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DIVERSITY, CHALLENGES AND MANAGEMENT OF ENSET (*ENSETE VENTRICOSUM* (WELW.) CHEESMAN) BY KEMBATTA PEOPLE, SOUTHERN ETHIOPIA

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ABSTRACT: Enset (*Ensete ventricosum* (Welw.) Cheesman) is an endemic multipurpose Ethiopian crop with a potential for food security for it grows in areas where there is a high population pressure and scarce cultivable land. Studies indicate that pests and diseases are among the challenges to sustainability of enset agriculture. A survey on diversity, challenges and management of enset was conducted in Kambatta Tembaro Zone. Twelve farmscapes each with 15 sampling sites were randomly selected for the study. The identification of enset landraces and recording of data on criterion for landraces identification and selection, and cultural management practices were conducted with the help of farmers using interviews, questionnaire and group discussion. Shannon Index (H') and multiple linear regression, and ANOVA were employed to analyze the data. Farmers' characterization identified a total of 111 named enset landraces, of which 21 had medicinal value. There was high significant difference ($P<0.01$) in enset landraces among economic classes and agroclimatic zones. Dega agroclimatic areas cultivated twice the number of enset landraces in kola areas (mean = 11.5/HH). The number of enset landraces per farmscapes ranged from 8 to 61 with an average of 27.3 whereas the mean Shannon (H') and evenness (E) indices were 1.84 and 0.64 in the zone, respectively. Multidimensional preference ranking showed that amicho, fiber quality, storability, yield, and earliness were useful in discriminating enset landraces. Enset diversity increased with access to market and wealth status of the households. Wild mammalian pests, enset bacterial wilt, and shortage of farmland were challenges to sustainability of enset agriculture. Apposite attention should be given by the government to incorporate enset in the current extension system. Furthermore, experts in ethnobotany, anthropology, microbiology and other appropriate fields should work together with the local people for a workable solution.

Key words/phrases: Amicho, Characterization, Enset diseases, Landraces, Preference ranking.

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BACKGROUND AND JUSTIFICATION

Heterogeneous landscapes, traditional agricultural practices, and inaccessibility have created and maintained diverse subsistence agroecosystems (Samberg *et al*., 2010). The Ethiopian highlands are centres of diversity for several useful indigenous cultivated crops, including enset (*Ensete ventricosum* (Welw.) Cheesman) (IBC, 2005). Enset is an endemic multipurpose tree-like perennial herbaceous crop belonging to Family Musaceae (Edwards *et al*., 1997). It possessed many recognizable farmer varieties or landraces. Landraces are dynamic population(s) of cultivated plants that have historical origin, discrete identity, genetically diverse, locally adapted and culturally selected (Camacho Villa *et al*., 2005). They are recognized by farmers on the basis of a number of morphological and agronomic criteria (Brush, 2000; van de Wouw *et al*., 2009).

Many scholars have reported different numbers of enset landraces from various localities in Ethiopia, for instance, 78 from Ari (Shigeta, 1990), 65 from Kafa and Sheka (Almaz Negash, 2001), 42 from Sidama (Tesfaye Abebe *et al*., 2010), and 105 from Gamo Gofa (Sabura Shara and Mulugeta Diro, 2012). Landraces are named differently among different cultures and localities in Ethiopia. As a result, regardless of the existing similarity among cultures, different enset landrace numbers were reported. The inconsistency of naming pattern due to the lack of clear and common identification techniques probably has created inflated landrace reports in most cases.

Enset is distributed at altitudes between 1600 and 3000 m a.s.l., and chiefly propagated vegetatively (Almaz Negash *et al*., 2002). It was noted for its tolerance, storability for long periods, cultural values (Eyasu Elias, 2003), and for its multiple uses (Shigeta, 1990), i.e., both food and non-food uses of enset (Brandt *et al*., 1997). The major foods from enset are kocho and bulla, obtained from pseudostem and leaf petioles (Yemane Tsehaye and Fassil Kebebew, 2006). But amicho is obtained from the underground corm and consumed after cooking. Bulla is a water insoluble starchy product obtained by squeezing the scrapped pseudostem (leaf sheath) and corm. Scholars view enset as a food security (Admasu Tsegaye and Struik, 2002) for over 20% of the populations of Ethiopia living in the southern and southwestern parts (Gizachew Wolde-Michael *et al*., 2008), covering about 18% of the farm, in mixture with coffee, kale, and others (Tilahun Amede and Endale Tabogie, 2006). Furthermore, some enset varieties are used for both humans and livestock to cure bone fractures, birth problems, and diarrhea (Brandt *et al*., 1997).

Most enset plant parts serve as cattle feed whereas livestock offer manure for soil fertility, chiefly for enset in the home gardens. Furthermore, enset culture is a polyculture where young enset plants are intercropped with annuals (e.g., maize,), and older enset plants with perennials such as coffee , which is shaded by enset (Tadesse Kippie, 2002). As to Admasu Tsegaye and Struik (2002), the intercropped annual crops are used to supplement the low protein and vitamin content of enset products and generate cash from sales. Therefore, enset cultivation is suitable for sustainable agricultural systems due to its contribution to soil fertility, its multiple use, its accessibility at any time, relatively high productivity, cultural practices and varietal differences (Genet Birmeta, 2004).

However, the sustainability of enset cultivation is threatened by a number of factors (Tsedeke Abate *et al*., 1996), such as wild animals pests, e.g., crested porcupine (German *et al*., 2012), enset root pests (Temesgen Addis, 2005) and leaf pest such as leaf hopper, population pressure, degradation of the soil (Tsedeke Abate *et al*., 1996; Teshome Yirgu, 2016), and cash oriented crop production (Almaz Negash, 2001; German *et al*., 2012). Moreover, different types of diseases (fungal, bacterial and viral) (Tsedeke Abate *et al*., 1996) as well as poor post-harvest technology (Solomon Tekalign and Suneetha, 2012) are challenging enset production. Consequently, the vulnerability of enset to genetic erosion was reported (Admasu Tsegaye and Struik, 2002; Abrham Shumbulo *et al*., 2012). Furthermore, the scarcity of farmland that led many young farmers to focus on few short season agricultural crops, the impact of climate, and drought resulted in the loss of several useful enset landraces.

Significant number of studies were conducted on enset, mainly on enset production and utilization in Ethiopia (Taye Bezuneh and Asrat Feleke, 1966), enset based foods, biotechnology and enset yield (Tsedeke Abate *et al*., 1996), enset diversity (Shigeta, 1990; Admasu Tsegaye and Struik, 2002; Almaz Negash *et al*., 2002; Bizuayehu Tesfaye and Lŭdders, 2003; Zippel, 2005; Yemane Tsehaye and Fassil Kebebew, 2006; Abrham Shumbulo *et al*., 2012; Zerihun Yemataw *et al*., 2016), enset challenges (Teshome Yirgu, 2016), including enset bacterial wilt (also called Enset Xanthomonas Wilt or EXW) (Kidist Bobosha, 2003; Gizachew Wolde-Michael *et al*., 2008).

In the past the majority of researches on Ethiopian agriculture have focused mainly on the cereal-based systems (Brandt *et al*., 1997), and the agricultural policy of the country gave little regard for indigenous enset

production (FAO, 2010). Kambatta Tembaro Zone was suggested to be rich in enset landraces (Ethiopian Biodiversity Institute, 2010). The extent, distribution, and management of available diversity as well as factors that control enset diversity needs appropriate investigation for the development of efficient conservation strategies (Clawson, 1985). Therefore, this study was aimed to examine the diversity and management of landraces across the agroclimatic zones by the people in Kembatta Tembaro Zone. It mainly focuses on documenting the available enset landraces, uses, and factors governing enset diversity and distribution, and examining the challenges that influence enset production.

MATERIALS AND METHODS

The study area, the Kembatta Tembaro (KT) Zone, is one of the Zones in Southern Nations, Nationalities and Peoples' Region, located between latitude 7.10 –7.500 N and 37.31-38.070 E longitude and found between altitudinal ranges of 501 and 3080 m a.s.l. It covers a total area of 1523.6 sq. km (KTZARD, 2011), and it is divided into seven districts or Woredas for administrative purpose. The study area has a bi-modal rainfall distribution. The main rainy season stretches from July to September/October with the highest peak in August is locally called *Ojaa*. The minor rainy season called *Gilaallo* and extends from March to the beginning of June. At Durame meteorological station (National Meteorological Agency) of the zonal capital, the maximum mean temperature record was 26.8°C in June, and the mean annual temperature and mean annual rainfall was 19.3°C and 1144 mm, respectively.

Kembatta Tembaro Zone has a population of 1,055,828, out of which the number of males and females was 559,713 and 496,115, respectively (KTZARD, 2011) and 86% of the people live in rural areas (Central Statistical Authority, 2007b). The average land holding per house hold (HH) is less than 1 hectare and there were an average of 6 persons to a household, and about 708 people per sq. km (Central Statistical Authority, 2007a). The Zone has three agroclimatic zones, namely *Dega* (cool and humid) 25%, *WoynaDega* (cool semi-arid) 67% and *Kolla* (Semi desert) 8%. Of the total area of the land, about 75% is cultivated (KTZARD, 2011). Dry ever green afromotane forest and grassland complex and *Combretum-Terminalia* woodland and wooded grassland are the characteristic vegetation types of the study area (Friis *et al*., 2011).

The economy of the local people is mainly based on subsistence agriculture where mixed farming is a common practice (KTZARD, 2011). Although

enset is a staple crop to most people, other crop types such as cereals, pulses, and vegetables are grown in enset cultivation systems. Moreover, the local people are engaged in livestock rearing. The waste from livestock and other household wastes serve as organic fertilizer for enset home gardens.

Selection of study sites

Agroclimate was the main factor in selecting the study sites (hereafter farmscapes). Farmscape is a landscape in which farming has largely played and does play a large role. The three traditional agroclimatic zones were determined as *Dega*, *Weyna-Dega*, and *Kola* following Daniel Gamachu (1977).

In total, 12 farmscapes were selected from the study area. At each farmscape, 15 sampling sites (farmlands owned by households or HHs) were randomly sampled, making the total sampling sites 180. Among the selected 180 HHs, 156 (87%) were male headed and 24 (13%) were female headed. But the percentage of female participants in the interview was 47% (n=85) of the total respondents. The wealth status of the farmers was determined with the help of kebele or peasant association development agents, community leaders and elders based on the context of the local farmland size, livestock holding, amount of crop production and the engagement of some off-farm activities.

Data collection on enset landraces

The total enset landrace composition was determined by making a presence-or-absence record in farms of each sampled HH. In order to investigate the pattern of diversity that exists in the area, the identification of enset landrace and recording of basic information such as uses of landraces, farmers' preferences, criterion for landraces identification, and the cultural management practices were recorded with the help of farmers. There is no standard descriptor relevant for the identification of enset landraces (Kefale Alemu and Sandford, 1996; Eyasu Elias, 2003). Thus, farmers' identification and the response were complemented by identifying landraces using the color (pseudostem, midrib and leaf petiole) of the plant at adult stage. Finally, field notes and photographs of plants representing the different landraces were taken, and the identification of landraces and listing of the names was conducted by consulting scientific literatures following previous scholars (Del Greco *et al*., 2007).

The characters of enset landraces that were used to evaluate the knowledge of farmers on use values were based on qualities of bulla, amicho (hamicho), kocho, taste, storability, yield, earliness, fiber, fodder and medicinal values. Additional characters used were the resistance to enset diseases like the destructive bacterial wilt/EXW (locally called *Ganshoo*/*alloya*) as well as the resistance to drought. To study the perception of 80 informants on the end uses of the enset landraces, 38 recognized enset landraces were ranked by farmers (1 = poor, 2 = intermediate, 3 = best) and converted to binary data (1 best or 0 poor). The summarized data were subjected to multidimensional preference analysis (MDPRE) to assess the possible association between enset landraces and the various attributes mentioned following Yemane Tsehaye and Fassil Kebebew (2006).

Environmental and socioeconomic data

Data on farm characteristics (slope, altitude, aspect, location and the farm size), HH characteristics (age, education, family size, off-farm activities, and the TLU) and market characteristics (access to road and town), the area share of enset landraces of each farm, were collected following previous researchers (Coomes and Ban, 2004; Tesfaye Abebe *et al*., 2006). Similarly, the data on challenges linked with enset production and cultural management were collected through Focus Group Discussion of the 10 selected key informants.

Data analysis

Species diversity was determined by means of species richness and species evenness. Total species richness was calculated just by counting the number of landraces in a given sampling unit. But Shannon Index (H') and Shannon evenness (E) were used to estimate landrace diversity in the farmlands, respectively. H' was calculated using the formula, $H' = - \Sigma\ pi\ lnpi$ (Magurran, 2004), where pi is the proportion enset landraces composed of species i. E is a measure of how similar the abundance of different species are. It was calculated as the ratio of observed diversity (H') to maximum diversity (Hmax) (Pielou, 1969) using the formula, $E = H'/Hmax, = H'/lnS$, Where S= number of species, and ln is a natural log. Similarly, in order to examine the effects of biophysical and socioeconomic variables on enset landraces, the linear multiple regression was employed using Minitab ver 14 (Minitab Inc, 2003). ANOVA was computed to examine any significance differences in enset landraces among wealth groups and agroclimatic zones. Moreover, the multidimensional preference analysis (MDPRE) was

conducted using SAS ver. 8.02 (SAS, 1999).

RESULTS

Characterization of enset landraces

This study used farmers' characterization as the means of detecting enset varieties, and found a total of 111 named enset landraces. The indigenous people grouped enset landraces into two based on sex. The classification into "male" and "female" does not represent the biological reproductive parts of the plant, but rather a set of qualities desired by local people.

There was high significant difference ($P<0.01$) in enset landraces among the three economic classes, and there was also extremely significant difference among the three agroclimatic zones ($P<0.001$). The mean number of enset landraces in the Zone was 7.2/HH. Dega agroclimatic areas cultivate large number of enset landraces (mean = 11.5/HH) but the number of enset landraces grown in Kola areas is half of the enset grown in Dega agroclimate. Enset landraces also vary in their frequency across the zone. Poor farmers grow few numbers of landraces, and the number of enset landraces is related to the farmland size, area allocated to enset, and the size of livestock (Table 1).

Table 1. Average number of farm size, enset area, and the number of enset landraces cultivated by 3 economic classes across the 3 agroclimatic zones of the study area (N = 180).

Wealth category	Farmland Size (ha)	Enset area (ha)	No of livestock	No of landraces in agroclimatic zones			Total	Std. Dev.
				Dega	WD*	Kola		
Poor	0.8	0.11	1.86	9.2	7.9	3.5	6.9^{a}	3.9
Medium	1.9	0.23	4.6	11.4	11.2	6.3	9.7^{ab}	3.6
Rich	3.3	0.39	12.5	13.8	10	7.5	10.4^{b}	4.2
Average	2	0.24	6.3 ± 0.7	11.5^{a}	9.7^{b}	5.8^{c}	9	3.9

WD* = Woyna Dega; letters with different superscripts are significant ($P<0.05$)

The top 10 most frequent enset varieties are shown in Table 2. The top three most frequent enset landraces were Sisqella, Dirbo, and Gishra with frequency of 57.2, 53.5, and 47.5%, respectively. These are the male varieties. There was high significant difference ($P<0.01$) in the mean density of enset landraces across the farmscapes. The density of enset per hectare was 445, 1037, and 3081 for Dega, Woyna Dega, and Kola agroclimatic areas, respectively, and the mean density was 1520 (Table 3). In general, people in Kola agroclimate grow limited number of landraces but more dense in their small home gardens.

Table 2. Frequency of the ten most widely cultivated landraces in KT Zone.

Local name	Sisqela	Dirbo	Gishra	Gimbo	Unjamo	Laqqaqa	Sebera	Abat-merza	Sheleqe	Xorrore
Frequency (%)	57.2	53.7	47.5	43.1	39.6	32.9	30.2	23.1	19.8	19.6

Diversity in enset landraces

The enset plantation area in the homegardens of the study area ranged from 0.01 to 1.25 ha with a mean of 0.24 ± 0.02 ha (Table 3) but enset plantation covers 9% of the total crop land in the study zone. The number of enset landraces per farmscapes ranged from 8 to 61 with an average of 27.3, whereas the mean Shannon diversity index (H') and evenness (E) indices were 1.84 and 0.64, respectively, in the zone. Similarly, the mean number of enset landraces at farmland level was 9 ± 3.9. But the number of enset landraces showed extremely significant difference ($P<0.001$) across the farmscapes. Enset landrace diversity tends to decrease down elevation (Table 3). The highest number of enset landraces, 61(55%) was recorded from farmscape 1 (A/Sadicho) where the altitude is above 2500 m asl. It had also the highest average number of enset landraces, 15.1 per farmland indicating that each farmland represents about 15% of the enset varieties in that farmscape. Furthermore, this farmscape had the highest evenness value (0.88). However, the highest landrace diversity (H’ = 2.36) was recorded from farmscape 5 in Woyna Dega agroclimate.

Nonetheless, the least number of enset landraces was recorded from farmscape 10 (H/Zato), 8 and 0.93 at site and farmland level, respectively. This farmscape falls under Kola agroclimate (< 1800 m asl) where cereals are the main staple food. Due to the prevalence of sandy soils, few farmers grow enset for uses other than staple food. As a result, there were very low values of E and H’, 0.20 and 0.7, respectively (Table 3). The H’ value is below the theoretical range which signals few numbers of landraces in the sample as well as the absence of landraces in other samples.

Table 3. Total and mean number of enset landraces, mean values of the Shannon (H') and the Evenness (E) indices, and enset density across the farmscapes.

Farmscape number	Farmscape Name	Altitude (m)	Area share (ha)	Total Landraces	Mean	Std. Dev	Shannon Index, H'	Std. Dev	Evenness Index, E	Enset density (indvls/ha)
1	A/Sadicho	2619	0.39	61	15.1^{g}	7.9	2.26^{a}	0.03	0.88^{a}	435
2	Kazalla	2350	0.35	20	14f^{g}	5.1	2.18^{a}	0.03	0.83^{a}	236
3	Hobicho	2407	0.29	58	13.6^{fg}	5.8	2.22^{a}	0.02	0.85^{a}	324
4	Sigazo	2310	0.30	18	2.7^{b}	3.8	0.89^{b}	0.08	0.31^{b}	784
5	Kerekicho	2259	0.25	42	11.6^{ef}	3.8	2.36^{a}	0.01	0.65^{a}	768
6	Agara	2120	0.21	22	8.7^{de}	4.6	2.0^{a}	0.03	0.64^{a}	543
7	Mesafe	2126	0.37	24	7.1^{cd}	3.1	2.16^{a}	0.03	0.68^{a}	476
8	Chacho	1892	0.19	25	4.2^{abc}	1.8	1.80^{a}	0.04	0.57^{a}	2358
9	Kaillama	1790	0.18	15	6.2^{bcd}	2.9	1.86^{a}	0.03	0.76^{a}	2535
10	H/Zato	1745	0.04	8	0.93^{a}	2.3	0.7^{b}	1.67	0.20^{b}	4508
11	Ajora	1557	0.21	24	5^{bc}	4.4	1.64^{a}	0.05	0.52^{a}	533
12	Soyame	1677	0.15	10	3.5^{b}	1.4	1.90^{a}	0.02	0.70^{a}	4747
	Average	2071	0.24	27.3	9	3.9	1.84	0.31	0.64	1520

Note: Dega agroclimate = farmscape (site) 1-4; Woyna Dega = 5-8 and Kola = 9-12.

The use values of enset

The ordination analysis performed to identify the relationships among 38 landraces in 12 farmscapes revealed that 84.5% of the total variation to have been accounted by the two dimensions or axes (1and 2) (Fig. 1). The use values with long vectors (amicho, earliness, storability, fiber, and high yield,) are useful in discriminating enset landraces. The enset landraces investigated showed a high significant variability ($P<0.01$) in their use values, and there was some sort of clustering of landraces, especially towards amicho, bulla, taste, and earliness. Multidimensional preference ranking analysis separated the landraces locally distinguished as 'males' towards negative dimension of the first axis, particularly landraces such as Gishira, Sisqella, and Unjamo. These landraces are the most frequent and dominant in the study area (Table 2). They are highly acknowledged for their fiber quality, and also claimed to have better tolerance to drought. However, they are poor in amicho and bulla quality, and fermented lately when processed for kocho.

Most enset landraces were females, which yield better quality amicho and Kocho. Moreover, the quality of amicho, storability and yield are also useful in discriminating enset landraces. Thus, it is possible to state that names given to different landraces on the basis of their use values by enset-growing farmers seem consistent. Amicho, taste, and earliness were pointed roughly to the same direction, which may display similar preference patterns. It means those enset landraces that are preferred to amicho are tasty, which also ferment early if desired to process kocho.

Bulla and amicho contributed more to the positive axis of the first dimension where varieties of the 'female' category dominated. The varieties under this dimension also overlap with their uses. For example, Itine, Woa, Woshameda, Goemorsa, and Usquruzuare known for processing a quality bulla, and also preferred to their tasty amicho. The short length of arrow for bulla shows its relatively low significance in grouping enset landraces. In general, most of the studied enset landraces were used for preparing amicho ($\approx$ 51%), followed by bulla (50%), processing kocho (41%), and medicine (19%).

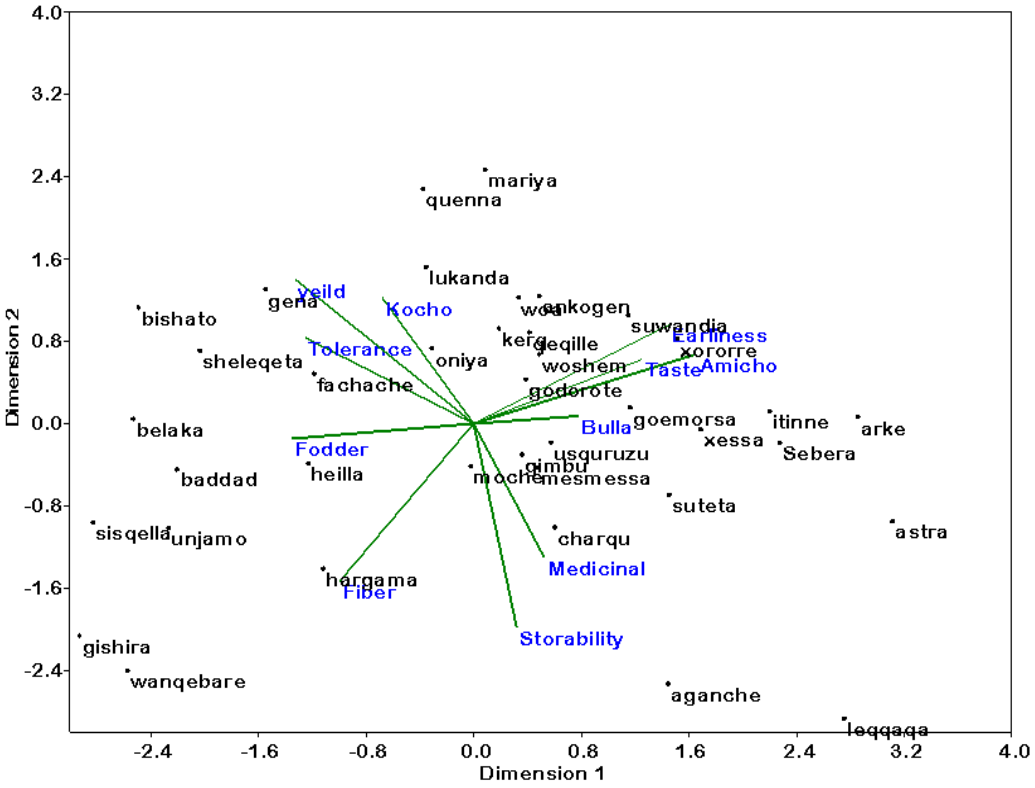

Fig. 1. Ordination of 38 enset landraces based on the end uses obtained from multidimensional preference ranking (Note: Qualities selected for ranking were amicho, bulla, kocho, medicine, fiber, fodder, and tolerance (to drought or EXW).

Medicinal use of enset

Table 5 shows that twenty one enset landraces were identified for their medicinal use. Thirteen enset landraces were known to cure problems of broken bone fractures and joint displacement both in human as well as livestock.

The enset landraces like Laqaqqa is used to heal the boil (a painful infected swelling). The watery liquid squeezed from the pseudostem of some varieties is boiled and the skin is washed to heal fungal disease called ulaama (Tineacorporis), e.g., Hargama and Moche. Qeqilleis uniquely a red coloured variant with abortifacient action, used to expel placenta. The management of such medicinal landraces differs in that they are planted closer to home in order to take care by supplying adequate manure, and to

protect them from pests. Moreover, the processed enset food, called kocho is used against dysentery.

Table 5. Medicinally useful enset landraces used to treat various ailments.

Ailment type	Name of enset variety	Part used	Used for	
			Human	Livestock
Bone setting	Aganche Astra Charquwa Fello Gimbuwa Gishira Ketanne Qeniware Sebera Sheleqoma Xebare Xessa Zinke	Corm	The corm is cooked and fed with milk or it is ground , cooked and butter is added	Fed raw
Boil	Laqqaqa Teresseqa	Corm	Cooked and fed with milk	Not common
Skin fungal problems	Oniya Hargama Moche Wolagella	Pseudostem	Watery liquid squeezed, boiled	X
Afterbirth	Qeqille	Corm	Cooked and	fed raw
Hepatitis	Unjamo		fed with milk	X

Note: X mark indicates the absence of report in livestock.

Non-medicinal use of enset

Table 6 shows non-medicinal multiple uses include human food, livestock fodder and non-food uses. Enset varieties like Gishira, wojuSorphe, wojuQeqille, Aganne, and Wolanche are used to fatten cattle, mainly oxen. But all landraces are not given to cattle because informants declared that if some landraces, for instance, Qeqille are given to a pregnant cow, it results in abortion. Many of the female varieties have large amount of bulla or starch, which may deter digestion and can cause death to cattle, e.g., Buqane is not recommended.

Some landraces are highly recognized by the local people. For example Bishato, Bunache and Usquruzu have high quality kocho from which injera (thin, and flat Ethiopia bread) can be made. Varieties like Abatmerza, Gimbo and Sebera are used to process a high quality kocho from which a traditional food called atakana is made. Atakana is made mainly during the Ethiopian Meskel holiday, which commemorates the finding of the true

cross. Kocho is dried for a month to allow it lose its moisture. Then, it is powdered, baked on flat clay material, cooled, and spiced. Then, it is softened by adding purified butter and milk until it is made to be taken with spoon.

Table 6. Some of the non-medicinal uses of enset.

S. No	Products of enset	Uses	Remark
1	Waasa (Kocho)	Food	Surplus for sale
2	Hamicho (Amicho)	Food	
3	Bu'ula (Bulla)	Food	Mainly for income generation
4	Qancha (fiber)	For making ropes, tying fences, builing houses, bondage, mats	Mainly for sale
5	Habara (leaves)	Bread wrapper, serving plates, and pit liners to store kocho	
6	Hofcho (dried leaf pseudostem and sheaths)	Wrapper for butter and kocho	
7	Halana (pulp from the dried petioles and midribs)	Diaper for babies, brusher	
8	Wesse (all fleshy part of adult enset)	fodder for cattle	Some female named landraces, rich in bulla are abortifacient and excluded

In general, over the course of time, indigenous people in the study area have made enset production a part of their life activity. It is a food to humans, fodder to cattle, medicine to humans and livestock, a source of income, a source of useful materials (e.g., sacks, bags, mats, fiber and sieves), material for building houses and tying fences, ornamental crop around the home gardens, and its ability to reduce soil erosion are some of the important uses of enset, among others. Hence, enset is everything to indigenous people. They describe this in their proverb ‘mini xawahawessewassahalamenobaa’, meaning family issues and kocho are never bored of. That means although kocho is fed often, any one never losses interest to eating it. This shows the strong attachment of the indigenous people to enset plant.

Determinants of enset landrace diversity

Enset based homegardens of the study zone varied in the number and types of enset landraces they held (Table 3). Table 7 shows that the socioeconomic factor primarily off-farm activity and the physical environmental factors (i.e., elevation, access to main road and access to market) have significantly influenced the diversity of enset landraces. Other factors such as age of the HH, TLU, family size (labour force), and cultivated crops diversity did not show any significance though they were

positively correlated to enset diversity (Table 7). However, the landrace diversity increased with decrease in distance to market. This could be related to the benefit that the local people gain by selling various enset products including enset leaves (used to bake breads) to urban areas.

Challenges to enset landrace diversity and indigenous management systems

The enset plant growing in small areas of the home garden is a renowned food security crop. However, most respondents confirmed that the shortage of farmland, influences of vertebrate pests and enset diseases (Fig. 3) are challenging the diversity and production of enset. The focus on fast growing cash crops by young generation is also another emergent challenge. Informants also described that fragmentation of the home garden (farm subdivision) due to large family size resulted into a shift towards short season growing crops, and avoiding less disease/pest tolerant enset landraces.

There is a prudent interaction between enset and livestock in enset farming areas particularly in the highlands where enset serves as a source of fodder, and livestock provide manure to fertilize enset fields. Eighty six percent of farmers stated that there is a shortage of grazing land as well as arable land, which in turn tend to limit livestock number. In addition, about 52% of the farmers described that enset landraces faced difficulties from wild animal pests and diseases, mainly porcupine (79%), Aloya/Gansho (EXW) (9%) (Fig. 3B), the disease called Zi'iraor sheath rot (8%) (Fig. 3A), mealy bug (5%) and the mole rat (4%).

Sixty percent of the informants confirmed that porcupine causes great loss of various enset varieties that are highly preferred to edible corm (e.g., Astra, Aganne, Leqqaqa, and Oniya), medicinal values, quality bulla and Kocho. As a result, many farmers abandoned cultivating highly preferred varieties for they are easily damaged by porcupine. However, there are various methods that indigenous people developed to protect enset from pests and diseases. For instance, methods to protect porcupine include repelling by smoking bones in the crop fields, building stone bench terraces around crop field, filling porcupine holes, deep digging around its den, and adding manure around the victim enset varieties. Farmers also suggested the significance of cooperation of local communities, including neighbour peasant association in the protection of this pest.

Table 7. Multiple linear regression between number of enset landraces, socio-economic and biophysical factors (n=180) (Pearson correlation).

Variables	Enset diversity	Age	Education	Family size	Off farm activity	TLU	Crop diversity	Aspect	Slope	Elevation	Access to road	Access to market	Farm land Size
Enset diversity	_	0.05	0.01	0.06	-0.18*	0.02	0.07	0.1	0.18	0.68**	-0.15**	-0.45**	0.1
Age		_	-0.39**	0.28**	-0.09	0.31**	0.24**	0.04	-0.17*	0.04	0.02	0.11	0.3**
Education			_	0.04	0.27**	0.1	-0.09	0.07	0.1	0.05	-0.14	-0.05	0.04
Family size				_	-0.04	0.37**	0.16*	0.07	-0.01	-0.03	0.01	0.01	0.43**
Off farm activity					_	0.19**	-0.03	0.12	0.03	-0.01	-0.08	0.08	-0.1
TLU						_	0.38**	0.1	-0.2**	-0.09	0.07	0.14	0.71**
Crop diversity							_	0.06	-0.2**	-0.11	0.2**	0.22**	0.31**
Aspect								_	0.08	0.07	0.04	0.02	0.05
Slope									_	0.13	-0.20**	-0.17**	-0.15*
Elevation										_	-0.16**	-0.53**	-0.07
Access to road											_	0.45**	0.05
Access to market												_	0
Farmland size													_

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Note: 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.

Source: (Jahnke, 1982)

Traditional methods that are used to prevent the mole rat include the removal of large grassy crop field margins, trapping, and flooding the mixture of cow and horse dung into its hole. Furthermore, highly recognized enset varieties are planted very close to the home meant to protect from pests. Informants also discussed that though not regularly practiced by all, knowledgeable indigenous people 1). Grow some plants like *Pycnostachys abyssinica* and *Canna indica* near enset plant that is affected by EXW. During the field work, some recovered landraces were observed after planting this species; 2). Plant healthy, disease-free enset suckers, and use clean farm tools, and 3). Remove infected enset from the area and rotate cereal crops to avoid bacterial recycling. But very few farmers use the combination of these methods.

Fig. 3. Commonly observed enset diseases (Photos by Melesse Maryo). A) Zi'ira (sheath rot) forms a freckle like spots that coalesce to form a big one, the leaf sheaths of the pseudostem dries up. It is caused by fungal sp. A plant has an opportunity to recover), B) Aloyaa/Ganshua (EXW) kills a plant.

DISCUSSION

Indigenous knowledge and enset diversity

Although folk botanical nomenclature is not guided by a set of written rules, there are prominent similarities in the way that plants are named by indigenous people around the world as described by Martin (1995). The

classification of enset varieties into male and female based on certain farmer based characterizing qualities such as fiber quality and drought tolerance is in agreement with traditional knowledge from Bonga (Yemane Tsehaye and Fassil Kebebew, 2006) and Kaffa Shaka (Almaz Negash, 2001). This may show either independent development of similar cultures or the diffusion of cultures or both for the management of enset over years. The local people, mainly women provide great care and treatment to female landraces because 1) The varieties are more susceptible to drought, pest and EXW; 2) They are early maturing and can be harvested any time for the household consumption among poor families; and 3) Their products are tasty and have relatively high price. This agrees with earlier study on enset (Asnakech Woldetensaye, 1997).

Farmers sustained diverse range of enset landraces on their home gardens for the landraces could differ in their uses. This agrees with the report of Eyasu Elias (2003) from Ethiopia. The most frequent enset types were male landraces. Similar observation was reported from Sidama by Bizuayehu Tesfaye (2008). The dominance of male enset landraces such as Sisqella, Dirbo and Gishira across the studied agroclimatic zones may be linked with the low susceptibility to diseases and drought conditions, low preference by wild pest animals, and their uses both for human and livestock. Zippel (2005) also stated that farmers in Ethiopia always grow some less favoured landraces that withstand severe weather conditions.

Enset landraces are resistant to drought and disease, which seems a means to cope with uncertain environmental conditions. This was explained by Admasu Tsegaye and Struik (2002) that in a relatively dense enset plantation the leaf canopy conserves soil moisture, suppresses weed growth and reduces organic matter decomposition by reducing soil temperature besides full use of the land. Enset is widely spaced in Dega and Woyna Dega to avoid competition, and enhance leaf branching meant for fodder use and thickness of pseudostem for kocho processing.

More than four decades ago, Taye Bezuneh and Asrat Feleke (1966) reported 70 enset landraces from the whole Ethiopia. Our finding showed 111 enset landraces, which is the highest record documented so far from zonal level in the country. Such deviation could be attributed due to the evolution of new landraces or the method of sampling or both. Other previous reports on enset landrace diversity in the country include 78 from Ari (Shigeta, 1990), 65 from Kaffa Shaka (Almaz Negash, 2001), 42 from Sidama (Tesfaye Abebe *et al.*, 2010), 70 from Kafa (Feleke Woldeyes,

2011), 105 from Gamo Gofa (Sabura Shara and Mulugeta Diro, 2012), and recently total of 66 folk landraces from Kambatta Tembaro Zone (Zerihun Yemataw *et al*., 2016b).

The richness of enset landraces in the current study when compared with the previous studies might be due to the agroclimate condition where mid and highland areas comprise 92%, which are appropriate for enset cultivation. The stratified sampling method that involved different agroclimatic zones as well as different wealth categories probably has also contributed to the high landrace diversity record of the current study. The study zone is bordered by Wolayita, Hadiya, and Dawro zones where the improved infrastructure might have permitted the local people to exchange landraces (sprouts or suckers forms) over the long distances. The exchange of enset landraces from the neighboring ethnic groups and peoples culture to use the diversity for different purpose perhaps made the area to be one of the richest in enset landrace diversity. The significance of the use value based criteria was suggested for landrace diversity maintenance and management (Zerihun Yemataw *et al*., 2016). Enset landrace exchange was reported from Sidama by Bizuayehu Tesfaye and Lűdders (2003). New landraces can also be introduced through trade (Zippel, 2005). Enset landraces are exchanged mostly at *sima* stage (a year-old sucker) or mother corm pieces.

The similarity in enset landrace names among different enset cultivating ethnic groups of southern Ethiopia is shown in Table 4. The similarity in names with or without slight modification may indicate the landrace exchange between different ethnic groups.

The mean number of enset landraces identified at farm level in the present study was nine but Zerihun Yemataw *et al*. (2016b) reported 7.8 from the same study zone. The difference could be chiefly associated with sampling method employed. The corresponding figure from Sidama (Tesfaye Abebe *et al*., 2010) and Gamo Gofa (Sabura Shara and Mulugeta Diro, 2012) was 6 and 7.4, respectively. This shows that farmers of the study area maintain fairly considerable number of enset landraces at individual farmland level. The finding also exhibited that the highest number of enset landraces was recorded from farmscape 1 (AnchaSadicho) with altitude > 2500m asl, and it had also the highest evenness value, showing that the farmscape was characterized by a large number of landraces which are better distributed equally in most sample households of the farmscape.

In general, the current survey can offer information about the level of existing enset landrace diversity and the distribution in KT Zone. It also may serve as a baseline data to allow monitoring of future genetic erosion. The study area differs both in the number and type of landraces across the agroclimatic zones. Farmers in lowland areas mostly cultivate landraces tolerant to drought and disease. However, in highland areas highly diverse enset landraces over relatively wider areas are grown. This finding is in agreement with the work of Asnakech Woldetensaye (1997). Since highlanders grow diverse enset landraces, they use to feed various enset products or the products of enset-cereal mix. This may show the maintenance of enset diversity through use.

Benefits from enset

Eyasu Elias (2003) identified seven medicinal landraces from Wolaita. Similarly, Admasu Tsegaye (2002) reported three medicinal landraces from Kaffa-Shaka Zone and twelve from Hadiya Zone. The other study conducted in Gurage identified eleven medicinal varieties (Worku Nida, 1996). The high number of enset medicinal varieties (total number = 21) of this study area may indicate the knowledge that indigenous people of KT Zone had developed over the course of time towards the efficient exploitation of the diverse enset landraces.

Studies confirmed that enset is rich in calcium, magnesium, potassium, and iron. The concentration of calcium is 36,100 – 39,100 μg/g on dry weight basis (Ayalew Debebe, 2006). Similar study showed that enset products are rich in calcium, and are free of heavy metals (Cd and Pb) (Minaleshewa Atlabachew, 2007). Presumably, the high calcium content, common among certain enset types, must be the quality that contributes to the preference of enset in healing fractured bones. Similarly, a chemical substance called phenylphenalenone, which has antitumour, antibacterial, nematicidic and antifungal activity has been reported from some enset landraces (Hölscher and Schneider, 1998). This indicates that more has to be done on the analysis of nutrient contents of various landraces that may help for the development of food quality as well as modern medicinal treatment. According to Dessalegn Rahmato (1996), during environmental hazards and famine, enset can be harvested and consumed before it is fully mature, though the quality of food may be poor. Such qualities of enset plant permitted enset growing regions to suffer less during famine periods in the past.

DETERMINANTS OF ENSET DIVERSITY

Elevation was the only variable that positively related to the enset landrace diversity. Thus, there was a strong and positive correlation of the number of enset landraces with altitude (Fig. 2). The result is consistent with the study in Sidama (Bizuayehu Tesfaye and Lüdders, 2003). This could be due to relatively optimum temperature and moisture, as well as fertile and well-drained loamy soils in highland areas. For optimum growth, enset plant requires an annual average rainfall of 1100-1500 mm, and a mean temperature of 16-20°C (Taye Bezuneh and Asrat Feleke, 1966). They also described that *E. ventricosum* occurs at altitude from 1500-3100m asl. Similarly, the study zone falls under these ranges.

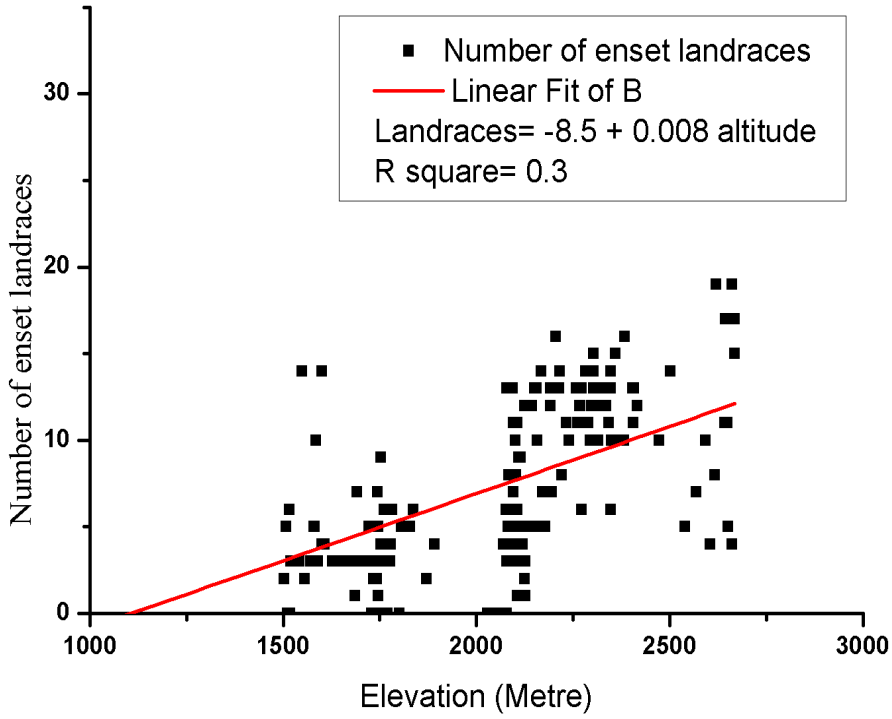

Fig. 2. The relationship between elevation and number of enset landraces in KT Zone.

Our result showed that landrace diversity increased with decrease in distance to market. The finding contrasts with the hypothesis that associates market isolation with higher levels of crop diversity (Van Dusen and Taylor,

2005; Winters *et al*., 2006). But other studies reported that farmers cultivating in close proximity to major market centers maintain relatively high levels of crop diversity (Perales *et al*., 2003; Sthapit and Shrestha, 2006). On the other hand, enset landrace diversity found to decrease with increase in exogenous income (e.g., trading). This finding is consistent with the report by Brandt *et al*. (1997).

Enset diversity decreases with increase in off- farm activity. This could be because enset cultivation is an incessant labour seeking activity. Any interruption in enset growing activities may affect its diversity and production. Another worker also affirmed that exogenous income could contribute to significant losses in crop genetic resources (Isakson, 2007). It was shown that the growing prevalence of exogenous income undermined the cultivation of maize genetic diversity in Mexico (Fitting, 2006). Van Dusen and Taylor (2005) also discussed that households located in communities where a greater percentage of agricultural tasks are performed by hired labour tend to plant fewer crop varieties.

Finally, there was a remarkable correlation between on-farm diversity of enset landraces and the house hold characteristics of the better off (Table 1). Wealthy farmers grow more enset landraces which is in accord with an earlier finding in south western Ethiopia (Almaz Negash and Niehof, 2004). This could be attributed to the possession of large landholding. They also have an aptitude to manage environmental risks that might affect enset production as described by Isakson (2007). That means the status of these households to maintain the sanitary measures as a means to control enset disease plus methods used to protect enset pests might be significantly higher.

Problems related to enset management

Our study indicated that the scarcity of farmland influenced enset landrace diversity. The study on Gamo highland (Cartledge, 1999) also agrees with this finding. Enset farming requires high fertilizer application, which can only derived from livestock manure. Limiting the livestock number per household in turn affects the enset farming system (Brandt *et al*., 1997). Brandt *et al.* (1997) also expressed that the decrease in livestock and manure may cause reductions in yields and soil fertility, thereby reducing the long-term sustainability of the enset system. Likewise, the shortage of agricultural land was stated as a challenges to enset production that caused the young generation to rely on cash crops other than enset This was also described by other studies (Almaz Negash, 2001; German *et al*., 2012).

Enset diseases and pests were more common in the highland areas but mealy bug (Fig. 4a) was dominant in the enset fields where moisture is less available. It was reported that sheath rot in enset is caused by bacteria (Quimio, 1991). Fifty five percent of the farmers affirmed that among wild mammalian pests that damage enset, porcupine stood the first, which is followed by mole rat. Previous study also indicated that 97% of the farmers reported attack to enset by pest like porcupines and moles to be the leading followed by EXW (Shiferaw Tesfaye, 1996). Other studies also emphasized that vertebrate pests and EXW to be threats to enset production (Million Tadesse *et al*., 2003; Bizuayehu Tesfaye, 2008; Abrham Shumbulo *et al*., 2012). More recently, enset diseases and enset damaging wild animals were also reported as the major production constraints in the Gamo highlands in Ethiopia (Teshome Yirgu, 2016).

Fig. 4. Enset plantation loss due to mealy bug and EXW disease.

Cultural sanitary activities against enset disease and pests management methods used by some local people should be integrated into scientific approaches to effect sustainability of enset landrace diversity. Disinfecting farming tools, uprooting and burning the infected enset plants, keeping fields and surrounding areas free of weeds, exposing the soil during dry season prior to planting, proper spacing, avoiding overflow of water from

infested to uninfected fields, controlling porcupine, mole rat, and other domestic animals from browsing, use of clean planting materials, rotation of crops, and use of resistant/tolerant landraces were suggested as the management package used and promoted country in the past (Zerihun Yemataw *et al*., 2016).

Similarly, one study confirmed positive effect of *Pychnostachis abyssinica* against the parasitic bacteria (Kidist Bobosha, 2003). Therefore, these are the indications of the need of scientific investigation of the indigenous knowledge and practices for the future controlling measures. Informants claimed that there is little or no extension package that enables development workers at kebele level to benefit farmers in managing enset diversity. It was stated that subsequent training given to farmers and extension workers enhance farmers' understanding about Enset Xanthomonas Wilt (EXW) means of transmission and ultimately disease prevention and control options (Zerihun Yemataw *et al*., 2016).

CONCLUSON

Kambatta people possess rich traditional knowledge on enset landrace diversity, namely naming, using the diversity for different purposes, conserving, etc enset landraces. This is associated with people's rich culture of using enset landraces for various uses developed through ages. For instances, about twenty percent of all the identified landraces were used to treat various human and livestock ailments, which is the highest report in the country. The exchange of planting materials with neighbouring ethnic groups, and the pertinent agroclimate affect growing enset. The diversity of enset landraces is directly correlated with socioeconomic aspects of households such as the size of farmland, family size and the size of tropical livestock units. However, the diversity was found to increase with altitude ranging from 2000 to 2500 m a.s.l. whereas the density of enset landraces was increases with decrease in altitude. This is because at higher altitudinal areas there is a wider spacing between enset crops to enhance leaf branching for animal fodder as lowlanders increase the density to counteract the loss due to unfavorable environmental conditions.

Nonetheless, there are significance challenges that could hamper enset diversity and its productivity, particularly, scarcity of farmland and young farmers trend to focus on short season growing crops and other cash crops, continuous land fragmentation across generation line, enset bacterial wilt, mainly in highland areas, wild pests such as porcupine, mole rat, and mealy bug.

Many traditional methods of mammalian pest management method include flooding a water mixed of cattle manure, and removing grassy area from crop field that may encourage mole rat multiplication. Moreover, some plant species such *Pycnostachys abyssinica* and *Canna indica* were found effective against the impact of *Xanthomonas campestris* when grown near to enset plant. Thus, the biocontrolling activities of such plants should be evaluated. Similarly, phytochemical analysis of the examined landraces of medicinal significance should be assessed to recognize their medicinal properties.

Still, there is need to encourage livelihood diversification among farmers with very small plots of farmland. The kebele extension workers in enset growing areas should have a special training program that capitalizes on enset diversity and its management in order to assist farmers to apply integrated methods in protecting enset landraces against enset disease and pests, maintenance of enset diversity and maximizing enset productivity. They also need to have a mandate to facilitate the exchange of better clones/varieties within peasant associations and peasant associations to maintain landrace diversity. In order to protect and conserve the diversity scholars in ethnobotany, microbiology and genetics should work together for a realistic workable solution. Appropriate attention should be given by the Ministry of Agriculture and Natural Resources to incorporate enset crop in the current extension system. The extension workers who will train in enset agriculture will help farmers in the maintenance of landraces diversity, in pest and disease controlling activities.

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