LANDRACES DIVERSITY, POTENTIAL CHALLENGES AND A TRADITION OF CONSERVATION OF *ENSETE VENTRICOSUM* IN ENEMORINA EANER WOREDA, SOUTHERN ETHIOPIA

Selamawit Fikadu[1], Melesse Maryo[2*] and Zerihun Girma[3]

[1]Department of Natural Resource Management, Wolkite University, P.O. Box 07, Wolkite, Ethiopia.

[2]Ethiopia Biodiversity Institute; P.O. Box 30726, Addis Ababa Ethiopia.

[3]Department of Wildlife and Eco-tourism, Hawassa University, P.O. Box 5, Hawassa, Ethiopia.

ABSTRACT: Enset is a multipurpose crop that supports the livelihood of over 20 million people in Ethiopia. This study was aimed to assess the diversity and challenges of enset landraces in Enemorina Eaner Woreda. Six rural *kebeles* were purposively selected for the study based on their enset cultivation potential. A stratified and systematic sampling methods were used to select a total of 364 farmers for the household survey. Data were obtained through households and key informants' interviews, focus group discussions, and field observation. Shannon diversity indices and both descriptive and inferential statistical means were used to analyze the data. A total of 50 enset landraces were identified, of which 11 had medicinal importance. Enset occupied about 17% of the cropland area share in the Woreda, whereas the mean Shannon diversity and evenness indices were 2.61 and 0.78, respectively. The diversity of landraces among households was found to be significantly different ($P<0.000$) among agro-climatic zones as well as wealth groups. Wild animal pests, enset bacterial wilt, introduction of commercial crops, and labour constraints were identified as major challenges to the sustainability of enset production and landrace diversity. Furthermore, eucalyptus plantations occupied about 24% of the major cropland area share, posing a threat to enset sustainability. The establishment of an appropriate land use policy at national level, and effective collaboration of the local community, government, and academia in searching for technologies to are recommended to alleviate the observed threats and establishment of in-situ conservation sites at different agroclimatic areas of the country.

Keywords: Distribution, Diversity, Enemorina Eaner, Enset, Enset landraces.

INTRODUCTION

Enset (*Ensete ventricosum* (Welw.), Cheesman) is a multipurpose, perennial, herbaceous and monocarpic crop belonging to the family Musaceae (Cheesman, 1947). According to Brandt et al. (1997), enset supports the livelihood of more than 20% of Ethiopia's population though some succeeding researchers (Fetene and Yemata, 2018; Mengesha et al., 2022) have discussed that enset supports more than 20 million people with

*Corresponding author: melessedevid@gmail.com

its significant role in food security in the south and southwestern parts of Ethiopia. The ethnobotanical information on intraspecific enset diversity and community knowledge on farmers' use and management is crucial for enset conservation and sustainable use (Mengesha et al., 2022). It was reported that the agricultural systems in southern Ethiopia maintain a greater level of enset intra-specific diversity than any other crop species (Olango et al., 2014). Enset farmers' varieties or landraces have a great range of genetic and phenotypic variations (Yemataw et al., 2012). Farmers' rich knowledge of enset, accumulated over years, plays a significant role in the characterization and maintenance of the existing genetic diversity. Enset growers can distinguish one enset variety from the other phenotypically by examining the leaf orientation, color of petiole and midrib, size, circumference, and length of pseudostem (Shumbulo et al., 2012; Yemataw et al., 2014; Maryo et al., 2018).

Ensete ventricosum is distributed as a wild form in the central and eastern Africa including Congo, Mozambique, Uganda, Tanzania and Zambia (Brandt, 1996). In Ethiopia, wild *E. ventricosum* is mainly found in Kaffa Zone, some area along the Omo river, and in Gamo Gofa Zone (Birmeta et al., 2004) as well as in Sheka forest (Garedew et al., 2017). Enset is distributed at altitudes between 1200 -1600 m.a.s.l., and propagated naturally by seed (Brandt and Vorobyev, 1997). *Ensete ventricosum* is cultivated only in Ethiopia (Tsegaye, 2002), occurring in the south and southwest Ethiopia (Tsegaye and Struik, 2002; Maryo et al., 2018). The domesticated enset is distributed at altitudes between 1500-3100 m.a.s.l. (Tekalign and Suneetha, 2012) and performs best at elevations of 2000-2750 m.a.s.l. (Brandt and Vorobyev, 1997), and predominantly reproduce vegetatively (Negash et al., 2002).

In Ethiopia, research on enset started in the 1970s and the major activities were clone collection, evaluation of the food and fiber values of the crop and agronomic traits, and maintenance of germplasm (Fetene and Yemata, 2018). A total of 163 enset farmers' varieties were collected initially, of which 103 and 60 were established at Holeta and Bishoftu, respectively. In 1986 a field gene bank was established at Areka Agricultural Research Center, Wolaita Zone, to conserve the diversity of enset landrace. Currently, a total

of 623 distinct enset farmers' varieties sampled from 12 major enset growing areas of Ethiopia are maintained in the center (Yemataw et al., 2017). More than 170 enset landraces have been conserved currently under the ex-situ system at Angacha center by the Ethiopian Biodiversity Institution (Personal observation and communication by the corresponding author).

Different researchers have reported different numbers of enset landraces based on morphological characterization from various enset growing areas in Ethiopia, which indeed was aided by local farmers, which include, 76 enset landraces by Shigeta (1990) from South Omo, 146 by Negash et al. (2002) from Hadiya, Keffa-Sheka, Sidama, and Wolaita; 312 by Yemataw et al. (2016) from eight enset growing Zones, 111 by Maryo et al. (2018) from Kembatta-Tembaro, and 34 by Mengesha et al. (2022) from Guji Zone .

All parts of *E. ventricosum* are utilized for various purposes. It is used for human food, animal forage, and traditional medicine. The major foods from enset are *Kocho* and *Bulla*, acquired from pseudostem and leaf petioles (Tsehaye and Kebebew, 2006) while *Amicho* is obtained from the underground corm (Yemataw et al., 2014; Maryo et al., 2018). Enset is the major food and revenue source in the highly populated southern and south-western parts of Ethiopia. The high yield per unit area linked with its ability to endure drought makes it an ideal and strategic crop for the inhabitants (Shumbulo et al., 2012). However, the sustainability of enset cultivation, enset diversity, and productivity are threatened by factors such as enset bacterial wilt (Shumbulo et al., 2012; Ayele and Sahu, 2014; Maryo et al., 2018), wild animal pests, such as porcupine and mole rat (Maryo et al., 2018), degradation of the soil (Bayu, 2016), cash-oriented crop production trends (Negash, 2001; Maryo et al., 2018), as well as poor post-harvest technology (Tekalign and Suneetha, 2012). The Gurage zone is one of the major enset production areas in the Southern Nations and Nationalities People Region (SNNPR) (Shank, 1996). Studies conducted from Kebena, Cheha and Ezha woredas (Mojo, 2017) and Gedebano Gutazer Welene woreda of Gurage Zone (Nudego, 2016) revealed that enset landrace diversity in these localities is under serious problems. In Enemorina Eaner woreda, enset is extensively cultivated for environmental, social, economic and medicinal benefits. From enset producing areas, data on

area share of enset plantation and its current status is required in order to make decisions related to conservation. In the current study area, enset is the major food crop. Like any other densely populated enset farming areas, the crop suffers from pests, diseases, lack of labor power, fragmentation of land and other similar factors (Maryo et al., 2018). Similarly, the diversity, distribution, uses, challenges, and management practices of the local communities on enset production have not been studied exhaustively and were poorly documented. Therefore, the objective of this study was to examine the enset landrace diversity, challenges, and the cultural management practices of enset in the study woreda.

MATERIALS AND METHODS

Description of the study area

The study area, Enemorina Eaner, is one of the woredas in the SNNPR, located between 7° 58′ N to 8° 6′ N latitude and 37° 45′ E to 37° 56′ E longitude (Figure 1). Its altitude ranges from 800 to 3400 m.a.s.l with bi-modal rainfall distribution (short rain from January to April and the main rain from June to September) and an average annual rainfall of 1100.5 mm. The average minimum and maximum temperature are 13°C and 25°C, respectively (EEWFEDO, 2019). The woreda has a population of 168, 183 (49% men and 51% women), and over 85% of the people live in the rural area. The average population density was 200 per km^2. The total land area of the woreda is 107,584 hectares, of which *Woyna-Dega* (mid-highland) is 57.3%, *Kola* (low land) 26.88%, and *Dega* (highland) 15.82 %. The major soil types are clay (26%), sandy (16%), and silts (58%). Agriculture is the dominant economic activity in the woreda; crop production is the leading means of livelihood supplemented by livestock production. The major crops of the study area are enset (49.89%), coffee (23.01%), ch'at (6.2%), and fruit crops (6.05%). The dominant livestock types are cattle, sheep, poultry, and goat (EEWFEDO, 2018).

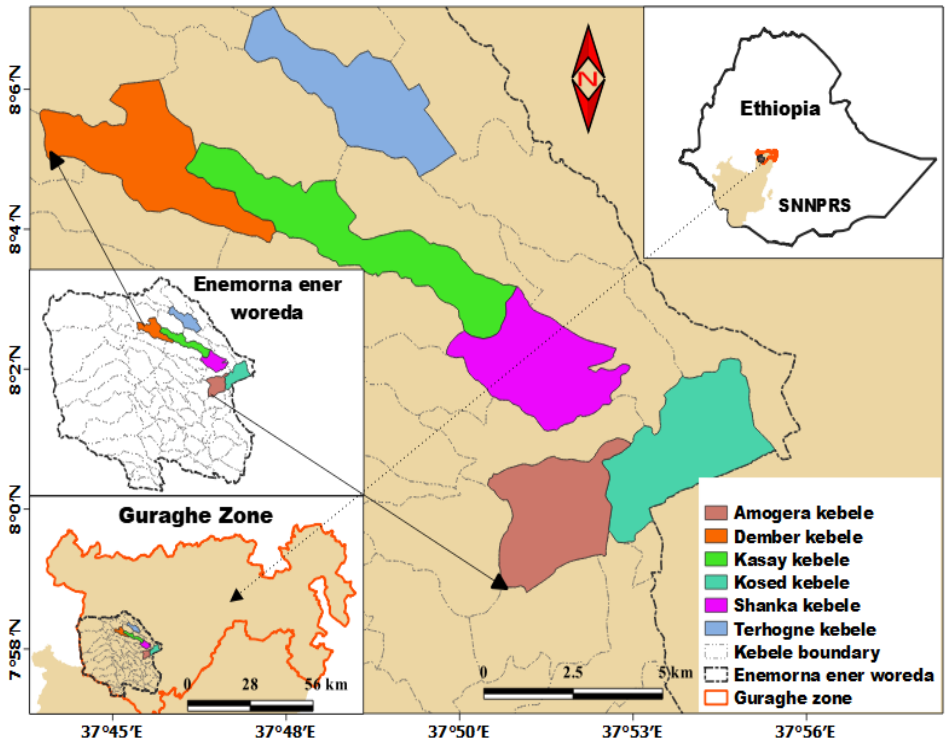

Figure 1. Location map of the study area.

Study sites and sample size

A reconnaissance survey was conducted from October 2019 to November 2019 in Enemorina Eaner woreda (district) of the Gurage zone. The woreda consists of 42 *Kebele*s (the lowest administration level in Ethiopia) that grow enset though they vary in the quantity of land size and landrace diversity. Six *Kebele*s were selected purposively based on enset cultivation potential and diverse agro-climatic zones (*Dega, Woyna-Dega*, and *Kola*). Two k*ebele*s were considered from each zone for the study.

The total sample size was determined through a stratified sampling technique, based on different agroclimatic zones and the socioeconomic background of the households. Accordingly, a total of 364 (287 males and 77 females) households (HH) were selected at 95% confidence level and acceptable sampling error (e=5%) using a simplified formula provided by Taro and Israel (1992). Three hundred thirty-four household respondents were selected using simple random sampling through the lottery method. However,

30 key informants' selection was done based on the snowball method with the help of knowledgeable farmers, *Kebele* leaders, and developmental agents.

Data collection

Data were collected through household interviews, key informants' interviews, focus group discussions, and field observation. From December 2019 to May 2020 364 household surveys were conducted. The use, challenges (such as pests and socioeconomic), and cultural management practices were recorded with the help of farmers. Since there was no clear and common identification technique for the identification of enset landraces (Elias, 2003; Maryo et al., 2018), this study utilized traditional method used by farmers. Farmers identify enset landraces just by looking at the colors of the midrib, petiole color, leaf color, leaf orientation and circumference, and length of pseudostem (Olango et al., 2014; Yemataw et al., 2014). The data collection was conducted primarily through individual interviews direct on-farm participatory observation, and key informant and focus group discussions. The participants were at the age range of 20-90 years old. Data about the wealth status of the farmers was collected with the help of key informants, *Kebele* leaders, and development agents based on the context of the local farmland size, the number of livestock owned, diversity of enset landraces, amount of crop production (enset, coffee, and ch'at area) and eucalyptus tree coverage.

Field observation was carried out to identify enset farmers' varieties, traditional management practices and challenges. Finally, five key informant groups with six members in each group and six focus groups with eight members in each group were consulted and the information was used to triangulate data collected from the households' interviews.

Data Analysis

Data were analyzed and summarized using descriptive statistics such as percentages, pie charts, and bar graphs using Microsoft excel 2010 and SPSS version 20.0 for ANOVA test. To analyze the enset diversity,

the Shannon-Weaver diversity (H') and Evenness measure (E) indices were employed following Magurran (2004). Accordingly, Shannon diversity index was calculated using the formula,

$$H'=-\sum_{i=1}^{S} Pi \ln Pi$$

where, H′ *is* the Shannon diversity index, pi is the proportion enset landraces composed of species and ln is a natural logarithm. Shannon evenness is calculated as the ratio of H' to maximum diversity (Hmax),

$$E = \frac{H\prime}{H'\max}, = \frac{H\prime}{lnS}$$

where, S= number of species and ln is a natural logarithm.

ANOVA test was conducted to examine any significant differences in enset farmers' varieties among farmers groups of different wealth status and the different agro-climatic zones.

RESULTS

Characteristics of the study group

Table 1 describes the characteristics of the study population and depicts that about half of the respondents lack the skill to read and write. About 79% of the respondents were male and the majority of the respondents (42%) belong to the 36-50 age groups, where > 96% were married. About 60% of the households (HHs) own a land ranging in size from 0.25 to1 hectare (ha). However, the enset planted area of most (>84%) of the respondents ranged between 0.25 and 1 ha. On the other hand, about 41% of the respondents confirmed that there were 5-10 enset landraces/HH.

Table 1. Characteristics of the study population.

Characteristics	Number of households	Percentage (%)
1. Age		
20-35	60	16.5
36–50	153	42.03
51–75	142	39.01
>75	9	2.5
2. Sex		
Male	287	78.9
Female	77	21.2
3. Educational status		
Cannot read and write	**173**	**47.5**
Read and write	83	22.8
Grade 1-4	26	7.1
Grade 5-8	68	18.7
Grade >9	*14*	*3.9*
4. Total land size in		
0.25-1	213	58.51
1_2	102	28.02
>2	49	13.45
5. Enset land size (ha)		
0.25-1	307	84.34
>1	57	15.66
6. No. of enset landraces		
< 5	98	26.92
5–10	148	40.65
11–15	81	22.25
>15	37	10.16

According to respondents, out of the land share of major crops, that of enset accounts for about 17%, followed by ch'at and coffee at 15 and 12%, respectively (Table 2). However, there is a tendency of the eucalyptus tree to occupy the greatest share of cropland, where about 24% of the study area of the cropland was occupied by eucalyptus tree, which is also considered as potential income generating plant in the area.

Table 2. Area share of enset Vs other agricultural crops and tree plantation.

Crop/tree type	Area in hectare	Percentage (%)
Enset	74.52	16.55
Wheat	19.75	4.39
Food barley	14.25	3.16
Teff	35.87	7.97
Maize	33.62	7.47
Potato	25.87	5.74
Avocado	14.54	3.23
Banana	0.403	0.09
Orange	0.146	0.03
Chat	67.79	15.05
Coffee	56.42	12.53
Eucalypts tree	107.15	23.79
Total	450.329	100

Diversity of enset farmers' varieties

In the current study, a total of 50 enset landraces were recorded based on farmers' local system of identification and classification (Annex I). The mean Shannon diversity (H') and evenness (E) indices were 2.61 and 0.78, respectively (Table 3). Table 3 also indicated that as enset land size increases, the enset landrace diversity and evenness also increases with altitude. Accordingly, high landrace richness and evenness were exhibited for Kosed *Kebele* (high altitude area) whereas landrace richness and evenness values were determined to be low at Dember *Kebele* (lower altitude area).

Table 3. The areas share of enset, mean number of enset landraces, Shannon (H') and the Evenness (E) values across the study *Kebeles.*

***Kebele*s**	**Altitude**	**Area share**	**Richness**	**Mean**	**Std.Dv**	**H'**	**Std.Dv**	**Evenness**
Kosed	2435	**0.35**	41(24.26)	**12.2**	4.51	**3.41**	0.074	**0.92**
Amogera	2290	0.20	32(18.93)	9.61	4.41	2.98	0.07	0.85
Shanka	2101	0.24	32(18.93)	5.56	2.84	2.79	0.081	0.8
Kasay	2018	0.23	37(21.89)	8.72	3.75	2.87	0.081	0.77
Dember	1762	0.1	15(8.88)	**3.98**	1.87	**1.77**	0.111	**0.64**
Terhogne	**1864**	0.08	12(7.1)	4.08	0.98	1.84	0.121	0.72
Average	2078	0.2	28.16	7.6	4.545	**2.61**	**0.089**	**0.78**

Note: Dega-agro climate =Kosed & Amogera, Woyna-Dega = Shanka & Kasay and Kola = Dember & Terhoghe

In *Dega* agro-climatic zones, higher numbers of enset landraces (mean=10.69 ± 0.365) were cultivated, while fewer enset landraces (mean=6.91) and (mean=4.04) were cultivated in *Woyna-Dega* and *Kola* agro-

climatic zones respectively. Based on the wealth-based grouping, a large number of enset landraces (11.72 ± 1.181) were obtained from the rich households, whereas it was the lowest (5.07 ± 0.295) among poor households (Table 4). However, the mean number of enset landraces in the study area was 7.6 ± 0.63. The number of enset landraces in each household exhibited significant difference (P<0.000) at 0.01 significant levels among agro-climatic zones as well as wealth groups (Table 5).

Table 4. Wealth status ranking of the study HHs across the three agroclimatic zones (N = 364).

Wealth Status	**Farmland Area (ha)**	**Enset Area (ha)**	**Coffee area (ha)**	**Ch'at Area (ha)**	**Eucalypts Tree area (ha)**	**No. of live stock**	**No. of enset farmers' varieties**			**mean**	**StD**
							Dega	***Woyna-Dega***	***Kola***		
Poor	0.711	0.079	0.083	0.069	0.171	1.717	9.4	3.99	3.91	5.07	0.295
Medium	1.276	0.241	0.167	0.207	0.267	3.577	10.59	7.18	4.09	8.18	0.4
Rich	2.939	0.351	0.318	0.442	1.04	10.957	12.43	8.67	6.00	11.72	1.18
Mean	1.237	0.204	0.154	0.186	0.294	3.57	**10.69**	**6.91**	**4.04**	**7.6**	**0.63**

The tropical livestock unit (TLU) is commonly taken to be an animal of 250 kg live weight. TLU conversion factors constitute a compromise between different common practices. 1 TLU = 250kg. Accordingly, Bull = 1.1, calves = 0.2, Chickens = 0.01, Cows (cross) = 1.2, Cows (local) = 0.8, Donkeys = 0.5, Goats/ sheep = 0.1, Heifers = 0.5, Horses/mule = 0.8, and Immature males 0.6.

Table 5. The diversity of enset landraces among agro-climatic zones and wealth groups.

Source of variation of enset farmers' varieties	Sum of Squares	df	Mean Square	F-value	P-value
Between agro-climatic areas	2741.393	2	1370.697	112.218	0.000
Within agro-climatic areas	4409.453	361	12.215		
Total agro-climatic areas	7150.846	363			
Between wealth groups	1138.005	2	569.003	34.162	0.000
Within wealth groups	6012.841	361	16.656		
Total wealth groups	7150.846	363			

Frequency of the distribution of dominant enset landraces across the agro-climatic zones

The study showed that there were many differences between enset landrace distributions across agro-climatic zones. In *Dega* agro-climatic zones the widely distributed enset farmers' varieties were *Agade*, *Nechiwe*, *Amerad*, *Lemare*, *Quashqashiye*, *Guarye* and *Sapara*, while in *Woyna-Dega* agro-climatic zones the widely distributed enset landraces were *Amerad*, *Sapara*, and *Eshirafriye*. In *Kola* agro-climatic zone

Eshirafriye and *Badaded* were widely distributed. The most cultivated enset farmers' varieties in the study areas are *Agade, Nechiwe, Eshirafriye,* and *Amerada* (Table 6). According to the respondents the wider availability of the aforementioned enset landraces in the study areas is due to their resistance to disease and drought.

Table 6. Most widely cultivated enset landraces /farmers' varieties in Enemorina Eaner woreda.

No.	Landrace Name	No. of respondents (N=364)	Percentage (%)	Distribution of enset landraces		
				Dega	*Woyna-*	*Kola*
1	*Agade*	245	67.3	√√√	√√	√
2	*Nechiwe*	224	61.5	√√√	√√	√√
3	*Eshirafriye*	200	54.9	√	√√√	√√√
4	*Amerad*	194	53.3	√√√	√√√	√
5	*Sapara*	186	51.1	√√√	√√√	√
6	*Lemare*	172	47.25	√√√	√√	√
7	*Bazeriye*	156	42.9	√√	√√	√
8	*Guarye*	142	39.01	√√√	√√	√
9	*Quashiquashiye*	142	39.01	√√√	√	-
10	*Badaded*	129	35.43	√√	√√	√√√

√√√= high frequency; √√ = average frequency, and √= low frequency of landrace distribution across the agroclimatic area.

Uses of enset by local communities

The present survey's result showed that enset crop is used for food, feed, fiber production, and medicinal uses. The major food products of enset are *kocho* and *bulla,* and the quality of these products varied from landrace to landrace. For instance, enset landraces selected for *Kocho* in the order of quality were *Amerad, Eshirafriye, Bazeriye, Nechiwe, Agade, Gezwed, Fereziye, Shertiye, Buaeche, Keswe, Anikofiye, Mishrad, Eweredіye, Bosere, Zobir,* and *Yiregye*. About fifty percent of the respondents reported that *Amerad* is the best quality enset landrace for *Kocho* production, of which, 40% of the respondents reported *Agade* as the best enset landrace for high *Kocho* yield in the study area. Enset landraces selected for *Bulla* production in their order of preference include *Lemare, Gimbuwe, Gumbura, Badaded, Yiregye, Nechiwe,* and *Bazeriye*. Among these, 29% of the respondents indicated *Lemare* as the best enset farmers' variety for *Bulla* production across the three agro-climatic zones.

Enset landraces preferred for *Amicho* production in their order of importance were *Guarye, Kibnar, Egendiye, Astara, Gimbuwee, Bazeriye, Agade, Gezwed, Yiregye, Quashqashiye, Dereeye, Agorgurkanchuwe, Tereriye, Edemerti, Enba, Tedrader, Abakita, Tegaded,* and *Wonadiye*. According to the survey result, about 38% of respondents indicated *Guarye* as the best quality enset landrace for *Amicho* production. Most respondents (60%) showed the enset landraces *Agade, Eaneragade, Eshirafrye, Eweredіye, Fereziye, Guarye, Keswe, Kibnar, Kinbat, Leamare, Ousmair, Quashqashiye, Tedrader, Tereriye, Wonade,* and *Yiregye* were preferred by growers for fiber production.

Traditional medicinal use of enset

The present study revealed that different enset parts such as a corm, pseudostem, and leaf are used by growers for traditional medicinal purposes to treat human and livestock ailments. Accordingly, 11 enset landraces were reported for their traditional medicinal values (Table 7).

Table 7. Enset farmers' varieties used for traditional medicinal value.

Ailment type	Name of enset farmers' varieties	No. of respondents	Part used	Used for	
				Human	Livestock
Healing Bone fracture	*Astara,*	101	Corm	The corm is cooked and feed with milk	Feed raw
	Agade	87			
	Kibnar	102			
	Gaurye	142			
	Sapara	67			
	Tereriye	30			
Initiate milk production	*Astara*	69			
Wound healing	*Dereye*	44			
Hepatitis	*Edemert*	17			
For healing the abscess	*Tegadedi*	12			
Remove specific implanted foreign body	*Quashiquashiye*	141			
Antiparasitic effect	*Badaded*	84	All part	Not common	Feed raw

Five landraces (the corm) were used to treat bone fracture both in humans and his livestock. The corm of different landraces was mentioned to treat wound, hepatitis, and abscess (one for each case) both in human

and livestock. Two landraces (all plant parts) were mentioned to treat pathogens both in human and livestock whereas one enset landrace (the corm) was reported to initiate milk production in livestock.

Challenges associated with enset cultivation and maintaining landrace diversity

From the interactions made with farmers to obtain information on the cultivation status of enset and the number of landraces maintained at farm and landscape level, it was found that both the production of enset and the diversity of enset varieties showed a declining trend. Respondents described that wild pest, diseases, focus on short period growing cash crops, labor shortage, lack of modern technology for processing enset, climate change, and land scarcity as major challenges that influence the production of enset and growing diverse varietal forms in the study area. In terms of magnitude, the impact of wild animals is mentioned by the highest proportion of respondents (40%, n= 364) and that of various diseases, cited by the second highest proportion (30%, n= 364), indicating that these two factors are the leading challenges of enset diversity and its production in the study area (Figure 2).

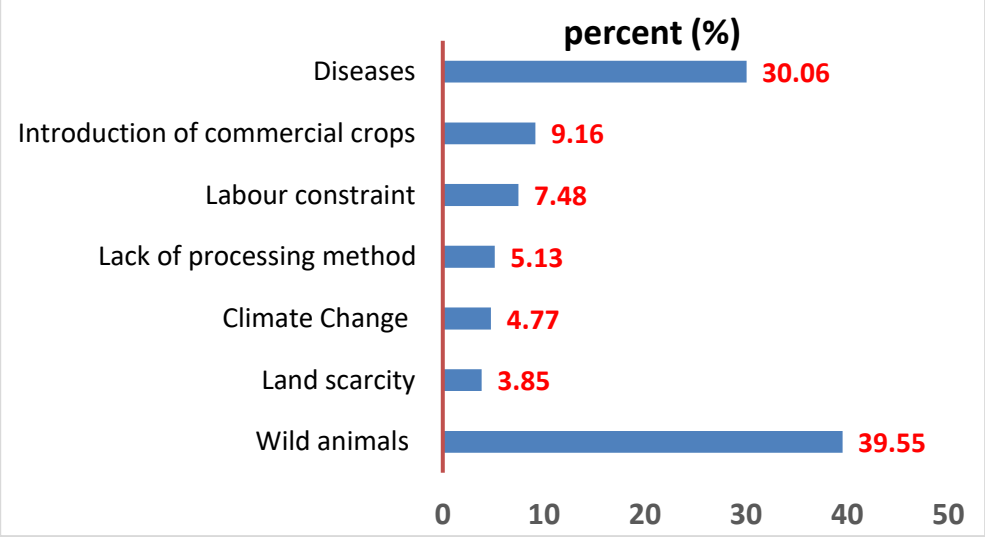

Figure 2. Major challenges of enset production in Enemorina Eaner woreda.

Among the enset pests and diseases, porcupine (30.85%), warthog (25.16%), enset bacterial wilt (18.67%), corm rot, locally called *Bure* (8.07%), wilting due to fungal and insects (9.65%) and zi-ire (sheath rot by fungi) (7.59%) were reported as major problems in the study areas. The majority of respondents (31%)

confirmed that porcupine causes a great loss to enset landraces (Figure 3), that are highly preferred for edible corm (e.g., *Sapara* and *Astara*) and landraces that have traditional medicinal values (e.g., Astara). As a result, farmers are forced to abandon the production of enset landraces that are socioeconomically important and highly susceptible to diverse diseases and pests. Warthog, and porcupine, from animal pest category, and enset bacterial wilt, corm rot (the mealybug), and *Ziire* (sheet rot), form the list of diseases which were described as problematic which pose a serious threat to the sustainability of enset landrace diversity. Enset bacterial wilt was reported as a major constraint in *Dega* agro-climatic zones as it was cited by a fair proportion of respondents (19%, n=364) while in *Woyna-Dega* and *Kolla* agro-climatic zones porcupine was mentioned to be a major challenge for enset production by about one-third of the respondents (31%, n= 364). Some enset landraces such as *Eshirafriye*, *Nechiwe*, *Lemare*, *Gumbura*, *Bazerye*, *Badaded*, and *Gezwod* were found to show either recovery after infection or were less affected by the disease.

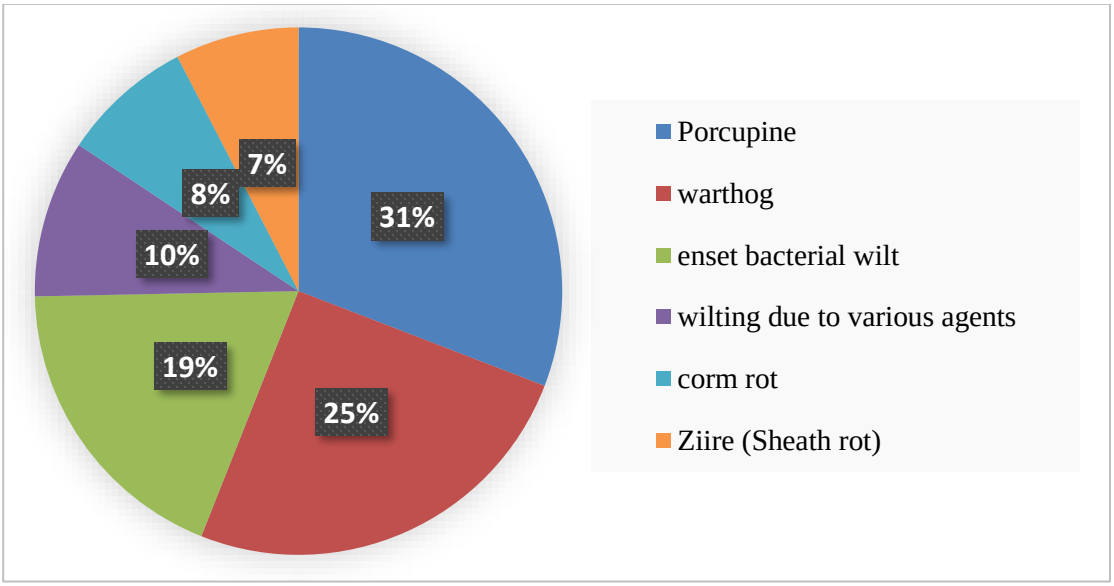

Figure 3. Major enset diseases and pest in the study area.

Local knowledge on the cultivation of enset and management of its diversity

The respondents reported that they differentiate enset landraces based on the use value (corm edibility, fiber, *Kocho* and bulla quality, etc.), color (leaf/petiole, midrib, and pseudostem), disease resistance, and fermentability. Nonetheless, the color of pseudostem was the dominant descriptor for identification. Almost

all informants agreed that planting material is obtained mainly from the three years old mother by distracting of the apical meristem of the corm. Enset is grown dominantly in the home garden. However, the local people intercrop enset crop with maize, coffee, cabbage, and other crops. Females' attachment to enset production is greater than the male's since they know the production nature of each enset landraces, the test of *Kocho* and *bulla*, fermentability, and the like. Accordingly, females are more knowledgeable and able to describe landraces better than males. About 73% of the respondents reported that they plow land three times before planting. The land preparation usually starts around October to December. Enset is propagated vegetatively using a corm of an immature plant. From December to March, farmers uproot 3 to 4 years old enset plant and cut off the pseudostem, remove the central growing bud, and rebury it covering with organic matter-rich porous soil (pit) so as to encourage the emergence of more than one sucker from the mother plant (after two to three months). Farmers in the study area transplant enset suckers (*Boshe*) from two to three times until their permanent fields are occupied. It is allowed to grow for one year, and then transplanted to the next stage called *Hiniba.* At this stage, the sucker is separated and planted in the individual hole called *Bekir* and allowed to grow for one to two years. Then, the most vigorous suckers will be transplanted into a permanent field as *Esed.*

Farmers practiced weeding by hand or with a sickle more frequently in earlier growth stages or during the rainy seasons (May-October). They used manure to fertilize the enset fields. Farmers use different local protection practices against pests and diseases to maintain the diversity, production, and health of enset landraces. These include fencing around the crop field, chasing the pest in a group of farmers organized at village level, capturing and killing the animal pest using traps, filling porcupine holes by soil, and sprinkling manure (usually the semi-solid form) around the enset stand.

DISCUSSION

The diversity and distribution of enset landraces

Farmers in the study area maintain a diverse range of enset local varieties on their home gardens for numerous reasons, mainly based on yield and quality of the products *Kocho, Bulla,* and *Amicho* and also for their traditional medicinal value, fiber quality, disease resistance, and low preference by wild animals. Since this finding is in agreement with previous reports (Olango et al.,2014; Yemataw et al., 2014; Maryo et al., 2018) it could be argued that the rational for maintenance of enset diversity by farmers across the country is related to its various use values.

Regarding intraspecific diversity, 50 different enset landraces were identified of which, the dominant landraces such as *Agade, Nechiwe, Eshirafriye, Ameradi, Sapara, Quashiquashiye,* and *Badaded* were widely distributed across-the agro-climatic regions. The dominance of these landraces across the agroclimatic areas of Gurage Zone was also reported by Mojo (2017), and such dominance could be linked with their resistance to disease and adaptation to local environmental situations. A similar study in Kembatta Tembaro zone (Maryo et al., 2018) also revealed the dominance and abundance of some enset landraces across agroclimatic areas; and this was interpreted in terms of the local varieties' resistance to various environmental conditions, including pests and diseases.

Comparison of the level of landrace richness of the study area (50) with other enset growing areas in SNNP showed that the diversity status is comparable with that reported for Aleta Chuko woreda in Sidama Zone (Seifu and Fitamo, 2016) and Offa woreda in Wolaita Zone (Shumbulo et al., 2012) since an equivalent number of landraces (55) was reported from each site. On the other hand, a lower number of landrace richness was reported from other studies; i.e. 42 landraces from Keffa Zone (Tsehaye and Kebebew, 2006), 42 landraces from Sidama zone (Abebe et al., 2010), and 33 landraces from three woredas of Gurage Zone (Mojo, 2017). This could be associated with the tradition of enset use for various purposes as well as its management practices and the variation of sample size among those studies. Furthermore, there were former

reports with high landraces diversity than the present study, and these include studies that yielded 67 landraces from Wolaita zone (Olango et al., 2014); 312 from Dawro, Gedeo, Gurage, Hadiya, Kembatta Tembaro, Sidama, Silte and Wolaita zones (Yemataw, et al., 2016); 111 from Kembatta Tembaro Zone (Maryo et al., 2018), and 93 from Yem special woreda (Zerfu et al., 2018). The variation in landrace diversity of enset among different localities might be associated with the variations in geographical locations, area coverage, and the sociocultural aspects of the local people.

In the present study, the number of enset landraces recorded ranged from 2 to 33/HH with the mean value determined being 7.6 ± 0.24. Accordingly, the maximum number of enset landraces per farm recorded from Kosed *Kebele* was 12, whereas the maximum altitude recorded was 2435 m.a.s.l. Furthermore, this *Kebele* exhibited the highest Shannon diversity (H'=3.4) and evenness (E=0.92) values showing the presence of a large diversity of enset landraces in this *kebele*. On the other hand, minimum number of landraces per farm (mean=3.98) was recorded from Dember *Kebele* with altitude of 1762 m.a.s.l, which exhibited the lowest landrace diversity (H'=1.77) and evenness (E=0.64) values, suggesting few numbers of enset farmers' varieties in this *Kebele*. The cultivation of fewer enset landraces in this *kebele* might be associated with the adaptation of the limited landraces to the environmental setting as well as low sociocultural dependence of the community on enset as a staple food in the lowland setting which favors cereal production (Maryo et al., 2018). In general, the mean values of enset Diversity (H') and Evenness (E) were found to be 2.61 and 0.78, respectively, and this is higher than previously reported (H'= 1.84 & E= 0.64) by Maryo et al (2018) from a study on Kembatta Tembaro Zone. The finding in this study therefore suggested a greater tendency by farmers to maintain diverse enset varieties with a fair abundance of each type.

As indicated in the result section, a significant difference in the diversity of enset landraces exists among agroclimatic areas ($P<0.001$). Furthermore, the result revealed a decreasing trend in the diversity of landraces as one goes from higher elevation to lower elevation areas. Therefore, the trend in the number of enset landraces across agro-climatic zones follows a similar pattern with what Maryo et al. (2018) reported

from an earlier study. The possible reason for this variation could be due to the differences in agro-climatic conditions in terms of temperature, moisture, soil fertility, cultural background, population pressure, and household assets (Tsegaye, 2002; Zeberga et al., 2014).

A highly significant difference ($P<0.001$), in the diversity of enset landraces among the wealth classes where the wealthy farmers grow twofold diverse enset varieties than that of the poor farmers was also observed. This finding is in agreement with a previous report by Tsegaye (2002) that stated the cultivation of enset on a large area is a sign of wealth among the community. The present study revealed that poor households possess a small plot of land and few livestock resources as a source of manures to fertilize their enset farms resulting in low landrace diversity in such farms. Similar findings have been reported by Shumbulo et al. (2012). Besides their low landholding size and lack of farm animals, poor farmers of the area are partly hired to serve as daily laborers on the farms of wealthy ones to fulfill their daily needs, and this might have favored the growing of diverse landraces by wealthy farmers as reported by Negash (2001) and (Jacobsen et al., 2018).

Uses of enset landrace

Enset is a multipurpose crop used as food for humans, fodder for livestock, traditional medicinal values, and fiber for the house construction material among others. The findings of this study agree with previous reports (Shigeta, 1990; Tsegaye and Struik, 2002; Olango et al., 2014; Maryo et al., 2018). The present study identified 11 enset landraces reported to have medicinal uses which is the largest reported so far from Gurage zone. In earlier studies from the zone, six landraces from Gedebano, Gutazer, Welene woredas (Nudego, 2016), and eight landraces from Kebena, Cheha, and Ezha woredas (Mojo, 2017) were reported to have medicinal uses. However, the reported enset landraces with medicinal values from Gurage zone is noticeably lower than the number of medicinal enset landraces (21) reported from Kembatta Tembaro zone (Maryo et al., 2018).

Challenges associated with enset production

The present study showed that major challenges for the diversity and production of enset in the study are wild animals and diseases. Porcupine is the leading enset pest followed by warthog. Porcupine causes the greatest damage on those enset farmers' varieties such as, *Astara*, *Kibnar*, and *Guarye*, that are highly preferable for their traditional medicinal values and edible corm. Similar results were reported by Negash (2001), Zeberga et al. (2014), Bayu (2016), Nudego (2016) and Maryo et al. (2018). Due to the animal pest attack related impact, and also climate change-related factors like drought, the number of enset landraces which are used for traditional medicine and edible corm were reported to have been degraded or lost. However, the various traditional methods which farmers use to prevent crop damage (fencing, filling holes, application of manure, collective hunting) have helped to reduce the impact. Similar methods are practiced in other parts of the country such as the Gamo highlands (Bayu, 2016), and Kembatta Tembaro Zone Maryo et al. (2018).

As the study put forward, enset disease, mainly enset bacterial wilt, is also the major challenge in the study area. The problem is more common in *Dega* (highland) areas (Amogera and Kosed *Kebele*s) while in low land areas (Terhogne and Dember *Kebele*s) the impact of enset bacterial wilt was reported to be minimum. This finding is in agreement with a previous report (Maryo et al, 2018) which stated that enset bacterial wilt infestation is high in relatively humid environment (high moisture) and low-temperature conditions. Additionally, respondent farmers confirmed that the impact of enset bacterial wilt disease is high during the rainy season than the dry season.

An additional threat to enset cultivation verified through the study is the competition for space by Eucalyptus, which is considered as a fast-growing commercial crop by many farming families. It has got attention and a relatively larger agricultural land allocation. This is a big threat to the sustainability of enset production in the study area. This study showed that enset makes only 17% of the crop land share in the area. A previous report however showed that the share of enset cover out of the total agricultural cropland

was about 50% in the study *Woreda* (EEWFEDO, 2019). The shrinkage in enset land, is assumed to have occurred due to the replacement of agricultural land by other fast-growing and cash-generating crops, including Eucalyptus and *Ch'at.*

Indigenous management of enset Diversity

Farmers identify enset farmers' varieties by employing indigenous phenotypic characterization. In this study, it was also noted that landraces are named by local people based on the origin, a location from which the farmers' variety was obtained. This traditional knowledge of identification is similar to the method of identification reported by Yemataw et al. (2014) in Wolaita, Kembatta, Hadiya, Sidama, Gamo Gofa, Gurage, and Dawro Zones; Olango et al. (2014) in Wolaita Zone, and Seifu and Fitamo (2016) in Sidama Zone. Farmers in the study area cultivate enset at their home gardens, which is located around the home where livestock and household members live together. Enset is used as fodder for cattle, and the livestock provides manure that is used to fertilize the enset plantation. A similar result was reported from Wolaita (Olango et al., 2014). Enset is grown as a sole crop or intercropped with other root crops, maize, and coffee (Garedew et al., 2017). The crop is reproduced vegetatively using the corm of a juvenile plant. Farmers in the study area transplant enset suckers from two to three times until they get permanent field. The finding is in agreement with previous reports of Mojo (2017) from Gurage Zone and Negash (2001) from Keffa Sheka Zone. Enset needs a series of follow up after planting. Maintaining sanitation, weeding, and application of manure are common practices done by the farmers as it was described in earlier works by Negash (2001) and Bayu (2016).

CONCLUSION AND RECOMMENDATION

The present study helped to assess the status of enset cultivation, its diversity, and the challenges encountered by local farmers. The study enabled the recording of 50 enset landraces that are differentiated and recognized by farmers via phenotypic characterization. The enset landrace richness, diversity, and evenness varied significantly across agro-climatic zones and wealth groups. Accordingly, it was verified

that *Dega* agroclimatic areas and wealthy classes in the community possessed higher number enset varieties. The distributional difference of enset landraces increases among agroclimatic zones is attributed to environmental variables as well as sociocultural aspects. The cultivation of enset in the study area and its intraspecific diversity is challenged by several factors including the attack by animal pests, diseases, the introduction and expansion crops with immediate economic benefit, labor shortage, lack of modern processing technology, climate change, and scarcity of land for the ever-increasing human population. Despite local efforts made to control or reduce losses caused by animal pests, the overall outcome is far from satisfactory. The rapid expansion of eucalyptus as a commercial crop will likely lead to its dominance on the enset agricultural landscape and this, in turn, will end up in a significant reduction of the area cover share of enset, threatening the sustainability of its production and diversity.

In the study area, local community members grow diverse landraces to meet objectives such as diversifying produce and thereby ensuring food and nutritional security, maintaining varieties used for medicine, and minimizing the risk of total yield loss. Although enset has been taking the greatest share of land in the local production system, a multitude of crops (e.g., cereals, legumes, tuber/root crops, vegetables, spices, and coffee) are grown alongside it. This concomitant cultivation of crops where enset forms the backbone of the production system has allowed locals to lead a sustainable living within a more or less stable environment. The present study, however, revealed that changes in the local production system, in general, and that of enset cultivation and diversity, in particular, have been occurring with a potential impact on the livelihood of local people and their environment. It is, therefore, recommended that all concerned bodies should consider and take appropriate measures that range from undertaking further research to implementing conservation interventions on the ground. Furthermore, it is advisable to develop an appropriate land use policy that aids in not converting enset land into other forms. Similarly, farmers need the means to build their capacity in areas of pest control and enset disease prevention to encourage them to grow diverse enset landraces.

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Annex I: **Diversity of enset landrace along the three agro-cimatic areas in Enemorina Eaner Woreda.**

No	Local name of landrace	Dega	Woinadega	Kolla	Total
		Frequency (Percent)			
1	*Abakita*	3(0.1)	13(0.4)	0	16
2	*Agade*	121(3.9)	87(2.8)	37(1.2)	245
3	*AgorgurKanchuwe*	1(0.001)	36(1.1)	0	37
4	*Amerad*	83(2.6)	87(2.8)	23(0.7)	193
5	*Anikofiye*	28(0.9)	0	0	28
6	*Astara*	61(1.9)	40(1.3)	0	101
7	*Badaded*	37(1.2)	29(0.9)	63(2)	129
8	*Bazeriye*	84(2.7)	71(2.3)	1(0.0001)	156
9	*Bosere*	43(1.4)	8(0.3)	0	51
10	*Buaeche*	19(0.6)	1(0.0001)	0	20
11	*Chohedye*	0	1(0.001)	0	1
12	*Dereeye*	37(1.2)	7(0.2)	0	44
13	*Eaner Agade*	0	1(0.001)	0	1
14	*Edemerti*	4(0.1)	9(0.3)	4(0.1)	17
15	*Egendiye*	43(1.4)	44(1.4)	20(0.6)	87
16	*Emiriye*	0	1(0.0001)	7(0.2)	8
17	*Enba*	2(0.1)	5(0.2)	8(0.3)	15
18	*Eshirafrye*	58(1.8)	76(2.4)	66(2.1)	200
19	*Eweredіye*	14(0.4)	20(0.6)	10(0.3)	44
20	*EzerBadadedit*	3(0.1)	3(0.1)	0	6
21	*Fereziye*	42(1.3)	0	0	42
22	*GebenaBadadede*	4(0.1)	2(0.1)	0	6
23	*Gebenaesed*	0	2(0.1)	0	2
24	*Gezwed*	54(1.7)	28(0.9)	0	82
25	*Gimbuwee*	60(1.9)	34(1.1)	0	94
26	*Guarye*	84(2.7)	49(1.6)	9(0.3)	142
27	*GudKanchuwe*	2(0.1)	1(0.0001)	0	3
28	*Gumbura*	84(2.7)	30(1)	9(0.3)	123
29	*Kembeto*	2(0.1)	0	0	2
30	*Keswe*	8(0.3)	20(0.6)	0	28
31	*Kibnar*	65(2.1)	31(1)	6(0.6)	102
32	*Kinbat*	1(0.0001)	0	0	1
33	*Lemare*	97(3.1)	73(2.3)	2(0.1)	172
34	*Mishrad*	19(0.6)	5(0.2)	1(0.0001)	25
35	*MoherKanchuwe*	1(0.0001)	4(0.1)	0	5
36	*Muyed*	2(0.1)	5(0.2)	0	7
37	*Natasibr*	0	1(0.0001)	0	1
38	*Nechiwe*	85(2.7)	84(2.7)	55(1.8)	224
39	*Ousmair*	0	2(0.1)	45(1.4)	47
40	*Quashqashiye*	96(3.1)	45(1.4)	0	141
41	*Sapara*	97(3.1)	84(2.7)	5(0.2)	186
42	*Shertiye*	26(0.8)	6(0.2)	0	32

No	Local name of landrace	Dega	Woinadega	Kolla	Total
		Frequency (Percent)			
43	*Tedrader*	14(0.4)	0	0	14
44	*Tegaded*	16(0.5)	0	0	16
45	*Tereriye*	37(1.2)	0	0	37
46	*Wonadiye*	24(0.8)	0	0	24
47	*Yirengye*	24(0.8)	0	47(1.5)	71
48	*Zewiyred*	4(0.1)	1(0.0001)	0	5
49	*Zobir*	36(1.1)	20(0.6)	0	56
50	*Zogired*	18(0.6)	6(0.2)	0	24