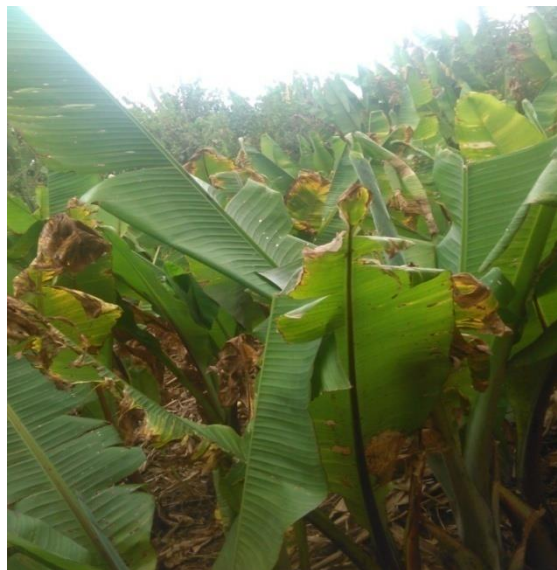




**Morphological Diversity and Ethnobotanical Study of
ENSET(*Ensete ventricosum* (Welw.) Cheesman) Landraces in
Kebena, Cheha and Ezha Woredas, Gurage Zone, SPNNRS,
Ethiopia**

Adanech Jarso Mojo



**Addis Ababa University
Addis Ababa, Ethiopia
June, 2017**



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(Welw.) Cheesman)Landraces in Kebena, Cheha and Ezha Woredas, Gurage
Zone, SPNNRS, Ethiopia**

Adanech Jarso Mojo

A Thesis Submitted to
The Department of plant Biology and Biodiversity Management
Presented in Partial Fulfilment of the Requirements for the Degree of Master of
Science in Plant Biology and Biodiversity Management

Addis Ababa University
Addis Ababa, Ethiopia

June, 2017

ADDIS ABABA UNIVERSITY

GRADUATE PROGRAMMES

This is to certify that the Thesis prepared by Adanech Jarso Mojo, entitled: Morphological diversity and Ethnobotanical Study of ENSET (*Ensete ventricosum* (Welw.) Cheesman) Landrace in Kebena, Cheha and Ezha Woredas, Gurage zone, Ethiopia and Submitted in Partial fulfillment of the Requirements for the Degree of Master of Science (Plant Biology and Biodiversity Management) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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Name	Signature	Date
1. <u>Prof.Zemedet Asfaw</u> (Examiner)	_____	_____
2. <u>prof. Sileshi Nemomsa</u> (Examiner)	_____	_____
3. Prof. Sebsebe Demissew (Advisor)	_____	_____
4. Dr. Tigist Wondimu (Advisor)	_____	_____
5. <u>Dr. Ermias</u> (Chairman)	_____	_____

Abstract

*Morphological Diversity and Ethnobotanical Study of ENSET (*Ensete ventricosum* (Welw.) Cheesman) landraces in Kebena Cheha and Ezha Woredas, Gurage Zone, Ethiopia*
Adanech Jarso Mojo, MSc Thesis.

Addis Ababa University, May 2017

Ensete ventricosum is a perennial, banana-like crop, indigenous to Ethiopia. It is an important food crop consumed in the form of Bulla, Kocho, and Amicho. Besides, it used as animal feed, as well as source of medicine and fiber. This study was undertaken on the ethnobotanical use of ENSET landraces and to identify variability of the morphological traits among the landraces. The study was carried out in purposively selected ten kebeles of three districts in Gurage Zone. A total of 100 (20 purposively selected key informants and 80 randomly selected general informants) were interviewed using semi-structured interview; field observation and guided field walk were also used to collect ethnobotanical data. Morphological traits were measured according the IBPGR (International Board for Plant Genetic Resources) descriptors for ENSET. The data were analyzed by using computer software R v 3.2.2 and SPSS v 16.0 as well as Excel 2010 spread sheet. Direct matrix ranking and preference ranking were also used to analyze the ethnobotanical information. A total of 33 ENSET landraces were identified from the study area. Farmers give the name for their landraces based on morphological trait and sources of planting material. Identified landraces were grouped in to five clusters based on Morphological trait variability. Mean plant height, pseudostem height and circumference, leaf size and number have significant difference ($p < 0.05$) among clusters. Cluster number five had highest mean in plant height, pseudostem height and circumference and cluster number three had lowest mean. The highest landrace richness was recorded from Wosharbe (3.2) while the lowest was from Girar (2.5). The most abundant landraces were Lemat Nechiwe Yeshirafire and Kanchiwe in Kabena district where as Agade and Yeshiraqinqe were the most abundant in Cheha. Yeshirakinke, Nechiwe, Agade and Kibinar were most dominant landraces in the Ezha district. This study confirms that the Gurage zone is rich in diversity of ENSET but, reduction in production and loss of some landraces was observed because of different factors. Therefore, attention must be given to conservation and maintenances of enset landraces.

Key words: Cheha, *Ensete ventricosum*, Ethnobotany, Ezha, Kebena, Morphological trait

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Acronyms

CSA	Central Statistical Authority
FAO	Food and Agricultural Organization
FDRE	Federal Democratic Republic of Ethiopia
IBPGR	International Board for Plant Genetic Resources
IK	Indigenous knowledge
EMA	Ethiopian Metrological Agency
SNNPRS	Southern Nation Nationalities People Regional State
SPSS:	Statistical Package for Social Sciences

CHAPTER ONE

1. INTRODUCTION

1.1. Background of the study

Root and tubers are plants yielding starchy root, tuber, rhizomes, corms, and stems. They are used mainly for human food, for animal feed and for manufacturing starch, alcohol including beer (Hildebrand, 2001). ENSET (*Ensete ventricosum*) is one of root crop which is a perennial herbaceous and monocotyledonous crop that belongs to the family Musaceae and flowers only once in its life cycle (after 6–10 years) depending on climate and landrace type. It is a banana-like plant that grows 4-8 m (sometimes even up to 11 m) in height. It is closely related to and has physical resemblance with the banana plant, as a result of which it is sometimes known as a false banana.

ENSET is a multipurpose crop of which every part is utilized; not only for food but also for several cultural applications and livestock feed. It is primarily used as food, feed, medicinal, ornamental, raw material for industries and construction materials. The major foods obtained from ENSET are *Kocho* and *bullu* (the pseudostem products) and *Amicho* (root product). ENSET has also diverse socio-economic, cultural, and ritual use (Geber Yantis, 1996). Being perennial, ENSET improves local climate and soil conditions (Abraham Shum bolo *et al.*, 2012).

ENSET(*Ensete ventricosum*) is distributed as a wild species in many parts of Sub-Saharan Africa (Tumescent Maule *et al.*, 2014). It is the main crop of a sustainable indigenous African system that ensures food security in a country that is food

deficient. Ethiopia is one of the centers of diversity and origin for various agricultural crops (IBC, 2007). ENSET is one of the oldest cultivated plants of Ethiopia, which is sole country domesticating over 50 landraces and use the plant as food and fiber crop (Aare Serif and Daniel Fatima, 2016). Records suggest that ENSET has been grown in Ethiopia for more than 10,000 years (Yamane Tsehaye and Fassil kibebew, 2006).

According to Abraham Shumbolo *et al.* (2012), the cultivation of ENSET in Ethiopia was estimated to spread over 67000 square kilometers. 'ENSET' planting economy is one of the major activities of the agriculture in southern Nation, Nationalities and People Regional State.

Productivity of ENSET is very high compared to other crops but varies depending on edaphic factors, altitude, cultural practices and varietal differences (Peveri, 2000). Landrace is a variable population, which has a local name, lacks formal crop improvement, is associated with the traditional uses, knowledge, habits, and celebrations of the people who developed and continue to grow it (Mercer and Perales, 2010).

ENSET is one of the crops which have many landraces. As landraces are morphologically different, farmers can identify and subsequently attach local names to them. Besides, different landraces are recognized to have characteristic adaptation to edaphic factors, reveal individual response to time of seeding, and have typical days to maturity, height, nutritive value, use, and other properties (Buzayehu Tesfaye *et al.*, 2003).

The loss of diversity of traditional crop landraces or landraces throughout the world has been under the subject of considerable concern in the past three decades it is because of landraces are difficult to reclaim once they disappear.

Local diversity of ENSET is limited despite the use value of the crop as food for majority of the people in southern Ethiopia. This might have entailed loss of the existing diversity and associated indigenous knowledge (IK) (Yemane Tsehaye and Fasil Kibebew, 2006). Traditional ENSET farming systems have so far been studied by agronomists and geneticists, who have attempted to assess the level of morphological diversity found in some parts of the country (Kefale Alemu & Sanford, 1991).

As a species, ENSET morphology is highly variable and although the extent of its variation remains unknown. The purpose of this study is therefore; to identify the existing ENSET landrace diversity, to identify morphological traits diversity among landraces of ENSET; to identify threats that affect ENSET diversity and also to understand the associated indigenous knowledge in the study area with the ultimate goal of providing information that will help in constructing the scientific basis for the conservation and sustainable use of the plant.

1.2. Research Questions, Hypotheses and Objectives

1.2.1. Research questions

- ❖ How many landraces of ENSET are cultivated in the study area?
- ❖ What are the different ENSET (*Ensete ventricosum*) landraces found in the study area and which ones are most commonly used?

- ❖ Is there significant morphological variability within the existing ENSET landraces and among landraces grown in different parts of study area?
- ❖ What are the different uses of the ENSET? And which parts are used for what purpose?
- ❖ What are the different vernacular names of the different landraces of ENSET and what are their respective meanings?
- ❖ What are the problems associated with the production of ENSET in the study area (pests, diseases and etc.)?
- ❖ How do farmers cultivate ENSET in the different parts of the study Districts?
- ❖ What cropping systems were used (sole cropping, intercropping, and border cropping)?

1.2.2. Research hypotheses

- ❖ Altitudinal variation affects the number of ENSET landraces
- ❖ Cropping system, benefits of different cropping system and place of ENSET grown have difference among the districts of the study area.
- ❖ Planting material selection criteria and ways of traditional multiplication have differences among the districts of the study area
- ❖ Uses of different ENSET landrace have variation among districts of the study area
- ❖ Unique properties, amount of production, amount of household consumption and market of ENSET products have differences among the districts of the study area.

1.2.3. Objective

General objective

- The general objective of this study was to identify the landrace diversity, morphological traits variability among landraces of ENSE and to document ethnobotanical information of ENSET in the study area.

Specific objectives

- To study landrace diversity of ENSET
- To document ethnobotanical use of different ENSET landraces.
- To document indigenous knowledge of smallholder farmers associated with ENSET plant in the study area.
- To study morphological variability among landraces of ENSET.
- To estimate landraces lost and causes among the study sites.
- To study the present diversity status of the ENSET landraces and to propose information that will contribute to future management, utilization, and conservation strategies.

CHAPTER TWO

2. LITERATURE REVIEW

2.1. Origin, Domestication and Distribution of *Ensete ventricosum*

Given the restricted geographic distribution of domesticated ENSET and the degrees of complexity and variability in contemporary ENSET agricultural systems, agronomists and biogeographers have long considered the Ethiopian highlands to be the primary center of origin for ENSET agriculture (Brandt, 1991). Anthropologists, archaeologists, historians, and other scholars have also developed theories that argue for the domestication of ENSET in Ethiopia as early as 10,000 years ago. Today, the vast majority of ENSET farmers live in southern Ethiopia. However, historical evidence suggests that ENSET may have once played a much more important role in the agricultural practices of central and northern Ethiopia (Awol Zeberga *et al.*, 2014).

The plant seems to have no difficulty growing in lands beyond the seas and (at least in principle) Ethiopian immigrants in Israel and parts of the United States might try cultivating it. However, it seems unlikely that ENSET will ever make it onto the crop-production lists in any non-African nation. The immigrants are overwhelmingly from central and northern Ethiopia where ENSET as a food is unknown. And getting the plant to produce food takes time, and perhaps tradition. *Ensete ventricosum*, in Ethiopia, is concentrated in the southern highlands, but also grows in the central and northern highlands around Lake Tana, the Semien Mountains, and as far north as Adigrat and into southern Eritrea (Simmonds, 1958).

Wild ENSET propagates naturally by seed, and is restricted in Ethiopia to elevations of approximately 1,200 to 1,600 meters above sea level (Gebre Yntiso, 1996). Two wild ENSET species distributed over much of Asia, and four wild species in sub-Saharan Africa and Madagascar (Genet Birmeta *et al.* 2004).

2.2. Taxonomic description of ENSET

ENSET (*Ensete ventricosum*) is perennial monocarpic crop, belonging to Kingdom: Plantae Order Zingiberales and family Musaceae along with bananas. Musaceae is a family of (monocotyledonous) flowering plants. The family is native to the tropics of Africa and Asia consisting of 2 genera, *Musa* and *Ensete*, with about 50 species. They are grown mainly for their fruit, the banana, and for their fibers, manila and hemp, used for making rope. They are also grown as ornamental plants. ENSET (*Ensete ventricosum*) is Ethiopia's most important root crop, a traditional staple in the densely populated south and southwestern parts of Ethiopia (Genet Birmeta, 2004).

2.3. Botanical Description of ENSET

ENSET (*Ensete ventricosum*) is a plant which closely resembles the banana plant; forming a single corm underground and a pseudostem above the ground (Brandt *et al.*, 1997). Unlike domesticated bananas the seedy leathery fruits of the ENSET plant are inedible. ENSET is diploid with $n=9$ (Zerihun Yemataw *et al.*, 2012). While species of *Musa* have different ploidy levels (diploid, triploid and tetraploid) with $n=10$, 11 or 14. Both *Ensete* and *Musa* have a large underground corm, a bundle of leaf sheaths (pseudostem), and large, paddle-shaped leaves. The meristem region is located at the junction point of pseudostem and underground corm, near the soil surface. Although ENSET is thicker and larger than banana, often reaching up to 12 m in height and more than one meter in diameter, both ENSET and banana are herbaceous perennial monocarpic crops; they produce flowers only once at the end of their life cycle

(Endale Tabogie, 1997). When a banana plant dies, it is spontaneously replaced by new suckers sprouting from pre-existing buds in the corm. However, in ENSET, sucker production is induced only when the meristem is wounded. The main sources of food are the corm, pseudostem, and leaf petioles (Hildebrand, 2001).

2.4. Ecological Description of ENSET

Domesticated ENSET is planted at altitudes ranging from 1,200 to 3,100 meters. However, it grows best at elevations between 2,000 and 2,750 meters. Most ENSET-growing areas receive annual rainfall of about 1,100 to 1,500 millimeters, the majority of which falls between March and September. The average temperature of ENSET growing areas is between 10 and 21 degrees centigrade, and the relative humidity is 63 to 80 percent. ENSET is not tolerant to freezing. Frost damage on upper leaves is commonly observed above 2,800 meters above sea level, and serious stunting is seen above 3,000 meters (Brandt *et al.*, 1997). For a certain range below 1,500 meters, the constraint to ENSET plant growth probably is more related to available water than to high temperatures. In most areas of Ethiopia below 1,500 meters, the total rainfall and the length of the rainy season decrease, and the potential water use by plants increases because of the greater evaporative demand. Most ENSET plantings below 1,500 meters have supplemental irrigation or are small enough in size that household wastewater may be applied (Admasu Tsegaye and Struik, 2001).

2.5. Cropping Systems and Agronomy of ENSET

Ensete ventricosum is cultivated at the backyard of the home followed by *Coffea arabica* and *Chata edulis*. The early growth and development of *Ensete ventricosum* (Musaceae) are seedlings. Farmers do not plant suckers directly in permanent field. The spacing Varies from phase to phase: the distance between plants is increased at each successive. Transplantation until it reaches its final spacing in the permanent

location. At each stage of transplanting, ENSET has different local names as it indicates the growth stage of ENSET (Admasu Tsegaye and Struik, 2001).

2.6. Uses of ENSET

ENSET is staple food crop for over 15 million people. It provides year round food, fiber, animal feed and medicine .Gives higher yield per unit area (25 t ha⁻¹ yr⁻¹)than wheat (Admasu Tsegaye, & Struik, 2001).In Ethiopia ENSET is cultivated mainly for food. The edible parts of the plant are formed by the pseudostem and the underground corm (Zerihun Yemataw *et al.*, 2012).

2.6.1. Food uses of ENSET

The major foods obtained from ENSET are *Kocho*, *bulla* and *Amicho*. *Kocho* is the bulk of the fermented starch obtained from the mixture of the decorticated (scraped) leaf sheaths and grated corm (underground stem base). *Kocho* can be stored for long periods of time without spoiling. The quality of *Kocho* depends on the age of the harvested ENSET plant, the type of clone (variety), and the harvesting season. Moreover, within one plant, the quality is influenced by the part of leaf sheath and corm processed. The preferred type is white in color and is obtained from the innermost leaf sheaths and inner part of the corm, while the lowest grade is blackish and is obtained from the outer leaf sheath and corm. Although many different dishes are prepared from *Kocho*, pancake-like bread is the most common. *Kocho* prepared as fermented ENSET bread has also become extremely popular at restaurants that serve the Ethiopian delicacy of *kitfo* (raw ground beef mixed with butter and spices). The combination of *Kocho* and *kitfo* is now virtually required at restaurants (Zerihun Yemataw *et al.*, 2014).

Bulla is obtained by: 1) scraping the leaf sheath, peduncle, and grated corm into a pulp; 2) squeezing liquid containing starch from the pulp 3) allowing the resultant starch to concentrate into a white powder by removing the water by evaporation and 4) rehydrating with water. It is considered the best quality ENSET food and is obtained mainly from fully matured ENSET plants. *Bulla* can be prepared as a pancake, porridge, or dumpling.

Amicho is the boiled ENSET corm, usually of a younger plant. ENSET plants may be uprooted for preparing meals quickly if the amount of ENSET harvested is insufficient, or for special occasions. The corm is boiled and consumed in a manner similar to preparation methods for other root and tuber crops. Certain clones are selected for their Amicho production (Brandt *et al.*, 1997).

2.6.2. Medicinal uses of ENSET

Particular clones (or landraces) and parts of ENSET plants are used medicinally for both humans and livestock to cure bone fractures, broken bones, childbirth problems (i.e., assisting to discharge the placenta), diarrhea, and birth control (Brandt *et al.*, 1997).

2.6.3. Other uses of ENSET

ENSET provides fiber as a byproduct of decorticating the leaves sheaths. ENSET fiber has excellent structure, and its strength is equivalent to the fiber of *abaca*, a world-class fiber crop. About 600 tons of ENSET fibers per year are sent to factories. In rural areas the fiber is used to make sacks, bags, ropes, cordage, mats, construction materials (such as tying materials that can be used in place of nails), and sieves. (Zerihun Yemataw *et al.*, 2014).

ENSET leaves are used as bread and food wrappers, serving plates, and pit liners to store *Kocho* for fermentation and future use. During ENSET harvesting ENSET leaves are used to line the ground where processing and fermentation take place. The dried petioles and midribs are used as fuel, and to make mats and tying materials for house construction. The dried leaf sheaths are used as feed and wrapping materials. The pulp from the dried leaf sheaths, petioles, and midribs is used as cleaning rags and brushes, baby cushions/diapers, and cooking pot stands. Dried leaf sheaths are used as wrappers for butter, Kocho, and other items to transport to local markets (Spring *et al.*, 1996). ENSET leaves are an important cattle feed, especially in the dry season when grasses are scarce. Leaves are carried into the house for stall feeding of cattle during the night time (Marsha *et al.*, 2014).

2.7. Production Constraints and Local Management Systems

2.7.1. Diseases of ENSET

Diseases are collectively the most severe biological problem facing ENSET. The damage that diseases can cause and the lack of knowledge about or implementation of preventative strategies contribute to the severity of ENSET plant diseases. Diseases are caused by several bacteria, nematodes, fungi, and viruses. Bacterial wilt, caused by the bacteria *Xanthomonas campestris pv musacearum*, is the most threatening to the ENSET. The wilt causes complete death of the plant within weeks of the first symptom, i.e. yellowing and drying of the emerging shoot. Individual plant infection and loss is common but 'hot spot' losses can amount to half of the harvestable plants. Pathologists and extensionists recommend uprooting and burying of diseased plants as well as fire sterilization of knives, machetes and tools (Awol Zeberga *et al.*, 2014).

ENSET is attacked by numerous diseases in addition to bacterial wilt. They include ENSET corm rot, ENSET sheath rot and ENSET dead heart leaf rot, caused by an unknown bacterial pathogen and fungus, respectively, as well as root-knot, lesions, nematodes, and virus diseases. The most important factors responsible for spreading disease of bacterial wilt include disease-infected planting material, contaminated farming and processing tools, and human and animal vectors. (Daniel Ashagrie,1969).

The only research-recommended control measures for diseases are cultural measures to prevent the movement of the causal agent. For bacterial wilt, these measures include the use of healthy, disease-free suckers for planting material; destruction and controlled movement of diseased plants; cleaning of equipment that has come in contact with diseased plant material; and rotation of crops(*Robert and Chernet Ertiro, 2009*).

2.7.2. Animal and pest attack

Porcupine, mole rat, and wild pig attack ENSET plants in the field. They usually damage the plant by feeding on the corm and pseudostem. Among these pests, the mole rat ranks number one. Since these animals are not microscopic like the bacterial and viral diseases, farmers are knowledgeable about them, and many employ effective management practices. These practices include woven fences and ditches around ENSET fields, to retard the movement of animals into the field, and traps for catching them (McCabe and Lee, 1996). Wealthier farmers use steel traps to snare wild pigs and monkeys, and others traps for porcupines and mole rats. Burning coals may be dumped into the rat tunnels. Farmers also protect against porcupines by digging pits around ENSET plants so that it is difficult for the animals to get in or to climb up and

get away. In some areas, farmers organize themselves on a village basis to hunt wild pests with sticks, spears, and machetes. Insects have been considered a minor problem in ENSET cultivation. However, over the last several growing seasons, mealy bugs have been identified as a serious problem in certain regions (Temesgen Addis *et al.*, 2006). Mealy bugs are soft-bodied insects that feed on the corm and roots. ENSET plants infected by mealy bugs show stunted growth; the damage appears more severe during the dry season. Because they live underground, their damage often goes unnoticed until serious loss has occurred. As they are slow moving insects, mealy bugs are controlled with methods similar to those used against diseases such as bacterial wilt (Ferdu Azerefeqn *et al.*, 2009).

2.7.3. Weeds

Weeds can cause greatly reduced plant growth while ENSET plants are small, i.e., during the sucker stage and for one or two years after the first transplant. The total land area used for production during these stages is usually relatively small compared to the farm size, and therefore weeding can be accomplished with available labor. As the ENSET plants become larger, the perennial leaf canopy and leaf litter on the soil surface prevent most weed growth. In annual crop production, the labor available for weed control can be a serious restriction to production. Although labor data are not available, there is probably much less labor required for weed control per ton of food in ENSET than on any annual crop. The reduction in labor for weed control may be offset in part by the additional labor required during harvesting and processing of ENSET (Abraham Shumbolo *et al.*, 2012).

2.8. ENSET harvesting and processing

Although ENSET is usually harvested just before flowering, the preferred harvesting time is just when the plant flowers. The time duration required to flower depends

upon climatic conditions, clone type, and management. Hence, the flowering time varies from 3 to 15 years but is optimally around 6 or 7 years. ENSET processing is carried out by women using traditional tools. At harvest, leaves and older leaf sheaths are first removed from the designated plants. The internal leaf sheaths (commonly up to two meters in length) are separated from the pseudostem down to the true stem, which is about a 20 centimetre section between corm and pseudostem. Then the true stem is separated or stumped from the underground corm. The concave side of the leaf sheath is peeled and cut into pieces of about one meter length and split lengthwise in order to shorten the leaf sheath to a workable size. Then the leaf sheath is decorticated using a locally made bamboo scraper while the leaf sheath is held on an incline (at 45 to 80 degrees from the ground) against a wooden plank. In some groups, women may sit on the ground (often on ENSET leaves) and use one leg to hold the leaf sheaths in place, while in other areas they bind the sheath to the board and stand to decorticate. The working area used for decortications is covered with ENSET leaves. (Temesgen Magule, 2014).

2.9. Role of Women on ENSET Production and Processing

Gender roles (in terms of the division of labor for all aspects of ENSET production and marketing) are of critical importance. Without women to process ENSET, there would be no food produced and it would simply be an ornamental plant, as it is in other parts of Africa and Asia. But women's work is often relegated to lesser significance than men's. Both researchers and farmers often believe that women are involved "only" in processing and cooking of the ENSET, and rank these tasks below cultivation tasks. Women, in fact, do participate (in some areas and in some households) in production activities (e.g., manuring and varietal selection), and in households where there are no

women knowledgeable about ENSET clones and processing, ENSET is not eaten unless others are paid to process and cook it (Asnakech Woldetensaye *et al.*, 1997).

Tesfaye Habte-Wold *et al.* (1996) argue that women farmers know a great deal about the different landraces of ENSET, and that “when men and women of the same household were interviewed together, women tended to dominate discussion about landraces, contrasting and comparing them and saying what should be harvested at different Ages.

2.10. Landrace Diversity

Landrace is a variable population, which has a local name, lacks formal crop improvement, is associated with the traditional uses, knowledge, habits, and celebrations of the people who developed and continue to grow it (Mercer and Perales, 2010).

Landraces have been selected by farmers for adaptation to specific sets of field conditions as well as particular uses within the food system. They are often highly variable in appearance, but they can be identified and almost always have distinct local names. They have particular characteristics (e.g. early or late maturing), a reputation for adaptation to local climatic conditions and cultural practices, and resistance or tolerance to diseases and pests (Harlan, 1992).

Major advantages of landraces are adaptation to their specific agro-systems and low input requirements, and ethnic reasons are also present in traditional agriculture practices. The genetic diversity of landraces is very important for global biodiversity conservation for future world production (Wood & Lenné, 1997).

Diversity is expressed as genetic differences between species, subspecies, varieties, populations, or individuals. Diversity can be measured at the morphological level, the physiological level, diversity in a plant’s resistance to pest and disease or in its degree of tolerance to drought.

2.11. Genetic erosion

Genetic erosion is the loss of a crop, variety or allele diversity; the reduction in richness and evenness it implies that the normal addition and disappearance of genetic variability in a population is altered so that the net change in diversity is negative. There are numerous factors that negatively impact plant species and their populations which will result in taxonomic (species, subspecies, and varietal) and genetic diversity erosion, and eventual extinction (Nabhan, 2007). The main factors that contribute to the genetic erosion of landrace diversity are changes in agricultural practices and land use; use of pesticides and herbicides; replacement of traditional varieties with modern, uniform cultivars which lead to a genetic bottleneck; once landraces have been replaced by modern cultivars, unless the landrace is conserved in *ex situ*, the unique combination of genetic diversity is unavailable to breeders; as a consequence, the total number of different varieties grown is reduced and/or cultivars grown by farmers become increasingly similar to each other;

CHAPTER THREE

3. MATERIAL AND METHOD

3.1. Description of the Study Area

3.1.1. Geographical location

The field sites for this study were Kabena, Cheha, and Ezha districts of the Garage Zone (Southern Nations Nationalities) (Figure1). Garage zone is located in Southern Nations Nationalities and people regional state (SNNPRS). It is situated 158 kilometers southwest of Addis Ababa. Based on the 2010 Census conducted by the Central Statistical Agency of Ethiopia (CSA), this Zone has a total population of 1,279,646, of whom 622,078 are men and 657,568 women. The population of the study area is almost entirely of the Gurage ethnic group (82%). The Gurage people live a sedentary life based on agriculture, involving a complex system of crop rotation and transplanting. ENSET is their main staple crop, but other cash crops are grown, which include coffee and chat. Animal husbandry is practiced, but mainly for milk supply and dung.

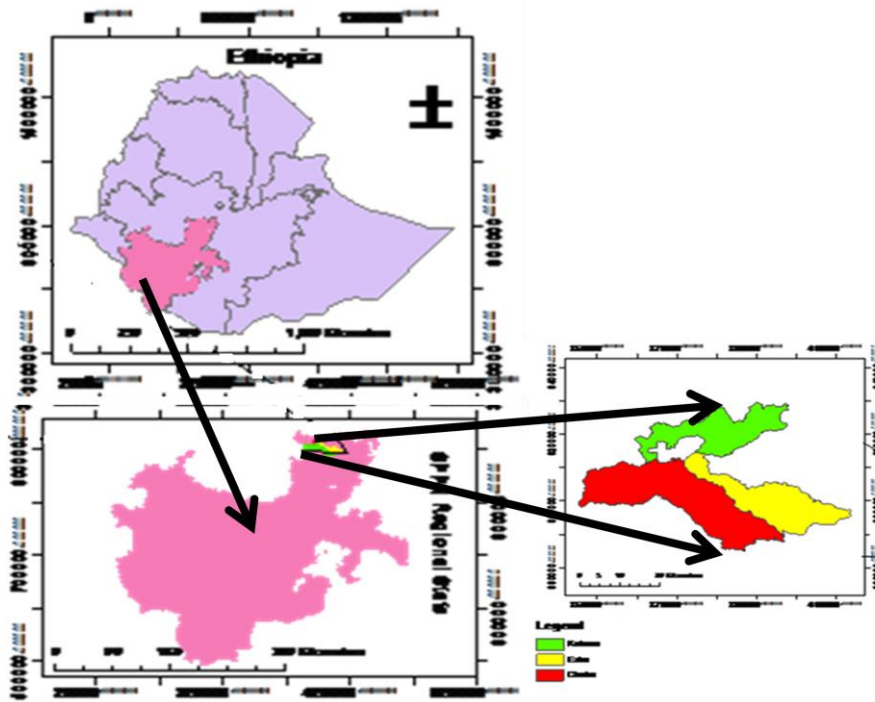
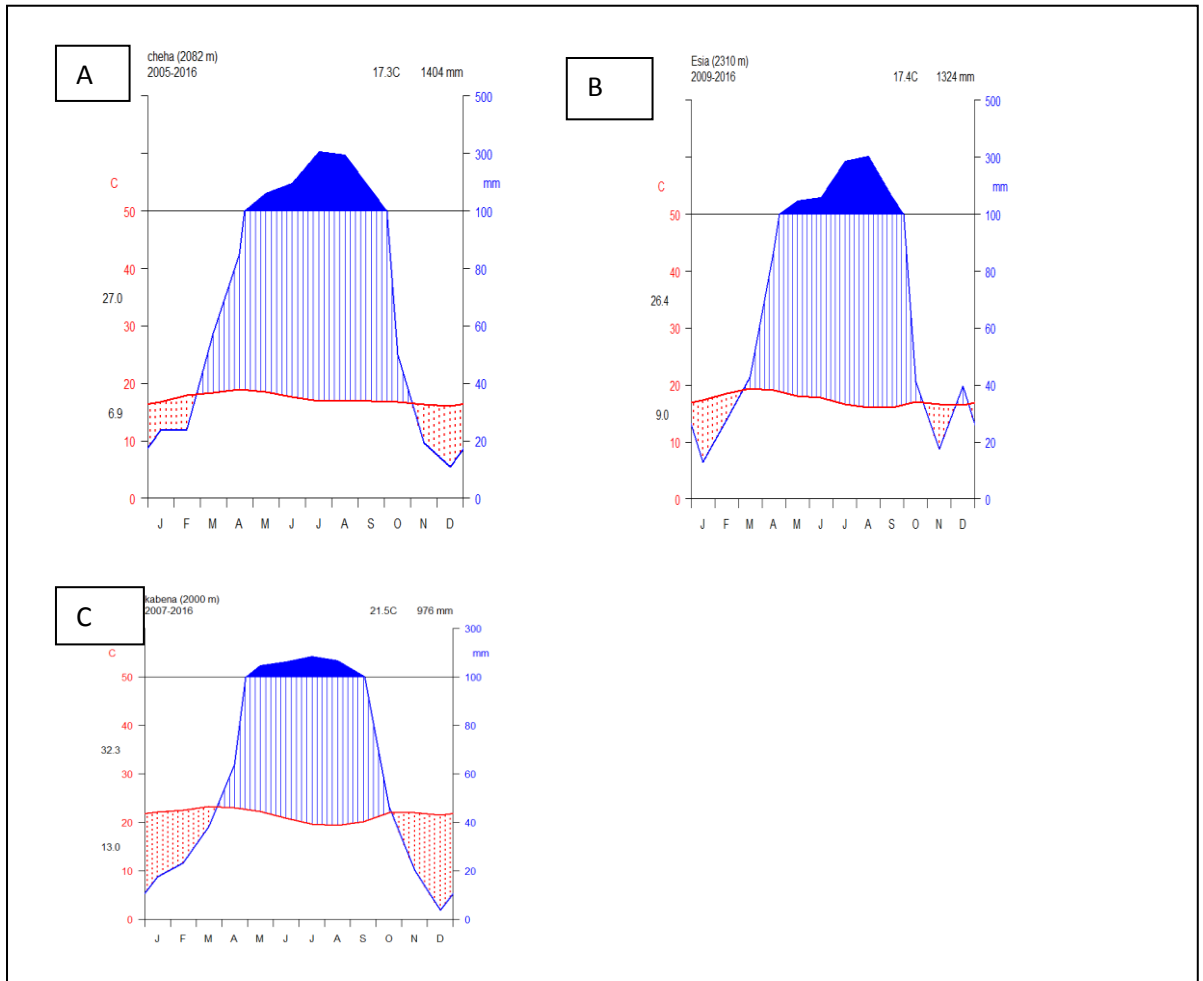


Figure 1 Map of Ethiopia showing the location of the study area

3.1.2. *Climate of the study area*

The climate of the study site has been represented by using rain fall, maximum, and minimum temperature obtained from National Metrological Service Agency (NMSA) for the last ten years. The climate of the study area is given in Figure 2. The average annual maximum temperature of the study area ranges from 26.4-32.3⁰c. The mean annual rain fall of the study area ranges from 976-1404mm.



A= Cheha district B=Ezha district C=Kabena district

Figure 2 Climadiagram of study area.

3.2. Material used

Materials used to conduct this research were:

- Global positioning system (GPS) to collect longitude, latitude and elevation of study area.
- Digital camera to take picture of plants and landscapes,
- meter for measurement.
- Color chart for identification of color of ENSET morphology and other material were used to conduct the research.

3.3. Method

3.3.1. Sampling Research Sites and informants

The study sites were selected based on areas that have high production of ENSET and those ENSET landraces which play economic and cultural roles. These study areas were selected by referring to different literature sources, by referring to the survey made by CSA (2015) on area and production of major crops and also by using the suitability map of ENSET made depending on data obtained from FAO (1984) on the crops' ecological requirements. Information about the production of ENSET from agricultural institutions of study zones was used. Based on the above selection criteria the study was conducted on three purposively selected representative Districts (Kabena, Ezha, and Cheha) and four kebeles from each Ezha and Kabena Districts and two kebeles from Cheha Districts with total ten randomly selected representative Kebeles. From each Kebele 10 households were selected bringing the total number of sampled households to 100 informants having different ethnic, religious, age and sex categories were interviewed. From the total informants, 80 were randomly selected general informants and 20 were purposively selected key informants who were very interested and those who were recommended by elders, local authorities, and local farmers.

Table 1 Region, zone, districts, kebeles and number of informants used in the study

Region	Zone	Districts	Kebeles	Number of informants		
				General	Key	Total
SNNPRS	Gurage	Kabena	Wosherbi	8	2	10
			Lencha	8	2	10
			Rimuga	8	2	10
			Katbare	8	2	10
		Cheha	Girar	8	2	10
			Yewozhe	8	2	10
		Ezha	Yesirayi	8	2	10
			Desene	8	2	10
			Shebraden	8	2	10
			Mentir	8	2	10
Total number of informants				80	20	100

3.4. Method of Data Collection and Sources of Data

Both primary and secondary data were used in this study. The primary data were collected through semi-structured interview and field observation. Secondary data were collected from different district offices and different written material.

3.4.1. Ethnobotanical Data Collection

Ethnobotanical data were collected in order to know the indigenous knowledge of participants or farmers on ENSET. Different qualitative and quantitative ethnobotanical data collection methods like field observation, guided field walk, semi-structured interview, and market surveys were used in order to get needed information from the participants.

Semi-structured interview was used to gather ethnobotanical information on local name of the crop and landrace, time of cultivation and harvesting, traditional management practices, cropping system, uses and market value of the crop, landraces which survive drought, disease, pest and have short maturity time, planting material exchange system and production constraints and perception of the farmers towards the crop (Appendix 1).

The necessary information on morphology of ENSET, how ENSET is cultivated, intercropped, used and marketed were systematically recorded. The local perspectives on dominant crops produced, landscapes, and soil type of the study area were identified through personal observation and discussion with local experts (Appendix 4)

Market survey undertaken to record the *Ensete ventricosum* landraces that are sold in the market together with information on market values. This is especially a good method to conserve landraces of ENSET that have high economic value.

3.4.2. Morphological traits of landraces

To characterize the agromorphological traits of the landraces, all landraces found at

study area were measured. Fifteen agronomic descriptors of ENSET (Table 2) were evaluated according to the IBPGR (1993) procedure for each landrace.

Table 2 Morphological traits measured from ENSET landraces of the study area (Cheha, Ezha and Kebena districts), Gurage zone, Ethiopia

Character	Code	Qualitative categories or quantitative measure
Pseudostem color	PSC	1 = light green, 2 = deep green, 3 = greenish black, 4 = light red, 5 = dark red, 6 = reddish yellow,
Petiole color	PC	1 = light green, 2 = deep green, 3 = yellowish green, 4 = light red, 5 = dark red, 6 = reddish yellow,
Midrib color	MC	1 = light green, 2 = deep green, 3 = greenish yellow, 4 = greenish red, 5 = light red, 6 = dark red, 7 = dark brown
Leaf color	LC	1 = light green, 2 = deep green, 3 = light red, 4 = dark red, 5 = purple
Kocho quality	KQ	1=high quality, 2=medium quality, 3=low quality
Bulla quality	BQ	1=high quality 2=medium quality 3=low quality
Fiber quality	FQ	1=high quality 2=medium quality ,3=low quality
Drought resistance	Dr. R	1=resistant, 2=venerable
Disease resistance	D.R	1=resistant, 2=susceptible
Pseudostem length	PL	Meter
pseudostem circumference	Psc	Meter
Leaf length	LL	Meter
Leaf width	LW	Meter
Number of leaves	NL	Number
Plant height	PH	Meter

3.5. Data Analysis method

3.5.1. Descriptive Statistics

Descriptive statistics were used to analyze data obtained through interview and guided field walk. The data were analyzed by entering in to SPSS and excel spread sheet and summarized by computing means, standard deviations, ranges, and other tools.

3.5.2. Preference Ranking

In preference ranking, 20 key informants were asked to arrange a group of items according to a given criterion such as personal preference or importance of a species. Each item was then assigned a value, with the most important or preferred one ranking the highest value, while the least important or preferred one ranking the lowest value. Therefore, in this study different use values of ENSET species were short-listed and ranked by informants following the procedure explained by Martin (1995).

3.5.3. Direct Matrix Ranking

Direct matrix ranking was applied in order to answer the question, which landrace was best for which purpose. Landraces and purposes commonly reported by informants were selected. Then, each key informant was asked to rank the landraces for each purpose listed. The values of each landraces were summed up and ranked for each informant, and then for the total informants.

3.5.4. Morphological Diversity analysis

ENSET landraces diversity analysis (Shannon 1949) including (Shannon-Wiener Index, H') and richness and evenness) of each study *Kebele* were analysed. Shannon Weaver Index (H') were used to analyze the phenotypic diversity of ENSET depending on the traits that were measured, counted and recorded. It was calculated using the formula,

$$H = - \sum_{i=1}^s p_i \ln p_i$$

Where:

S is the number of phenotypic classes for a character and p_i is the relative proportion of the total number of entries (N) in the i^{th} class (Spellerberg and Fedor, 2003). Richness refers to the number of different kinds of individuals regardless of their frequencies. Evenness, however, measures how similar the frequencies of the different variants are, with low evenness indicating dominance by one or a few types. Evenness has values between 0 and 1 where 1 indicates the condition where all landraces are equally abundant while 0 indicates that few landraces are more abundant.

Evenness is calculated as: $E = \frac{H}{H_{max}}$, where H is Shannon-Weaver Diversity Index,

H_{max} is $\ln(N)$, N is total number of landraces. Simpson's index of diversity $(1-D) = 1 - \sum (n/N)^2$

Where:

n = the frequency of the i^{th} cultivar, i.e., frequency of the cultivar embodied in the i^{th} farms in the district and N = the total number of farms surveyed in the district

CHAPTER FOUR

4. RESULT

4.1. General Household and landrace Information

4.1.1. Household Characteristics

Out of the total interviewed households (N =100), (29%) were females and (71%) were males. Unequal pattern of gender distribution was observed in the specific study sites (Table 3). From the total respondents, 16 % of the household's heads younger less than 35 years old, while the household heads (42 %) were in age range between 35-50 and older than 50 years old. Females and teenagers have less knowledge about landraces of ENSET even they don't know the name of their landraces this shows there is no flow of indigenous knowledge about ENSET on study area. This may causes loss of indigenous knowledge on study area.

Assessment on size of land that respondents own indicate that majority (58%) of respondents own 1-3 hectare of land used for farming including the home gardens and the maximum hectare possessed by respondent was 10. The size of ENSET farm was found to be smaller than the pieces of land used for harvesting other crops. The largest recorded land cover of ENSET was 2.5 hectare and on average 1.3 hectare of the land in a farm. The size of land is one of the factors that affect diversity of ENSET landraces. As the size of land increase, the diversity of ENSET landraces could also be increase. Thirteen percent of the respondents reported 17-20 ENSET landraces growing in their yards, while most of the respondents (45%) grow only four to eight ENSET landraces.

Table 3 Households Characteristic of study area

Characteristics	Number of respondents	percentage of respondents
Sex		
Female	29	29.0
Male	71	71.0
Total	100	100.0
Age		
<35	16	16.0
35-50	42	42.0
>50	42	42.0
Total	100	100.0
Size of total land in hectares		
>3	58	58.0
4-6	30	30.0
<7	12	12.0
Total	100	100.0
Size of land for ENSET production		
<1	60	60.0
1-2	30	30.0
>2	10	10.0
Number of land race		
4-8	45	45.0
9-15	39	39.0
16-20	16	16.0
Total	100	100

4.1.2. Diversity of ENSET landraces

A total of 33 landraces were identified from different Districts of study area based on names and descriptions given by local farmers (Table 4). Based on data collected from informants and agricultural office of study districts, there was no improved ENSET variety used by farmer.

Table 4 Vernacular names of ENSET landraces with their district of cultivation

No	Local name of landrace	Meaning of the name and reference	Districts/Districts
1	AGADYE	-	Kabena, Cheha, Ezha
2	ASTARA	-	Kabena, Cheha, Ezha
3	CHARQIMA		Kabena
4	AMORATE		Kabena, Cheha, Ezha
5	DARYE		Kabena, Cheha, Ezha
6	ENIBA		Ezha
7	FAREZYE		Kabena, Cheha, Ezha
8	GIMBIWE	huge(plant size)	Cheha,Ezha
9	GUARYE		Kabena, cheha, Ezha
10	GUNFUNNE	Short(plant size)	Kabena
11	JEJEB A	Hard to eat	Kabena
12	QIBINAR		Kabena,cheha,Ezha
13	QANCHIWE		Kabena,Ezha ,Cheha
14	KOBERETE		Kabena
15	KOSHKOSHE	Foolish(broke n easily)	Kabena
16	LEMAT		Kabena,cheha,Ezha
17	MUXUXI		Kabena
18	NECHIWE	White	Kabena,cheha,Ezha
19	OWRET		Kabena
20	SAJA		Kabena
21	SEBARA		Kabena, cheha, Ezha
22	SINNIWE		Kabena Cheha
23	WOLAMU ASTARA		Kabena
24	WONADYE		Cheha Ezha
25	WORET		Cheha,Ezha

26	YEQEBERO ENSET	fox ENSET	Kabena
27	YEQESIWE		Kabena, Cheha, Ezha
28	YESHIRAQINQE	Thin leaf	Cheha,Ezha
29	YESHIRAFIRE	Emerge flower fast	Kabena, Cheha, Ezha
30	YEGONDYE		Kabena,Ezha ,Cheha
31	YIREGYE		Cheha, Ezha
32	ZEGEZIWE		Kabena
33	ZOBIR	Large	Kabena, Ezha

4.1.3. Landrace identifications mechanism

There were different morphological and agronomic characteristics that farmers used to identify their landraces in the study area. Of these color of (pseudostem, midrib, leaf and petiole), time of maturity, disease resistance, yield, leaf dimensions (width and length), and pseudostem length (Figure 4). Depending on the landraces cultivated in the home gardens, the most frequently mentioned descriptors for identification were pseudostem color (31% of the respondents), midrib color (17% of informants) plant size(14 % of the respondents) and leaf color (25% of respondents).

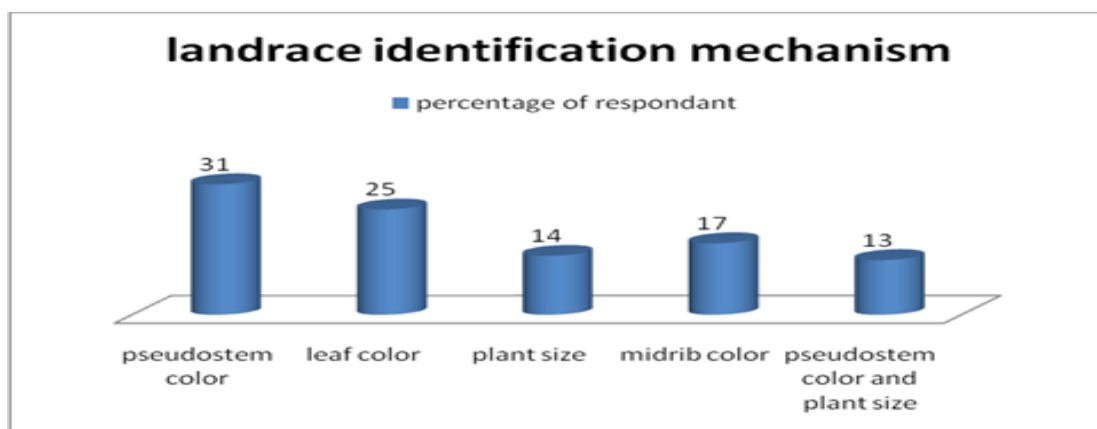


Figure 3 Landrace identification mechanisms of farmers

4.1.4. Local extinction of some landraces from of study area

There were some landraces which have been lost from the study area because of different reason. These landraces were lost at different time; majority (52 %) of farmers loss their landraces within last 10-20 years ago (figure 4). While few farmers loss last before 20 years ago. Lost landrace were known as BOSERET and MISHRAT

and others which were lost completely from all study Districts and some landraces like GIMBIWE, SEBBAR and other were lost from Cheha and Ezha Districts and farmers reduce cultivation of some landraces (specially those have medicinal use). Farmer's mention different causes of extinction of their landraces, farmer's preference to high yielding plant and disease resistance landraces to be the root cause of loss. Drought and climate were also reported by few farmers forcing them to select only resistant landraces.

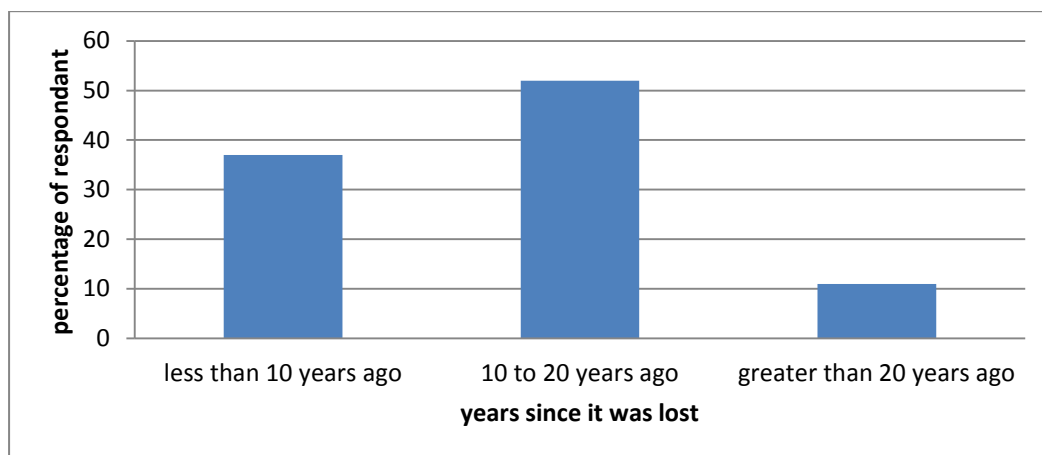


Figure 4 Year of local extinction of ENSET landraces

4.1.5. Status of ENSET cultivation

Fifty-seven (57%) of farmers reported that production (farmers interest to grow ENSET) decreased, 33 (33 %) said that production of ENSET increases and 10 (10 %) of the farmers said there is no change on the production of ENSET seen Figure.5.

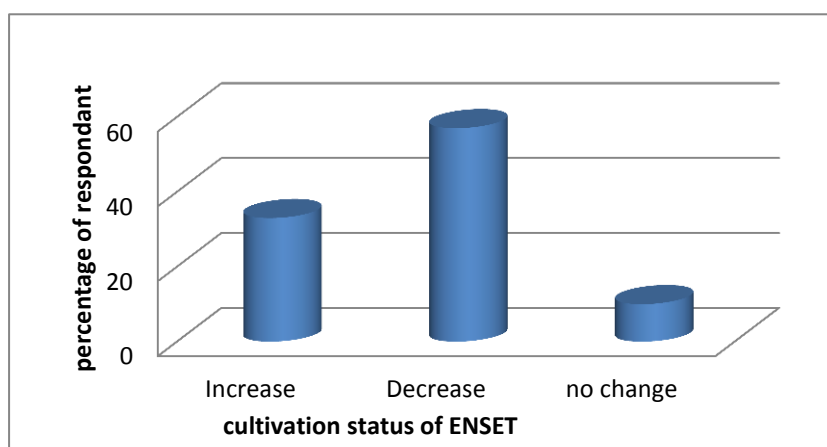


Figure 5 Development of ENSET landrace production

4.2. Measured morphological traits.

In the study area some quantitative and qualitative morphological trait were recorded. Most of the qualitative traits recorded were similar at different study districts. The original identified 33 ENSET landraces were grouped in to 5 clusters based on morphological trait (pseudostem color, petiole color, leaf color, midrib color, Kocho quality, bulla quality, fiber quality) and agronomic characters (disease resistance and drought resistance) the dendrogram shown on figure 6).

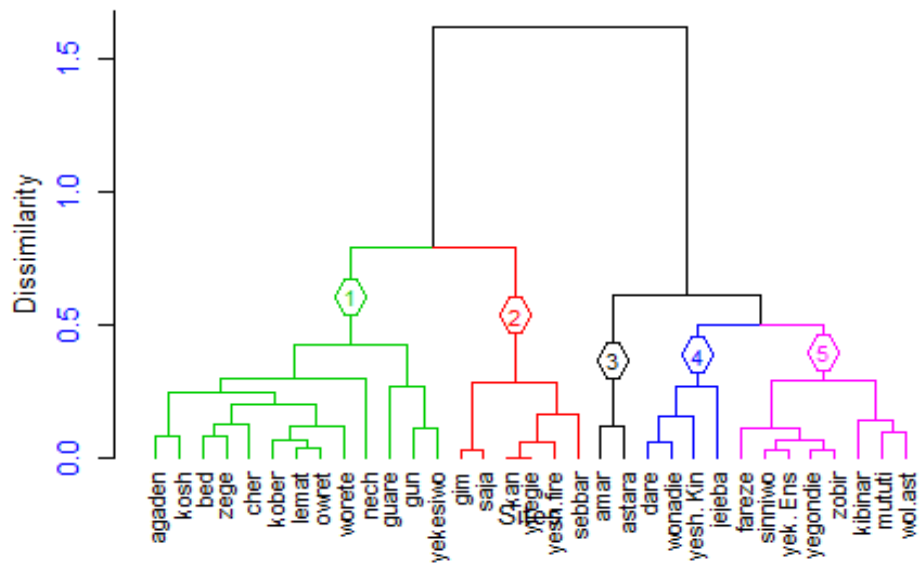
Cluster one: This cluster includes the largest number of ENSET landraces 13 out of 33 landraces recorded. Landraces in this group are characterized by having light green pseudostem, deep green leaf, light green midrib, high quality fiber, drought and disease resistant.

Cluster two: This was well defined on the bases of Kocho, bulla, and fiber quality. Landraces in this group provide high quality bulla, Kocho, and fiber.

Cluster three: This cluster includes only two ENSET landraces (ASTARA and AMORATE). The members of this group have dark red pseudostem, deep green leaf medium fiber quality vulnerable to drought and diseases.

Cluster four: This cluster includes four landraces of ENSET and it was well defined on the bases of leaf and resistance to drought and diseases. They have purple leaf and resistant to diseases and drought.

Cluster five This cluster comprises landraces having deep red pseudostem, deep red petiole, yellowish green leaf, highly resistant to disease and drought. In this cluster there was wild ENSET landrace called YEQEBERO ENSET which mean fox's ENSET, the seed of the ENSET seed was brought by fox. It was wild ENSET landraces which was cultivated by some farmers of study area.



Cluster one=Agadye, Koshkoshe, Bededet, Zegeziwo, Cherkima, Koberete, Lemat, Owret, Woret, Nechiwe, Guarye, Gunfunne.Yekesiwe. ClusterTwo=Gimbiwe, Saja, Kanchiwe, Yiregye, Yeshirafire, Sebbar. ClusterThree=Amarate, Astara. Cluster Four=Darye, Wonadye,Yeshiraqinqe, Jejeba. Cluster Five=Ferezye, Sinniwe, Yeqebero Enset, Yegondye, Zobir, Qibinar, Mututi, Walamu stara

Figure 6 Dendrogrmof 33landraces of ENSET (*Ensete ventricosum* (Welw.) Cheesman) based on morphological variability

Table 5 Mean of the quantitative characters for each cluster of ENSET landrace

Clusters	Mean plant height(M) \pm SD	Mean pseudostem (M) height \pm SD	Mean pseudostem circumstan ce (m) \pm SD	Mean leaf width (M) \pm SD	Mean leaf length \pm SD	Mean leaf number \pm SD
Cluster 1	6.64 \pm 0.87	2.65 \pm 0.64	1.7 \pm 0.30	0.53 \pm 0.14	3.6 \pm 0.7	14 \pm 4
Cluster 2	7.7 \pm 0.54	2.98 \pm 1.13	2 \pm 0.36	0.56 \pm 0.15	4.33 \pm 0.3	13 \pm 4.4
Cluster 3	5.5 \pm 0.282	2.2 \pm 0.28	1.3 \pm 0.14	0.65 \pm 0.07	3.3 \pm 0.6	22 \pm 4.24
Cluster 4	7.3 \pm 0.72	2.7 \pm 0.46	1.67 \pm 0.49	0.62 \pm 0.06	4.47 \pm 0.2	12 \pm 5.73
Cluster 5	8.5 \pm 0.897	3.07 \pm 0.64	2.10 \pm 0.37	0.62 \pm 0.15	4.63 \pm 0.6	15 \pm 5.28

4.3. Richness and Evenness of ENSET Landraces

When diversity of ENSET is estimated based on number of landraces (richness) Wosherbi Kebele (of Kebena District) shows the largest richness (Shannon H'=3.17: Simpson D =23.99) followed by Yewozhe Kebele (of Cheha District) (Shannon H'=

3.04: (Simpson D=20.99). But Girar kebeles (of Cheha District) shows the lowest richness (Shannon H=2.56: Simpson D=15.9).(Table 6).

Table 6 Landrace diversity in study kebeles expressed as Richness (C), Evenness (E), Simpson (D) and Shannon (H') diversity indices.

Kebeles	Richness(C)	Diversity index (H')	Evenness
Wosherbi	24	3.18	1
Lencha	18	2.89	1
Rimuga	18	2.89	1
Katbare	16	2.77	1
Girar	13	2.56	1
Yewosie	21	3.04	1
Yesirayi	18	2.89	1
Shebraden	19	2.94	1
Desene	19	2.94	1
Mentir	20	3.00	1

The average number of landrace listed by farmer was high in case of Wosherbi followed by Yesirayi. Whereas Desene was the fewest. Beta diversity was high in Desene. While beta diversity of Yesirayi is lowest.

Table 7 Gama Diversity (GD), Alpha Diversity (AD) and Beta Diversity (BD) of ENSET at study kebeles

Kebeles	GD	AD	BD
Wosharbi	25	9.2	2.71
Lencha	18	7.2	2.50
Rimuga	18	8.0	2.25
Katbare	16	6.8	2.30
Girar	13	5.8	2.24
Yewosie	21	8.1	2.59
Yesirayi	18	8.2	2.19
Shebraden	19	7.9	2.40
Desene	19	5.6	3.39
Mentir	20	7.3	2.73

As household surveyed increase number of ENSET landrace recorded increase and after some increments it becomes constant. This is shows the farmers cultivate same landraces.

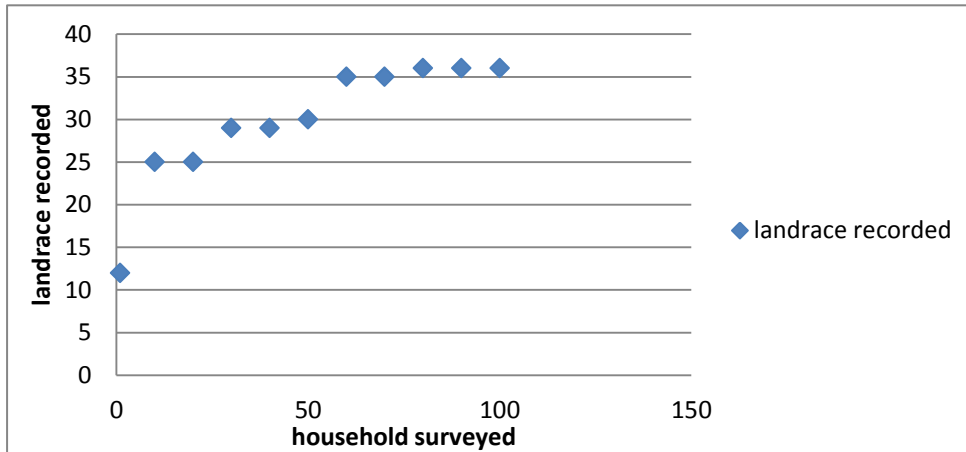


Figure 7 Total number of landraces and households surveyed

Distribution and abundance of ENSET landraces at study area

In Kabena Districts the most dominant ENSET landraces were LEMAT followed by FAREZYE, NECHIWE and YESHIRAFIRE respectively, while in Cheha Districts dominant landraces were YESHIRAQINQE and AGADYE. In Ezha Districts YESHIRAQINQE, NECHIWE, AGADYE and QIBINAR was the dominant respectively.

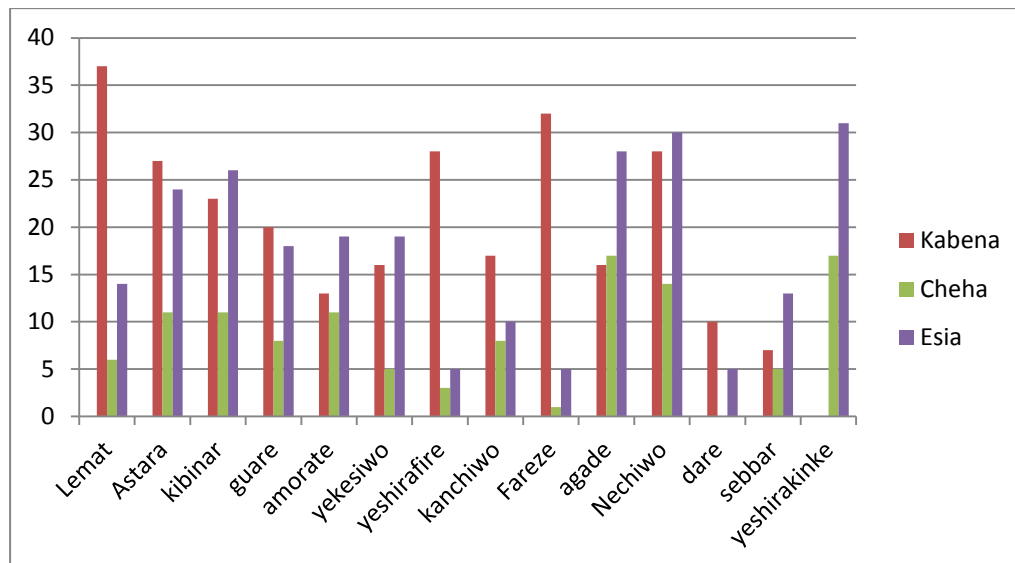


Figure 8 Dominance of ENSET landrace at different Districts of study area

In kebena District the local name of ENSET was known as WESITE. In this district about 25 different ENSET landraces were identified from those the major and widely used landraces were 10. LEMAT, ASTARA, GUARE, AMORATE, YESHIRAFIRE, KANCHIWE, NECHIWE, YEKESIWE, FERZY, SEBBAR, QIBINAR. In this study, eight key informants were asked to rank the landraces for eight selected properties (Table.8). The ranking showed that YEKESIWE was more preferred by the local informants followed by KANCHIW, NECHIWE, LEMAT, YESHIRAFIRE, AMORATE, GUARYE, ASTARA, SEBBAR and QIBINAR respectively.

Table 8 Direct matrix ranking of ten landraces of Kebena Woredas against eight properties (with value 3=highest, 2=medium,1= lowest)

No	Properties	Landraces									
		Astara	Guarye	Lemat	amorete	Yeshirafire	Nechiwe	Qanchiwe	Sebbar	Kibinar	Yekesiwe
1	Yield	1.40	1.40	2.8	2.40	1.40	2.60	2.25	2.50	1.40	2.90
2	Maturity time	1.40	1.60	1.5	2.20	2.80	2.60	2.60	3.00	1.40	1.25
3	Taste	2.50	1.40	1.8	1.50	1.25	2.25	2.50	1.50	2.80	2.80
4	Drought tolerance	1.25	2.20	2.6	2.50	2.50	1.40	2.80	1.50	1.6	3.00
5	Disease resistance	2.60	2.30	2.8	2.25	2.50	2.60	2.80	1.12	1.4	2.80
6	Kocho quality	1.60	1.25	2.4	2.50	2.60	2.90	2.60	1.40	1.75	2.80
7	Bulla quality	1.40	1.40	2.5	2.40	2.50	2.90	2.60	2.40	2.6	2.90
8	Fiber quality	2.60	2.25	3.0	1.90	2.50	2.60	2.60	1.60	1.5	2.60
	Total	14.75	13.80	19.4	17.80	19.15	19.80	20.75	15.02	14.45	21.05
	Rank	8 th	10 th	4 th	6 th	5 th	3 rd	2 nd	7 th	9 th	1 st

In Ezha Districts the local name of ENSET is known as ASSETE. In this Districts around 19 different landrace were identified by local farmers. In this study eight key informants were asked to rank the landraces for eight selected properties (Table.9). The ranking showed that YESHIRAQINQE was more preferred by the local informants followed by KANCHIWO, NECHIWO, LEMAT, SHIRAFIRE, AMORATE, GUARE, ASTARA, SEBBAR and KIBINAR respectively.

Table 9 Direct matrix ranking of ten landraces of Ezha Woredas against eight properties (with value 3=highest, 2=medium,1= lowest)

No	Properties	Landraces									
		Astara	Yeshira qinke	Lemat	Woret	Wonadye	Nechiwe	Kanchiwe	Agade	Yiregye	Yequesiwe
1	Yield	1.5	2.8	2.50	2.00	2.25	2.6	2.40	1.60	1.60	2.9
2	Maturitytime	1.6	1.6	1.50	1.60	1.25	2.6	2.25	3.00	1.13	2.9
3	Taste	2.9	2.25	1.80	2.40	2.40	2.6	2.25	1.13	2.00	2.6
4	Drought tolerance	1.4	3.00	2.25	2.50	2.50	2.6	2.40	2.00	1.80	2.6
5	Disease resistance	1.4	3.00	2.80	2.60	2.60	2.6	2.80	1.40	1.60	2.5
6	Kocho quality	2.8	2.25	2.50	2.50	2.40	2.5	2.60	1.50	2.25	2.8
7	Bulla quality	1.4	3.00	1.50	2.00	2.50	2.8	2.40	1.60	1.90	2.8
8	Fiber quality	1.4	2.80	3.00	2.25	1.60	2.8	2.40	1.60	1.90	2.8
	Total	14.4	20.70	17.85	15.35	20	21.1	19.50	13.83	14.18	21.9
	Rank	8 th	3 rd	6 th	7 th	4 th	2 nd	5 th	10 th	9 th	1 st

In Cheha Districts the local name of ENSET was known by ASSETE. There were 19 ENSET landraces which were identified in two kebeles from these the major and dominant one were ten. In this study the four key informants were asked to rank the landraces for eight properties (Table 10) The ranking showed that YESHIRAQINQE was more preferred by local farmers followed by KANCHIWO and FERZEZE.

Table 10 Direct matrix ranking of ten land races of Cheha Woredas against eight properties (with value 3=highest, 2=medium,1= lowest)

No	Properties	Landraces									
		ASTARA	OWRET	LEMAT	AMORATE	YESHIRAQINQE	NECHIWE	KANCHIWE	SEBBARA	KIBINAR	FAREZE
1	Yield	1.50	1.25	3	1.8	2.8	2	3	2.8	2.5	2.25
2	Maturity time	1.25	1.25	1.25	1.8	1.25	1	2.25	2.8	1.25	1.8
3	Taste	1.5	1.8	1.5	1.5	1.5	1.25	2.25	1.5	2.5	2.5
4	Drought tolerance	2.25	2	2.8	2.5	3	2.5	1.5	2.5	1.5	2.5
5	Disease resistance	1.25	2	2.5	1.8	3	2.5	2	2.5	1.25	1.8
6	Kocho quality	1.8	2.25	2	1.5	2.5	2.8	2.5	1	2	2.8
7	Bulla quality	2.8	1.8	2	2.25	2.5	2.8	2.5	1	2.8	2.5
8	Fiber quality	1.8	1.8	3	1.8	3	1.8	2.25	2.5	1.8	2
	Total	14.15	14.15	16.25	14.95	19.55	16.65	18.25	16.6	15.6	18.15
	Rank	9 th	9 th	6 th	8 th	1 st	4 th	2 nd	5 th	7 th	3 rd

4.4. ENSET cultivation and cropping system

All ENSET growing farmers of the study area are growing ENSET at their home garden. ENSET was grown as a sole crop or intercropped with chat, coffee and different fruits like apple, mango, avocado, and border cropped (figure 10). Forty (40%) of respondents grow ENSET as a sole crop and 50% inter cropping and the rest 10% border cropped (Table 14).

Table 11 Cropping system practiced in study area

Cropping system	Percentage of respondents	Plants grow in Association	Use of cropping system
Sole cropping	40%		To control disease and pest spread and to minimize food and water competition
Intercropping	50%	Coffee, chat, mango, avocado, apple, guava	To use the land efficiently
Border cropping	10%	Vegetables like cabbage, tomato	To protect susceptible crops from disease and pest attack and also use ENSET as wind break

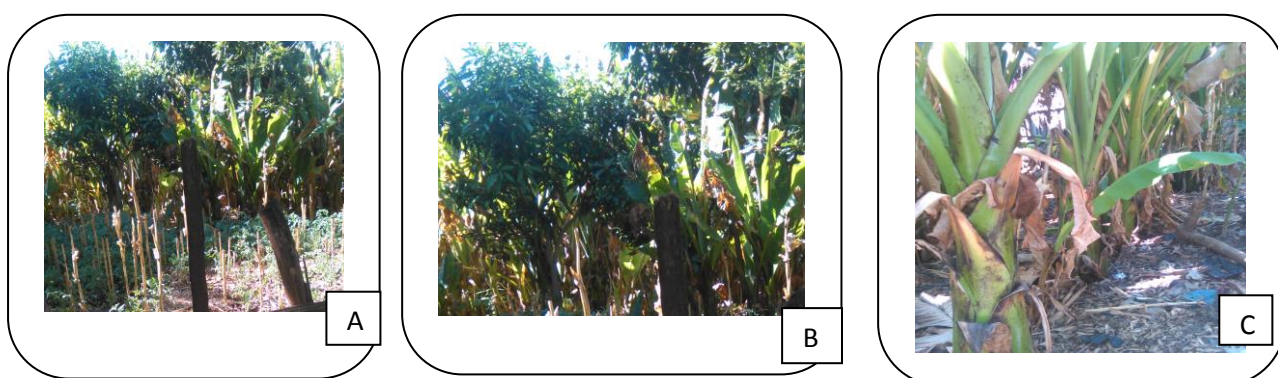


Figure 9 Cropping system of ENSET at study area, Border cropping (A), Inter cropping (B) and sole cropping (C)

4.5. Sources of ENSET planting material and selection criteria

Most of 57 (57%) of informants have got their planting material by multiplying the planting material by them self, 34(34%) by informal exchanging with neighbors and relatives and 9% by purchasing from others (figure11). All farmers of study area select their planting material for next season based on different traits of the landraces (size of landrace, Kocho, and bulla quality, fiber quality, uses of landraces, disease, and pest resistance of landraces).neighbors

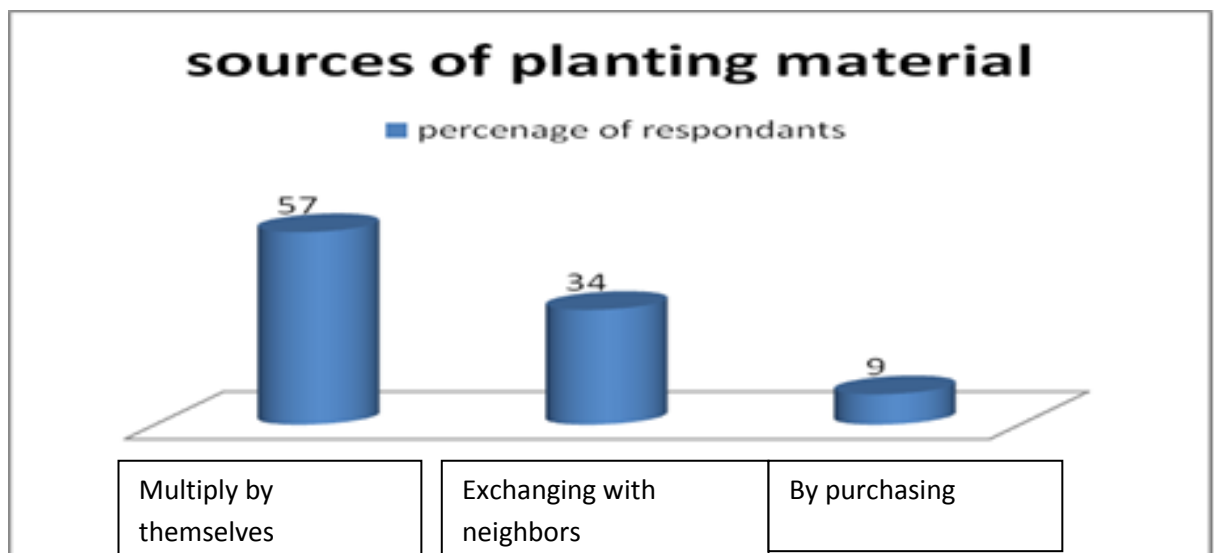


Figure 10 Sources of planting material of ENSET

4.5 Importance of ENSET landraces at study area

ENSET is multipurpose staple crop used for different purposes. At study area farmers use ENSET for household consumption (for food, medicinal purpose, fiber, and feed) and income generation. Out of the total informants, 80% use ENSET only for household consumption while 20% use quarter of their ENSET product for income generation.

4.5.1. Use of ENSET as food

Table 12 Food uses of ENSET and method of preparation

Landraces name	Types of food	Methods of preparation
All landrace	Kocho	scraped leaf sheaths and grated corm mixed ,wrapped in enset and stored underground until ferment
All landrace	Bulla	scraping the leaf sheath, peduncle, and grated corm into a pulp; and squeezing liquid containing a starch from the pulp allowing the resultant starch to concentrate into a white powder; and rehydrating with water
All landrace	Amicho	boiling ENSET corm, usually of a younger plant

4.5.2. Landraces used for disease treatment

In the study area, there were eight landraces that were reported for use to treat disease;

they were: GUARE, ASTARA, KIBINAR, DARE, CHERKIMA, SINNIWO, AGADE, WORET.

Table 13 ENSET landrace, part/s used for treatment, type of disease and use as medicine and preparation method

Landraces name	Parts used	Used to treat	Methods of preparation
GUARYE	Corm	-To dried abscess, - For normal functioning of body, -To cure from cough.	The corm boiled and eaten with milk.
KIBINAR	Corm	Used to join the broken body (bone), for lung disease & cough, to harden the damaged organ.	The corm boiled and the boiled Amicho eaten with cheese
ASTARA	Corm and pseudostem	To repair & soften the broken body (bone), initiate milk production for mammary gland for women.	The corm sliced and boiled and the amicho and starchy powder bulla are eaten with milk.
DARYE	Corm and pseudostem	-For dried the wound of Human and cattle	
CHERKIMA	corm and pseudostem	-Important for body protein development for both human and cattle's.	
SINNIWE	pseudostem	-For fattening of livestock -For normal functioning of body.	Corticated and given to the livestock.

4.6. Preferred use value of ENSET at study area

Preference ranking on the use value of ENSET by 20 key informants showed that ENSET use as food stood first followed by use as medicinal and least for income generation. Preference ranking on use value of ENSET at study area 1=least useful 5=most useful.

Table 14 Preference ranking on use value of ENSET

Data collection kebeles	Food	feed	Medicinal	Fiber	Income generation
Washerbi	5	3	4	2	1
Lencha	5	4	3	3	2
Remuga	5	2	4	1	1
Katbare	5	4	3	3	1
Girar	5	3	3	3	2
Yewozie	5	2	4	2	2
Yesirai	5	2	3	2	1
Desene	5	4	2	2	1
Shebraden	5	3	3	2	1
Mentir	5	2	2	1	2
Total	50	29	31	21	14
Rank	1 st	3 rd	2 nd	4 th	5 th

4.7. Unique properties of ENSET

ENSET has unique characters that make it selective when compared to other crops at the study area. Out of these properties of ENSET, farmers of different study area mention the major. It's socio-cultural significance as status symbol, high household material culture benefits, flexibility in farming systems as an intercrop with annual and perennial crops, drought tolerance, suitability for preparation of staple and high social value dishes, storability of ENSET products for long periods, possibility of harvesting at any time of the year, use for integration of crop-livestock system, use for production

of high quality fiber, use as water source from pseudostem, use as firewood source mainly from dried plant parts, generating income from sales of propagules, processed food products and fiber and medicinal purposes for humans and livestock make it preferable when compared to other crop.

4.8. Production constrain of ENSET

ENSET production and productivity is affected by several biotic and abiotic influences. ENSET diseases caused by bacteria, fungi, nematods, as well as pests such as the attack from mole rats and porcupines are among the many other factors causing less productivity. Farmers in the study area identified ENSET wilting diseases, ENSET corm rot, and ENSET leaf sheath rot as great problems of ENSET productivity (figure12)

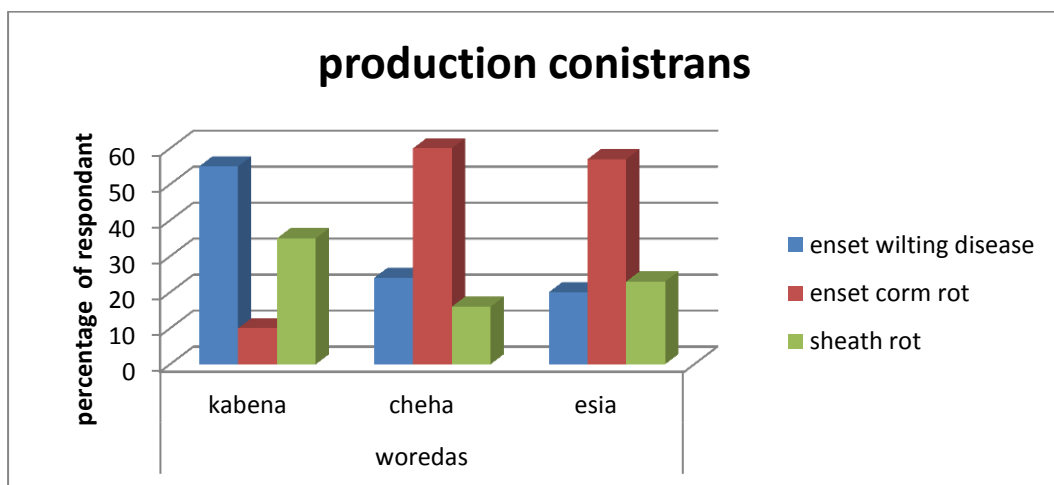


Figure 11 Constrains of ENSET production



Figure 12 Diseases of ENSET on study area, ENSET wilting disease (A), ENSET leafsheath (B), ENSET corm rot

4.8. Gender Roles on ENSET production and Maintaining Landraces

In the study area, ENSET production activities are responsibilities of both female and males. But the majority of activities are done by females (appendix 4) except preparing seedlings, digging the hole, planting and uprooting the ENSET during harvest which are done by male only. Without women cultivation of ENSET is meaningless. At the study area the role of women in production was very high but on the maintenances of landrace they are poor, even they don't know the name of the landraces, they ask their husbands.

4.9. Market survey

Markets were there, but the existing market were not strong, with few buyers and farmers have poor access to market information on ENSET products. ENSET was thought as women's property and the only person who decide on ENSET were women and they only use for income generating if they have enough product for their annual consumption. Market survey was undertaken in five markets found in the study area, two from Kebena district (Wosherbi market and wolkite market), two from Cheha Districts (Gubre and Emdibir market) and one from Ezha (Agena market). The price of ENSET product have no significant difference ($p>0.05$) along Districts. At Cheha Districts 90 and 52 birr/kg bulla and Kocho price respectively while the lowest price was recorded at Kebena districts compared to others. As the informants respond the reason for the rise of price in two Districts was reduction of ENSET production because of the occurrence of disease in last two years, and the farmers use their product for home consumption only.

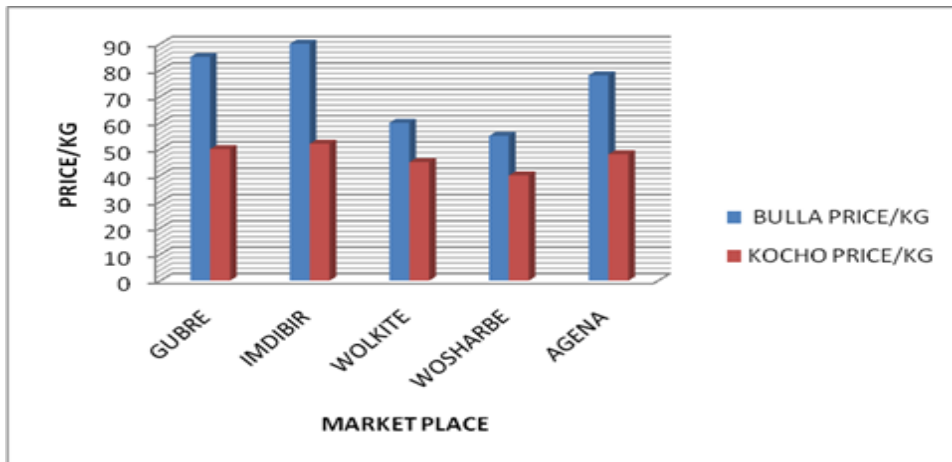


Figure 13 Market price of ENSET product

CHAPTER FIVE

5. DISCUSSION, CONCLUSION AND RECOMMENDATION

5.1. Discussion

5.1.1. Diversity of ENSET landraces

Ensete ventricosum is found at greatest frequency with different landraces. According to informant report ENSET was very diverse ranging from 4 to more than 20/farm on this study area. Each farmer own various number of ENSET landraces in his/her farm. The landrace identification mechanism used by farmer on different study districts has no significant difference ($p>0.05$). They identify each landraces by using different morphological traits like (pseudostem, petiole and midrib color plant size the tradition identification mechanism used by farmers of this study area is similar with the way of identification used by Sidama zone and Wolaita Zone (Temesgen Magule *et al.*, 2014, Amare Seifu *et al.*, 2016)

In this study, the identified landraces found to differ related to morphology, adaptation to diseases and pests, drought resistance, maturity time, uses. In case of maturity time, almost all landraces of the study area have the same (long) maturity time (7-9) years except AGADYE and YIREGYE which have short maturity time (4-5) years.

ENSET is drought and disease resistant crop. However, there were differences on adaptation to drought and disease between landraces. Two landraces LEMAT and YESHIRAKINKE were the most resistant landraces of study area and landraces which are used for medicinal purpose such as: GUARYE, ASTARA, QIBINAR were the most susceptible landraces of study area. The difference based on use landraces like

GUARYE ASTARA QIBINAR DARE CHARKIMA SINNIWE, are used for their medicinal purpose, YEKESIWE, NECHIWE, YESHIRAFIRE for their quality Kocho. Difference of landrace based on yield AGADYE, LEMAT, FAREZE are high yielding landrace, but have low quality Kocho and bulla.

In this study landraces KANCHIWO NECHIWO AND LEMAT in Kebena District, YESHIRAQINKE and In Ezha, YESHIRAKINKE, YEKESIWO and KANCHIWO in Cheha are most preferred and widely used ENSET landraces than others. Their preference was based on Kocho and bulla quality, yield and disease and drought resistance. Landraces which were used for medicinal purpose have low yield and easily affected by disease because of this they were grown only by farmers which have more hectares of land.

5.1.2. Status of ENSET cultivation

According to the results, ENSET is cultivated by every farming household in study area and it is the crop of choice for the community, but majority of farmers, respond that cultivation of ENSET falling from time to time similar with studies which conducted in Gedebano Gutazer welene district by (Kedir Abdella , 2017). As a result at present because of food shortage ENSET products are consumed immediately after harvest i.e. They do not store ENSET products for many years as they did in the past.

Increasing demand to engage in the production of other crops was one of the reasons that accounted for the decreasing trend of ENSET production. This is because of population growth and shortage of land which lead them to food shortage and they forced to grow short season crop instead of ENSET. This agrees with recent reports on the vulnerability of agricultural systems and agro-biodiversity in Southern Ethiopia by (Tenaye Abebe, 2009).

Difficulty of processing system was also the one and alarming reason for reduction of ENSET production. This result was similar with studies of Kefale Alemu, 1996) in north omo.

5.1.3. Measured Morphological Traits.

The dendrogram obtained from the Ward's (1963) hierarchical cluster analysis grouped 33 identified ENSET landraces in to five clusters based on qualitative characters taken. This clustering helps to know landraces which have related character. Based on cluster means, variation of mean values among the cluster were recorded for different quantitative characters. Mean plant height of cluster five and cluster two were significantly different ($p < 0.05$) by having highest mean and cluster three have significant difference ($p < 0.05$) in having the smallest mean of plant height (Table 6). A reasonable amount of morphological variation was displayed for the traits evaluated. The result is in agreement with Zerihun Yemataw *et al.*(2009) who reported a wide range of variation in different characters of ENSET. Variation, as it is expressed by morphological analysis was reasonable among the ENSET landraces and variation of ENSET landraces, of which farmers were little aware, is significant in their recognition of variation and therefore plays a role in their selection and maintenance of the overall variability

5.1.4. Richness and Evenness of ENSET Landraces

On this study 33 ENSET landraces were identified. In similar studies conducted on ENSET landrace in Gurage zone Zerihun Yemataw (2010) reported a total of 32 locally known landraces. Moreover Awol Zeberga (2014) studied ENSET landrace in Gurage zone and found 63 locally known ENSET landraces. Variations in a number of ENSET landraces found may be because of the difference in number of sampled

districts. The number of ENSET landrace (richness) per household varies from Kebele to kebele. Wosherbi has the highest landrace richness, Shannon diversity and evenness while Girar Kebele has the lowest. A high diversity index (at Wosherbi) suggests that the area is not dominated by one or two landraces rather by a number of successful landraces. A low value for the index diversity (at Girar), suggesting only a few successful landraces, or it indicates that the kebele is dominated by a limited number of landraces. In this kebeles majority of the landraces were replaced by landraces which is diseases resistant known as YESHIRAQINQE since the kabele was highly affected by diseases and the kebeles was dominated by YESHIRAQINQE. Applying these concepts at the scale of traditional landraces requires prior determination of the identity of the landraces (Jarvis *et al.*, 2008). Evenness, also measures how similar the frequencies of the different variants are, with low evenness indicating dominance by one or a few types. There were no significance difference ($p>0.05$) in number of landraces at districts level. Beta diversity was high at Desene kebeles this shows in this kebeles farmer's plant different landraces. Number of landraces increases as number of surveyed household increases and become constant as number of households increase and increase. This showed that farmers exchange their landraces with each other.

5.1.5. ENSET *cultivation and cropping system*

Similar with (Temesgen Mugale 2014) which was done in Wolaita, Southern Ethiopia, every farming household cultivates ENSET in its home garden. On study area ENSET cultivation system, planting and harvesting time have no significant difference ($p>0.05$) among study Districts. ENSET grow at the home garden, followed by chat and coffee. Planting of ENSET is done from October-December. On this study area, the planting of ENSET was done only by male. ENSET cultivation needs careful

attention, similar to studies conducted in Offa District, Wolaita zone (Abraham Shumbolo, 2012).

Farmer not plant suckers directly in permanent field. They transplanted ENSET suckers from one to four times until it gets to permanent field. At each stage of transplanting, ENSET has different local names as it indicates the growth stage of ENSET. The first stage is known as **Fomfo** which is a younger stage of sucker usually grow in mass from planted half corm. It takes one year to be transplanted to the next stage called **Boshen**. Boshen is the stage when separated sucker and planted in individual hole and allowed to stay for two years depending on management.

Mase is transplanted in to wider spacing so as to allow vigorous growth of suckers at least two years. From this onwards, the most vigorous suckers are finally transplanted in to permanent field as **Hiniba**. ENSET needs series fallow up after planting at each step, sanitation, hand weeding, and application of manure are the common practice done by the farmers.

In this study ENSET has been grown mainly as sole cropping system and some cropping system like border cropping, and enter cropping were mentioned by the informants. Enter cropping practiced in all study Districts by some informants, they used this cropping system for efficient use of lands and they got many products at the same time for market and for their children. The crop planted enter crop with ENSET were chat, coffee and different fruits like mango avocado etc. Border cropping was practiced in Kabena District only people used border cropping to protect the entire crop from different attack like animal, pest and use ENSET as wind break also.

5.1.6. Importance of ENSET on study area

In Ethiopia ENSET is produced mainly for foods (Zerihun Yemataw, 2012). On this study also ENSET is produced mainly for food and uses as medicine, feed for cattle, fibber for house construction and material culture and for income generating were the rank of priority given by farmers based on preference ranking given by key informants. ENSET was not produced purposively for fiber. Fibber and leaves for material and house construction were the by-products of ENSET. This study goes hand in hand with Abraham Shumbolo *et al.* (2012). As a source of food, corms, pseudostem and stalk of the inflorescences were used in the form of ferment of scraped leaf sheaths and grated corm mixed (Kocho), squeeze of scraped leaf sheath, peduncle, and grated corm (bulla) and boiled ENSET corm (Amicho).

On this study, the different ENSET parts corm, pseudostem, and leaf were used for medicinal purpose for human and livestock. As a report of farmers there were no recommended dosage known, one can use (ate) until he/she/it become cure from the disease. The fibber used for house construction and material construction. On this study almost all farmers of study area were not produce ENSET for income generation they sell if they have enough product only.

5.2. CONCLUSION

Generally 33 ENSET landraces were identified from all districts with different local names. These ENSET landraces have different purpose. All of farmer use these ENSET land race mainly as source of food, which is followed by animal feed, medicine, and fiber, and only few of them use it as income generation.

This research confirms that the role that local farmers play on maintenance of their ENSET landraces was high. Farmers have their own planting material selection, multiplication, and management system. The result of this study indicate that, even if intercropping and border cropping are practiced at the study area, sole cropping system was more preferable for more production and quality products.

The identified ENSET landraces have morphological variability by plant height, pseudostem (color, length, and circumstances), midrib color, leaf dimension, disease and drought resistance, Kocho quality, bulla quality and fiber quality. In addition to the farmer characterization, measurement was done for some quantitative and qualitative traits. Although some characters were the same throughout the study area, some characters like plant height, pseudostem (height and circumstance), leaf dimensions shows some differences. Based on this measurement, ENSET landraces of study area classified in to five clusters depending on their similarity. This clustering similar landraces together and knowing morphological variation among landrace helps the farmers for their selection and maintenance of their landraces.

Generally, as the result of this paper indicate, Gurage zone is rich in having different ENSET landrace and culture and indigenous knowledge on ENSET production and maintenance, but there were some ENSET landraces which have been lost due to different factors like shortage of land, climate change and replacement with high

quality landraces and as a result of production of ENSET at study area reduced. From those factors, the main one was replacement of these landraces with high quality and disease resistant landrace. Not only reduction in landrace, but also loss of some landraces and their habitat will ultimately cause loss of the knowledge, services and cultural values about ENSET that has been accumulated over time. From those factors the main one was replacement of these landrace with high quality and disease resistance landrace.

5.3. RECOMMENDATION

Generally from the above conclusion, the following recommendations are forwarded

- ✓ Promoting a better technology for ENSET processing system.
- ✓ Expanding ENSET cultivation culture in all rounds of the country.
- ✓ Further studies on propagation of ENSET and morphology of ENSET including seed and flower of the identified landraces for further identification of landraces.
- ✓ Extension service and training have to be given by government for local farmer on different production constraint like other crops.

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APPENDICES

Appendix 1. Data collection formats

I. General Information

Date _____

Informant's Name _____ Age _____ Sex _____

Location: Region _____ Zone _____ Wereda _____ Kebele _____

Altitude _____ Latitude _____ Longitude _____

II. Ethnobotanical Information

Enset

1. Name all the landraces you grow and indicate if they are improved or farmers variety

Name of the variety	Improved	Farmers variety	Use		Parts used
1.			medicinal	food	
2.					

2. Which one is the most commonly used landrace in your area? What is the special thing about it to be commonly used?

-

For key informants

For each landraces you mentioned, rank the table below.

Landrace Name	Yield(1=highest, 2=lowest) 3=moderate	maturity time(1=fastest maturing, 2=slowest maturing) 3=moderate	Taste (1=tastiest, 2=least tasty) 3=moderate	Drought tolerance (1=least affected, 2=most affected) 3=moderate	Disease resistance (1=least affected, 2=most affected) 3=moderate	Kocho quality(1=low quality, 2=midium quality, 3=high quality)	Bulla quality(1=low quality, 2=midium quality, 3=high quality)	Fiber quality(1=low quality, 2=midium quality, 3=high quality)
1.								
2.								
3.								
4.								

Do you know any traditional landraces that are no longer cultivated? What were their names?

For each variety mentioned as lost:

5.1. Was the lost variety an old variety (say at least 20 - 30 years old)?

A. Yes B. No C. Do not know

5.2. How long is it since the variety disappeared?

A. Over the last 10 years B. Over 10-20 years C. 20 – 30 years D. More than 30 years E. Do not know

5.3. Was it a sudden loss or a gradual process?

A. Sudden B. Gradual C. Do not know

5.4. How popular was the variety?

A. Very popular B. Popular C. Not so popular D. Do not know

5.5. Why do you think the landraces lost or not cultivated at the present time?

A. Replacement by high yielding improved landraces B. Climate change C. Market price and demand

Enset In General

3. What is the local name of Enset in your language? What is its meaning? _____

4. Is there any wild relative of this species you know? What is it called? For what purposes is it used? _____

5. List the top four crops cultivated in your area? _____

6. What makes enset different from other crops? _____

7. What do you think about the amount of production of Enset in your area (in your life time)? Because of what do you think this happened?

A. Increased B. Decreased C. No change

8. What are threats of Enset variety in your farm land?

9. By what kind of pests and diseases is Enset affected in your farm land? What do they cause? _____

10. What are the common weeds that attack this crop? What do they cause? _____

11. How do you traditionally manage such pests and diseases? _____

12. What kind of fertilizer do you use?

A. Compost B. Urea C. DAP D. Fresh Manure E. Natural F. Nothing G. Other

13. If you don't use fertilizer, why? _____

14. Are there limitations in the cultivation and utilization of enset in your locality? _____

15. How much hectares do you own? _____

16. How much of it do you use for Enset production? _____

17. How much do you get from that hectare? _____ -

18. What amount of Enset do you use for household consumption?

A. 1/2 B. 2/4 C. 3/4 D. All

19. What amount of Enset do you use for selling to market?

A. 1/2 B. 2/4 C. 3/4 D. All

28. Could you tell me the amount or dosages that are used for disease treatment?

29. What are the different uses of Enset? Which parts of the plant are used for what purpose? How?

Planting material, Selection and Storage

30. From where do you get planting material?

A. Market places B. Stored seeds C. exchange with other farmers D. Research center E. Other (specify) _____

31. Do you select planting material for next season? If so, what are the criteria of selection?

A. Yield amount B. corm color C. corm size D. leaf size E. Other (specify) _____

32. Where do you store planting material? _____

33. What kinds of pests affect the enset landraces during storage? _____

Cultivation and management practices

34. How do you manage your land before planting? _____

35. How do you manage your land after plating? _____

36. How do you manage it after harvest? _____

37. What are the responsibility of females in the cultivation and management of Enset? _____

38. How many times is it weeded? _____

39. What is the environmental requirement for the crop to grow? _____

40. Which soil type is suitable for Enset growth? _____

41. Where do you grow this crop? _____

A. Home garden B. Main field D. Other (specify) _____

42. Which cropping system do you use to grow Enset?

A. Sole cropping B. Intercropping C. Border cropping D. multiple cropping E. Other (specify) _____

43. If intercropping, which crops do you grow in association with Enset?

44. If boarder cropping, which crops do you grow in association with Enset?

45. What are the uses of boarder cropping? _____

46. If multiple cropping, which crops do you grow in association with Enset? _____

Appendix 2 Description list format for Enset morphology

Variety	Plant height	Pseudostem color	Pseudostem height	Pseudostem circumference	Petiole color	Leaf color	Leaf height	Leaf width	Midrib color	Leaf number	Kocho quality	Bulla quality	Fiber quality
Agaden	6	light green	240	180	deep green	green	320	54	Green	10	low	Low	high
Amarate	5.7	Red, with dot	200	120	deep red	green	375	60	dark red	25	high	highhigh	midium
Astara	6	light red	240	140	Red	deep green	290	70	light red	9	low	midium	midium
Cherki ma	7	White	300	125	green light	deep green	400	64	light green	9	midium	midium	midium
Dare	6.9	Green	240	220	red	yello wish green	450	60	yellow	11	Midium	Midium	high
Fereze	7.6	Red	260	190	green	Yelo wish	500	80	light red	14	Midium	midium	midium
Gimbiwo	7.9	light red	320	200	green	470	75		light green	16	midium	midium	Midium
guare	6.5	light green	250	180	Dark red	green	400	30	Green	25	midium	midium	midium

Jejeba	7.6	Green	340	120	green	dark yellow	420	70	yellow	7	high	high	high
Kibinar	7.9	deep red	320	180	Deep	light green	470	35	Deeb	6	Midium	midium	midium
Nechiwo	7	White	360	180	light	light green	320	50	Light green	5	Midium	midium	midium
Owret	8	light green	340	220	green	green	460	30	Green	15	midium	midium	midium
Qanchiwo		light red	350	200	green	Light green	450	45	Green	13	high	high	high
Saja	8.4	Light red	460	420	green	green	370		light red	13			
Sebara	6.8	black	180	230	Green	Deep green	420	70	Greenish red	12	High	high	midium
Siniwo	6.5	dark red	290	240	Light red	Light green	350	80	light red	12	midium	midium	midium
Wolamustara	8.6	greenish black	400	210	yellowish green	green	350	60	light red	20	midium	midium	midium
Wonadi	6.6	light red	260	200	reddish yellow	yellowish green	460	55	greenish red	21	low	low	low

Woret	8	white	260	220	green	light green	290	65	redish yellow	21	high	high	high
Yekebero onset	7.6	reddish yellow	290	180	dark red	yellowish green	500	73	Green	20	midium	midium	midium
Yekesiwo	9.8	deep red	450	260	red	light red	470	57	dark red	11	midium	midium	midium
Yeshirakinke(guragina)	8	green	390	230	green	green	550	53	deep red	11	midium	midium	midium
Yeshirafire	8.2	red	250	130	dark red	yellowish green	410	49	Green	14	high	high	low
Yegondie	7.7	300	230	230	light red	green	450	56	Green	14	high	high	low
Yiregie	7.5	260	250	130	green	green	450	45	Green	9	high	high	low
Zegeziwo(kabeni gna)	6.3	green	250	200	light green	light green	440	39		15	high	high	midium
Zobir(kabenigna)	9	red	350	145	light red	dark yellow	350	40	light green	20	midium	midium	midium

Appendix 3.Raw data collected

No.	Farmer Code	Latitude	longitude	Altitude	kebele	Districts	Zone	Reign
1	W01	08°19'179' 'N	037°59'17 5''E	2087	Washabi	Kabena	Gurage	SNNPRS
2	W02	08°19.455' N	037°58.253 'E	2080	Wosharb i	Kabena	Gurage	SNNPRS
3	Wo3	08°19.363' N	037°57.235 'E	2091	Wosharb i	Kabena	Gurage	SNNPRS
4	W04	08° 19.229'N	037°58.205 'E	2091	Wosharb i	Kabena	Gurage	SNNPRS
5	W05	08°19.360 'N	037°48.220 'E	2113	Wosharb i	Kabena	Gurage	SNNPRS
6	W06	08°19.157' N	037°58.200 'E	2079	Wosharb i	Kabena	Gurage	SNNPRS
7	W07	08°19.433' N	037°49.122 'E	2096	Wosharb i	Kabena	Gurage	SNNPRS
8	W08	08°19.148' N	037°58.190 'E	2105	Wosharb i	Kabena	Gurage	SNNPRS
9	W09	08°19.137' N	037° 48.143'E	2089	Wosharb i	Kabena	Gurage	SNNPRS
10	W10	08° 19.255'N	037° 58.431'E	2089	Wosharb i	Kabena	Gurage	SNNPRS
11	L01	08°18.643' N	037°48.982 'E	2055	lencha	Kabena	Gurage	SNNPRS
12	L02	08°18.792' N	037°49.065 'E	2060	lencha	Kabena	Gurage	SNNPRS
13	L03	08°18.533' N	037°48.883 'E	2050	lencha	Kabena	Gurage	SNNPRS
14	L04	08° 18.649'N	037°49.038 'E	2059	Lencha	Kabena	Gurage	SNNPRS
15	L05	08°18.669' N	037°48.970 'E	2063	Lencha	Kabena	Gurage	SNNPRS
16	L06	08° 18.723'N	037° 49.047'E	2063	Lencha	Kabena	Gurage	SNNPRS
17	L07	08°18.543' N	037°48.961 'E	2048	Lencha	Kabena	Gurage	SNNPRS
18	L08	08° 18.633'N	037° 49.025'E	2066	Lencha	Kabena	Gurage	SNNPRS
19	L09	08° 18.776'N	037° 48.675E	2062	Lencha	Kabena	Gurage	SNNPRS
20	L10	08° 18.659'N	037° 49.047'E	2069	Lencha	Kabena	Gurage	SNNPRS
21	R01	08°16.839' N	037°45.149 'E	2013	Rimuga	Kabena	Gurage	SNNPRS
22	R02	08°16.489' N	037°44.839 'E	1729	Rimuga	Kabena	Gurage	SNNPRS

23	R03	08 ⁰ 16.524'N	037 ⁰ 47.148'E	2028	Rimuga	Kabena	Gurage	SNNPRS
24	R04	08 ⁰ 16.652' N	037 ⁰ 47.150 'E	1850	Rimuga	Kabena	Gurage	SNNPRS
25	R05	08 ⁰ 16.349	037 ⁰ 47.231'E	2018	Rimuga	Kabena	Gurage	SNNPRS
26	R06	080 16.446'N	037044.688 'E	2023	Rimuga	Kabena	Gurage	SNNPRS
27	R07	08 ⁰ 16.293'N	037044.872 'E	1900	Rimuga	Kabena	Gurage	SNNPRS
28	R08	08 ⁰ 16.495' N	037044.165 'E	1880	Rimuga	Kabena	Gurage	SNNPRS
29	R09	08 ⁰ 16.597'N	037 ⁰ 47.183 'E	1885	Rimuga	Kabena	Gurage	SNNPRS
30	R10	08 ⁰ 16.933'N	037 ⁰ 53.253 'E	1800	Remuga	Kabena	Gurage	SNNPRS
31	K01	08 ⁰ 16.787' N	037 ⁰ 53.244'E	2100	Katbare	Kabena	Gurage	SNNPRS
32	K02	08 ⁰ 16.990' N	037 ⁰ 53.219 'E	2059	Katbare	Kabena	Gurage	SNNPRS
33	K03	08 ⁰ 16.777' N	037 ⁰ 53.339 'E	2065	Katbare	Kabena	Gurage	SNNPRS
34	K04	08 ⁰ 16.652' N	037 ⁰ 53.257 'E	1820	Katbare	Kabena	Gurage	SNNPRS
35	K05	08 ⁰ 16.448' N	037 ⁰ 53.198 E	1890	Katbare	Kabena	Gurage	SNNPRS
36	K06			2010	Katbare	Kabena	Gurage	SNNPRS
37	K07			1990	Katbare	Kabena	Gurage	SNNPRS
38	K08			1900	Katbare	Kabena	Gurage	SNNPRs
39	K09			2080	Katbare	Kabena	Gurage	SNNPRS
40	K10			1998	Katbare	Kabena	Gurage	SNNPRS
41	G01	08 ⁰ 09.880'N	037 ⁰ 57.099 'E	2360	Girar	Cheha	Gurage	SNNPRS
42	G02	08 ⁰ 06.198' N	037 ⁰ 57.263	2257	Girar	Cheha	Gurage	SNNPRS
43	G03	08 ⁰ 06.274' N	037 ⁰ 57.224	2373	Girar	Cheha	Gurage	SNNPRS
44	G04	08 ⁰ 09.772' N	037 ⁰ 57.125 'E	2280	Girar	Cheha	Gurage	SNNPRS
45	G05	08 ⁰ 06.236' N	037 ⁰ 57.102 'E	2300	Girar	Cheha	Gurage	SNNPRS
46	G06	08 ⁰ 06.236' N	037 ⁰ 57.102 'E	2360	Girar	Cheha	Gurage	SNNPRS
47	G07	08 ⁰ 09.174' N	037 ⁰ 57.240 'E	2347	Girar	Cheha	Gurage	SNNPRS
48	G08	08 ⁰ 09.888' N	037 ⁰ 57.87' E	2293	Girar	Cheha	Gurage	SNNPRS
49	G09	08 ⁰ 09.927' N	037 ⁰ 57.137 'E	2278	Girar	Cheha	Gurage	SNNPRS
50	G10	08 ⁰ 06.172' N	037 ⁰ 57.788 'E	2333	Girar	Cheha	Gurage	SNNPRS
51	YEW01	08 ⁰ 06.824' N	037 ⁰ 55.477 'E	2205	Yewosie	Cheha	Gurage	SNNPRS
52	YEW02	08 ⁰ 06.907' N	037 ⁰ 55.456 'E	2274	Yewosie	Cheha	Gurage	SNNPRS

53	YEW03	08 ⁰ 06.842' N	037 ⁰ 55.462 'E	2210	Yewosie	Cheha	Gurage	SNNPRS
54	YEW04	08 ⁰ 06.666' N	037 ⁰ 55.557 'E	2250	Yewosie	Cheha	Gurage	SNNPRS
55	YEW05	08 ⁰ 06.849' N	037 ⁰ 55.352 'E	2243	Yewosie	Cheha	Gurage	SNNPRS
56	YEW06	08 ⁰ 06.910' N	037 ⁰ 55.470 'E	2198	Yewosie	Cheha	Gurage	SNNPRS
57	YEW07	08 ⁰ 06.747' N	037 ⁰ 55.320 'E	2265	Yewosie	Cheha	Gurage	SNNPRS
58	YEW08	08 ⁰ 06.822' N	037 ⁰ 55.257 'E	2219	Yewosie	Cheha	Gurage	SNNPRS
59	YEW09	08 ⁰ 06.722' N	037 ⁰ 55.480 'E	2277	Yewosie	Cheha	Gurage	SNNPRS
60	YEW10	08 ⁰ 06.991' N	037 ⁰ 55.259 'E	2237	Yewosie	Cheha	Gurage	SNNPRS
61	YES01	08 ⁰ 08.708' N	038 ⁰ 01.212 'E	2601	Yesirayi	Esia	Gurage	SNNPRS
62	YES02	08 ⁰ 08.689' N	038 ⁰ 01.201' E	2610	Yesirayi	Esia	Gurage	SNNPRS
63	YES03	08 ⁰ 08.703' N	038 ⁰ 01.201 9'E	2620	Yesirayi	Esia	Gurage	SNNPRS
64	YES04	08 ⁰ 08.677' N	038 ⁰ 01.203 1'E	2589	Yesirayi	Esia	Gurage	SNNPRS
65	YES05			2282	Yesirayi	Esia	Gurage	SNNPRS
66	YES06			2613	Yesirayi	Esia	Gurage	SNNPRS
67	YES07			2605	Yesirayi	Esia	Gurage	SNNPRS
68	YES08			2617	Yesirayi	Esia	Gurage	SNNPRS
69	YES09			2571	Yesirayi	Esia	Gurage	SNNPRS
70	YES10			2611	Yesirayi	Esia	Gurage	SNNPRS
71	S01	08 ⁰ 09.685' N	037 ⁰ 57.314 'E	2281	Shebrade n	Esia	Gurage	SNNPRS
72	S02	08 ⁰ 09.723' N	037 ⁰ 57.287 'E	2270	Shebrade n	Esia	Gurage	SNNPRS
73	S03	08 ⁰ 09.687' N	037 ⁰ 57.322 'E	2278	Shebrade n	Esia	Gurage	SNNPRS
74	S04	08 ⁰ 09.657' N	037 ⁰ 57.222 'E	2278	Shebrade n	Esia	Gurage	SNNPRS
75	S05	08 ⁰ 09.706' N	037 ⁰ 57.330 'E	2287	Shebrade n	Esia	Gurage	SNNPRS
76	S06			2290	Shebrade n	Esia	Gurage	SNNPRS
77	S07			2285	Shebrade n	Esia	Gurage	SNNPRS
78	S08			2275	Shebrade n	Esia	Gurage	SNNPRS
79	S09			2281	Shebrade n	Esia	Gurage	SNNPRS
80	S10			2293	Shebrade n	Esia	Gurage	SNNPRS
81	D01	08 ⁰ 8.415' N	037 ⁰ 59.437 'E	2291	Desene	Esia	Gurage	SNNPRS
82	D02	08 ⁰ 08.400' N	037 ⁰ 59.440 'E	2459	Desene	Esia	Gurage	SNNPRS

83	D03	08 ⁰ 08.396' N	037 ⁰ 59.428'E	2445	Desene	Esia	Gurage	SNNPRS
84	D04	08 ⁰ 08.411' N	037 ⁰ 59.441' E	2427	Desene	Esia	Gurage	SNNPRS
85	D05			2420	Desene	Esia	Gurage	SNNPRS
86	D06			2460	Desene	Esia	Gurage	SNNPRS
87	D07			2460	Desene	Esia	Gurage	SNNPRS
88	D08			2458	Desene	Esia	Gurage	SNNPRS
89	D09			2470	Desene	Esia	Gurage	SNNPRS
90	D10			2439	Desene	Esia	Gurage	SNNPRS
91	M01			2476	Mentir	Esia	Gurage	SNNPRS
92	M02			2469	Mentir	Esia	Gurage	SNNPRS
93	M03			2285	Mentir	Esia	Gurage	SNNPRS
94	M04			2260	Mentir	Esia	Gurage	SNNPRS
95	M05			2258	Mentir	Esia	Gurage	SNNPRS
96	M06			2289	Mentir	Esia	Gurage	SNNPRS
97	M07			2247	Mentir	Esia	Gurage	SNNPRS
98	M08			2239	Mentir	Esia </td <td>Gurage</td> <td>SNNPRS</td>	Gurage	SNNPRS
99	M09			2273	Mentir	Esia	Gurage	SNNPRS
100	M10			2285	Mentir	Esia	Gurage	SNNPRS

Appendix 4 Photographs



Declaration

I, the undersigned declare that this Thesis is my original work and it has not been presented in other universities, colleges or institutes for a degree or other purpose. All sources of the materials used have been duly acknowledged.

Name: _____ Signature: _____ Date: _____

This work has been done under my/our supervision.

Name: _____ Signature: _____ Date: _____

_____ Signature: _____ Date: _____