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Research Article

Enset Landrace Diversity and Ethnobotanical Uses in the Gedeo Zone: A Living World Cultural Heritage Site

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Enset (*Ensete ventricosum* (Welw.) Cheesman) is a monocarpic, perennial herbaceous plant in the Musaceae family. Ethiopia is the origin and center of enset diversity and is the only country to have domesticated and used enset for food. Enset-based farming systems are widespread in the south, southwest, and central parts of Ethiopia. Variation in agroecology, continuous farmer selection, and varied agronomic practices have led to the development of diverse enset landraces (clones) in Ethiopia. The Gedeo zone in Southern Ethiopia, which is the focus of the current study, is known for its well-established and diverse enset farming systems, shaped by long-term farmer selection and management. However, the reported number of enset landraces in Gedeo, ranging from 20 to 26, is relatively low compared to other enset-growing areas, where studies report between 44 and 86 landraces. This disparity in reported landraces number underscores the need for further research and investigation. The main objectives of this study are to: i) conduct an in-depth assessment and survey of enset landraces in the Gedeo zone and ii) evaluate the conservation status and unique ethnobotanical use of enset clones in the area. A total of 120 households from 4 districts and 12 kebeles were interviewed for the study. Additionally, focus group discussion (FGD), key informant interview (KII), and literature review were applied. The study identified 37 previously undocumented landraces, each with unique vernacular names. Combined with landraces identified in earlier studies, this raises the total number of enset landraces in Gedeo to 57, which is over 100% greater than previously reported. Different landraces support different needs of the community. Nonetheless, only 4–6 enset landraces are frequently and widely used. Among the widely cultivated enset landraces, the most frequently used are ranked in the following order: Ganticho, Nifo, Qarase, Dimoye, Toracho, and Ado. Most landraces are rare, cultivated in restricted locations, and thus vulnerable to socio-ecological changes. Enset and its diverse landraces are deeply intertwined with the culture of the people in Gedeo. It has shaped their livelihoods, culture, and environment, helping them thrive for millennia in a densely populated area naturally prone to degradation. Enset offers a wide range of food, medicinal, fiber, and environmental benefits. As no single landrace meets all these needs, conserving enset diversity is crucial to sustaining its full cultural, nutritional, and ecological value. However, recent socio-ecological changes, such as pest and disease outbreaks, climate change, and rapid population growth leading to land use intensification, are threatening the diversity of enset landraces in the Gedeo zone. Despite some efforts made by various actors to conserve the enset landraces in the area, results so far are not encouraging. The findings underscore the significance of diversified enset landraces and their ethnobotanical implications, raising awareness of the need to support the conservation and sustainable use of enset landraces to maximize their socio-ecological significance.

Keywords: conservation status; cultural value; enset farming systems; enset landrace; environmental resilience; Ethiopia; Gedeo

1. Introduction

Enset (*Ensete ventricosum* (Welw.) Chessman), also known as the false banana, is a perennial, herbaceous, and monocarpic crop belonging to the family Musaceae [1]. Ethiopia is the center of origin diversity and domestication of enset [2]. Over 20 million people in central, southwest, and southern Ethiopia depend on the enset-based farming system for their livelihood and as a primary source of staple food [3]. Enset provides a wide range of products and services such as food, traditional medicine, fiber, as well as significant cultural and environmental values [4, 5]. Its benefits in food security are enormous due to its year-round harvest, long storage life, adaptability to different environmental conditions, high productivity per unit area, and drought tolerance [3]. Enset is a space-efficient crop, producing high yields and feeding a large number of people per unit area compared to common cereal crops. This efficiency is perhaps the main reason for its wide adoption as a staple crop in the densely populated regions of Ethiopia, such as the Gedeo [6], Gurage [7], and Wolaita zones [8], as well as in the Sidama region [9]. Moreover, enset plays a significant environmental role by regulating microclimate, conserving soil, and enhancing soil fertility through large quantity of organic matter input [3, 6, 10–13].

Environmental variability, continuous farmers selection, and diverse agronomic practices have given rise to a large number of distinct enset landraces across enset-growing regions of Ethiopia. These regions also exhibit significant variations in ethnobotanical uses of enset [9, 14]. However, despite this diversity, there remains limited documentation and scientific investigation, particularly at the local level—on the extent of landrace diversity and their associated ethnobotanical uses in certain areas such as the Gedeo zone. This gap underscores the need for comprehensive research to assess and record enset diversity and traditional knowledge systems that support its conservation and use. Understanding the diversity and ethnobotanical uses of the enset-based farming system is crucial for its conservation and sustainable utilization, specifically in the face of climate change, which is affecting most farming-based livelihoods in Ethiopia. Previous studies have reported between 44 and 86 enset landraces in most enset-growing regions of southern Ethiopia [7, 9, 14–17]. Nonetheless, despite the high agroecological variation, which is typically considered the foundation of biological diversity, and old-aged cultivation of enset in Gedeo, the reported number of enset landraces from the area (20–26) is surprisingly low compared to other enset-growing areas [5, 18], which may indicate incomplete assessment and a need for further research. The objective of this study was twofold: first, to conduct a more comprehensive assessment and survey of enset landraces in the Gedeo zone in order to justify the reasons behind the previously reported lower diversity, and second, to investigate the unique ethnobotanical uses of enset among the Gedeo people and evaluate the current conservation status of enset landraces in the study area.

2. Materials and Methods

2.1. Description of the Study Area. This study was conducted in the Gedeo zone, one of the administrative zones in South Ethiopia regional sate. It is situated approximately 360 km south of Addis Ababa, the nation's capital. The zone is located on the southeastern escarpment of the Ethiopian Rift Valley, offering a picturesque view of the southern Rift Valley. Its latitude ranges between 5°N and 7°N, and its longitude spans from 38°E and 40°E (Figure 1). The total surface area of the zone is 1347 km^2, and its altitude ranges from 1200 to above 3000 m above sea level [6]. This variation in elevation contributes to a wide range of agroecological zones, making the area particularly suitable for enset cultivation and mixed agroforestry systems [5].

According to the traditional agroecological classification, most part of the study area, ca. 62%, falls under the subtropical climate (woina dega or mid altitude). While 37% belongs to a high-altitude climate (Dega) the remaining 1% fall within the hot tropical climate (Kolla) [18]. The mean annual temperature varies from 12.5 to 28°C [19]. The area receives a bimodal rainfall with annual precipitation ranging from 800 to 1800 mm [20]. The first rainy season occurs from March to May, and the second rainy season from July to December [18].

Enset plays a significant role as the staple food for the rural population and constituting a considerable component of the agroforestry systems in the Gedeo zone. According to Negash et al. [21] and Abiyot [18], three main agroforestry systems are practiced in the zone: (1) an enset-based agroforestry system found at elevations of 2100–2400 m with annual rainfall ranging from 800 to 1200 mm; (2) an enset–coffee-based agroforestry system, occurring between 1900–2200 m with similar rainfall patterns; and (3) a fruit–coffee-based agroforestry system, found at lower elevations of 1500–1900 m with 800–1000 mm of annual rainfall. Enset is dominantly cultivated in the first two systems, where it plays a central role in food security and land use. Although its proportion is relatively low in the fruit–coffee-based system, enset is also grown in the lowlands and has been expanding into these areas in recent years, highlighting its adaptability and increasing importance across agroecological zones. The soils in the area predominantly originate from volcanic rock, and although there are a variety of soil types present, the most dominant ones are Nitisols, Cambisols, and Luvisols, according to FAO [22].

2.2. Sampling and Data Collection. The study utilized a combination of primary and secondary data sources. Primary data were collected through questionnaire surveys, enset field visits, focus group discussions (FGDs), and key informant interviews (KIIs). The research covered four districts representing the two enset-growing agroecological zones in Gedeo (highland and mid altitude). Accordingly, Bule and Gedebe districts from the highlands and Yirigachefe and Dilla Zuria from the mid-altitude were included. From each district, three kebeles (the lowest administrative units in Ethiopia) were selected based on their diversity and intensity of enset farming practices, resulting in a total of 12 kebeles. The selection of districts and kebeles was guided by information collected from key informants such as people from the offices of agriculture at zonal and district levels.

A questionnaire was prepared, pretested and administered to 120 farm households, with 10 households randomly selected from each of the 12 kebeles. Enset fields of the selected farm

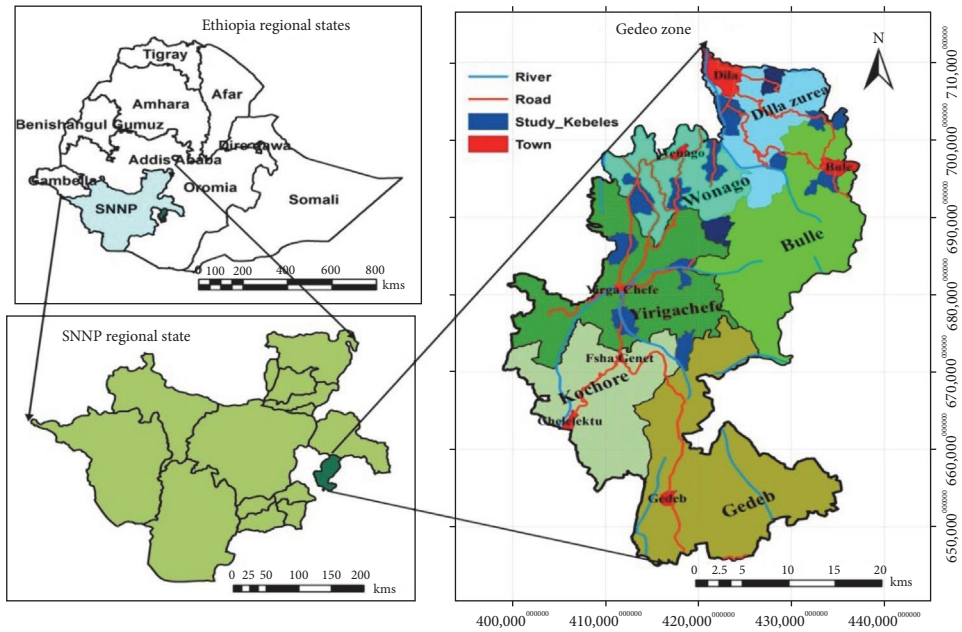


FIGURE 1: Map of the study area.

households were visited to describe and identify enset landraces on their fields. The landraces were characterized by their vernacular names and morphological attributes such as leaf and stem colors. The methodology used by Tesfaye and Lüdders [17] was employed for the characterization and identification of landraces.

Furthermore, FGDs were held, one in each kebele, involving 4–6 individuals per group. The purpose of these discussions was to verify the data collected from individual interviews, specifically in terms of list of landraces, their naming, and ethnobotanical uses. The household interview and FGDs were conducted in the local language, Gedeoffa, with the assistance of a local translator.

Additionally, KIIs were held in each kebele. The KIIs were conducted to gather additional information for the study, including insights to challenges facing enset cultivation, as well as the state of conservation of enset landraces. The KII involved a range of participants, including key agricultural officials, experts, elderly farmers, and innovative farmers. KII was conducted at different times during the period of the study.

In addition, locally available secondary data were reviewed to complement the findings. Literatures on enset landraces diversity and use were collected from platforms such as Web of Science, Google Scholar, Scopus, AGRIS, Research Gate, and PubMed. A total of 15 articles, comprising five from the study area and 10 from other enset-growing regions, were selected and reviewed.

2.3. Data Analysis. In this descriptive study, both qualitative and quantities were employed to analyze data related to enset diversity, conservation status, and ethnobotanical uses. Qualitative data were analyzed using narrative summaries and descriptive statistics using Microsoft Excel 2016. The data were organized using percentage calculations, frequency tables, and charts. These tools were particularly useful in analyzing and summarizing qualitative data related to conservation status and cultural significance.

To assess clonal diversity across the study area, various diversity indices were applied. These included landrace richness, the Shannon–Wiener index, and the Simpson diversity index, allowing for comparison of enset diversity among villages, districts, and peasant associations (PAs). In addition, frequency of occurrence was calculated to identify the most prevalent landraces, and their morphological and phenotypic characteristics were documented to understand local selection criteria.

A comparative analysis was also conducted using data extracted from previously published reports. This involved comparing the list of enset landraces identified in the current study with those reported in earlier studies from Gedeo, as well as assessing reported landrace richness across other enset-growing regions of Ethiopia. This helped contextualize the findings and evaluate changes in reported diversity over time. Overall, the study employed these techniques to explore enset diversity, conservation status, and ethnobotanical use.

3. Results and Discussion

The survey analysis of enset landraces diversity reveals that there is a total of 37 distinct enset landraces across the Gedeo zone with variations in enset landraces richness and diversity indices across districts, villages/kebele and agroforestry systems, or agroecology (Figures 2 and 3). The enset landraces richness is highest in Bule (32 landraces), followed by Gedebe (29), Dilla Zuria (25), and Yirgachefe (25). This suggests that Bule harbors a higher number of distinct enset landraces,

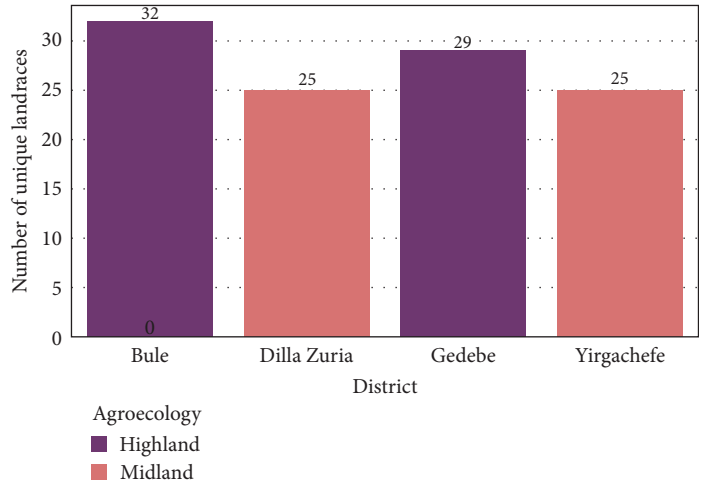


Figure 2: Landrace richness across districts and agroecology.

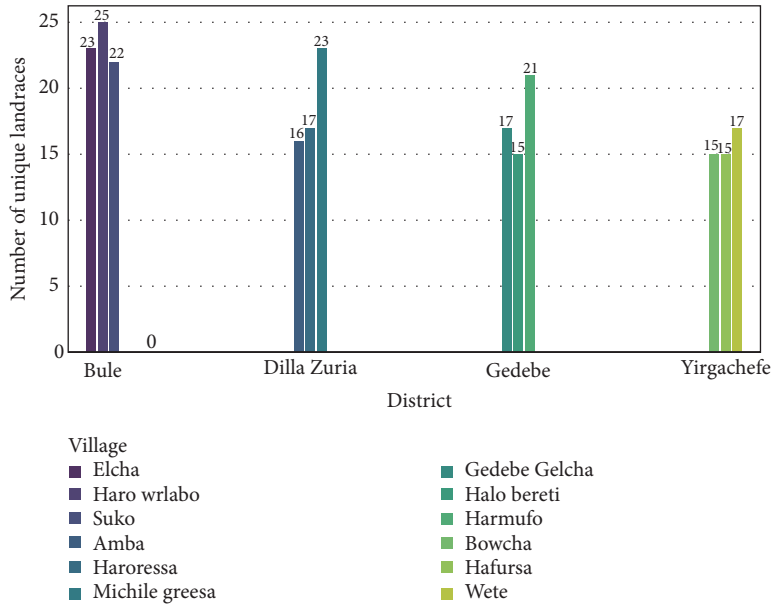


Figure 3: Landrace richness across districts and villages.

compared to others potentially due to its favorable agroecological conditions and long-standing traditional enset cultivation practices.

The analysis of enset landrace diversity at the village (kebele) level across the four districts of the Gedeo zone revealed substantial variation in clonal richness within and between districts (Figures 3 and 4). In Bule district, enset diversity was particularly high, with Elcha recording the greatest number of unique landraces (25), followed closely by Haro Wirlabo (23) and Suko (22) (Figures 3 and 4). This reinforces Bule's status as a hotspot for enset diversity in the zone. In contrast, one village in Bule reported no landraces, possibly due to the lack of enset cultivation or data gaps. In Dilla Zuria, the highest number of landraces was found in Amba (23), while Haroressa and Michile Greesa reported 17 and 16, respectively (Figures 3 and 4). Similarly, in Gedebe, Gedebe Gelcha showed relatively high diversity with 21 landraces, whereas Halo Bereti and Harmufo had 17 and 15. In Yirgachefe, diversity was comparatively lower and more uniform, with Bowcha reporting 17 landraces, and Hafursa and Wete each recording 15 (Figures 3 and 4). These variations indicate that enset clonal diversity is not evenly distributed, even within the same district, reflecting the influence of localized factors such as land use patterns, cultural preferences, and agroecological suitability.

3.1. Enset Landraces Diversity and Their Distribution Across Ddistricts and Agroecology. The analysis of enset landraces diversity across four districts in the Gedeo zone—Bule, Dilla Zuria, Gedebe, and Yirgachefe—revealed notable variations in enset landraces,richness, and diversity indices (Table 1). When

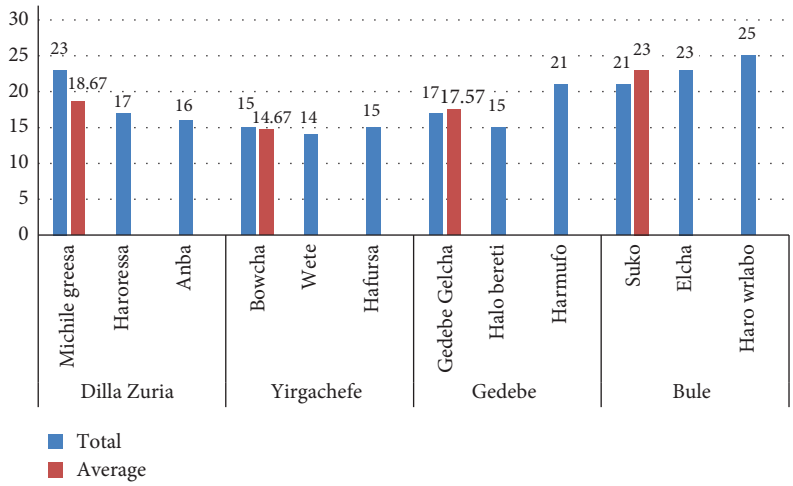


Figure 4: Enset landraces richness across the districts and peasant associations (PAs).

Table 1: Diversity indices by districts.

District	Shannon index	Simpson index
Bule	3.406236	0.965306
Dilla Zuria	3.136470	0.954082
Gedebe	3.263555	0.958348
Yirgachefe	3.101047	0.950656

Table 2: Diversity indices by village.

District	Village	Shannon index	Simpson index
Bule	Elcha	3.135494	0.956522
Bule	Haro wrlabo	3.218876	0.960000
Bule	Suko	3.091042	0.954545
Dilla Zuria	Amba	2.772589	0.937500
Dilla Zuria	Haroressa	2.833213	0.941176
Dilla Zuria	Michile greesa	3.135494	0.956522
Gedebe	Gedebe Gelcha	2.833213	0.941176
Gedebe	Halo bereti	2.708050	0.933333
Gedebe	Harmufo	3.044522	0.952381
Yirgachefe	Bowcha	2.708050	0.933333
Yirgachefe	Hafursa	2.708050	0.933333
Yirgachefe	Wete	2.833213	0.941176

analyzed by agroecological zones, highland areas (Bule and Gedebe) exhibited greater diversity compared to midland regions (Dilla Zuria and Yirgachefe).

Bule district exhibited the highest Shannon diversity index ($H' = 3.41$) and Simpson diversity index ($D = 0.965$), indicating a more diverse and evenly distributed landraces population. Gedebe followed with $H' = 3.26$ and $D = 0.958$, while Dilla Zuria ($H' = 3.14, D = 0.954$) and Yirgachefe ($H' = 3.10, D = 0.951$) showed slightly lower diversity. These results suggest that Bule district harbors a greater number of distinct enset landraces, contributing to its higher diversity index values. These findings suggest that highland agroecologies may support greater landrace diversity, possibly due to more favorable climatic conditions, traditional farming practices, or conservation efforts. Another possible reason for the higher clonal diversity and landrace richness in Bule is that farmers in this district tend to cultivate enset as a sole crop, unlike in Gedeb and Yirgachefe where it is commonly integrated with coffee, or in Dilla Zuria where fruit trees dominate. This dedicated cultivation may contribute to the preservation and accumulation of a greater number of enset landraces.

Within each district, the diversity indices varied significantly across villages (Table 2). In Bule, Haro Wrlabo exhibited the highest Shannon index ($H' = 3.22$) and Simpson index ($D = 0.96$), suggesting a highly diverse and well-distributed enset population. Elcha and Suko followed with $H' = 3.14$ and 3.09, respectively. In Dilla Zuria, Michile Greesa had the highest diversity ($H' = 3.14, D = 0.956$), whereas Amba displayed the lowest diversity ($H' = 2.77, D = 0.937$). Similarly, in Gedebe, Harmufo showed the highest diversity ($H' = 3.04$, $D = 0.952$), while Halo Bereti had the lowest ($H' = 2.71$, $D = 0.933$). Yirgachefe had the least diverse villages, with Bowcha, Hafursa, and Wete all show relatively low Shannon and Simpson values ($H' \approx 2.71, D \approx 0.933$– 0.941). This variation highlights localized differences in enset landrace management, cultivation practices, and conservation efforts across the region.

Overall, the study highlights Bule as the most diverse district, with Haro Wrlabo, Michile Greesa, and Harmufo are the most diverse villages. Additionally, highland areas generally support greater enset diversity than midland zones. These findings emphasize the importance of targeted conservation strategies in lower-diversity areas such as Dilla Zuria and Yirgachefe while leveraging the biodiversity-rich regions for germplasm conservation and sustainable agricultural development.

In the present study, a total of 37 enset landraces were identified. When combined with those documented in earlier studies, the total number of known enset landraces in Gedeo zone rises to 57 (Table 3), which is more than double (100%) the previously reported number from the area. The number of enset landraces identified in this study exceeds those reported in earlier studies in the same area, such as Abiyot [18], Zerihun

Table 3: List of enset landraces/clones extracted from published report and the current study in Gedeo zone.

Number	List of landrace/clones	Number of landraces	(Studied area) (sample area)	Sources
1	Nifo, Ganticho, Toracho, Qarase, Dambale, Harame, Dimoye, Astara, Shana, Qoshe, Qorqoo, Mundame, Galisho, Ado, Tilale, Danbalicho, Guluma, Areme, Kake, Dinke, Agana, and Ado	22	Bulle, Dilla zurea, Wonago, and Yirgacheffe	Abiyot [18]
2	Fokonie, Shasha, Agina, Astara, Denbola, Deneka, Dimoye, Filil, Foneqe, Galasho, Ganetecho, Gatara, Gosalo, Haramo, Haranjo, Helila, Kake, Mundame, Nefo, Qarasie, Qelitate, Qeralicho, Qorqor, Shegna, Toramy, and Torore/Toracho	26	Bule and Gedebe	Zerihun [23]
3	Ado, Kake, Agena, Kosha, Astarakeyi, Medalacho, Astaranechi, Miqi, Burtukan, Mundoye, Dembele, Nifo, Denka, Qarase, Dimoye, Qorqoro, Ganticho, Shana, Gasola, Tilila, Gecha, Toracho, Genta, Torame, Harame, and Wekeso	26	Bule, Yirgachefe, and Dilla zuria	Abdi and Tafesse [5]
4	Mundo, Kake, Qarasse, Ganticho, Astara, Nipho, Toracho, Denbele, Shagna, Agana, Dinke, Ado, Filele, Harame, Qoshe, Dine, Gosalo, Qorqoro, and Dimoye	20	All six districts of the zone	Zerihun and Brihanu [4]
5	Ado, Agena, Astara, Astara(Tikur), Bale, Bira, Bufe, Dabare, Dimoye, Astara(keyi), Dine, Dinke, Ebisho, Filila Fuga, Ganta, Ganticho, Gatira, Gosalo Harame, Harenjo, Henco, Kake, Qorqoro, Mike, Mundo, Nifo, Qarase, Qosre, Shegna, Astara(nich), Toracho, Torame, Wolamo, Tara, Cicibito, and Gantole	37	Gedebe, Bule, Dilla Zuria, and Yirgachefe	This study

Note: Sources: Tesfaye and Lüdders [17] (Sidamo), Yemataw [14] (Gurage, Dawro, Silite, Kembata-Tembaro), Tsegaye [9] (Wolayita, Hadiya), Alemu and Sandford [15] (GamoGoffa), Negash [16] (Kaffa), Shigeta [7] (Ari, South Omo) and the current study (Gedeo).

and Brihanu [4], Zerihun [23], and Abdi and Tafesse [5]. For instance, [4] and Abiyot [18] reported 20 and 22 enset landraces, respectively. Similarly, Zerihun [23] and Abdi and Tafesse [5] reported 26 enset landraces each from the area (Table 3; Figure 5). The difference may arise from the methodology employed, including the size of the sample area surveyed and the diversity of data collection techniques applied.

Out of the 57 enset landraces documented, only seven landraces (Agana, Dimoye, Ganticho, Kake, Nifo, Qarase, and Shagna) were mentioned in all of the five studies, including the present study, conducted in the area (Table 3). Additionally, five enset landraces (Astara, Danbale, Gosalo, Harame, Toracho) were recorded in four of the previous studies. Among these mentioned landraces, Ganticho, Astara, Qarase, Dimoye, Nifo, and Harame were consistently reported as abundant landraces in all of the previous and the current study (Tables 3 and 4).

Nonetheless, compared to the number of landraces reported from many other enset-growing regions, the number in the Gedeo zone is still relatively low. For example, 86 enset landraces were reported in the Sidama zone [17], 75 in Dawro [14], 76 in Ari [7], 69 in Silite [14], 66 in Kembata-Tembaro [14], 63 in Gurage [14], 65 in Kaffa [16], 59 in Hadiya [9], and 55 in Wolayita [9]. A lower number of landraces, 44, compared to Gedeo, is reported only from GamoGoffa [15] (Figure 6).

Despite the high number of landraces, only a few are widely distributed and frequent in the zone. Ganticho (83%) followed by Nifo (51%), Karase (37%), Dimoye (27%), and Toracho (19%) are the five most frequent and widely distributed enset landraces in the zone (Table 4). The number of landraces per household varied from 2 to 14, with the majority of farmers (69%) holding 3–6 landraces. There was significant variation in the distribution of landraces across districts and kebeles in the Gedeo zone (Figure 4).

The abundance of a few landrace is attributed to farmers' preferences based on desirable traits such as good yield and

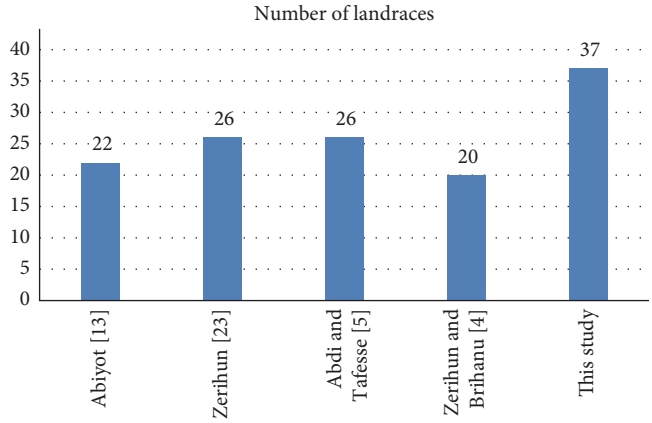


Figure 5: The comparison of richness of enset clones in Gedeo zone as per different research.

Table 4: The landraces or clones frequency of occurrence in the study area.

Number	Name landrace	Frequencies of despondences in the study districts. $N = 30$ in each district				Overall frequency ($N = 120$) on study area	Frequency (%)
		Dilla Zuria	Yirgachefe	Gedebe	Bule		
1	Ganticho	25	25	25	25	100	83.33
2	Nifo	7	20	14	20	61	50.83
3	Qarase	7	10	19	8	44	36.67
4	Dimoye	12	8	9	4	33	27.50
5	Toracho	8	9	1	6	24	20.00
6	Ado	9	8	6	0	23	19.17
7	Dinke	7	8	1	3	19	15.83
8	Shegna	10	4	2	3	19	15.83
9	Kake	7	4	4	2	17	14.17
10	Astara(keyi)	11	0	1	4	16	13.33
11	Harenjo	8	0	3	5	16	13.33
12	Gatira	9	5	0	1	15	12.50
13	Astara	0	7	2	4	13	10.83
14	Gosalo	7	2	2	2	13	10.83
15	Qorqoro	0	8	1	3	12	10.00
16	Agena	6	0	1	3	10	8.33
17	Bufe	1	2	3	4	10	8.33
18	Harame	7	0	2	1	10	8.33
19	Ebisho	1	4	1	3	9	7.50
20	Torame	1	1	3	4	9	7.50
21	Astara(Tikur)	4	0	2	2	8	6.67
22	Mundo	2	2	0	3	7	5.83
23	Dine	0	0	1	5	6	5.00
24	Ganta	1	2	1	2	6	5.00
25	Gantole	1	0	2	3	6	5.00
26	Mike	3	1	1	1	6	5.00
27	Dabare	0	0	1	4	5	4.17
28	Astara(nich)	3	0	0	1	4	3.33
29	Fuga	0	3	1	0	4	3.33
30	Tara	0	1	2	1	4	3.33
31	Bale	0	2	0	1	3	2.50
32	Cicibito	0	1	0	2	3	2.50
33	Filila	1	1	1	0	3	2.50
34	Henco	0	0	0	2	2	1.67
35	Bira	0	0	1	0	1	0.83
36	Qosre	0	0	0	1	1	0.83
37	Wolamo	0	1	0	0	1	0.83
Total	37	158	139	113	133	—	—

taste, disease and drought resistance, maturation and fermentation period, medicinal values, forage and fiber quality, and other qualities [24]. Since no single landrace can fulfill all of these criteria, farmers tend to maintain a diverse set of enset clones on their farms to meet their various needs and minimize risk. Among the various enset landraces grown in the Gedeo zone, Ganticho followed by Nifo are the two most preferred and thus common landraces. Ganticho, in particular, is highly esteemed by farmers for its high yield per unit area. Its rapid growth, adaptability to different soil and climatic conditions, drought resistance, early maturity, and disease resistance are key factors influencing its preference by farmers. Astara, Nifo, Dimoye, and Ado are early-maturing enset varieties that reach maturity within 2–3 years, making them valuable for quick food production and short-cycle farming systems.

The maturity period of enset is influenced not only by the genetic traits of the landrace but also by environmental conditions and management practices. For instance, the same enset clone may mature earlier in lowland or warmer areas compared to highland regions with cooler temperatures. Moreover, enset grown in fertile soils and receiving adequate compost or manure tends to mature faster than those planted in poor soils or with limited organic input.

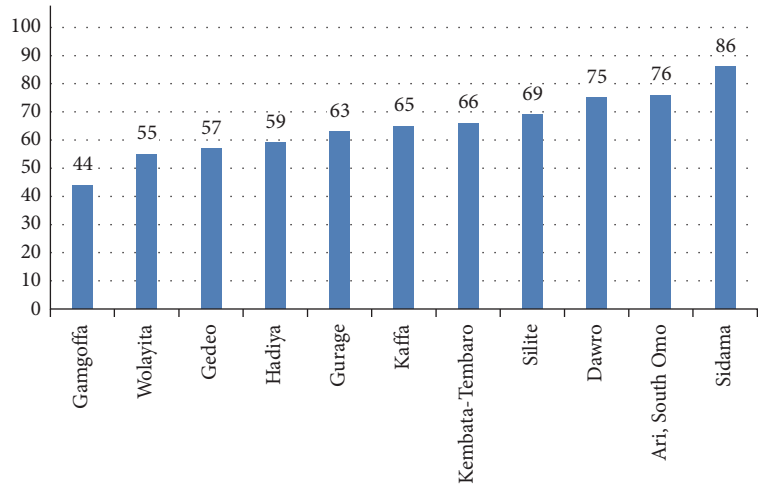


Figure 6: Reported enset clone richness across different enset growing areas.

Other criteria farmers employ in selecting and maintaining landraces include quality of food produced, fiber and medicinal values, fresh edibility, ease of scraping and fermentation, and the quality of the corm [25].

Some enset clones, such as Ganticho and Torecho, have raw corms (gumme) that are edible and commonly consumed by children and youth. In contrast, varieties like Astara, Qarase, and Nifo are preferred for their boiled fresh corms (amicho), which are palatable and suitable for direct consumption. Torecho is also notable for its rapid fermentation; it is typically squeezed and fermented within 15 days, making it one of the fastest-fermenting enset landraces. Additionally, landraces such as Qarase and Astara are highly valued for their medicinal properties.

3.2. Morphological Attribute of the Enset Landraces. The diverse enset landraces identified in the study present distinct morphological attributes. The landraces exhibited significant variations in size, shape, height, color, and overall morphological appearance (Figure 7). This observation aligns with the report by Bezuneh [26], who noted that the pseudostem and leaf midrib colors of enset plants vary considerably. While most enset landraces exhibit a light green coloration with variegated brown patches, some display purple to dark red hues—highlighting the crop's high morphological diversity. Farmers distinguish one landrace from another based on various morphological features, such as the color of the pseudostem, petiole, mid-rib, and leaf sheath; the angle of leaf orientation; the size and circumference of the leaf; and the length of the pseudostem and leaf (Figures 8 and 7). The different landraces also serve different purposes. farmers preferred enset clones/landraces with white-colored pseudostems for production of bread like food, called kocho; those with tasty corms for porridge like food, used by boiling called amicho, and red-colored enset landraces for medicinal products and fiber. This indicates that farmers selectively choose specific landraces for different uses, resulting in the maintenance of diverse clones to fulfill various functions. This selective preference by farmers for different purposes indicates the reason for their maintenance of diverse landraces on their farm to fulfill various culinary and medicinal functions. This traditional knowledge also aids in the conservation of a variety of enset landraces, guaranteeing their continuous accessibility and meeting various requirements within the community.

The enset landraces observed display a wide range of pseudostem colors, which are important for local identification and classification (Figure 7). Several varieties, including Dimoye, Qarkeh, and Kake, exhibit deep red to reddish-purple pseudostems, indicating strong pigmentation. Dimoye's name itself is derived from dima, meaning red. Dinke also shows a bright reddish pseudostem and is notable for its short stature—the name refers to its dwarf-like form. Torocho, Cicibito, and Ganticho display green pseudostems with purplish or reddish streaks, reflecting intermediate pigmentation. Qarase, Shana, and Jaldesa have predominantly green pseudostems with dark brown or black vertical markings, creating a patterned appearance. In contrast, Qorqoro and Ado are characterized by light green to pale yellowish or white pseudostems with minimal pigmentation. Nifo presents a unique gray-green color, and Astara is known for its dark brown pseudostem. Harame has a clean light green color, while Harenjo is distinguished by its striking mix of black, white, and green, making it easily recognizable. These color traits not only support identification but are also linked to the varieties' cultural, ecological, and practical significance.

Morphological variations of enset landraces were also observed across different agroecology, reflecting the influence of local environmental conditions and farmer selection practices. In the midland areas, most landraces hold white pseudo stems and petioles. As the altitude increases from the midland to the highland, the color gradually shifted from white to black. The color variations were also related to the age of the enset plants. The same landrace exhibited different appearances at younger ages (1–2 years) compared to older ages (> 2 years). Distinguishing between different landraces at an early age requires experience and skill possessed by experienced farmers. For most farmers, it was not difficult to distinguish landraces older than 2 years.



Figure 7: Showcases photographs of various enset landraces found in the Gedeo zone (Source: field photos taken by the first author, current study (2024).

3.3. Ethnobotanical Uses of Enset Landraces. Enset landraces are utilized as a source of a wide variety of goods and services in the Gedeo zone. They provide essential products such as food, medicine, and fiber. In addition to goods, enset landraces also provide vital ecosystem services such as environmental protection, specifically in conserving soil and water, and enhancement of soil fertility through the production of a large quantity of slowly decomposing litter. Enset holds special cultural significance as well. In Gedeo, traditions, beliefs, and worldview are deeply intertwined with enset-based systems (Tables 5–7). The Gedeo people assign distinct values to different parts of the enset plant based on their cultural values. The following sections provide a detailed account of some of the ethnobotanical uses of enset in Gedeo.

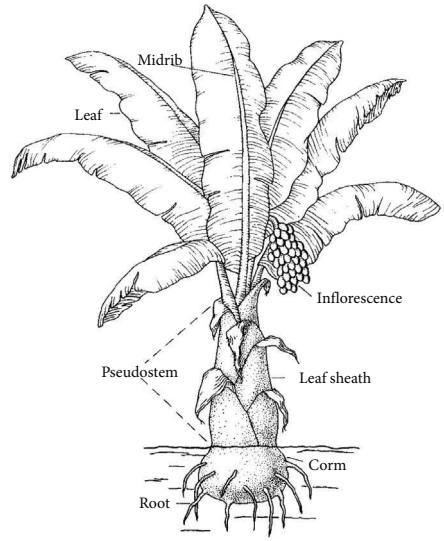


Figure 8: Parts of mature enset plant (Source: [2]).

Table 5: Farmers' preference for enset clones for different ethnobotanical uses.

Ethnobotanical uses	Preferred enset clones	Preparation	References
Food; Kocho	Genticho, Ado, Toracho, Gasola, Madalacho, Astarakey, and AstaraNech	The freshly decorticated mass was squeezed by hands to extract bulla. The fresh extract was drained down into a pit lined with a fresh enset leaves	Current study; Abdi and Tafesse [5]
Food; Bula	Nifo, Ado, Toracho, Gasola, and Madalacho	—	Current study; Abdi and Tafesse [5]
Food; Amich	Ado, Toracho, Astarakey, and AstaraNech	—	Abdi and Tafesse [5]
Fiber	Ganticho, Toracho, and Ado	—	Abdi and Tafesse [5]
Medicine	Qarase, Medalacho, Qorqoro, Shana, Gecha, Genta, AstaraNechi, Astarakeyi, and Kake	—	Current study; Zerihun and Brihanu [4]; Abdi and Tafesse [5]
Fermentation starter	Astara, Qarase, Ganticho, Agena, and others	—	Abdi and Tafesse [5]
Environmental (soil) maintenance	Gantole, Nifo and Harame, Ganticho, and Toracho	—	Current study; Kipie [6]

3.3.1. Food Security. Enset is widely preferred as a food security crop in Ethiopia due to its unique resilience and multifunctionality. Unlike many annual crops, enset is a perennial plant that can withstand periods of drought once established, making it a reliable food source during times when other crops fail [2]. Enset provides a significantly higher yield per unit space and time than any other crop cultivated in Ethiopia. For example, Tsegaye [9] documented yields of up to 26.26 t/ha/yr under optimal spacing conditions, underscoring enset's remarkable productivity and its potential contribution to food security. This highlights enset's remarkable productivity and its potential role in enhancing food security in enset-growing regions. Enset also provides significantly higher food energy yields per unit area than cereals—1.3 – 3.5 times more than maize under similar management conditions [27]. Additionally, enset can be harvested at any time and stage of growth, allowing flexible responses to household food shortages. Its processed products (like kocho and bulla) can be stored for extended periods without significant quality loss, enabling long-term food availability and consumption smoothing during lean seasons. In the Gedeo zone, these advantages are even more critical. The region is characterized by steep terrain, high population density, and limited cultivable land—factors that heighten the risk of food insecurity. Enset thrives under these conditions due to its adaptability and ability to stabilize soils on slopes. Moreover, its integration into the Gedeo agroforestry system enhances not only food security but also ecological sustainability. As a result, enset is more than just a crop in Gedeo; it is a vital component of the people's livelihood, culture, and long-term survival strategy.

Table 6: General use of enset in the Gedeo zone (without considering the landraces).

Number	Part or product used	Local name (Gedeofa)	Uses
1	Leaves	Fresh/green leaves (hochcho)	Symbol of peace (meditation), and bedding and packaging and thatching
2		Dried leaves (hashupha)	Bedding particularly for lactating mothers is used as a filter in house walls as well as in fences
3	Mid-rip	Fresh midrib (merecho)	Water line, livestock fodder, and used during enset processing
4		Dried midribs (xude)	Fuel, fiber for making mats (gash or xaxxo)
5		Dried mid-rip (xushsho)	Fiber (the strongest) particularly used in construction (as nail substitute)
6	Pseodostem	Fresh pseodostem (hachcho)	Container
7		Dried pseodostem (ooffee)	Packaging enset food and butter, fiber in house construction, fuel
8	Root	Hiddichcho	Medicine, symbol of the truth (dhugaa)
9	Inflorescence	Dagaguma	Vegetable eaten by shepherds
10	Seeds	Gumma	Stone in the local game, saddeega
11	Shoot tip	Huumaa	Vegetable eaten by women processing enset
12	'Kocho'	Waasa	Used to treat amoebiasis and cramp
13	'Bulla'	—	For back pain, for a woman give a born
14	Corm	Gamama (spoiled/fermented corm)	Used to prepare traditional starter culture (gamama) for kocho fermentation
15	—	Amicho (boiled corm)	Used as food
16	—	Gumme (raw corm, i.e., central part of soft starchy corm)	Used as food by youth and children directly in the field

Note: Source: current study and Kipie [6].

Enset foods are an essential part of the daily diet for the Gedeo people. The Gedeo people consume five different food categories prepared from enset: bulla, kocho, amicho, mooca, and gumme. Bulla refers to the unfermented squeezed enset products. Kocho or waasa is the fermented product made from the pseudostem and corm tissue. In contrast, amicho is unique among enset products in that it is not processed or fermented —it consists of the boiled corm and is ready to eat immediately after harvesting, often consumed like a root vegetable on the same day it is dug up. This feature makes amicho particularly valuable for immediate food needs. Mooca is a product obtained from the liquid extracted during the squeezing process of kocho preparation. Gumme is a soft, starchy part of the enset plant that is systematically extracted from the center of the corm during the harvesting process. It is traditionally consumed raw, especially by youth and children, often directly in the field. Several other dishes are also prepared from enset such as dassa, qoxee, karssa, aala, maqita, haarra, uurro, and doobbala. Among these dishes, kocho bread (Bite), Kunchisa, and Talta are very common(Figure 9). The Gedeo people prefer to enjoy kocho bread (Bite) with meat, a practice that not only enhances flavor but also helps overcome enset's protein deficiency by complementing it with animal-source protein. Mellisse et al. [28] reported that dietary diversity varies across enset-based farming systems in the Gedeo zone. The enset–cereal–vegetable system provides the highest diversity, offering a broader range of food groups year-round. In contrast, the enset-based system shows the lowest diversity, while enset–coffee and enset–livestock systems offer moderate diversity. To address enset's low protein and fat content, integrating legumes such as beans and peas is recommended. These not only enhance nutrition but also improve soil fertility. Promoting systems like enset-cereal -vegetable and enset–legume and enset –livestock intercropping will help to strengthen their food and nutrition security in the region.

3.3.2. Environmental Sustainability. The agroforestry system in Gedeo, which includes enset as a main component, is acknowledged for its environmental protection role [6, 21]. Unlike other enset-growing areas where monoculture cultivation is common, in Gedeo, enset is cultivated as part of the diverse traditional multistory agroforestry systems. In this system, enset is grown alongside several perennial trees, shrubs, and crops such as coffee, multipurpose native and exotic tree species, and vegetables [21]. This distinct planting pattern sets Gedeo apart from other enset-growing regions, highlighting the innovative and adaptive land use practices in Gedeo that have evolved to match their ecological and socioeconomic context [29]. Such adaptation likely explains their ability to sustainably thrive for millennia in a very densely populated, about 900 persons/km^2 and rugged landscape naturally prone to degradation. The Gedeo people believe that enset cultivation is the

Table 7: Ethnobotanical use of the major enset landraces and their parts in the Gedeo zone.

Name of landaces	Part used	Uses
Astara (keyi)	Corm	For medicine to repair a bone broken
	Bulla	For back pain, for woman give born
Astara (Tikur), Dimoye, Dinke, and Filila	Pseodostem and corm	Pseodostem and corm together used for kocho, the psedostem used for bulla and fibre, the corm used for amicho
Ganticho	Pseodostem and corm	Pseodostem and corm together used for kocho, the psedostem used for bulla and fibre, the corm used for amicho and to treat human ailments, central starchy part of corm used raw food for children and youth
	Kocho	Used to treat amoebiasis and cramps
	All parts	Is highly regarded by farmers due to its high productivity and Koch yield
Gantole	All parts	Used for soil protection and environmental sustainability
Harame	Pseodostem and corm	Pseodostem and corm together used for kocho preparation, pseodostem used for bulla, corm used for amicho
	All parts	Used for soil protection and environmental sustainability
Kake	Corm	Medicinal values for couphe
	Mid-rip	Bone fracture, tonsil, abdominal pain, back pain, coughing,
Mundo	Leaf and mid-rip	Squeezed water preventing skin scabies
Nifo	Bulla	Back pain, bone fractures, and joint displacement, For a woman give a baby
	Corm	Used as best amicho
	All parts	Used for soil protection and environmental sustainability
Karase	Mid-rip	The sequeze of the midrip used for abdominal pain, malaria, hepatitis, for Eba and eye disease
	Fruit and corm	Squeezed water, fruit, boiled corm used for abdominal pain, malaria, hepatitis, for Eba and eye disease
Toracho	Pseodostem and corm	Pseodostem used for fibre production: the corm used to treat human ailments, central starchy part of corm used raw food for children and youth
Selected mature clones	Corm	Used to prepare traditional starter culture (gamama) for kocho fermentation

cornerstone of their sustainable way of living, regarding enset as the symbol of agroforestry, landscape sustainability, and food security [6].

Enset, due to its perennial nature, provides permanent land cover and conserves soil and water. Its dwarf stature, compared to trees, helps interrupt rainfall, reduce the splashing effect, and direct rainwater falling on its leaves to the base of the pseudostem, thereby reducing erosion caused by raindrops [2, 30]. Its multilayered and broad-leaved nature allows it to cover a wider surface area per plant, making it effective in capturing and channeling raindrops safely to the soil beneath it (Figure 10 A). Additionally, enset produces a large quantity of litter that acts as a shield, reducing surface runoff, water loss through transpiration and evaporation, and increasing infiltration by enriching the soil with organic matter (Figure 10 C,D).

Enset plants are harvested selectively, and each harvested plant is replaced by a new one, ensuring a permanent land cover throughout the year contributing to soil–water conservation (Figure 10 A–D). Farmers recognize four distinct enset growth stages—Sima (< 1 year), Kufa (1.5–2 years), Sema (2–4 years), and Degicho (4–5 years, mature). By strategically rotating these clones, they ensure a continuous food supply year-round. This practice also indirectly contributes to soil conservation by maintaining consistent canopy cover. Enset plants possess specialized leaf structures and water storage capabilities, enabling them to adapt to climate changes. Their funnel-shaped leaves efficiently capture rainwater and direct it toward the base of the plant (Figure 10B). Additionally, the overlapping arrangement of leaves and tightly packed sheaths act as a reservoir and storage tank, ensuring water availability even during dry periods or when rainfall is limited (Figure 8).

Its fibrous roots protect the soil, while its large body helps harvest and store water. Farmers in the Gedeo region rotate their enset processing sites within their field believing that the exudates from fermenting enset biomass enrich the soil. Enset leaves also contribute to reducing soil erosion by capturing and storing large volumes of rainwater. Farmers often trim and use the giant leaves as green manure to prevent understory crops from being overshadowed and deprived of light (Figure 10C, D). Environmental sustainability is a priority for Gedeo



(A) (B)

Figure 9: Traditional feeding style A, kocho bread (Right) with meat B (A), Kocho injera and bread (Kunchisa and Talta) with meat (B). Photo credit Zerihun and Brihanu [4].



(A) (B) (C) (D)

Figure 10: Enset integrated with trees in the Gedeo agroforestry system (A); enset plants at different growth stages from young to mature or inflorescence stage (B); harvested pseudostem and corm with leaves retained in the field for soil enrichment (C and D).

farmers, who use specific enset landraces for soil fertility amendment. There are two main categories of enset landraces based on their role in soil amendment: the "soft" group (shaqatawese) includes varieties like Qarase, Danbale, and Torame, while the "hardy" group (jabatawese) includes varieties like Gantole, Nifo, Harame, Ganticho, and Toracho (Tables 3 and 4). The soft group is planted in exhausted soils to rehabilitate them. Hardy enset varieties such as Genicho and Toracho are commonly planted in erosion-prone areas due to their strong, deep root systems, which help prevent soil erosion and detachment. They are especially valued in sloped areas for their role in soil conservation and environmental protection. Understanding the environmental regulatory aspects of enset is crucial for comprehending the dynamics of Gedeo agroforests and designing more sustainable land use systems in the region.

Apart from soil and water conservation, the enset system also supports the conservation of rich plant biodiversity. The enset-based agroforestry in Gedeo is known for harboring a large number of plant species, including many native tree species of conservation concern (Figure 10A). The presence of enset-based agroforestry systems, such as the enset-coffee system and theenset system, contributes to the conservation of native woody species due to farmers' tree management practices. Consequently, such integration of trees holds significant contribution to the overall sustainability of the region. For example, Negash et al. [21] identified 59 woody species in three traditional homegarden agroforestry systems—enset-based, enset–coffee-based, and coffee–fruit tree-based systems—demonstrating the role of enset farming in supporting plant biodiversity. The presence of trees in the system provides shade for enset, reducing evapotranspiration and adding green manure to the soil [31]. The enset-coffee system, in particular, has the highest number of native woody species of conservation concern. This highlights the significant value of maintaining enset farming and diversity in conserving other threatened plant species. Therefore, it may be more effective to approach enset landraces conservation in conjunction with native plant conservation, water conservation, and soil conservation, rather than focusing solely on enset diversity conservation.

3.3.3. Social and Cultural Values. Enset also holds cultural significance in Gedeo. Traditions, beliefs, and worldview of the people of Gedeo are deeply intertwined with the enset. They assign distinct values to different parts of the enset plant based on their cultural importance (Tables 3 and 4). This practice reflects their unique traditions and attachment to the plant that have evolved over millennia. For example, the live leaves of enset, known as hochcho, symbolize peace and meditation, while the root, referred to as hiddichcho, symbolizes truthfulness. The use of fresh enset leaves is an integral part of various ceremonies and practices. For example, fresh butter is applied using enset leaves during birth, circumcision, and wedding ceremonies. Enset leaves are also used as a seating cover for elders and disputing parties during arbitration.

The following excerpt from Kipie [6] summarizes the social value of enset in Gedeo:

> "Enset is not just their means of livelihood; it is inseparably connected to every aspect of their lives, from birth to death. The Gedeo welcome newborns on dried enset leaves (hashupha), and the placenta is received in an enset leaf sheath (hachcho) within the house. The birth of a new baby is announced by placing an enset leaf (cichcha) on the door. During the first few months of infancy, the infant's excreta are collected on enset leaf sheaths and fibers (haanxxa) until the initiation ceremony. The excreta is then used as mulch under three enset plants (bululo) planted to mark the initiation (cichchafula). During marriage, newlyweds spend their first night on a bedding of enset leaves. When constructing a house, enset is planted at the location of the future pillar (utupha). Even in the final stages of life, a dying person is placed on a bedding of enset leaves and midribs."

According to an elder cited by Abiyot [18], the significance of enset to the Gedeo people is profound: "Enset is everything for us; it is our main source of food; our bed; our umbrella; our house, our medicine, our cloth, our source of wealth, food for our animals. It protects our soil from erosion, increases soil fertility, and conserves our water. We cannot live without enset."

3.4. Conservation Status of the Enset Landraces. Enset landraces face various challenges that could significantly threaten their long-term sustainability. Decline in landrace diversity is already noticeable across enset-growing regions in Ethiopia [32–34].

Land-use intensification and the growing threat of pests and diseases are among the primary challenges to the conservation of enset landraces. The expansion of cash crops and changes in traditional farming practices are reducing the space and attention given to enset cultivation. Simultaneously, the spread of pests and diseases—particularly bacterial wilt and root mealybugs—is contributing to the decline or loss of important landraces [35]. These pressures underline the need to strengthen conservation strategies, including complementing in situ efforts with ex situ conservation to preserve enset's genetic diversity.

In the Gedeo zone, several enset landraces require conservation attention. Farmers maintain diverse enset landraces for various reasons, including their suitability for different food products, such as sources of fiber, fodder, or medicine, and their tolerance to different climates and pests [36, 37]. However, despite the existence of 57 reported landraces in the Gedeo zone, farmers typically prioritize only 3–6 high-yielding and disease-resistant varieties. This prioritization leaves most landraces susceptible to the threat of extinction. Therefore, it is crucial to collect and conserve those landraces rarely used to safeguard their potential future uses as well as maintain the genetic pool of the enset crop.

Some rare landraces include Tilila, Miqi, Shana, and Cicibito, which are found in a few farmers' gardens (Table 2). The Mundoye/Mudo landrace, known for its medicinal value, is also rare. Landraces such as Birra, Qosre, and Woamo exhibit an overall frequency of 1% across the study area (Table 2). This low frequency indicates that these landraces are currently facing local threats and are at risk of declining or disappearing entirely. There is therefore an urgency of conservation effort and intervention aimed at safeguarding and maintaining these valuable but rare landraces.

At the national level, efforts are underway to collect and conserve enset landraces, primarily through institutions like the Areka Agriculture Research Center and the Ethiopia Biodiversity Institute (EBI). In Gedeo, institutions such as Dilla University Botanical and Ecotourism Garden (DUBEG). The Gedeo Zone Natural and Environmental Protection Office have established in situ gene banks for enset landrace conservation. Dilla University manages two in situ field gene banks, while EBI operates an enset field gene bank in Gedebe district. However, current conservation efforts face challenges. Conservation priorities often prioritize farmers' preferred landraces for multiplication and distribution rather than focusing solely on the conservation needs of threatened enset landraces. Additionally, despite collecting threatened landraces and planting them in field gene banks, there is a lack of continuous propagation practices. Given that enset is a monocarpic plant, continuous propagation is crucial for sustaining its generations. Furthermore, lack of coordination and collaboration among agencies remains a challenge, as many operate independently rather than complementing each other to broaden the scope of landrace conservation efforts in the zone.

4. Conclusion

The study identified a total of 57 enset landraces, marking over 100% increases in the total number of landraces in Gedeo compared to previous reports. The discrepancy between this study and earlier reports may be attributed to difference in the methodology employed and sample size. The study not only highlights the diversity of enset landraces in the Gedeo zone but also reveals their unique ethnobotanical uses and their conservation status.

Enset landraces hold profound importance for the Gedeo people, serving as the cornerstone of their environmental sustainability, food security, and sociocultural values. It is an asset that helped them thrive for millennia in an environment that is otherwise susceptible to socioeconomic and ecological disaster due to its rugged natural terrain and high human population pressure.

Farmers in the area select and maintain a number of landraces on their farms to address their various food, fiber, and medical requirements. As no single landrace meets all these needs, conserving enset diversity is crucial to sustaining its full cultural, nutritional, and ecological value. Despite the rich diversity in enset landraces, only a few of them are widely used leaving most landraces threatened with extinction. The majority of the identified enset landraces in the study area are area-specific, rare, and threatened, facing both natural and anthropogenic pressures. This calls for increased attention and immediate conservation measures from research and development stakeholders in a collaborative approach.

As this study identified enset landraces based on their local names and morphological traits, there may be duplication among vernacular names. Therefore, further genetic characterization is required to verify the current work. The growing threats posed by disease outbreaks, pests, and climate change highlight the urgent need for strengthened conservation efforts. A coordinated approach involving both research and development stakeholders is essential to safeguard enset biodiversity. To complement existing in situ conservation practices, the collection and ex situ preservation of enset landraces may be necessary—especially in areas where intensified land use, disease, and environmental stressors threaten the survival of valuable genetic resources. Enset is deeply intertwined with the cultural identity and heritage of communities in the Gedeo zone, serving not only as a staple crop but as a symbol of resilience, tradition, and indigenous knowledge. Preserving enset diversity and traditional practices is vital for maintaining the integrity of these culturally significant landscapes in a sustainable way. Such efforts contribute to the long-term conservation of the Gedeo zone as a living World Heritage landscape.

Data Availability Statement

Data will be available upon request directly from the first authors or from the corresponding authors.

Disclosure

The authors affirm that this manuscript is our original work, and we have appropriately acknowledged all sources of materials used in its creation. This manuscript has been submitted for publication and is deposited in the publisher's database, where it will be made accessible online according to the publisher's regulations. We solemnly declare that this article has not been submitted to any other publishers or institutions for publication.

Conflicts of Interest

The authors declare no conflicts of interest.

Author Contributions

Mitiku Muanenda and Getahun Haile designed the field survey, collected and analyzed data, and drafted the manuscript. Beyene Tekelu, Getachew Agegnehu, and Mulugeta Lemenih contributed to reviewing the manuscript and ensuring the overall quality of the work.

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Supporting Information

Additional supporting information can be found online in the Supporting Information section. (*Supporting Information*) Table S1 contains the complete dataset of enset landrace frequencies and percentages across Dilla Zuria, Yirgachefe, Gedebe, and Bule districts, as recorded in this study.

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