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ON-FARM DIVERSITY AND MANAGEMENT OF ENSET (*Ensete ventricosum*(Welw)

Ceeseman) IN KEMBATA TEMBARO ZONE, SOUTHERN ETHIOPIA

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Addis Ababa, Ethiopia

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(Welw) Cheeseman) IN KEMBATA TEMBARO ZONE, SOUTHERN ETHIOPIA**

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Presented in Partial Fulfillment of the Requirements for the Master of
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GRADUATE PROGRAMMES

This is to certify that the Thesis prepared by Tarekegn Deboch Gute, entitled: "On-farm diversity and management of enset (*Ensete ventricosum* (Welw) Cheeseman) in Kembata Tembaro Zone, Southern Ethiopia" and submitted in Partial fulfillment of the Requirements for the Degree of Master of Science (microbial, cellular and molecular science) complies with the regulations of the University and meets the accepted standards with respect to originality and quality.

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List of Acronyms and Abbreviation

AFLP	Amplified Fragment Polymorphism
EIAR	Ethiopian Institute of Agricultural Research
EXW	Enset <i>Xanthomonas</i> wilt
FAO	Food and Agriculture Organization of the United Nations
EBI	Institute of Biodiversity Conservation and Research
KA	Kebele Administration
MOA	Ministry of Agriculture
SNNPRS	Southern Nations Nationalities and Peoples Regional State

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ON-FARM DIVERSITY AND MANAGEMENT OF ENSET (*Ensete ventricosum* (Welw) Cheeseman) IN KEMBATA TEMBARO ZONE, SOUTHERN ETHIOPIA

By – Tarekegn Deboch - B.Sc

Abstract

*The Ethiopian highlands are a center of genetic diversity for enset, tef, sorghum, barley and finger millet. Enset (*Ensete ventricosum* (Welw.) Cheesman) belongs to the order Sctaminae, the family Musaceae. The family is subdivided into the genera *Musa* and *Ensete*. Enset is an important staple crop for about 20 million of the population of the people living in the densely populated regions of South and Southwestern Ethiopia. The crop is grown in mixed subsistence farming systems, often in association with coffee, multi-purpose trees, and annual food and fodder crops. It is also used for livestock feed, fuel wood, construction materials, containers, and as a provider of shade to intercropped annual or perennial crops. It is cultivated between 1500 and 3100 meters above sea level (m.a.sl), where daily average minimum and maximum temperatures are 8 and 27°C, respectively. The survey was aimed at investigating a central hypothesis that the traditional use and management of enset contributes to its conservation. The sampled households varied considerably in resource endowments, demographic and geographic factors. Generally, there were neither any differences between woredas, Kebele Administrations (KAs), nor among villages regarding the management and use of enset. Result of the survey revealed that farmers select and characterize Enset clones based on their own criteria and they were able to name 80 distinct enset clones. The number of enset clones maintained on individual farms ranged from 1 to 13 (mean of 5.97 ±1.11). Doyogena with 41 clones had the highest richness and Demboya with 28 clones had the lowest richness; mean richness being 36.66±4.88 clones per zone. Simpson's D and Shanon-Weaver's H had a very narrow range; 0.97 and 0.93 with a mean of 0.95 ± 0.01, and 3.46 to 2.91 with a mean of 3.2 ± 0.20, respectively, indicating high level of genetic diversity of Enset in the region. Clone abundance was the highest at Doyogena (7.39) and the lowest for Domboya (4.57). Mean abundance was 5.96±2.19 farms per clone. Out of the 80 clones 28 (35%) were observed at only one woreda and were localized. Eight clones were present at six and had the maximum distribution and abundance. Sorenson's similarity index has shown that Angacha and Doyogena shared the highest number of clones (27). Doyogena and Kedidagamela, Hadero-Tunto and Kedidagamela also had 22 clones in common and were therefore more similar. Farmers have noted that few clones such as Dirbo, Siskela, and Gishra are replacing previously grown clones due to their resistance to bacterial blight. It was also observed that clones previously known by farmers have been lost due to different reasons, pointing to the genetic erosion going on and the necessity of genetic conservation. Landrace diversity in the region is affected by a number of factors. Enset *Xanthomonas* is the main factor limiting enset richness and diversity.*

We therefore conclude that the existing farmers' naming, classification be complemented with morphological, biochemical and molecular marker study and maintenance of the creative dynamics of traditional knowledge and transmission of the knowledge are crucial for constructing sustainable management.

Keywords: diversity, enset, Ethiopia, farmers' varieties

1. INTRODUCTION

Enset, *Ensete ventricosum*, is a traditional staple crop for about 20 million of the population of the people living in the densely populated regions of South and Southwestern Ethiopia. The crop is grown in mixed subsistence farming systems (Zippel 2002). Enset is also utilized for livestock feed, fuel wood, construction materials, containers, and to shade other crops (Shigeta 1990).

The major food types obtained from enset are *kocho*, *bulla* and *amicho*. *Kocho* is fermented starch obtained from decorticated (scraped) leaf sheaths and grated corms. *Bulla* is a liquid which is obtained when leaf sheaths and corms are pulverized, the liquid containing starch is squeezed out from scraped leaf sheathes and grated corm and the resultant starch allowed to concentrate into white powder. *Amicho* is cooked enset corm pieces that are prepared and consumed in a similar manner to other root and tuber crops (Brandt *et al.* 1997).

Admasu (2002) reported that numerous enset cultivars were identified in each zones of major enset growing areas and the variations in the number of cultivars were attributed to a combination of socio-cultural and agro-ecological factors. Furthermore, Genet (2004) reported that the observed genetic diversity in cultivated enset in a particular area appears to be related to the extent of enset cultivation and the culture and distribution pattern of the different ethnic groups.

A number of researchers have reported that the communities that cultivate and use the crop in Ethiopia recognize and maintain a considerable assemblage of enset varieties (Zerihun *et al.* 2014b; Bizuayehu, 2002; Admasu and Struik, 2002; Shigeta 1996). The different varieties are individually identified and given separate names by farmers.

Despite this, the current agricultural policies largely focus on national or regional important crops without due consideration of indigenous crop production. Major agricultural development and extension programs are biased towards the cultivation of high yielding commercial crops. However, this does not seem realistic, especially to subsistence farmers in developing countries like Ethiopia, who prefer to increase their option by diversifying their small plots of land rather than homogenizing them with high external inputs and varieties.

Indigenous knowledge is used to sustain the community and its culture. Placing value on such knowledge could strengthen cultural identity and the enhanced use of such knowledge to achieve social and development goals, such as sustainable agriculture, affordable and appropriate public health, and conservation and sustainable use of biodiversity. Jabulani (2007) claimed that Indigenous knowledge is an essential resource for any human development process.

Enset in Kembata Tembaro zone of southern Ethiopia is one of the major sources of food and income, and contributes significantly to household food security. Since the last few decades, however, farmers declared that the production of the crop has been declining. Introduction of new cereal crops, recurrent droughts, land scarcity, long maturation period coupled with devastating disease and pest are the major factors that have contributed to the decline. The local knowledge of the zone on the use and management of enset has not been studied exhaustively and also not well documented. The objective of the present study was to obtain an understanding of cultivar diversity, distribution and to exploit farmers' indigenous knowledge on enset clone diversity management through the of farmers interviews.

2. Literature Review

2.1. Taxonomy and Domestication of Enset

Enset is a monocot that belongs to order Schistaminae and family Musaceae. Enset was considered as member of the genus *Musa* as it morphologically resembles banana (Taye, 1980) and because of this some of the species names formerly given to Enset were *Musa ensete* and *Musa ventricosum* (Lye and Edwards, 1997). It was Cheesman cited by Endale (1997) who separated Enset from banana on the basis of differences in pseudostem morphology and chromosome number.

Other than *Ensete ventricosum*, there are species in the genus *Ensete* but there is some ambiguity regarding their number. Chessman cited by Endale (1997) revised the Musa family and transferred about 20 species from the genus *Musa* to the genus *Ensete* and listed 24 species, which are distributed in Africa and Asia. But Simmonds (1962) and Pursglove (1972) recognized 6 and 7 species under this genus, respectively. Out of the six species, *Ensete gillettii*, *E. homblei*, *E.perrieri*, and *E.ventricosum* are with an African distribution and *E.glaucum* and *E.superbum* with an Asian distribution. *E. ventricosum* is widely spread in a wild state in Africa from Cameroon to East Africa and Transvaal (South Africa), and but only cultivated in Ethiopia.

Centers of origin of *Ensete* are the low land and mountain areas of Uganda, Tanzania and the Sudan (Smeds, 1955). Westphal (1975) on the other hand stated that the center of origin of Enset is in the high lands of southwestern Ethiopia, where it is found in forests. Enset is found in its wild state in the south and southwestern parts of Ethiopia. Anthropologists, archeologists,

historians and other scholars have developed the hypothesis that argues for the domestication of Enset in Ethiopia as early as 10000 years ago (Brandt *et al.*, 1997).

2.2. Morphology and Floral Biology of Enset

Enset is a giant herbaceous monocotyledonous plant consisting of adventitious root system and underground stem structure known as corm, a pseudostem which is formed from leaf sheaths that extend from the base of the plant, leaves and inflorescence (fig 1) (Smeds, 1955).

A mature Enset plant has an average height of 4 to 8 meters but, can reach a height of 10 meters depending on the cultivars used and site conditions (Tesfaye, 2005).

The leaves of some Enset plant are 5-7 meters long and 1 meter in diameter and are more erect than a banana plant (Brandt *et al.*, 1997; Kefale and Sandford, 1991). Color of Enset midrib includes brown to red, green, yellowish, red, light red, light green, pink to red, dark brown, black and brown (Almaz, 2001). The stem has three parts: The Pseudostem is swollen at the base and is made up of succulent spirally arranged leaf bases surrounded by outer leaf bases (FAO, 1998). Endale et al. (1996) reported that the pseudostem circumference of Enset is in the range of 1.5 – 3.0 meters and the height of decorticable pseudostem is in the range of 1.5 to 5 meters. The underground corm is an enlarged lower portion of the stem with an average of 0.7 to 1.8 meter length. The average weight of grated corm is 12-47 kg (Endale et al., 1994). The fibrous rooting system of Enset grows out from this part. The true stem is short at the base of a central growing shoot between the pseudostem and the corm near the ground in vegetative state. It is white and soft and develops into peduncle at flowering stage. Usually it grows up during maturity and initiates a single flower head, which forms multiple flowers, fruits and seeds (Taye and Asrat, 1966).

Enset has both unisexual and bisexual flowers. Unisexual ones found at bases and upper parts of inflorescence and bisexual ones at the middle. Several groups of flowers were observed on one inflorescence: on the lower portion of inflorescence are female flowers, in the middle hermaphrodites and at the upper portion male flowers. The fruits of Enset resemble those of banana but are smaller and inedible. At the earlier stage, Enset fruits are whitish and turn dark green followed by yellow at maturity. Enset fruits are leathery, dry or with very scanty pulp. Enset seeds vary in size and weight among different clones (Tesfaye, 1992).

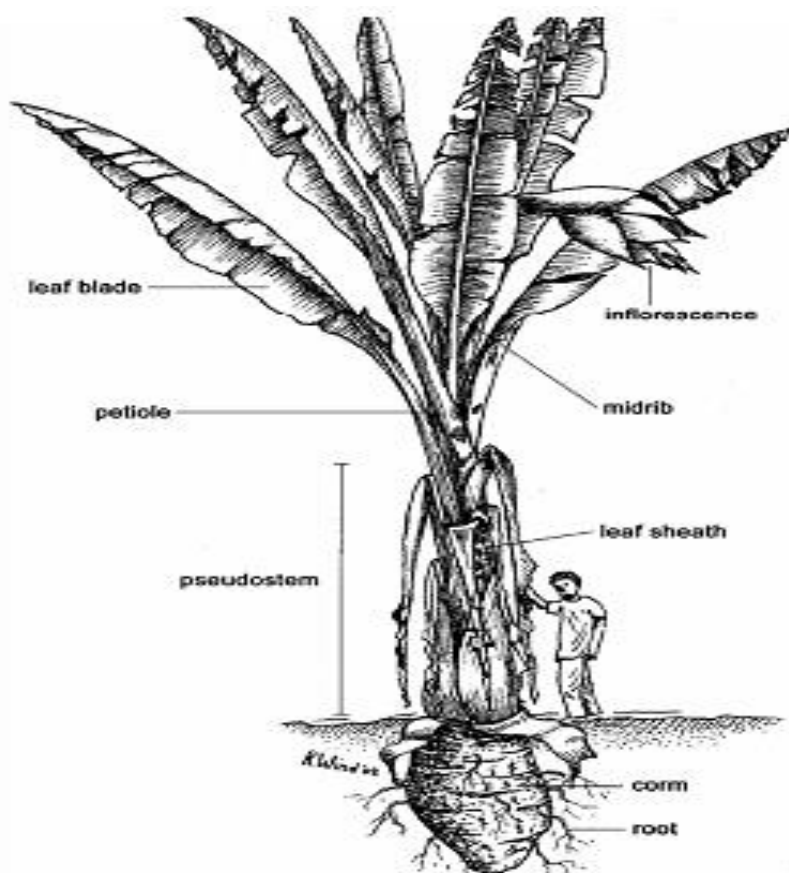


Figure 1. Description of Enset plant (Adapted from Admasu Tsegaye, 2002)

2.3. Economic and Ecological Uses of Enset

Enset is a multipurpose crop which is utilized for human food, animal feed, medicinal or ornamental uses. Farmers indicate that Enset is their food, their cloth, their house, their bed, their cattle feed and their plate (Brandt *et al.*, 1997). The corm and the pseudo stem are the most important sources of food (Kefale and Sandford, 1991). The major foods obtained from Enset are *kocho*, *bulla* and *amicho* (Spring *et al.*, 1996). *Kocho* is the bulk of the fermented starch obtained from the decorticated (scraped) leaf sheathes and grated corm. *Bulla* is obtained by squeezing out the liquid containing starch from scraped leaf sheathes and grated corm and allowing the resultant starch to concentrate into white powder. *Amicho* is cooked corm of Enset plants, prepared and consumed in a similar manner to other root and tuber crops (Brandt *et al.*, 1997).

Among important characteristic features of Enset are its productivity of food per unit of land and storability of processed products such as *kocho* for a long period without spoilage (Seifu, 1996). Enset fiber is the by-product of Enset that is left after decorticating the leaf sheathes. Its strength is found to be equivalent to the important fiber crop, *Musa textiles* (abaca) (Taye, 1984). Enset fiber is used for making bags, ropes, twines, cordage, and mats. The variety, the age of the plant, and the way in which the fiber is extracted and stored determine its length and quality (Kefale and Sandford, 1991; Yohannes and Mengel, 1994).

Enset can significantly help to ensure food security in a country like Ethiopia (Brandt *et al.*, 1997). The average yield of refined Enset product (*kocho*) ranged from 7 to 12 tons ha⁻¹ year⁻¹. The amount of food attainable from 50-60 Enset plants per year could provide enough food for an average family of 5-6 persons (Tilahun and Ludders, 1998). Enset products are

available throughout the year as kocho and can be stored in pits for long periods of time without spoilage.

Enset is rich in carbohydrate and minerals like calcium and iron (Shigeta, 1990; Taye and Asrat, 1966). The energy yield of Enset is by far higher than that of several cereals. A mature Enset plant could yield $20 \times 10^6 \text{ cal ha}^{-1} \text{ year}^{-1}$ which is 20 times higher than that of barley (Olmstead, 1974). Enset energy yield was also reported to be higher than that of potato, sweet potato and banana (Pijls *et al.*, 1994). The average energy production rate of Enset was about 286 and 172% higher than that of cereals and root and tuber crops (Admasu, 2002). This shows that cultivation of Enset can significantly improve food security at household and at national level.

Some Enset clones are known by farmers to have medicinal value for both humans and animals. These clones are claimed to heal bone fractures, are used for treatment of diarrhea and delivery problems i.e. assisting to discharge the placenta (Spring *et al.*, 1996). In addition farmers believe that eating bulla from clones like Boliac (Wolaita) after taking traditional medicines against tapeworm protects the liver from the side effect of the medicine. Bulla supplemented with milk and milk products is also known to be important for quick recovery of women after child delivery (Kefale and Sandford, 1991).

The fresh and dried leaves of Enset have various uses. They are used as food wrappers, serving plates and pit liners during kocho storage. Dried petioles and midribs are used as fire wood, to make mats and as tying materials (Brandt *et al.*, 1997). In the dry season, the fresh leaves are used as cattle feeds. Dereje and Ledin (1997) reported that the degradability of *Ensete ventricosum* lamina given to rumen animals was better than that of straw and banana

leaf and similar with that of stoker and *Chloris gayana* hay. These authors further explained that other parts of Enset such as leaf midribs, pseudostem sheath, pseudostem core and corm were all found to have high degradability than green *Chloris gayana*, setaria grass, elephant grass and Guatemala grass.

Enset contributes to higher reduction of losses of plant nutrients particularly nitrogen loss through leaching as compared to annual crops (Brandt et al., 1997; Lee-R and Zawdie, 1997). Research conducted on fields where Enset is continuously cultivated has revealed that there is a higher soil nutrient status in the Enset fields than in other crop fields. This indicates that Enset cultivation is a sustainable system with regard to maintaining the soil fertility (Asnaketch, 1997). Eyasu (1998) has also confirmed that soil fertility is maintained and even increased around the garden area of Enset and taro fields.

2.4 Diversity of Enset Crop

The variability within and between landraces was developed in response to, and was maintained by, the tremendous diversity of cultural and environmental regimes present in traditional farming systems (Wood and Lenne, 1999). Today millions of hectares of many crops are traditional cultivars or landraces selected by traditional farmers in prehistory or at least before agricultural science was developed (Wood and Lenne, 1999). Admassu (2002) stated that the phenotypic variation of Enset landraces expressed under farmers' conditions is enormous. Farmers have managed this diversity for centuries with limited influence from outside.

Most of the genetic diversity of Enset is traditionally maintained *in situ* by farmers. Unfortunately, many valuable clones have been lost due to various human and environmental factors (Seifu, 1996) which may reduce the total available genetic diversity of the crop. Genetic erosion, which is the reduction of diversity and the main cause of extinction of a species, is a global threat to agriculture. Since the beginning of this century about 75 percent of the genetic diversity among agricultural crops has been lost (Cooper *et al.*, 1992). It has been described as a loss of plants with potential agricultural and economic value, and has implications for the food supply and sustainability of both intensive as well as locally adopted traditional agricultural systems (Bizuayehu, 2002).

Lack of knowledge about the genetic diversity that is still available complicates the conservation, improvement and utilization of Enset, either by farmers or conservationists and breeders. Studies of distribution of Enset genetic diversity using AFLP markers in clones obtained from south and south western Ethiopia showed that within the total number of 146 clones, there were 19 duplication groups consisting of a total of 54 clones (Almaz, 2001).

The role of local knowledge in agricultural systems has been given attention. Thurston *et al.* (1999) stated that communication between farmers and scientists in the exchange of agricultural knowledge is a crucial issue, as people have different perceptions, symbols, socioeconomic positions, meanings and associations. Close relationship and regular exchange of ideas and knowledge between two sets of knowledge systems is therefore indispensable. Indigenous people have a long tradition in maintaining biodiversity as a sustainable resource. Farmers have played and still continue to play a tremendous role in developing and nurturing crop genetic diversity (Almaz, 2001).

Farmers have been cultivating, conserving, maintaining and developing diversity of traditional crop varieties in their farming systems (Brookfield, *et al*, 2002). Based on thousands of years of experience and a deep knowledge of their needs and their agricultural production systems, farmers have developed multiple strategies for their farming systems, almost all of which maintain genetic diversity (Thurston *et al*, 1999). Studying the farming system along with the people, their culture and the socio economic environment, will give a better understanding of and insight into the role of a rural household in potential utilization of the crop (Almaz, 2001).

2.5. Challenges of Enset Production

Enset production in many regions is declining due to a combination of abiotic and biotic production constraints; soil fertility decline being one of the major abiotic production constraints (Kelsa, 1996). Although Enset-farming systems support a large number of Ethiopian populations and a number of research activities have been made so far, production constraints such as lack of improved varieties, appropriate cultural practices, effective disease, insect pests, weed and rodents control measures, mechanically efficient processing devices, storage and utilization practices are the main constraints. Consequently, production and productivity of Enset is strongly affected (EARO, 2000). Out of all the above mentioned constraints, the most acute problem threatening Enset production at present is the disease problem.

Several types of diseases are known to affect Enset plants under field conditions. So far a number of fungal, nematode, viral and bacterial diseases were reported to cause damage at different degrees of intensity (Quimio, 1992). The occurrence, distribution and the incidence level also indicated to vary from one Enset-growing locality to the other. Therefore, the

damage inflicted by each disease also varied. Among various diseases, Enset bacterial wilt is considered as the most important one that reduces Enset yield.

Objectives of the study

General objective

The main aim of this study was to assess and document the skills with which farmers identify, maintain, promote and on-farm enset landrace diversity and management of enset (*Enset ventricosum* (Welw) Cheesmen) in Kembata zone, Southern Nations Nationalities and Peoples Regional State of Ethiopia.

Specific objectives

- To identify the enset landraces based on the use value in the study area;
- To investigate on-farm enset landrace diversity and management of enset in the study area;
- To determine the effects of agronomic factors on on-farm diversity and management of enset in the study area;
- To identify the major constraints of enset production and its prevention of on-farm diversity and management of enset in the study area;
- To document farmers' folk knowledge for naming and classification in the study area;

3. Material and Methods

3.1. Description of the study site

The present study was conducted in the Kembata-Tembaro administrative zone of Southern Nation and Nationalities People Region. The zone was selected for the following reasons:

1. The crop has coexisted with the people for centuries and enset production is predominantly based on farmers' varieties. Hence, farmers' expected to have an established folk naming, classification system of appraisal of enset.
2. The ethnic groups have rich on-farm genetic resources of enset that made it suitable to study ethno botanical descriptions of enset.
3. In the zone, enset cultivation is the center of the cropping system in which the entire farming system is based and the crop is the major food security and livelihood source.

Two kebeles which are major enset growing areas were purposively selected from each wereda/district based on the importance of enset cultivation and information about enset distribution obtained from the Departments of Agriculture and Natural Resource of the respective zone (Table 1).

Table 1. Description of the woreda and Kebele Administrations included in the study (source; Agriculture and Natural Resource Woreda Office).

<i>No</i>	<i>Woreda</i>	<i>Kebele</i>	<i>Altitude</i>	<i>Mean T^o</i>	<i>Annual RF</i>
1	Kedida Gamella	Dega Kedida	2300m	24	1120mm
		Fullasa	2250m	23	1125mm
2	Damboya	Bonga	2300m	24	900-1100mm
		Dato	2900m	16	900-1400mm
3	Angacha	Bondena	2600m	16	900-1250mm
		A/Wasara	2650m	16	900-1300mm
4	Doyogena	Gomora	2801m	16	900-1500mm
		Lemi Suticho	2800m	16	900-1500mm
5	Kachabirra	Ashira	2400m	22	1120mm
		Mesafe	2300m	25	1080mm
6	Hedaro Tunto	H-chacho	2100m	24	900-1100mm
		Lalo	2200m	23	900-1050mm

3.1. Sampling

Multistage sampling technique was employed for selection of samples, zones, woredas and Kebeles. All stages were selected purposefully from high (> 2500 m.a.sl) and mid altitude (1800 -2500 m.a.sl) areas in consultation with stakeholders engaged in the subsector. Six woredas/districts and two Kebele Administration (KA) (Kebeles are the lowest administrative unit) from each Wereda (12 KAs), were selected purposefully based on agro-ecology variant. A total of 168 households (28 household heads from

each woreda) in the two crop ecologies were directly monitored on farms. The survey focused on the investigation of farmers' folk knowledge for naming, classification, diversity and management of enset landraces in the region.

3.3 Data collection

Diverse data collection methods were employed in order to understand the many features for the acquirement of local knowledge of enset in the center of diversity. The data collection was conducted mainly through: i) individual interviews and direct on-farm participatory monitoring and observation, and ii) key informant and focus group discussions.

3.1.1. Individual interviews and direct on-farm participatory monitoring and observation

Before interviews were performed, informal conversation was conducted with 15 inhabitants of the enset community with the objective of determining which type of information needed to be collected. Based on these conversations, semi-structured interviews were designed and data collected with the head of the household or the person responsible for maintenance of the enset plantation. One hundred sixty eight farmers were interviewed and directly monitored on farms, over the selected woredas in order to assess the farmers' ethnobotany knowledge on enset.

3.1.2. Key informant interviews

In order to assess the general indigenous knowledge of farmers' in the zone: key informants up to five per Kebele Administration, community leaders, local administrations, and MOA (Ministry of Agriculture), and other members in each ethnic site were interviewed.

3.2. Indigenous Classification Method

The indigenous classification systems of Enset were assessed during the survey by asking farmers to describe the distinguishing features, selection criteria and attributes of each clone that are important in their decision to maintain the clone. Data collection methods including listing of local names and description of each clone through individual interviews were employed as per Zerihun *et al.* (2014). This permitted description of the main features of indigenous classification method which was also compared with the results of qualitative morphological characterization (Table 2).

Table 2. Farmers' criteria for classification of enset clones in the study area

<i>Trait</i>	<i>Descriptor state</i>
Plant vigor	Poor (<4m) Medium (4-6m) High (>6m)
Maturity (cycle duration)	Early (<4 years) Intermediate (4 -5 years) Late (> 6 years)
<i>Kocho</i> yield	Low (<9.9 t ha ⁻¹ yr ⁻¹) Medium (9.9 to 20 t ha ⁻¹ yr ⁻¹) High (> 20 t ha ⁻¹ yr ⁻¹)
<i>Bulla</i> quality	Not good Good
Corm use	Not used Used
Fiber quality	Low Medium High
Medicinal value	Not used Used
Disease response	Susceptible Intermediate Tolerant

Source: (Zerihun *et al.*, 2014(a))

3.3. Data Analysis

Lists of all clones described throughout the study area were summarized after grouping known synonyms or names that refer to the same clone in each woreda with the help of elderly farmers. Then, the number of different clones recorded in each woreda was considered a richness index of the woreda. The number of woredas in which the clone was observed was considered abundance of the clones.

As measure of diversity that takes into account the proportional abundance of clones (richness and evenness), Simpson and Shannon diversity indices were calculated for all the woredas.

Simpson's index (D) basically measures the probability that two individuals randomly selected from a sample belong to the same category (Simpson, 1949) and hence, as D increases, diversity decreases. It was therefore transformed as 1-D with values ranging from 0 to 1. The index was computed for all the woredas and all the accessions using the function:

Simpson's Diversity Index (1-D) = $1 - \sum (n/N)^2$

$$\rightarrow D = \sum_{i=1}^n \frac{(n_i (n_i - 1))}{(N(N - 1))}$$

Where, n_i = the frequency of the i^{th} clone, frequency being the number of farms in which the clones was found in the woreda, and

N = the total number of farms surveyed in the woreda

The frequency distributions and the number of phenotypic classes were used to calculate the Shannon-Weaver diversity index (H') for each character as per the formula suggested by Hennink and Zeven (1991). For a K class trait, the observed normalized Shannon Weaver diversity index (SWDI) is given by:

$$H' = -\sum p_i \ln p_i$$

Where, p_i is the proportion of the total number of individuals (clones) in the i^{th} class and n is the number of phenotypic classes.

Where p_i = proportion of clones i relative to the total number of clones or $p_i = \left(\frac{n_i}{N}\right)$.

Shannon diversity index (H) also referred to as Shannon Weaver diversity index takes into account both number and evenness of categories considered and can be increased either by greater evenness or more unique species or clones in our cases.

Although Shannon's index takes into account evenness of the abundance of clones, evenness can be calculated separately as a measure of the observed diversity to the maximum diversity. It is defined by the function $E = H' \ln S /$, where H' is Shannon index and S refers to the number of clones described in each Woreda. High evenness resulting from all clones having equal abundance is normally equivalent to high diversity (Magurran, 1988).

Measures of similarity/variation are almost as numerous as measures of species diversity. The purpose of these functions is to quantify the similarity between two or more sampling sites. The variation expected in clone composition that exists between sites will be analyzed using Sorenson's (1948) similarity coefficient (C_s), which is calculated as

$$C_s = \frac{2J}{a+b}$$

Where: - a is the number of clones at site A

- b is the number of clones at site B, and

- J is the number of clones common to both locations.

Sorenson's similarity coefficient ranges in value from zero (no similarity) to one (complete similarity).

Clones diversity (D and H) were measured separately for each woreda. Pearson's correlation coefficient was used to compare diversity values at different sites.

4. Results and Discussion

4.1 Enset clones on-farm richness

The survey was aimed at investigating a central hypothesis that the traditional use and management of enset contributes to its conservation. The sampled households varied considerably in resource endowments, demographic and geographic factors. Generally, there were neither any differences between woredas, KAs, nor among villages regarding the management and use of enset.

Ensete is the genus name, while different ethnic group use different vernacular terms as a local name for Enset. The Kembata-Tembaro calls the enset plant *Waiese*. The variation among woreda with respect to the total number of clones recorded in each woreda (Richness of the woreda) and the number of Enset clone per farm visited (Farm richness) is summarized in Table 3. The original data on the number of cultivars per farm, for all the 28 farms of the six districts is given in Appendix 1.

In Kembata-Tembaro, enset is represented by a large number of specific units. A total of 80 named units of enset and landraces were recorded in this study alone (Appendix 2). A comparable number of named vernaculars are recognized and maintained by Sidama farmers (Bizuyehu, The 2002). Large number of folk enset vernacular recorded reflects the existence of considerable diversity within the crop and the long history of its cultivation in Kembata-Tembaro.

In Doyogena with a total of 41 named clones recorded is the richest woreda followed by Kedida-Gamela with 40, Hadero-Tunto with 39 clones, Angacha with 38 clones, Kachabira

with 34 clones, and Demboya with 28 clones (Appendix 2). An average number of clones per farm ranged between 7.4 for Angacha to 4.6 for Demboya. Kedida-Gamela with 7.14, Doyogena with 6.0, and Kacha-Birra with 5.46 clones per farm had high farm level richness (Table 3). Most of the farms have 6-10 clones, which can be categorized as high on-farm variability.

The extent of clone diversity described in this study is also comparable with earlier reports. Admasu (2002) described 146 named Enset clones from three zones of SNNPR (52 clones from Sidama, 55 clones from Wolaita and 59 clones from Hadiya). Moreover, Almaz (2001) described 146 different named Enset clones from three zones of SNNPRS (66 clones from Kefa-Sheka, 30 clones from Sidama, 45 clones from Hdaiya and six clones from Wolaita). Genet (2004) also described 111 Enset clones from nine Enset growing regions of Ethiopia, while Bizuayehu (2002) studied 79 clones from Sidama.

Diversity indices for the six woreda were computed from the richness of the 28 farms within the district (Table 3). Simpson's and Shannon-Weaver's diversity indices are given in Table 3. Simpson's 1-D ranged between only 0.97 and 0.93, H ranged between 3.46 to 2.91 and evenness also had a very narrow range (0.86 to 0.95). All these values indicate the high enset diversity present in these six woredas.

The total number of clones observed in the six districts was 220 which are grouped into 80 distinct clone types with their own specific clone names. The eighty named clones maintained by different households in the six districts are presented in Appendix 2. During the survey we were able to confirm that each farmer is determined to maintain as much enset diversity as

possible as long as he/she has enough land. We were able to verify the existence of up to 13 different enset clones maintained by one household (Table 3).

Table 3. Variation in the number of Enset clones planted per farm in the six woreda

<i>Woreda/ District</i>	<i>Number of clones per farm</i>			<i>Richness of the woreda</i>				<i>I-D</i>	<i>H'</i>	<i>E</i>
	≤ 5 clon es	6-10 clone s	11- 15 clo nes	Total	Max	Min	Avera ge			
Angacha	6	21	1	38	13	2	7.4	0.97	3.46	0.95
Domboya	21	7	0	28	10	1	4.6	0.93	2.91	0.87
Doyogena	8	15	5	41	12	3	6	0.95	3.33	0.89
Hadero-Tunto	19	9	0	39	8	3	5.21	0.95	3.22	0.88
Kachabira	18	8	2	34	12	3	5.46	0.94	3.02	0.86
Kedida-Gamela	14	11	3	40	13	4	7.14	0.95	3.28	0.89
Mean & Std. Deviation				36.66± 4.88	11.33± 1.96	2.66±1 .03	5.97 ±1.11	0.95 ± 0.01	3.2 ± 0.20	0.89 ±0.03

4.2. Distribution and Abundance of the Enset Clones

There were considerable differences among enset clones with respect to their distribution across the woredas covered by this study (Appendix 2) and (Table 4 & Fig. 2). Out of the 80 distinct clones, 28 (35%) were observed at only one woreda and were localized/endemic, while 15 (19 %) of the clones were identified in two districts. A total of 11 clones (14 %) were recorded at 3 districts, while nine clones (11 %) were identified at four and five of the six districts and eight clones were identified at six with maximum distribution.

Table 4. Frequency of occurrence of the most abundant and widely distributed enset clones in the study sites

<i>Clone name</i>	<i>Demboya</i>	<i>Kachabira</i>	<i>Doyogena</i>	<i>Kedida Gamella</i>	<i>Angacha</i>	<i>Hadero Tunito</i>	<i>Total farm</i>	<i>Total woreda</i>
Bishato	7	16	1	9	-	4	37	5
Dego	3	2	8	3	9		25	5
Dirbo	20	26	3	19	11	15	94	6
Disho	2	1	3		5	2	13	5
Gembo	2	4	6	2	12	16	42	6
Gishra	7	13	9	16	10	8	63	6
Hele	3	16	-	2	5	-	26	4
Lekake	1	1	11	5	5	9	32	6
Merza	6	-	16	-	7	3	32	4
Sebere	7	3	1	19	4	7	41	6
Sheleke	3	3	10	3	5	1	25	6
Siskela	14	7	25	11	16	14	87	6
Tebere	3	-	3	8	7	6	27	5
Torore	2	3	9	1	5	2	22	6
Ungeme	17	-	5	6	5	7	40	5
Cherkwa		11	3	4	4	1	23	5
Qoyna	-	6	4	-	5	2	17	4
Meriya	-	2	9	-	7	3	21	4
Moche	-	3	5	4	7	2	21	5
Wolancha	-	11	4	7	-	2	24	4
Etnete	-	-	16	1		5	1 23	4

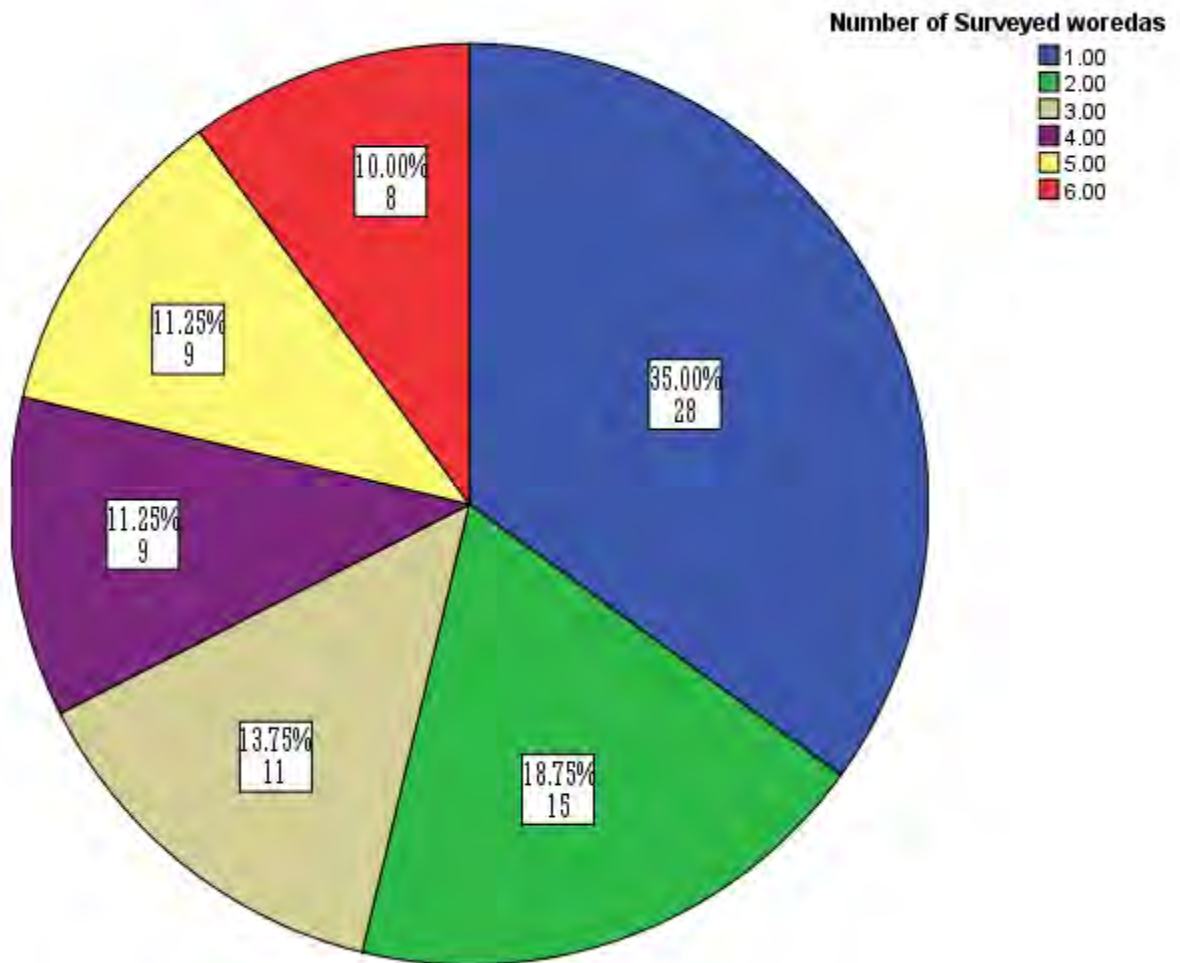


Figure 2: Enset clones distribution across the woredas

There was also a considerable difference among the clones with regard to number of farms where the clone was grown in individual districts (clone abundance). Dirbo (entry # 6 in Appendix 2) was the most abundant clone as it was recorded on 94 (55%) of the farms surveyed (Appendix 2). Most of the clones (28%) were encountered on less than 5% of the farms surveyed. Dirbo was present on 26 of the 28 farms in Kachabira, on 20 of the 28 farms in Demboya and on 19 of the 28 farms in Kedidagamela. It is recorded in the six districts and had, therefore, a distribution of $6/6 = 1$. However, there was a significant correlation between

distribution and abundance of the clones ($r=0.66$ $p\leq 0.0001$). Clones which are used by many farmers in any woreda tend to be introduced to other woreda and have wider distribution.

The abundance of clones across sites within a woreda and the distribution of clones across the six woredas were generally uneven, because of a limited number of widespread and dominant clones. The other clones had a rather limited abundance and distribution. The hierarchical nature of the spatial distribution of enset clones where a small number of highly abundant clones which are also grown throughout the zone and a much larger number of moderately common and rare ones has been documented for several other crop species and also detected in landraces of a number of cultivated crops including enset (Bizuyehu, 2002), yam (Muluneh, 2006).

The widespread distribution of some clones also challenges the view that traditional farming systems are isolated and closed, with limited exchange of germplasm. Our findings and those of others mentioned above depict that this system is rather open and dynamic, where local knowledge exists for moving planting materials across wider areas and heterogeneous environments. The unequal distribution and abundance of clones reflects their relative importance of farmers and provides strong evidence for selection.

4.3. Farmer' perceptions on major local clones

All households surveyed grow local cultivars of the crop. Interviewed farmers reported that earlier they had been growing a wider diversity of local clones for various reasons. These days, however, they have specialized on few clones that they thought would meet their needs best (Table 5) and all of them had been selected by farmers. There is, however, evidence of ongoing genetic erosion, which has resulted in the complete loss of some local clones.

Some of the interesting distinguishing characteristics used by farmers so as to distinguish the local clones include: Plant vigor, Maturity, Kocho yield, Bulla quality, Amicho use, fiber quality, medicinal use and EXW disease response are the major criteria for the maintenance of each clone.

Farmers recognize several agro-morphological and end-use features so as to identify and enhance their local clones. They often prioritize their local cultivars based on specific use values and their response to different factors of production such as disease tolerance, drought, productivity, maturity days, and taste. Farmers also grow different proportions of early-maturing and late maturing local cultivars in the same field. Earliness to maturity enables them to plant and subsequently harvest early, as well as to plant late and still harvest a mature crop. Thus, maintenance of two to three cultivars in the same field is a common phenomenon in all study sites and used to minimize risk. The data gathered on the dominant and widely occurring clones (Table 5) on the several attributes also corroborate this fact. For instance, the *Bishato* clone was highly valued by farmers for its earliness, vigorous growth and medicinal use. Teshome (2006) also reported that though farmers maintain diverse varieties, they have different preference to different local cultivars. Local names are often useful clues for the characteristics of crops and are needed in communicating back to the farmers who use the crops (Yemane, 2006). Despite the fact, most farmers in the study area are not well aware of the meaning of the local names. They can simply distinguish them by their distinct characteristics.

Table 5. Characteristics of the common local cultivars in the study area

<i>Enset clones</i>	<i>Plant vigor</i>	<i>Maturity^a</i>	<i>Kocho yield</i>	<i>Bulla</i>	<i>Amicho use</i>	<i>Fiber quality</i>	<i>Medicinal use</i>	<i>EXW Disease response</i>
Bishato	1	1	3	2	2	2	1	2
Cherkwa	1	1	3	2	1	1	1	1
Dego	2	2	3	2	1	2	1	1
Dirbo	3	3	3	3	1	3	1	2
Disho	1	1	3	1	1	2	1	2
Etnete	1	1	2	2	1	2	1	1
Gembo	1	1	3	2	1	1	1	1
Gishra	3	3	3	2	1	1	2	1
Hele	3	3	3	2	1	2	1	1
Lekake	2	2	3	2	1	2	1	2
Meriya	3	3	3	2	1	2	1	1
Merza	3	3	3	2	1	2	1	1
Moche	3	3	3	2	1	2	1	1
Qoyna	3	3	2	2	1	3	1	3
Sebere	2	2	3	2	1	2	2	1
Sheleke	1	1	3	2	2	2	1	2
Siskela	3	1	3	2	1	3	1	1
Tebere	1	1	2	3	1	2	1	2
Torore	1	1	3	2	2	2	1	12
Ungeme	3	3	3	3	1	3	1	2
Wolanche	1	1	3	2	1	3	1	1

^a See the materials and methods section for the abbreviations of the characters.

The number of clones shared between pairs of districts and Sorneson's similarity indices are presented in Table 6. Angacha and Doyogena shared the highest number of clones (27). Doyogena and Kedidagamela, Hadero-Tunto and Kedidagamela also had 22 clones in common. These are adjacent districts. The findings are in line with Bizuayehu (2002), who studied diversity and regeneration of enset in Sidama and reported that 52% of the enset clones were shared among the farmers of the study area suggesting that the informal exchanges among farmers are limited within narrowly defined ethnic groups.

Table 6. Number of clones shared (Bold and above diagonal) and Sorenson similarity Indices (below diagonal) between pairs of Woredas

<i>District</i>	<i>Angacha</i>	<i>Domboya</i>	<i>Doyogena</i>	<i>Hadero-Tunto</i>	<i>Kachabira</i>	<i>Kedidagamela</i>
Angacha		19	27	24	18	23
Domboya	0.58		19	18	14	19
Doyogena	0.68	0.55		25	18	22
Hadero-Tunto	0.62	0.54	0.63		23	22
Kachabira	0.5	0.45	0.48	0.63		18
Kedidagamela	0.59	0.56	0.54	0.56	0.49	

4.4. On-farm mmanagement practices of Enset

During the household surveys, we were able to observe management practices such as land preparation, propagation, weeding, transplanting, and manure application. Cultural practices of enset for each location are described in Table 7. Most farmers (over 95%) responded that the cultivation technique of enset is time taking and laborious.

4.4.1. Land Preparation

Every household selects site for enset mainly based on soil fertility and ease of manure application. Fertile soil near the residence is used for enset production. The land preparation usually commences around the month of November and has different cycles. More than 75% of the respondents reported that they plough the land more than three times before planting. This also enables them to mix the farmyard manure with the soil, to make the soil fertile and suitable for growing enset. Family labor is the principal source of agricultural labor in this woreda. Farmers use hand tools such as hoe and spade for cultivation of the land.

4.4.2. Propagation and seed source

All farmers in the survey area use vegetative means of propagation. The corm of onset of 3 to 4 years old plants with some portion of the pseudostem is used for propagation. Farmers in all district use bored out corm for propagation. The corm used for propagation is then filled with dry dung, mud clods or stones. The bored corm is then, stored in the shade for 2 to 3 days before planting. Almost all the farmers use dry period for planting. The corm is usually planted in November to January. A combination of corm and sucker planting material sources is a common practice in the area.

Sources of planting materials in the study areas include own savings, material from relatives or the market, or combinations of these sources. The traditional seedling/seed supply systems are the only means of seed supply in the study area. Most farmers get seed tubers for planting each year from market (Fig. 3). Those farmers who save tubers often select plants from the standing crop in the field to be used as source of planting material.

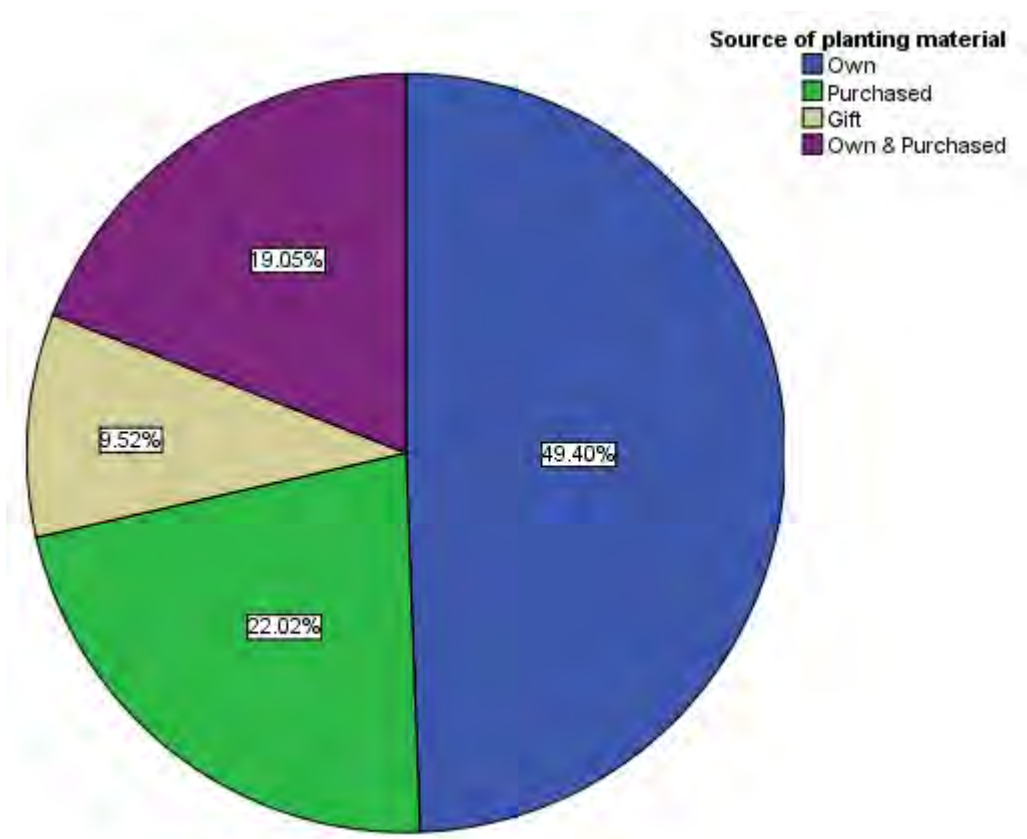


Figure 3. Planting material sources and exchange among farmers in the study

Brush (1999) also reported that in times of local extinctions farmers often acquire, through seed exchange among farmers, the seed that was locally extinct. Farmers also reported that few years before there was still a possibility of getting planting materials free of charge among the closely related farmers in the community. However, now a day since the production is declining, it becomes very difficult to get planting material in the above manner. Planting material is neither given as gifts nor is exchanged with other crop species. Teshome (2006) also reported that crops for which production is declining, seeds cannot even be obtained from friends and/or relatives as gifts.

Table 7. Enset management practices in Kembata-Tembaro zone

<i>Cultural practice</i>		<i>(Reported by number of farmers N=28) Woreda</i>					
		Angacha	Demboya	Doyogena	Hadero-Tunto	Kachabira	Kedidagamelaa
Land preparation	1 hand tool	20	24	22	27	19	27
	2 oxen	8	4	6	1	9	1
Frequency of land preparation	2 times	16	21	20	22	17	15
	≤3 times	12	7	8	6	11	13
Time of propagation	1 before rain	26	18	25	24	18	19
	2 after rain	2	10	3	4	10	9
No. of days of corm exposure before planting	2 days	20	26	24	20	27	21
	> 2 days	8	2	4	8	1	7
Age of mother plant used for propagation	< 3 years	2	3	3	2	5	8
	≤3 year	26	25	25	26	23	20
Frequency of weeding/year	2 time	18	5	22	23	16	17
	>2 time	10	23	6	5	12	11
Method of manure application	1 broadcast	14	16	18	17	19	14
	2 ring	10	4	3	5	3	6
	3 side/heaping	4	8	7	6	6	8
Frequency of transplanting	2 times	6	1	2	6	6	7
	>2 times	22	27	26	22	22	21

† Numbers in the table are the number of farmers that use the specified practice (out of 28 individuals)

4.4.3. Transplanting

The suckers of Enset are usually transplanted several times in nursery beds before taking them to the permanent field. Frequency of transplanting varied from place to place. From the survey we observed that frequency of transplanting is usually 3 to 4. The stages of transplanting with their local names are described below. The majority of farmers in the survey area use 4 times transplanting. In the second year in the month of December to March after corm propagation, the propagated sucker is uprooted and transplanted in to well prepare soil. Local names of different stages of transplanting for the surveyed woredas are common for all except in Doyogena, the second stage is Monu, however, the remaining stages are the same. These common stages are Dubo, Sima, Ero and Weshu.

4.4.4. Weeding and Manuring

Farmers practiced hand weeding and slashing for weed control. Frequency of weeding decreased as the plant age increases. From the interview we observed that weeding is accomplished at the end of rainy season. Farmers reported that two to three times weeding is practiced. Hand weeding is a common practice mainly from March to October. Cultivation is done during the rainy season once in a year.

Almost all farmers reported that they use manure in enset production. The majority of the farmers practiced manure application throughout the year, however; it was applied at a maximum rate during rainy season. The majority of farmers reported that cow dung is carried to the plantation, placed between two plants and around the base of the two plants. During cultivation it is spread.

Based on the household survey, in each location the enset production practices such as land preparation, propagation, and weeding frequency were almost the same for all farmers. Only a few differences were observed on the age of the parent corm for propagation, the method used in propagation and enset stage of transplanting. These findings markedly in line with the findings of Admasu (2002), who stated that cultivation methods varied mainly between ethnic groups rather than within groups.

4.5. Enset Harvesting, Processing, Storage and Utilization

Almost all farmers in all the locations agree that the proper time for harvesting Enset for kocho is when it produces an inflorescence. However, for amicho use farmers uproot Enset in early stage. From the survey we observed that method of processing and storage of Enset and bulla squeezing for all locations is relatively the same (Table 8).

Enset processing is carried out by the women. The men assist in cutting the upper part of the leaf, uprooting the corm and transporting to the place of processing. According to the information from the women, enset can be harvested any time of the year, however they preferred dry periods. Kocho processed during dry period have high quality because of low amount of water in the pseudostem. Almost all farmers in each location said that bulla is squeezed out from the scrapped pseudostem. The number of plants processed and time of storage of enset for each location was variable (Table 8). Almost all farmers store kocho for less than a year; only few farmers store for a year and above.

During the survey we observed that farmers maintain different types of enset clones for different purposes. *Kocho*, *bulla*, *amicho* and fiber are products obtained from enset plant. In all the location farmers grow enset for the same uses. Based on our discussion with farmers it

has been noted that enset is used as raw material to produce mat, rope and baskets locally. Enset leaves are also used for animal feed, wrapping and serve as a plate to put kocho porridge and bread.

Table 8. Average number of harvested Enset plants per year per households and distribution of households by storage time for all location

Zones	Number of harvested Enset plant year ⁻¹	Distribution of households by storage time (year)		
		<1 year	1 year	>1 year
Angacha	52	18	7	3
Domboya	50	14	10	4
Doyogena	44	20	7	1
Hadero-Tunto	56	22	6	0
Kachabira	46	21	6	1
Kedidagamela	43	19	6	3

In the foregoing discussion, enset processing is still a part of the house wife's work. Grater attention has therefore, to be given to reducing the work load through the introduction of simple but efficient mechanical enset processing equipment.

Several aspects of the total picture on enset utilization have been analyzed. There exist traditional regions specific patterns for utilization of enset (kelbesa, *et al.*, 1996). The nutritional benefit of Enset in the diet of the rural population of the regions has been widely recognized. However, substantial research and development has not been carried out in the enset growing areas of Ethiopia for processing of enset in order to facilitate wide consumption.

4.6. Threats and loss of enset clones

Farmers continue to face many risks because of enset's vulnerability to biotic and abiotic problems, and global climate change. Landraces which perform better under different biotic stress, and diverse agro-ecological conditions, and having multiple uses should be recommended to these subsistence

farm households in order to sustain their livelihoods. Almost all informants stated that the population of enset has declined in recent times both in abundance and in distribution. The factors purportedly responsible for this decline were both agriculture and natural (disease and pest and drought) (Table 9).

Almost all farmers' reported that Enset *Xanthomonas* wilt (EXW) had the greatest impact on enset production. Nearly 36% of farmers reported the existence of EXW in their fields (Table 9) Each respondent was able to name a significant number of vernacular names though not all landraces are planted and maintained in his or her backyard. Prior to the arrival of EXW, farmers in the region would have selected enset landraces for a number of traits. However; this disease causes complete death of the plant within weeks after the first symptoms and it has completely wiped out enset in some areas. The disease has forced farmers to abandon enset production resulting in critical food shortage in the densely populated areas of southern Ethiopia. It is now recognized as a national problem, having increased in severity

Table 9. Most frequently reported enset production constraints in the study area

<i>Major constraints in enset production</i>	<i>Reported by number of farmers</i>					
	Angacha	Demboya	Doyogena	Hadero-Tunto	Kachabira	Kedidagamela
Enset <i>Xanthomonas</i> Wilt	26	26	24	20	21	25
Leaf hopper	2		3	2	4	3
Porcupine	4	4	9	8	4	2
Swine	2	2	0	0	1	3
Corm rot	2	2	4	4	2	4
Drought	18	20	16	14	19	17

Plant diseases can also reduce the level of biodiversity or limit the variety of plants grown in an area. It has been observed that, the genetic base has been vulnerable to a range of very damaging biotic and abiotic stresses such as Enset Xanthomonas wilt (EXW), enset root mealy bug, leaf hopper, mole rat, Porcupine, wild pigs, corm rot, and drought. It is the EXW which has had the greatest impact on enset production. In Hadiya zone Lemu wereda 30% of enset crop affected by EXW (Zerihun *et al.*, 2015). Therefore, farmers are forced to develop their coping strategies and all surveyed farmers in the region practice cropping and dietary patterns change and grow more number of disease tolerant plants as a strategy for the management of the disease. For instance, Rao and Hodgkin (2002) indicated genetic diversity can be seen as a defense against problems caused by genetic vulnerability. To reduce the likelihood of spread, establishment and growth of EXW in enset crops, a systematic operational approach to the management of EXW should be adopted. This should include giving training to farmers on appropriate production practices, using healthy suckers and planting in clean soils. Future efforts surely need to focus on developing core collections representative of the widest possible genetic diversity for enset improvement and using this to strengthen *in situ* or on farm conservation.

5. Conclusion and Recommendation

5.1 Conclusion

The survey study was initiated with the main objectives of assessing the diversity of Enset in different woredas of Kembata Tembaro zone of SNNPRS which is inhabited by Kembata and Tembaro ethnic groups, based on quantitative and qualitative characteristics, and document the indigenous knowledge of farmers from these zones on classification, cultivation and utilization of enset. A farm level survey was conducted that covered one hundred sixty eight households from the six selected woredas of Kembata Tembaro zone, from April 2016 to July 2016. The main outcome of this study is concluded as follows.

There is no adequate information on the clonal variations in enset clones. The attempts made so far to document the indigenous knowledge related to the use and management of the crop is minimal. Zerihun *et al.*, (2014) studied the indigenous multiplication and production practices of enset in Kembata Tembaro zone, in southern Ethiopia. Areka Agricultural Research Centre and the Ethiopian Biodiversity Institute (EBI) have made collection expeditions to sample the diversity of enset is found at farmer's field few years ago.

Farmers' have been growing enset for many years. The farmers' knowledge and enset have been coevolving together. This has resulted in the prevalence of rich indigenous knowledge of the farmers.

The study looked at the use and management practices, and factors affecting the production of enset growing in Kembata Tembaro zone. Enset Bacterial Wilt disease and drought are major problems affecting the production of enset in the zone. Farmers also blamed the current extension system for not giving adequate attention to the cultivation of enset and according to

them this had also contributed much to the current decline in the production. They confirmed that the cultivation of enset is laborious, and to some extent was a reason for the current reduction in production. Despite this, farmers are maintaining some diversity of the crop and are making efforts to sustain the cultivation. For this diversity farmers' selection and traditional knowledge have played a great role. Maintaining the knowledge of the available diversity is therefore, essential for effective management of the existing diversity. Moreover, the use and maintenance of the different clones by farmers in the study area can also be seen as an adaptation strategy for meeting various objectives.

The result from surveyed area indicated that each woreda is characterized by very high enset diversity.

Landrace diversity in the study area is affected by a number of factors. EXW is the main factor limiting enset richness and diversity. Any attempt to improve enset has to give emphasis on enhancement of farmers' varieties and a systematic operational approach to the management of EXW.

The sampled households varied considerably in endowments, demographic and geographic factors. Generally, there were neither any differences between woredas, KAs, nor among villages regarding the management and use of enset.

5.2. Recommendation

Based on the result of this study the following points are recommended.

- The existing farmers' naming and classification be complemented with morphological, biochemical and molecular marker study and maintenance of the creative dynamics of traditional knowledge and transmission of the knowledge are crucial for constructing sustainable management and sustainable use.
- Landrace diversity in the surveyed woredas are affected by a number of factors. From these one of the main factor is enset xanthomonas wilt which is limiting enset richness and diversity. So any responsible person needs to be aware to control this enset xanthomonas wilt disease, so as to increase the richness and diversity.
- To be aware of farmer' have been cultivating, conserving, maintaining and developing diversity of enset varieties in their farming systems which is contribute to existence of enset plant richness and abundance in the zone.

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7. Appendices

Appendix 1. Number of clones per farm (richness) in the six woreda

Farm	Name of surveyed woredas and number of clones per farm					
	Domboya	Kachabira	Kedida Gamela	Angacha	Doyogena	Hadero-Tunto
1	5	12	5	8	7	6
2	2	12	8	6	13	8
3	10	3	5	10	13	6
4	4	4	5	10	8	5
5	7	6	7	6	3	5
6	5	6	5	8	9	4
7	6	4	6	6	4	5
8	6	5	5	8	9	7
9	3	5	12	6	10	6
10	3	3	9	7	6	4
11	4	3	3	8	6	4
12	4	3	6	5	10	5
13	3	5	5	6	5	7
14	5	6	5	8	7	4
15	5	8	12	13	12	8
16	6	8	1	10	7	7
17	4	10	9	7	6	5
18	7	4	5	6	3	4
19	5	6	6	7	10	5
20	4	4	4	5	7	6
21	4	4	6	9	6	4
22	5	5	4	8	3	5
23	3	5	10	6	4	3
24	5	6	4	8	7	4
25	4	3	4	5	13	5
26	4	3	6	4	13	4
27	2	5	6	5	2	5
28	3	5	5	5	4	5

Appendix 2. List of named clones in the six woredas, Diversity of the clones and richness of the woredas

No.	Clone	Demboya	Kachabira	Doyogena	Kedida Gamella	Angacha	Hedaro Tunito	TOT	Total woreda
1	Abet merza	2		2			1	5	3
2	Astera	1		1	2			4	3
3	Bishato	7	16	1	9		4	37	5
4	Chirkone	1						1	1
5	Dego	3	2	8	3	9		25	5
6	Dirbo	20	26	3	19	11	15	94	6
7	Disho	2	1	3		5	2	13	5
8	Fechanche	1		1		3		5	3
9	Gembo	2	4	6	2	12	16	42	6
10	Gishra	7	13	9	16	10	8	63	6
11	Godorot	2			6		1	9	3
12	Hele	3	16		2	5		26	4
13	Kekile	2		3	3	2	3	13	5
14	Lekake	1	1	11	5	5	9	32	6
15	Mendiluka	9	3		1			13	3
16	Merza	6		16		7	3	32	4
17	Mesmesa	1			1	4		6	3
18	Metinche	3					1	4	2
19	Odole	3						3	1
20	Sebere	7	3	1	19	4	7	41	6
21	Sheleke	3	3	10	3	5	1	25	6
22	Siskela	14	7	25	11	16	14	87	6
23	Tebere	3		3	8	7	6	27	5
24	Torore	2	3	9	1	5	2	22	6
25	Ungeme	17		5	6	5	7	40	5
26	Wankorotita	2	2					4	2
27	Woea	2			9	2	1	14	4
28	Woshemeda	2		3		4		9	3
29	Agene		1			6	1	8	3
30	Arkita		10				2	12	2
31	Bunech		1					1	1
32	Cherkwa		11	3	4	4	1	23	5
33	Gerigeda		4					4	1
34	Gomorsa		1				5	6	2
35	Gonomora		1		3	3		7	3
36	Hankogena		1				3	4	2
37	Hedere		1					1	1
38	Kesete		1				1	2	2
39	Qoyna		6	4		5	2	17	4

Appendix 3. List of named clones in the six woredas, Diversity of the clones and richness of the woredas

40	Meriya		2	9		7	3	21	4	
41	Moche		3	5	4	7	2	21	5	
42	Oniya		11	3	4			18	3	
43	Sirera		2					2	1	
44	Suki		1				1	2	2	
45	Terseke		4					4	1	
46	Usgurezo		1	3	2	3	1	10	5	
47	Waleme		3		3		1	7	3	
48	Wolanche		11	4	7		2	24	4	
49	Argemu			1			1	2	2	
50	Ashuru			9				9	1	
51	Banku			4				4	1	
52	Dereketa			1				1	1	
53	Etnete			16	1		5	1	23	4
54	Gewada			11					11	1
55	Ginewa			1					1	1
56	Lukande			1			1		2	2
57	Sinara			2					2	1
58	Sorpe			4	13		5	2	24	4
59	Tessa			1	2		6	1	10	4
60	Wachiso			3				4	7	2
61	Wakebere			1					1	1
62	Yebule			2					2	1
63	Henwa			1			3		4	2
64	Ayaset				1				1	1
65	Lembo				1				1	1
66	Genu				1				1	1
67	Horbe				2				2	1
68	Gonorsa				1				1	1
69	Kerkere				1		2		3	2
70	Menera				4				4	1
71	Shelekuma				7				7	1
72	Tefelege				1				1	1
73	Wolande				1				1	1
74	Wonadiya				2			1	3	2
75	Gagabo						2		2	1
76	Gote						5	1	6	2
77	Lisho						3	1	4	2
78	Shododona						1		1	1
79	Wolegela						4		4	1
80	Tuzuma							4	4	1

3. Enset characterization and production

3.1. How many Enset plants do you have on the Enset area?

3.2. Age structure of Enset plantation (proportion)

1. Suckers % 2. New transplants % 3. Medium (2-3 years) % 4. Matured (4-7 years) %

3.3. What is your primary objective of Enset production?

1. Food 2. Cash income 3. Medicinal 4. Other (specify)

3.4. Do you believe that Enset is more important than other crops to secure food supply throughout the year?

1. Yes 2. No

Why _____

3.5. Do you think that Enset is more important than other crops to generate cash income?

1. Yes 2. No

3.6. Do you prefer Enset foods than others? 1. Yes 2. No

Why _____

3.7. Do you perceive that Enset is more important than other crops to minimize risk of crop failure?

1. Yes 2. No

Why _____

3.8. List types of Enset clones grown on your farm and purpose of growing/their special characters

		Character							
No.	Enset clone	Plant vigor Poor=1, medium= 2, high =3	Maturity Early=1 intermediate =2 late=3	kocho yield Low=1 medium= 2 high=3	Bulla Not good=1 good=2 intermediate=3	Amicho use Not used=1 used=2	Fiber quality Low=1 Medium=2 high=3	Medicinal value Not used=1 used=2	Disease response Susceptible=1 intermediate=2 tolerant=3

3.9. Do you use different criteria for characterization of Enset clones? 1. Yes 2. No

3.10. If your answer is yes, what are the Criteria for selection of Enset clones

Clones selection criteria	Rank of criteria

3.11. Do you use plant part for clone’s identification? 1. Yes 2. No

3.12. If your answer is yes, what part of the clones are used for identification purpose, mention the part of the clone. A. _____ B. _____ C. _____
 D. _____ E. _____

3.13. Trend of Enset production in terms of area

Period	Trend*	Reason (major events) i.e., disease, drought, hunger, replaced by other crops, etc...
Before Derg		
During Derg regime		
Current period		

*1. Increasing, 2. Decreasing, 3. No change

3.14. Clonal changes

Enset clone no more under production	Reason for loss	Enset clone newly acquired	Reason for acquisition	Source of new clone

3.15. Trend of change in number of Enset clones cultivated during the last 20 years

1. Increasing 2. Decreasing 3. no change

3.16. If decreasing, reasons for decrease:

3.17. If increasing, reasons for increase:

3.18. Do you want to acquire additional clones? 1. Yes 2. No

3.19. If yes, what are the reasons for needing each clone?

Enset clone needed	Reason

3.20. Planting pattern 1. Dense planting 2. Row planting

3.21. Enset propagation and transplanting

Time of propagation	Method of propagation	Age of transplanting	Time of transplanting	Frequency of transplanting

3.22. If you have more than one time transplant, what are the reasons?

3.23. Do you practice leaf pruning? 1. Yes 2. No

Type of leaf	Time of pruning	Purpose	Advantage	Disadvantage

3.24. If your answer is yes, which part of the leaf is pruned?

3.25. Enset planting time and method of transplanting

Enset stage	Planting method 1. Row 2. Random	Stage duration	Spacing

3.26. Time and method of land preparation for different stages

Enset stage	Time of land preparation	Method of land preparation (oxen plow, hand hoe, etc.)	Remark

3.27. Fertilizer application

Enset stage	Fertilizer type 1. Manure 2. DAP 3. Urea	Time of application (months)	Frequency and rate of application	Method of application 1. Broad cast 2. Ring 3. Side/heaping 4. Other, specify

3.28. Enset weeding

Enset stage	Time of weeding (Month)	Frequency of weeding in a year

3.29. Enset diseases and pests

Name of disease/pest	Causal agent	Stage of Enset attack	Parts of Enset attack	Tolerant clones	Susceptible clones	Favorable season	Latest time of occurrence	Control measures

3.30. What do you do with the plants affected by bacterial wilt?

1. Rog out 2. Process 3. Do nothing 4. Other (specify)

3.31. Did you get training/extension advice on how to control Enset diseases or pest? 1. Yes
2. No

3.32. If yes, from where did you get training/advice?
1. BOA 2. Research center 3. NGO (specify) 4. other (Specify)

3.33.. Enset harvesting

Age of Enset harvesting	Purpose of harvesting 1. Amicho 2. Kocho 3. Kocho and bulla	Frequency of harvesting per year	Number of Enset plants harvested per year
Matured Enset plants (4-7 years)			
Unmatured Enset plants (2-3 years)			
Unmatured enste plants (<2 years)			

3.34. Kocho yield in local units from matured Enset plant

3.35. Do you have improved Enset-processing devices?

1. Yes 2. No

3.36. If yes, what type? 1. Kocho decorticator 2. Bula extractor 3. Corm chopper

3.37. Gender role in Enset production and processing

Operation	Who is responsible
Planting and field management	
Decorticating	
Bulla extraction	
Corm chopping	
Digging pit	
Uprooting Enset	

3.38. How long does it take to ferment kocho to make it ready for consumption?

1. Less than two weeks 2. Two to four weeks 3. one to two months 4. More than two months

3.39. Do you store kocho? 1. Yes 2. No

3.40. If yes, what method of storage do you use?

1. Underground storage (pit storage) 2. Wrapping with Enset leaves and mid ribs and storing within home 3. Other (specify)

3.41. For how long do you store fermented kocho?

1. Less than one month 2. 1 to 2 months 3. 2 to 6 months 4. 7 to 12 months 5. More than one year

3.42. Kocho management during storage

Activity	Time interval
Changing wrapping leaves	
Changing storage pit	

Declaration

I declare that the thesis hereby submitted by me for the Masters Degree in Biology to the School of Graduate Studies of Addis Ababa University is my own independent work and has not previously been submitted by me or anybody else at another university. The materials Obtained from other sources have been duly acknowledged in the dissertation.

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