



Indigenous knowledge and socio-economic Significance of Enset (*Ensete ventricosum* (Welw.) Cheeseman) cultivation and food processing in Sidama, Southern Ethiopia

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Research

Abstract

Background: Peoples' culture and natural resources tie has first line survival value in Ethiopia. The drought resistant crop locally called enset supports about 20 million populations. The aim of this research is to investigate the farmer's indigenous knowledge in cultivation, food processing and use value of enset in Sidama, southern Ethiopia.

Methods: The research was undertaken in Hula district in March and May 2017. The study area is predominantly enset growing highland ranging from 2100-3200 masl. Focus group discussion with key informants and interview with development agents were used to collect data in six kebelles. For enset landraces survey about 13 households backyard were randomly visited and the result was concretized with field observation.

Results: A total of 26 landraces were recorded and farmers identify enset landrace using combinations of agro-morphological traits. Utilitarian and cultural values are the main determining factors for the maintenance and conservation of large number of landraces. Majority (80%) of the people are dependent on kocho-bulla and Amicho for food and suckers for income. The farmers' indigenous knowledge in selection and maintenance of enset

landrace diversity is powerful; environmental stresses and selection are the main causes for the loss of some landraces.

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Conclusion: There is strong link between the community and the diverse landraces of enset in the study area. Food processing from enset is laborious, hence demands technological innovation that ease job and maintains food quality. The use of suckers as means of reproduction helped to maintain the

quality existed but adaptation to changing climate is low and seed utilization must be encouraged during in-situ conservation.

Key words: Enset, indigenous knowledge, landrace diversity, Sidama

Background

Enset (*Ensete ventricosum* (Welw.) Cheesman) is a cropper dominantly growing in south and southwestern Ethiopia. It has both the cultivated and wild types. The existence of the wild type in Ethiopia has been described by many researchers only from south and south western Ethiopia (Borrell *et al.* 2019), but the wild type is locally called gunaguna used as ornamental and packaging exists in Tigray regional state, Northern Ethiopia. It has also been proved its existence in the same region since the antiquity perhaps in Aksumite kingdom from the archeological finding in Mai-Adrasha (Niall 2005), which consolidates Ethiopia being the origin of enset. The cultivated enset is a multipurpose crop plant that belongs to the family Musaceae. All parts of the plant are economically important. The corm, pseudostem and the inflorescence stalk of enset are the most important sources of food. The food stuffs prepared from enset are called Kocho, Bulla and Amicho. Brandt *et al.* (1997) defined the food item as: Kocho is fermented starch obtained from decorticated (scraped) leaf sheaths and grated corms. Bulla is a liquid which is obtained when leaf sheaths and corms are pulverized, the liquid containing starch is squeezed out from scraped leaf sheaths and grated corm and the resultant starch allowed to concentrate into white powder. Amicho is boiled enset corm/rhizome pieces that are prepared and consumed in a similar manner to other root and tuber crops. The fiber extracted during the processing of food is used for making strings, ropes and other products. Enset fiber has an excellent structure and its strength is only next to *Musa textilis*, a world class fiber crop (Alemu & Sandford, 1991). Fresh leaves of enset used as bread and food wrappers, serving as plates and pit liners to store kocho for fermentation and future use. Especially during the dry season, when grasses are scarce, the leaves of enset are good sources of animal fodder. Some particular landraces of enset are also used as medicine for both humans and livestock's (Nida 1996). Besides these, enset's perennial canopy of leaves and abundant accumulation of litter from its dried leaf sheaths protect the soil from erosion and degradation (Brandt *et al.* 1997).

The enset farming system is believed to be indigenous to Ethiopia and mainly practiced in the highland area of south and southwestern Ethiopia. In these regions, enset is regarded as a food security

crop and occupies a central position in the livelihood of the community. The presence of enset in the farming system contributes significantly to stability of food supply by several mechanisms. The primary strategic importance of enset in food security is that enset helps prevent famine by surviving prolonged drought when other crops fail. Once enset plants are established, they are able to tolerate occasional years of very low rainfall (Brandt *et al.* 1997). Secondly, it gives higher yield per unit area than other crops, thus supporting the densely populated areas of the country. According to Alemu and Sandford (1994), enset yields 1.3 to 3.5 times more food energy per hectare per year compared to cereals grown under similar area and management conditions. Thus, for households facing shortage of land, the higher productivity of enset relative to cereals makes enset an important food security crop. Thirdly, the processed enset food products can be stored for long term uses. The ability to store processed enset food products for long periods with little storage loss provides households with a mechanism to smooth consumption during periods of food shortage. Fourthly, enset plants can be harvested at any time and growth stage, allowing households to pass periods of food shortage.

Despite all these desirable attributes, the enset farming system has received very little research attention compared to that given to cereal based cropping system. As a result, the potential of the farming system has not yet fully exploited and utilized. Information regarding indigenous knowledge and experiences concerning selection, management and on farm conservation of enset landraces among the different enset growing ethnic groups remains far from being completed (Borrell *et al.* 2019, Harrison *et al.* 2014). Assessing and documenting the local people's knowledge and experiences on how to manage and maintain the existing enset resources is crucial for designing conservation strategies.

Materials and methods

Description of study site

The study was conducted in Hula district of the Sidama administrative zone in the Southern Nations Nationalities and Peoples Regional State (SNNPRS). The district has small town called Hagereselam geographically located between 6° 03' North latitude and 38° 31' East longitude about 365 km southeast of Addis Ababa and 90 km far from the regional capital, Hawassa (Figure 1). The Sidama ethnic communities are main inhabitants of the district and in terms of livelihood zone, the district is categorized under Sidama-Gedeo highland enset-barely livelihood zone and the area is known for the

high quality Kocho-Bulla production and export (SNNPRS, 2005).

The district has an elevation ranging from 2100-3200 meter above sea level (masl) and temperature range 10-18°C. The rainfall pattern of the area is bimodal and receives ranging from 1100-1400 mm per annum, allowing two cropping seasons in a year. The long rainy season begins from July and ends in September and the short rainy season ranges from March to May. The human population density of the area is high (about 350 people/ km²). The farming

system is characterized by mixed crop-livestock systems and enset is the main staple food crop in Sidama in general and Hula in particular. In addition to enset, other crops like barely, wheat, peas, bean, potato and maize are the main agricultural products. Shallots (locally called *kitel-shinkurt*, local name), loose cabbage (*Yabesha gomen*, local name) and garlic are the additional cash crops of the area. As far as livestock is concerned, cattle, sheep and horses are the major types of livestock kept by the different households.

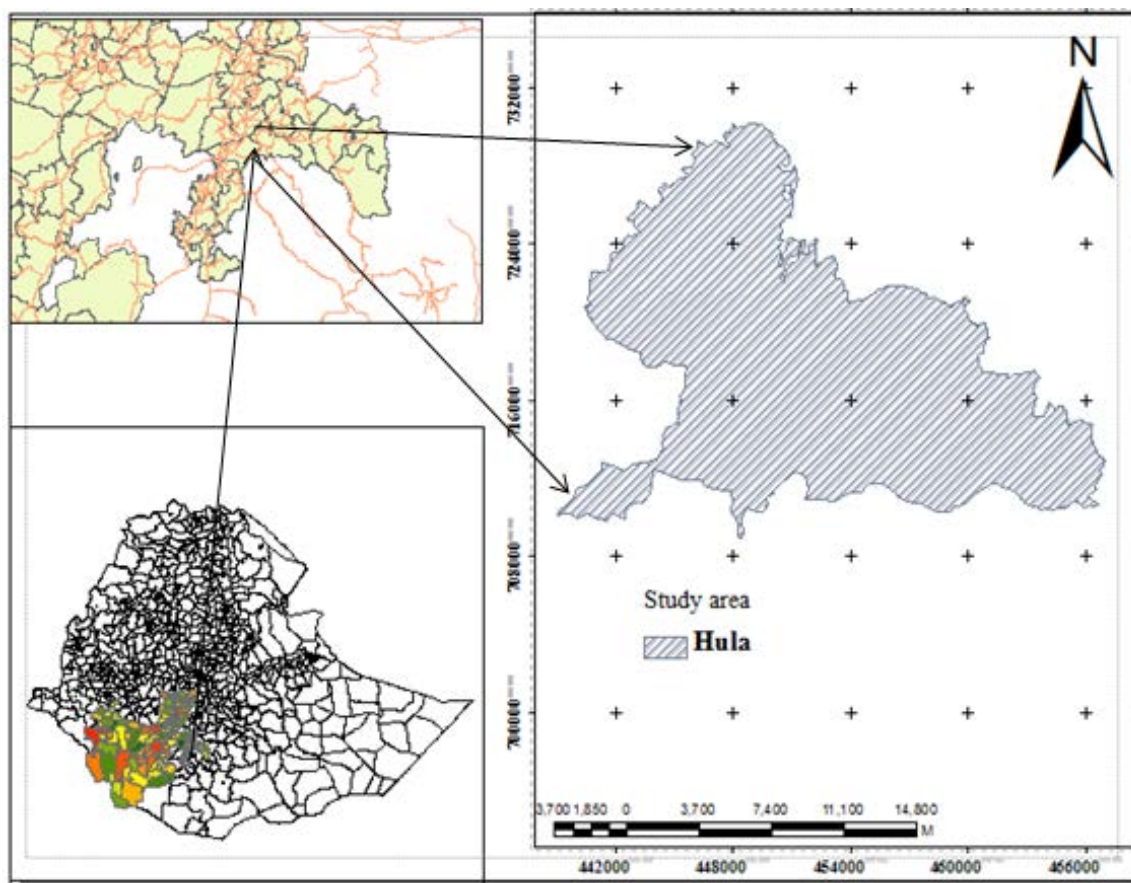


Figure 1. Map of study area

Selection of study kebele and informants for social survey

Ethnographic survey was undertaken in six selected kebeles Hageresalam, Odessa, Bochessa, Loya, Wurama and Wixabono in March to May 2017. Focus group discussion with key informants and interview with Agricultural development agents (DA) using triggering and open-ended questions was implemented to collect data after confirming existence of consistency in heterogeneous community classes response in the first step of data collection as Yemane and Kebebew (2006) suggested from multidimensional preference analysis. Total of 60 knowledgeable elderly people, 10 selected elderly peasant households in each kebele and six DA participated in the discussion.

Selection of model farmers and sample kebeles was undertaken together with DA. The DA involved had been working closely with the community for a long time. Elders' wealth of indigenous knowledge in enset cultivation, diverse enset landraces, and income they generated by selling suckers and kocho-bulla were the bases for the selection. For enset landraces survey, 13 households involved in the discussion was randomly visited from the six kebeles, of which more (7) households were taken from Odessa and 2 from Bochessa, 1 from the other each kebeles, for Odessa is inhabited by more farmers. Finally, the result was concretized with field observation (supported with photos and videos).

Field Data collection

Total landrace composition was determined by recording landraces present in farms of each household. Methods of identification of landraces, particular use of landrace and basis for farmer's preference of a landrace over the other was asked and recorded. In addition, farmer's evaluation of each landrace in terms of different attributes like yield quality and quantity, time of maturity, and reaction to biotic and abiotic stresses were noted. Basic steps in propagation, cultivation and processing of enset and farmers indigenous knowledge regarding management of enset plant to enhance yield and plant resistance to different environmental stresses were assessed. Finally, field notes were taken and photographs on enset propagation and processing methods were captured.

Data analysis

For the qualitative result further elaborations has been conducted examining the land use of the study area. The quantitative data gathered from individual interviews using questionnaire were entered in Excel sheet 2010. Data about the landraces recorded was summarized and tabulated. Descriptive statistics was employed for enset landraces' frequency / abundance recorded in the house holds visited.

Results and Discussion

Diversity of enset landraces

The study showed that more than 50% farmers in the study area have two ha and above size of home gardens, where they generally maintained a combination of different landraces of enset. In the

present study, a total of 26 locally recognized landraces were recorded (Table 1). The number of landraces maintained per household varied between 5- 18, the mean being 11 landraces for the whole site. In enset system, local farmers recognize different landraces. For example, Tsegaye and Striuk (2003) reported 52 types of landraces grown in Sidama zone. On the other hand, Tesfaye and Ludders (2002) reported 86 locally recognized landraces from the same zone. 79 locally recognized landraces were also recorded from 10 sites of Sidama (Tesfaye & Ludders, 2003). A number of factors have been found including household economic status, cultural background, and agro ecology influencing the number of enset landraces on a given farm (Tsegaye & Striuk 2003). It is indicated that wealthier households tend to have greater clonal diversity as well as a great number of landraces in general. This is mainly because of their larger landholding size, greater social networking for obtaining more landraces, larger income to purchase other landraces and better all-round management practices (Brandt *et al.* 1997). In enset growing regions, planting many different landraces in the backyard is a sign of high status, prestige, within the community. Farmers prefer to have specific clone types to fit their specific household needs. 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 (Tsegaye & Striuk, 2003). Since one clone can never fulfill all criteria, farmers tend to maintain more than one enset types on their own farm (Figure 2).



Figure 2. Home garden with diversified and with different age classes of enset at Hula

The name and number of enset landraces identified in the present study is comparable to the number of enset landraces previously reported by Tesfaye and Ludders (2003) from a place called 'Teticha', which is situated at an altitude of 2600 masl and located close to Hagereselam. Whereas, much less than recorded in Welaita area, found in the same regional state, about 67 enset landraces were recorded under cultivation (Olango *et al.* 2014). If we went back to a decade ago, Sidama farmers had the highest number of landraces per farm, which was 57% and 21% more than found on Wolaita and Hadiya farms respectively by then (Tsegaye & Struik 2002). According to Yemataw *et al.* (2016), in the whole region, SNNPRS, a total of 312 folk landraces have been estimated. The number of landraces encountered physically in the home gardens during the study time, however, was even lower than half of the landraces listed by Tsegaye and Struik (2002), which entails existence of ignored landraces perhaps due to their unwanted traits. The study also revealed that the diversity and abundance of enset landraces were not the same from one household to another. It is indicated by discussant that because of large landholding size, greater social networking for

obtaining more landraces, larger income to purchase other landraces and better all-round management and wealthier households tend to have greater landrace diversity. In contrast, only household economic status and family stage (Tsegaye and Struck 2003) and systematic propagation of the landraces, exchange of planting material and selective pressure (Tsegaye & Struik 2002) described as main influential factors.

Using Brown's (1978) scheme of classifying alleles, enset landraces recognized in this study have been arbitrarily grouped into two categories based on their abundance. These are i) common (occurring with frequency of greater than 10% in the sample) ii) rare (occurring with frequency less than 10%). The name of landraces identified and their respective abundance in the study area are presented in Table 1. Accordingly, in the present study, 16 landraces were found to be common and the remaining 10 landraces found to be rare (Table 1). The unequal abundance and distribution of landraces reflects their relative importance to farmers and provides strong evidence for selection (Tesfaye & Ludders 2003).

Table 1. Name and status of enset landraces recognized from Hagereselam district

No	Name of landrace	Abundance	No	Name of landrace	Abundance
1	<i>Ado</i>	Common	14	<i>Genna</i>	Rare
2	<i>Agana</i>	Rare	15	<i>Gulummo</i>	Common
3	<i>Alaticho</i>	Rare	16	<i>Herbegoncho</i>	Rare
4	<i>Arisho</i>	Rare	17	<i>Hirborcho</i>	Rare
5	<i>Astara</i>	Common	18	<i>Keshe</i>	Common
6	<i>Birra</i>	Common	19	<i>Kincho</i>	Rare
7	<i>Boricho</i>	Common	20	<i>Kiticho</i>	Common
8	<i>Bowe Ado</i>	Common	21	<i>Kule</i>	Common
9	<i>Chacho</i>	Common	22	<i>Lemicho</i>	Common
10	<i>Derasi-Ado</i>	Common	23	<i>Madde</i>	Rare
11	<i>Dowiramo</i>	Rare	24	<i>Midasho</i>	Common
12	<i>Gadimae</i>	Common	25	<i>Uwishsho</i>	Common
13	<i>Ganticha</i>	Common	26	<i>Wankoree</i>	Rare

Among the commonly occurring landraces, the following *Ganticha*, *Ado*, *Midasho* and *Kiticho* are recognized to be the most widespread landraces in the study area. According to local farmers the reasons for the occurrence and abundance of these landraces relative to others is attributed to their high yield and quality kocho and also their better resistance to environmental stresses. On the other hand, landraces such as *Alaticho*, *Arisho*, *Dowiramo*, *Genna*, *Harbegoncho*, *Hirborcho*, *Kule*, *Lemicho* and *Madde* were found to be very rare and recorded only from 1 or 2 farms indicating that large numbers of landraces are being in verge of extinction.

To date, researches indicate that there is limited availability of enset germplasm in living collections

and seed banks (Borrell *et al.* 2019). The high-altitude areas of Sidama including Hula are playing important role in supplying suckers of enset to farmers of mid and low altitude areas and other neighboring regions beyond consumption. Therefore, the result of the present study has important implication for the source of collections and *in-situ* conservation of these rare landraces.

Methods of identification of enset landraces

For identification of different landraces, the local farmers of the study area mainly use combination of morphological characteristics such as color of the leaf, midrib, petiole, pseudostem and plant vigor.

Similarly, morphological characteristics have been reported as means for identification of different landraces of enset among local farmers of Wolaita (Olango *et al.* 2014) as well as in Kambata and Gurage (personal communication). In general, during the study time, the indigenous knowledge of the farming communities acquired for identifying the landraces was complex that you cannot do it at a spot, and these Knowledge of farmers' practices had been used by expertise to validate agronomic innovations and inform the setting up of a network of phenotype collections (Yemataw *et al.* 2016, Yemataw *et al.* 2014). Similarly, Tesfaye and Struck (2003) also indicated local farmers in Sidama use different descriptors for identification of enset landraces. Those descriptors are related to: morphological characteristics (pseudostem color, midrib color, and petiole patches/strips colors), agronomic characteristics (reaction to drought, reaction to disease and pests, maturity time). In some cases, farmers also use sap color, corm shape and corm color for identification. The local farmers use combinations of descriptors and when asked for key identification characteristics, they referred first to the morphological characters of a landrace. Character descriptors related to the use-value (uses for food, fiber, fodder, medicinal), culinary quality and agronomic characteristics came only after morphological characteristics (Tsegaye, 2001). The observed farmer classification of enset revealed that genetic diversity of cultivated enset in Ethiopia is substantial and appears to be maintained as a result of the diverse use of landraces by local farmers and the high rates of plant material exchange between settlements (Birmeta *et al.* 2004).

Naming of enset landraces

Naming of enset landraces based on different attributes such as places of origin, plant morphology, yield quality, wild animals and physical entities such as moon and sun have been examined in the farming communities. For instance, the landrace Ado so named depicting the whitish color of the plant (in Sidamigna Ado means milk/white). On the other hand, farmers often attach names with places from which the plants originally brought or came from such as Alatico (brought to the area from Aleta), Harbegoncho (brought from Harbegona) and Derasi-Ado (brought from the amined neighboring Gedeo zone). In some others, farmers use certain agronomic characteristics in naming of landraces as in the case of landrace Chacho, to describe the slow growing and consequently, late maturing attributes. Table 2 below summarizes the names of some selected enset landraces and their implied meanings. Our present findings are also similar to what was reported by Olango *et al.* (2014) in Wolaita. According to Olango *et al.* (2014) local farmers in Wolaita just like that in Sidama give separate vernacular name for each landrace they grow. The names are often descriptive and reflect variations of landraces in places of origin, morphology, as well as agronomic and cooking characteristics. Often farmers attach names of places in neighboring Zones and Woredas to the landrace names (e.g. Dawro-arkiya, Kucha-arkiya, Kambata, Kambata-maziya). The naming may include the indication of physical entities (e.g. Agino, the Moon), cultivated plants (e.g. Banga, barley); domestic animals (e.g. Bora, ox, and Fara, horse) and of wild animals (e.g. Godariya, hyena and Genessa, antelope).

Table 2. Source of enset landraces names in Hula district of Sidama zone

Basis of naming	Examples of landraces	Meaning
<i>Morphological character</i>	<i>Ado, Boricho, Dowiramo, Kule, Hirborcho, Lemicho</i>	<i>Referring to the color of the Pseudostem</i>
<i>After name of places</i>	<i>Alatico, Derasi-Ado, Harbegoncho,</i>	<i>Implying origin of landraces from nearby woreda or zones</i>
<i>After moon</i>	<i>Agana</i>	<i>Implying looks like moon</i>
<i>After sun</i>	<i>Arisho</i>	<i>Implying shining like the sun</i>
<i>After agronomic characteristics</i>	<i>Chacho</i>	<i>Slow growing/late maturing</i>

Agronomy and propagation management of enset in Sidama

Compared to other crops the production of enset involves many stages. The major activities include propagation, transplanting, manuring, weeding, harvesting and processing. The details of each of these processes are described as follows.

Propagation and cultivation methods

In Sidama like any other rural areas in Ethiopia, newly married couples share lands from their parents. The new couples in the study area start with cereal cultivation, hand in hand they plant enset and cabbage (Figure 3) yearly until enset, the staple food, and cabbage cover majority of their home garden. Therefore, enset planted in different years mature for consumption at different years starting the earliest at the third year.



Figure 3. A climax of home garden covered ultimately by enset and cabbage plants

In Sidama, enset cultivation from propagation to harvesting involves five different successional stages. These stages locally named as *Funticho*, *Moggicho*, *Simancho*, *Mala'ncho*, *Etancho* (Figure 5). In other areas such as Wolaita, there are only four successional stages (Olango *et al.* 2014). In Sidama, enset is generally propagated vegetatively using suckers although enset plants do bear seeds. Thus, the first stage in cultivation cycle or propagation of enset is production of suckers, the stage locally termed *Funticho*. According to our informants, to initiate suckers ('*Funta*'), a three years old mother plant is selected and its whole corm is dugout with its pseudostem cut at around 10-20cm length (Figure 4). Then, the base of apical meristem, greenish colored, situated at the center of the corm is removed manually to eliminate the apical dominance. Experimentally, halved uprooted corms and immediately replanted or left *in situ* was found to produce more vigorous suckers with better growth than whole corm (Diro *et al.* 2002) and also found suckers increasing with increasing corm pieces (Karlsson *et al.* 2015), for slicing helped elimination of the strong apical dominance while leaving reasonable portions of the mother corm to sustain initiation, growth and development of suckers. In the study area, shortly, the decapitated corm is planted in fertile soil, hoed ahead using digging man's height long stick with sharpened metal at the end, having

the opening left after removal of the meristem covered using piece of stone or cow dung in slightly slant position to prevent it from light effect and water accumulation (Figure 2).

According to the respondents, corms which had lost its apical meristem never give to suckers for 12hrs after unplanted exposed to the sun, moisture and low temperature. Hence the sooner it is buried, the better it gives rise to suckers. Putting the corm upside down after removal of the pseudostem helps prevent exposure to the unwanted conditions that cause damage, hence gives longer time for planting (Figure 5-1). When such corm fails to protrude the shoot in 12 hrs, it ensures complete removal of the shoot meristem from the base. As reported by Mikias *et al.* (2011), farmers are well aware that vegetative propagation method preserves the familiar plant quality. This propagation method is a wise decision of farmers, because seeds produce new and unknown plants due to genetic recombination which occurs under sexual reproduction (Mikias *et al.* 2011). Thus, the plants with genetic variation may not possess the desired phenotype for the intended purpose, if seedlings are used directly. However, seedlings can be selected and used for genotype improvement through conventional breeding.



Figure 4. A corm ready to be planted having the above ground shoot completely removed

After one to three months, multiple of suckers begin to merge in circular manner from the corm (Figure 5-2). According to our informants, propagation of suckers is carried out either in October-November in contrast to Kembata and Gurage in lower altitude, where propagation is usually done December to January (Yemataw *et al.* 2018). In all sites, planting the mother corm takes place shortly after rainy season and harvesting suckers for planting or/ and selling is done after a year and half at the beginning of the second rainy season. The newly emerging plantlets, suckers, survive consuming the food stored in the corm at early stage, which finally dries and shrinks giving rise to independent suckers with numerous roots ready to be transplanted. After one to three months, multiple of suckers begin

The young suckers or locally called 'Funta' (Figure 5-1) plants left with the mother corm for one and half years before being transplanted to a new site where they are called *Mogicho* (Figure 5-3). The matured suckers, *Mogichos*, are then left to grow independently for another one year and at the third year they are called *Simancho* (Figure 5-4). Some of the *Simancho* plants are used as a mother corm plant for raising sucker for the next planting cycle (in Sidama community, propagation of suckers is a general practice and carried out every year). In

addition of being used as mother plant, the *Simancho* plant can also be harvested for consumption particularly during the time of food shortage. At fourth year, the *Simancho* plants grow to the stage called *Malancho* (Figure 5-5) and the final mature plants become ready to be harvested named *Etancho* (Figure 5-6). Farmers in the upland like Hagereselam, suckers are planted in a crowded manner and after a year, weak or less competent suckers are uprooted and replanted elsewhere in free spaces in about half a meter distance between plants. This is completely different from the practices of Butajira, Wolkite and west shewa, found in lower altitudes of the same region, where uprooting and replanting is done three times with increasing the intra plants distance to 1.5m and finally 2.5m for harvest at maturity. More frequent transplanting often delays flowering and results in higher yields per plant (Tsegaye & Struik 2000), which of course demands large suitable cropping systems and techniques that allow farmers to have enset plants at different developmental stages in order to have enough mature enset plants that can be harvested for food every year. The direct transplanting of suckers into permanent fields in overcrowded way might help to escape the frost effect prevailing in the highlands like the study area in addition to other advantages explained elsewhere such as to obtain

early yields and overcome disease problems (Tsegaye & Struik 2000). Moreover, thinning is commonly practiced throughout, and shoots are used both for feeding cattle and as source of water for washing hands by squeezing it in scarce times, where the corm is replanted. In the study area, the enset plants are left at higher density per area even

at maturity (Figure 2), for frost effect is more severe and even mature plants are seen bleaching. During the onset of frost, enset plants show bleached lamina and even necrosis may appear at margins but they recover when the frost effect is relaxed.

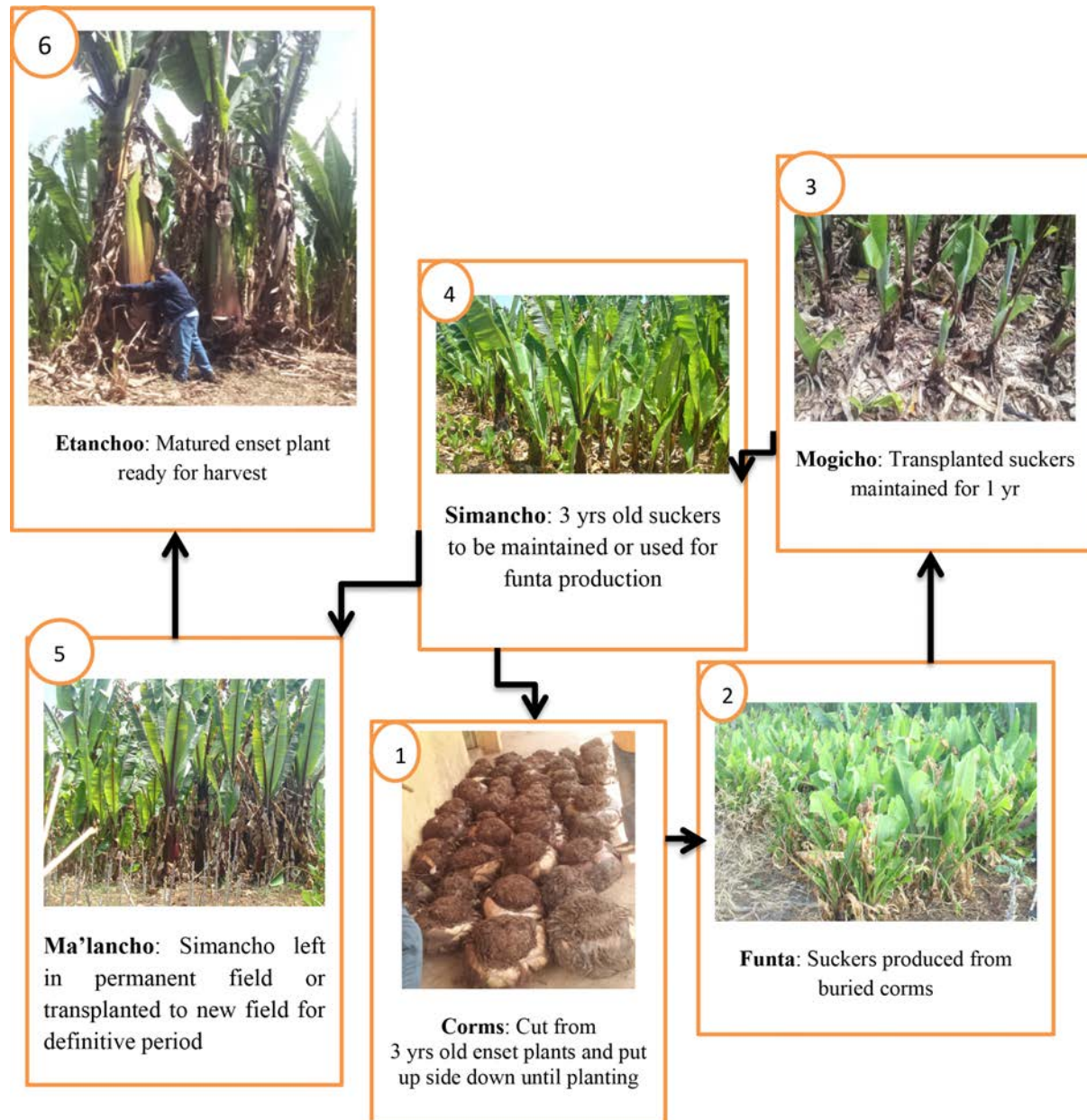


Figure 5. The developmental stages of enset at Sidama area: Stages 1. Corms cut from 3 yrs old Enset plants called Simancho 2. Funta... 1 and ½ yrs old suckers ready for transplanting. 3. Mogicho transplanted suckers left for one year; 4. Simancho three years old plants that can be used as mother plant for initiating suckers or left for definite growth; 5. Malanchoo intermediate stage between Simancho and Etancho; 6. Etancho mature enset plant for harvest

Manuring and weeding of enset

Besides propagation and regular cycles of transplanting, field management of enset involves manuring and weeding. Also, there is a clear gender-based division of labor for the accomplishment of these activities. Hoeing and weeding is done by hand using traditional tools and it is mainly the activity of men. On the other hand, application of manure is the task of women. Enset requires heavy application of manure especially during its early stage of growth (Kebede 2013). According to our informants, in Sidama in general enset cultivation solely rely on use of organic fertilizers such as cattle manure and household wastes, especially ash and they never use inorganic fertilizers to enset.

In connection with field management of enset, farmers use different techniques to enhance yield and plant stress resistance abilities. For instance, the bacterial wilt (*Xanthomonas musacerum*) is a challenging pathogen that kills enset (Zerfu *et al.* 2018) and removing/ avoiding the infected plant from the field and using sterile or neat instruments are the only methods being used against today. To enhance drought resistance farmers' use techniques like mulching, covering the exposed root of the plant using soil and cutting of older leaves to reduce evapotranspiration. Discussants reported a unique technique on how to prevent frost effect at early seedling stage that they prevent it fencing with branched bamboo twigs in the incoming direction of frost. Moreover, dried older leaves are also left hanging with the mature enset plants for same purpose (Figure 5-5), similar activity was also practiced by enset farmers in Wolkitie area, Gurage zone during the study time (our observation).

Harvesting and processing enset

In Sidama, the optimum harvesting time for enset is shortly after flowering. Age of flowering depends on type of enset landrace, climatic condition and management. Hence, flowering time in enset varies from 3 to 15 years and optimally 6 to 7 years. However, enset plant can also be harvested at its premature stage especially when there is lack of food. According to the local people, the enset plant at flowering stage would give high quality yields of Bulla and Kocho. Alemu and Sandford (1991) also reported that enset has its maximum storage of food at its flowering stage. Local farmers in the study site had the knowledge of the yield loss due to harvesting enset at the age of post inflorescence emergence, during seed filling and removing the inflorescence is a solution. We also observed the existence of similar practices among farmers of Wolaita and Gurage districts. In the study site, plugging the cut end using a piece of metal or wooden material is a common practice among farmers in Hula district; perhaps this

practice avoids unwanted fast drying and growth of pathogens which would spoil the taste of the produce. However, in Wolaita after they have removed the inflorescences, farmers usually cover the tip using dry enset leaf sheathes whereas in Gurage it is left free.

In the study area, harvesting is usually done during the dry season mainly December to January to avoid excess water content, which may affect the taste of the food. The work of harvesting and processing of enset for food is generally laborious and tiresome and is undertaken by women (Figure 7). At harvest, the matured plant is selected, the oldest enset before seed setting is always preferred and easily uprooted by pushing it side way. Thereafter, older leaves from the matured and uprooted plant are removed using traditional short sword like instrument locally called *worimae* (Figure 6c). The working area used for decortication is, therefore, prepared from these cut leaves and outer leaf sheath. Following this, the internal leaf sheaths are peeled off from the pseudo stem and cut about one-meter workable size.

At the same time, the underground corm dug out are trimmed and grated using hip bone of an ox locally called *kehfoo* (Figure 6b, Figure 7a). The scraped pseudostem and chopped corm tissue are mixed and then squeezed to extract more starch fluid before they are placed in a pre-prepared pit lined with enset leaves for fermentation.

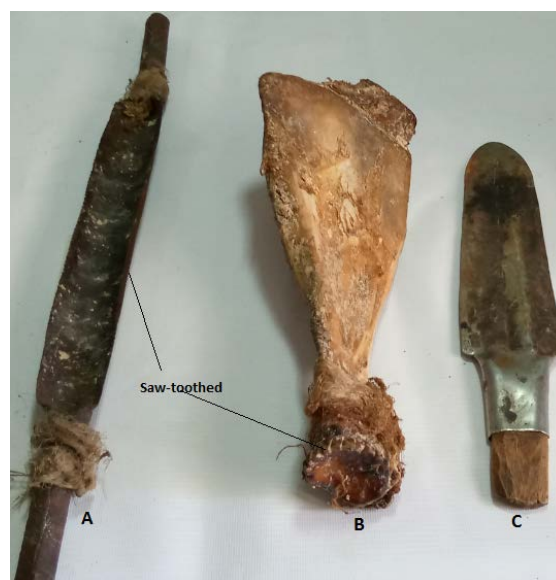


Figure 6. Traditional enset harvesting tools: A- *sisicho*; B- *kehfoo*; C- *worimae*.

The process of turning, mixing and chopping of the scrap (Figure 8a) will continue until the mixture ferments to what referred Kocho. According to the informants, the total period of fermentation ranges from 15 to 30 days. During fermentation some landraces are selected to be used as starter and their

scrapped sheath is added to speed up fermentation of other landraces. On the other hand, the starchy fluid /extract/ that is immediately squeezed and allowed to flow during the process is collected in small hole lined with the leaves prepared ahead (Figure 8b) and left up to 2 days to precipitate to the powder product called Bulla, a source for first quality food from enset. The remaining outer part of the bark

is the quality fiber used for different purposes (left side in Figure 7B).

The inner side of the leaf sheath is then scraped using a locally made metal or bamboo scraper called *sisicho* (Figure 7A) putting on 45° inclined wooden plank, *meetta* (Figure 7B).



Figure 7. Extracting food staff from corm and pseudostem: A-Chopping of the corm/Amucho; B-Scraping the inner wall of the sheath

The average kocho yield ranges from 16.30 to 37.30 kg per plant with an average for the whole southern region of 30.15 kg/plant. The regional average of kilograms bulla per plant is 10.4 (Tsegaye 2002). The traditional fermentation process has been reported as the main cause for the production loss in enset (Tsegaye & Struik 2003) and the process of extraction is highly tedious. Suitable models analyzed with the ArcGIS software used to quantify the yield and demand of kocho estimated squeezed (moisture-removed) kocho yield 16.2 kg/plant, which is equivalent to 417 tons/ha, and annual yield 6500 kg/ha, and 4.5 million tons of kocho as standing stock in Wabe River catchment of Gurage Mountains in Southern Ethiopia (Sahle *et al.* 2018). Allometric

equations have been derived to estimate the biomass of kocho and Bulla using all harvestable parts and ages of the plants (Fig. 8). From allometric equations, strong correlation exists between kocho-Bulla biomass per plant and diameter (Mellisse *et al.* 2017), circumference (Tsegaye & Struik 2003) and height (Negash *et al.* 2013). Combination of diameter with height was found strongly correlated with the biomass of kocho and Bulla (Mellisse *et al.* 2017). Bulla yield was best predicted by combined measurements of diameter and height variables of older plants greater than 4 yrs (Mellisse *et al.* 2017), who also shown diameter measurements being better predictor variable for kocho than height.



Figure 8. Output of enset pseudostem and corm

Socio-economic significances of enset landraces

Enset is the most staple food crop that occupies a central position in agricultural system of Sidama people. The crop has enormous nutritional, socio-cultural, medicinal, environmental and economic values.

Cultural value

The enset plant has special cultural meaning and value in Sidama in general and Hula in particular. It is a symbol and expression of the identity of the people. It is also used as an indicator of the wealth status of a household. The community appreciates and owes special respect to a household having a large number of enset plantations at its backyard. The special social and cultural value of enset holds in Sidama community often expressed in the form of folklores and sayings. For instance, the following are some of the sayings collected from elders during our stay in Hula district.

¹"*Gobba harrumoo Burssa*

Seketee kasirii wassee etatonna Bulla"; meaning that the one who has managed to cultivate and

maintain sufficient enset in one's garden will consume quality food and has no worry at all.

²"*Wasse kasiri kiticho*

Etatonna dancha biticho", is to mean that if you want to eat quality diet, plant enset landrace called Kiticho.

Dietary values

Enset is used both for human and animal consumption in the study area. Enset is mainly used as food in three forms: Bulla, Kocho and Amicho. *Kocho* is a fermented pulp of the enset pseudostem derived by scraping the individual pieces and excluding the fibrous remains. Bulla is the small amount of water-insoluble starchy product that may be separated from *Kocho* during the processing phase by squeezing and decanting the liquid. Amicho is a boiled enset corm, which is edible only from some landraces. In Sidama, enset foods serve as staple daily diet and also consumed during occasions of cultural festivals such as Fichee, wedding's, births and deaths. For instance, during birth a postnatal mother eats *Sherkko*, a buttered and spiced porridge prepared from Bulla (Figure 9).



Figure 9. Enset foods: A- kocho made bread with kitfo, B- bulla made Porridge

Burisamee or *Koffamae*, buttered and spiced food prepared from Kocho or Bulla. *Tiimma* is bread prepared from Kocho or Bulla (Figure 9). In addition, *Duwamae* and *Omolchoo* are also produced from Kocho. Enset as a food crop is used to prepare many different staple dishes in Hula and majority are prepared from solely enset. Olango *et al.* (2014) reported enset foods are served both as staple daily diet as well as in occasions of cultural festivals in Wolaita; hence enset foods have both nutritional and cultural values for the society. Similarly, Nida (1996) reported similar result from Gurage region. Nutritionally, enset products are rich in carbohydrates but low in protein and fats (ENI, 1981). Agren and Gibbson (1968) found protein and fat content of 1.1–2.8g, fat 0.2–0.5g from kocho and 0.4–0.8g, fat 0.2–0.4g from bulla per 100gm, respectively. Due to poor protein and fat content,

enset food products are not consumed by their own; except during periods of extreme famine or by poor households who do not have the means to vary their diet (Pankrust 1996). Thus, in order to supplement the poor protein and fat content, enset food products are mostly consumed together with other crops such as cabbage, beans and animal products such as milk, meat and butter. Because of this basic reason, enset is always grown along with other crops and livestock. The people in Hula district are also dependent on wild edible fruits that ripen in different/similar seasons. Sina and Degu (2015) reported about 50 wild edible plants belonging to 46 genera and 31 botanical families that serve as alternative food source in bad times including food in secured times in Hula district. Kocho and Bulla are, however, rich in Ca and Zn compared to other similar foodstuffs and contains comparable concentration of

Cu, Fe, and Mn (Atlabachew and Chandravanshi 2008; Nurfeta *et al.* 2008b), besides Kocho and Bulla were found free of heavy metal (Cd and Pb) contaminations compared to others.

The local people used enset leaves as animal feed. As farmers responded cattle during the dry season are supplemented more with enset feed. The digestibility of enset lamina has been described by Fekadu and Ledin (1997) better than that of straw and banana leaf and found similar to crop stover and Rhodes grass (*Chloris gayana* kunth) hay at 48 hrs. A study on 10 landraces came up with a conclusion that enset is a valuable dry-season feed, especially due to high crude protein contents of leaf lamina and high dry biomass degradability of corm (0.942) and pseudostem (0.889) followed by leaf midrib (0.668) and leaf lamina (0.450) at 96 h of incubation (Nurfeta *et al.* 2008a).

Medicinal value

Particular landraces of enset are also used medicinally for both humans and livestock to cure fractured and/or broken bones, childbirth problems, diarrhea, birth control (as an abortifacient), jaundice, back-ache and heart diseases. Regarding enset landraces valued medicinally, the landrace called *Astara* (in some locality called *Askala*) is the most widely recognized landrace in Hula. According to the informants, the *Astara* landrace is proved to be effective in expulsion of delayed placenta during birth. In case of humans, the boiled corm of the plant is used and in case of livestock's every part of the plant including the leaves, pseudostem and corm can be used for treatment of various complications. Similar results were reported by Nida (1996) and Olango *et al.* (2014) from Gurage and Wolaita areas respectively. Olango *et al.* (2014), further added that although all farmers in Wolaita know and believe that enset is medicinally important, only a few people use it for this purpose. Traditional healers in the area confidentially keep ethno-medicinal knowledge of enset landraces and many other medicinal plant and animal species. Mostly administered in the form of food products, traditional enset medicines include (i) porridge made of *Itima* from Agino and Gefetanuwa landraces, for strengthening women after delivery, and healing bone fractures in humans respectively; (ii) very highly fermented *Uncca* from Maziya and Halla landraces, for curing stomach cramps; and (iii) boiled corm of *Lochinga*, for birth control and abortion in humans, and to feed cows to facilitate placental expulsion (Olango *et al.* 2014).

Material culture values of enset

In addition to food and medicine, enset has many other uses. The fiber extracted during processing locally called '*Hanticho*' is used locally for making

strings, ropes and other products. The pseudostem and leaf of enset are important source of feed for cattle. Fresh enset leaves are used as bread and food wrappers, serving plates (the local food staff called *kitfo* is traditionally served to individuals using enset leaves) and pit liners (Figure 8) to store kocho for fermentation and future use. During enset harvesting enset leaves are also used to line the ground, where processing takes place. Dried leaf sheaths are used as wrappers for butter, kocho and other items to transport to local markets. Especially in the dry season when grasses are scarce, enset is an important cattle feed. The dried petiole and midribs of enset are used as a source of fuel. Similar material culture value of enset was reported from other enset growing regions (Nida 1996, Weldetensay 1997, Tesafye & Ludders 2003, Tsegaye & Struck 2002, Olango *et al.* 2014).

Income generation/source

Hula district is the best source of sucker for other enset cultivating areas in the region and many of the sites cultivating enset buy enset suckers from this area due to the highest suckers' propagation potential and cheaper prices. A three year old, whole decapitated mother corm can sprout about 30-50 mature suckers (Figure 5-2) after a year and half. Therefore, extra suckers are for sell to generate income. Some large-scale farmers residing in Hagereselam town have got farmlands in the outskirts, which propagate enset suckers for commercial purpose. The suckers in Hagereselam town cost on average up to 5 birr each, but the market price fluctuates based on the demand and supply and always suckers become expensive or are rarely obtained on the market after the right time for transplanting. Besides its sucker, the food products of enset, namely, Kocho and Bulla are important sources of income for farmers in the study area and elsewhere. Although the yield of Kocho and Bulla varies with the landrace and climate, reports of our present survey have shown that the average yield of Kocho and Bulla per mature plant is 30 and 5kg, respectively on wet weight basis. On the other hand, on local market 1 kg of Kocho and Bulla cost about 5 and 15 birr, respectively. Tsegaye and Struck (2002) reported a maximum yield of 26.26 tons ha⁻¹ year⁻¹ for a plant spacing of 2.83 m². From this one can roughly estimate an income as high as of 130, 000 birr from sell of Kocho yield and 390, 000 birr from bulla per hectare per year. In addition, the fibre extracted from the pseudostem of enset is also important source of income for farmers. Although information on the exact price of enset fiber is lacking, it has been estimated that about 600 tons of fiber per year is sent to the factories (Brandt *et al.* 1997). Olango *et al.* (2014) indicated that surplus production and planting materials are sold in local

markets and generate income for the household in Wolaita.

Environmental role of enset

The enset plant plays a very important ecological role. The broad leaves act like umbrella and protect the soil from erosion by reducing runoff. It serves as shade and improves the microclimate for the undergrowth vegetation, and the litter from the leaves and other parts improve soil fertility. Tillage practice is so low in comparison to grano-culture. In fact, in enset plantation areas, native soil has been altered for the better due to the long-term application of manure, natural mulching of leaf and stem residues, the rainfall capture from the plant leaves, and the resulting soil moisture conservation and reduced run-off when compared to bare earth farming. Enset plants, which are traditionally grown in small plantations adjacent to homesteads, can grow to a height of six meters, and thus provide valuable windbreaks and shade from direct sunlight. Because of its large leafy fronds, it is also a good plant to inter-crop with coffee, potato and other food crops, which benefit from shady growing conditions. Intercropping with legumes and cabbage is common for increasing soil fertility. According to Olango *et al.* (2014), enset agriculture fulfills an ecological role, because it is an organic farming system using only farmyard manures, with no external chemical fertilizers, herbicides and insecticides.

Constraints

Particularly, nowadays, because of significant increase in human population and decrease in livestock, low soil fertility is one of the major constraints of enset production. In addition, shortage of land, diseases like bacterial wilt caused by *Xanthomonas campestris* v *musacerum* and recurrent drought are among the limiting factors of enset production. Similar factors have been described as major constraints of enset production in Wolaita (Shembulo *et al.* 2012). Zeberga *et al.* (2014) also reported bacterial wilt, caused by the bacteria *Xanthomonas campestris* v *musacearum*, is the most threatening to the enset.

Conclusion

The farming communities in Hula district are endowed with many landraces of enset used as source of food, feed and income. Enset is predominantly growing in the densest farming communities in SNNPRS including Hula district and the people are the least food aid donated in Ethiopia. This is because enset is perennial, drought tolerant and multipurpose crop, where its food staff can be stored tree age long and after harvest for many years underground. This shows perennial crops like enset can better support populous communities than the

grano-culture in recurrent drought prone areas. While utilitarian and cultural values are the main determinant factors for the maintenance and conservation of large number of enset landraces, selection of enset landraces for their better traits or performance and severe effect of the pathogen *Xanthomonas campestris* v *musacearum* are among the top factors decreasing the enset biodiversity from time to time. The high -ltitude areas of Hula district conducive for enset production is playing important role in supplying enset landraces to other farmers in the region or beyond and has important implication as source of collections for *ex-situ* and site of *in-situ* conservation for the rare landraces. The age-old processing of enset would require the concerted effort of food microbiologists and food processing technologists to lessen the pressure on women and to avoid spoilage during fermentation in order to produce wholesome products. The important traditional practices of enset processing that have been revealed during the present study could be utilized as information on how to conserve biological resources and improve the traditional processes, thus, ultimately contributing to food security.

Declarations

List of abbreviations: SNNPRS-Southern Nations Nationalities and Peoples Regional State; DA-Agricultural Development Agents; ENI-Ethiopian Nutrition Institute; MU-HU-NMBU- Mekelle University-Hawassa University- Norwegian University of Life Science; ETH- Ethiopia; CoDANR-College of Dryland Agriculture and Natural Resources.

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Authors' contributions: Yemane G.Egziabher collected and analyzed the data and developed the manuscript; Firew Kebede was the major contributor of the study, drafted the manuscript, cooperated in data collection and translated the local language during data collection. All authors contributed in the research proposing the problem, data collection, and approved the final manuscript.

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