trotter	Poaceae
Dagussa	Finger millet	*Eleusine coracana* (L.) Gaertn	Poaceae
Tinkish	Sorghum/Sweetst-alk/	*Sorghum bicolor* (L.) Moench	Poaceae
Bunign (Teff)	Tef (minor)	*Eragrostis tef* (Zucc.) Trotter	Poaceae
Sinde	Wheat	*Triticum sativum* L.	Poaceae
Pulses			
Arenguade/ Adengua -re	Bean	*Phaseolus sp.*	Fabaceae

Bakela	Broad bean	*Vicia faba* L.	Fabaceae
Ater	Pea	*Pisum sativum* L.	Fabaceae
Arenguade(Jergade ,Kechine)	Cow pea	*Vigna unguiculata* (L.) Walp.	Fabaceae
Boloke	Tepary bean	*Phaseolus sp.*	Fabaceae

Oil crops			
Ye-Ferenji Suf	Sun flower	*Heliathus annuus* L.	Asteraceae
Selit	Sesame	*Sesamum indicum* L.	Pedaliaceae
Nug	Niger seed	*Guizotia abyssinica* (L.f.) Cass.	Asteraceae
Vegetables			
Gomenzer	Cabbage	*Brassica carinata* A.Br.	Brassicaceae
Timatim	Tomato	*Lycopersicon esculanta* L.	Solanaceae
Duba	Pumpkin	*Cucurbita pepo* L.	Cucurbitaceae
Key shinkurt	Onion	*Allium cepa* L.	Alliaceae
Berbere/Kaira/	Peper	Capsicum sp.	Solanaceae
Spice			
Tikurazmud	Black cumin	*Nigella sativa* L.	Rannunculaceae
Senafich	Ethiopian mustard	*Brassica nigra*(L) Kotch.	Brassicaceae
Fruit			
Papaye	Papaya	*Carica* papaya L.	Caricaceae
Turungo	Citron	*Citrus medica* L.	Rutaceae
Zeytuni	Guava	*Psidium guajava* L.	Myrtaceae
Lomi	Lime	*Citrus aurantifolia* L.	Rutaceae

Appendix 4. Non food crops recorded in Ye guaro meret

Plants used as medicin, narcotic, fiber, utility			
Ede-Buda/Gizawa/	-	*Withania somnifera* (L.) Dunal	Solanaceae
Feto	Cress	*Lepidium sativum* L.	Solanaceae
Timbaho	Tobacco	*Nicotiana rustica* L.	Malvaceae
Tit	Cotton	*Gossypium arboreum* L.	Cucurbitaceae
Kil	Gourd	*Lagenaria sp.*	Cucurbitaceae
Construction and implements			
Bahirzaf	Eucalyptus	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae
Kurkura		*Ziziphus mucronata* Willd.	Rhamnaceae
Wanza		*Cordia africana* Lam.	Boraginaceae
Wulaga		*Ehretia cymosa* Thonn	Boraginaceae
Ade-kurkura		*Ziziphus spina-christi* (L.) Desf	Rhamnaceae

Appendix 5 Food crops recorded in Ye-dur meret

Cereals			
Local name	Common English name	Scientific name	Family
Mashila	Sorghum	*Sorghum bicolor* (L.) Moench	Poaceae
Bokolo	Maize	*Zea mays* L.	Poaceae
Aja	Emmer wheat	*Triticum dicoccon* Schrank	Poaceae
Sinde	Wheat	*Triticum sp.*	Poaceae
Gebse	Barley	*Hordeum vulgare* L.	Poaceae
Dagussa	Finger millet	*Eleusine coracana* (L.) Gaertn.	Poaceae

Teff		Eragrostis tef (Zucc.) Trotter	Poaceae
Pulses			
Bakela	Broad bean	*Vicia faba* L.	Fabaceae
Ater	Pea	*Pisum sativum* L.	Fabaceae
Shimbira	Chick peas	*Cicer arietinum* L.	Fabaceae
Guaya	Vetch	*Lathyrus sativus* L.	Fabaceae
Arenguade (Kechine /Jergade)	Cow pea	*Vigna unguiculata* (L.) Walp.	Fabaceae
Arenguade	Common beans	*Phaseolus sp.*	Fabaceae

Oils			
Nug	Niger seed	*Guizotia abyssinica* (L.f.) Cass.	Asteraceae
Selit	Seasame	*Sesamum indicum* L.	Pedaliaceae
Telba	Flax (linseed)	*Linum usitatisimum* L.	Linaceae
Ye-Ferenji suf	sunflower	*Helianthus annuus* L.	Asteraceae
Vegetables			
Gomen zer	Cabbage	*Brassica carinata* A.Br.	Brassicaeceae
Duba	Pumpkin	*Cucurbita pepo* L.	Cucurbitaceae
Timatim	Tomato	*Lycopersicon esculanta* L.	Solanaceae
Key shinkurt	Onion	*Allium cepa* L.	Alliaceae
Nech shinkurt	garlic	*Allium sativum* L.	Alliaceae
Sugar			
Shekora ageda	Sugar cane	*Saccharum officinarum* L.	Poaceae
Spice			
Abish	Fenugreek	*Trigonella foenum-graecum* L.	Fabaceae
Netch azmud	Bishops weed	*Trachyspermum ammi* (L.) Torrill.	Apiaceae
Tikur azmud	Cumin (black cumin)	*Nigella sativa* L.	Rannunculaceae

Dimbilal	Coriander	*Coriandrum sativum* L.	Apiaceae
Besobila	Sweet (sacred) basil	*Ocimum basilicum* L.	Lamiaceae

Fruit			
Muz	Banana	*Musa paradisiaca* L.	Musaceae
Zeituni	Guava	*Psidium guajava* L.	Myrtaceae
Mango	Mango	*Mangifera indica* L.	Anacardiaceae
Lomi	lime	*Citrus aurantifolia* L.	Rutaceae

Appendix 6. Non-food crops recorded in Ye-dur meret

Medicinal			
Feto	Cress	*Lepidium sativum* L.	Brassicaceae
Narcotic			
Timbaho	Tobacco	*Nicotiana rustica* L.	Solanaceae
Fiber and utility			
Tit	Cotton	*Gossypium arboreum* L.	Malvaceae
Kil	Gourd	*Lagenaria sp.*	Cucurbitaceae
Plants for construction, implements, soil conservation, shade			
Wanza		*Cordia africana* Lam.	Boraginaceae
Bisana		*Croton macrostachyus* Del.	Euphorbiaceae
Wacho (Girar)		*Acacia seyal* Del.	Fabaceae
Wulaga		*Ehretia cymosa* Thonn	Boraginaceae
Adabule		*Gardenia ternifolia* K. Schum.and Thonn.	Rubiaceae
Ade-kurkura		*Ziziphus mucronata* Willd.	Rhamnaceae
Kinchib		*Euphorbia tirucalli* L.	Euphorbiaceae
Sensel		*Justicia shimperiana* (Hochst. ex Nees) T. Anders.	Asteraceae
Senbelet		*Hyparrhenia spp.*	Poaceae
Embuacho		*Rumex nervosus* Vahl	Polygonaceae
Kurkura		*Ziziphus spina-christi* (L.) Desf.	Rhamnaceae

Appendix 7 Reliability analaysis of farmers' response, (Farmers who were interviewed to indicate factors that determine the distribution of crops in Fontanina).

Source of variation	SS	DF	MS	F
Between farmers	1.4111	29	0.0487	0.5208 ^{ns}
Between factors	21.8667	8	2.7333	29.2377***
Residual	21.6889	232	0.0935	

*** P < 0.001, ns = non significan

Appendix 8. Reliability analysis of reasons for sowing some crops on nearby farms

Source of variation	SS	DF	MS	F
Between farmers	1.8944	29	0.0653	0.3242 ^{ns}
Between reason	12.2944	5	2.4589	12.2079***
Residual	29.2056	145	0.2014	

*** P< 0.001, ns = non significant

Appendix 9. Reliability analysis of farmers reasons for sowing crops on main fields far from the dwellings.

Source of variation	SS	DF	MS	F
Between farmers	2.9600	29	0.1021	1.4606 ^{ns}
Between reasons	23.4933	4	5.8733	84.0828***
Residual	8.1067	116	0.0699	

*** P < 0.001, ns= non significant

Appendix 10 Reliability analysis of farmers' response concerning soil fertilizing methods

Source of variation	SS	DF	MS	F
Between farmers	4.9833	29	0.1718	1.0825 ^{ns}
Between methods	18.5333	8	2.6476	16.6829***
Residual	32.2167	203	0.1587	

*** P < 0.001 , ns=non significant

Appendix 11.Reliability analysis of farmers' responses concerning factors facilitating the introduction of new crop varieties into the village

Source of variation	SS	DF	MS	F
Between farmers	1.9167	29	0.0661	0.3876 ^{ns}
Between Methods	7.1167	5	1.4233	8.3500***
Residual	24.7167	145	0.1705	

*** P < 0.001, ns= non significant

Appendix - 12. PLANT SPECIES COLLECTED FROM THE STUDY SITE

No.	Coll. No	Scientific Name	Family	Local Name	Common use	Habit.
1	42	*Acacia brevispica* Harms	Fabaceae	Amezaze	For making "gotera" (barn); Fence	Shrub or tree
2	46	*Acacia lahai* Steud. &Hochst. ex Benth.	Fabaceae	Tikur girar	For farm implements (for "Digir")	Srub or tree
3	49	*Acacia seval* Del.	Fabaceae	Wacho	Fuel; "Mama'' (bird watching site)	Tree
4	9	*Achyranthus aspera* L.	Amaranthaceae	Telenze	Medicinal (Used to stop bleeding)	Herb
5	2	*Amaranthus spinosus* L.	Amaranthaceae	Esholam alma	Weed	Herb
6	101	*Annona cherimola* Mill.	Annonaceae	Annio (Ye-bere lib)	Edible fruit	Tree
7	106	*Annona reticulata* L.	Annonaceae	Sikuar Be-mankia	Edible fruit	Tree
8	71	*Aristida adscensionis* L.	Poaceae		Fodder	Herb
9	96	*Artemisia absinthium* L.	Asteraceae	Ariti	Medicine for belly-ache; Fragrance	Herb
10	111	*Arundo donax* L.	Poaceae	Shembeko	For house construction (Roof making)	Shrub
11	52	*Asparagus africanus* Lam.	Asparagaceae	Ye-set kest	Tooth brush	Liana
12	25	*Bothriochola insculpta* (Hochst. ex A. Rich.) A. Camus	Poaceae	Nech- Sar	Fodder	Herb
13	14	*Barassica carinata* A.Br.	Barassicaceae	Gomen -zer	Vegetable; Oil (from Seed)	Herb
14	85	*Brassica nigra* (L.) Koch	Barassicaceae	Senafich	Pungent Spice (eaten with sprout of bean, pea etc.)	Herb
15	117	*Caesalpinia decapetala* (Roth.) Alston	Fabaceae	Kontir	Fence	Shrub
16	118	*Calpurnia aurea* (Ait.) Benth.	Fabaceae	Digita	Farm implement ("Erif "), construction,fence, fuel	Tree-Shrub
17	86	*Canavalia africana* Dunn.	Fabaceae	Ye-Ferengi Adenguare		Liane
18	89	*Carica papaya* L.	Caricaceae	Papaye	Edible fruit; Fence	Shrub
19	43	*Carissa edulis* (Forssk.) Vahl	Apocynaceae	Agam	Edible fruit; Fence	Tree
20	87	*Casimiroa edulis* La Llave	Rutaceae	Casmir	Edible fruit	Tree
21	115	*Casuarina equisetifolia* L.	Casuarinaceae	Shew-Shewe	Fuel, construction	Tree
22	103	*Catha edulis* Forssk.	Celasteraceae	Khat	Stimulant (Leaf chewed)	Tree

23	104	*Citrus aurantifolia* L.	Rutaceae	Lomi	Edible fruit	Tree Shrub
24	125	*Citrus medica* L.	Rutaceae	Tirungo	Edible fruit	Tree-shrub
25	116	*Citrus sinensis* (L.) Osb.	Rutaceae	Birtukan	Edible fruit	Tree - Shrub
26	110	*Combretum molle* R.Br. ex G.Don	Combretaceae	Woiba	- Fragrance for ladies (smoke) - Medicine for cattle eye infection	Tree
27	27	*Commicarpus plumbagineus* (Cav.) Standl.	Nictaginaceae	Konteb		Herb
28	107	*Cordia africana* Lam.	Boraginaceae	Wanza	Mortar, Yoke, construction, Edible fruit	Tree
29	38	*Coriandrum sativum* L.	Apiaceae	Dimbilal	Spice (Flavour)	Herb
30	65	*Cucumis pustulatus* Naud ex Hook. f.	Cucurbitaceae	Ye-midir Embuai	Root part is medicine for diarrhoea; Belly ache	Liana
31	102	*Cymbopogon citratus* (DC.) Stapf	Poaceae	Tej-sar	Fragrance	Herb
32	80	*Cynodon dactylon* (L.) Pers.	Poaceae	Serdo	Fodder	Herb
33	29	*Cyphostemma adenanthum* (Fresen.) Descoings	Vitaceae	Milas-Golgul	Leaf loosens wound ("Ebachi"); poisonous	Liana
34	22	*Desmodium dichotomum* (Klein ex. Willd.) DC.	Fabaceae	Kimero	Fodder (Fattening)	Herb
35	44	*Dichrostachys cinerea* (L.) Wight and Arn.	Fabaceae	Horsamessa	Fence; construction ("Chefeka")	Shrub
36	11	*Digitaria diagonalis* (Nees) Stapf	Poaceae	Ye-wisha Sindedo	Fodder	Herb
37	21	*Dinebra retroflexa* (Vahl) Panzer	Poaceae	Chew-Chewiye	Fodder	Herb
38	54	*Diospyros abyssinica* (Hiern) F. White	Ebenaceae	Selewa	Farm implements ("Mofer"); Construction; walking stick	Tree
39	33	*Ehretia cymosa* Thonn.	Boraginaceae	Wulaga	Yoke (Farm implement)	Tree
40	10	*Eleusine coracana* (L.) Gaertn	Poaceae	Dagussa	Cereal for food and local drink making	Herb
41	7	*Eragrostis aspera* (Jacq.)	Poaceae	Ye-koki Tef	Fodder	Herb

		Nees				
42	78	*Eragrostis aethiopica Chiov.*	Poaceae		Fodder	Herb
43	12,13, 31	*Eragrostis tef* (Zucc.) Trotter	Poaceae	Teff	Cereal (staple food crop)	Herb
44	69	*Eriochola fatmensis* (Hochst. & Steud.) Clayton	Poaceae	Tif-tifiye sar	Fodder	Herb
45	84	*Eucalyptus camaldulensis* Dehnh.	Myrtaceae	Bahirzaf	Construction; Fuel	Tree
46	45	*Euclea shimperi* (AD.C.) Dandy	Ebenaceae	Dedeho	Construction; Children eat fruit	Shrub
47	121	*Euphorbia candlabrum* Kotschy	Euphorbiaceae	Kulkual	Fence; construction	Tree
48	123	*Euphorbia tirucalli* L.	Euphorbiaceae	Kinchib	Soil conservation; Fence	Shrub
49	93	*Ficus thonningii* Blume	Moraceae	Shibaha		Tree
50	98	*Foeniculum vulgare* Mill.	Apiaceae	Kumen	Medicine (Gives relief for urination problem)	Herb
51	50	*Gardenia ternifolia* K. Schum. and Thonn.	Rubiaceae	Adabule	"Mama" (Bird watching post); processed timber is used as writing board	Tree
52	91	*Gossypium arboreum* L.	Malvaceae	Tit	Fiber for cloth	Herb
53	83	*Grewia bicolor* A. Juss.	Tiliaceae	Hido	Bark is used as a rope; Walking stick	Tree-Shrub
54	40,92	*Grewia mollis* A. Juss.	Tiliaceae		Bark is used as a rope; Forage (feed calf)	Shrub
55	73	*Grewia villosa* Willd.	Tiliaceae	Agobdi	Forage	Shrub
56	15	*Guizotia abyssinica* (L.f.) Cass.	Asteraceae	Noug	Oil seed	Herb
57	32	*Guizotia scabra* (Vis) Chiov.	Asteraceae	Mech	Flower for bee forage	Herb
58	74	*Heliotropium cinerascens* Steud. ex DC.	Boraginaceae	Beg-agenen		Herb
59	26	*Heteropogon contortus* (L.) Roem. & Schult.	Poaceae	Bila (Bale eshoh)	Fodder	Herb
60	30	*Hordeum vulgare* L.	Poaceae	Gebs	Cereal (Food)	Herb

61	4	*Hyparrhenia anthistirioides* (Hochst. ex A. Rich.) Stapf	Poaceae	Bila	Soil conservation; Fodder; Roof	Herb
62	5,67	*Hyparrhenia hirita* (L.) stapf	Poaceae	Gaza,Senbelet	Soil conservation; Fodder; Roof cover	Herb
63	68	*Hyparrhenia dregeana* (Nees) Stent	Poaceae	Senbelet	Soil conservation; Roof cover; Fodder	Herb
64	81	*Ipomoea sinensis* (Desv.) Choisy	Convolvulaceae	Ye-ayit hareg		Herb
65	113	*Jacarada mimosifolia* D. Don	Bignoniaceae	Jacaranda	Construction; Fuel	Tree
66	78	*Justicia shimperiana* (Hochst. ex Nees) T. Anders.	Acanthaceae	Sensel	To wash (clean) big jars (barrel)	Shrub
67	55	*Lantana camara* L.	Verbenaceae	Kese		Shrub
68	34	*Leonotis nepetifolia* (L.) R. Br.	Lamiaceae	Ye-feres zeng	Anti-caterpillar (stops caterpillars from entering home)	Herb
69	119	*Leucaena leucocephala* (Lam.) De. Wit	Fabaceae	Anja-Granja (Lucena)	-Forage; Soil fertilizing; fuel	Tree
70	35	*Linum usitatisimum* L.	Linaceae	Telba	-Oil seed	Herb
71	56	*Maytenus arbutifolia* (Hochst. ex A. Rich.) R.Wilczek	Celasteraceae	Atat	Walking stick; Fuel	Shrub
72	88	*Mangifera indica* L.	Anacardiaceae	Mango	Edible fruit	Tree
73	70	*Melinis repens* (Willd.) Zizka	Poaceae	Leslase sar	Fodder	Herb
74	90	*Moringa oleifera* Lam.	Moringaceae	Shiferaw	Medicinal leaf (anti-amoeba)	Tree
75	109	*Nicotiana rustica* L.	Solanaceae	Timbaho	Narcotic	Herb
76	7	*Nigella sativa* L.	Ranunculaceae	Tikur metafet (Tikur azmud)	Spice	Herb
77	39,112	*Ocimum basilicum* L. var. *thyrsiflorum* Baker	Lamiaceae	Ajuban (Tikur Ariti)	Fragrance	Herb
78	48	*Ocimum gratissimum* L.	Lamiaceae	Damakese	Medicine for "Shiwita" or "Michi"	Herb
79	99	*Olea europaea* (L.) *subsp. cuspidata* (Wall. ex DC.).	Oleaceae	Woira	Farm implement; construction; Fuel	Tree

80	122	*Opuntia ficus-indica* (L.) Miller	Cactaceae	Are-kulkual (Beles)	Edible fruit	Shrub
81	1	*Panicum maximum* Jacq.	Poaceae	Worodoro	Fodder	Herb
82	63	*Pavetta gardeniifolia* A. Rich.	Rubiaceae	Dingay seber	Fence	Shrub
83	75	*Pterolobium stellatum* (Forssk.) Brenan	Fabaceae	Kentafa		Shrub
84	53	*Premna schimperi* Engl.	Verbenaceae	Chocho	Leaf extract for cattle eye infection treatment; Fuel	Shrub
85	51	*Rhus natalensis* Krauss	Anacardiaceae	Dcbobosha (Takima)	Farm implements ("Maneko"; "Erif")	Shrub
86	108	*Ricinus communis* L.	Euphorbiaceae	Agullo (Gullo)	Oil for polishing baking plate Fuel	Shrub
87	97	*Rosmarinus officinalis* L.	Lamiaceae	Azmerino	Flavour (For roasting meat)	Shrub
88	19;41	*Rumex nervosus* Vahl	Polygonaceae	Embuacho	Soil conservation; edible (young stem)	Herb
89	94	*Ruta chalepensis* L.	Rutaceae	Tena-Adam	Medicinal	Herb
90	120	*Sansevieria sp.*	Dracaenaceae	Dibulbul Halge	Fiber (Rope)	Herb
91	105	*Schinus molle* L.	Anacardiaceae	Kundo berbere	Boiled and inhaled for common cold; Fuel	Tree
92	8	*Senna occidentalis* (L.) Link	Fabaceae	Hasenmeca	Medicinal (Leaf for "shiwita" or"Michi")	Shrub
93	16	*Sesamum indicum* L.	Pedaliaceae	Selit	Oil	Herb
94	114	*Sesbania sesban* (L.) Merr.	Fabaceae	Sesban	Soil fertilizing; Fuel	Tree
95	23	*Setaria verticillata* (L.) P. Beauv.	Poaceae	Ascndaba	Fodder	Herb
96	77	*Solanum incanum* L.	Solanaceae	Embuai	Root for belly ache	Shrub
97	66	*Sorghum bicolor* (L.) Moench *subsp. arundinaceum* (Desv.) de Wet & Harlan	Poaceae	Kilo	Weedy wild relative of sorghum, used for making non-alcoholic drink (karebo)	Herb
98	20	*Sorghum bicolor* (L.) Moench	Poaceae	Mashila	Cereal (Food)	Herb
99	3	*Striga hermontica* (Del.) Benth	Scrophulaceae	Akenchira	Parasitic weed of sorghum	Herb
100	57	*Snowdenia polystachya*	Poaceae	Yedaget sar		

		(Fresen.) Pilg.				
101	24	*Thelepogon elegans* Roem. and Schult.	Poaceae	Sokeke		
102	36	*Trachyspermum ammi* (L.) Sprague ex Turrill	Apiaceae	Nech kimem (Nech azmud Spice) ,Kemun	Spice	Herb
103	72	*Trichodesma zeylanicum* (L.) R. Br.	Boraginaceae	Chiguagot	Medicine (shiwita or mich)	Herb
104	37	*Trigonela foenum-graecum* L.	Fabaceae	Abish	Spice; Feed children (solution)	Herb
105	58	*Triticum dicoccon* Schrank	Poaceae	Aja	Cereal (serebat-kita)	Herb
106	59	*Triticum sp.*	Poaceae	Tsequram (sinde)	Cereal (bread)	Herb Herb
107	60	*Triticum turgidum* L.	Poaceae	Gunde (Sinde)	Cereal (bread)	Herb
108	82	*Verbascum sinaiticum* Benth.	Scrophulariaceae	Ye-ahiya joro	Root extract used to treat cattle with leech	Herb
109	17,18	*Vigna unguiculata* (L.) Walp.	Fabaceae	Jergade, kechine (Arenguade)	Legume used to make soup(wot or shiro wot)	Liana
110	95	*Withania somnifera* (L.) Dunal	Solanaceae	Ede-Buda (Gizawa)	Evil eye protector	Shrub
111	76	*Xanthium spinosum* L.	Asteraceae	Ye-set milas (ye-seitan merfe)	Weed	Herb
112	28	*Xanthium strumarium* L.	Asteraceae	Deha nikel	Weed	Herb
113	100	*Zehneria scabra* (L.) Sond.	Cucurbitaceae	Areg-resa	Boiled and inhaled with Schinus molle L. for common cold	Liana
114	101	*Ziziphus micronata* Willd.	Rhamnaceae	Ade-kurkura	-Farm implement ("mofer", "kember") -Edible fruit	Tree
115	62	*Ziziphus spina-christi* (L.) Desf.	Rhamnaceae	Kurkura	"Mana" (Bird watching post), Fuel, Construction, Farm implement	Tree

Appendix 13 Information on cultivated plants (Crops)

Informant's name _____ Age _____ Sex _____

Profession _____ Social Status _____

Study area _____ Wereda _____ Language_____

1. What are the first five major crops grown in this area?

_____ _____ _____

_____ _____ _____

2. What are the factors that determine the distribution of crops/varieties on the farm land?

_____

3. Does distance from the home affect the distribution of crops/ varieties on the farm lands?

Yes ☐ No ☐

3.1 If yes, tell me the first three crops grown on farm lands nearer to the home

_____ _____ _____

3.2 Why do you plant the above mentioned crops on nearer farms?

_____

3.3 Which crop varieties are grown on distant farms?

_____ _____ _____

3.4 Why? _____

4. Where do you get seeds of landrace(farmers varieties) during s owing?_____

5. How do you maintain landrace varieties?_____

6. Why do you maintain landraces? _____

7. Are new varieties cultivated in the area?

☐ Yes ☐ No

7.1 What factors cause the introduction of new varieties? _____

7.2 Tell me new crop varieties introduced in to this area

Crop Varieties	Origin and year of introduction	Brought by
A.		
B.		
C.		
D.		
E.		

7.3 How and by whom new varieties introduced for the first time in this area?_____

_____

7.4 Have you encountered any problem following the introduction of new varieties?

_____

7.5 When newly introduced sorghum varieties are compared with the land races

A. New varieties are early (fast) maturing

☐ Yes ☐ No

B. New Varieties are better yielding

☐ Yes ☐ No

C. New Varieties are pest resistant

☐ Yes ☐ No

D. New varieties are drought resistant

☐ Yes ☐ No

8. Are there land races disappeared from this area or replaced by new varieties?

☐ Yes ☐ No

If yes, Why? _____

9. Which crops grow in association and on which farm land?

_____

9.1 Give reason for the associations or cropping patterns._____

_____

9.1.1 Which crop varieties grow in association on farm lands nearer to home?

A. Crop Varieties growing in association | Reason

9.1.2 Which varieties grow in association on farmlands for from the villages or home?

Crop Varieties growing in association | Reason

10. How crop fields are possessed by farmers and distributed in the study area?

_____

11. What are the soil fertilizing methods in the area?_____

12. Is there reliability in precipitation and is it sufficient for crop development?

13. What kind of crop pests, weeds and diseases are prevalent?

Crop pest:_____

Weeds _____

Crop diseases _____

13.1 How do you control or eradicate?

Pests_____

Weeds _____

Diseases _____

14. What do you suggest about the conservation or maintenance of traditional crop diversity?

15. Is there any other plant species (tree, shrub or herb) purposely grown in association with crops in crop fields or in vicinity?

☐ Yes ☐ No

If yes, give the name of these species and their use.

16. Tell me landraces which are decreasing in this area or the disappeared ones.

Disappeared or decreasing landraces	Reason and/ or year of disappearance
A.	
B.	
C.	
D.	
E.	

17 Grouping sorghum varieties

A. Bird Resistant	Not bird resistant
B. Pest (Insect) resistant	Not insect resistant
C. Drought resistant	Not drought resistant
D. Striga resistant	Not Striga resistant
E. Storable	Not storable
F. High yielding	Low Yielding