ON FARM CULTIVAR DIVERSITY OF ENSET (*ENSETE VENTRICOSUM* W.) IN SOUTHERN ETHIOPIA

Awol Zeberga[1], Zerihun Yemataw[2], Woldeyesus Sinebo[3], Sadik Musemil[2], Daniel Ambachew[1]

Abstract

This study was initiated to explore farmers' strategy on choice of enset cultivar mix and features pertaining to farm cultivar diversity. The survey was undertaken on eight geographical zones in southern Ethiopia. Enset is an important food crop, after cereals and pulses, with coverage of 25% of arable land in the region. Primary data were collected from enset producing sample farmers. The crop supports 6.7 persons per household in 0.71 ha of land holdings on average. Large number of enset cultivars (312) was recorded with an average of 10.2 cultivars per individual holding. Diversity indices have shown that there exists high diversity of cultivars (on the basis of local vernaculars) with few cultivars appeared to be highly abundant with less common and rare cultivars characterize the distribution-abundance pattern. Uneven distribution and abundance of few cultivars suggest their relative importance and provide evidence for deliberate clonal mix for on-farm conservation. Farmers had also prioritized and rated traits/values for selection and maintenance of cultivars and the prime ones, among many others, were identified. The traits comprise disease resistance, early maturity, kocho quality, kocho yield and tolerance to drought. They are the decisive factors shaping the distribution-abundance pattern of cultivars. Nonetheless, several biotic and abiotic stresses, according to respondents, were confronting on-farm diversity management, particularly production and productivity due to varied level of susceptibility to shocks, while some cultivars celebrated for distinctive merits encountered risk of extermination. The association of farmers' choice of values/traits with other cultural, socioeconomic and biophysical factors needs to be investigated further. Efforts aimed at maintaining enset landraces need to be enhanced and heightened via combination of approaches (gene banks, breeding programs and in-situ conservation). Due emphasis has to be given to farmers ascribed values/traits and resistance mechanisms to various shocks in landrace deployment efforts as part of enset variety development strategy.

Key words: enset, cultivars, traits/values, diversity, conservation, abundance, distribution

---

[1]Southern Agricultural Research Institute, P. O. Box 06, Awassa, Ethiopia
[2]Southern Agricultural Research Institute, Areka Agricultural Research Center, P. O. Box 79, Areka, Ethiopia
[3]NEPAD, Uganda

Introduction

Enset (*Ensete ventricosum W.*) belongs to the order *Scitamineae,* family *Musaceae,* and genus *Ensete.* The crop is versatile and environmentally resilient and serves for 20 percent of Ethiopian population as staple and/or co-staple food. According to CSA (2009/10) the area covered by enset is more than 300,000 ha. Enset is accredited for its tolerance to drought with high productivity and consequently, considered as top priority food and cash security crop in the country. It is primarily used as food, feed, medicinal, ornamental, raw material for industries and construction materials. It has also diverse socio-economic, cultural and ritual worth. Farmers claim enset as their food, clothes, beds, houses, cattle-feed, plates (Brandit et al, 1997). Regardless of widespread distribution of its wild relatives, it is only in Ethiopia that the plant has been domesticated and cultivated with more than 50 different varieties, cultivars, or landraces (Alemu and Sandford, 1996; Shigeta, 1991).

On-farm diversity management of enset was studied by various scholars in various locations in Southern Nations and Nationalities Regional State (SNNPRS). Yemataw (2010) described 218 different enset cultivars from seven zones in SNNPRS. Moreover, Birmeta (2004) described 111 enset cultivars from nine growing areas of Ethiopia and Tesfaye (2002) had studied 79 cultivars from the Sidama zone of the southern region. Negash (2001) also described 146 cultivars in four zones. However, the rationale for this large scale cultivar mix was less investigated and none of the scholars had attempted to link diversity management with aspired purpose of cultivars that has to be maintained. Shigeta (1996) argued that enset diversification is cultural, like favoring cattle with diverse coat colors rather than disparities in intrinsic worth and other desirable horticultural/agronomic traits of various cultivars. Nevertheless, this conclusion appears to be reprehensible conception without comprehensive reconsideration about farmers' multifaceted criterion of clonal mix up and detailed horticultural/agronomic data.

Information pertaining to farmers' criterion of cultivating and maintaining diversity of enset cultivars is deficient and that has to be comprehended and utilized in breeding and variety development efforts. Consequently, this study was devised to investigate prospects and essence of on-farm cultivar mix and characteristics of farmers' ascribed values for conservation with a hypothesis that states farmers have been cognizant and have been cultivating a mix of cultivars for parameters related to yield, quality and reaction to different biotic and abiotic shocks.

Materials And Methods

The study area

Southern Nations, Nationalities and Peoples' Regional State (SNNPRS) has a total area of 117,506 km^2, with altitudes ranging from 378 to 4,207 masl (Abebe 2005). The study was conducted in eight sample zones, namely, Wolaita, Kembata, Hadiya, Sidama, Gedeo, Silte, Gurage and Dawro (Figure 1).

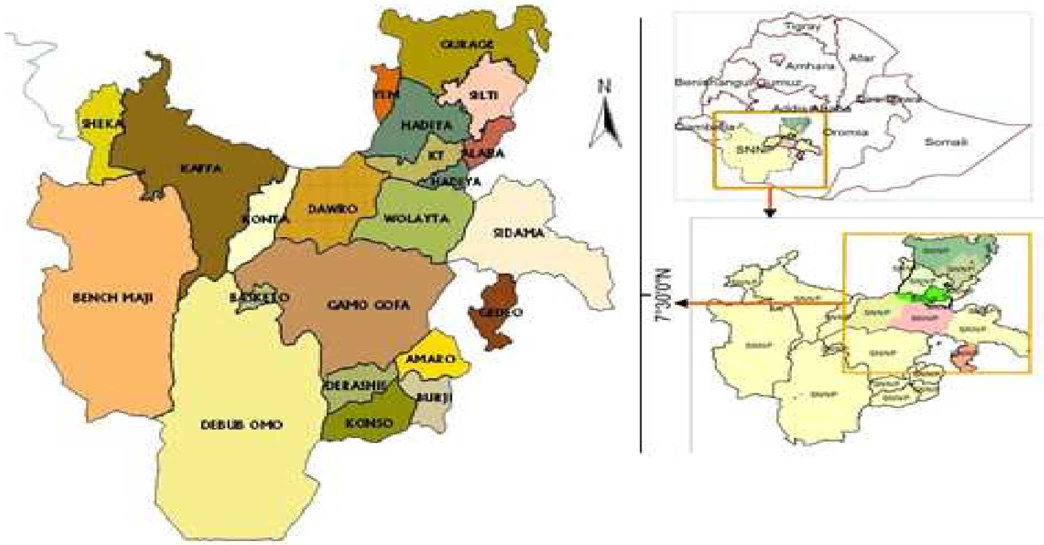


Figure 1. Study location.

Sampling and data collection

Multistage sampling was employed for selection of sampling units, which in this case were individual farmer households. Eight zones were drawn purposefully based on enset production potential in SNNPRS, where more than two-third of the country's enset production is located. From each zone two woredas and two peasant associations (Pas) (the lowest tier of government administration unit), were selected purposefully based on agro-ecology variant. Ten households were randomly selected from each PA and a total of 320 households were interviewed using structured questionnaire. Information presented hereafter inferred stances from these respondents.

Data analysis

Various data diagnostic techniques were employed to comprehend information from the results. Descriptive and inferential statistics were applied to describe the distribution of respondents and other demographic and socioeconomic characteristics.

Simpson (1949) and Shannon and Weaver (1949) diversity indices are widely used as measure of heterogeneity (Magurran, 1988), and these were calculated for all sample zones to explore on- farm enset diversity management. Simpson's index (D) 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. This is neither intuitive nor logical, so to get over this problem, D is often subtracted from 1 to give Simpson's Index of Diversity (1 – D). The value of this index ranges between 0 and 1; the greater the value, the greater the diversity. The index was computed for all zones and cultivars using the connotation shown below.

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

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

Where:

n_i= the frequency of the i^{th} cultivar, i.e, frequency of the cultivar embodied in the i^{th} farms in the district and

N = the total number of farms surveyed in the district.

The Shannon–Weaver diversity index (Shannon & Weaver, 1949) and Evenness measure (E) are commonly used tools that combine both richness and evenness of cultivar abundance (Magurran, 1988). The Shannon diversity index (*H'*) is high when the relative abundance of the different species or cultivars in the sample is even, and is low when few species are more abundant than the others. 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 cultivars, indeed in this case.

The Shannon–Weaver diversity index, H' = - $\Sigma\, p_i \ln p_i$ (Magurran, 1988).

Where **pi** is proportional abundance of the ***i*^th^** cultivar i.e pi = $\left(\frac{ni}{N}\right)$.

Although Shannon's index takes into account evenness of the abundance of cultivars, evenness can also be computed separately as a measure of the observed diversity to the maximum diversity. It is defined by the function:

E = H'/lnS,

5 *Where H' is the Shannon index and S refers to the number of cultivars in each zone.*

A high evenness, resulting from all cultivars having equal abundance, is normally equivalent to high diversity (Magurran, 1988). Measures of similarity/variation are almost as numerous as measures of clonal/species diversity. The purpose of these functions is to quantify the similarity between two or more sample locations. The expected variation in cultivar composition that exists between locations was analyzed using Sorenson's similarity coefficient (Cs) (Sorenson, 1948).

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

6

Where: *a* is the number of cultivars at locations A

b is the number of cultivars at locations B, and

J is the number of cultivars common to both locations.

Sorenson's similarity coefficient ranges in value from zero (no similarity) to one (complete similarity). Cultivar diversities (Simpson's and Shannon-Weaver diversity indices) were measured separately for each zone. Pearson's correlation coefficient was used to compare diversity and distribution values at different locations.

Nonparametric test statistics was applied for comparison of farmers' attributed purpose of conserving various enset cultivar mix. Multiple related samples with a repeated measure of samples were used for nominal test variables. Cochran's Q test was used to statistically analyze success rate data and tests the hypothesis that several related dichotomous variables measured on the same individual or matched individuals have the same mean. Tests for several related sample procedure compares the distributions of two or more variables and subsequently this model was employed to test and rank the proportion of farmers who vote for particular matching purpose of enset cultivar mix that they aspire for conservation. This test was employed to designate and rank the corresponding farmers' ascribed purpose of various enset cultivars conservation. The procedure tests the null hypothesis that multiple related proportions are the same and responses are random. The probability of obtaining a chi-square statistic ($\chi 2$ distribution with k−1 degrees of freedom) in repeated samples if the frequencies of success are only randomly different and defined as (Cochran, 1950):

Cochran $$Q = (k-1)\sum_{i-1}^{k} C1 \wedge 2 - \left(\sum_{k-1}^{k} C1\right) \wedge 2 \Bigg/ \sum_{i=1}^{k} C1 - \sum_{i-1}^{N} \mathrm{R}^\wedge 2$$

- Where: k is the number of related paired variables to be compared (matched)

- The number of "Vote for the first value" for case i will be designated R_i
- The total number of "Vote for the first value" for case i will be designated C_l.

Traits for each of the enset cultivar that are hypothesized to retain differently rated and matched in factorial (k= 9! ==36). These are High kocho yield (A), High bulla yield (B), Fiber yield/quality (C), Kocho quality (D), Bulla quality (E), Amicho yield/quality (F), Tolerance to drought (G), Disease resistance (H), Early maturity (I).

For each of the N cases (opt one of the two traits), the k variables specified might take on only one of two possible values. The first value encountered is designated as "vote for the first trait" and for each case the numbers of variables that are "vote for the first trait" are counted (In this case vote for the criterion that farmers value most). The significance level of Q is from $\chi 2$ distribution with k−1 degrees of freedom (35).

Result and Discussion

Distribution of respondents

Distribution of sample respondents on demographic and socioeconomic characteristics has been described in Table-1. Among the respondents, 82.6% of households were male-headed and 17.4% were female-headed farm families, with mean age of 46.5 years. Around 46.7% of respondents were illiterate and 14% have informally educated and were able to read and write.

Table 1. Demographic characteristics of sample respondents

Variable	Category	Zone								Total	F/χ2
		Ged*	Wolt	Silti	Gur	Kemb	Sid	Daw	Had		
Sex of HHD	Male	36	34	30	38	31	36	35	36	276	13.4*
	Female	3	6	12	4	10	4	5	4	48	
Family Size	Mean	6.6	8.8	6.2	5.8	6.0	6.6	6.5	7.2	6.7	80.3***
Age of HHD	Mean	40.9	45.7	51.8	44.4	51.9	47.4	48.7	39.4	46.5	3.92***
Education status of HHD	Illiterate	8	15	18	12	19	13	15	13	113	
	Read & write	8	1	8	8	9	2	7	0	43	
	Grade 1-4	10	5	4	4	2	7	4	2	38	70.1*
	Grade 5-8	7	9	4	12	5	16	6	15	74	
	Grade 9-10	5	5	3	2	4	1	3	3	26	
	Above 10	0	3	0	1	0	1	4	5	14	

Source: computed from survey data, 2012/2013;
**Ged = Gedeo, Wolt = Wolaita, Gur = Guraghe, Kemb = Kembata, Sid = Sidamo, Daw = Dawro, Had = Hadiya*

More than 50% of the respondents under no circumstances have access to formal education which can potentially be a latent threat for access to information on agricultural production and marketing. The average family size of enset based farming communities was 6.7 per family (Table 1), that is higher than the national average of 5.4 persons per household (CSA,2005). Enset cultivation hence supports this densely populated region (>300person/km^2).

Farming system and the role of Enset

As indicated earlier, farmers per capita land holding on average was found to be 0.71 hectares. Enset, wheat, food barley, Irish potato, faba bean and field peas were in the major crops cultivated by smallholder farmers with different degree of crop mix (Table 2). , However, enset ranks first in total land area coverage, where 25% of the total arable land is occupied by enset, which is considerably greater than other competing crops. . Hence, the role of enset in the study area has to remain the centre of research and development as its importance was demonstrated by sustaining 6.7 families with 0.71 hectare of landholding per household. Only enset, wheat, faba bean, field peas and potato were cultivated in all zones while the remaining crop types were grown in one or more zones. Barley and haricot beans were cultivated in 7 and 6 zones, respectively.

Table 2. Crop diversity and their distribution

Crop type	Mean land area coverage (ha) household								Total
	Ged	Wol	Silti	Gur	Kemb	Sidam	Daw	Had	
Total land area	0.55	0.36	0.82	0.87	0.52	0.81	1.44	0.28	0.71
Enset	0.21	0.06	0.14	0.22	0.14	0.24	0.28	0.08	0.17
Wheat	0.02	0.04	0.10	0.04	0.11	0.06	0.17	0.16	0.09
Barley	0.14	NA*	0.06	0.03	0.04	0.06	0.08	0.07	0.07
Maize	0.17	0.14	0.03	NA	0.02	0.08	NA	NA	0.09
Faba bean	0.17	0.02	0.07	0.02	0.05	0.05	0.05	0.04	0.06
Field peas	0.16	0.07	0.03	0.03	0.09	0.03	0.07	0.05	0.07
Common bean	0.13	0.13	0.06	0.01	0.03	0.04	NA	NA	0.07
Potato	0.09	0.06	0.05	0.23	0.05	0.04	0.06	0.05	0.08
Carrot	NA	NA	0.02	0.06	NA	NA	NA	NA	0.04
Cabbage	NA	NA	0.01	0.34	NA	0.01	0.06	NA	0.11
Garlic	NA	NA	0.02	0.15	NA	NA	0.02	0.05	0.06
Coffee	0.08	0.06	NA	0.03	NA	0.28	NA	0.03	0.10
Chat	0.01	0.10	NA	NA	NA	NA	NA	0.03	0.05
Teff	NA	0.14	NA	0.13	0.02	0.13	0.09	NA	0.10
Chickpea	NA	0.05	NA	NA	NA	NA	NA	NA	0.05
Lentil	NA	NA	NA	0.03	NA	NA	0.02	NA	0.02

Source: Computed from survey data
**NA: Not available*

The largest mix of crop types (13) and the lowest (9) were recorded in Guraghe and Hadiya zones, respectively, with an average of 0.87 and 0.28 hectares of landholding per household. The low crop diversity in Hadiya zone might be due to the fact that the low per capita landholding of farm families. On average, in almost all instances, land allotted to enset was more than to other crops, mainly to ensure food security (Table 2). Future research need to address the biophysical and socioeconomic factors contributing to crop diversity across zones.

On-farm Enset Cultivar Diversity

Enset cultivar richness

This study identified and recorded more than 312 distinct enset cultivars (as identified by local vernaculars) in eight zones of SNNPRS in Ethiopia, signifying the cultivation and maintenance of diverse enset cultivars. The number of cultivars recorded per farm varies from less than 3 to more than 22, depending upon the zone. Zones, such as Guraghe, Sidama and Silte had highest variation; up to 28 cultivars were recorded in the farms. The lowest number of cultivars was recorded at Gedeo and Wolaita, up to 7 and 9 cultivars, respectively (Table 3). Based upon local vernacular names (not based on taxonomical classification), 75 cultivars were identified at Dawro, 69 at Silte, 66 at Kembata, 63 at Guraghe, 62 at Sidama, 51 at Hadiya, 28 at Wolayta, and 26 were identified at Gedeo. The lowest (26) richness of cultivars was observed at Gedeo. In previous studies, comparable results were reported by Yemataw (2010), who described 218 different enset cultivars from seven zones, (59 cultivars from Hadiya, 43 from Kembata, 41 from Dawro, 39 cultivars from Wolayta, 34 cultivars from Gamo Goffa, 31 cultivars from Gurage and 30 cultivars from Sidama. Tsegaye (2002) also described 146 different enset cultivars from three zones (52 cultivars from Sidama, 55 cultivars from Wolayta and 59 cultivars from Hadiya). Negash (2001) recorded 146 different enset cultivars from four zones (65 cultivars from Kefa-Sheka, 30 cultivars from Sidama, 45 cultivars from Hadiya and six cultivars from Wolayta). Moreover, Birmeta (2004) described 111 enset cultivars from nine enset growing localities of Ethiopia. Two zones (Silte and Gedeo) from the present geographical study regions were not included in the previous studies (Table 3).

Table 3. Variation in the number of enset cultivars cultivated in each farm

No. of Enset	Number of farms							
cultivars per farm	Daw	Ged	Gur	Had	K-T	Sid	Sil	Wol
≤3	2	14	3		1	5	1	27
4 to 6	6	15	7	10	17	11	11	11
7 to 9	10	11	15	15	10	8	11	2
10 to 12	14		9	10	10	4	8	
13 to 15	6		3	2	3	3	3	
16 to 18			4			3	3	
19 to 21			1			3	2	
≥22	2					3	3	
Total	40	40	42	37	41	40	42	40

Source: computed from survey data, 2012/2013

The number of cultivars cultivated on individual farms ranged from one to twenty eight (with mean of 10.2) (Table 4). Average number of cultivars per farm ranged between 10.43 for Silte to 3.55 for Wolaita. Dawro and Sidama with 10.2 and Gurage with 9.45 cultivars per farm had high farm level richness of cultivar mix. This is because many of the farms were composed of 11-15 cultivars, while other zones, such as Kembata, had few such cultivars, although the total number of cultivars in the zone was high.

Diversity indices were computed from the number of cultivars present on 40 farms within each zone. The Simpson's 1-D ranged between 0.97 (Dawro) to 0.90 (Gedeo). The high value obtained in all cases signifies a great diversity among the cultivars (Table 4). The Shannon diversity index (H′) had ranged between 3.71 (Dawro) and 2.6 (Gedeo), showing a low relative abundance of cultivars, signifying few cultivars are more abundant than the others. Evenness indices had shown a very narrow range of differences, indicating high enset cultivar diversity in the eight zones (Table 4). The richness indices of cultivar abundance were relatively high within the zones except in two zones, Wolaita and Gedeo (Table 4).

Table 4. Enset cultivar diversity in the eight zones, richness, Simpson (1-D) and Shannon (H') diversity indices, and Evenness

Districts	Richness (%)	Mean richness / farm	Minimum richness	Maximum richness	No. of unique landraces	1-D	H'	Evenness
Dawro	75 (17.04)	10.20	1	28	21	0.97	3.71	0.86
Gedeo	26 (5.91)	4.75	1	8	26	.90	2.6	0.80
Gurage	63 (14.32)	9.45	3	21	15	0.96	.69	0.89
Hadiya	51 (11.59)	8.19	4	15	20	0.95	3.4	0.86
Kembata	66 (15)	7.83	3	15	15	0.96	3.6 2	0.86
Sidama	62 (14.1)	10.27	3	28	58	0.96	35	0.85
Silte	69 (15.68)	10.43	3	24	20	0.96	3.6 7	0.87
Wolaita	28 (6.36)	3.55	2	7	55	0.93	2.86	0.86

Source: computed from survey data, 2012/2013

The total number of cultivars observed in the eight zones was 440 (as identified by local vernaculars). During the survey we were able to confirm that each farmer had managed to maintain as much enset cultivar diversity as possible as long as he/she owns sufficient unused land. During discussion with farmers it had also been affirmed that there were more than one hundred enset cultivars grown at each locality a few years back; however, farmers had reported that most of the cultivars were lost due to diseases and pests, such as, enset Xanthomonas wilt (EXW), mole rat, porcupine and wild pigs. Tesfaye (2002) had indicated that in Sidama farmers had reported the names of 20 enset cultivars that were not encountered in any other farms visited.

Distribution and abundance of cultivars

Large differences were evident among cultivars in their abundance and distribution. Some cultivars had a rather patchy distribution, i.e. there was a very high local abundance at one or two locations and almost absent from the other areas. Small number of cultivars played a dominant role in more than one zone. These were ‘Agade’, ‘Gentich’a, ‘Badedet’, ‘Siskela’, ‘Gena’, and ‘Astara’. Agade was the most abundant cultivar as it was recorded on 76 (23.6%) farms surveyed, but a much higher proportion was recorded in the two zones, Gurage, and Silte, i.e. in 38 (11.8%) farms out of 40 farms visited.

There was also a considerable differences among cultivars with respect to distribution across locations. Out of 312 cultivars identified in all locations, 231 (74.04%) cultivars were cultivated in one location. Fifty three (17%) of the cultivars were present in two locations, seventeen cultivars (5.44%) in three locations, , six cultivars in four zones, four cultivars (1.28%) in five zones, and only one cultivar (Torore/Toracho) was present in all eight zones (Table 5). Household characteristics, distance among locations and ethnic preference contributes to high clonal diversity for few cultivars in some locations, while large number of cultivars that do not fulfill the selection criteria of farmers in a given ethnic group or location attributes to low cultivar diversity and abundance.

Table 5. Distribution of enset cultivars across locations

Number of locations	Number of enset cultivars (%)
One	231 (74.04)
Two	53 (17)
Three	17 (5.44)
Four	6 (1.92)
Five	4 (1.28)
Six	0
Seven	0
Eight	1 (0.32)
Total	312

Source: computed from survey data, 2012/2013

The expected variation in cultivar composition that exists between locations was analyzed using Sorenson’s similarity coefficient (Cs). The number of cultivars shared between pairs of zones and Sorneson’s similarity indices are presented in Table 6. Kembata and Silte zones shared 33 cultivars, while Silte and Gurage, Kembata and Hadiya also shared 26 and 27 cultivars, respectively. Wolaita and Dawro had 10 cultivars in common. These pair of zones were adjacent to each other while Gurage and Silte, Kembata and Hadiya, and Wolaita and Dawro zones were, until recently, under one administrative geographical structure. Strong cultural and linguistic similarities exist between Gurage and Silte, Kembata and Hadiya, and between Wolaita and Dawro. This may be reflected in the observed high similarity in cultivated cultivars.

Table 6. Shared cultivars (bold and above diagonal) and Sorenson similarity indices (below diagonal) between pairs of zones.

Zones	Dawro	Gedeo	Gurage	Hadiya	Kembata	Sidama	Silte	Wolaita
Dawro		**2**	**9**	**4**	**4**	**4**	**4**	**10**
Gedeo	0.02		**2**	**2**	**2**	**5**	**2**	**1**
Gurage	0.13	0.04		**11**	**19**	**3**	**26**	**3**
Hadiya	0.06	0.05	0.19		**27**	**2**	**17**	**3**
Kembata	0.06	0.04	0.29	0.46		**2**	**33**	**5**
Sidama	0.06	0.11	0.05	0.03	0.03		**2**	**2**
Silte	0.05	0.04	0.4	0.28	0.49	0.03		**1**
Wolaita	0.19	0.04	0.06	0.07	0.11	0.04	0.02	

Source: computed from survey data, 2012/2013

These findings, noticeably similar with Yemataw (2010), who reported Hadiya and Kembata zones shared 17 cultivars and Wolaita and Gamo Gofa, and Wolaita and Dawro had 11 cultivars in common. The informal exchange of planting material among farmers mainly occurs within the geographical zone occupied by an ethnic group and it is hence difficult to compare values with results of previous surveys due to differences in the number of locations and ethnic considerations.

Farmers' criteria of cultivating diverse enset cultivars on their farms

Shigeta (1996) argued that enset diversification is cultural, like favoring cattle with diverse coat colors rather than disparities in intrinsic worth and other desirable horticultural/agronomic traits of various cultivars. Nevertheless, this conclusion appears to be reprehensible conception without comprehensive reconsideration about farmers' multifaceted criteria of clonal mix up and detailed horticultural/agronomic data. According to the information from respondents (farmers), each enset cultivar has distinct merits that are valued by farmers with different social group. Future breeding and variety development efforts should comprehend those decisive factors attributed to different enset cultivars and bring them into consideration as per farmers' on-farm diversity management standard.

The Cochran *Q* procedure tests the null hypothesis that multiple related matching pair (criteria of enset cultivar choice for conservation) is random and retains equal chance of appearance (0.5). For each of N (36) cases association of criterion, k (9) variables specified assume only one of two possible events (1, 0). The asymptotic significance is the approximate probability of obtaining a chi-square statistic as extreme as 199 in repeated samples if the frequencies of success are only randomly different. Because a chi-square this large is unlikely to have arisen by chance (with significance level of 0.00), the null hypothesis that states all tasks have an equal frequency of successes is rejected. Hence the rate for different enset cultivar selection criteria by farmers is not random with high certainty (100 % probability).

Table 7. Test Statistics

N	193
Cochran's Q	199
Df	35
Asymp. Sig.	0.00

a. 1 is treated as a success for traits down the column in table 8.

The values encountered down the column (Table 8) is designated as the proportion of "vote for particular choices" or choosing high kocho yield (A) is rated 0.83 times higher than high bulla yield (B). For each of k case the frequency (proportion) of variable is counted and presented in Table 8. The k variables are sorted and ranked, with average rank being assigned in the case of ties and for each of the k variables, the sum of ranks over k cases are shown in the last column. The shaded portion represents the proportion of choices in favor of the alternative attribute (B=1-A).

Table 8. Cultivar Selection and criteria for conservation

Criterions	A	B	C	D	E	F	G	H	I	Aver. rank
High kocho yield (A)	A	0.83	0.87	0.36	0.64	0.61	0.42	0.35	0.42	0.56
High bulla yield (B)	0.17	B	0.80	0.18	0.37	0.49	0.26	0.21	0.26	0.27
Fiber yield/quality (C)	0.13	0.20	C	0.09	0.09	0.13	0.11	0.05	0.07	0.13
Kocho quality (D)	0.64	0.82	0.91	D	0.75	0.71	0.33	0.27	0.41	0.64
Bulla quality (E)	0.36	0.63	0.91	0.25	E	0.52	0.17	0.16	0.19	0.40
Amicho taste/quality (F)	0.39	0.51	0.87	0.29	0.48	F	0.21	0.07	0.14	0.32
Tolerance to drought (G)	0.58	0.74	0.89	0.67	0.83	0.79	G	0.28	0.34	0.53
Disease resistance (H)	0.65	0.79	0.95	0.73	0.84	0.93	0.72	H	0.61	0.70
Early maturity (I)	0.58	0.74	0.93	0.59	0.81	0.86	0.66	0.39	I	0.69

Source: computed from survey data, 2012/2013

Based on the statistics and frequency portrayed in table 8, highly rated attributes accountable for enset cultivar mix up to be cultivated and maintained on farm have been identified. On average farmers' prime purpose of various enset cultivars are ranked and presented in descending order of importance, among others comprise:

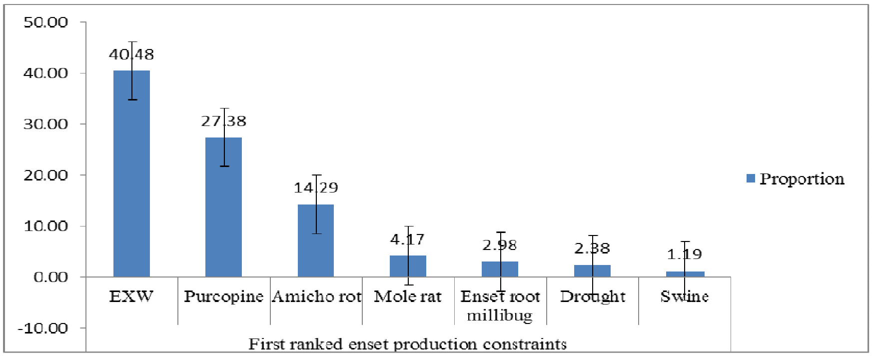
- Disease resistance (0.70)
- Early maturity (0.69)
- Kocho quality (0.64)
- Kocho yield (0.56) and
- Tolerance to drought (0.53).

However other attributes, such as bulla quality (E), Amicho yield/quality (F), Bulla yield (B) and Fiber yield/quality (C) still worthy enough with different proportion of success rate. The association of choice of these attributes with other cultural, biophysical and socioeconomic dynamics however needs to be investigated further.

Enset Production Constraints

Previous research works by various scholars revealed that enset production and productivity is embarrassed by several biotic and abiotic influences. These comprises many diseases and pests that attack different parts of the plant caused by bacteria, fungi, nematodes, and viruses, pests and wild vertebrates such as mole rat and porcupine (Taye, 2012, Lulseged et al., 2012). Farmers were asked to list and rate most important enset production constraints and the result has been portrayed in figure 2.

Figure 2. Proportion of sample respondents who ranked enset production constraints



Source: computed from survey data, 2012/2013

Among Enset production constraints in Ethiopia, EXW (Enset Xanthomonal wilt) disease rated (40.48%) the first in its devastation and distribution in this study area. Porcupine, corm rots and mole rat also impede serious damage for enset production and productivity in their respective order of importance. From the total sample respondents, 35.9% had reported the existence of EXW in their enset field with various level of incidence. The highest (70%) and lowest (5%) prevalence rate was recorded at Gedeo and Kembata zones, respectively. EXW disease distribution is highest in Gedeo, Dawro, Hadiya with 70, 55 and 50 percent, respectively, with an average of 13 percent of enset stands from the total enset population in farmers' field were vanished due to EXW disease. However, the coverage of these traits varied across locations and the aforesaid highly rated menace and impairment has reference to economic importance rather than geographical coverage.

Conclusion

All diversity indices had revealed that there exists high diversity of enset cultivars based upon farmers' method of characterization in each of the enset growing zones. In general, a small number of highly abundant cultivars were grown in most parts of the region, while a much larger number of moderately common and rare cultivars characterize the distribution-abundance pattern. Uneven distribution and abundance of some cultivars ensure relative importance accredited by farmers and provide strong evidence for strategic clonal mix for conservation. Consequently, future enset landrace deployment effort requires due consideration of farmers ascribed values attributed to various cultivars. The widespread distribution of some cultivars challenges the view that traditional farming systems are isolated and closed, with limited exchange of landraces.

Relatively, highland areas have higher number of diverse and unique landraces and should be given priority in efforts aimed at collection and *in situ* germplasm conservation and variety development agendas. Farmers in the study locations, successfully maintained diversity of enset cultivars which supports their livelihood. Managing cultivar diversity through a combination of strategies and approaches (gene banks, breeding programs and on-farm conservation) are essential for sustained socioeconomic development of enset farming communities.

Acknowledgements

The authors are decidedly grateful to Southern Agricultural Research Institute (SARI) and National enset research project based at Areka for hosting the study. We also extend our appreciation to McNight Foundation for funding the study and showing enthusiasm to support enset research and development efforts in Ethiopia.

References

Abebe, T. (2005.) Diversity in homegarden agro-forestry systems of southern Ethiopia. PhD dissertation, Wageningen University, The Netherlands. 143 pp.

Alemu, K. & Sandford, S. 1991. Enset in North Omo Region. Farmer's Res. Projec Technical Pamphlet No. 1. Farm Africa, Addis Abeba. 49 pp.

Birmeta, G. 2004. Genetic variability and biotechnological studies for the conservation and improvement of *Ensete ventricosum*. Doctoral thesis, Swedish University of Agricultural Sciences, Alnarp. 91pp.

Boster, J. 1985. Selection for perceptual distinctiveness: evidence from Aguarina cultivars of *Manihot esculenta*. *Econ Bot* 39: 310-325.

Brandt, S.A., Spring, A., Hiebsch, C., McCabe, S.T., Taboge, E., Diro, M., Welde-Michael, G., Yentiso, G., Shigeta, M. and Tesfaye, S. (1997) . The 'Tree Against Hunger'. Enset-based Agricultural Systems in Ethiopia. American Association for the Advancement of Science. 56 pp.

Cochran, W.G. (1950) The Comparison of Percentages in Matched Samples. Biometrika, 37, 256-66.

Engels, J. and Hawkes, J. (1991) The Ethiopian gene centre and its genetic diversity. In: Engels J, Hawkes J, Worede M (eds). *Plant Genetic Resources of Ethiopia*. Cambridge University Press, Cambridge

Lulseged B., Waga M. and Mikias Y., 2012. Mole Rat and Porcupine as Enset Production Trait and their Management Options. Enset research and development experiences in Ethiopia, Proceedings of Enset National Workshop, 19-20 August 2010, Wolkite, Etiopia. (eds) Mohammed Y.et al.. 2012.

Magurran, A. (1988) . Ecological diversity and its measurement. Croom Helm, London. 125 p.

Negash, A. (2001) . Diversity and conservation of enset (*Ensete ventricosum* Welw. Cheesman) and its relation to household food and livelihood security in South-western Ethiopia. PhD dissertation, Wageningen University, The Netherlands. 247pp.

Negash, A., Tsegaye, A., Van Treuren, R. and Visser, B. (2002) . AFLP analysis of Ensete clonal diversity in south and southwestern Ethiopia for conservation. *Crop Science* 42(4): 1105-1111.

Nei, M. (1987). *Molecular evolutionary genetics*. Colombia University Press, New York.

Rao, C. (1952). Advanced statistical methods in biometrical research. John Wiley and Sons Inc. New York. pp. 390.

SAS. 2002. Statistical Analysis Systems SAS/STAT user's guide Version 9 Cary NC: SAS Institute Inc. USA.

Shannon, C. and Weaver, W. 1949. The mathematical theory of communication. University of Illinois, Urbana, IL 117pp.

Shigeta, M. 1991. Folk *in situ* conservation of enset (*Ensete ventricosum* (Welw.) Cheesman): Towards the interpretation of indigenous agricultural science of the Ari, Southewestern Ethiopia. Asia and African Area Studies. 2, 1-25.

Simpson, E. 1949. Measurement of diversity. *Nature* 163: 688.

Sorenson, T. 1948. A method of establishing groups of equal amplitude in plant sociology based on similarity of species content, and its application to analysis of the vegetation on Danish commons. *K dan Vidensk Selsk Biol. Skr.* 5: 1-34.

Tamru, M. 2006. Assessing diversity in yam (*Dioscorea spp.)* from Ethiopia based on morphology, AFLP marker and tuber quality, and farmers' management of landraces. Ph.D. thesis, George –August University. Germany. P 13-39

Taye Bezuneh, 2012. Technological Challenges of Sustainable Enset Farming System: For Enhancing the Production of food/Fiber and Industrial Outputs. Enset research and development experiences in Ethiopia, Proceedings of Enset National Workshop, 19-20 August 2010, Wolkite, Ethiopia. (eds) Mohammed Y.et al., 2012.

Tesfaye, B (.2002). Studies on landrace diversity, *in vivo* and *in vitro* regeneration of enset (*Ensete ventricosum* Welw.). PhD dissertation, Humboldt University, Berlin, Germany, 129 pp.

Tsegaye, A. (2002.) On indigenous production, genetic diversity and crop ecology of enset (*Ensete ventricosum* (Welw.) Cheesman). PhD dissertation, Wageningen University, The Netherlands. 197pp.