Addis Ababa University, College of Natural and Computational Sciences

Analysis of Indigenous Production Method and Farm Based Varieties of *Ensete ventricosum* (welw.) Cheesman in Three Major Enset Growing Kebeles of Dedo District, Jimma Zone, South western Ethiopia

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A Thesis Submitted to Department of Zoological Science

In Partial Fulfilment of the Requirement for Master of Degree in Biology

March, 2024

Addis Ababa Ethiopia

Approval Sheet Form

Addis Ababa University School of Graduate Studies

This is to certify that the thesis prepared by Bikila Gadisa entitled: "**Analaysis of Endigenous production method and farm based varieties of *Ensete ventricosum* (welw.) cheesman in three major Enset growing kebeles of Dedo District, Jimma Zone, South western Ethiopia**" and submitted in partial fulfillment of the requirements for the degree of master of science in Biology complies with the regulation of the university and meets the accepted standards with respect to originality and quality.

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ABSTRACT

Title: **Analysis of indigenous production method and farm based varieties of *Ensete ventricosum* (welw.) cheesman in three major Enset growing kebeles of Dedo District, Jimma Zone, South western Ethiopia**

By: Bikila Gadisa

Addis Ababa university, 2024

Enset (Ensete ventricosum) is a multipurpose crop that is cultivated solely in Ethiopia, mainly in the south and southwest part of the country. It provides a variety of services. Every part of the crop is extensively exploited. The objective of this study was to examine farm-based biodiversity and the traditional Enset production method in three kebeles of Dedo District in the Jimma Zone in the southwestern of Ethiopia. Purposive sampling was applied for selecting the study kebeles, and the simple random approach was used to choose home informants based on the potential for Enset growing households. A total of 188 households were used. The data were collected using questionnaires, key informant interview, field observation and focus group discussion. Then the data was analysed using SPSS 20 Software and microsoft excel. In the present exploration 28 Enset local varieties have been identified. Among the commonly occurring landraces, Nobo, Fia, Molge and Buriti were recognized to be the most widespread landraces in the study area. Most of the farmers highly practiced mono-culturing (73.93%) growing. Enset was predominantly produced in almost all kebeles which accounts about 23% compare to other crops and the indigenous farmers used Enset crops most of the time for food accounts (78.18%) animal feed (9.57%) and medicine (2.12%). Where the corm and the pseudostem are the most important sources of food. The types of food from these parts are 'Kocho and'Bulla or Etino. Enset bacterial wilt disease was the most common problem in surveyed area.

Keywords*: Enset, indigenous knowledge, landraces, household, bacterial wilt, farmers, kocho, production constraints.*

ACKNOWLEGEMENTS

I would like to thank Dr. Bikila Warkineh, my advisor, for all of his support and encouragement from the start of choosing a title to the completion of my work. I am also grateful to the farmers and locals in my study area for providing me with pertinent and helpful information. My deepest appreciation goes out to the Dedo District Educational Bureau for providing me with the chance to get a master's degree. I am also grateful to the Department of Zoological Sciences, College of Natural Sciences, and Addis Ababa University for providing me with all the facilities I needed for my studies, including financial support. In conclusion, I would want to thank my family for their moral support and encouragement. Last but not least, I would like to acknowledge all my friends who helped me in one or the other forms for the work to be fruitful.

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LIST OF ACRONOMY AND ABBREVIATION

EFS……Enset farming system

IKS……..…Indigenous knowledge system

SPNNRS…….Southern people nations nationalities regional state

AARC…….….. Areka agricultural research center

DM…….....Dry matter

CSA…….…..…..Center of statistics agency

FGD……...Focus group discussion

KI……..Key informants

DA……. ……..... Development of agricultural office

LIST OF APPENDICES

UNIT ONE

INTRODUCTION

1.1. Back ground of the study

Ensete ventricosum (Welw.) Cheesman, commonly referred to as Enset, is a monocarpic perennial herb from the Musaceae family. This plant is native to Ethiopia, where it holds significant cultural and agricultural value. Enset is widely distributed as a wild species across Sub-Saharan Africa and parts of Asia (Cheesman, 1951; Simmonds, 1958).

According to Brandt et al. (1997), Enset is primarily cultivated in its indigenous agricultural systems in southern and southwestern Ethiopia. It is considered one of the most crucial crops in the country, contributing significantly to food security and rural livelihoods for approximately 20 million people, or about one-fifth of Ethiopia's population. Enset's domestication dates back to the Neolithic era or even earlier (Brandt et al., 1997; Stanley, 1996). Its traditional farming techniques are recognized for their sustainability and are among the few traditional agricultural systems still practiced in Africa (Westphal, 1996; Tsegaye, 2002).

Currently, Enset cultivation spans over 300,000 hectares, making it one of the largest perennial food crops in Ethiopia (CountryStat, 2013).

The Enset farming system (EFS), in which Enset is grown as a perennial plantation in a homestead ring among other companion crop species growing on main agricultural land, is rich in both inter-specific and intra-specific variation (Tsegaye and Struik, 2002). The diversity of crop species found in EFS is the product of evolutionary processes across countries, impacted by environmental heterogeneity, and domestication processes driven by native cultures, knowledge, and customs. The generation and continued maintenance of on-farm Enset diversity is supported by traditional farmers' knowledge and practices. However,recent studies have noted that the Enset agricultural system of Ethiopia is changing or has changed in its social, biological and environmental context (Tsegaye, 2002; Tenaye,2009) and Samberg et al., 2013). Indigenous knowledge system (IKS), or otherwise called local knowledge system, is a wide comprehensive concept which includes, but it is not limited to the botanical knowledge, traditional food knowledge, surrounding environmental and ecological knowledge that enable farming communities to lead stable livelihoods in their environments (Das Gupta, 2012;Kwick, 2008). IKS off farming community, expressed in the form of folklores and transmitted orally from one generation to next, is embedded in the food cultures, crops planted and animals reared by the farmers, and the environment and ecological setting the community lives in. It is well established that documenting and deploying the local knowledge of farmers management and use system of agro-biodiversity is a crucial

starting point for improving farming systems as well as for fending-off the loss of biocultural diversity (Das Gupta, 2012).

Enset (*Ensete ventricosum)* is a multipurpose crop that provides a variety of benefits including food, fodder, medicine, ritual, construction, and soil preservation. Different Enset types are responsible for the various uses (Tsehaye and Kebebew, 2006). Enset is found in the wild across much of central, eastern, and southern Africa. However, it has been farmed (Simmonds, 1958; Bizuneh et al., 1967), domesticated (Brandt, 1996), and incorporated into Ethiopian farming systems (Ehret, 1979). Currently, almost one-fifth of Ethiopia's population (20 million) relies on this crop, primarily in the southern region and surrounding areas in the Oromiya and Gambella regions. The overall area under Enset crop in Ethiopia is predicted to be 312.17 thousand hectares (SWSZANRO, 2018), whereas in Southern Nations Nationalities and Peoples Regional State, it is 217 thousand hectares; in Oromia, it is 94 thousand hectares; and in Gambella, it is 0.382 thousand hectares (SWSZANRO, 2018).

In some regions of Ethiopia, Enset is regarded as a crop for food security since it can endure protracted droughts, heavy rainfall, and flooding that destroy other crops (Kasa and Woldeab , 2015). When grain harvests fail, it is primarily farmed for food security and consumed as kocho and amicho. Additionally, farmers have employed the crop as a means of adapting to climate change (Laila et al., 2016, Sahle et al., 2018). Listed are kocho, bulla and amicho as the major food products obtained from the Enset. Enset crop is crucial in the Ethiopian context and specifically in the study district. It has a significant contribution to the livelihood of producers as income sources as well as ensuring of food security.

As with any perennial crop, Enset agriculture helps maintain soil fertility and environmental sustainability by preventing erosion and keeping moisture and nutrients. Compared to other fields, Enset fields have higher levels of nutrients and soil organic matter (Tensaye et al., 1998). Enset is a carbon dioxide sink, much like forests, and its large root system stays in the soil long after harvest. Enset is known as a drought-tolerant crop; during the famines of the 1970s and 1980s, it is reported that farmers who grew Enset did not experience starvation (Brandt et al., 1997). Enset is a food resource that is comparable to potatoes (Mohammed et al., 2013). Of the crops planted in Ethiopia, it yields the most edible energy per area and time unit (Tsegaye and Struik, 2001). Farmers have traditionally used Enset agriculture as a means of adapting to the effects of climate change. There are undoubtedly many advantages for the economy, society, and environment. Enset propagation, management and food processing techniques rely on indigenous technical knowledge of farmers. Farmers continue to employ the same landraces since there has been no purposeful breeding or improvement in genotype. The

national center for Enset research, Areka Research Center, released six landraces as cultivars with specific traits.

1.2. Statement of the problem

The majority of people living in southwestern Ethiopia depend on the Enset for a variety of daily needs. Enset is utilized by the residents of Dedo, one of the area's Districts, for plenty of purposes, including food security, medication, and livestock consumption. However, there are many restrictions on how they grow and produce Enset: farmers only use a limited number of Enset varieties that are unable to fulfill multiple roles; Enset cultivation is limited to home gardens; and there is a lack of scientific knowledge about Enset farming. Thus, in order to address the aforementioned issues that Enset producer farmers in three kebeles in the Dedo District were facing, this study was conducted to analyze the indigenous production method and farm-based biodiversity of Enset.

1.3. Research question

The purpose of this study was to answer the following questions:

1. How many different varieties of *Ensete ventricosum* are there in the study area as well as in each house hold?
2. Which types of varieties of Enset are abundant in this area?
3. How can farmers produce Enset indigenously?
4. What were the main challenges faced farmers during the production of Enset traditionally

1.4. Objectives

1.4.1. General objectives

- To analysis the indigenuous production method of Enset and farm-based varieties.

1.4.2. Specific objectives

- To describe and assess the indigenous knowledge that is currently available on production methods and constraints
- To identify the existing diversity and its potential use in improving the production systems.
- To identify house hold characteristics that determine Ensete's production and biodiversity.
- To determine the Enset varieties grown in three kebeles of Dedo District

1.5. Significance of the Study

This study identified the main Enset production constraints, number of landraces grown and farmers' preferred traits of Enset in Dedo District. The finding of this study will help to Enset breeders and producers for selection, sustainable Enset production and conservation of Enset genetic resources in the study area. The result will change the indigenous knowledge of farmers to the scientific form, how to produce and cultivate Enset in their farm land to diversify the fuction of Enset to food, forage, medicine, construction, ritual and soil protection instead of limit for food security only. The study can create awareness on farmers how they can get more products from small area of farm lands. In another way the study on analysis of indigenous production is important to provide relivant information on the existing knowledge gap. Thus, the present study carried out analysis of Enset indigenous production method and farm based biodiversity in Dedo District. Therefore, the results of this study will broad the community understand on Indigenous production method of Enset and useful to overcome the traditional production method of Enset. The study makes a significant contribution to enhance food security and income generation to the rural households in the country.

1.6. Delimitation (Scope of the study)

The study is restricted to the Dedo District, Jimma Zone, Oromia Region in the southwestern of Ethiopia. The district consists of 36 rural kebeles and three urban administration towns for administrative purposes. Of the 36 rural kebeles in Dedo, the study was conducted in three of them, specifically chosen for their purpose and accessibility to produce Enset. The purpose of the study was to analyze the indigenous production method Enset and farm-based biodiversity between February and May,2023.

1.7. Limitation of the study

The study of the analaysis of indigenous production method of Enset and farm based biodiversity requires time, resource, different scientific instruments and methods. In this study, all crucial aspect of the analysis of indigenous production method of Enset on all farmers in this district did not included. Without a detail data sets of the above mentioned, conclusion drawn become a limitation of this study. The study would be more effective and beneficial if the data was taken from the whole study site of the District. However due to time, financial and resources constrains the study was limited to the selected sample sites of three rural kebeles of Dedo District.

1.8. **Organization of the paper**

There were five chapters in the thesis. The background of the study, the problem statement, the objective, the study's scope, its limitations, the research question, and the paper's organization are all included in the first chapter's introduction section. The second chapter reviews relevant research on the examination of farm-based biodiversity and indigenous production of Enset (*Ensete ventricosum*). The study area and technique were described in detail in the third chapter of the paper. The research design, sample data collecting, and analysis methods are justified by the methodology. The findings and conversations are discussed in the fourth chapter and the recommendations and conclusion were included in the fifth chapter. Lastly, the appendices and references at the end.

UNIT TWO

2. LITERATURE REVIEW

2.1. Enset Cultivation in Ethiopia

2.1.1. Historical Context and Domestication

The domestication of Enset in Ethiopia is thought to date back several millennia, with some research indicating that it may have begun as early as 10,000 years ago (Brandt, Spring, & Harlan, 1997). The southwestern highlands of Ethiopia, especially the Kefa region, are recognized as the primary centers for the diversity and domestication of Enset (Westphal, 1975; Harlan, 1969). Recent studies have expanded on this historical understanding by exploring how Enset spread across various regions of Ethiopia and became integrated into different agricultural practices.

2.1.2. Current Cultivation Practices

Enset continues to be a crucial crop in Ethiopia, notably in the Southern Nations, Nationalities, and Peoples' Region (SNNPR), western Oromia, and parts of the highlands (Smeds, 1955). Contemporary research has documented both traditional and innovative methods of Enset cultivation and management. For example, Tsegaye and Beyene (2023) discuss the shift from traditional practices to more sustainable cultivation approaches in response to evolving environmental and socio-economic factors.

2.1.3. Role in Food Security and Climate Adaptation

Enset is valued for its ability to withstand varying climatic conditions, which makes it a crucial crop for maintaining food security in Ethiopia. Recent research highlights Enset's effectiveness in buffering against the effects of climate change, such as droughts and heavy rainfall (Berhanu & Haile, 2022). Its adaptability to climate variability is particularly important as it ensures a steady food supply when other crops may fail. A review by Woldemariam and Tesfaye (2020) underscores the role of Enset in enhancing food security and suggests that improving Enset-based agricultural systems could further strengthen resilience to climate challenges.

2.1.4. Socio-Economic Impact

The socio-economic importance of Enset has been increasingly recognized. Research by Girma and Kassahun (2021) illustrates how Enset cultivation underpins rural livelihoods by providing essential food and income for many Ethiopian farmers. The crop's integration into local economies is critical for its continued cultivation. Further studies emphasize Enset's significant contribution to local economies, highlighting its role in both income generation and food security across different Ethiopian regions (Tsegaye & Struik, 2001; Negash & Alemayehu, 2017).

2.1.5. **Sustainability and Environmental Impact**

Enset cultivation is noted for its environmental benefits, such as maintaining soil fertility and controlling erosion. Studies have found that Enset fields generally possess higher soil organic matter and nutrients compared to fields growing other crops (Fikadu & Derso, 2018). Additionally, the crop's extensive root system aids in carbon sequestration, enhancing its environmental sustainability (Mulugeta & Teshome, 2019).

2.1.6. **Challenges and Future Directions**

Despite its benefits, Enset cultivation faces several challenges, including the need for better pest management and more advanced breeding programs. Recent literature highlights the necessity of addressing these issues to improve productivity and sustainability. There is also a call for combining indigenous knowledge with modern agricultural practices to optimize Enset cultivation (Das Gupta, 2012; Shigeta, 1991).

2.2. Enset agronomy and farming systems

2.2.1. **Propagation and Tissue Culture**

Enset is primarily propagated through vegetative methods using suckers from the corm of a young plant. Because Enset plants are usually harvested before they fully flower, seeds are rarely available, and vegetative propagation is preferred for its effectiveness in producing vigorous plantlets (Alemu & Sandford, 1991). There is one domesticated Enset landrace from the Ari region that can produce suckers from the base of the leaf petiole, but Enset seeds generally have low germination rates compared to wild Enset, which reproduces primarily through seeds (Negash, 2001).

Suckers develop from buds on the upper part of the corm. While there are variations in corm preparation practices among different ethnic groups (Diro, Haile, & Tabogie, 1996), the core procedures are similar. Farmers typically harvest the pseudostem and retain the corm to generate suckers. Unlike bananas, Enset naturally produces few suckers due to the dominance of the apical meristem, which must be removed to encourage sucker formation. After removing the apical meristem, the corms are either left whole or cut into smaller pieces and then planted 20–30 cm deep in soil mixed with manure. Preferred corms are 2–4 years old and 10–35 cm in diameter (Bezuneh & Feleke, 1966; Yemataw, Mohamed, Diro, Addis, & Blomme, 2014). Each corm piece can yield between 40 and 200 suckers, influenced by factors such as cultivar, corm size, soil conditions, and rainfall (Shumbulo, Gecho, & Tora, 2012). Suckers typically emerge 2–3 months after planting, with split corms generally producing more and faster-growing suckers than whole corms (Karlsson, Dalbato, Tamado, & Mikias, 2015). In drought-prone areas, using whole

corms may prevent desiccation, while areas with reliable water sources benefit from using split corms and applying manure (Karlsson et al., 2015).

Several technologies have been developed to enhance sucker production, including macro-propagation methods where corms are cut into pieces and grown in controlled environments (Makiso, 1996). Other rapid propagation techniques include zygotic embryo culture (Bezuneh, 1980; Diro, van Staden, & Bornman, 2004), shoot tip culture (Afza, van Duren, & Morpurgo, 1996), and callus culture with somatic embryogenesis (Mathew, Manuel, & Philip, 2000). However, micro-propagated Enset plants often face issues such as phenolic oxidation, necrosis, and low shoot formation rates, limiting their effectiveness as an alternative to traditional sucker propagation (Diro et al., 2004).

2.2.2. Transplanting and harvest

Harvested suckers are planted in a nursery plot (0.5 to 1 m^2 $plant^{-1}$) where they grow for about one year. Subsequently, suckers are consecutively transplanted into ever more widely spaced arrangements, with a final minimal spacing of 2 to 4 m^2 $plant^{-1}$ (Bezuneh & Feleke, 1966; Hiebsch, 1996; Tsegaye & Struik, 2002), with wider spacing more common in areas of lower soil moisture e.g., Gurage (Sahle et al., 2018). Since the corm and pseudo stem are harvested, higher yields can be expected by successive transplanting steps which delay flowering, thus allowing a longer period of time for vegetative growth, which includes assimilation of starch in the pseudo stem and corm. Therefore, direct transplanting is advised when early yields are the objective, but more frequent transplanting will result in higher yields per plant (Tsegaye & Struik, 2000). Once equilibrium (planting = harvesting) has been achieved, annual yields will be higher for twice transplanted plants compared to once transplanted as this encourages greater partitioning of dry matter to the harvestable parts (Blomme, Jacobsen, Tawle, & Yemataw, 2018; Tsegaye, 2007). Systems involving up to five transplanting stages are used in some areas. An additional benefit of repeated transplanting is the smaller overall space required (i.e., all plots with varying plant size/density are grown together). Full maturity of the Enset plant is reached after 4 to 12 years, depending on the landrace and altitude of the farm, with higher locations significantly increasing cropping cycle duration (Negash, 2001). The ideal moment to harvest is at inflorescence emergence. At that time, dry matter yield is highest. After flowering, assimilates are redirected toward the inflorescence and away from the pseudostem and corm (Tsegaye & Struik, 2000).

2.2.3. Enset farm management and fertilization

As a perennial crop, Enset fields generally do not require tilling, although sequentially spaced and sized holes are dug for transplanting stages and reused for successive individuals (J. Borrell, personal observation). Due to its large leaf surfaces, enset intercepts rainfall, which helps to limit erosion. The leaf

bases also appear to trap water close to the pseudostem, with pools of water observed even several months into the dry season (J. Borrell, personal observation). No irrigation practices have been observed for Enset. The root system of enset is larger and has thicker root cords compared to banana, potentially aiding plant stability in its preferred natural habitat of steep riverbanks and slopes, with 89%–96% of roots found in the upper 40 cm soil layer (Blomme, Sebuwufu, Addis, & Turyagyenda, 2008). Enset leaves and discarded parts of the pseudostem are frequently used as mulch, which enhances soil moisture and organic matter.

Enset farming systems are reported to require relatively little off-farm input, though manure application is widespread and considered essential by Enset farmers. Manure is derived from livestock traditionally housed adjacent to the Enset fields for ease of transfer, resulting in soil fertility in Enset fields being higher than in surrounding fields or pastures (Shank & Ertiro, 1996). The rate, timing, and method of manure application vary among households and depend on the plantation's growth stage and manure availability (Tsegaye & Struik, 2002).

Few fertilizer response trials for Enset exist compared to other crops. Bezuneh (1984) applied 3 kg of manure-compost, 500 g of N, and 400 g of P2O5 per plant, achieving fresh kocho weights of 18.5, 22.2, and 29.8 kg for the landraces "Ferezae", "Tuzuma", and "Adow" respectively, though control comparisons were not reported. Uloro and Mengel (1996) applied 100 kg/ha of N and 100 kg/ha of P fertilizer, which improved plant appearance, above-ground growth, fresh biomass, and fresh rhizome yield in soils with low to medium nutrient status. The inclusion of 200 kg/ha of K further improved plant morphology and rhizome starch production, although it did not significantly affect above-ground biomass yield. Fertilizer application resulted in dry weight starch yields ranging from 10 to 12 t/ha, which is three to four times higher than without fertilizer application (Uloro & Mengel, 1996).

2.2.4. Enset agricultural systems

Enset-based agriculture is recognized as one of Ethiopia's most sustainable indigenous farming systems. It supports a higher human carrying capacity compared to other crops and systems within similar agroecological settings and input levels (Brandt et al., 1997). However, further empirical research is needed to fully understand its sustainability. Enset-based farms often originate from forested areas where farmers clear undergrowth to cultivate Enset, Coffee, and other crops, while preserving the upper canopy trees. This practice results in multi-story agroforestry systems that have been relatively stable over the centuries (Kippe, 2002).

Agricultural systems in Ethiopia are notably diverse. Asfaw and Nigatu (1995) reported 162 different crop species cultivated in the highlands of Ethiopia, and Enset farms typically grow over 10 crop and

livestock species (Sibhatu, Krishna, & Qaim, 2015). Some farms cultivate up to 20 different Enset landraces within a single plantation (Zippel, 2005). While Enset is sold less frequently compared to other Ethiopian crops (Kandari, Yadav, Thakur, & Kandari, 2014), cash crops and livestock are crucial for Enset-based production systems (Tsegaye, 2002). Enset offers flexibility and security, allowing for the sale of standing plants or portions of fermented kocho or bulla from storage at any time.

Enset production systems can be categorized based on environmental, agronomic, and cultural factors, as well as the importance placed on Enset within each system (Brandt et al., 1997; Shank, 1994; Westphal, 1975). For instance, the Enset–Coffee–Maize system is predominant in the Sidama zone. Variations in these systems arise from differences in household wealth, farming skills, landholding sizes, resource availability, access to transportation, and altitude (Abebe, 2005). Mellisse, Descheemaeker, Giller, Abebe, and Ven (2018) found that traditional Enset–Coffee systems had the lowest crop productivity (1,820 kg Dry Matter [DM] ha−1), while newly evolved Enset–cereal–vegetable systems achieved the highest (3,020 DM kg ha−1). Energy productivity from food crops was higher in Enset-based systems (43 Gigajoules [GJ] ha−1) than in other systems, but revenue was lowest in enset-based systems (719 US$ ha−1) compared to newly evolved chat-based systems (6,817 US$ ha−1). Consequently, farmers may need to explore new agronomic systems and crop combinations to maintain enset's role as a staple while enhancing cash crop income.

2.3. Processing methods, products and cultural importance

Enset exhibits significant variation in its morphological and agronomic characteristics (Yemataw, Tesfaye, Grant, Studholme, & Chala, 2019), and processing methods also differ across various regions of Ethiopia (Abate, Gebremariam, Hiebsch, & Brandt, 1996; Hunduma & Ashenafi, 2011; Tedla & Abebe, 1994). Traditionally, the processing of Enset is performed by women, who possess extensive knowledge of the techniques involved. However, these tasks are labor-intensive and time-consuming (Hunduma & Ashenafi, 2011). Garedew et al. (2017) emphasize the risk of losing this indigenous knowledge as younger generations move away from Enset-based agriculture. Therefore, documenting the diverse agronomic and processing practices is crucial.

2.3.1. Enset food products

At harvest, starch is decorticated (scraped) from the parenchymatous pseudopetioles forming the pseudostem (consisting of overlapping leaf sheaths), grated, and pressed from the corm (the underground base of the stem that serves as a storage organ) and collectively processed using fermentation pits into a number of starchy foods. Landraces that yield a white paste of fermented pulp and a white bulla are selected for kocho or bulla production, whilst landraces that produce a friable and sweet corm are

selected for amicho production (Yemataw, Tesfaye, Grant, Studholme, & Chala, 2019). The traditional tools developed for this purpose include: the watani, a flat wooden plank against which leaf sheaths are laid for decortication; the javga, a wooden tool with a pointed end (crusher) to mash the pseudostem and a serrated end (grater) to pulverize the corm; and the sibisa, a split bamboo scraper held at both ends and used to scrape the length of the leaf sheath (Abate, Gebremariam, Hiebsch, & Brandt, 1996). These tools are typically used in the West Shewa Zone of Oromia.

The most prevalent product is kocho, a starch-rich food obtained by fermenting the resulting pulp (from scraping the pseudostem and mashing the corm) wrapped in Enset leaves in an underground pit specially prepared within the Enset home garden. There is a perception that fermentation will not be successful or effective if the pit is not positioned within the Enset planting area, possibly due to factors like shade or temperature (Hunduma & Ashenafi, 2011). The remaining fiber is removed, and the resulting paste is baked into a flatbread with a slightly sour flavor known as kocho. This flatbread is extremely popular in Ethiopian restaurants and is often served with kitfo (raw minced beef mixed with butter and spices). Bulla, a by-product of kocho production, is prepared from the liquid extracted when the scrapings and pulp are squeezed. The starch in this liquid is separated out by settling and removal of excess water or by evaporation to produce a white powder that can be stored for long periods. Rehydrated bulla can be used in a variety of ways, including making pancakes, dumplings, porridge, soup, or a drink. In the SNNPR, bulla is mixed with seasoned butter and spices to produce small grains similar to couscous, whereas in Western Oromia, it is mixed with seasoned butter and fresh milk to create a gelatinous foodstuff (Garedew, Mekonnen, Tsion, & Tamirat, 2017). Amicho, the fleshy inner portion of the corm, can be cooked by boiling—similar to Irish potatoes. Amicho is typically derived from younger plants around three years of age (J. Borrell, personal observation), although some varieties, such as landraces ‘Nifo’ and ‘Zoober,’ are claimed to produce good quality amicho even at maturity. It is the least commonly encountered preparation method. Similarly, bulla is available in much lower quantities than kocho and is generally more expensive due to the additional processing involved, resulting in a premium price as it is pure starch with no fiber or other stem-derived materials (Jacobsen, Blomme, Tawle, Muzemil, & Yemataw, 2018).

2.3.2. Enset fiber and packaging products

Fiber is extracted from the pseudostem and leaves, primarily as a by-product of kocho production (Blomme, Yemataw, et al., 2018). The extracted fibers are dried and utilized to make various items such as sacks, ropes, sieves, and mats. Depending on the height of the pseudostem, fibers can exceed 4 meters in length and are noted for their strength and flexibility. Additional fiber is derived from the leaf sheath,

petioles, and midrib, which are commonly repurposed for animal feed, compost, and fuel (Teli & Terega, 2017). Teli and Terega (2017) analyzed Enset fiber characteristics, including tensile strength, elongation at breaking point, and thermal stability, and found them to be comparable to other natural fibers like abaca, flax, sisal, hemp, and jute. Specifically, Blomme, Yemataw, et al. (2018) reported that Enset fiber has a tensile strength ranging from 9.8 to 17.5 kg g^{-1} m^{-1}. The potential for Enset fiber to be used in a variety of novel applications beyond its traditional uses is significant, with performance likely varying among different genetically diverse landraces.

Enset leaves serve multiple purposes, such as lining fermentation pits for kocho, wrapping kocho and other traditional breads during baking, and transporting butter and honey to market. They are also used to make mattresses and cushions and as fuel (Tedla & Abebe, 1994). Additionally, leaves and dried midribs are used for thatching houses and fences and for mulch. It is important to note that wild Enset plants are also frequently harvested for these uses, particularly in western regions where both wild and domestic Enset plants are present (Tedla & Abebe, 1994).

2.3.3. Animal fodder

Several studies have examined the use of Enset as animal feed (Fekadu & Ledin, 1997; Gizachew, Hirpha, Jalata, & Smit, 2002; Nurfeta, Eik, et al., 2008; Nurfeta, Tolera, et al., 2008; Nurfeta, Tolera, Eik, & Sundstøl, 2009) (see Figure 6). Mohammed, Martin, and Laila (2013) found that Enset leaves are a valuable source of animal fodder, containing 13% protein, 20% crude fiber, and 10% sugar. They also noted that Enset is a good starting material for silage production. Although the pseudostem alone does not contain sufficient fiber to be a suitable fodder for ruminants, this limitation can be mitigated by mixing the remains of the pseudostem, after kocho preparation, with other plant materials. Additionally, the pseudostem provides essential nutrients such as potassium, magnesium, zinc, and manganese, but its calcium content is insufficient to fully support ruminant health and lactation. The energy provided by the pseudostem is comparable to that of oats and performs similarly to barley in terms of net energy provision for lactation (Mohammed et al., 2013).

2.3.4. Nutritional content

Despite its significance as a dietary staple, relatively few nutritional analyses have been conducted on raw Enset plant tissues compared to other regional crops. Studies such as those by Fanta and Satheesh (2019), Fekadu and Ledin (1997), Mohammed et al. (2013), and Nurfeta, Eik, et al. (2008) have analyzed only a limited number of Enset varieties (maximum of 10) with a low number of replications (maximum of 3). The calorie content of kocho, at 200 kcal per 100 g of edible material, is reported to be 57% lower than that of 100 g of food grains (Urga, Fite, & Biratu, 1996). Other studies have focused on the

nutritional value of Enset food products (Atlabachew & Chandravanshi, 2008; Forsido, Rupasinghe, & Astatkie, 2013) or its role in animal feeds (Afele, 2014; Nurfeta et al., 2009). A recent study by Bosha et al. (2016) compared the nutritional content of kocho from wild and domestic Enset varieties, finding that cultivated varieties generally had higher levels of protein, fat, sugar, and minerals, whereas wild varieties contained more starch. It is noteworthy that farmers often distinguish Enset landraces based on the quality of kocho, bulla, and amicho they produce (Tsegaye, 2002).

A dietary survey by Pijls et al. (1995) involving 39 households and 237 people found that an average daily intake of 0.55 kg of Enset products provided 68% of total energy intake, 20% of protein, and 28% of iron, but no detectable Vitamin A levels. The low protein content of Enset is often supplemented with alternative protein sources such as kidney beans or cabbage (Abebe, Stoecker, Hinds, & Gates, 2006). The Enset farming system typically includes a variety of food plants, including legumes, vegetables, and fruits, along with animal products, which together help balance the nutritional intake.

Enset is recognized for providing important dietary micronutrients, though data are limited and results vary. Abebe et al. (2007) reported that while cereals (mainly unrefined maize) were the primary sources of energy, protein, iron, and zinc in subsistence farming in Sidama, Enset-based foods were key sources of calcium and an additional source of iron. Atlabachew and Chandravanshi (2008) found that kocho and bulla were high in potassium, followed by sodium, calcium, and magnesium, with kocho containing more minerals overall than bulla. Both kocho and bulla were richer in calcium and zinc compared to other local starchy foods and had comparable levels of copper, iron, and manganese. Mohammed et al. (2013) noted that the Enset corm contains 17 of 20 essential amino acids, with concentrations similar to or higher than those found in potatoes for 12 of these amino acids.

2.3.5. Enset traditional medicine

Enset is widely regarded as a significant medicinal plant in Ethiopia, with consistent uses reported across various ethnic groups and specific phenotypic traits associated with its medicinal value. Plants used for medicinal purposes generally feature red or reddish-purple leaf blades, with midribs and pseudostems varying in red coloration (Alemu & Sandford, 1991; Assefa & Fitamo, 2016; Tsehaye & Kebebew, 2006).

Two main medicinal properties are commonly attributed to Enset. First, the boiled corm (amicho) from different varieties, often consumed with milk, is believed to aid in healing fractured or broken bones, potentially due to the high calcium content in some varieties, which may accelerate recovery (Tsehaye & Kebebew, 2006). Second, amicho from several varieties is used with milk and butter to facilitate placental discharge in both humans and livestock, and it may also induce abortion in some cases (Assefa

& Fitamo, 2016; Tsehaye & Kebebew, 2006). Additionally, Enset root has been reported to treat nematode worms (Pijls et al., 1995), a finding supported by Hölscher and Schneider (1998), who identified a novel phenylphenalenone in Enset, along with compounds known from other Musaceae, which may possess antibacterial, anticancer, and nematicidal properties. Tsegaye (2002) also noted that farmers in Sidama, Wolaita, and Hadiya use the corm and other parts of specific enset landraces to treat cirrhosis, diarrhea, and venereal diseases.

2.3.6. Enset microbiome and fermentation

Traditionally, the parenchymatous tissue of the Enset pseudostem and the pulverized corm are buried in an earthen pit wrapped in enset leaves for fermentation, which enhances the organoleptic properties and shelf life of the product (Urga et al., 1996). This fermentation process reduces the toxicity of the raw plant materials and contributes to flavor development. However, some loss of protein and dry matter occurs during fermentation, potentially due to the permeability and extended duration (2–3 months) of storage in the pit, which allows for the leaching of water-soluble proteins and amino acids (Besrat, Mehansho, & Bezuneh, 1979; Tsegaye, 2002). Initially, kocho has high moisture content, a neutral pH, and contains various microorganisms, including aerobic and anaerobic spore formers, lactic acid bacteria, Enterobacteriaceae family members, and yeasts. During the early stages of fermentation, Leuconostoc mesenteroides initiates the process, followed by homofermentative Lactobacillus species. By the final stage, the pH can drop to 3.8, accompanied by a sharp increase in acidity due to organic acid accumulation, while the number of spoilage microorganisms decreases.

Characterizing and standardizing the bacterial and yeast species used in Enset fermentation is crucial for improving the quality and consistency of the food products and developing effective starter cultures. Gizaw, Tsegaye, and Tilahun (2016) identified seven non-Saccharomyces yeast species from fermented kocho and bulla samples, including Cryptococcus albidus var. aerus, Guilliermondella selenospora, Rhodotorula acheniorum, Trichosporon beigelii, Cryptococcus terreus (99%), Candida zylandase (98%), and Kluyveramyces delphensis (86%). However, this study was limited to a single area in South West Ethiopia, where processing techniques and yeast cultures may vary (Gashe, 1987; Urga et al., 1996). More recently, Birmeta, Bakeeva, and Passoth (2018) identified 12 yeast and 17 bacterial species through rDNA sequencing at different fermentation stages, indicating changes in microbial composition throughout the process.

There is significant potential to improve the efficiency and effectiveness of enset processing, which is currently labor-intensive. For example, the Shakacho people add Mandillo (*Crassocephalum macropappum*) stems during fermentation, which results in a lower pH compared to natural fermentation

and is believed to reduce spoilage and extend shelf life (Gonfa, 2016). Ashenafi (2008) and Tafere (2015) emphasized the value of controlled fermentation studies with selected cultures and starters to optimize the process. Hunduma and Ashenafi (2011) and Gizaw et al. (2016) suggested that these improvements could reduce labor for women, minimize spoilage, enhance long-term storage and product quality, and contribute to food security.

2.3.7. Cultural importance

Enset holds significant cultural importance for several Ethiopian ethnic groups who have traditionally cultivated it (Assefa & Fitamo, 2016; Negash & Niehof, 2004; Olango, Tesfaye, Catellani, & Pè, 2014). In the Kaffa Zone of SNNPR, Tsehaye and Kebebew (2006) found that farmers grow various Enset varieties based on myths, poems, and beliefs regarding their medicinal and ritual significance. Similarly, Assefa and Fitamo (2016) report that songs and rituals associated with Enset are integral to Sidama culture. The Gurage people, who consider Enset a crucial staple, identify themselves as the "people of Enset" (Shank & Ertiro, 1996). Sahle et al. (2018) described how Enset plays a central role in Gurage economic and social life, including its cultivation and storage alongside other crops like coffee and khat in a mixed horticultural system. Within the family, women are primarily responsible for processing and cooking Enset foods, and the crop is often referred to as a “women’s crop” due to the significant role women play in its processing, cooking, and marketing (MacEntee, Thompson, Forsido, & Jihad, 2013).

2.4.National Production and Yield Trends

Analysis of data from Ethiopia’s Central Statistics Agency (CSA, 1995–2017) reveals a significant increase in the area of land dedicated to Enset production, with an approximate 46% rise over the past two decades. However, this data raises several concerns. Firstly, it contradicts findings from other studies which indicate that farmers perceive a decline in Enset production (Abebe, 2013; Negash, 2001; Yemataw et al., 2017; Zippel, 2005). Additionally, during the same period, Ethiopia’s population grew by 77%, from 59 to 105 million (Center for International Earth Science Information Network, 2017). This discrepancy might be partly due to a proportional decrease in Enset land per capita, as Enset agriculture struggles to match population growth. Yet, this factor may not fully account for the reported yield increases. Furthermore, there is scant evidence of policy or developmental drivers that might explain this productivity surge. Cochrane and Bekele (2018) highlight issues related to ‘methodological changes’ at the CSA, noting problems with data quality, methods, and potential politicization, with inconsistencies observed in other tuber crops like taro and sweet potato.

Another challenge in estimating Enset yield is the application of survey methods designed for annual or perennial crops to Enset, which is a multi-year crop. Unlike perennial crops that produce annually after

the initial harvest, harvesting Enset ends the life of the plant, and the complex transplanting practices often alter plant densities per hectare Recent surveys (2012–2017) (Central Statistics Agency, n.d.) have improved data collection by recording the number of harvested plants and multiplying this by expected yields of food products (e.g., kocho, bulla, and amicho) per plant. However, the long time lag between planting and harvesting (4–10 years) can introduce data artifacts. For example, overharvesting may create a false impression of increased production while hectarage decreases unless comprehensive survey methods are employed. Therefore, accurate evaluation of production hectares, harvested plant numbers, and overall yield is essential for monitoring Enset's contribution to food security.

Yield assessments for 2017/18 indicated that Enset was the second most produced crop in Ethiopia, with the fourth highest yield per hectare, underscoring its importance in Ethiopian agriculture (Central Statistics Agency, n.d.). Much of this variation is due to the challenges in surveying Enset, but regional differences in cultivation density and yield also play a role, influenced by local agroecological conditions (Shank & Ertiro, 1996). For instance, the Gurage region, being drier than other Enset-growing areas, has lower planting densities and yields per hectare ranging from 2.9 to 7.7 tons across different agroecological zones (Sahle et al., 2018) (see Table 1). Pijls, Timmer, Wolde-Gebriel, and West (1995) found that Enset's energy yield per unit area and time (1,450 kcal/m² per year) is significantly higher than other Ethiopian staples such as cereals, potatoes, sweet potatoes, and bananas. Thus, Enset is considered one of the most efficient Ethiopian crops per unit of space and time in certain areas (Tsegaye & Struik, 2001). Despite this, enhancing Enset yields remains a priority for Ethiopia's agricultural development, as emphasized by Taffesse et al. (2013) and other researchers.

2.5. Household Utilization, Supply, and Demand

Data from the Central Statistics Agency (CSA) covering the period from 2008 to 2016 highlights the significant role of Enset in household food security. Enset is the most consumed crop for both human and livestock consumption, is frequently used for wage payments in kind, and is sold the least compared to other crops (Central Statistics Agency, n.d.). This high level of household consumption likely contributes to the limited market price information for Enset products, unlike cereal crops. Recent research by Sahle et al. (2018) examined the supply and demand for kocho in the Wabe River catchment of the Gurage Mountains in southern Ethiopia. Their findings indicate that the average demand for kocho per person is met by 16 Enset plants, aligning with earlier estimates by Demeke (1986). However, Sahle et al. (2018) also reported that only 38% of households are able to meet their kocho needs from their home gardens, and while kocho supply is generally sufficient, there is a shortfall in 25% of the catchment area.

2.6. Opportunities and Challenges of Enset Cultivation

Having a field that encompasses the homestead is considered aesthetically desirable by Enset-based societies. Enset enhances the landscape with its green foliage and positively impacts the macro environment of a region (Brandt et al., 1997). In areas where Enset is cultivated over extended periods, the long-term application of manure improves local soil quality. Enset's perennial leaves create a canopy and the abundant accumulation of litter help to reduce soil erosion and organic matter depletion. Similar to trees, Enset shields humans, other vegetation, and animals from the sun and wind. Plant species with long-lasting leaf canopies and deep roots, like Enset, enhance regional hydrological dynamics. They improve soil water content and aquifer levels by increasing water infiltration and reducing surface runoff, which consequently boosts water availability, discharge to springs, and decreases the effective dry season length (Brandt et al., 1997).

Enset has a high carrying capacity, supports a dense population, and requires minimal labor or commercial fertilizer during its growth. It also has numerous non-food values as discussed previously. However, Enset agriculture faces significant challenges, primarily from diseases. These include viral infections, lesions, nematodes, root knots, and various forms of rot affecting the sheath, corm, and leaves, often caused by unidentified bacterial pathogens and fungi (Brandt et al., 1997). The severity of these diseases is exacerbated by inadequate preventative measures and diverse pathogens. The most detrimental issue is bacterial wilt, caused by *Xanthomonas campestris* pv. *musacearum* (Brandt et al., 1997). This disease can affect Enset at any growth stage, including after maturity, leading to substantial financial losses for farmers who have invested considerable time and resources. In some cases, this has led farmers to replace Enset cultivation with annual crops, abandoning their fields. Additionally, the crop's weak nutritional profile, particularly in terms of protein and minerals, presents another challenge. Therefore, research and development of suitable nutritional methods are essential to promote the industrial processing of enset food.

2.7. Effects of the land use change on productivity and sustainability

A high species diversity, including a variety of crops, trees, and animals with different functions and life cycles, can preserve land, which is the basis of resource utilization. This preservation is contingent on the quantity and quality of inputs used in the system. According to Tilman et al. (2002), Pretty et al. (2003), and Godfray et al. (2010), "sustainable intensification" is a strategy designed to reduce environmental impacts while simultaneously increasing food production on the same land area (Royal Society of London, 2009). Although the Enset-Coffee agroforestry systems in Southern Ethiopia exhibit traits of sustainable agriculture, there is still potential to enhance productivity through intensification. However, if

intensification leads to a reduction in plant diversity and the perennial nature of the systems, creating monoculture fields, it may disrupt the ecosystem services provided by these integrated multistorey agroforestry systems. Conversely, sustainable intensification might be achieved by incorporating high-value crops into the systems without significantly altering the diversity and composition of the existing components. Thus, maintaining the components of current Enset-Coffee agroforestry systems is crucial for their ecological and socioeconomic viability. Ecological sustainability refers to the extent to which natural resources are conserved to Ensure continued farming, while economic sustainability reflects its suitability, adaptability to local conditions, and economic viability (Pretty et al., 2003; Ojiem et al., 2006; Peyre et al., 2006; Holden & Linnerud, 2007). Below, we assess the ecological and socioeconomic sustainability aspects of Enset-coffee agroforestry systems and justify the need for their preservation.

UNIT TREEE

3. MATERIALS AND METHODS

3.1. Description of the study area

The study was conducted in Dedo District in Jimma zone, Oromia Regional State of Southwestern Ethiopia. The District is found at 373 and 18 km far from Addis Ababa and Jimma, respectively. Geographically the district is located between 07º5´-7°45´N Latitude and 036º39' – 37° 15´E Longitude and the altitude of this District ranges from 880 – 3046 m a.s.l . It is bordered on the south by the Gojeb river which separetes it from the southern nations, nationalities and peoples region, on the west by Seka chokorsa, on the north by Sarbo District and on the east by Mancho District. Recently the District was divided to 36 kebeles;from these 33 kebeles are peasant associations and the rest three are urban centers. Sheki is the capical town of the district. The total area coverage of Dedo District reaches 797.8km^2. The relief of the district is found with in the south western highlands of Ethiopia; it has three agro ecological zones namely; highland (Dega) (32.6°), midland (Wainadega) (49.2°),and lowland (Kola) (18.2°). The climate of the district is tropical in nature and so experiences high incoming solar isolation due to high angle of the solar rays with over head sun twice a year. However, this tropical nature of its climate is rather modified by altitude (Abdo, 2018) and central parts of the District have a cool agro climate with the mean annual temperature ranges between 15°c -18°c.While the vast part of the District is classified as sub-tropical with mean annual temperature ranges between 18°c- 29°c. The minimum temperature of the district is 11.27°c and the maximum temperature is 28.99°c. The rain fall of the district is weakly bimodal with spring having a small rainy season during the months of march and April, while summer a long rainy season during the months of June, July, August and September. Annual rainfall varies between 1300mm and 1700mm in major areas of the District (DDFEDO, 2019). The farming system of the District is characterized by crop-livestock mixed farming with the two dominant perennial crops Enset and coffee are grown in a friendly association with other crops. Agriculture forms the major lifeline in the district as major crops grown include Coffee, Barley, Enset, Maize, Sorghum, Teff, Faba Bean, Wheat, Common bean and Potato (CDOARD, 2015). The 2007 national census reported a total population for this District of 288,457 of whom 143,935 were men and 144,522 were women 5,755 or 2p of its population were urban dwellers.

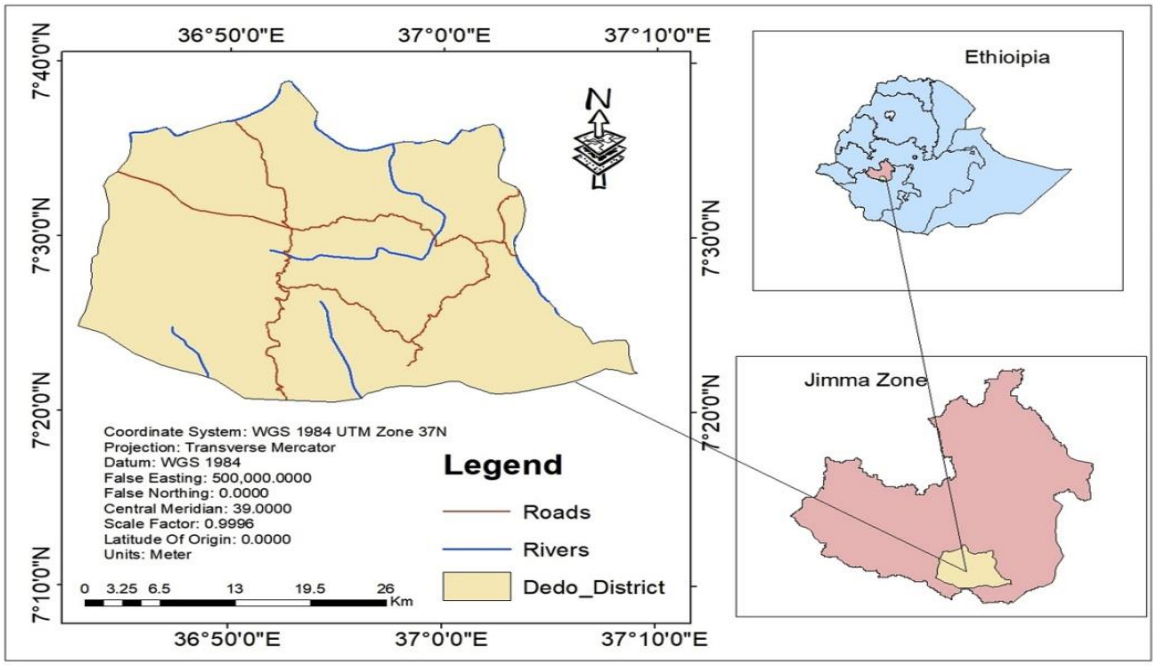

Figure 1:Map of the study area. Source from Arc GIS

3.2. The Research Design

A research design describes the methodology for a study. Whether to employ a single approach or a combination of two or more procedures is determined by the research design. Consequently, the researcher adopted an explanatory mixed research design, with a predominance of qualitative data, for this study. The researcher mainly used the qualitative method, which is useful for producing non-statistical data easily. Thus, in addition to using a qualitative approach to analyze indogenous production methods and farm-based biodiversity, the researcher also employed a quantitative method to supplement the qualitative results in this study. At the end of the data analysis process, the researcher triangulated the data that came from both qualitative and quantitative sources

3.3. Sampling techniques and sample size determination

Both purposive and random sampling techniques were employed for the study. Purposive sampling technique was used to select the study District and kebele (smallest administrative unit) and random sampling techniques were used to select sample respondents for the interview. Following this, Dedo District was purposely selected from 23 District of Jimma Zone, due to the reason of widely existance of Enset production and farm based biodiversity of Enset. Then ,three potential of Enset producers kebeles, namely Defkela, Askira and Gera were selected purposively from 33 kebeles in the District because they are the predominantly engaged in Enset production.According to Dedo District administrative reports the three sample kebeles had a total of 2577 house hold heads from which the house hold population of Defkela, Askira and Gera were 1223,731 and 623 respectively. To keep the representativeness of sample

in the population,the study used the formula given by kothari(2004) for sample size determination(equation 1)

$$n = \frac{Z^2.p.q.N}{e^2(N-1) + z^2p.q}$$

Where, n=desired sample size,

z=standard normaldevice at the requered(95%)confidence limit(1.96),

p= is 0.05 (proportion of the target population to be included in the sample,q=1-p(1-0.05=0.95),

e=level of statistical accuracy set at 0.03 and

N=total number of population

$n = \frac{1.96^2 x 0.05 x 0.95 x 2577}{0.03^2(2577-1)+1.96^2 0.05 x 0.95}$ =188

Having the selected sample size 89, 53 and 46 respondents were randomly selected from Defkela, Askira and Gera kebeles respectively by using proportional probability.

Summary of population sample size and sampling technique

Table 1:Summary of population sample size and sampling technique

S.No	Kebeles	Total of house hold head			Sample size of house hold			Sampling technique
		M	F	Sum	M	F	Sum	Simple random sampling method
1	Defkela	1165	58	1223	85	4	89	
2	Askira	669	62	731	49	4	53	
3	Gera	580	43	623	43	3	46	
	Total	2414	163	2577	177	11	188	
	For FGD							
1	Defkela	12	2	14	12	2	14	Purposively
2	Askira	13	1	14	13	1	14	
3	Gera	12	2	14	12	2	14	
	Total	37	5	42	37	5	42	
	Key Informant Interviews							
1	Defkela	2	1	3	2	1	3	Purposively
2	Askira	1	1	2	1	1	2	
3	Gera	1	1	2	1	1	2	
	Total	4	3	7	4	3	7	

3.4. Data sources and methods of collection

In order to get the information required for this study about the demographic and socio economic profile of Enset producers, as well as the circumstances surrounding Enset production and farm-based biodiversity, both primary and secondary data sources were used. The primary data from the chosen sample producers was obtained using the structured questionnaire. The respondents in the chosen sample were the source of the primary data. Furthermore, focus group discussions (FGDs) and key informant interviews were used to obtain additional data compared to that obtained from a subset of respondents. Additionally, secondary data came from records that were both published and unpublished and came from a variety of entities, such as the District office of agriculture and rural development. In addition to them, a researcher studies related books, journals, articles, analyses of these sources, and other correlated research to gain additional knowledge. The participants are farmers, administrative bodies and experts

3.4.1. Questionnaires

In order to gather the necessary data for the study area, the data was mostly gathered via distributing questionnaires that included both closed-and open-ended questions, or mixed questionnaires. Closed ended questions are used to make it easier for respondents to respond to questions. Additionally, an open-ended response lets the participants build their response using their own words. Mixed questionnaires, on the other hand, are more beneficial since they allow respondents more options for providing information and reflecting ideas. Every copy of the questionnaire is distributed, gathered, and analyzed. Data is presented in the form of tables and paragraphs. A structured questionnaire is used to gather household-level data on farm-based biodiversity and endogenous production methods..

3.4.2. Interview

Interviews are used to obtain additional primary data for this research. To obtain more precise and trustworthy data regarding the study, the researcher conducts semi-structured interviews. Depending on the predetermined set of questions given to the responders, it is crucial to ask additional questions.

3.4.3. Key Informant Interviews

This was used to generate in-depth information on the issues based on interview guide line from the key informants (KI). The key Informants are locally selected elders people, agricultural office and developments (DA), purposively seven (7) peoples were identified based on their special involvement in the issue of Enset production method and farm based biodiversity of Enset one (1) from agricultural office expert, three (3) DA’s from sample kebeles, and three (3) local elders 50 and above age selected.

In order to get rich information about indigenous production method of Enset and farm based biodiversity for the sake of supporting the quantitative data.

3.4.4. Focus-group discussion

The two ways of communication were conducted between selected groups and interview in order to make effective the process of data collection. The study also incorporated six different focus group discussion from the three sample selected kebeles at district level to gather additional data to substantiate the data collected through questionnaires. The focus group discussion were conducted with a group of farmers that constitute 6-8 groups of elderly people with the age of more than fifthy and young women and man with the age between 25 and 35. This was used to collect primary information with regard to the current conditions of Enset production, adaptation practices to copy with indigenous production method of Enset through walking across the kebeles with the aid of checklist paper.

3.4.5. Semi-structure

Semi-structure interview was used to gather information from the three kebeles of the study area of Enset producer farmers. The interview was analyzed and presented in the paragraphs and some questions was prepared orally in order to get information on analysis of indeginous production method and farm based biodiversity of Enset in three kebele of dedo district.

3.5. Methods of Data analysis

Both qualitative and quantitative analysis and interpretation were done on the information gathered from key informant interviews, focus groups, and questionnaires. While quantitative data were initially recorded and arranged in the statistical package of the social sciences (SPSS Version 20), qualitative data were evaluated using descriptive statistics, And Several kinds of graphs, figures, and tables were used to support the study's findings.

UNIT FOUR

4. RESULTS AND DISCUSION

4.1. Households and farming characteristics of the study districts:

The household survey involved the interviewing of 188 respondents in total (Table 2). The percentage of farmers from Askira, Defkela, and Gera kebele were, respectively, 28.2%, 47.3%, and 24.5%. 177 (94.15%) of the responders were men, and 11 (5.85%) were women. The high percentage of male farmers in study area may be due to their access to farmland and their position as head of family. The mean family size was 7.8 with 38.3% of interviewed households having a family size of 5-8 members. Household family size had implications for family labor force for Enset production. In all surveyed area, 170 (90.4%) were married, which suggested that married people are more responsible to control and manage farming activities in the study areas. The majority 98 (52%) of households' heads interviewed were aged between 31-50 years and the lowest (1%) age between 15-20 years. Based on the farmers' educational background, it was found that 149 (79.3%) were illiterate and had never attended formal school; 23 (12.2%) had completed elementary school, and just 1.6% had a diploma or higher. The majority of inhabitants in the research areas (47.3%) owned 1-1.5 hectares of total farmland; however, 135 (71.8%) of the respondents claimed that their Enset area coverage was less than 0.25 hectares, and 63.8% of the respondents reported cultivating six to ten landraces.

Table 2:Description of household characteristics in surveyed kebeles of the district

Alternative		Response in		Alternative		Response in	
		Number/frequency	Percent			Number	Percent(%)
Kebele	Askira	53	28.2	Sex of house hold	Male	177	94.15
	Defkela	89	47.3		Female	11	5.85
	Gera	46	24.5		Total	188	100
	Total	188	100	Family size	1-4	28	14.9
Age of house hold	15-20	2	1		5-8	72	38.3
	21-30	64	34		9-10	67	35.6
	31-50	98	52		Above 11	21	11.2
	Above 50	24	12.7		Total	188	100
	Total	188	100	Marital status	Single	11	5.85
Ed	Illiterate	149	79.3		Married	170	90.4

	Read and write	5	2.7		Widowed	7	3.7
	1-4	23	12.2		Divorsed	-	-
	5-12	8	4.3		Total	188	100
	Diplom and Above	3	1.6	Number of enset landrace per farm	1-5	34	18.1
	Total	188	100		6-10	120	63.8
Land size owned by	<1	9	4.8		11-15	30	15.95
	1-1.5	89	47.3		>16	4	2.1
	1.5-2	79	42		Total	188	100
	>2	11	5.8	Farm land covered by enset per farmer(ha)	<0.25	135	71.8
	Total	188	100		0.25-0.5	34	18
					0.5-1	19	10.1
					Total	188	100

4.2. The Production of Enset

Only Ethiopia grows Enset as a crop for food and fiber, mostly in the southwest, south central, and western regions of the country (Maryo et al. 2014). Struik and Tsagaye, 2001). Although the distribution and quantity of Enset vary among the research sites' kebeles in terms of cultivars and productivities, nearly all of the farmers grow it in addition to grains as a staple diet. In response, the farmers in the research region stated that they exclusively grow Enset in their backyard gardens. According to reports from Magule et al. (2014) and Maryo et al. (2014), who state that Enset production occurs in both home gardens and main fields, Enset was therefore grown in both. Farmers cultivate many Enset types of crops using varying methods of association. According to (Table 3), which presents the information gathered from the respondents, the majority of farmers highly practiced mono-culturing (73.93%) growing, followed by intercropping only (26.06%). This is because, in most cases, intercropping is only permitted during the early stages of cultivation, between one and two years, when the size of the Enset is less than one meter, as the water drop from the Enset's leaf can affect the development of other varieties nearby. This is related to the idea that certain Enset cultivars do better when there is no shade or other relationship present. It is also thought that when other plants are present, the corm and pseudostem (false stem) of the Enset plant may be impacted when other surrounding crops are harvested. As shown (Figure 2), the local farmers believed that the purpose of intercropping Enset crops with other grains or tubers

was to improve soil fertility because of the residue of these crops in the home garden or farmland and possibly to obtain a good crop yield or product for the production of the following season. In their home gardens, farmers in the research area intercrop Enset with maize, cabbage, beans, and various fruits including mango, avocado, coffee, and so forth (Figure 2). This finding correlates with the research by Magule et al. (2014), which indicated that in the study region, maize, cabbage, beans, and godere were the most often intercropped crops with Enset.

Table 3:Different farming system practicing with Enset by farmers in surveyed kebele

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Mono culture or sole	139	73.9	73.9	73.9
	Intercropping with potato	7	3.7	3.7	77.7
	Intercropping with other fruit	10	5.3	5.3	83.0
	Intercropping with maize	12	6.4	6.4	89.4
	Intercropping with Khat	10	5.3	5.3	94.7
	Intercropping with cabbage	10	5.3	5.3	100.0
	Total	188	100.0	100.0	

a, Intercrop with maize

b, Intercrop with cabbage

Figure 2:typical intercropping Enset cultivation in the study area

Most of the surveyed farmers (63.8%) had 6-10 Enset clones and (18.1%) had between 1-5 Enset clones. Land allocated for Enset production varied among households with the majority (71.8%) of farmers Enset farm size allocating <0.25 ha (Table-2). About 19 (10.1%) had on average of 0.75 hectare of Enset farm. However, productivity of Enset under farmers' fields was very minimal with mean yield of 22.43 t ha–1/ year.

Farmers solely depended on the perennial nature of the crop and the soil fertility status of the area. Lack of awareness was the predominant reason furthermore, having high soil fertility in nature limited use of fertilizer not only in Enset production but also in other crops (Table 4). Enset is principally propagated vegetative by using underground corms. From all tested districts, 21.27% of farmers used corms as a source of planting materials from their own fields, 20.2% from their family, 14.89% backyards, while only 13.82% sourced planting materials from neighbors, (Table 5). Most farmers 8.51% and 10.63% in Defkela kebeles received planting materials from their own farms and family, respectively. The timing of Enset planting varied among three kebeles. Most farmers (85.6%) planted Enset from April to June. At Defkela, Enset was planted during April & May. There were multiple planting seasons at Askira and Gera where farmers planted Enset during April–June and September–December (Table 6). Plantings depended on the onset of long and short rains, respectively. High rainy season like July and August and dry season from December to February are not good for planting in all study area

Table 4:Reasons for not using fertilizers in Enset production and corresponding proportion of respondents

Reason	Kebeles			Total	Mean
	Askira	Defkela	Gera		
Expensive	5.31	10.1	3.72	19.14	6.38
No knowledge	3.72	6.38	2.6	12.76	4.25
Soils naturally fertile	16.48	25.53	15.42	57.44	19.14
Fertilizers destroy soil	1.59	4.25	2.12	7.97	2.65
Fertilizer burn the crop	1.06	-	0.53	1.59	0.53
Fertilizer reduce quality	-	1.06	-	1.06	0.56

Table 5: Sources of enset planting materials reported by farmers across surveyed kebeles of Dedo district

Source	Kebele			Total		Mean
	Askira	Defkela	Gera	No	%	
Own fields	7.44	8.51	5.31	40	21.27	7.09
Neighbors	4.25	5.85	3.72	26	13.82	4.6
Backyards	4.79	6.91	3.19	28	14.89	4.96
Family	5.31	10.63	4.25	38	20.2	6.73
Own fields and neighbors	3.72	6.91	2.65	25	13.3	4.43
Own fields and family	2.65	8.51	5.31	31	16.48	5.49

Table 6:Time of Enset planting season in surveyed kebeles of the district

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	September-November	17	9.0	9.0	9.0
	March-May	161	85.6	85.6	94.7
	June – August	10	5.3	5.3	100.0
	Total	188	100.0	100.0	

4.3. Propagation System of Enset

Using traditional knowledge for intercropping, propagation, transplanting, harvesting and processing, and disease and insect prevention is beneficial. For their small bits of land, farmers are unable to purchase pricey, exotic technologies or travel great distances. It is important to remember that among cultivated crops, root and tuber crops have a strategic place, and their positions differ among the various agro-ecological zones in the study region. While Enset held the top spot in the Southwest region of the nation for staple foods that address the issue of food insecurity. Once the farmland has been properly prepared, Enset can be propagated via suckers of stem and seed. Suckers are usually produced from the two- to three year-old corms (10 to 20 centimeters in diameter) and the true stem. To obtain these mother corm pieces, healthy plants must be harvested, the pseudo stems must be cut off, the roots must be removed, and the center or apical bud must be removed. These lateral buds develop into suckers along the edge of

the mother corm piece after the apical bud is removed. Each corm component will yield 20–200 suckers. . Usually, a year is given to these suckers to grow before transplanting. To cultivate Enset crops and obtain high-quality goods, the majority of farmers in the three kebeles of Dedo District use compost (manure) fertilizer and residual straw. In this research area, no farmers employed inorganic fertilizers on their farms. Farmers preferred organic compost because of its high Enset growth productivities, or yields. And some informants responded that inorganic fertilizers are expensive to purchase from the market or supplied by the government, so they just use animal dung, leftover vegetables, and old Enset leaves as fertilizer in their home gardens. This is way they cultivate Enset at home garden only;in addition to these their farm land is naturally fertile. Observations in areas that have been planted with Enset for many years suggest that native soils have been altered positively by the long-term application of manure. Enset's perennial canopy of leaves and the abundant accumulation of litter also reduce soil erosion. Because Enset production improves soils, particularly with adequate manure, many Enset fields have been in continuous production for decades, if not centuries. Because of the multiple roles that manure plays in improving soils biologically, chemically, and physically properties

4.4. Maturity, Harvesting and Storage of Enset

The farmers use several types of indicators to identify whether each root and tuber crop is mature or not. Mature, harvesting time, and storage place varied depending on the location and type of Enset that local farmers cultivated in the study area. Among the indicators related to Enset maturity that the indigenous farmers used to harvest the crop in the study area are: first, the size of each plant could be used as an indicator of Enset maturity in relation to its calendar, i.e., by its years (3–4-5/5 that the plant is ready to eat or matured to eat) (Appendix 2). Secondly, Farmers examine whether the corm (referred to as Utto or Amicho) develops above ground. Thirdly, although many respondents indicated that the indicator of Enset maturity is its ability to bear inflorescence (Table 7), this is not always the case because Enset can mature before bearing inflorescence. Local farmers in the study area used their traditional knowledge to gather and store their Enset products once they reached maturity. Once the corm reached maturity, farmers harvested and stored the Enset at the proper time and location to increase the crops' shelf life. To ensure a continuous supply of food, the local farmers preserve Enset products (such as Bula and Kocho) by wrapping and covering them in deep holes. In fact, Enset is a flexible-harvest crop in that households have the option to utilize it at any time after maturity i.e. a mature Enset plant becomes a mini household food security system available for harvesting and processing immediately or it can be `held in reserve' for another 5 to 10 years and it continues to grow and mature (Mulualem and Walle, 2014).

Table 7:Maturity indices of Enset and respective proportion of respondent farmers

Maturity indices	Kebele			Total	mean
	Askira	Defkela	Gera		
color of leaf	0.53	1.59	1.06	3.19	1.06
Year	2.65	2.65	2.12	7.44	2.44
Flower development	4.78	6.38	3.72	14.89	4.96
Uprising corm from the ground level	1.59	2.12	1.59	5.31	1.77
Plant size	4.25	4.78	4.78	13.82	4.6
Size and year count	5.31	6.91	3.19	15.42	5.14
Plant size, leaf color change, year count, flowering and uprising corm from ground	9.04	22.87	7.97	39.89	13.29

4.5. Processing of Enset Products for Consumption

Although all parts of Enset are utilized, the corm and pseudostem are the main food sources. These parts are referred to as "Kocho," "Bulla or Etino," and "Amicho or Utto." Amicho/Utto is the boiled corm of young Enset plants that is known for best quality of corm; however, only kocho and bulla or etino are well-known in this study area. The corm is prepared and consumed similarly to methods for other root and tuber crops (Maryo et al. 2014). Farmers specifically select certain clones for the capability to produce bulla or etino. For instance, the Dedo people prefer native varieties like Burritti and Fia for etino/bulla functions, but they are susceptible illness. The majority of the fermented starch that is extracted from the grated corm and decorticated (scraped) leaf sheaths is called kocho. As reported by the locals in the region Bulla is made by squeezing the starch-containing liquid from grated corms and scraped leaf sheathes, then allowing the starch to concentrate into a white powder using a variety of techniques: 1) scrubbing the peduncle, grated corm, and leaf sheath into a pulp; 2) extracting starch-containing liquid from the pulp; 3) allowing the concentrated starch turn into a white powder; and 4) rehydrating with water. It is considered as the best quality Enset food and is obtained mainly from fully matured Enset plants. Enset products are available year-round and, according to (Maryo et al and tesfaye 2014) may be kept in pits for a longer period of time without going bad. The by-product of Enset that remains after the leaf sheaths are decorticated is called fiber. It is said to have strength comparable to that of the significant fiber crop Musa textiles (abaca). Fiber is used to make a range of items, including bags, ropes, twines, cordage, mats, and house siding. The length and quality of the fiber are determined by the

plant's age, variety, and methods of extraction and storage. For instance, from the variety of Enset Nobo have very strong fiber. Enset processing is a tedious and time-consuming process that is performed by women with traditional tools. This suggests a field for future processing technology development research. Given that Enset is a native crop, it requires much more from Ethiopian researchers in order to be improved. Even with existing processing problem Enset based farming systems play an important role in food security in Ethiopia (Maryo et al. 2014).

A-Chopping of the corm/Amucho B-Scrapping the inner wall of the sheath

Figure 3:Extracting food staff from corm and pseudostem

4.6. socio cultural use of enset

Ensets are a type of root and tuber crop that are primarily used for fiber production, medicine, animal feed, and human food (raw or processed) (Howard and Holloway, 1988). These crops are the main source of carbohydrates in the southern and southwest Ethiopia. According to the above (Figure 3), the majority of the time, the indigenous farmers utilized Enset crops for food accounts (78.18%), with animal feed (9.57%), medicine (2.12%), and other uses (10.08%). Here, "other purposes" refers to using Enset crops, such as mat, baking bread, Kocho, fibers, and shade. For instance, Enset is a significant multipurpose subsistence crop that may be used in every part of the plant. In addition to being a food plant, Enset has a variety of commercial, cultural, and environmental uses, including as mulching, shade, medicine, rope and string, animal feed, and the control of soil moisture and fertility. For the majority of people in the Southwestern regions of Ethiopia, especially in Jimma Zone Dedo District, Enset is a staple meal that is more productive and drought-tolerant than annual crops. Similarly, Enset serves as a home medication.

For example, variety Gariye is used to remove the placenta from animals after birth, and Anciro is used to treat cases of abdominal pain of human in Dedo (Appendix 2). Taking kocho or bula after taking traditional medicine is believed to reduce side effects. The region's Enset products are also commonly utilized to produce foods for family and guests in celebration of the Dedo community's festivities, including weddings, holidays, and Sundays.

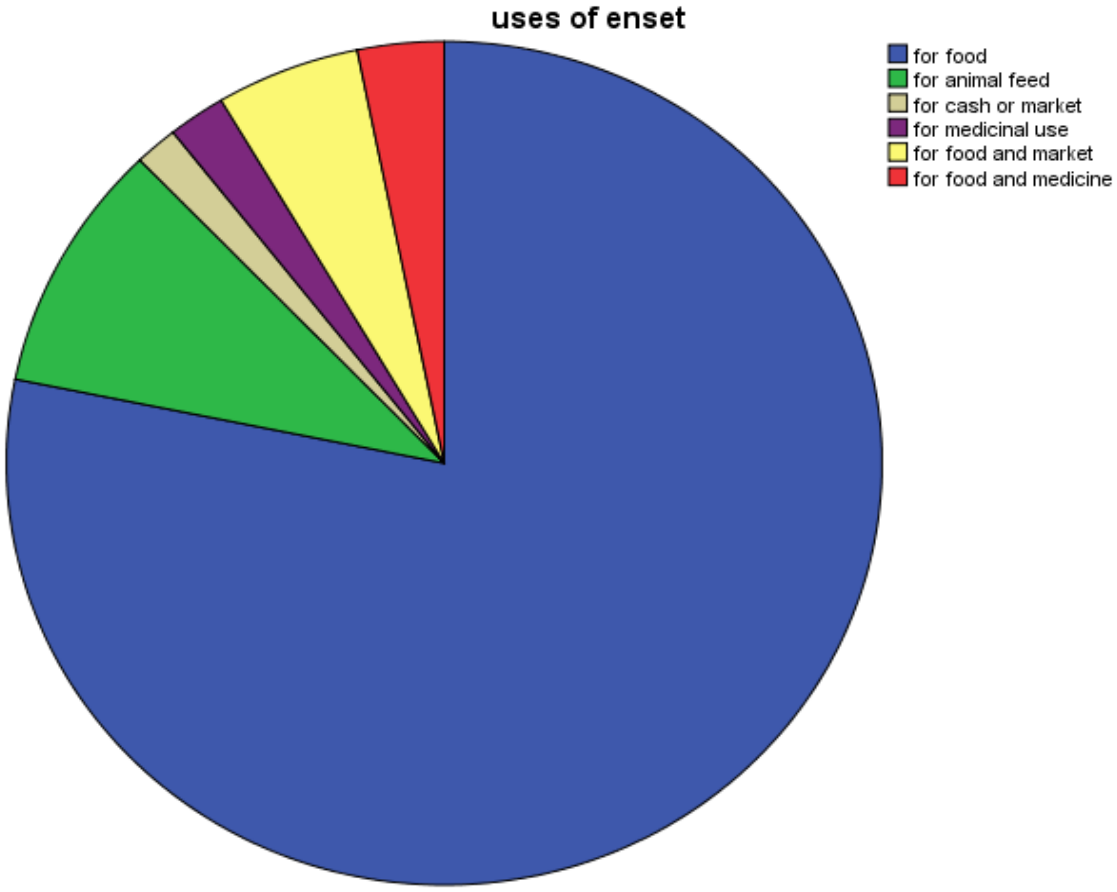

Figure 4:Uses of Enset and corresponding proportion of respondent farmers

4.7. Enset production constraints

Enset production constraints in all tested districts were presented in (Table 9). The most important constraints identified were low yield, low market preference, drought in the early season, low soil fertility, shortage of land, and wild animal attacks. Other constraints were a lack of extension service and post-harvest losses. Enset bacterial wilt disease was the most common problem in the surveyed areas (24.33%). Farmers clearly described typical symptoms of the disease, such as wilt, stunted growth, and leaf death. Most of the farmers in the study area prevented spreading and controlled Enset bacterial wilt disease by uprooting infected plants, but some of them did not consider the cause and spreading of the

disease. Low yields and market preferences were regarded as major Enset production constraints, limiting farmers ability to pull out of poverty. Farmers sold the produce in the fields, at local markets, and along public roads. The price of produce was very low and unprofitable for farmers. The low prices were due to the fact that middlemen determined the price of the produce, and farmers were forced to sell at low prices due to the perishability of the crop. Early- and late-harvested Enset fetched high prices compared with produce sold during peak harvesting periods,(Birmeta & Seleshi,2020).

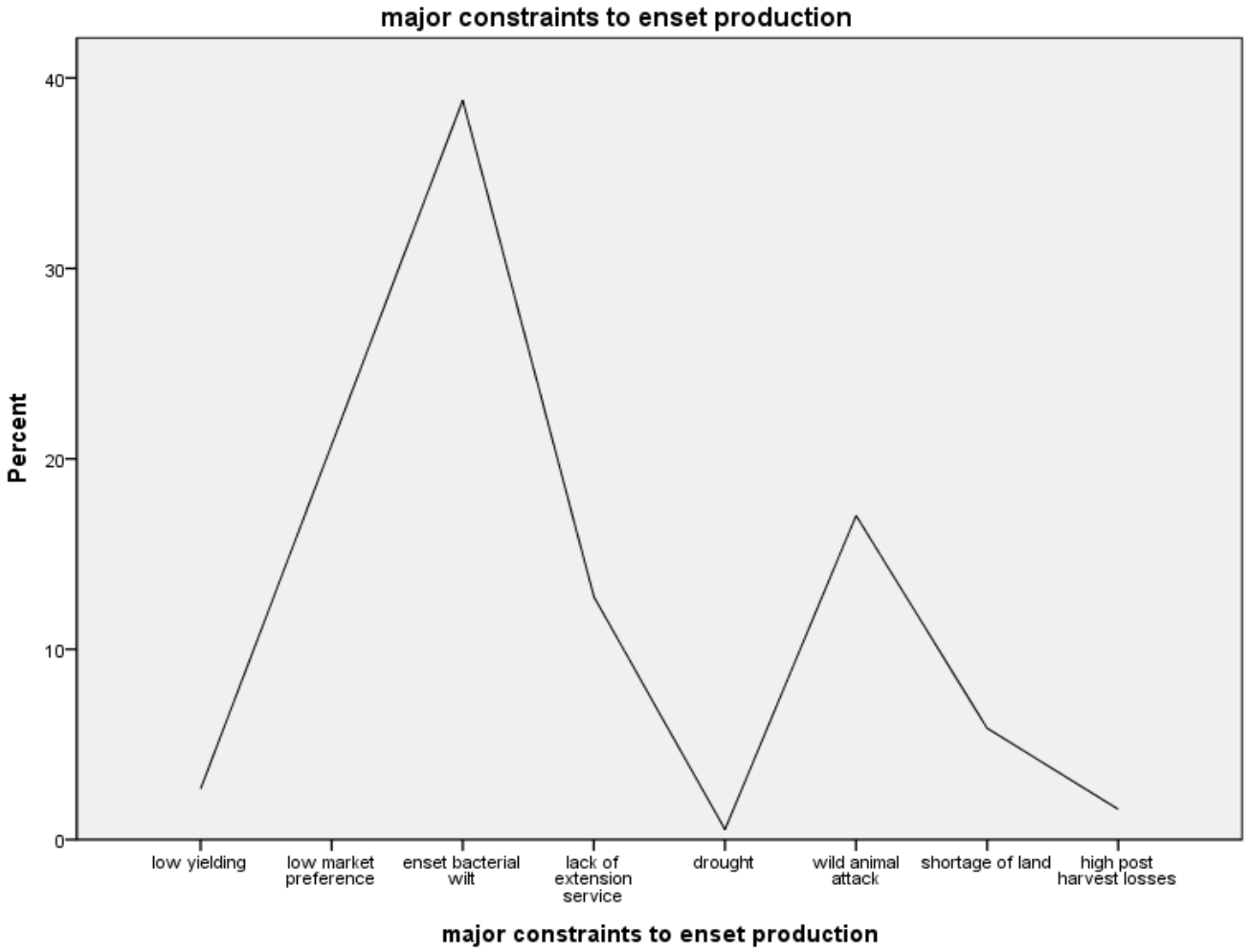

Figure 5:major constraints to Enset production in the surveyed kebele

4.8. **Diversity of enset landraces**

According to the study, over 50% of the farmers in the study area had home gardens larger than one hectare, and they typically kept a variety of Enset landraces. A total of 28 locally recognized landraces were identified in this investigation (Table 10). The number of landraces maintained per household varied between 6 and 14, with the mean being 10 landraces for the whole site. Different landraces were

identified by local farmers. For example, Tsegaye and Striuk (2003) reported 52 types of landraces grown in the Sidama zone. On the other hand, Tesfaye and Ludders (2002) reported 86 locally recognized landraces from the same zone. 79 locally recognized landraces were also recorded from 10 sites in Sidama (Tesfaye & Ludders, 2003). Numerous factors have been identified as impacting the number of Enset landraces on a particular farm, including agroecology, cultural background, and household economic situation (Tsegaye & Struik 2003). Research suggests that households with higher incomes typically have higher levels of clonal diversity and a larger population of landraces overall. Their bigger landholding size, greater social networking to acquire more landraces, greater income to buy further landraces, and superior all-around management techniques are the primary causes of this (Brandt et al. 1997). In Enset-growing regions, planting many different landraces in the backyard is a sign of high status and prestige within the community. Farmers prefer to have specific clone types to fit their specific household needs. The selection criteria for household use include quantity and quality of food products, maturation period, disease and drought tolerance, forage and fiber quality, and medicinal value (Tsegaye & Struik, 2003). Since one clone can never fulfill all criteria, farmers tend to maintain more than one Enset types on their own farm (Figure 5).

The research additionally demonstrated that the kind and quantity of Enset landraces varied throughout households. Richer households tend to have more landrace diversity, according to the speaker, because of factors including larger landholding sizes, stronger social networks for acquiring additional landraces, higher incomes for buying additional landraces, and better overall management. However, only the family stage and household economic position (Tsegaye and Struck 2003), as well as the trade of planting materials, systematic landrace propagation, and selective pressure (Tsegaye & Struik 2003), were identified as the primary important factors. Based on their abundance, the Enset landraces identified in this study have been arbitrarily divided into two categories using Brown's (1978) system of classifying alleles. These are i) common (occurring with a frequency greater than 10% in the sample) and ii) rare (occurring with a frequency less than 10%). Table 10 lists the names of the landraces that have been identified, along with each one's relative abundance in the research area. Consequently, nine landraces were determined to be common in the current study, while the remaining nineteen landraces were determined to be rare (Table 10). Strong evidence for selection can be seen in the differential richness and distribution of landraces, which reflect their relative importance to farmers (Tesfaye & Ludders 2003). Among the commonly occurring landraces, the following Nobo, Fia, Molge and Buriti are recognized to be the most widespread landraces in the study area. According to local farmers the reasons for the occurrence and abundance of these landraces relative to others is attributed to their high yield and

quality kocho and also their better resistance to environmental stresses. On the other hand, landraces such as Fatalo, Kura,Yeku, Kepe, Margu and Fatalo were found to be very rare and recorded only from 1 or 2 farms.

Figure 6:Home garden with diversified and with different age classes of enset at Defkela

Table 8:Name and status of enset landraces recognized from the study area

No	Name of landrace	Abundance	No	Name of landrace	Abundance
1	Anciro	Common	15	Gesero	Common
2	Argawi	Rare	16	Gisiro	Rare
3	Asu	Rare	17	Gonasa	Common
4	Bera	Rare	18	Kepe	Rare
5	Bobeti	Rare	19	Kokori	Commom
6	Buriti	Common	20	Kura	Rare
7	Dawula	Rare	21	Margu	Rare
8	Digabae	Rare	22	Matalafe	Rare
9	Elawa	Rare	23	Molge	Common
10	Fatalo	Race	24	Nobo	Common
11	Fia	Common	25	Shutu	Rare
12	Finafina	Rare	26	Wagu	Common
13	Gariye	Rare	27	Warabo	Rare
14	Geno	Rare	28	Yeku	Rare

4.9. Distribution and Abundance of Enset

Enset is a type of multipurpose crop that is a staple meal in many parts of the country and provides the majority of a big population's daily intake of carbohydrates. These crops are grown as traditional foods or are adapted to unique ecosystems and are little importance to world food production. (Edison et al., 2006;FAO, 2006;BC, 2008;Mekbib and Deesse, 20016). Enset is endemic in Ethiopia and widely distributed edible root crops in southern and southwestern of the country. Cultivation of Enset is important in the study area because they met local food preferences, providing an important part of the diet as they produce more edible energy per hectare per day than any other crop groups which play an important role in food security, nutrition and climate change adaptation. Despite their importance investment in Enset has been much lower than in the cereal crops. When compared to other crops that are cultivated elsewhere, Enset was given less attention (Howard and Holloway, 1988). However, in the smaller case, the non-edible Enset were dispersed over the kebele of Defkela, Askira, and Gera in the Dedo District, where they were naturally adapted to the forest. Enset distributions in the three kebeles of the Dedo District varied, as shown by the data gathered from informants and field observations (Table 10). Enset was predominantly produced in almost all kebeles, of the study Districts which accounts about 23 percent compare to other crops. The presence of other crops as well as ecological factors like soil and climate, as well as a lack of information on the selection of Enset varieties based on disease resistance and adaptability, were the main causes of the variance in the distribution and abundance of Enset crops in different kebeles. The main crops that are farmed in each of the examined districts are listed in (Table 11.) In every kebele that was analyzed, Enset, Potato, and Bean were the three most important crops. In every tested kebele, root crops also predominated. These crops were mostly farmed for household use; very little was sold to generate income for other household expenses like clothing and healthcare costs. Since most people use Enset for consumption at home, other crops were used as the primary cash crop in all three kebeles in the study area a side from Enset.

Table 9:Major crops grown by farmers in surveyed kebeles of the district.

Crops	Kebele						Total		Mean
	Askira		Defkela		Gera				
	No	%	No	%	No	%	No	%	
Maize (*Zea mays*)	2	1.06	4	2.12	-		6	3.19	1.06
Barley (*Hordeum vulgare L.*)	5	2.66	9	4.79	-		14	7.44	2.48
Enset (*Ensete ventricosum*)	11	5.85	21	11.17	12	6.38	44	23.4	7.8
Khat (*Catha idulis*)	5	2.66	6	3.19	3	1.59	14	7.44	2.48

Potato (*Solanum tuberosum*)	8	4.25	12	6.38	10	5.31	30	15.96	5.32
Cabbage (*Brassica oleracea*)	4	2.12	7	3.72	7	3.72	18	9.57	3.19
Teff (*Eragrostic tef*) (	4	2.12	5	2.66	2	1.06	11	5.85	1.95
Faba bean (*Vicia faba L.*)	9	4.79	18	9.57	8	4.25	35	18.6	6.2
Wheat (*Triticum aestivum L.*)	5	2.66	7	3.72	4	2.12	16	8.5	2.83

Figure 7:Representative type of Enset plants in the farmland, Defkela kebele

4.10. Local Varieties of Enset(*Ensete ventricosum*)

Using their traditional knowledge, farmers choose and care for the local varieties that best suit their needs. In terms of the distribution and abundance of Enset the study area has a variety of landraces (variety) based on agro-ecological features or climatic conditions. For instance, from three kebeles, the greatest number of variations (landraces) documented was approximately twenty-eight. In contrast, the highest number of kinds found in each home in the Defkela kebele was approximately fourteen. However, only ten types per family were reported from Gera kebele and a maximum of twelve kinds from Askira kebele. However, there were 26, 21, and 18 landraces/varieties of Enset in Defkela, Askira, and Gere, respectively. As a result, the number of people and landraces (varieties) of Enset that these three kebeles in the Dedo District adopted for main and minor staple food reasons on their farm fields varied. There was variety in the types, numbers, and varieties of Enset plants in each kebele, displaying the largest number of landraces documented in this study. The local farmers in the Dedo District were attempting to use their traditional ways of variety selection, which they had only used for their home

gardens. These methods were based on the productivity, adaptability, resilience to constraints, and cultural significance of Enset, which they carried down from generation to generation. The availability of the current local variety is a result of the centuries-long use of these traditional production methods. Preferred characteristics for specific landraces were reported by farmers in Tables 12 and 13. Farmers assessed a number of selection criteria to choose their landraces using their indigenous knowledge. In this study, farmers selected Enset landraces for production on the basis of high kocho and bulla yield, good market preference, good taste, medicinal use, maturity, drought tolerance and disease and insect pest resistance (Table 12). Farmers preferred early-maturing varieties, which could escape seasonal food shortage, drought and diseases. Some landraces had distinct, market-preferred traits, such as bulla color, which varied across markets. Early maturing and resistance to diseases were some of the other traits preferred by farmers in the study areas. As mentioned in the (Table12), the main parameter used to categorize and adapted different varieties of Enset by local farmers were on the basis of resistance to pest and disease accounted (41.48%) and followed by Kocho and bulla yield (28.72),taste of Enset product (10.1%), maturation period (9.57%), High market price (4.79%) and Medicinal use 4.25). Whereas least considering Drought tolerance (1.06%). Using the above criteria of indigenous knowledge of farmers, for instance 28 Enset varieties were recorded from Askira,Gera and Defkela Kebeles. Some of the local varieties of Enset that were investigated from the area include Nobo, Warabo, Molge, Argawi, Gesero, Aanciro, Gonasa, Yeku, Matalafe, Wagu, Buritti, Gariye, Kokori, Finafina, Asu, Gisiro, Bobeti, Fia, Fatalo, Margu, Kura, Kepe, Bera, Dawula, Elewa, Shuta, Guna, and etc.(appendix 2).Table 13 provided a summary of the number and names of Enset landraces for each District. Defkela kebele had a comparatively higher number of farms with more landraces out of the three kebeles. The most common landraces among all those taken into consideration were Nobo, Fia, Kokori, Molge, and Burriti in all tested kebeles; landraces such as Elaga, Fato, Margu, Shitu, and Yeku were only discovered in Defkela kebele from the study area. Farmers grew local landraces bearing different names. The name of the landrace was given either by taste/quality or place of origin of the landrace. From all tested kebeles, Defkela exhibited richness high, and have less diverse partly due to comparatively lower number of unique landraces. The lowest number of landraces, least diverse and none of which was unique were observed in Askira and Gera kebele's of Dedo district. Among these Enset varieties, the local farmers selected the most common diseases resistance using the their indigenous knowledge were Nobo which are again approved by the District agricultural office of Jimma Zone. The most tasty and preferable varieties of Enset were Molge, Buriti, Fia and Fatalo.

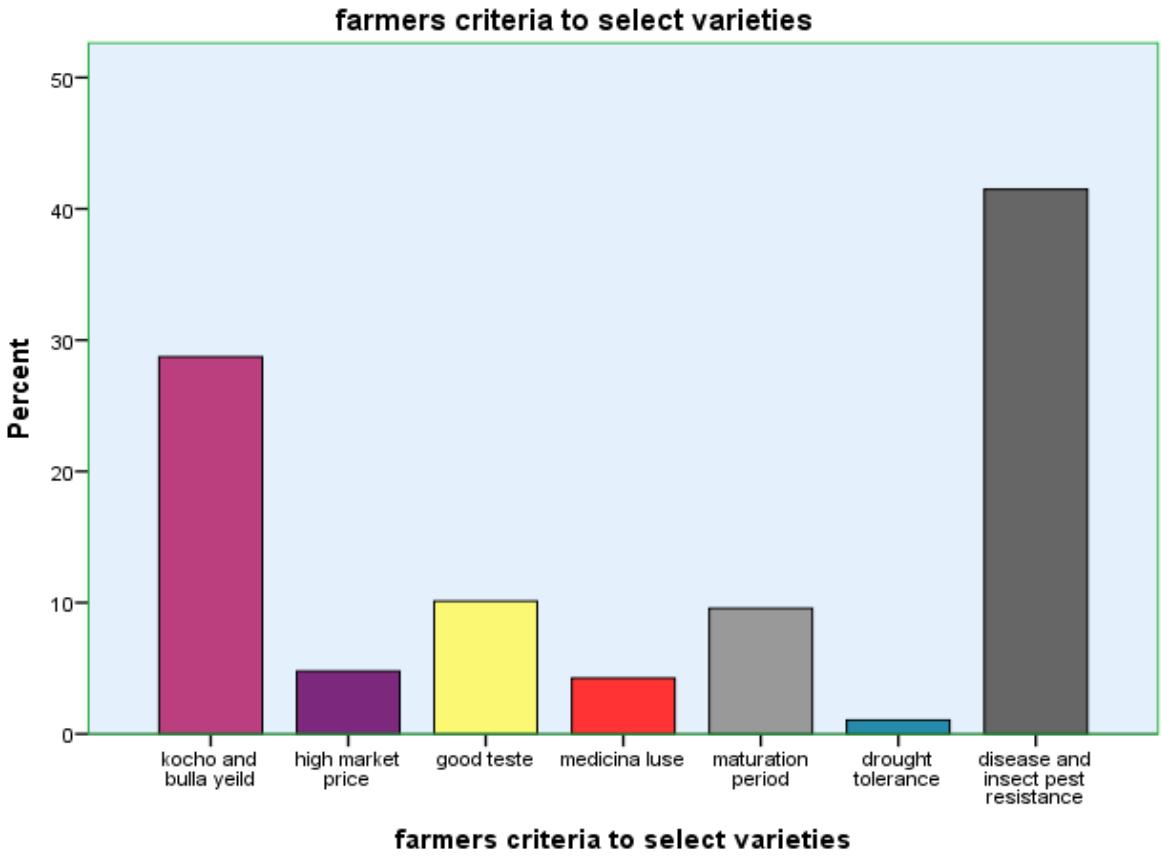

Figure 8: Farmers criteria to select varietie

Table 10:Enset landraces grown across surveyed kebeles of Dedo district.

Landraces	Kebele			Total	Mean	Landraces	Kebele			Total	mean
	Askira	Defkela	Gera				Askira	Defkela	Gera		
Anciro	24	19	15	58	19.3	Gesero	6	26	31	63	21
Argawi	6	7	8	21	7	Gisiro	-	-	8	8	2.66
Asu	6	12	14	32	10.6	Gonasa	11	25	15	51	17
Bera	6	13	-	19	6.33	Kepe	12	19	-	31	10.33
Bobeti	18	13	7	38	12.66	Kokori	12	24	23	59	19.66
Buriti	35	64	16	115	38.33	Kura	5	18	-	23	7.66
Dawula	6	-	38	44	14.66	Margu	-	13	-	13	4.33
Digabae	24	6	7	37	12.33	Matalafe	7	26	-	33	11
Elawa	--	12	--	12	4	Molge	41	51	30	122	40.66
Fatalo	-	13	-	13	4.33	Nobo	36	64	46	146	48.66

Fia	35	70	38	143	47.66	Shutu	-	20	-	20	6.66
Finafina	6	7	8	21	7	Wagu	6	18	7	31	10.33
Gariye	12	25	8	45	15	Warabo	5	5	8	18	6
Geno	-	13	-	13	4.33	Yeku	-	13	-	13	4.33

Figure 9:Local varieties which representatives of ensets in the Dedo District

UNIT FIVE

5. CONCLUSIONS AND RECOMMENDATIONS

5.1. CONCLUSIONS

The study examined and described the indigenous production method and Enset biodiversity. The results showed that there was a significant diversity of local Enset types, or landraces, and that the older residents of the area still held good traditional knowledge about the plant's use, production, propagation, and management. According to the farmers' responses, they either intercropped (36.29%) or monocultured (73.93%) Enset in their home gardens. Compared to other crops, Enset was grown primarily in practically all kebeles, accounting for over 23% of production. Enset is a crop with several uses, and every part of it is fully utilized. In the three kebeles of the district, where the corm and the pseudostem are the primary food sources, Enset is mostly grown for food (78.18%).The types of food from these parts are known as ‘Kocho’, ‘Bulla (Etino) and Amicho. In addition to their usual usage as food, the crop has medicinal and cultural significance. Only 28 Enset local varieties (cultivars) have been identified in the current exploration. The main parameter used to categorize and adapted different varieties of Enset by local farmers were on the basis of resistance to pest and disease accounted (41.48%) and followed by Kocho and bulla, taste of Enset product, maturation period, medicinal use and drought tolerance. Based on the previous points of indigenous knowledge the majority of the local farmers said that Nobo was a disease- and pest-resistant variety of Enset. The size of an individual, the formation of an utto above the ground, and the bearing of inflorescence were the primary criteria used to determine the maturity of Enset.

5.2. RECOMMENDATION

Based on the findings of the present study, the following recommendations are forwarded:

- The indigenous knowledge and traditional farming system that contributed for the availability of present day diversity need to be maintained and developed further.
- Better attention from all stakeholders is required to effectively maximize Enset's potential for producing food and fiber, considering its roles in the traditional agricultural system and people's culture.
- Farmers ought to receive assistance and motivation to carry out on-farm conservation activities and expand their production into main fields.
- Enset processing is a tedious and time-consuming procedure that is performed by women with traditional tools. Thus, future processing technology development study is required to address this issue and maximize production.
- To improve the production system and increase productivity per unit area, compatible crops for intercropping and the best mixtures of Enset landraces need to be investigated.
- More research is needed to identify, characterize and conserve genetic diversity, and to improve the cultivation practices for Enset.

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APPENDICES

Appendex 1: Demographic and Socio-economic Characteristics of Household Head

ADDIS ABABA UNIVERSITY

COLLEGE OF NATURAL SCIENCE

DEPARTMENT OF ZOOLOGICAL SCIENCE

I am very much thankful for your cooperation in advance and here I am kindly requested you to provide the necessary information based on the questions included in this questioner form. Below are stated questionnaires used for data collection from the 3 kebeles‟ households and elder people of dedo District. I am MSC student in Addis Ababa University in the department of Zoological science. The Title of my research is "assessiment of indigenous production method and farm based biodiversity of Ensete ventricosum in Dedo district of Jimma zone Target population- local people in 3 kebeles of dedo District.

Data collection techniques- structured interview questionnaires

Name of respondent (optional) _____

Kebele Name_____

Part I: Demographic and Socio-economic Characteristics of Household Head

1. Age of house hold head: A.15-20 B .21-30 C.31-50 D.51 and above
2. Sex of household head: a, Male. B, Female
3. Marital status A. Single B. Married C. Divorced D. Widowed
4. Size of household: A. 1-4 B. 5-8 C. 9-10 D. >11
5. What is educational level of household?

Class	Yes	No
Illiterate		
Read and write		
1-4 class		
5-12 class		
College Diploma and above		

6. Land size owned by the respondents(ha) a,<1 b, 1-1.5 c, 1.5-2 d, >2
7. Farm land covered by enset per farmer(ha) a, <0.25 b, 0.25-0.5 c,0.5-1
8. Number of enset landrace perfarm a, 1-5 b, 6-10 c, 11-15 d, >16
9. What are the major sources of income? A, Sales of crop production B, Sales of animals feed C. off farm income D, Income from government

10. House hold income per year? A, <5000 B, 5001-10,000 C. 10,001-15,000 D.>15,00

Part II. Questionnaires related to food value and classification of Ensete ventricosum in the area.

1. What are the landraces of enset cultivated in your house hold?_____
2. From the types of landrace which one is more common_____
3. And which one is rare _____
4. Which varieties of ensets are preferred more for food _____
5. Where do you cultivate enset mostly(cultivation site)
   a, in home garden b, in main field c, both home garden and main field
6. Which farming systems did you apply?
   A. mono culture B. Multiple /inter cropping c .others specify.
7. If your answer of number 10 is b'' with which types of crops you use intercropping with enset_____ a, potato b, maize c, cabbage d, other fruit e, sole(monoculture only)
8. Do you use inorganic fertilizer for enset cultivation a, yes b. no
9. If '' no'' What are the traditional fertilizer you were used for cultivation of enset to get good product
   a, manure b, waste from house c, both
10. What are the reason not using inorganic fertilizer? A, soil naturaly fertile b, expensive
    c, reduce quality d, reduce soil fertility e, burn the crop f, have no knowledge
11. From where do you get enset planting material? From____ a, family b, neighbor
    c, ownfeild d, backyards
12. Which season(months are preferred for planting enset a, sep-nov b, dec-feb c, march-may d, june –aug
13. From month of the year which one is more preferred for propagation and for harvesting
    a, march b, April c, Jun d, July d, other
14. What are the maturity indices of enset a, size b, by year count c, colour of leaf d, bearing of flower/inflorescence e, uprising corm from the ground(dev.t of utto or amicho above the ground)
15. What are the uses of enset in your house hold a, food b, animal feed c, market d, medicine e, others
16. What are the major constraints for enset production a, low yielding b, enset bacterial welt c,law market preference d, drought e, wild animal attack f, lack of extension service

17. What are the major crops grown by farmers in your house hold?_____
18. What are the criteria to select the varieties of enset crop? A, maturity period b, drought c, disease and inset pest resistance d, good taste e, high market price f, kocho and bula yield.
19. How many year is enough for maturation of enset averagely a, 3 b,4 c,5 d, 6 e,7
20. What cause can affect the maturation time ____
    a, types of landrace b, climatic condition c, good work under enset d, other
21. Which parts of enset is useable a, corm b. leaf c, pseodostem d, other
22. Who is more knowledgeable about d/t attributes of landrace a, women b, men c, elders d, children
23. What can influence the landrace diversity of enset? a, house hold resource b, cultural background c, population pressure and agro ecology e, drought f, disease
24. How many number of enset plant are there on your farm land?
    a,< 100 b, 100-200 c, 200-300 d, > 300
25. What are the criteria's for classification of enset being males or female? A, maturity time b, fibrosity c, susceptibility to disease and pests d, by production quality/quantity e, by size
26. What are the different criteria for naming enset landrace a, place of origin b, plant morphology c, yields of quality d, maturity time e, physical entities
27. What are the characteristics to identify wild enset from domestic enset a, morphology b, leaf color c, mid rib color d, petiole color e, pseudo stem color/shape f, corm color/size

Appendex 2:List of authenticated Enset varieties (landraces) with the types, adaptable in disease resistant, maturation time (years) and importance

Table 14: List of authenticated Enset varieties (landraces) with the types, adaptable in disease resistant, maturation time (years) and importance of enset that identified traditionally in Defkela, Askira and Gera kebeles in 2015.

No	Varieties of enset	Disease resistance nature	Maturation time to yeild food(years)	Significance
1	Anciro	NO	3	Food,(it's corm can be eaten as a sweet potato only by boiling), source of fibers, leave as a mat, medicinal use, more preferred by animals to eat
2	Argawi	No	5	Food, source of fibers, leave as a mat &animal feed
3	Asu	No	3-4	Food, source of fibers, leave as a mat &for animal feed
4	Bera	No	4	Food, source of fibers, leave as a mat &for animal feed
5	Bobeti	No	3	Food, source of fibers, leave as a mat &for animal feed
6	Buriti	No	3	Food(Good for bulla/ittino) source of fibers, leave as a mat &for animal feed
7	Dawula	No	4	Food, source of fibers, leave as a mat &for animal feed
8	Digabae	No	3	Food, source of fibers, leave as a mat &for animal feed
9	Elawa	No	4	Food, source of fibers, leave as a mat &for animal feed
10	Fatalo	No	3	Food (good for ittino/bulla), source of fibers, leave as a mat &for animal feed
11	Fia	No	3	Food (Good for Amicho production than others), source of fibers, leave as a mat
12	Finafina	No	3	Food, source of fibers, leave as a mat

13	Gariye	No	3-4	Food, source of fibers, leave as a mat and as a fertilizer medicinal value for animals and for human being
14	Geno	No	4	Food, source of fibers, leave as a mat &for animal feed
15	Gesero	No	4	Food(good for bulla), source of fibers, leave as a mat and as a fertilizer
16	Gisiro	No	4	Food, source of fibers, leave as a mat &for animal feed
17	Gonasa	No	Above 4	Food, source of fibers, leave as a mat &for animal feed, medicinal value
18	Kepe	No	3	Food, source of fibers, leave as a mat &for animal feed
19	Kokori	No	4	Food, source of fibers, leave as a mat &for animal feed
20	Kura	No	3	Food, source of fibers, leave as a mat &for animal feed
21	Margu	No	3-4	Food, source of fibers, leave as a mat &for animal feed
22	Matalafe	No	3	Food, source of fibers, leave as a mat &for animal feed
23	Molge	No	3	Food (Good for bulla), source of fibers, leave as a mat
24	Nobo	High disease resistance	Above 4	Food (Rigid with much fibrous and less tasty), source of fibers, leave as a mat and as a fertilizer
25	Shutu	No	3	Food, source of fibers, leave as a mat &for animal feed &for animal feed
26	Wagu	No	3	Food, source of fibers, leave as a mat &for animal feed
27	Warabo	No	4	Food, source of fibers, leave as a mat &for animal feed
28	Yeku	No	4	Food, source of fibers, leave as a mat &for animal