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Research Article

On-Farm Diversity of Enset (*Ensete ventricosum* (Welw.) Cheesman) Landraces, Use, and the Associated Indigenous Knowledge in Adola Rede District, Guji Zone, Oromia, Ethiopia

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Background. Enset (*Ensete ventricosum* (Welw.) Cheesman) is an important staple crop for more than 20 million people in Ethiopia. Precise ethnobotanical information of intraspecific enset diversity and local knowledge on how farmers maintain, manage, and benefit from enset genetic resources is imperative for the promotion, conservation, and improvement of enset and its farming system. The aim of this study was to identify and document the wealth of indigenous knowledge associated with the distribution, diversity, and management of enset in Adola Rede District. *Methods*. The study was conducted in Adola Rede District of Guji Zone, Oromia, Ethiopia. To identify and document the wealth of indigenous knowledge, the data were collected mainly through individual interviews and observation with 139 farm households and key informant interviews. *Results*. Thirty-four landraces were identified. The number of landraces cultivated in individual households ranged from 3 to 14 (mean of 6.08 ± 2.17). The farmers distinguish landraces primarily using morphological features such as pseudostem color, midrib color, plant height, and leaf color. Agronomic characteristics such as resistance to disease and pest and maturity time were secondary criteria for the identification of enset landraces in the study area. Enset is mainly used as food (kocho, bulla, and amicho) and source of fiber, and it has also medicinal value for both humans and livestock. Farmers prefer a landrace to the other, for example, Gantichoo for *worqee (kocho)* and fiber, *Adoo* for *budhaa (bulla)*, *Nimfoo* for amicho, and *Astaraa* for medicinal use. The majority of the informants (74.10%) have got their plant material by multiplying planting material by themselves, exchanging with neighbors (16.50%), and purchasing from the market (9.40%). *Conclusion*. There was relatively high on-farm enset landrace diversity, and the indigenous people had a long tradition of enset cultivation, conservation, and maintenance of landraces in the district. The information is crucial for developing community-based complementary in situ and ex situ conservation strategies to foster conservation of enset genetic resources and associated indigenous knowledge system.

1. Introduction

Enset (*Ensete ventricosum* (Welw.) Cheesman) belongs to the family Musaceae and the genus Ensete. Also known as the "false banana," enset is a giant herbaceous perennial monocarp that accumulates standing biomass and can be harvested at any time prior to flowering and senescence (~7–12 years) [1]. Geographically distributed as a wild species in many parts of sub-Saharan Africa and Asia [2–5], enset is cultivated only in its native indigenous farming systems of south and southwestern Ethiopia [5–8]. In fact, in Ethiopia, *E. ventricosum* is arguably the most important crop, contributing to food security and rural livelihoods for more than one fourth of the country's population [4, 5]. Enset is among the highest yielding crops per hectare in the region, while vegetative propagation enables rapid multiplication of favorable genotypes [7]. A recent study by Koch et al. [5] indicated contemporary bioclimatic suitability for a 12-fold range expansion, equating to 21.90% of cropland and 28.40% of the population in the region. Integration of crop

wild relative diversity, which has a broader climate tolerance, could enable a 19-fold expansion, particularly in dryer and warmer regions. While climate change may cause a 37–52% reduction in the potential range by 2070, large centers of suitability remain in the Ethiopian Highlands, Lake Victoria Region, and the Drakensberg Range [5].

Enset domestication dates back to Neolithic time or even earlier [6, 9, 10], and its farming system is regarded as one of the few ancient and sustainable agricultural systems in Africa [11, 12]. An estimated land area used for enset cultivation is over 300,000 hectares of land, one of the largest areas for perennial food crops in the country [4, 13, 14]. Historical production data show that the area of land under enset production in Ethiopia has reportedly increased 46% in two decades, while the yield increased 12-fold over the same period, making enset the second most produced crop species in Ethiopia [7].

Indigenous people in southern and southwestern Ethiopia have a rich knowledge of enset, accumulated over millennia, which plays a significant role in the characterization and maintenance of the existing genetic diversity of this crop [4–6, 13, 14]. Farmers can differentiate enset landraces based on morphological characteristics, such as the color of petiole, midrib and leaf sheath, angle of leaf orientation, size, and color of leaves, circumference, and length of pseudostem [7, 13–15]. Enset is one of the crops that have many landraces. These landraces exhibit variations in morphology, agronomical features, and resistance to biotic and abiotic stress, and farmers could identify and subsequently give folk names to them. Besides, different landraces are recognized to have a characteristic adaptation to edaphic factors, which reveal an individual response to the time of seeding and have typical days to maturity, height, nutritive value, use, and other properties [13, 14, 16–18].

Enset successfully supports very high rural population densities and has the highest yield per hectare of regional crops [7]. The productivity of enset is threatened by several factors such as degradation of the soil due to increased population pressure, which is associated with more extreme cultivation and changing environmental temperatures [4–7]. In this regard, enset cultivating farmers mention different factors for reduction enset productivity, for example, pest and diseases, in Wolaita and Hadiya zones, and climate change in Kembata–Tembaro [19]. Enset cultivation is also susceptible to various diseases caused by fungi, bacteria, viruses, nematodes, and pests. Bacterial wilt disease, caused by *Xanthomonas campestris pv. musacearum* (Xcm), is the major constraint on main enset-producing areas and is responsible for the reduction in productivity [6, 13, 14, 19–21].

Enset is a multipurpose crop with both food and nonfood use values. The major food types obtained from enset are kocho, bulla, and amicho. Upon harvesting, the entire pseudostem and corm are processed to extract starch, which is fermented and stored until required for consumption [22]. Kocho is fermented starch obtained from decorticated (scraped) leaf sheaths and grated corms. Bulla is obtained by squeezing out the liquid containing starch from scraped leaf sheaths and grated corm and allowing the resultant starch to concentrate in white powder. Amicho is a name given to the corm of enset, mainly obtained from young enset plants that are prepared and consumed in a similar manner to other root and tuber crops by boiling [4–6, 13, 14]. The nonfood use value enset includes traditional medicine (for both human and livestock diseases), aesthetic, spiritual/ritual, livestock feed, fuelwood, construction materials, containers, provider of shade to intercropped annual or perennial crops, and as alternative income sources [6, 13, 14, 18, 21]. Precise ethnobotanical information on intraspecific enset diversity and local knowledge on how farmers maintain, cultivate, propagate, manage, and benefit from enset genetic resources is imperative in the promotion, conservation, and improvement of enset and its farming system. In this regard, a couple of studies [13–19] had been conducted to document the wealth of indigenous knowledge associated with folk naming, classification, distribution, abundance, and conservation of enset landraces in enset-growing cultures in Ethiopia. However, to the best of our knowledge, there have been few or no attempts done so far to investigate enset landrace diversity, cultivation, propagation, management, and associated indigenous knowledge in Adola Rede District. Therefore, this study addresses the following main question: what is farmers' knowledge associated with the distribution, diversity, cultivation, propagation, and management of enset landraces in Adola Rede District?

This study aimed to investigate the diversity, distribution, and abundance of enset landraces, to identify and document associated indigenous folk knowledge of naming, classification, and understanding of the corresponding knowledge related to utilization, management, and conservation of enset landraces.

2. Materials and Methods

2.1. Description of the Study Area. Adola Rede District is located in Guji Zone of Oromia State, Ethiopia. Geographically, the district lies between longitude E 38° 40′ and E 39° 10′ and latitude N 5° 40′ and N 6° 10′, and lies in an altitudinal range from 1350 to 2340 m asl (Figure 1). It is located at 468 km south of Addis Ababa, the capital city of Ethiopia. The district contains 28 rural kebeles and three urban kebeles [23]. The study area is believed to have ample genetic diversity and local knowledge on the use and management of enset. However, no comprehensive work was done so far to research the wealth of indigenous knowledge associated with folk naming, classification, distribution, abundance, cultivation, propagation, and conservation of enset landraces in Adola Rede District.

2.2. Methods of Data Collection. During the survey, leaders of the kebeles and development agents working in each kebele assisted us in producing the list of farmers growing enset. Based on the discussion with stakeholders, six kebeles (Anfarara, Biloya, Dole, Maleka, Masina, and Sakaro) were selected.

Diverse data collection methods were employed to understand the many features for the acquirement of local

knowledge of enset naming, classification, diversity, cultivation, propagation, and management in the study area. The data collection was conducted mainly through individual interviews and direct on-farm participatory monitoring and observation, and key informant and focus group discussions. From the targeted population, the sample size ($n = 139$ households) was determined by the formula provided by Taro [24]. From the list, informants were selected randomly, and this random sampling permitted all wealth categories to be represented. All of the interviews were held based on a checklist of the questions prepared in English language and translated into Afaan Oromo (native language). The questionnaire covered different topics such as information about the study area, landholdings, crops commonly grown, and specific information on the use and management of enset. The detailed information was focused on enset diversity, cultural practices, source of planting materials, and traditional use values of enset. The respondents were also asked about their perception of enset production constraints and their indigenous knowledge about the disease. To assess the general indigenous knowledge of farmers in the study area: key informants up to five per kebele, community leaders, and local administrations were interviewed. The educational levels of the informants include local farmers with no formal reduction (42.4%), basic education (17.30%), primary education (33.10%), and high school education (7.20%). Interviews were conducted with the head of the household or the person responsible for the maintenance of the enset plantation [13, 14, 21]. During field observation, the altitude, longitude, and latitude of each household's farm were taken by GPS (GPS-72h).

2.3. Ethnobotanical Analyses. Collected survey data were subjected to descriptive statistics (frequencies, percentages, and average). Landrace richness, diversity, and dominance per farm were also calculated. Richness was calculated as the total number of landraces per farm and averaged this figure per kebele. Abundance was calculated as the total number of individual plants of each landrace per farm/household. Frequency was estimated as the number of individuals of landraces with respect to the total number of landraces composing the enset farm.

Preference ranking, direct matrix ranking, pairwise ranking, and group discussions were conducted following the method described by Martin [25]. Cluster analysis was performed using *past3 exe* [26] for classification enset landraces. The Simpson and Shannon diversity indices were calculated for all the kebeles. Simpson's index (D) measures the probability that two individuals randomly selected from a sample belong to the same category [27]. The indices were computed using the function:

$$\text{Simpsons's Diversity Index}\,(1-D) = 1 - \sum \left(\frac{n}{N}\right)^2, \quad \sum_{i=1}^{n} \frac{\text{ni}\,(\text{ni}-1)}{N\,(N-1)}, \tag{1}$$

where ni = the frequency of the i^{th} landraces, frequency being the number of farms in which the landraces were found in the kebele, and N = the total number of farms surveyed in the kebele.

The frequency distributions were used to calculate the Shannon–Weaver diversity index (H′) for each character as per the formula suggested by Hennink and Zeven [28]. For a K class trait, the observed normalized Shannon–Weaver diversity index (SWDI) is given as follows:

$$H' = -\sum \text{pi} \ln \text{pi}, \tag{2}$$

where pi = the proportion of landraces + relative to the total number of clones or $pi = (\text{ni}/N)$.

The Shannon–Weaver diversity index takes into account both numbers and evenness of categories considered and can be increased either by greater evenness or by more unique species or landraces [29]. Evenness was calculated separately as a measure of the observed diversity to the maximum diversity. It is defined by the function.

$$E = H' \ln S, \tag{3}$$

where H' is the Shannon index and S refers to the number of landraces described in each kebele. High evenness resulting from all landraces having equal abundance is normally equivalent to high diversity [30]. Measures of similarity/variation are almost as numerous as measures of species diversity. The purpose of these functions is to quantify the similarity between two or more sampling sites. The variation expected in landrace composition that exists between kebeles was calculated using the similarity coefficient [31], which is as follows:

$$\text{Cs} = \frac{2J}{a+b}, \tag{4}$$

where a is the number of landraces at kebele A, b is the number of landraces at kebele B, and J is the number of landraces common to both locations.

3. Results and Discussion

3.1. Diversity, Distribution, and Abundance. We have documented 34 folk varieties (landraces) (Table 1). The number of landraces cultivated on individual households ranged from 3 to 14 (mean of 6.08 ± 2.17) (Table 2). The majority of respondents, 70.50%, cultivated 3–6 landraces, 26.60% of informants grew 7–10 landraces, and the rest (2.90%) of the farmers had 11–14 landraces. Higher variations between the minimum (3) and maximum (14) values of enset landraces per household were observed in *Anfarara*. The highest numbers of landraces (31) were recorded in *Anfarara,* whereas the least were recorded in *Maleka* and *Dole*. According to the informants, the inhabitants of *Anfarara* had Gedeo cultural heritage and have a long tradition of cultivation, processing, and using enset for different purposes. Our result also indicated that farmers from *Anfarara* exchange planting material with their relatives from the neighboring Gedeo Zone. The numbers of landraces documented in this study are comparable to that of a study conducted by Jarso [32] who reported 33 landraces in three districts in Gurage Zone.

Table 1: Name of enset landraces based on farmers naming in Adola Rede District.

No.	Landrace name
1.	*Gadimee*
2.	*Cacaa*
3.	*Diimaa*
4.	*Adoo*
5.	*Gantichoo*
6.	*Bobe'aa*
7.	*Astaraa*
8.	*Muundoo*
9.	*Nimfoo*
10.	*Miqichamaa*
11.	*Qararsee*
12.	*Qoshee*
13.	*Waanqoree*
14.	*Kakkee*
15.	*Wa'ee*
16.	*Dikkoo*
17.	*Alattaa*
18.	*Buusaa*
19.	*Ji'aa*
20.	*Tooramee*
21.	*Dinkee*
22.	*Qoomaa*
23.	*Damballee*
24.	*Leemaa*
25.	*Shaanyaa*
26.	*Aganaa*
27.	*Dinnee*
28.	*Astaraadii*
29.	*Haadhafacce*
30.	*Gosalloo*
31.	*Bulultoo*
32.	*Bonaqii*
33.	*Birraa*
34.	*Bulloo*

Table 2: Landrace diversity in study kebeles expressed as richness and evenness.

Kebeles	Biloya	Maleka	Sakaro	Anfarara	Masina	Dole
Landrace S	22	13	20	31	28	13
Dominance	0.08	0.13	0.10	0.07	0.08	0.12
Simpson 1-D	0.91	0.86	0.89	0.92	0.91	0.87
Shannon H	2.74	2.23	2.54	2.93	2.91	2.27
Evenness	0.71	0.71	0.63	0.60	0.65	0.74
Individual	170	123	130	190	151	81

However, the richness is lower compared with 68 landraces [33], 65 landraces [34], 67 landraces [13], 52 landraces [35], and 55 landraces [36] observed in enset-growing areas of south and southwest Ethiopia. A higher number of landraces were observed in this study compared with 26 landraces in Hula District, in Sidama Region [21]. It is evident that the enset crop and its farming have huge nutritional, sociocultural, medicinal, environmental, and economic values, and if promoted, it could highly contribute to sustainable food security and poverty reduction in enset-producing areas and beyond [4, 5, 13, 14, 21, 22].

The diversity indices indicated the existence of variations in both richness and abundance of landraces across the study kebeles (Table 2). Anfarara has the highest Simpson diversity and Shannon H followed by Masina. The Simpson diversity index values ranged between 0.86 (Maleka) and 0.92 (Anfarara) with the mean value of 0.89 ± 0.02. The high diversity index at Anfarara suggests that the area is dominated by different landraces, whereas Maleka had a few landraces. A mean value of 0.89 showed that all the selected kebeles were different in the richness of enset landraces per household. The evenness showed a narrow range (0.60 to 0.74) between Anfarara and Dole, respectively, with the mean value of 0.67. 67% relative evenness indicates that enset landraces are evenly or uniformly distributed throughout the district. The Shannon H value ranged between 2.23 (Maleka) and 2.93 (Anfarara) with the mean value of 2.6 ± 0.30. In Anfarara, the Shannon H was the highest and has a more even abundance of the species than Maleka. Ymataw et al. [14] reported Simpson's index between 0.97 (Dawro) and 0.90 (Gedeo), $H' = 3.71$ for Dawro, $H' = 2.60$ for Gedeo, whereas evenness had a very narrow range: 0.89 for Gurage to 0.80 for Gedeo. The Shannon H value, observed at Anfarara in this study, is comparable to that of Gedeo corroborating the hypothesis of planting material exchange between farmers at the two locations.

The similarity between pairs of kebeles ranged from 0.54 to 0.84 with a mean of 0.66 ± 0.09 (Table 3). 0.84 similarity coefficient was recorded between (*Masina*, *Anfarara*) and (*Masina*, *Biloya*). The reason for this similarity could be due to their closeness and exchange of planting materials. Sharing of planting material is common practice among enset growers in different parts of southern Ethiopia [16, 37].

The study site had different landraces with different abundance and distributions. Of the 34 enset landraces, seven enset landraces (*Adoo*, *Astaraa*, *Diimaa*, *Gadimee*, *Gantichoo*, *Muundoo*, and *Nimfoo*) were reported from all selected kebeles, yet with different frequencies. These 7 landraces were widely distributed and dominant in the study area. Six landraces namely *Cacaa*, *Damballee*, *Kakkee*, *Leemaa*, *Qararsee,* and *Qoshee* were recorded at five kebeles, while two landraces (*Astaraadii* and *Bulloo*) were observed in a single kebele. The *Gantichoo* landrace was recorded in all households, followed by *Adoo,* which is recorded in 134 households. According to the informants, these landraces are disease-resistant and gave high-quality *budhaa*, worqee, and fiber, thus widely distributed in the study area. The two landraces are also common in Sidama Region due to their high yield and quality of kocho and also their better resistance to environmental stresses [21, 36]. The selection criteria for household use include quantity and quality of food products, maturation period, disease and drought tolerance, forage and fiber quality, and medicinal value [38]. However, landraces such as *Diimaa*, *Muundoo*, and *Nimfoo* were the next frequent ones, while the least frequent folk variety was *Bulloo*.

3.2. Identification, Nomenclature, and Classification. Our results indicated that farmers in the study area had rich knowledge that is accumulated over many years, which plays

Table 3: Sorenson's similarity index values for enset landraces in study kebeles.

Kebele	Biloya	Maleka	Sakaro	Anfarara	Masina	Dole
Biloya						
Maleka	0.62					
Sakaro	0.66	0.72				
Anfarara	0.75	0.54	0.78			
Masina	0.84	0.58	0.66	0.84		
Dole	0.62	0.61	0.58	0.59	0.58	

a significant role in the naming, characterization, and maintenance of the existing genetic diversity. The most frequently mentioned descriptors for the identification were pseudostem color of 41.00%, midrib color of 33.10%, the importance of the enset landraces of 18.00%, and agronomic characteristics of 7.90%. Enset-producing farmers have their own folk naming and classification system to distinguish one landrace from the other. The classification of enset landraces had been accompanied by phenotypic differences, unique traits, and specific uses of landraces (Table 4). Based on the information collected from the farmers, the primary criteria for identification of landraces were morphological features such as pseudostem color, midrib color, plant height, and leaf color. Agronomic characteristics such as resistance to disease and pest and maturity time are secondary criteria for the identification of enset landraces in the study area. The farmers in the study area also identify their enset landraces based on the use values such as bulla (*budhaa*), kocho (*worqee*), amicho quality, and medicinal value. Studies conducted in Gedeo, Hadiya, Sidama, and Wolaita indicate the use of morphological features (e.g., pseudostem, midrib, leaf, and petiole features) to identify landraces [13, 14, 21, 32, 33]. Farmers in Wolaita area identify landraces they grew, most frequently using leaf color, plant size, and pseudostem color [13]. Local people in south and southwestern Ethiopia also use three morphological characters (midrib color, petiole color, and leaf color), growth attributes (vigor, maturity), disease resistance and use value (kocho yield and quality, bulla quality, amicho use), fiber quality, and medicinal value to identify enset landraces [14].

Enset-producing farmers have their folk naming system to distinguish one landrace from the other. Local farmers give a vernacular name for each landrace. The naming of landraces is the second step that farmers ensure next to the identification. Our result indicated that farmers in the study area give a specific name for each landrace that is available in their locality (Table 4). The names come from different characteristics of the plant material such as unique morphology, place of origin, flavor, and quality of food, disease resistance, and use of the landraces. Names are descriptive and reflect variations of landraces' places of origin, morphology, and cooking characteristics [13].

The major criteria for the classification of enset landraces in the study area depended on domestication, use value, and nature of plant (hardness and softness). During the survey, wild ensets were observed at *Biloya* kebele near the forest area. The local people named the wild enset "Wessi Waaqqaa," which means God's enset. The wild enset has similar morphology to that of cultivated enset but does not ferment quickly and has poor kocho (*worqee*) quality. According to some informants, during drought season some people use wild enset as a source of food and feeding their cattle.

Based on the nature of plant, enset crops are classified as soft and hard (Table 5). The farmers named soft enset landraces Muklaafee—means soft and highly susceptible to disease, while the hard enset landraces called Jabaa— means hard and disease-resistant. Furthermore, the soft enset is early maturing, whereas the hard enset is late maturing and hard during processing. Farmers in Gurage area also classify enset landraces based on maturation time, plant size, and hardness during processing [39]. Olango et al. [13] identified three gender categories for enset landraces, i.e., female, male, and an ambiguous sex designation, in Wolaita Zone. Female landraces are less vigorous, susceptible to disease, have a higher kocho quality, and produce edible and tasty amicho [34]. On the contrary, farmers in the study area did not classify enset landraces as "male" and "female." Studies conducted elsewhere [33, 40] classify enset landraces based on the production, maturation time, size of enset, and male and female types.

3.3. Cluster Analysis. Hierarchal cluster analysis grouped the enset landraces into five clusters (Figure 2) based on morphological traits—pseudostem color, midrib color, plant height, leaf number, leaf width, and pseudostem circumference and agronomic traits—disease-resistant and maturity time.

Cluster A: this cluster contains 4 (11.76%) enset landraces and is characterized by having a light yellow-green pseudostem color and having dark brown midrib color, intermediate maturity time, highly susceptible to disease, medium plant height, intermediate pseudostem height and circumference, leaf width, and leaf height and many numbers of the leaves.

Cluster B: this group includes 6 (17.64%) landraces, having a dark red pseudostem color and having light red midrib color. This encompasses landraces with shorter plant height, which are highly susceptible to disease and pests and early matured. Four landraces used as medicinal value were included in this cluster. All landraces categorized under this cluster were high quality in amicho.

Cluster C: this cluster was the second highest group composed of 10 landraces accounting for 29.41% of enset landraces and is characterized by having light green pseudostem color and deep green midrib color. This group was categorized by having medium plant height, short pseudostem, among all clusters, susceptible to diseases, and early maturity time.

Cluster D: this cluster had 12 landraces, representing 35.29% of tested enset landraces. The landraces grouped under this cluster have green-colored pseudostem with green midrib color. This group was characterized by early maturity time, highly susceptible

Table 4: Landraces names, associated meaning, and sources/origin of the names.

SN	Name	Associated meaning	Source/origin
1	*Ji'aa*	Shine like a sun	Sun
2	*Diimaa*	Have red pseudostem color	Color of pseudostem
3	*Shagnaa*	It similar to fresh ox meat	Ox (animal)
4	*Adoo*	Contains white spot at the back of the leaves	Color (Sidama)
5	*Agena*	Shine during the night on the moon	Moon (Gedeo)
6	*Mundo*	Blood-like drops during the leaf cut	Blood (Gedeo)
7	*Gantichoo*	Disease-resistant and hard in processing	Hardness (Gedeo)
8	*Nimfo*	Thin and longer in height	Physical
9	*Bulloo*	Contains visible color on the body	Physical and color

Table 5: Farmers' descriptors for the classification enset landraces in Adola Rede.

SN	Criteria	Soft (*Muklaafee*)	Hard (*Jabaa*)
1	Maturity	Early mature	Late mature
2	Fibrosity	Low quality of fiber	High quality of fiber
3	Size	Small in size, pseudostem height, and pseudostem circumference	Large in size, pseudostem height, and pseudostem circumference
4	Disease resistance	Very susceptible to disease and pests	Highly resistant to disease and pests
5	Period of fermentation	Quickly fermented	Slowly fermented
6	Quality of amicho	High quality in amicho	Less quality in amicho

to disease and high plant height, pseudostem height, leaf height, leaf width, and numerous leaf number followed by cluster E.

Cluster E: a member of this cluster comprises only 2 (5.88%) enset landraces. Landraces in this group encompass two-colored pseudostem with light red and yellow-green with light green and light red midrib color. This group of enset landraces was unique from another cluster by having late maturity, highly resistant to disease and higher plant height, pseudostem height, high width of pseudostem circumference, leaf height, leaf width, and numerous leaf number.

Cluster analysis demarcates genotypes into clusters, which exhibit high homogeneity within a cluster and high heterogeneity between clusters [41]. Yamataw [42] had found five clusters for 387 landraces collected from eight enset-growing areas in south and southwestern Ethiopia. The clusters are characterized by a specific morphological or agronomic feature or a combination of both. For instance, landraces grouped under cluster I are characterized by intermediate maturity time, plant height, pseudostem height, pseudostem circumference, leaf sheath number, and fermented squeezed kocho yield per hectare per year. This indicates the potential for the use of morphological traits to classify landraces according to their similarities/differences using cluster analysis. Hence, the selection and crossing of enset germplasm landraces included in different clusters would provide greater heterosis in enset breeding program in Ethiopia [42].

3.4. Cultivation System and Propagation of Enset. During the survey, a similar way of enset management and propagation was observed in the study area. Based on the information obtained from respondents, they cultivated enset mostly in their home garden (84.90%) and main field (15.10%). Most of the farmers practiced intercropping 53.20%, sole cropping 25.20%, multiple cropping 20.10%, and boarder cropping 1.40%. Intercropping and multiple cropping with vegetables (e.g., hot pepper, cabbage, and brassica) and fruits (e.g., banana, avocado, khat, coffee, and apple) are common practices in the study area. The farmers also grew enset in the main field as sole cropping. Also, farmers in Gurage Zone [32] and in Shekicho area [33] practice sole cropping followed by intercropping. According to the informants, intercropping and multiple cropping way of cultivation was associated with the limitation of farmland. The respondent farmers asserted that enset crop can shade other plants around it, especially coffee and tuber crops.

Our results revealed that all farmers use vegetative reproduction to multiply enset landraces. The informants reported that enset is reproduced from the corm of immature enset by removing the lower part of pseudostem attached to the corm, roots, apical bud from the center of the corm. During the cutting of the corm, some of the farmers cleaned their knife by direct heating on the flame to protect enset disease transmission. The farmers had also stated that the cutting of mother corm took place from January to February. In Sidama, the propagation of suckers is carried out from October to November [21], whereas in Kembata and Gurage, the propagation is usually done from December to January [43]. The mother corm is divided into four parts depending on the size of the corm to avoid water accumulation at the center where the apical bud was removed (Figure 3). The prepared corm is buried in the soil for 3–4 months. During May-June (first rain season), the suckers started to appear. Depending on the size of the corm, on average 30–100 seedlings (suckers) were obtained from a single mother plant. Shumbolo et al. [15] pointed out that all farmers do not get equal numbers of seedling from mother

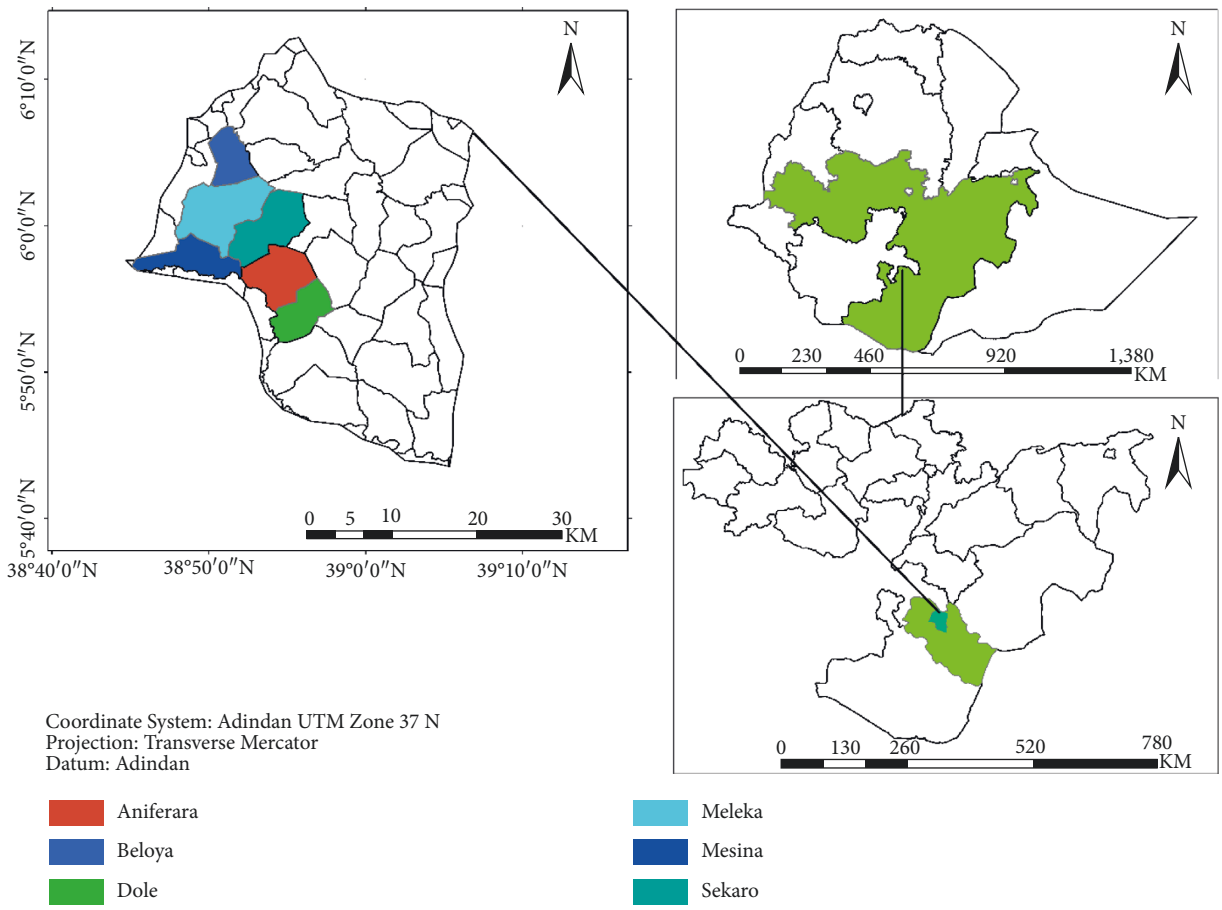

Figure 1: Location of the kebeles in Adola-Rede District, Guji Zone of Oromia Region, Ethiopia.

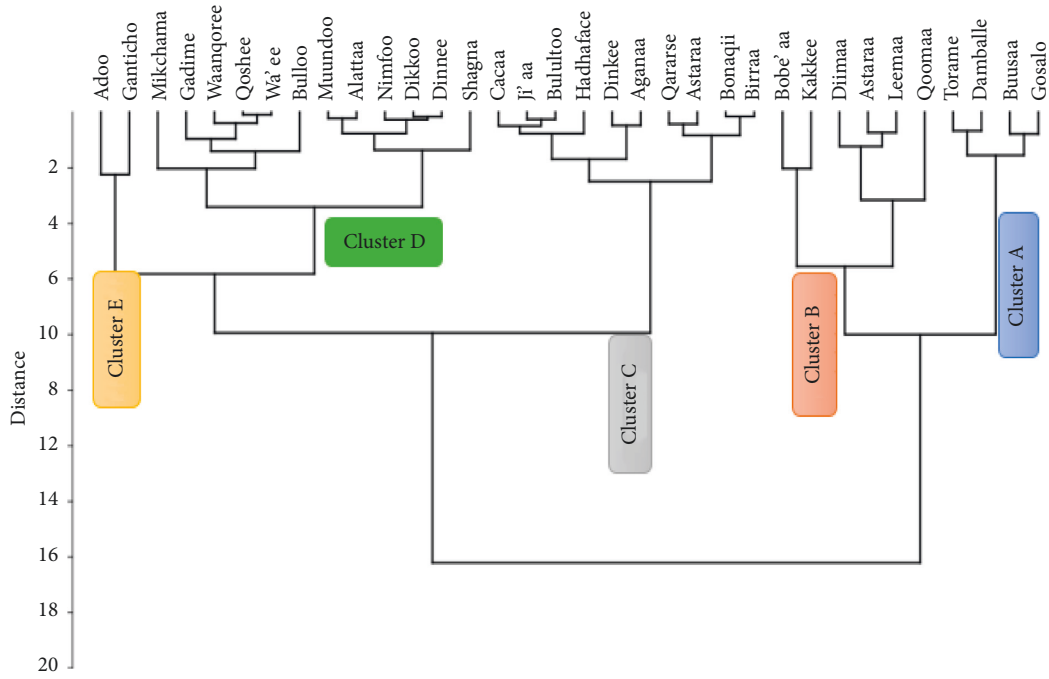

Figure 2: A dendrogram showing the clustering pattern of 34 enset landraces collected from the study area.

enset plant. The suckers of enset are usually transplanted a couple of times in the nursery until planted in the permanent field. However, in the study area the frequency of transplanting is usually two to three times. In Sidama, transplantation is done once at a time even if the growing stages were different [44]. Ayenew et al. [40] stated that after three times the seedling was transplanted into the main field. However, a couple of studies [14, 32, 37] disclosed that the frequency of uprooting is usually three to four times.

Informants stated that five-month-old suckers called Funtaa would be parted and transplanted in group to the prepared hole. The first transplantation stage of enset plant is locally called *Funtaa* (Figure 3). Each cycle of seedling transplantation had its own name, and the second transplantation is called *Simaa*. *Simaa* was also transplanted in assemblage. After the duration of one year, the *Simaa* would be moved into another plot, or depending on their size *Simaa* can be transferred to a permanent field. The third transplantation stage is locally called *Wessi*.

The enset-based farming system is the major perennial-stand permanent crop and most important food security source. Age-old customary cultivation of enset in the area, which does not involve the use of chemical inputs [6, 13], portrays an example of a small-scale, low-external input, and organic farming systems. In the study district, no informants used inorganic fertilizer, but animal manure was highly used. Enset is commonly grown in the home garden of the farmers, and this makes it manageable for the application of animal manure. Enset production and cattle possession were closely entangled. The respondents prefer productive and fertile soil for the cultivation of enset. In the unproductive environment, the crop could take more than 8 years to mature, but in fertile environment, it could mature within 3–5 years. Manure is important for crop production; mainly, enset relies on manure from cattle to increase productivity [21, 45].

3.5. Source of Landraces for Cultivation. Most of the informants, 103 (74.10%), have got their planting material by saving their own seedling, 23 (16.50%) by exchanging with neighbors, and 13 (9.40%) by purchasing from the market. According to Deboch [37], the sources of planting materials were own savings, gift from relatives or bought from the market, or combinations of these sources. Sources of planting materials in the south and southwestern Ethiopia are own saving, neighbors, relatives, local market, exchange, gift, purchase, and free distribution [14].

3.6. Processing and Harvesting of Enset for Food Consumption. Enset is served as daily stable food in the study area. Every part of enset is useable, and the corm and pseudostem are the most important parts of enset as the source of nutrient. Depending on the presence and absence of food consumption and the presence of mature enset plantation, harvesting of enset takes place at any time, but dry seasons were preferred by farmers as plants do not take up much water and the kocho tastes better [21]. In west Shoa, enset can is processed throughout the year, but processing is mainly taking place from October to early December [46]. Similarly, in Sidama area harvesting is usually done during the dry season mainly from December to January to avoid excess water content, which may affect the taste of the food [21].

Harvesting of enset before it matures is not common, because it is related to the yield. The farmers believe that immature enset is poor in quality of kocho/worqee, bulla/budhaa, and fiber. Users in the study area stated that waiting for maturation time is no problem for *amicho*. It was observed that the method of processing and harvesting is the same in all kebeles. During harvesting, leaves and older leaf sheaths were removed from the plant and the older pseudostem was removed until the palatable part remains. The pseudostem is cut into two parts for easy processing, and when the fiber product is needed, the pseudostem was divided into two but not less than one meter.

Processing of enset is laborious and tedious and carried out mainly by women using traditional tools. In this regard, one of the great challenges of enset production is poor or little developed processing technologies. We observed that women in the study area still use the age-old traditional methods of enset processing, which is highly prone to contamination, yield reduction, and highly labor-intensive. In Sidama Region too, the work of harvesting and processing of enset for food is undertaken by women [21]. Our results indicate that men's responsibility is to assist in cutting the upper part of the leaf, uprooting the corm, and transporting it to the place of processing. Leaf sheath of the pseudostem is peeled off one by one and then scarped using locally made *Shagira* to separate the bulb from the fiber and wooden plate *Meyate* to hold the pseudostem firmed. Most of the households in the study area reported that they use different cultural tools during enset processing. Hunduma and Ashenafi [46] described that the processing of enset for food is based on traditional knowledge of the people and mainly performed by women using different cultural tools, which is consistent with this study. The traditional way of enset storage and decorticating is presented in Figure 4. The grated corm serves as a ferment by mixing it with various species of herbs and spices; this would give a flavor to the processed enset. In the study area, women prepare the starter or fermenting substance locally called *Gemama* from the grating corm by mixing it with aromatic plants and spices. The women believe that the starter or *Gemama* initiates the fermentation process and makes the kocho have a good smell. Hunduma and Ashenafi [46] reported that *Gamma* is a homemade fermentation enhancer prepared by women and composed of different herbs, aromatic plants, and rotten and blackened enset leaf sheath. The time of fermentation depends on the temperature and storage condition. In Sidama region, local farmers use some landraces as a starter and their scrapped sheath is added to speed up the fermentation of other landraces [21].

The decorticated leaf sheath and grated corm are transported into the pit and covered with enset leaves within the enset farm. The leaf sheath pulp is spread on fresh enset leaves covering the pit, and after that, the grated corm is spread over the pulp. The mixture of these contents is

(a) (b)

Figure 3: New suckers: *Funtaa (left)* (a) and *Simaa (right)* (b).

Figure 4: Traditional way of enset processing in the study area.

systematically kneaded and placed into a pit with fresh enset leaves. Hunduma and Ashenafi [46] reported that the leaves from harvested plants that were left under the sun become flaccid and relaxed and were used to line the inner part of the pit. After two weeks, the mixture is removed from the pit, the pulp is squeezed, and the liquid starch is collected.

3.7. The Importance of Enset. Enset is a well-established, sustainable, and ecologically resilient farming system that contributes to food security of farmers, and in particular, it serves as a food security crop in densely populated areas. People in the study area said that enset plant has a high ability to resist drought, and there is also evidence that the enset farming-based societies are less prone to famine and starvation [6]. The socioeconomic importance of enset in the study area includes household consumption as food, fiber, animal forage, and medicine, for income generation, and shading for crops such as coffee and tuber crops. Shumbolo et al. [15] stated that farmers cultivate several enset clones in mixtures that are used for different purposes, and some of the landraces are best for *kocho,* while others are selected for *bulla*, *amicho,* and fiber. A similar observation was also reported in other enset-growing areas [32, 40, 47]. Brandt et al. [6] revealed that dread leaf sheaths from pulp, petiole, and midribs are used as cleaning rags, brushes, baby diapers, and cooking pot stands. A direct matrix comparison of the most widely used 7 multipurpose landraces indicated that *Astaraa* was the most preferred landrace by local informants followed by *Nimfoo* (SI1).

3.7.1. Kocho/Worqee. Almost all landraces recorded in the study area were used for *worqee production*. During focus group discussion with the farmers, they stated that *worqee* quality depends on the type of landrace, age of enset plant, and period of fermentation. By maintaining multiple age classes, enset provides subsistence farmers the flexibility to harvest as required (e.g., depending on the availability of other crops or resources), buffering seasonal, social, and climate-driven variability [4]. *Worqee* can be prepared from the mix of two or more enset landraces. Depending on the lifestyle of the household, worqee diet could be combined with supplementary foods such as dairy products, meat, and vegetables. Of ten enset landraces compared for worqee quality, *Gantichoo* ranked first, followed by *Adoo* (SI2). The landraces *Gantichoo* in Sidama and *Shodedenia* in Dawro are preferred for a high kocho quality [19]. A study by Tamrat et al. [22] indicates that there is significant variation in enset nutritional diversity, partitioned across multiple stages of enset cultivation and processing from the selection of landraces, environmental conditions, and management practices, to the timing and selection of tissues for harvest and the microbial community associated with enset processing. Compared with regionally important tubers and cereals, enset is high in calcium, iron, potassium, and zinc and low in sodium [22].

3.7.2. Bulla/Budhaa. Budhaa is a water-insoluble starchy food product obtained during enset processing by squeezing the contents of the mixture of decorticated leaf sheath and grated corm and then decanting the liquid. The local people in the study area reported that *budhaa* can be eaten as porridge and bread. The landrace Adoo was more preferred by local informants followed by *Gantichoo* (SI2) for budhaa preproduction. The Wolaita people in southern Ethiopia also prefer enset landraces, which produce a whiter *itima* (bulla) for the preparation of visually attractive and specialty dishes [13].

3.7.3. Amicho. Amicho is the fleshly inner portion of the enset corm, which may be cooked and eaten separately, tasting similar to potato. The preparation method of amicho is similar to other tuber crops in which its corm is boiled and consumed. The landrace, *Nimfoo,* was highly preferred by informants followed by *Diimaa* (SI2) for flavorsome amicho

preparation. Female landraces are preferred for a higher kocho quality and for producing edible and tasty amicho [34].

3.7.4. Fiber. According to respondent, pseudostem of an enset is an important source of fiber production. The fiber is a byproduct of extracted decorticated the leaf sheath of pseudostem, which is used for making ropes and construction materials. Some farmers in the study area use the fiber product as a source of income generation by selling to the local market. The landraces *Gantichoo* and *Adoo* were selected first and second, respectively, as their pseudostems are longer and the fibers are harder in nature (SI3). Brandt et al. [6] reported that enset fiber is equivalent to the fiber of *abaca*, a world-class fiber crop. In enset-growing area, fiber is used to make mats, bags, robes, and construction material [21]. Ayenew et al. [40] also indicated that certain enset landraces such as "*Sisqela*," "*Geshera*," "*Ongame*," "*Dirbo,*" and "*Sheleqe*" are commonly used as a source of fiber in Kembata-Tembaro areas.

3.7.5. Medicinal Use of Enset. Five enset landraces namely *Astaraa*, *Birraa*, *Kakkee*, *Qararsee,* and *Qoomaa* (SI4) with medicinal value were identified (which are used for treating both human and livestock ailments). The farmers use different parts of enset such as corm, leaf, and pseudostem to treat a disease. *Astaraa* is also proven to be effective in the expulsion of delayed placenta during birth [21]. Brandt et al. [6] explained that particular clones (or local varieties) and parts of enset plants are used medicinally for both humans and livestock to treat bone fractures, broken bones, and childbirth problems. Similarly, Olango et al. [13] stated that enset plant and its parts contribute to the ethnomedicinal value of the Wolaita and identified four landraces used as medicinal value. According to this study, ethnomedicine is administered in the form of food products. A study conducted in Sheka Zone by Garedew et al. [33] revealed that *Shuri* landrace was used for delivery (abortion) cases. Ayenew et al. [40] identified that the amicho of *Geshera* and *Cherqewa* is used to treat broken bone, corm of *Tesa* is used to cure broken bones and remove spines, and boiled corm of *Welgela is* used to wash body and to treat skin problems and all parts of *Qeqele* are used to discharge delayed placenta and used to reduce fertility. Abdella [39] described that the landraces *Astara* and *Qibnar* are used to cure both human and animal diseases in Gurage areas. Jarso [32] reported six enset landraces with ethnomedicinal value, parts used for treatment and preparation methods from Gurage Zone (central Ethiopia). *Tayo*, enset landrace, with a light red pseudostem and midrib with deep green leaf, is used to treat broken bone fracture in both human and domesticated animals [47]. A genomic analysis, medicinal landraces indicate that, except for two, all "medicinal" landraces with distinct vernacular names were found to be genetically different, showing that vernacular names are a good indicator of genetic distinctiveness in these specific groups of landraces [18]. However, cluster analysis of enset landraces on the basis of use value shows no evidence for genetic differentiation between the enset grown for "medicinal" uses and nonmedicinal landraces. Medicinal properties may be restricted to a more limited number of genotypes, which might have resulted from the interaction of genotype with the environment or management practice, or partly misreported [18].

3.8. Challenges of Enset Production. According to the respondents the major factors that reduce the production and productivity of enset were bacterial wilt, fungi, mole rats, porcupine, and wild pig. Over one third (34.60%) of respondents reported landraces were infected by bacterial wilt, 23.80% porcupine, 5.70% mole rats, 3.50% wild pigs, and 12.30% were affected by different pests such as wild pigs, mole rats, and bacteria diseases, and 20.10% of the respondents had mentioned no challenges. Bacterial wilt was observed in all selected kebeles, but with different frequencies. The porcupine, wild pigs, and monkey were the major problem, especially in *Biloya*, *Masina,* and *Maleka* because those kebeles had a forest that was suitable for the living of these pests. Land shortage, drought, disease, absence of improved clones, disease resistance, lack of developed processing, and storage technology are the major challenges of enset production [15, 21, 33, 48]. According to Yemataw [14], climate change is the major constraint in the Kembata-Tembaro, whereas in the Hadiya zones enset landraces highly declined due to EXW.

4. Conclusion

Thirty-four enset landraces were identified indicating that the district has huge enset landrace richness. The farmers in the study area predominantly use landraces for kocho, bulla, amicho, fiber, and medicine. A great wealth of indigenous knowledge on the management and utilization of enset agrobiodiversity held by local communities in Adola Rede District was documented. It was evident that the farmers' knowledge and enset have been coevolving together. This has resulted in the occurrence of rich indigenous knowledge of the farmers. Any attempt to improve the crop needs to take into account the farmers' knowledge and experience. Local farmers in Adola Rede area have potential indigenous knowledge of the farming style, propagation, transplantation, harvesting, and processing activities. Finally, the age-old processing of enset would require the concerted effort of food scientists and technologists to lessen the pressure on women and to avoid spoilage during fermentation to produce wholesome products.

Data Availability

The data used in this study are available from the corresponding author on reasonable request.

Conflicts of Interest

The authors declare that they have no conflicts of interest.

Supplementary Materials

SI1 table: direct matrix ranking of multipurpose landraces by respondents. Seven multipurpose and most widely used landraces were identified to carry out a direct matrix ranking. Six criteria were used to order the landraces according to their relative importance perceived by the local community. SI2 table: preference ranking of enset based on their *worqee*, *amicho,* and *budhaa* quality. The key informants were asked to rank 10 enset landraces for kocho/ **worqee**, 6 landraces for amicho, and 7 landraces for bulla/ **budhaa** quality, respectively. SI3 table: pairwise ranking of five enset landraces based on fiber quality. Pairwise ranking of five local enset landraces was conducted based on the most frequently mentioned landraces by informants. SI4 table: enset landrace, the parts used to treat disease and preparation method. Five enset landraces were identified as medicinal plants. The farmers use different parts of enset such as corm, leaf, and pseudostem to treat a disease. (*Supplementary Materials*)

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