ANALYSIS OF ON-FARM DIVERSITY AND GENETIC EROSION IN BARELY (*Hordeum Vulgare*L) LANDRACES FROMDIKSIS AND LODE HETOSA DISTRICTS,ARSI ZONE, CENTRAL ETHIOPIA

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Submitted by: **BeleteTilaye**

Major Advisor: TemesgenBedassa (*Assistant Professor*)

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We, the undersigned, members of the Board of Examiners of the final open defense by Belete Tilaye have read and evaluated his thesis entitled "Analysis of On-farm diversity and genetic erosion in barely (*Hordeum Vulgare*L.) landraces from Diksis and Lode Hetosa districts, Arsi Zone,Centeral Ethiopia" and examined the candidate. This is, therefore, to certify that the thesis has been accepted in partial fulfillment of the requirement of the Degree of Master of Science in Biology.

_____	_____	_____
Supervisor /Advisor	Signature	Date
_____	_____	_____
Chairperson	Signature	Date
_____	_____	_____
Internal Examiner	Signature	Date
_____	_____	_____
External Examiner	Signature	Date

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To: Biology department

Subject: Finalized MSc. Thesis Submission for defense

As thesis research Major advisor, I hereby certify that I have read and evaluated this thesis entitled "Analysis of On-farm diversity and genetic erosion in barely (*Hordeum Vulgare*L.) landraces from Diksis and Lode Hetosa districts, Arsi Zone,Centeral Ethiopia" which is normally prepared under my guidance and supervision by Belete Tilaye to be submitted to Biology department in partial fulfillment of the requirements for Master of Science degree in Biology. Therefore, I recommend that the student, Belete Tilaye, has fulfilled all the requirements for the thesis defense and hence he can submit the finalized thesis to the department.

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Name: ----------Signature: ----------

Date of submission----------

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LIST OF ABBREVIATIONS AND ACRONOMYS

AFLP	Amplified Fragment Length Polymorphism
CSA	Centeral Statistical Agency
DA	Development Agents
EBI	Ethiopian Biodiversity Institute
FAOFGD	Food and Agriculture Organization of United Nation
	Focal Group Discussion
FV's	Farmers varieties
GE	Genetic Erosion
GI	Genetic Integrity
IPGRI	International plant Genetic Resource Institute
MOE	Ministry Of Education
MWU	Madda Walabu University
NGO	Non-Governmental Organization
PAs	Peasent Associations
PGRCE	Plant Genetic Resource Center of Ethiopia
SPSS	Statistical Package for Social Scientists

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ABSTRACT

The term genetic erosion was not exactly clear when it was first coined. The loss of genetic diversity, in a particular location and over a particular period of time, including the loss of individual genes, and the loss of particular combinations of genes, such as those manifested in landraces or varieties are referred as genetic erosion. Barley is one of the cereal founder crops, domesticated about 10,000 year ago in the Fertile Crescent and it is one of the eight founder crops of old world agriculture. In Ethiopia, barley is a main staple crop and human consumption in the limelight. In Arsi Zone, where barley varieties are potentially cultivated, the causes and effects of genetic erosion is poorly understood. Thus, the objectiveof this study was to assess the extent of genetic erosion in barley landraces and justify reasons for its erosion at community and household levels in Diksis and Lode Hetosa districts, Arsi Zone. This research included cross-sectional survey based type, focused on the selected districts. Close and open-ended questions were prepared and distributed to 216 selected households to get information about extent, status and determinant of on-farm diversity and genetic erosion of barley landraces from March to June, 2018. Among a total of two hundred sixteen (216) sample size more than 40 years old, twelve (12)HHs were non respondentwhile two hundred four (204) HHs were interviewed.Genetic erosion was estimated for both districts systematically by exploring 14 barley landraces cultivated for 2 to 3 decades compared with the present situation and 8(57.14%) were eroded while 6(42.86%)barley varieties were still produced.The bivariate association indicated that barley genetic erosion status was strongly associated with respondents' age, proportion of farmland size covered by barley, topography, Use of improved barley varieties, Dominant barley varieties, person who select seed and factors that decline the production of barley land races in were significant predictors of barley genetic erosion at 0.05 p-values.Thus, farmers, policy makers and researchers should give attention to conservation and indigenous knowledge of farmers for better use of genetic resources.

Keywords: Barley,Genetic Erosion,Genetic Integrity,Landraces,On-farm diversity,Variety

1. INTRODUCTION

1.1 Background of the Study

Barley is one of the cereal founder crops, domesticated about 10,000 year ago in the Fertile Crescent (Yadun*et al.,* 2000). In Ethiopia, the long history of cultivation and the diverse agro-ecological and cultural practices have resulted in a wide range of barley diversity. Vavilov, 1951 declared that nowhere else in nature observed such a diversity of forms and genes. Therefore, he proposed Abyssinia (the former Ethiopian Empire) as a center of cultivated barley. The diverse series of endemic botanical varieties may be the result of either an independent domestication or independent development after an introduction from south East Asia at an early date (Harlan, 1969, Negassa, 1985, Orabi*et al.,* 2007). Today, Ethiopia is at least considered as centers of barley diversification. Ancient methods of till age, sowing, harvesting, threshing, winnowing, de hulling and processing as described by Harlan, (1969) in the late 1960s are still practiced by the majority of subsistence farmers in the Ethiopian highlands. The term landrace denotes varieties developed and maintained by farmers. Other authors have used this term to include local varieties, traditional varieties or farmers 'varieties.

The term genetic erosion was first used in the 1960s to describe the process of the loss of genetic diversity in agriculture (Mark *et al.*, 2009). Since the advent of modern plant breeding, there has been concern that the substitution of improved seed for traditional crop varieties poses a threat to biological diversity (Harlan, 1975). Such decrease in diversity is commonly referred to as genetic erosion (Frankel and Bennett, 1970). Similarly, it is defined as "the loss of genetic diversity, in a particular location and over a particular period of time, including the loss of individual genes, and the loss of particular combinations of genes, such as those manifested in landraces or varieties"(FAO/IPGRI, 2002; Brush, 1999).

The traditional perception of genetic erosion has been that of the loss of a stable and diverse set of locally adapted landraces resulting from the adoption of a small number of modern varieties (Hawkes, 1983). Hammer *et al.* (1996) defined it broadly as the loss of particular local landraces expressed as the ratio of the number of landraces currently available to their former number. The term "genetic erosion" is sometimes used in a narrow sense, that is, the loss of genes or alleles, as well as more broadly, referring to the loss of varieties (FAO, 1998). It is a process acting both on wild and domesticated species. It is

also both natural and man-made process. Naturally, it occurs when there is inbreeding between members of small population that will reveal deleterious recessive alleles. It causes a population "bottleneck" by shrinking gene pool or narrowing the genetic diversity available. In recent years, a different picture of genetic erosion has emerged for crops that are basic sources of human food. Particularly for wheat, rice, maize and barely, it has been shown that landraces often became minimized after the introduction of improved seed (Perales*et al.,* 2003a). For instance, according to FAO, (2010b), 30 countries in the world had reported genetic erosion within accessions of cereals and grasses, followed by vegetables, fruits and food legumes.

In China, until 2014 only 30 to 40 % of wild rice relatives survived the expansion of agricultural land or remained conserved for specific local purposes (Last, 2014). In particular countries such as Germany, Finland or Ethiopia, genetic erosion has been detected for up to 100 % of cereal landraces in general as well as in oat and *Triticum* landraces, e.g. *T. durum* and *T. dicoccon* (Teklu& Hammer, 2006). Even regions which are still supposed to be the European hotspot of landrace diversity such as the Mediterranean Basin experienced a severe decline of landraces of various crop species of crops used in agriculture, at the level of varieties of a specific crop or at the level of alleles (Hammer et al., 1996; Hammer &Diederichsen 2009; Laghetti& Hammer 2004).

The concept of genetic erosion in agriculture can be applied at different levels of integration; at crop level as an impoverishment in the assemblage. Genetic erosion in ex situ collections may occur due to the loss of accessions or loss of alleles as a result of regeneration and storage practices (Parzies*et al.,* 2000). Genetic erosion as reflected in the assemblage of crops used in agriculture was also recognized and numbers of crops grown have been declining steadily (Harlan, 1975). A trend towards regional crop specialization as agriculture develops is well established (Kurasaki, 2003), a process resulting in a reduced evenness and richness in crop species at a regional scale.The Genetic erosion reduction in richness (reduction in the total number of crops, varieties or alleles) is a better indicator for genetic erosion, as it does recognize the dynamics in the system. Genetic erosion as a reduction in evenness originates from the diversity used in vegetation ecology and population genetics, such as Shannon's index (Maughan*et al.,* 1996).

There are different views on methods to quantify genetic erosion can be found. Genetic erosion means as absolute loss for a crop, variety or allele. The use of an absolute loss as evidence of genetic erosion ignores the dynamic nature of farming system and population genetic processes (Peroni and Hanazaki, 2002; Gao, 2003; Tsegaye and Berg, 2007).

1.2 Statement of the Problem

In Ethiopia, barley is the main staple crop for human consumption in the limelight. Barley is the predominant cereal in the high altitudes and cultivated in some regions in two distinct seasons:- belg, the short rainfall period (from March to April) and Meher, the long rainfall period (from June to September) (Bekele *et al.,*2005,Lakew *et al.,*1997). Barley is the most dependable and desirable crop for the resource poor highland farmers where poor soil fertility, frost, water logging, soil acidity and soil degradation are the major yield limiting factors, and where other cereals fail to grow.

In Arsi Zone, where barley varieties are potentially cultivated, the causes and effects of the genetic erosion of plant genetic resources are poorly understood. On-farm genetic resource conservation receives less attention. Agricultural extension in the zone gives more attention to the improved varieties than the traditional landraces varieties. In this study area, improved varieties of barley have been disseminated to the farmers since 2000.

Barley are the genetic bases for further breeding works because they are in equilibrium with both environment and pathogens and genetically dynamic (Harlan's, 1975). However, the barley landraces are currently eroded by many factors into new varieties. There is no enough research made on the genetic erosion of barley landraces in potential barley producing areas such as Diksis and Lode-Hetosa districts of Arsi zone. Therefore, the current study was aimed to assess on-farm diversity and extents of genetic erosion of the barley landraces at Diksis and Lode-Hetosa Districts to be used as base line information for further breeding and conservation.

1.3 Significance of the study

The purpose of this study is to assess the extent of genetic erosion in barley landraces and justify reasons for its erosion at community levels in Diksis and Lode Hetosa districts, Arsi Zone. The findings have contribution to deepen knowledge about farm diversity and genetic erosion of barley landraces conservation practice in study area in particular. In addition the

aim of this study is to record the barley landraces in hands of farmer, to know the extent of genetic erosion on landraces, identify the reason for genetic erosion and historical evaluation of genetic erosion in both districts Diksis and Lode-Hetosa. The result of this research has a great advantage to know the current extent of genetic erosion of barley landraces in those study districts, which are more barley producing area of Arsi zone. It could also serve as base line for those who need to perform further research and give information to all stake holders who actively participate in conserving barley landraces. The information would assist policy makers, researchers, conservationists and related stakeholders to act accordingly in innovating strategies of avoiding complete loss of threatening farmer varieties and replacement of lost barley landraces.

1.4 Objective of the study

1.4.1 General objective

The General objective of the study is to evaluate the extent of on-farm diversity and genetic erosion of barley landraces in Diksis and Lode Hetosa districts of Arsi Zone, Ethiopia.

1.4.2 Specific objectives

To assess the on-farm diversity status of barely landraces in Diksis and Lode Hetosa districts of Arsi Zone.

To estimate the extent of genetic erosion of barely landraces in Diksis and Lode Hetosa districts of Arsi Zone.

1.5 Research Questions

What is the current status of on-farm diversity of barely landraces in Diksis and Lode Hetosa districts of Arsi Zone?

What is the extent of genetic erosion of barely landraces in Diksis and Lode Hetosa districts of Arsi Zone?

What is the current status of the genetic integrity in barely landraces in Diksis and Lode Hetosa districts, Arsi Zone?

2 LITERATURE REVIEW

2.1 Origin of Barely (*Hordeumvulgare* L)

The origin of barley probably took place prior to 7000 B.C. in the origin of the Near East known as "Fertile Crescent along with its domestication". The Fertile Crescent includes parts of Jordan, Lebanon, Palestine, Syria, Southeastern Turkey, Iraq and Western Iran. The wild progenitor of cultivated barley (*Hordeum vulgare* subsp. *spontaneum*) is still widely distributed along the Fertile Crescent, particularly in the driest areas (Harlan and Zohary 1966). Archeological evidence indicated that emmer and einkorn wheat led to the foundation of the old world agriculture (Zohary and Hopf 1993).

The domestication of barley is assumed to have taken place from two-rowed wild barley *Hordeum vulgare*L. Subsp.*Spontaneum* in the Near East (Harlan and Zohary, 1966). However, evidences suggesting alternative ways of barley domestication have been reported (Tanno et al. 2002; Molina-Cano *et al.,* 2005). The controversies surrounding the origin of cultivated barley in the last centuries can be summarized: (1) the six-rowed barley originated repeatedly at different times and in different regions, through independent mutations of *Vrs1* allele (two-rowed spike) (Komatsuda *et al.,* 2007); (2) Tibet is unlikely to be a center of origin for cultivated barley (Yang *et al.* 2008); (3) the numerous other forms are either direct descendants of one or other ancestral forms *H. agriocrithon or H. spontaneum*, or derived from hybridization between the two ancestral forms (Li *et al*., 2004). With the development and advancement of molecular markers in recent years, more precise information on origin and domestication history of barley is emerging. Badr*et al.,* 2000) demonstrated a monophyletic nature of barley origin based on allele frequency at 400 polymorphic AFLP loci studied in a world collection of wild and cultivated barley and showed that the Israel-Jordan area in the southern part of the Fertile Crescent has the highest probability of being the geographical area within which wild barley was domesticated.

The hypothesis of monophyletic origin of barley is further supported by Li *et al*., (2004), who analyzed the rDNA polymorphism in wild barley accessions derived from Tibet and other parts of the world. However, Molina-Cano *et al.,* (1999) suggested barley domestication could have taken place outside the Fertile Crescent, particularly in Morocco. It is now generally accepted that *H. spontaneum* is the progenitor of cultivated barley, however, it is not clear whether cultivated barley is of monophyletic origin or the domestication events happened in other parts of the world besides the Fertile Crescent.

2.2 Genetic Erosion

2.2.1 Description of Barley Genetic Erosion

Genetic erosion is a process where the limited gene pool of an endangered species diminishes even more when reproductive individuals die off before reproducing low population. The term is sometimes used in a narrow sense, such as when describing the loss of particular alleles or genes, as well as being used more broadly , as when referring to the loss of a phenotype or whole species. Genetic erosion occurs because each individual organism has many unique genes which get lost when it dies without getting a chance to breed. Low genetic diversity in a population of wild animals and plants leads to further diminishing gene pool inbreeding and a weakening immune system can then fast- tracks that species towards eventual extinction. By definition, endangered species suffer varying degrees of genetic erosion. Many species benefit from a human –assisted breeding program to keep their population viable, thereby avoiding extinction over long time-farms. Small populations are more susceptible to genetic erosion than larger population.

Genetic erosion as reflected in a reduction of allelic evenness and richness appears to be the most useful definition, but has to be viewed in conjunction with events at variety level (Hammer and Laghetti, 2005).It is not exactly clear when the term genetic erosion was first coined, but probably sometime in the 1960s it was first used to describe the process of the loss of genetic diversity in agriculture (potorius, 1997). The diversity in crops consists of the crops, landraces and grown by farmers.

2.2.2 Genetic Erosion Causes and Consequences in Ethiopia

In Ethiopia, native barley varieties are suffering serious genetic erosion (Mekonen et al., 2000). According to Megersa (2014), on single factor was solely responsible for farmer varieties genetic erosion in Degem district. According to this study, introduction of improved varieties, replacement by other crops, recurrent drought, government policy, change in land size and cropping pattern were factor reported for barley genetic erosion. Similarly, Tsegaye and Berg (2007) as cited in Megersa (2010) reported that the causes of genetic erosion are multifaceted, emanating from responses to changing natural, socio-economic and policy environments. As one of the oldest cereal crops cultivated since ancient times in Ethiopia, barley has passed through the processes of farming which in turn have been affected by the complex socio-cultural attitudes of communities and the prevailing environmental changes. Information concerning the impacts of socio-cultural

conditions of farmers on the maintenance of crop genetic resources is rare in Ethiopia. In most cases, the conservation and maintenance of landraces as part of cultural heritage of a region or country has received too little attention (Seven 1998).Landraces are in many ways comparable with monuments, traditional costumes and folk songs as examples of cultural heritage. In Ethiopia native barley varieties are suffering serious genetic erosion (FAO 1998; Worede et al., 2000). Brush (1999) defined genetic erosion as the loss of variability from crop populations in diversity centers, i.e., areas of domestication and secondary diversification.

2.2.3 The case in Barley Landraces

Genetic erosion is defined broadly as the loss of particular gene complexes as manifested in locally adapted landraces (FAO, 1998). The concept of genetic erosion in cultivated plants could be traced back to the 1930's when H.V. Harlan and M.L. Martini wrote about their concern regarding the loss of genetic diversity in barley landraces (Harlen and Martini 1936).The continued concern about the growing loss of crop diversity both at the species and variety levels has gained global attention and efforts were made to counter the trend at national and international levels, among other things by forming the international board on plant genetic resources in 1974. Barley has a long history of cultivation in Ethiopian highlands. Barley is the major staple crop and it is deeply rooted in the socio-cultural life style of the communities. Over centuries, natural and human selection resulted in a huge diversity of landraces. This diversity, however, is subject to serious genetic erosion (Eticha *et al.,* 2010). The greatest frequency and diversity of barley landraces (Asfaw 2000;Bekele*et al.,*2005, Lakew*et al.,*1997;Yirga*et al.,* 1998).

Genetic Erosion is a process acting both on wild and domesticated species. It is also both natural and manmade process. Naturally, it occurs when there is inbreeding between members of small population that will reveal deleterious recessive alleles. It causes a population "bottleneck" by shrinking gene pool or narrowing the genetic diversity available. This natural process could be the causes for the losses of heterozygosity that reduces the adaptive potential of every population (Caro and Laurenson, 1999). In cultivated plants, genetic erosion is the loss of variability from the population, that is, the loss of heterogeneity of alleles and genotypes with their attendant morphotypes and phenotypes. The American plant explorers are credited for first recognizing the problem of genetic erosion in crops (Harlan and Martini, 1936).

2.3 On-Farm Diversity Landrace Conservation in Ethiopia

The concept of genetic erosion in cultivated plants could be traced back to the1930s when H.V. Harlan and M.L. Martini wrote about their concern regarding the loss of genetic diversity in barley landraces (Harlan and Martini 1936). The continued concern about the growing loss of crop diversity (both at the species and variety levels) has gained global attention, and efforts were made to counteract the trend at national and international levels, among other things by forming the international Board on plant Genetic Resources in 1974 (currently the international plant Genetic Resources Institute-IPGRI) and by the establishment of ex situ gene banks in different countries. The concept emerged strongly between 1965 and 1970, a period when crop improvement gained its momentum (Brush 1999). Among others, Fowler and Mooney (1990) discussed how the loss of genetic diversity had reached an irreversible state for some crops by presenting several cases from across continents. The increasing concern about genetic erosion and the concerted global efforts then engendered several innovative initiatives involving diversification of conservation strategies. The ex situ facility in Ethiopia, formerly established as plant Ethiopian Biodiversity Institute (EBI),was a result of this global effort.

3 MATERIALS AND METHODS

3.1 Description of the Study Site

3.1.1 Lode Hetosa District

Lode Hetosa District is located in Arsi Zone, Oromia Region, Ethiopia. Huruta is the capital town of Lode Hetosa District which was found to south east of Addis Abeba, about 164 km. This study area also found at a distance of 74 km from the Zone capital city, Assela town.The district is bounded by Dodota district in North, Diksis in South, Hetosa in West and Sire district in east. Administratively, the district comprises nineteen (19) PAs which connected with other towns and cities Adama, Asella, Eteya and Dera town. The topography of the study area consists of highland, moderate flat area that are suitable for production of various cereal crops such as teff, wheat and barley. It is also known with onions production. Altitudinal variation of the study area ranges from 1700m to 3800m above sea level. The study area has three agro-climatic Zones; Dega, WeineDega and kola, where the climate is comfortable for settlement and production of different crops. The dominant soil type of the study area includes vertisols, camisoles and clay dark soil. Generally the soil type of district is characterized by clay moderate and fertile soil suitable for growing different types of crops. The population density in the region is relatively high and small units of land are extensively cultivated by subsistence farmers. Based on the 2007 Centeral of the Statistical Agency of Ethiopia (CSA), the district has a total population of 107,688 of whom 53,807 are male and 53,881 female. Most of their income depends on agriculture and rearing of livestock.

3.1.2 Diksis District

Diksis is also one of the administrative units of Arsi Zone. The town of Diksis is found south east of Addis Abeba at a distance of 197km and 108km from Zonal capital city of Assela. Astronomically,the district is located between $8^0$3’37.47”N latitude and $39^0$33’41.16”E longitude. Relatively, the district share the boundary line with Sire and Lode Hetosa district, in the north and Robe and Tena district, in the south, Lode Hetosa and Tijo district in the West and Sude district in the east direction having the total area of district is 28312 hector. Administratively, the district comprises fourteen (14) rural kebeles and three (3) urban kebeles. The district also connects with different towns and city with social

infrastructure. The topography of the study area consists of the highland moderate flat area that is suitable for the production of various cereal crops, such as beans, peas, linseeds, and barleys are the common. Altitudinal variation of the district is range from 2600m to 3200m above sea level. The district has only one agro-climatic zone, Dega where the climate is comfortable for settlement and for production of different crops. The dominant soil types of the study area include vertisols and clay dark soil. The population density in the district is relatively high and small units of land are extensively cultivated by subsistence farmers. Based on the data of Centeralof the Statistical Agency of Ethiopia (CSA, 2007), the district has a total population of 72,301 of whom 35,970 are male and 36,331 are female. Most of their income depends on Agriculture and rearing of livestock.

3.2 Research Design and Procedures

This research was prospective and cross-sectional survey based type, focused on the selected districts. All varieties on the hand of farmers (cultivars) were assessed in the study districts since the last two to three decades. For the on-farm diversity analysis, practical identification was carried out through field observation of the morphological diversity based on phenotypic traits of cultivated barely varieties and landraces on the farmers' farm land in the selected PAs of the two districts from March to June, 2018.

3.3 Sampling Technique and Sample Size Determination

A reconnaissance survey and discussion with the zonal agricultural bureau experts was made before the main data collection to identify the appropriate farmers' kebeles (Peasant association) which were predominantly barely producing in the districts from the long history to the present. Based on the preliminary survey, three peasant associations: Tulu Bego, Aleko and Gabe from Lode Hetosa and two peasant associations: Aleko karra and Karra lencha from Diksis district were selected purposely. Selected sample households (HHs) of each PAswas employed in the study.

Following the Dickson and Nyariki (2009) principle,In agricultural and socio-economic research usually with a 95% confidence level and a margin error of less than 10% is considered to be representative. The sample size was calculated using a standard formula following Freund and Williams (1983);

$$n = \frac{(Z)^2\ (p * q)}{(d)^2}$$

$n = \frac{(1.96)^2\ (0.5*0.5)}{(0.07)^2} = \frac{0.9604}{0.0049} = 196$

Where: n = sample size

z = statistical certainty usually chosen at 95% confidence level, that is, $z = 1.96$

p = estimated level/coverage to be investigated, usually $p = 0.5$ is chosen

q = 1-p

d = precision desired, which need to be less than 10% and then for this research $d = 7\%$

Considering 10% non-response rate, a total of 216 households were expected to participate in the study that was carried out from December 2017 to March 2018 from the five selected PAs of Diksis and Lode Hetosa districts of Arsi Zone.

3.4 Source of Data and Methods of data collection

To attain the objective of the study, data was collected from both primary and secondary sources. The investigator was collected the primary data in the form of field observations, Focus Group Discussion, semi-structured interview and questionnaire. Secondary data was collected by using available sources of information such as published and unpublished documents. Formal and informal surveys were also employed.

3.4.1 Questionnaire

Close and open-ended questions were prepared and distributed to the selected 216 sample households to get information about extent, status and determinant of on-farm diversity and genetic erosion of barley landraces. The questionnaire was prepared in English and translated to Afan Oromo language then distributed to the respondents to collect necessary information by data collector. The closed ended questions were used to enable the respondents to select one option that meet; open ended questions were give opportunity to the respondents to express their perceives ,feeling and problem concerning the study. The households were interviewed using a semi-structured questionnaire prepared by the researcher. The questionnaire covered different topics such as information about the study area, landholdings, on farm morphology of barely landraces, commonly grown barely landraces before 20 to 30 years, introduced improved varieties by National Variety Releasing Committee. Purposive selections of farmers were done by using age as the

simple index to identify farmers with more experience. Households with different age groups were included. Farmers compared the situation of barely landraces cultivated 20 to 30 years ago with present situations. The detailed information focused on cultural practices, environmental stress on each landraces, end-use cultural values of barely and comparison of newly introduced barely varieties and landraces. They were selected from household heads of both sexes and specified age groups based on their availability, willingness and experience on barely landraces.

3.4.2 Focal Group Discussion (FGD)

Exploration of on-farm diversity of barely landraces was carried out for the first time. A questionnaire concerning production and conservation practices by the farmers was prepared in English and translated to local language which was Afan Oromo by language expert. Key informant interviews were also made with knowledgeable people in the area who were supposed to participate in the development workers. Key informants were selected with the help of development agents (DAs) and Kebele administrators. The DAs and the kebele leaders at each kebeles were also a part of key informant interview since they were the role player for the intervention. Two to three farmer focal groups per PA containing 4 to 10 individual farmers per group was formed. Development agents from the districts' agricultural offices assisted in organizing the farmers in groups. Selections of farmers were random in order to include target age groups and gender. During the focal group discussion, farmers compared the situation of barely landraces cultivated 20 to 30 years ago with present situations. In most cases the age of the farmers' was more than 40 years. Discussions were made among different groups of farmers following the questionnaire. Equal opportunities to raise their ideas was given for both gender groups during group discussion. After thorough discussion consolidated ideas were noted.

3.5 Data Analysis

The quantitative data which was collected by open and closed -ended questionnaires were checked for completeness and consistencies during and after the data collection and then,the data wasentered, coded and cleanedby Statistical Package for Social Scientists (SPSS) windows version 22 software for analysis. The quantitative data was analyzed by categorizing into different thematic area and narrating each topic separately. Descriptive statistics was used to describe the data of study area. The data was more of quantitative than

qualitative and main ideas from the interviews were used to explain the detail problems. The present status from March to June, 2018 of on-farm genetic diversity (genetic erosion) of barely landraces were quantified using the formula of Hammer *et al*. (1996) and it was given as:

GE= 100%-GI;

Where *GE* is genetic erosion and *GI* is genetic integrity which is given as:

GI=$\frac{N2}{N1}x100\%$;

Where *N1* is the number of landraces in previous time (in 1990s) and *N2* is the number of present(2018) landraces. Information about the 1990s collections was obtained from experienced farmers and agricultural office of Diksis and Lode Hetosa districts as initially stated under method of data collection.Concerning to the privacy and confidentiality of information from each respondent was maintained through anonymity.

Chi-square Test

The Chi-square test for independence is used in situations where there are two categorical variables. A categorical variable is a qualitative variable in which cases are classified in one and only one of the possible levels. Chi-square value was computed as:

$$X^2 = \sum\left(\frac{(observed\ frequecy - Expected\ frequecy)^2}{Expected\ Frequency}\right) = \sum\left(\frac{(O-E)^2}{E}\right)$$

The observed frequencies are measured values, the values that are found in the table. Then, the expected value could be calculated by the following formula,

$$Expected\ frequecy = \frac{(row\ total) * (column\ total)}{grand\ total}$$

The difference between observed and expected values is the basis of the Chi-square statistic, since it evaluates the likelihood that the differences between the observed and expected values would occur under the null hypothesis that there is no difference between these values.

Binary Logistic Regression:

Logistic regression is useful to predict the presence or absence of a characteristic or

outcome based on values of a set of predictor variables. It is similar to a linear regression model but is suited to models where the dependent variable is dichotomous. A logistic regression coefficient was used to estimate odds ratios for each of the independent variables in the model. It estimates models using block entry of variables or any of the following stepwise methods: forward conditional, forward LR, forward Wald, backward conditional, backward LR, or backward Wald.

Data: The dependent variable should be dichotomous. Independent variables can be interval level or categorical; if categorical, they should be dummy or indicator coded (there is an option in the procedure to recode categorical variables automatically).

Assumptions: Logistic regression assumes meaningful coding of the variables: it is difficult to interpret if the variables are not coded meaningfully. The convention for binomial logistic regression is to code the dependent class of interest as 1 and the other class as 0. The dependent variable must be categorical.The groups must be mutually exclusive and exhaustive; a case can only be in one group and every case must be a member of one of the groups.Logistic regression does not assume a linear relationship between the dependent and independent variables.

4 RESULTS AND DSICUSSION

4.1 Results

4.1.1 Descriptive Analysis

Descriptive statistics are a set of brief descriptive figures that summarizes a given data set, which can either be a representation of entire sample of study population.Among a total of two hundred sixteen(216) sample size, two hundred four (204) respondents all greater than 40 years old were interviewed through the provided semi-structured questionnaire. Out of two hundred four (204) respondents only 30 (14.7%) were women. Though the opportunities were given to both gender groups during group discussion, the number of women participants were much smaller than men participants as indicated in Table 1.As respondents in the study area reported,men are decision makers to conserve a plant variety largely depending on its usefulness to the household and socio-cultural importance. Farmers compared the situation of barley landraces cultivated in the last two to three decades with present situations. In addition seventy five (75) of the respondents were participated in group discussion. The discussions were made among different groups of farmers following the questionnaire and agenda of discussion.

Table 1: Respondents participated in household interview and group discussion

Study districts	Study kebeles	Total sample HHs			Participants of FGD		
		M	F	Sum	M	F	Sum
Diksis	Aleko-Karra	39	4	43	14	1	15
	Karra-Lencha	25	4	29	14	1	15
	Sum	64	8	72	28	2	30
Lode	Gabe	33	15	48	13	2	15
Hetosa	Aleko	45	6	51	15	0	15
	Tullu-Bego	38	7	45	14	1	15
	Sum	116	28	144	42	3	45
	TOTAL	180	36	216	70	5	75

HHs = House Holds, FGD= Focal Group Discussion

As per the result, from the total 204 respondents in the present study of rural households in

Diksis and Lode Hetosa districts of Arsi Zone,70(34.3%) were from Diksis district and 134(65.7%) were from Lode-Hetosa district of Arsi Zone. This indicates that the sample size of Lode-Hetosa district is greater than Diksis district because of its wideness.

Similarly the result of the study shows that out of the sampled households, 40.7%, 47.5% and 11.8% were in the age categories of 41-50, 51-60 and >60, respectively, Table 2 .

Table 2: Frequency and Percentage of age category of respondents participated in household interview

Age	Frequency	Percentage (%)
41-50 years	83	40.70%
51-60 years	97	47.50%
>60 years	24	11.80%
Total	204	100.00%

Majority of the respondents have primary education,Accordingly,in the order of magnitude,147 (72.06%), 28(13.73%), 28(13.73 %) and 1(0.49%) have reading and writing skill, High school and college diploma, respectively (figure 1)

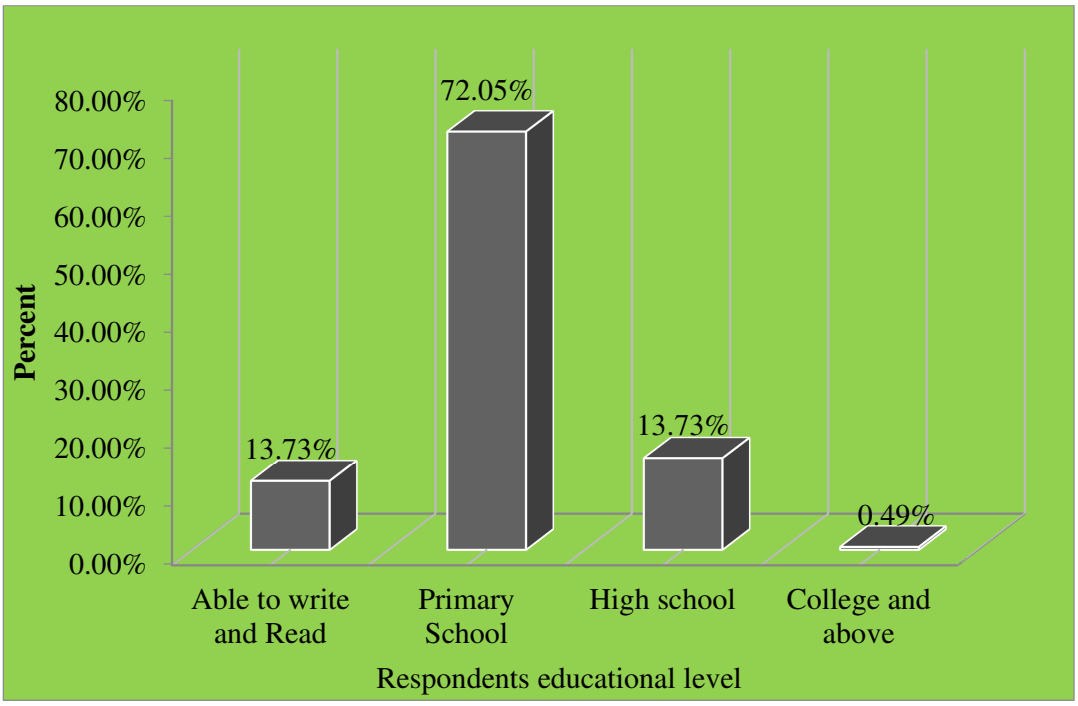


Figure 1: Proportion of respondents by educational level

In the same way, the farmers have been in the barley farming production and accordingly 86(42.2%) have produced for 21-30 years whereas the remaining 118(57.8%) produced the

barely for more than 30 years in the Diksis and Lode Hetosa districts.

4.1.2 On-Farm Status of Barley Diversity

The current status of on farm diversity of individual barley landrace was determined by listing of interviews for farmers cultivating on their farm. In the study area, barley was the dominant crop and also much more important for both home consumption and market to generate money. Farmers reported that barley does not needs better soil fertility as other crops. According to the report of interviewed household farmers there are two seasons:short rainy season from March to June (locally called Belg)and long rainy season from May to November (locallycalled Maher)season for barley production in the area. Farmer in the study area have grown barley on more than half of their land every summer season. In spring (locally called Belg) season some farmers grown barley on relatively small land coverage because of the availability of high rain during harvesting time. On the other hand, the entire total surveyed respondents reported that they cultivate barley both in short rainy and long rainy seasons in the Diksis and Lode Hetosa districts. However, all agreed that long rainy season is more productive in Diksis and Lode Hetosa districts.

4.1.3 Major crops grown by farmers in Diksis and Lode-Hetosa Districts

According to the result from table 3, the respondents list and rate the types of major crops grown at present in the districts are namely Barley, Wheat, Bean, Linseed and others. Accordingly, 75% of the respondents revealed that barley is highly produced in the area followed by bean (12.2%), wheat (5.9%), linseed (4.9%) and others (pea, maize, etc.(2%)).

Table 3: The Major Crops Grown by the Farmers in the study areas

Major crops growing	Frequency	Percentage
Barley	153	75.00%
Bean	25	12.20%
Wheat	12	5.90%
Linseed	10	4.90%
Others(pean, maize, etc)	4	2.00%

4.1.4 Barley landraces cultivated for the last 20 to 30 years and still under cultivation in Diksis and Lode-Hetosa Districts

Accordingly, from the interview result of the farmers, it was confirmed that the nationally released improved barleyvarieties are more dominantly used at the study area. As this survey indicated most of the farmers have been cultivatingabout 14 barley landraces for the last 2 to 3 decades, Table 4.

Table 4:Barley landraces cultivated for the last 20 to 30 years and still growing in Diksis and Lode-Hetosa Districts

Serial Number	Barleylandraces cultivated for the last 20 to 30 years	Frequency	Percentage
1	Shamame	6	2.94%
2	Kinchicho	11	5.39%
3	Farasgama	12	5.88%
4	Falibaye	12	5.88%
5	Samareta	13	6.37%
6	Kasale	14	6.90%
7	Sanafkolo adi	15	7.35%
8	Tesfaye	16	7.84%
9	Barsadad	16	7.84%
10	Aruso	16	7.84%
11	Kate	17	8.33%
12	Damoye	18	8.80%
13	Akalai	18	8.82%
14	Sanafkolo guracha	20	9.80%
Total		204	100.00%

4.1.5 The morphology of barley landraces in Diksis and Lode-Hetosa Districts

Farmers respondents repoted that they are familiar with the nature of barely landraces they grow, able to describe their agronomic characteristics and end-use. They use specific names for all the landraces and generic names for groups of landraces. Generic names were given based on characters like seed color, seed shape, e.g., kasale for black seed color, sanafkolo adi for white seed color, sanafkolo guracha for black seed color, kinchicho for short shape

respectively barley landraces. Most of the landraces have distinct and non-overlapping characters of their own. The descriptions were all given by farmers and supported by own field observations for those landraces which are still cultivated.Most of the barley landraces like falibaye, kasale, damoye, tesfaye, barsadad, farasgama, samareta, kinchico, aruso, akalati and shamame had near to six months maturity period while a few of them like kate, sanafkolo adi and sanafkolo guracha had four months. Based on number of rows on seeds(caryopses) some types of barley like kate, sanafkolo adi, sanafkolo guracha, samareta and Aruso had two rows(natala) seeds while others like barsadad, falibaye, damoye, tesfaye and shamame had six rows(dirib) seeds caryopses)).

4.1.6 Meanings of vernacular name of barley landraces

Vernacular names of each barley landraces have their own local meanings as for instance kasale has its name from its black seed color, damoye brown barley, the name refers to the seed color. Tasfaye named due to hope on it for huge production seed, Barsadad chosen seed because of its relatively high production and food qualities than others. The vernacular names are important within farming communities to distinguish a variety from the other. Vernacular names are simple and easily understood by farmers. They are also important to maintain the identity of a variety.

Table 5: Vernacular names, seed color,seed height/shape,number of rows and maturity months of barley landraces cultivated for the last 2 to 3 decades in Diksis and Lode-Hetosa Districts

Serial Number	Vernacular names	Seed color	Seed height	Number of rows/ caryopsis	Maturity time
1	Falibaye	White	Long	Six rows	Six months
2	Kasale	Black	Long	Six rows	Six months
3	Damoye	Brown	Long	Six rows	Six months
4	Tesfaye	White	Long	Six rows	Six months
5	Barsadad	White	Long	Six rows	Six months
6	Farasgama	White	Long	Six rows	Six months
7	Kate	White	Long	Two rows	Four months
8	Sanafkolo adi	White	Long	Two rows	four months
9	Sanafkolo guracha	Black	Long	Two rows	four months
10	Samareta	White	Long	Two rows	Six months
11	Kinchicho	White	Short	Six rows	Six months
12	Aruso	White	Long	Two rows	Six months
13	Akalati	White	Long	Six rows	Six months
14	Shamame	White	Long	Six rows	Six months

4.1.7 Preparation of farm lands for growing barley landraces

The majority of the repondents covered greater than half of their field for barley production in the study area. According to soil type and landraces, it is common that the farmers systematically divide their farm lands to different varieties every season. In the areas of vertisols and clay dark soil the farmer plough their farm lands three to four times before they sow barely seeds. Because, barley landraces no need more fertile soil as other crop like wheat. In the study area more than two landraces are sometimes grown in mixtures. According to the respondents of this study, the farmland is allocated to each landrace based on soil fertility and nutrient demand of the variety. The applied cropping practice, locally called ‘ikir’, should regain soil fertility and/or improve soil texture by fallowing the farmland every second season. Farmers indicated that planting barley after bean or any other cereal results high yield. The study also revealed, Table 6, that the proportion of

farmland size covered by varieties and accordingly, 55(27.0%) of respondents covered about half of their farmland size by barley varieties while the remaining149 (73.0%) of them covered greater than their farm size by barley varieties in Diksis and Lode Hetosa districts.

Table 6: Proportion of farm land size with barley in the Diksis and Lode-Hetosa Districts

Proportion of land size	Frequency	Percentage
Less than half	0	0.00%
About half	55	27.00%
Greater than half	149	73.00%



Figure 2: Preparation of farm land for barley cultivation

4.1.8 Selection of seed in sowing

The selection of seeds for sowing and food consumption is done by both men and women farmers based on the quality of food, high productivity (high yielding seed type) and the demands on market. This traditional practice of selection and depositing seed for the next season for growing is replaced by the announcement of new varietal by experts of agriculture (agronomist). Selections within and between landraces are seldom carried out and if it is rather a mass selection considering specific traits such as height, lodging, earliness, head type and shape, etc., than an individual plant selection. Concerning end-use quality, women are responsible for the decision of planting a particular landrace. Usually farmers sow their own seed, less often seed exchange and loans are practiced within the community. Most farmers reasoned out this because of the neighbor or relative might have

preferable types of seeds for sowing. For the last 20 to 30 years the household leader controls the outgoing and incoming of grain. However, the control is weak when the seeds are stored in traditional containers made from wood, mud and cow dunglocally called *gotera*. Recently, kinds of *sacks* locally known as madabaria or Kesha/ Donia are becoming popular mainly for easy control of grain seeds to store in the household. Grain is also sold in open markets or by retailers. Farmers in this area controlling the seedling from different weeds, pests, diseases and other disaster are traditional. For example, according to the respondents of this study, they store in dry area to prevent moisture that can cause early germination in gotera or in other storage.



Figure 3: Traditional, picking weed (a), collecting and harvesting (b), threshing(c) and winnowing of barley landraces in the study area.

4.1.9 End-Use

Concerning end-use quality, women are responsible for the decision of planting a particular landrace. The end-use of these barley landraces are food, trading crop, keeping environmental balance and food for cattle. Some landraces are popular and known to most farmers while others are not. This fact implicates wider adaptability of some landraces across a range of environments as well as their inherent values for consumption by households, socio-cultural needs and market demand. In the study area, women are the sole members of the households who are fully responsible for the processing of food and drinks. In rural societies women do also the wide farm labor. In this study women were better able to describe the landraces in regard to their grain texture, grain hardness, flour, cooking, malting, food and beverage-making quality, while men had better knowledge about

agronomic traits such as lodging, plant height, maturity, disease tolerance, thresh ability, yield performance and straw quality. Opposite to women, men's interest was on the typology and suitability of their farms for different landraces. The result of this study also revealed barley usage for ceremonial purposes and exposed that songs, tale, sayings, believes and incantations concerning barley in the locality of the study area(Table 7).As farmers responded, all barley landraces were used for preparation of different food items except Kate barley landraces which is not used for injera. Respondents also added barley land races are used for preparation of different local beverages as shown below (Table 8).

Table 7: Local food items prepared from barley landraces

Barley landraces	Food items prepared from barley landraces				
	Injera	Porridge	Kinche	Baso	kolo
Falibaye	√	√	√	√	√
Kasale	√	√	√	√	√
Damoye	√	√	√	√	√
Tesfaye	√	√	√	√	√
Barsadad	√	√	√	√	√
Farasgama	√	√	√	√	√
Kate	*	√	√	√	√
Sanafkoloadi	√	√	√	√	√
Sanafkologuracha	√	√	√	√	√
Samareta	√	√	√	√	√
Kinchicho	√	√	√	√	√
Aruso	√	√	√	√	√
Akalati	√	√	√	√	√
Shamame	√	√	√	√	√

√=yes,*=no

Table 8:Local beverages prepared from barley landraces

Barley landraces	Types of beverage prepared from barley landraces				
	Tala	Local Arake	Karibo/kurie	Soup/shorba	shameta
Falibaye	√	√	√	√	√
Kasale	√	√	√	√	√
Damoye	√	√	√	√	√
Tesfaye	√	√	√	√	√
Barsadad	√	√	√	√	√
Farasgama	√	√	√	√	√
Kate	√	√	√	√	√
Sanafkoloadi	√	√	√	√	√
Sanafkologuracha	√	√	√	√	√
Samareta	√	√	√	√	√
Kinchicho	√	√	√	√	√
Aruso	√	√	√	√	√
Akalati	√	√	√	√	√
Shamame	√	√	√	√	√

√=yes

4.1.10 Genetic Erosion

Farmers who participated in the present study have listed many natural and social factors that have been contributing to the loss or maintenance of barley landraces in the study area. In both, Diksis and Lode-Hetosa districts of Arsi Zone, barley production has passed through complex processes. Farmers reported that there was a brief period(2011-2015) when some the traditional barley varieties were replaced by newly released improved barley varieties. Improved barley varieties which were introduced into the system pushed to wider areas and barley became the main cereal crop at that period. Later on, barley cultivation declined to its prior acreage due to declining soil fertility, less resistance to water logging (forexample barely landrace called kate), less resistance to disease and pesticide, less productivity and less attention given by farmers, frost damage and release of new varieties by the government.

Based on genetic erosion formula,

GE=100%-GI; Where as GI=N2/N1*100%

N1=14,N2=6,finally the result of GI=42.86% and GE=57.14%

The other factors to the decline of barley landraces that explained by the respondent were less acceptance on market and the reduction in price when compaired with improved barley varieties. Currently, in both districts, almost more than half landraces of barley which were cultivated for the last 2 to 3 decades were eroded. Genetic erosion was estimated for both districts systematically by exploring barley landraces cultivated 2 to 3 decades compared with the present situation and 119(58.33%) was eroded while 85(41.67%)farmers still producing at least one type of (barley in Diksis and Lode Hetosa districts of Arsi Zone. The continuous cultivation of some landraces might be due to a wide adaptation to changing environments and end-use that is not obtained from other landraces or improved varieties(figure 4).

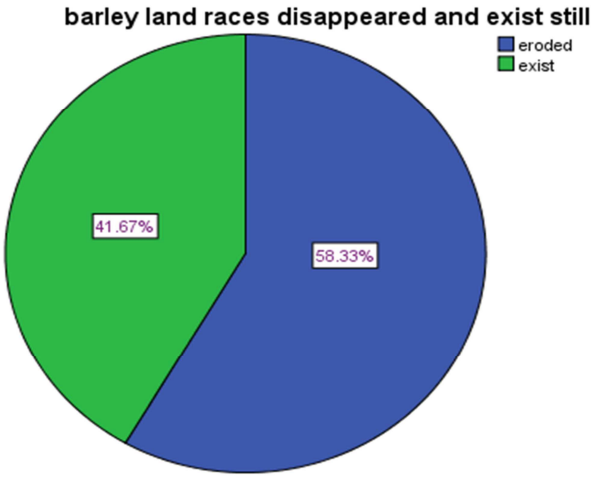


Figure 4: Barley landraces status in the study area

4.1.11 The extent of genetic erosion and genetic integrity of landraces in Diksis and Lode-Hetosa districts

From a total of two hundred fifteen (216) sample size two hundred four (204) respondents were interviewed. Among these, 119 (58.33%) revealed barley genetic erosion while 85 (41.67%)farmers still producing at least one types of the barley in Diksis and Lode Hetosa districts of Arsi Zone, Table 9.

Table 9: Barley landraces disappeared/eroded and still in cultivated/grown in Diksis and Lode Hetosa districts

S.N.	Barley landraces disappeared/eroded	Barley landraces still grown
1	Falibaye	Kasale
2	Damoye	Tesfaye
3	Farasgama	Barsadad
4	Kate	Sanafkolo adi
5	Samareta	Sanafkolo guracha
6	Aruso	Kinchicho
7	Akalati	
8	Shamame	
Total	8	6

4.1.12 Cause of genetic erosion

Based on the result of this study the production of barley landraces become decline in the last two to three decades in both Diksis and Lode-Hetosa districts of Arsi zone. As farmers interviewed in this study, many natural and manmade factors that have been contributing to

the loss or maintenance of barley landraces was listed, Table 10. The factors that decline the production of landraces in the districts were also identified as climate change, market price and demands, availability of high yielding variety, food quality and low consideration of conserving landraces in Diksis and Lode-Hetosa districts of the Arsi zone. The major factors were the availability of high yielding variety which accounts 17.6%. Among the respondents, 48% also revealed that the combination of the factors caused decline in production of landraces in the districts. No single factor was solely responsible for barley genetic erosion in Diksis and Lode Hetosa districts of Arsi Zone. Introduction of improved varieties, replacement by other crops, recurrent drought, government policy, change in land size and cropping pattern were factor reported for barley genetic erosion in the study area. Similarly, the relative contribution of each factor varies across space and time.

Table 10: Factors that decline the production of barley landraces in the study area

Factors	Frequency of respondents	Percentage
Climate change	17	8.30%
Market price and demands	23	11.30%
Availablity of high yielding new varieties	36	17.60%
Food quality	19	9.30%
Low consideration of conserving landraces	11	5.40%
Combination of all	98	48.00%
Total	204	100.00%

The topography of the barley cultivation land was also considered as an important factor for the investigation of barley genetic erosion in Diksis and Lode Hetosa districts, Table 11. Accordingly, the result shows that of from the total surveyed respondents, 82.8% preferred the plateu and the remaining, 17.2% had preferred plain level topography for cultivation of barley in Diksis and Lode Hetosa districts.

Table 11: Topographic factors that reduced the production of barley landraces in the study area

Types of topography	Frequency	Percentage
plain level	35	17.20%
Plateau	169	82.80%
Total	204	100.00%

4.1.13. Chi square test of association between barley genetic Erosion and particular predictors

The response variable considered in this study was the Barley genetic erosion (eroded or still existing). Before fitting any models to the relationship between barley genetic erosion and explanatory variables, we first examined the bivariate relationship between barley genetic erosion and predictors. This section reports the association between the response variable (barley genetic erosion) and each predictor variables. This was done by cross tabulating each predictor variables against the Barley genetic Erosion and tested using chi square test statistic. The result showed the row percentage and count of barley genetic Erosion status with respect to the categorical covariates. Pearson chi-square test was applied to know predictors having a strong association with the response variable (barleygenetic Erosion).For each predictor, a test of association was carried out using the Pearson χ^2 at 5% level of significance. High value of Pearson χ^2 for a given predictor indicates that there is a strong association between dependent and independent variable keeping the effect of other factors constant.The hypothesis testing is:

H_0: There is no association between Barley genetic Erosion and particular predictor Vs

H_1: There is association between Barley genetic Erosion and particular predictor.

4.1.14. The estimates of coefficients and odds ratio of binary logistic regression

In this section, the logistic regression analysis results obtained by using enter inclusion of variables, overall model evaluation, statistical tests of individual predictors and goodness of fit statistics are presented. Multiple logistic regressions were fitted based on the chi-square test result of bivariate analysis. Based on results displayed in table 13 predictor variables whose bivariate test had p-value less than 0.05 (i.e. associated with response variable) were considered for multiple logistic regressions.

In Table 12 below, the values in the column labeled $\hat{\beta}$ are estimated coefficients. They are the values (in log-odds units) for the logistic regression equation for predicting the dependent variable (barley genetic erosion) from the independent variables. S.E's are the standard errors associated with the coefficients, which are used for testing whether a parameter is significantly different from zero. The Df column gives the degrees of freedom associated with the tests of the coefficients. The Exp ($\hat{\beta}$) column gives the adjusted odds

ratios (OR) for each category of each variable. They are the exponentiation of the coefficients. The first categories of the explanatory variables are used as reference categories.Another finding of this study also indicates that proportion of farmland size is significantly associated with barley genetic erosion at 5% level of significance. The odds of barley genetic erosion of farmers' who covered less than half of their land size was 0.667 times greater than those who covered greater than half of their farmland size in Diksis and Lode Hetosa districts of Arsi zone, Table 12.

Table 12: The Estimates of Coefficients and Odds Ratio of binary logistic regression

Variables	β	S.E.	Df	Sig.	Odds Ratio
sex(1)	0.25	0.41	1	0.55	1.28
Proportion of their farm land size covered by barley			2	0.00	
Proportion of their farm land size covered by barley(1)	-0.41	0.57	1	0.47	0.67
Proportion of their farm land size covered by barley (2)	-2.02	0.44	1	0.00	0.13
Season in which they cultivate barley			2	0.08	
Season in which they cultivate barley(1)	0.43	0.36	1	0.23	1.53
Season in which they cultivate barley(2)	1.20	0.53	1	0.02	3.32
Dominant barley varieties	0.79	0.40	1	0.05	2.20
Barley food used for ceremonial purposes	0.17	0.47	1	0.73	1.18
Any tells, songs, believes about barley	0.07	0.33	1	0.83	1.07
Do you use different farm lands for barley?	-0.11	0.31	1	0.72	0.90
Factors that decline the production of barley landraces			5	0.34	
Factors that decline the production of barley landraces(1)	0.11	0.48	1	0.82	1.12
Factors that decline the production of barley landraces(2)	0.82	0.48	1	0.09	2.27
Factors that decline the production of barley landraces(3)	0.67	0.40	1	0.10	1.95
Factors that decline the production of barley landraces(4)	-0.22	0.54	1	0.69	0.80
Factors that decline the production of barley landraces(5)	0.10	0.53	1	0.85	1.11

S.E = standard error, Df= degree of freedom, Sig.= Significance level

The bivariate association between Barley genetic erosion status and predictors shown in Table 12 indicates that Barley genetic erosion status was strongly associated with, proportion of farmland size covered by barley,Season in which they cultivate barley, Use of improved barley varieties, Dominant barley varieties werefactors that decline the production of barley land races in Diksis and Lode Hetosa districts of Arsi zone.

The results from multi-varieties logistic regression analysis in table 13 revealed that proportion of farmland size covered by barley and season in which they cultivate barley were significant predictors of barley genetic erosion in Diksis and Lode Hetosa districts of Arsi zone at 5% level of significance (table 13).

Table 13: Estimates of Coefficients and Odds Ratio of multi-varieties logistic regression of genetic erosion of barley landraces

Variables	β	S.E.	df	Sig.	Odds ratio
Proportion of their farm land size covered by barley			2	0.00	
Proportion of their farm land size covered by barley(1)	-0.19	0.61	1	0.75	0.83
Proportion of their farm land size covered by barley (2)	-1.99	0.45	1	0.00	0.14
Season in which they cultivate barley			2	0.04	
Season in which they cultivate barley(1)	0.49	0.38	1	0.20	1.64
Season in which they cultivate barley(2)	1.51	0.60	1	0.01	4.51
Dominant barley varieties	0.69	0.46	1	0.13	1.99
Constant	-0.98	0.55	1	0.08	0.38

S.E = standard error, Df= degree of freedom, Sig.= Significance level

4.2. DISCUSSION

A total sample of 204 farmers' was included in this study. Among these, 119 (58.33%) revealed barley genetic erosion while 85 (41.67%)farmers still producing at least one type of barley in Diksis and Lode Hetosa districts of Arsi Zone. This finding was almost similar with a research conducted in Degem district of north shewa, (Megersa G., 2014) which was 65%. It said no single factor was solely responsible for barley genetic erosion in Degem district of north shewa. Introduction of improved varieties, replacement by other crops, recurrent drought, government policy, change in land size and cropping pattern were factor reported for barley genetic erosion at Diksis and Lode Hetosa districts of Arsi Zone. Similarly, the relative contribution of each factor varies across space and time.Barley (Hordeumvulgare L.) is a major traditional cereal crop in Ethiopia representing about 18% of the total national cereal production. It ranks third in area after teff and maize. On average, 1.0 million tons of barley is produced annually, with an average yield of 1.0 tons per hectare (Central Statistical Authority, 1992).).

Currently, in both districts Diksis and Lode-Hetosa almost more than half barley landraces were cultivated for the last 2 to 3 decades were eroded. Genetic erosion was estimated for both districts systematically by exploring barley landraces cultivated 2 to 3 decades compared with the present situation and 119(58.33%) was eroded while 85(41.67%)farmers still producing at least one type of barley in Diksis and Lode Hetosa districts of Arsi Zone. This finding was almost similar with a research conducted about the status of genetic erosion of barley landraces in Dandi and Jeldu districts in the Highlands of West Shewa, Ethiopia (FirdissaEticha, WoldeyesusSinebo and Heinrich Grausgruber,2010).

According to this study the major factors for genetic erosion were the availability of high yielding variety which accounts 17.6%. This study is different from the study done at highlands of west shewa, Ethiopia (Eticha et al., 2010) which said that environmental factors like degradation of soil fertility were the main factor for loss of diversity.The crop is cultivated in two seasons per year in most of the highlands of Ethiopia. The main cropping season, locally known as Meher, uses the June–September rains with harvest in December–January. The March–April rains provide moisture for a second season, locally called Belg, with the crop harvested in June–August. In some regions, such as Gojam, barley is also produced from September to January, locally known as Bega, under residual moisture. During the Belg season barley is the most widely grown cereal. It covers about 40% of the area and gives 46% of the total cereal production (Central Statistical Authority, 1992).

Similarly the results from this survey explain that there are two seasons in which barley cultivated in the study area.

Another study done on genetic erosion of Crop species (like barley) in Tigray,Ethiopia (Reda and Mesfin,2017) indicated 86.73% were under serious threat of extinction which was higher than the current finding at Diksis and Lode Hetosadistict of Arsi Zone.Barley grows best on well-drained soils and can tolerate higher levels of soil salinity than most other crops. Food barley is commonly cultivated in stressed areas where soil erosion, occasional drought or frost limits the ability to grow other crops (Berhanu B., Fekadu A. and Berhane L., 2005). Similarly in the study area barley landraces cultivated on vertisols and clay dark soil by plough the farm three to four times. Because, barley landraces no need more fertile soil as other crops.

According to the description of the respondents the selection of seeds for sowing and high productivity (high yielding seed type) and the demands on market is done by the men and women based on the quality of food. This traditional practice of selection and depositing seed for the next season for growing is replaced by the announcement of new varietal by experts of agriculture (agronomist).This report of the farmers is similar description with (Eticha et al., 2010). Farmers didn't have a culture of depositing seeds for the next season's sowing and for food consumption. But they differentiate seeds from its unwanted things include light, small sized grains and weed seeds and chaff are removed from the seeds by winnowing.

As farmers in both districts reported the barley have good test in food and beverages are commonly used for its excellent nutritional value of making injera, porridge, kinche, beso and kolo. Kasale is more preferable to prepare local drinks tella and areke; due to this the mothers take a great care when they prepare this drink from it. Barsadad is mostly used in making injera and porridge. Sometimes it is also used to prepare kinche,beso,kolo and local drinks. Sanafkoloadi and sanafkologuracha are the main one to produce kolo. The same explanation were given by (Negash G., 2013) Foods / snacks such as Budena / injera,Marka and kolo.

The present study also indicated the barley landraces were used in different cultural and believe ceremonies. In cultural ceremonies, Injera, porridge, kinche, baso andkolo are commonly used which were prepared from barley in special ways. In religious ceremonies chachabsa, porridge, michira (chuko) and kinche were prepared from well and careful preparation flour of kinchicho, barsadad, tasfye,shamame and sanafkoloadi.

From the respondents reflection each vernacular names of the barley landrace varieties have their own meanings. For example, the name Kasale has a meaning of black color. Barsadad is named from its greatest ability to resist starvation problem. Damoye resist all environmental stresses and has long maturity day. Sanafkolo adi and sanafkologurachanamed due to their seed color and easy to produce kolo from them. Farasgama indicatedby long spicks. Each vernacular name of barley landraces has their own meanings. For e.g.shamame has its name from its white seed color. Barsadad was chosen seed because it is better than other in product. The same description was given by (Negash and Heinrich, 2013) that the vernacular names are important within farming communities to distinguish a variety from the other. Vernacular names are simple and easily understood by farmers. They are also important to maintain the identity of a variety.

According to (Hammer and Laghetti, 2005) Genetic erosion may occur at three levels of integration: crop, variety and allele. (Brown and Brubaker, 2002) also explain the same idea that Genetic erosion is the process of the loss of portion of the gene pool of a species in a specific region. Here, we used the term in the sense of loss of particular alleles, or the loss of genotypes, subspecies, or varieties, while acknowledging some conservationists use it to describe species extinction. In this study the Genetic erosion was estimated in variety level for both districts systematically by exploring barley landraces cultivated for the last 20 to30 years compared with the present farmers reports in the study site. Genetic erosion was estimated for both Diksis and Lode Hetosa districts as 57.14%. The bivariate association between barley genetic erosion status and predictors shown in indicates that barley genetic erosion status was strongly associated with proportion of farmland size covered by barley, Season in which they cultivate barley, Use of improved barley varieties and Dominant barley varieties were factors that decline the production of barley land races in Diksis and Lode Hetosa districts of Arsi zone at 5% significancelevel.

5. CONCLUSION AND RECCOMMENDATIONS

5.1. Conclusion

In both study districts the respondents reported there were about 14 barley landraces cultivated for the last 2 to 3 decades. Eight of them (Falibaye,Damoye,Farasgama, Kate, Samareta, Aruso, Akalati and Shamame) were eroded, while six of them (Kasale,Tesfaye,Barsadad,Sanafkolo adi, Sanafkolo guracha and Kinchicho) are still cultivated. From the analysis of Binary logistic regression association between barley landraces genetic erosion status and predictors genetic erosion status is strongly associated with proportion of farmland size covered by barley, topography, Use of improved barley varieties, Dominant barley varieties, person who select seed and factors that decline the production of barley land races were significant predictors of barley genetic erosion in Diksis and Lode Hetosa districts of Arsi zone at 5% level of significance. The estimated Genetic Erosion of barley landraces was 57.14% (GE=100-Genetic Integrity (GI)) and the estimated Genetic integrity was 42.86% for the last 20 to 30 years.

From the analysis of multi logistic regression association between barley landraces genetic erosion status and predictors indicates that genetic erosion status was strongly associated with proportion of their farm land size covered by barley and season in which they cultivate barleywere significant predictors of barley genetic erosion in Diksis and Lode Hetosa districts of Arsi zone at 5% level of significance.The causes of genetic erosion were climate change, market price and demands, availability of high yielding variety, food quality and low consideration of conserving landraces in Diksis and Lode Hetosa districts of Arsi zone. Availability of high yielding variety is considered to be the main cause of genetic erosion in the study area. The loss of landraces from Diksis and Lode Hetosa districts do not totally mean the extinction of landraces. Those landraces may survive and can be grown somewhere in Ethiopia.

5.2. Recommendations

Barley as a food and feed grain is important to the livelihood of farmers and it was also observed that farmers' beliefs, tales, songs, social and cultural situations have strong linkages with foods and drinks made from barley in Diksis and Lode Hetosa districts of Arsi Zone. Therefore, farmers' participation in barley improvement is very important in

order to use their indigenous knowledge for varieties end-use and share their socio-cultural preferences. That means attention should be given to on farm conservation and enhancement of farmers' varieties. According to the finding of this study, the cultivars grown by farmers of the study area are increasingly similar to each other and the total number of different cultivars grown during the present time is reduced compared to that of the last 20 to 30 years, thus critical training must be provided for the farmers of the study area to preserve barley landraces. Therefore, farmers and other concerned bodies must try to bring the landraces to these potential barley producing areas and multiply them.

Farmers in the study area are giving much more attention to the newly released barley varieties than the varieties on their hand due to different reasons. This gradually reduces crop diversity leading to genetic erosion due to the replacement of landraces by new varieties. Therefore, the government must educate the farmers to grown both landraces and modern varieties side by side on their farm lands. The finding of this study shows that lack of education has highly significant effect on the occurrence of genetic erosion in the study areas, therefore, such an assessment and further research must be carried out to ensure the existence extent of genetic erosion and provide more ways how to solve the problem

The use of genetic resources will remain the best way of meeting future food needs and driving the economic and social benefits for the world's rapidly growing human population. Thus, policy makers and researchers should give attention to conservation and indigenous knowledge of farmers for better use of genetic resources in Ethiopia.

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7. APPENDEXES

A questionnaire to be filled by interviewer

Dear respondents, this questionnaire is designed to gather information on on-farm diversity and Genetic erosion of barley landraces with the main objectives of evaluating the extent of on-farm diversity and genetic erosion of barley landraces and justify reasons for its conservation at a community and household levels in Diksis and Lode Hetosa Districts of Arsi Zone, Ethiopia. The main purpose of this questionnaire is for M.Sc Research thesis fulfillment. Therefore, you are kindly requested to give your genuine response to the open ended and objective questions presented under section B which is very essential for the achievement of the research objectives. Your personal information other than stated under section A must be kept confidential. If you face a box like, ☐, in this questionnaire put a thick (√) mark in the box. Your cooperation is sought in completing and returning this questionnaire by the due date. Provision of information and answer for every provided question is compulsory. Thank you for your kind and genuine response!

Section A: Personal data

1. Sex: Male ☐ Female ☐
2. Age: 41-50 ☐ 51-60 ☐>60☐
3. Keble (Farmers association) ----------
4. Education: Only Read and write ☐ Primary school ☐ High school ☐
   College Diploma ☐ Degree ☐ Others ☐

SectionB: Farming Status (past and current situation)

1. As your area is distinctly known by barely production, how long have you been in barely farming? **Use (√) mark in the box.**10-20 years ☐20-30years☐More than 30 years ☐
2. List and rate the major crops, other than barely, you are growing _____
3. What proportion of your farm land size is covered by barley? Less than half☐, About half ☐, Greater than half ☐
4. What type of topography do you preferably use for cultivation in your locality?1. Swamp area☐2. Flood plain☐ 3. Plain level ☐ 4. Undulating hills ☐ 5. Steep hills ☐ 6. Plateau ☐

5. In which season do you cultivate barley in your locality? a. Long rainy season ☐ b. Short rainy season ☐ c. Both seasons ☐
6. In which of the two seasons barley is more productive? a. Long rainy season ☐ b. Short rainy season ☐Why? _____
7. Are you using improved barely varieties released by the governments.Yes ☐No ☐
8. List the name of the barely varieties released by the governments commonly used at your area.----------
9. Which of the two barely seed are more dominantly used at your area? New varieties☐barley landraces ☐Why? _____
10. Describe the barely cropping practices _____Compare the value given to barely varieties and landraces in terms of sawing, managing farming practices, harvesting, crushing and mechanizing style _____
11. What are the barley landraces you are using to grow? (List all the types of barely landraces **still in use and also disappeared** by their local names in the following table)

S/N	Local names	Still in use	Disappeared	Seed color and shape	Number of rows on the seed/ caryopsis	Maturity (Months)	Meaning its local name

12. What do you think is/ are the factor (s) contributed to the disappearance of some of the above disappeared barely landraces, table below?

S/N	Local names of **disappeared** barely landrace	factors for the disappearance			
		Less resistance to water logging	Less resistance to diseases and pests	Less productivity and less attention by farmers	Release of new barely varieties by the government

13. Please specify any factor, other than stated in the above table, for the disappearance of barely landraces in your area _____

14. Are there landraces that are known to be more tolerant to environmental stress than varieties, table below?

S/N	Environmental stress	More resistant barely Landraces than varieties
1	Frost	
2	Poor soil fertility	
3	Water deficiency	
4	Diseases resistance	
	Others	

15. When comparing the stated landraces, indicate the conditions given in the table 4 below, required to grow each; put a thick (√) mark in the following

S/N	Landrace	**Conditions**												
		Soil Fertility			Moisture			Application of fertilizers				Disease Resistance		
		High	Medium	Low	High	Medium	Low	High	Medium	Low	No	High	Medium	Low

16. Mention the local food varieties and types of local **beverages** from barley landraces grown at your area; fill the table a.

S/N	Landrace type	Type of **food** prepared from the landrace	Preparations	Remarks

Table b: Type of **beverage** prepared from the landrace:

S.N	Landrace	Type of **beverage** prepared from the landrace	Preparation	Remark

17. Which food types prepared from barley are usually utilized for the social group?

S/N	Social group	Barley food items usually utilized
1	Children	
2	Adolescents	
3	Male-elderly	
4	Female-elderly	
5	Child bearing Mothers	

18. Are barley foods used for ceremonial purposes? Use (√) mark in the box. Yes ☐ No☐
19. If your answer to question number 18 is yes, would you please enumerate the food types commonly used in ceremonies as:A. Cultural_____B. Religious_____
20. Is there any tale, songs, sayings, believes and incantations concerning barley in your locality? Yes ☐ No☐
21. If your answer to question 20 is yes, please mention some.----------
22. Which landrace is suitable for which season? Why?

S/N	Landrace	Season	Why? Reason (s)

23. Rank the landraces according to their level of significance; which landrace do you prefer? _____Why? _____
24. Do you use different farmlands specifically for short or long rainy season in barley cultivation? 1. Yes ☐ 2. No ☐
25. If your answer is yes, which barely landrace is used for short or long rainy seasons? Why?----------

26. Who selects seeds for cultivation at your area? a.Youngsters☐b.Female elderly ☐c. Male elderly ☐ d. Other (specify_____Why? _____
27. What is / are the source (s) of seed to be sown? 1. Self stored ☐ 2. Neighborhood ☐ 3. Market ☐ 4. Others (specify)_____
28. List the name of the barely varieties released by the governments ----------

Questionnaire for Focal group discussion

A .personal data

1. Sex: a) male b) female

2. Age: a) 40-50 years b) 51-60 years c) greater than 60 years

3. Keble(farmer association)----------

4. Education: a) Read and write only b) primary school c) high school d) college diploma e) degree

B. Farming status

1. Which barley landraces are grown in your area at the past 20 to 30 years?

2. Which of the barley landraces you are grown at the past 20 to 30 years are exist at this time?

3. Which of the barley landraces you are grown at the past 20 to 30 years are disappeared at this time?

4. What is the use of barley landraces you are grown at the past 20 to 30 years?

5. What are the causes of the disappearance of this barley landrace?

6. Is there any barley variety that replaces the barley landraces?

7. What are the barley varieties that replace the barley landraces?

8. Which of the barley seeds you are prefers to use? The new variety or the landraces? Why?











Thank you!