

Morphological Diversity and Ethnobotanical Study of Enset (*Ensete ventricosum*) (Welw.) Cheesman in Kebena, Cheha and Ezha Woredas, Gurage Zone, SPNNRS, Ethiopia

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Abstract: ENSET is a multipurpose crop in which every part is thoroughly utilized, not only for food but also for several cultural applications and livestock feed. It is primarily used as food, feed, medicinal, ornamental, and raw material for industries and construction materials. As a species, ENSET morphology is highly variable, although the extent of its variation remains unknown. The purpose of this study is therefore (i) to identify the existing ENSET diversity, (ii) to identify morphological trait variability among landraces of Enset, and (iii) to identify threats that affect ENSET diversity and to understand the associated indigenous knowledge in the study area with the ultimate goal of providing information that will help in constructing a scientific basis for the conservation and sustainable use of the plant. The study was carried out in ten purposively selected kebeles of three districts in the Gurage zone. A total of 100 (20 purposively selected key informants and 80 randomly selected general informants) were interviewed using semi-structured interviews; field observations and guided field walks were also used to collect ethnobotanical data. Morphological traits were measured according to Enset IBPGR (International Board for Plant Genetic Resources) descriptors. The data were analyzed by using computer software R v 3.2.2 and SPSS v 16.0 as well as an Excel 2010 spreadsheet. Direct matrix ranking and preference ranking were also used to analyze the ethnobotanical information. A total of 33 ENSET landraces were identified from the study area. Farmers give the name for their landraces based on morphological traits and sources of planting material. The identified landraces grouped into five clusters based on morphological trait variability. Mean plant height, pseudo stem height and cecum, leaf size and number were significantly different ($p < 0.05$) among clusters. The most abundant landraces were Lemat Nechiwe Yeshirafire and Kanchiwe in Kabena District, whereas Agade and Yeshirakinke were the most abundant in Cheha. Yeshirakinke, Nechiwe, Agade and Kibinar were the most dominant landraces in the third study district. ENSET is an important food crop consumed in the form of bulla, Kocho and Amicho. In addition, ENSET is used as animal feed, as well as a source of medicine and fiber. This study confirms that the Gurage zone is rich in diversity of ENSET, but a reduction in production and loss of some landrace was observed because of different factors.

Keywords: *Ensete ventricosum*, Kebena, Cheha, Ezha Morphological Trait

1. Introduction

ENSET is a multipurpose crop in which every part is thoroughly utilized, not only for food but also for several cultural applications and livestock feed. It is primarily used as food, feed, medicinal, ornamental, and raw material for industries and construction materials. The major foods

obtained from ENSET are *Kocho*, *bulla* (the pseudo stem products) and *Amicho* (root product). ENSET also has diverse socioeconomic, cultural, and ritual worth [7]. As a perennial, ENSET improves local climate and soil conditions [1] ENSET (*Ensete ventricosum*) is distributed as a wild species in many parts of Sub-Saharan Africa [12]. It is the main crop of a sustainable indigenous African system that

ensures food security in a country that is food deficient. Ethiopia is one of the centers of diversity and origin for various agricultural crops [8]. ENSET is one of the oldest cultivated plants of Ethiopia, which is the sole country domesticating over 50 landraces and uses the plant as a food and fiber crop [2]. Records suggest that ENSET has been grown in Ethiopia for more than 10,000 years [13]. According to [1] the cultivation of ENSET in Ethiopia was estimated to spread over 67000 square kilometers. The 'ENSET' planting economy is one of the major activities of agriculture in the southern nation, nationalities and people's regional states.

The productivity of Enset is very high compared to that of other crops but varies depending on edaphic factors, altitude, cultural practices and varietal differences [11]. Landrace is a variable population that has a local name, lacks formal crop improvement, and is associated with the traditional uses, knowledge, habits, and celebrations of the people who developed and continue to grow it [10]. ENSET is a crop that has many landraces. As landraces are morphologically different, farmers can identify and subsequently attach local names to them. In addition, different landraces are recognized to have characteristic adaptations to edaphic factors, reveal individual responses to the time of seeding, and have typical days to maturity, height, nutritive value, use, and other properties [3]. The loss of diversity in the form of traditional crop landraces or landraces throughout the world has been under the subject of considerable concern in the past three decades. This could be because landraces are difficult to reclaim once they disappear.

The local diversity of ENSET remains less limited despite the use value of the crop as food for the majority of the people in southern Ethiopia. This might have entailed loss of

the existing diversity and associated indigenous knowledge (IK) [13]. Traditional ENSET farming systems have thus far been studied by agronomists and geneticists, who have attempted to assess the level of morphological diversity found in some parts of the country [9]. As a species, ENSET morphology is highly variable, although the extent of its variation remains unknown. The purpose of this study is therefore to identify the existing ENSET diversity, to identify morphological trait variability among landraces of Enset, to identify threats that affect ENSET diversity and to understand the associated indigenous knowledge in the study area with the ultimate goal of providing information that will help in constructing the scientific basis for the conservation and sustainable use of the plant.

2. Methodology

2.1. Study Area

The field sites for this study were the Kabena, Cheha, and Ezha districts of the Garage Zone (Southern Nations Nationalities) (Figure 1). The Gurage zone is located in the Southern Nation Nationalities People Regional State (SNNPRS). It is situated 158 kilometers southwest of Addis Ababa. Based on [4] this Zone has a total population of 1,279,646, of whom 622,078 are men and 657,568 are women. The population of the study area is almost entirely of the Gurage ethnic group (82%). The Gurage people live a sedentary life based on agriculture, involving a complex system of crop rotation and transplanting. ENSET is their main staple crop, but other cash crops are grown, which include coffee and chat. Animal husbandry is practiced, but mainly for milk supply and dung.

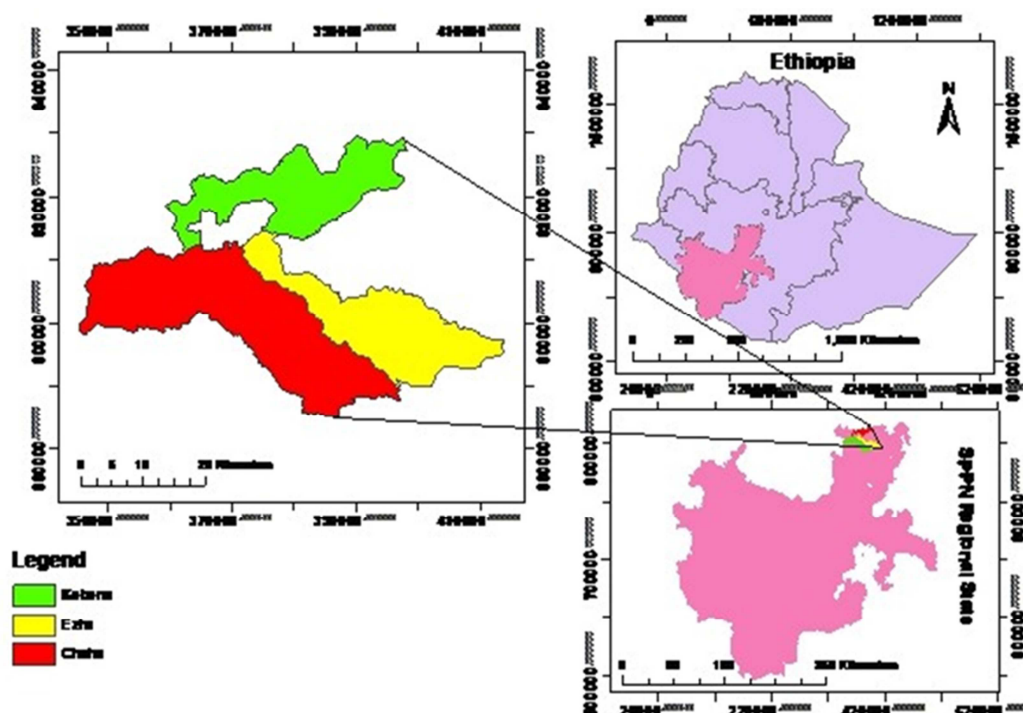


Figure 1. Map of the study area.

2.2. Sampling Research Site

The study sites were selected based on areas that have high production of ENSET and those ENSET landraces that play economic and cultural roles. These study areas were selected by referring to different literature sources, by referring to the survey made by CSA [5] on area and production of major crops and by using the suitability map of ENSET made depending on data obtained from FAO [6] on the crops' ecological requirements. Information about the production of ENSET from agricultural institutions in the study zones was used. Based on the above selection criteria, the study was conducted on three randomly selected representative districts (Kabena, Ezha and Cheha) and four kebeles from each Ezha and Kabena district and two kebeles from Cheha districts with a total of ten purposively selected representative kebeles. From each Kebeles, 10 households were selected, bringing the total number of sampled households to 100 informants with different ethnic, religious, age and sex categories. From the total informants, 80 were randomly selected general informants, and 20 were purposively selected key informants who were very interested and those who were recommended by elders, local authorities and local farmers.

2.3. Data Collection

Both primary and secondary data were used in this study. A combination of techniques was applied to collect the data needed to assess the landrace diversity of ENSET, and the ethnobotanical information of ENSET in the study area. The primary data were collected through semi structured interviews and field observations. The questionnaire generally includes data on production, diversity, indigenous knowledge on production and management, use and conservation of ENSET. Secondary data were collected from different district offices and different written materials. Ethnobotanical data were collected to determine the indigenous knowledge of participants or farmers on the ENSET. Different qualitative and quantitative Etnobotanical data collection methods, such as field observation, guided field walking, semi-structured interviews and market surveys, were used to obtain the necessary information from the participants. Information on the distribution of ENSET landraces, and interviews with informants were performed. The interviews were conducted in farmers' fields and homes. The interviews were used to gather ethnobotanical information on the local name of the crop and landrace, time of cultivation and harvesting, traditional management practices, cropping system, uses and market value of the crop, landraces that survive drought, disease, pest and have short maturity time, planting material exchange system and production constraints and perception of the farmers toward the crop (Appendix 1). The necessary

information on the morphology of ENSET, and how ENSET is cultivated, intercropped, used and marketed were systematically recorded. The local perspectives on dominant crops produced, landscapes and soil type of the study area were identified through personal observation and discussion with local experts. During the study, a market survey was undertaken to record the *Ensete ventricosum* landraces that are sold in the market together with information on market values. This is an especially good method to conserve landraces of ENSET that have high economic value.

2.4. Data Analysis

Descriptive statistics were used to analyze data obtained through questionnaires and guided field walks. The data were analyzed by entering them into SPSS and Excel spreadsheets and summarized by means, standard deviations, ranges and other tools. Ethnobotanical data were analyzed by preference ranking and direct matrix ranking. ENSET landrace diversity analysis (Shannon 1949), including the Shannon Wiener index (H') and richness and evenness, of each *Kebele* study was performed. The Shannon Weaver Index (H') was used to analyze the phenotypic diversity of ENSET depending on the traits that were measured, counted and recorded. It was calculated using the formula,

$$H = - \sum_{i=1}^s p_i \ln p_i \quad (1)$$

where:

S is the number of phenotypic classes for a character, and p_i is the relative proportion of the total number of entries (N) in the i^{th} class.

As a measure of diversity that takes into account the proportional abundance of landraces (richness and evenness). Richness refers to the number of different kinds of individuals regardless of their frequencies. Evenness, however, measures how similar the frequencies of the different variants are, with low evenness indicating dominance by one or a few types. Evenness has values between 0 and 1, where 1 indicates the condition where all landraces are equally abundant, while 0 indicates that few landraces are more abundant.

Evenness is calculated as: $E = \frac{H}{H_{\max}}$, where H is the Shannon-Weaver diversity index, H_{\max} is $\ln(N)$, and N is the total number of landraces. Simpson's index of diversity

$$(1-D) = 1 - \sum (n/N)^2 \quad (2)$$

where:

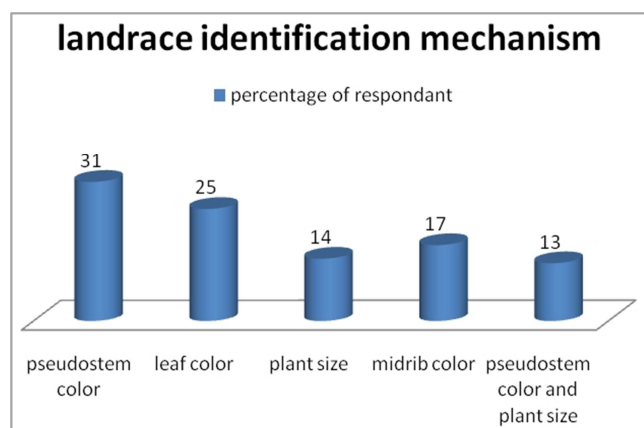
n = the frequency of the i^{th} cultivar, i.e., frequency of the cultivar embodied in the i^{th} farms in the district and N = the total number of farms surveyed in the district.

Table 1. Morphological traits measured from ENSET landraces.

Character	Code	Qualitative categories or quantitative measure
Pseudostem color	PSC	1 = light green, 2 = deep green, 3 = greenish black, 4 = light red, 5 = dark red, 6 = reddish yellow,
Petiole color	PC	1 = light green, 2 = deep green, 3 = yellowish green, 4 = light red, 5 = dark red, 6 = reddish yellow,
Midrib color	MC	1 = light green, 2 = deep green, 3 = greenish yellow, 4 = greenish red, 5 = light red, 6 = dark red, 7 = dark brown
Leaf color	LC	1 = light green, 2 = deep green, 3 = light red, 4 = dark red, 5 = purple
Kocho quality	KQ	1=high quality, 2= medium quality, 3=low quality
Bulla quality	BQ	1=high quality 2=medium quality 3=low quality
Fiber quality	FQ	1=high quality 2=medium quality, 3=low quality
Drought resistance	Dr. R	1=resistant, 2=vulnerable
Disease resistance	D.R	1=resistant, 2=susceptible
Pseudostem length	PL	Meter
pseudostem circumference	Psc	Meter
Leaf length	LL	Meter
Leaf width	LW	Mater
Number of leaf	NL	Number
Plant height	PH	Mater

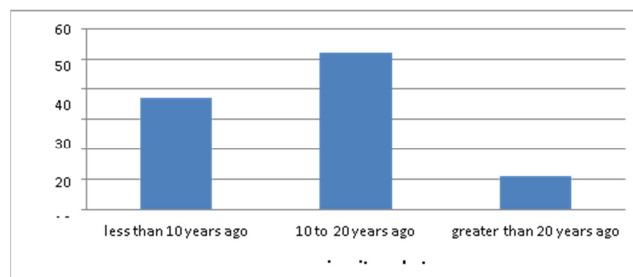
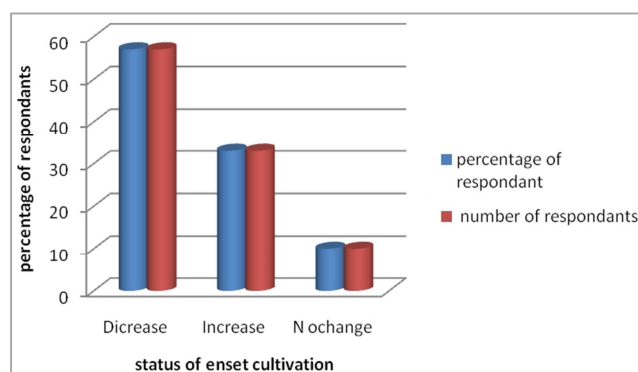
3. Results and Discussion

Out of the total interviewed households (N =100), 29% were females and 71% were males. An unequal pattern of gender distribution was observed in the specific study sites. From the total respondents, 16% of the household heads were younger than 35 years old, while the household heads (42%) were in the age range between 35-50 and older than 50 years old. Females and teenagers have less knowledge about landraces of ENSET even though they do not know the name of their landraces, which shows that there is no flow of indigenous knowledge about ENSET in the study area. This may cause a loss of indigenous knowledge in the study area. There were different morphological and agronomic characteristics that farmers used to identify their landraces in the study area. Of these colours (pseudo stem, midrib, leaf and petiole) time of maturity, disease resistance, yield, leaf dimensions (width and length), and pseudo stem length (Figure 4). Depending on the landraces cultivated in the home gardens, the most frequently mentioned descriptors for identification were pseudo stem color (31% of the respondents), midrib color (17% of informants) plant size (14% of the respondents) and leaf color (25% of respondents).

**Figure 2.** Landrace identification mechanisms of farmers.

There were some landraces that were lost from the study

area for different reasons. Lost landrace were known as BOSERET and MISHRAT and others which were lost completely from all study districts, and some landraces, such as GIMBIWE, SEBBAR and others, were lost from cheha and Ezha districts because of their low kocho and bulla quality. Some landraces (especially those with medicinal use) show indications of loss because of their low yield and susceptibility to disease, and some farmers stop cultivating these landraces and replace them with other landraces.

**Figure 3.** Year of local extinction of the ENSET landrace.**Figure 4.** Development of ENSET landrace production.

Farmer's mention different causes of extinction of their landraces, shortage of land, climate change, replacement by preferable landraces and others. The majority of farmers (33) in the study area agree that farmers prefer high-yielding plant and disease resistance landraces to be the root cause of loss. Drought and climate were also reported by a few farmers (9%), forcing them to select only resistant landraces. Farmers

reported that production (farmers' interest in growing ENSET) decreased. Increasing demand to engage in the production of other crops was one of the factors accounting for the decreasing trend of ENSET production.

In the study area, some quantitative and qualitative agronomic traits were recorded. Most of the qualitative traits recorded were similar in different study districts. The 33 originally identified ENSET landraces were grouped into 5 clusters based on morphological traits (pseudostem color, petiole color, leaf color, midrib color, Kocho quality, bulla quality, and fiber quality) and agronomic characteristics (disease resistance and drought resistance).

Cluster one: This cluster includes the largest number of ENSET landraces, 9 (27.2%) out of 33 landraces recorded. Landraces in this group are characterized by having light green pseudostems, deep green leaves, light green midribs, high quality fiber, drought and disease resistance.

Cluster two was well defined on the basis of Kocho, bulla,

and fiber quality. Landraces in this group provide high quality bulla, kocho, and fiber.

Cluster three: This cluster includes only two ENSET landraces (Astara and Amorate). The members of this group have dark red pseudostems and deep green leaf medium fiber quality and are vulnerable to drought and diseases.

Cluster four: This cluster includes four landraces of ENSET and was well defined in the bases of leaf and resistance to drought and diseases. They have purple leaves and are resistant to diseases and drought.

Cluster five comprised landraces with deep red pseudostems, deep red petioles, yellowish green leaves, and high resistance to disease and drought. In this cluster, there was a wild ENSET landrace called yeqebero ENSET which means fox ENSET, and the seed of the ENSET seed was brought by the fox. Wild ENSET landraces were domesticated and cultivated by some farmers in the study area.

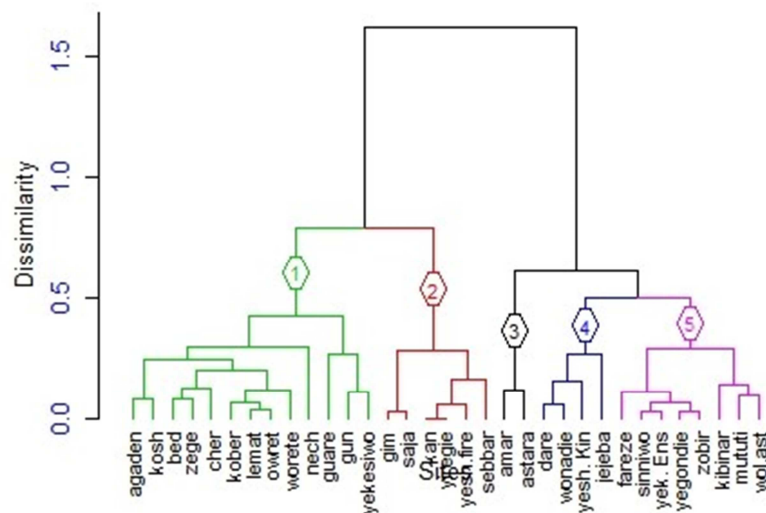


Figure 5. Dendrogram of 33 landraces of ENSET (*Ensete ventricosum* (Welw.) Cheesman) based on morphological variability.

Table 2. Mean of the quantitative characteristics for each cluster of the ENSET landrace.

Clusters	Mean plant height(M) \pm SD	Mean pseudostem height \pm SD	Mean pseudostem circumference (m) \pm SD	Mean leaf width (M) \pm SD	Mean leaf length \pm SD	Mean leaf number \pm SD
Cluster 1	6.64 \pm 0.87	2.65 \pm 0.644	1.7 \pm 0.301	0.53 \pm 0.142	3.6 \pm 0.712	14 \pm 4
Cluster 2	7.7 \pm 0.54	2.98 \pm 1.13	2 \pm 0.368	0.56 \pm 0.152	4.33 \pm 0.35	13 \pm 4.4
Cluster 3	5.5 \pm 0.282	2.2 \pm 0.28	1.3 \pm 0.141	0.65 \pm 0.07	3.3 \pm 0.6	22 \pm 4.24
Cluster 4	7.3 \pm 0.72	2.7 \pm 0.457	1.67 \pm 0.499	0.62 \pm 0.06	4.47 \pm 0.206	12 \pm 5.73
Cluster 5	8.5 \pm 0.897	3.07 \pm 0.64	2.10 \pm 0.370	0.62 \pm 0.152	4.63 \pm 0.643	15 \pm 5.28

Table 3. Landrace diversity in study kebeles expressed as Richness (C), Evenness (E), Simpson (D) and Shannon (H') diversity indices.

Kebeles	Richn (C)	Shannon (H')	Simpson (D)	Shannon Evn	Simpson evn
Wosharbi	24	3.178034933	23.99909246	0.999994054	0.999962186
Lencha	18	2.890362406	17.99966364	0.999996765	0.999981313
Rimuga	18	2.889846181	17.98090224	0.999818163	0.998939013
Katbare	16	2.771653038	15.97051927	0.999662523	0.998157454
Girar	13	2.564865856	12.99783337	0.999967445	0.999833336
Yewosie	21	3.044444095	20.99671352	0.999974268	0.999843501
Yesirayi	18	2.890353133	17.99933173	0.999993556	0.999962874
Shebraden	19	2.944434558	18.99983209	0.999998498	0.999991163
Desene	19	2.944417603	18.99918919	0.99999274	0.999957326
Mentir	20	2.99570982	19.99910526	0.999992505	0.999955263

The average number of landraces listed by farmers was high in the case of Washerbi followed by Yesirai. Desene was the least common. Beta diversity was high in Desene. The beta diversity of Yesirai was lowest.

Table 4. Gama diversity (GD), alpha diversity (AD) and beta diversity (BD) of ENSET at study kebeles.

Kebeles Wosharbi	GD	AD	BD
	25	9.2	2.71
Lencha	18	7.2	2.5
Rimuga	18	8	2.25
Katbare	16	6.8	2.3
Girar	13	5.8	2.24
Yewosie	21	8.1	2.59
Yesirayi	18	8.2	2.19
Shebraden	19	7.9	2.40
Desene	19	5.6	3.39
Mentir	20	7.3	2.73

In Ethiopia, ENSET is produced mainly for foods [14]. In this study, ENSET produced mainly for food and uses as medicine, feed for cattle, fiber for house construction and material culturing and for income generation were the order of priority given by farmers based on preference ranking given by key informants. ENSET was not purposively produced for fiber. Fibber and leaves for material and house construction were the byproducts of ENSET. This study goes hand in hand with [1]. As a source of food, corms, pseudostems and stalks of the inflorescences were used in the form of ferment of scraped leaf sheaths and grated corm mixed (Kocho), squeeze of scraped leaf sheath, peduncle,

and grated corm (bulla) and boiled ENSET corm (Amicho). In this study, the different ENSET parts corm, pseudostem, and leaf were used for medicinal purposes for human and livestock. As a report of farmers there were no recommended dosage known, one can use (ate) until he/she/it become cure from the disease. The fiber used for house construction and material construction. In this study, almost all farmers in the study area did not produce ENSET for income generation if they had enough products only. In the study area, there were eight landraces that were reported for use to treat disease; they were: guare, astara, kibinar, dare, cherkima, sinniwo, agade, and woret.

Table 5. ENSET landrace, part/s used for treatment, type of disease and use as medicine and preparation method.

LANDRACES NAME	PARTSUSED	USED TO TREAT METHODS OF PREPARATION
GUARE	Corm	To dried abscess, Important forThe corm boiled and eaten with normal functioning of body, curemilk. from cough.
KIBINAR	Corm	Used to join the broken body The corm boiled and the boiled (bone), for lung disease & cough, amicho eaten with cheese to harden the damaged organ
ASTRA	Corm and pseudostem	To repair & soften the broken The corm sliced and boiled and body (bone), initiate milk the amicho and starchy powder production for mammary gland forbulla are eaten with milk. women.
DARE	Corm and pseudostem	-For dried the wound of Human and
CHERKIMA		-To dried the wound of cae
SINIWO		-Important for body protein development for both human and cattles.
		For fattening of livestock Corticated and given to the
		-For normal functioning of body

4. Conclusion

Generally, as the results of this paper indicate, the Gurage zone is rich in having different ENSET land races and cultures and indigenous knowledge on ENSET production and maintenance, but there were some ENSET landraces that have been lost due to different factors, such as shortages of land, climate change and replacement with high-quality land races, and as a result, the production of ENSET in the study area was reduced. Of these factors, the main factor was the replacement of these landraces with high-quality and disease-resistant landraces. Not only reduction in landrace, but also loss of some landraces and their habitat will ultimately cause loss of the knowledge, services and cultural values about ENSET that have been accumulated over time. Of these factors, the main factor was the replacement of these

landraces with high quality and disease-resistant landraces.

Declaration

I, the undersigned Adanech Jarso hereby declare that I am the sole author of this thesis. I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name. t. In addition, I certify that no part of this work will, in the future, be used in a submission in my name, for any other degree or diploma in any university. To the best of my knowledge this thesis contains no material previously published by any other person except where due acknowledgement has been made.

Conflicts of Interest

The authors declare no conflicts of interest.

Appendix

Data Collection Formats

General Information

Date _____

Informant's Name _____ Age _____ Sex _____

Location: Region _____ Zone _____ Wereda _____ Kebele _____

Altitude _____ Latitude _____ Longitude _____

Ethnobotanical Information

Enset

1. Name all the landraces you grow and indicate if they are improved or farmers variety

Name variety	of	the	Improved	Farmers variety	Use	Parts used
1.					medicinal	food
2.						

2. Which one is the most commonly used landrace in your area? What is the special thing about it to be commonly used?

For key informants

In general,

3. What is the local name of Enset in your language? What is its meaning? _____

4. Is there any wild relative of this species you know? What is it called? For what purposes is it used?

5. List the top four crops cultivated in your area? _____

6. What makes enset different from other crops? _____

7. What do you think about the amount of production of Enset in your area (in your life time)? Because of what do you think this happened?

A. Increased B. Decreased C. No change

8. What are the threats of the Enset variety in your farmland?

9. By what kind of pests and diseases is Enset affected in your farm land? What do they cause? _____

10. What are the common weeds that attack this crop? What do they cause? _____

11. How do you traditionally manage such pests and diseases? _____

12. What kind of fertilizer do you use?

A. Compost B. Urea C. DAP D. Fresh Manure E. Natural F. Nothing G. Other

13. If you don't use fertilizer, why?

14. Are there limitations in the cultivation and utilization of enset in your locality? _____

15. How much hectares do you own? _____

16. How much of it do you use for Enset production? _____

17. How much do you get from that hectare? _____

18. What amount of Enset do you use for household consumption?

A. 1/2 B. 2/4 C. 3/4 D. All

19. What amount of Enset do you use for selling to market?

A. 1/2 B. 2/4 C. 3/4 D. All

20. Could you tell me the amount or dosages that are used for disease treatment?

21. What are the different uses of Enset? Which parts of the plant are used for what purpose? How? Planting Materials, Selection and Storage

22. From where do you get planting material? _____

A. Market places B. Stored seeds C. exchange with other farmers D. Research center E. Other (specify) _____

23. Do you select planting material for next season? If so, what are the criteria of selection?

A. Yield amount B. corm color C. corm size D. leaf size E. Other (specify) _____

24. Where do you store planting material? _____

25. What kinds of pests affect enset landraces during storage? _____

Cultivation and management practices

26. How do you manage your land before planting? _____

27. How do you manage your land after plating? _____

28. How do you manage it after harvest? _____

29. What are the responsibility of females in the cultivation and management of Enset? _____

30. How many times is it weeded? _____

31. What is the environmental requirement for the crop to grow? _____

32. Which soil type is suitable for Enset growth? _____
33. Where do you grow this crop?
A. Home garden B. Main field D. Other (specify)
34. Which cropping system do you use to grow Enset?
A. Sole cropping B. Intercropping C. Border cropping D. multiple cropping E. Other (specify) _____
35. If intercropping, which crops do you grow in association with Enset?
36. If boarder cropping, which crops do you grow in association with Enset? _____
37. What are the uses of border cropping? _____
38. If multiple cropping, which crops you grow in association with Enset?

Assistance to land use planning, Ministry of Agriculture, Addis Ababa, Ethiopia.

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