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Food security and environment conservation through sustainable use of wild and semi-wild edible plants: a case study in Berek Natural Forest, Oromia special zone, Ethiopia

Leul Kidane[1*] and Alemu Kejela[1,2]

Abstract

Background: Wild edible plants (WEPs) have an important role for rural communities in safeguarding food security, nutritive variation and continued earnings. Their significance, management and utilization are not fully documented. Objectives are to identify and document wild and semi-wild edible plants (WSWEPs) and their conservation status in Berek natural forest, Oromia special zone.

Methods: Various data collection tools were employed to gather data on WSWEPs. Ethnobotanical data were collected from 142 household representatives (77 men and 65 women) being at least 14 years old. Most of them (73.9%) had not received formal education. Data were analyzed using descriptive and inferential statistics, preference ranking, paired comparison, direct matrix ranking and informant consensus factor.

Results: A total of 34 useful WSWEP species belonging to 32 genera and 24 families were collected and identified. The family Rosaceae had the highest number of species (five species, 14.7%), followed by Anacardiaceae and Solanaceae with three species (8.8%) each. Growth form analysis showed that the majority of the species were trees (14 species; 41.2%), followed by herbs and shrubs (10 species each, 29.4%. These edible plants were available in different seasons; 15 (44%) of the plant species reached maturity in spring season while seven species (20.6%) were found in all seasons and eight (23.6%) species were able to reach maturity in autumn and winter. Although most of the local communities have an intimate relationship with their natural environment, there are common threats to WSWEPs and their habitat, particularly through overgrazing, fragmentation of the vegetation for agricultural expansion, introduction of exotic species, selective logging for construction purpose and charcoal making.

Conclusion: WSWEPs are valuable resources for improving the environment, food and nutritional security and income of households in rural areas. Moreover, to sustainably use edible plant species of the study area local communities and the Forest Administration should collaborate in managing these resources before becoming critically endangered.

Keywords: Berek natural forest, Biodiversity conservation, Food security, Wild and semi-wild edible plants

Background

Ethnobotany in broad terms is the study of direct interrelations between humans and plants [1, 2]. This includes plants used as food, medicine and building material and for any other economic application. WEPs refer to

*Correspondence: leul.kidane@mu.edu.et
[1] Department of Biology, College of Natural and Computational Sciences, Mekelle University, Mekelle, Ethiopia
Full list of author information is available at the end of the article

species that are neither cultivated nor domesticated but are available from their natural habitat and used as food [3–5]. WEPs are gathered for food, nutrition and livelihoods by different peoples around the world. These plants are gathered from varied habitats like natural forests, agricultural fields, as well as disturbed areas such as roadsides and waste lands. Various studies have found WEPs a potential source of nutrition as they are in many cases more nutritious than conventionally eaten crops [6, 7].

Indigenous knowledge refers to the accumulated knowledge, rules, standards, skills and mental sets, which are possessed by local people in a particular area [8]. The indigenous people have continuously developed this knowledge of traditional plant uses and plant resource management for prolonged interactions with the natural world [8].

Wild food plants play a very important role in the livelihoods of rural communities as an integral part of the subsistence strategy of people in many developing countries [7, 9, 10]. A serious challenge to human survival, particularly in the developing world is the ever-growing gap between human population and food supply. Research and development have focused on the lesser known edible plants that could assist in narrowing the gap between population growth and food deficiency currently escalating in developing countries [11]. The International Journal of Herbal Medicine and Mariana studied the use pattern and knowledge of wild food plants in distinct ecological environments in northwest Patagonia and found that knowledge and consumption of WEPs follow a pattern related to ecological conditions of gathering environments, as well as the cultural heritage of the Paineo people [11].

In recent decades, wild food plants have become a focus of research for many ethnobotanists, related to a global interest for documenting ethnobotanical information on neglected wild edible food sources [12]. Since traditional knowledge on WEPs is being eroded through acculturation of indigenous peoples and their cultural background and through the loss of plant biodiversity, promoting research on wild food plants is crucial in order to safeguard this information for future societies [7, 13]. Traditional knowledge of WEPs in Africa is, therefore, in a danger of being lost, when habitats, value systems and the natural environments change. There is a widespread decline in knowledge about wild food plants, especially among young people and urban dwellers. Therefore, to preserve this knowledge with its potentially high value for future generations, it needs to be recorded systematically [14]. Numerous publications provided detailed knowledge of edible wild plants in specific locations in Africa [3, 7, 8, 15]. All showed that wild plants are essential components of the diet of many Africans, especially in periods of seasonal food shortage. A study conducted in Zimbabwe revealed that some poor households rely on wild fruits as an alternative to cultivated food for a quarter of the dry season's meals [16].

Ethiopia is an ecologically diverse country that not only harbors an exceptionally rich botanical diversity, but is also known for its extraordinary agro-biodiversity, resulting from its varied geography, climate, ethnic diversity and strong food culture [17]. In Ethiopia, a large number of fruit species are used for human consumption, most of which come under the broad category of WSWEPs [14, 18]. Millions of rural people in developing countries, including Ethiopia, are unable to obtain or produce enough food through conventional means [5, 13, 14]. Thus, they often depend on wild and semi-wild plants to complement and enrich their diet, especially in periods of food shortage [19].

Earlier works [20] showed that about 8% of the nearly 7000 higher plants of Ethiopia are edible, 25% of which are cultivated, and there are also many WEPs that produce quantities of food. Still, many more wild species are believed to be edible but yet undocumented. More recently, some ethnobotanical studies have been undertaken in some parts of the country [20]. Nevertheless, the majority of these studies have dealt with medicinal species and little emphasis has been given to wild food plants. Ethiopia has been affected by repeated drought and famine, but the handling mechanisms were largely through foreign aid rather than inward looking and progress oriented. Growing and using wild vegetables is an opportunity that has never been adequately prospected to alleviate malnutrition and ameliorate food insecurity. Nevertheless, hundreds of edibles including many vegetables of wild/semi-wild origin are known to be sporadically consumed by rural communities in Ethiopia [21, 22].

The actual number of WEPs in Ethiopia is expected to be more than the presently cited number, given that the flora has more than 6000 species, and that many cultural groups and localities as yet remain ethnobotanically unexplored [20]. In the Ethiopian subcontinent, about 81 million rural people including 85% of the ethnic population live in forested areas and have traditionally depended on forest resources for sustenance and cash income [5]. However, due to the increase in human density near and within the forested areas, the pressure on plant and animal populations has increased, leading to forest degradation, loss of biodiversity and forest cover. The bases of forest loss and degradation need to be identified to articulate better management and policy decisions [21].

The percentage of wild vegetables in the diet is known to be high and the degree of ingestion varies from one socio-cultural setting to the other [22]. Except in a few

cases of south Ethiopian communities and some others, feeding of underutilized edible plants, vegetables in particular, has often been looked upon as a sign of poverty, largely a reflection of lack of knowledge on their nutritional benefits. Fast revival of most vegetables under limited soil moisture and availability of the perennial species all year round make these plants capable of bridging the gap during food shortages and famine situations practiced by rural communities. Domesticated and non-domesticated green leafy vegetables have abundant dietary and health welfares [21, 22]. They are cheap, easy to cook and are rich sources of macro- and micronutrients. Consistent consumption of vegetables is also recommended for better health and for management of chronic diseases such as cardiovascular complications, diabetes and cancer [22, 23].

Several studies have documented the occurrence of wild edible species in different areas of Ethiopia [5, 13, 14, 18, 24–41]. However, there is no documentation on indigenous knowledge and practice with wild and semi-wild edible plant species (WSWEPs) around Berek district in the central part of Ethiopia where their use is particularly prominent both at times of excess and food deficiency. Therefore, there is a need to study and augment the knowledge base, practices and attitudes of the communities towards use of WSWEPs in this area. This applies to the local coping mechanisms against intermittent food scarcity and famine and sustainable use and conservation of plants in general and WSWEPs in particular. Most of the natural vegetation in the study area is heavily affected by human impact. Hence, collecting and documenting ethnobotanical knowledge before it is lost persistently is a vital urgent task. For this reason, the present study aimed at investigating and documenting the sustainable use and management of WSWEPs by aboriginal communities in Berek Natural forest.

The study is aimed to test the following hypotheses:

Null hypothesis

- All habits of plants have equal food importance.
- All edible plants are sufficiently available in every season of the year.
- The state of conservation for edible plants is sustainable.
- Almost all structures of edible plants are equally used for food.

Alternative hypothesis

- The most used edible plants are trees.
- WEPs are mostly prepared directly after having produced fruits or roots.
- Drinking and eating are the most used application form of edible plants.
- Human impact puts threats to the sustainable existence of edible plants.
- Edible plants are mostly available in the spring season of the year.
- The particularly edible parts of plants are roots and fruits.

Methods

Description of the study area

The study was conducted in Berek natural Forest located in Oromia Special Zone surrounding Addis Ababa, in Berek District, near Sendafa town at about 52 km from Addis Ababa. The study area is 13 km from Sendafa town accessed via the gravel road to Dire Dum. The geographic location is: 9° 12′44″–9° 30′62″ N and 38° 82′86″–39° 13′82″ E (Fig. 1). The total extent of the forest is 10.15 km^2 from a total of 77.223 km^2 of the study area. The rest of the area is farm land, pasture land, forest land, bare land and settlement (Oromia Forest and Wildlife Enterprise Addis Ababa Branch, Berek District, 2017).

The total population in the area is 93,473 and of which 13,268 households depend on mixed farming for their livelihood [42]. Because of settlements and farmland the forest is fragmented into eight patches, namely Adare, Bura Maru, Cafe kulo, Dire sokoru, Hurufa, Godo, Lucho and Tabo (personal communication with staff of Agricultural and Forest Development of Berek District). The forest is a mix of eucalypt plantations and natural vegetation dominated by *Juniperus procera*, *Podocarpus falcatus*, *Acacia abyssinica*, *Olea europaea*, Ficus spp. and *Rosa abyssinica*. The area is also rich in different plants that help the people directly or indirectly for different purpose (see Additional file 1: Appendix S1).

Topographically the study area exhibits flat plains with undulating gentle slopes and a few mountainous landscapes. Its elevation ranges from 2260 to 3440 m.a.s.l. The study area is divided into two thermal zones, which broadly correspond to traditional agro-climatic zones: Dega (41%) and Weina dega (59%). Data collected from meteorological stations located adjacent to the study area show that the mean maximum and the mean minimum temperatures for the area vary within the range of 25 °C to 7 °C with 16 °C of optimum temperature. The average annual rainfall is 950 mm. The maximum rainfall was 1250 mm (recorded in 2017) and the minimum 750 mm. The 12 year average monthly rainfall data showed that the maximum precipitation was obtained from June to August, while October to February is the driest period

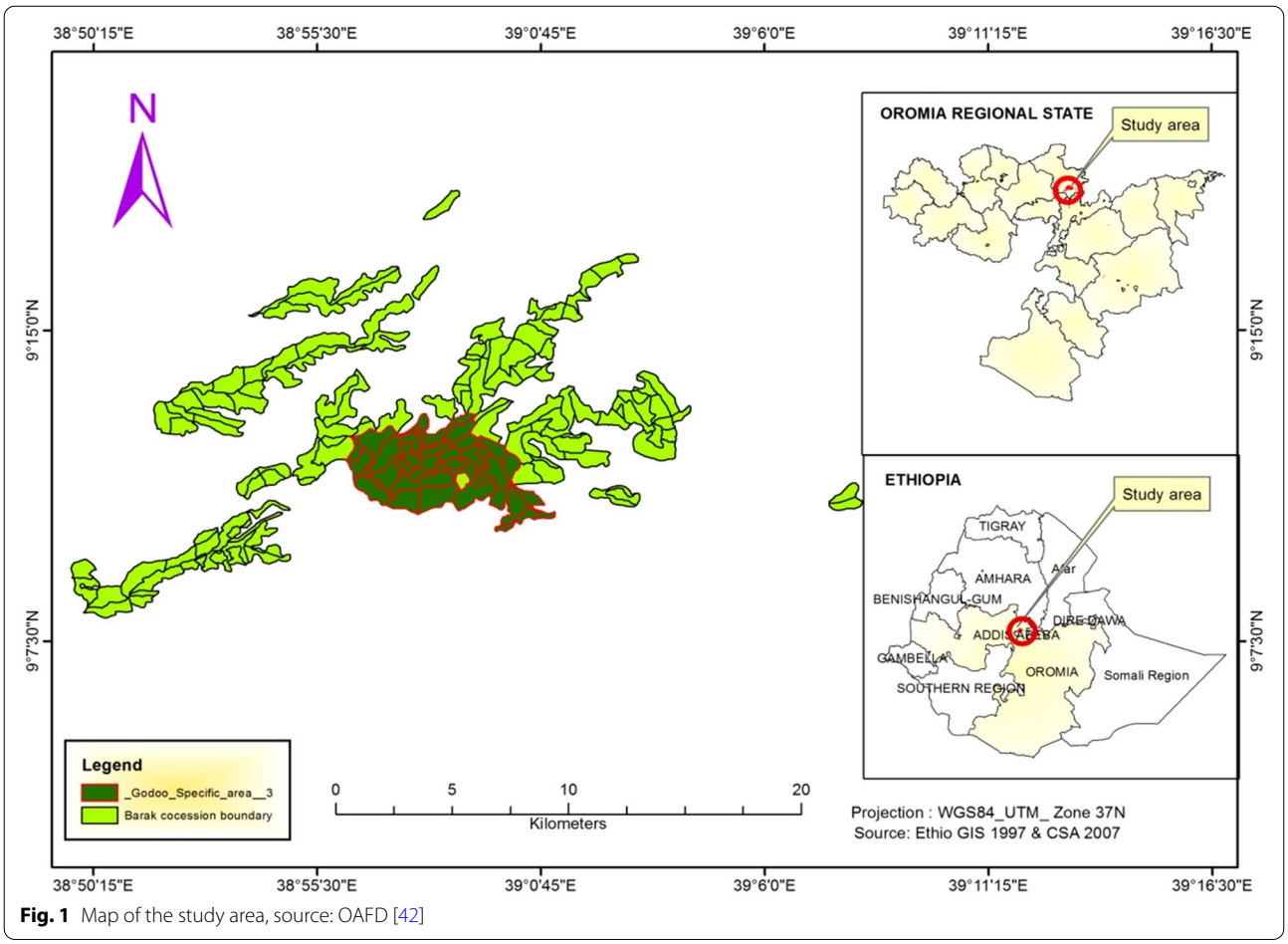

Fig. 1 Map of the study area, source: OAFD [42]

[42]. The study area has a variety of soils that can be used in various ways in food production.

Data collection methods

Reconnaissance survey and site selection

A reconnaissance survey of the study area was conducted during November 2017 to depict the different vegetation types, natural resource management and indigenous knowledge associated with the use of wild edible plant species. Following the survey, a focus group discussion was carried out with selected key informants in one of the study sites, which is the center for the whole study area. After the discussion, eight kebeles (villages) that border the forest were purposively selected as study sites out of the total 22 kebeles of the district. The study villages were chosen based on proximity to the existing remnant forest resources and representativeness of the different agro-ecological systems recommended by the key informants.

Sampling of informants

From the 4871 households, a total of 142 informants (77 men and 65 women) with an age of 14 years and above were selected from the eight kebeles (Table 1) and involved in the study. This sample size was determined by means of the Yamane formula for sample size at 95% confidence level [43]. These are the communities living either in or around the forest. Of the 142 informants, 102 general informants were selected randomly. In addition, 40 key informants (five from each study site) were selected in the ethnobotanical investigation since they have a straight interface with the forest. These were selected by using information and recommendations from the local kebele administrators and kebele agricultural officers, knowledgeable elders and religious leaders as well as the local community. The 102 general informants were selected randomly from the local people of the study area to get the general indigenous knowledge on the use and conservation status of WSWEPs.

Ethnobotanical data were collected in two trips; the first one during March 2018 and the second during April 2018 following Martin [1] and Cotton [44]. Accordingly, data collected through field observations, group discussions, key informant interviews, semi-structured interviews, preference ranking, photographing, voice

Table 1 Description of the selected kebeles surrounding the forest

No.	Name of kebele	Area in km^2	Population size	No. of households	No. of informants involved in the study
1	Adare	2.041	4085	581	17
2	Bura maru	2.112	4003	634	19
3	Cafe kulo	2.072	3752	691	20
4	Dire sokoru	1.184	3719	588	17
5	Godo	3.403	4152	722	21
6	Hurufa	2.667	3837	547	16
7	Lucho	1.091	3565	523	15
8	Tabo	1.215	3615	585	17
	Total	10.15	30,728	4871	142

recording, pairwise comparisons, direct matrix ranking and guided field walks with informants were employed to obtain indigenous knowledge of the local community on WEPs, local classification, vegetation, threats and conservation activities. Interviews were held based on a checklist of questions (see Additional file 2: Appendix S2), which was prepared beforehand in English language and converted into Afan Oromo, the local language. Following this, interviews and discussions were carried out with general and key informants. Both qualitative and quantitative data were collected through the questions. The time and place for interview and discussion were decided according to the interests of the informants.

Semi-structured interviews

The list of questions (see Additional file 2: Appendix S2) was probed to general informants and the interviews were conducted with the local language Afan Oromo. The interviews were based on the checklist and some issues were also raised based on the responses of the informants.

Focus group discussions

Group discussions were made earlier and during ethnobotanical data collection following Martin [1]. These were done with key informants, on specified time at each site with 6–8 key informants. Participants were asked about the wild and semi-wild edible plant use system of the people and its management. There were further question on how knowledge is maintained and transferred in the family or to younger generations. During these activities a video recorder and a photo camera were used as data gathering tools. At the end of the interviews the involvement of each informant was appreciated, indicating the value of their knowledge in wild and semi-wild edible food plants and biodiversity conservation.

Field observations

Repeated field observations were conducted using transect walks where most of the WSWEPs are grown. The purpose of the field observations was to obtain actual information of presence, growth habit, habitat characteristics and identification of the edible plant species mentioned during the interviews. During guided field walks, conversations were conducted while walking through the study sites to collect the data on WSWEPs. Hence, a number of field observations were done with the assistance of interviewed informants to collect plant specimens. Complete records about local names of plants, growth form, habitat, mode of collection, the nature of human activities and major threats, were recorded on place. Selected study sites, plant species, deforested and conserved areas were photographed. Voucher specimen were gathered both in homegardens and the wild of the study sites (see Additional file 3: Appendix S3). Besides, a total estimate (combined description of abundance and cover), probably the best method for obtaining a complete general picture of a plant community, was recorded for each species using the following scales as suggested by Braun-Blanquet [45]:

+ Individuals of a species very few; coverage very poor.
1. Individuals of a species in plenty; but coverage small.
2. Individuals numerous if small and a few if large; coverage 5% of the total area.
3. Individuals few or many; coverage 25–50% of the total area.
4. Individuals few or many; coverage 50–75% of the total area.
5. Plant species over 75–100% of the total area.

Plant specimen collection and identification

Voucher plant specimens were collected from the wild and home gardens based on ethnobotanical information

provided by informants. The collected voucher plant specimens were pressed, numbered and given local names on each sheet and dried. Identification of specimens was performed both in the field and later at the National Herbarium of Ethiopia (ETH) using taxonomic keys, descriptions and illustrations in the Flora of Ethiopia and Eritrea [46–53] and by comparison with already identified specimens at ETH and consulting with experts from the ETH and Mekelle University botany team. Finally, voucher plant specimens are deposited in Mekelle University, Mekelle, Ethiopia.

Data analysis

Descriptive statistics, preference ranking, paired comparison, direct matrix ranking and informant consensus were used to analyze the data. Ethnobotanical data were analyzed, both qualitatively and quantitatively using SPSS version 20 and excel spreadsheet. The spreadsheet data filter facility was employed to determine multipurpose uses, proportions of different variables like growth forms (habits), plant families, plant parts used and methods of food preparation.

Preference ranking

Wild and semi-wild edible plant preference ranking activates was carried out following Martin [1]. Accordingly, seven randomly selected key informants were asked to rank the five most preferred WSWEPs. The values were five for the most preferred and one for the least preferred. Finally, total scores were added and then ranked to identify the most preferred plant species.

Ranking of threatening factors

The six most threatening factors were ranked following Martin [1] to determine the most threatening factors in the study area. Eight key informants were asked to give the value five for the most threatening factor and one for the least. Finally, the values were summed up and cumulative scores and ranks were given to each threatening factor.

Informant consensus

In order to evaluate the reliability of information during the interview, informants were contacted at least two times based on the appointment made by them. Valid information was proved and recorded. Consequently, if the idea of the informant deviated from the original information, it was rejected since it is considered as unreliable. Only the relevant ones were statistically analyzed following Alexiades [54].

Results

Socio-demographic characteristics of informants

Socio-demographic characteristics of households and informants are summarized in Table 2. Informants from 142 households were selected of which 77 were men and 65 were women. From each study kebele, 15 to 21 households participated with an age range of 14 years and above. The majority had not received formal education (73.9%).

Taxonomic diversity of WSWEPs

The plant species of the study area are generally diverse and serve the communities in different ways. A total of 34 useful wild and semi-wild edible plant species belonging to 32 genera and 24 families were collected and identified. The family Rosaceae had the highest number of

Table 2 Socio-demographic characteristics of informants

Character	Informants information			
	Male	Female	Total	Percent
Age				
14–30	16	12	28	19.7
31–40	21	19	40	28.2
41–60	26	27	53	37.3
>60	14	7	21	14.8
Total	77	65	142	100
Marital status				
Married	52	49	101	71.1
Unmarried	16	12	28	19.7
Divorced	9	4	13	9.2
Total	77	65	142	100
Religion				
Orthodox	54	45	99	69.7
Muslim	5	3	8	5.6
Protestant	11	9	20	14.1
Wakefata	7	8	15	10.6
Total	77	65	142	100
Educational status				
Cannot read and write	51	46	97	68.3
Can read and write	6	2	8	5.6
Elementary school	4	1	5	3.5
Secondary school	9	6	15	10.6
Above grade 12	7	10	17	12
Total	77	65	142	100
Residence				
Rural	73	62	135	95.1
Semi-urban	4	4	7	4.9
Total	77	65	142	100
Gender	77	65	142	100
Percentage	54.2	45.8	100	

species, five species (14.7%), followed by Anacardiaceae and Solanaceae with three species each (8.8%), Lamiaceae and Moraceae with two species each. Plants said to be consumed and collected from the wild only were 25 (73.5%), and species that were both wild and cultivated (semi-wild) were nine (26.5%) (Table 3). The majority of the edible plants were recorded in the wild, but the integration of some plants in farm lands and home gardens indicate their potential to be used in different land use systems.

In the study area, physiographic variables such as altitude, longitude and latitude were measured using GPS for each plant. Most WSWEPs were found at altitudes 2276–2923 m.a.s.l. Longitudes were 9° 1.137′–9° 58.304′ N and latitudes 38° 42.597′–39° 4.773′ E where (see Additional file 4: Appendix S4).

Growth form, parts used and mode of consumption/preparation of WSWEPs

The plant species had different life/growth forms and different plant parts are consumed. The majority of the species were trees (41.2%, 14 species) followed by herbs and shrubs (29.4%, 10 species each) (Fig. 2). Trees had

Table 3 List of collected plants with scientific and vernacular name, family name, habit and habitat

S/no.	Scientific name	Local name (Afan Oromo)	Family	Habit	Habitat
1	*Acacia abyssinica* Hochst ex Benth	Laaftoo	Fabaceae	T	W
2	*Acanthus sennii* Chiov	Sokorruu	Acanthaceae	S	W
3	*Brassica carinata* A.Braun	Raafuu daggalaa	Brassicaceae	H	W
4	*Carissa spinarum* L.	Agamsa	Apocyanaceae	S	W
5	*Catha edulis* Forssk. ex Endl	Jimaa	Celastraceae	T	Sw
6	*Citrus simensis* (L.) osbeck	Burtukaana	Rutaceae	T	Sw
7	*Cordia africana* Lam	Waddeessa	Boraginaceae	T	W
8	*Cucurbita pepo* L.	Dabaaqula	Cucurbitaceae	H	Sw
9	*Dovyalis abyssinica* E.Mey. ex Arn	Koshommii	Flacourtiaceae	S	W
10	*Ensete ventricosum* (welw.) cheesman	Warqee	Musaceae	H	Sw
11	*Ficus sur* Forssk	Harbuu	Moraceae	T	W
12	*Ficus sycomorus* L.	Luugoo	Moraceae	T	W
13	*Grewia ferruginea* Hochst. ex A.Rich	Dhoqonuu	Tiliaceae	T	W
14	*Hagenia abyssinica* (Bruce) JF.Gmel	Heexoo	Rosaceae	T	Sw
15	*Impatiens paucidentata* De Wild	Burii	Balsaminaceae	H	W
16	*Lippia adoensis* Hochst. ex Walp	Kusaayee	Verbenaceae	S	W
17	*Nicotiana tabacum* L.	Tamboo	Solanaceae	H	Sw
18	*Ocimum lamifolium* Hochst. ex Benth	Damaakasee	Lamiaceae	S	W
19	*Opuntia ficus-indica* (L.) Miller	Adaamii	Cactaceae	S	W
20	*Persea americana* Mill	Avokaadoo	Lauraceae	T	Sw
21	*Phoenix reclinata* Jacq	Meexxii	Arecaceae	T	W
22	*Physalis peruviana* L.	Haawwuxii	Solanaceae	H	W
23	*Prunus africana* (Hook.f.) Kalkman	Kookii	Rosaceae	T	Sw
24	*Rhus glutinosa* A.Rich	Xaaxessaa	Anacardiaceae	T	W
25	*Rhus natalensis* (Berh. ex Krauss) Engl	Laboobessaa	Anacardiaceae	S	W
26	*Rosa abyssinica* R.Br. ex Lindl	Goraa	Rosaceae	S	W
27	*Rubus apetalus* Poir	Altufa	Rosaceae	S	W
28	*Rubus steudners* Schweinf	Goraa arbaa	Rosaceae	S	W
29	*Rumex nervosus* Vahl	Dhangaggoo	Polygonaceae	H	W
30	*Schinus molle* L.	Qundi barbaree	Anacardiaceae	T	Sw
31	*Solanum indicum* L.	Samaree	Solanaceae	H	W
32	*Thymus schimperi* Ronn	Xoosinyii	Lamiaceae	H	W
33	*Urtica simensis* Steudel	Doobbii	Utricaceae	H	W
34	*Ximenia americana* L.	Hudhaa	Olaceae	T	W

Habit (H = herb; S = shrub; T = tree) and habitat (Sw = semi-wild; W = wild)

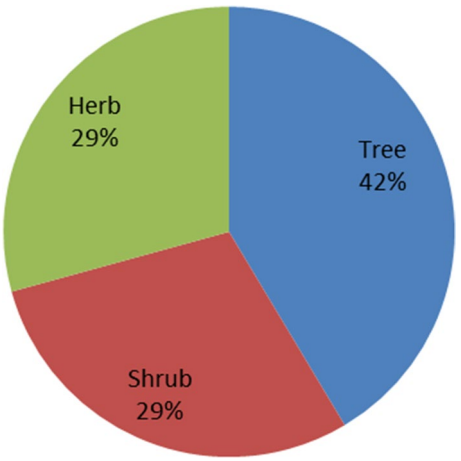

Fig. 2 Growth form of wild and semi-wild edible plants of the study area

Table 4 Plant parts used as food

Part used	Number of species	Percentage
Fruit	21	61.8
Gum and bark	1	2.9
Leaf	4	11.8
Leaf and fruit	2	5.9
Leaf and stem	2	5.9
Nectar	2	5.9
Stem and fruit	1	2.9
Young shoot	1	2.9
Total	34	100

the highest abundance because of a better adaptation of these plant species to the environment.

As for parts used, a total of seven edible parts were recorded. Of these, 61.8% were fruits, 11.8% were leaves and 5.9% nectar, while the remaining 20.5% were young shoots and stems, bark and gum (Table 4). This implies that more than one part of a plant species was consumed by humans in the study area.

Most of the plants were consumed raw, while a few were boiled, cooked, absorbed or chewed (Table 5). WSWEPs were recorded in different habitats (riverine areas, farm lands, natural forests, grazing lands and home gardens) and they were consumed in different forms (Table 5).

Availability of WSWEPs in different seasons

Key informants explained that the time/season and frequency of harvesting vary from plant to plant depending on the availability. It varied from place to place due to ecological and seasonal conditions (Table 5). They were most abundant during the short rainy season (belg) from February to April and during the dry season during November to March, while less abundant during the main rainy season in June to August. That they are less abundant during the main rainy season may pose a challenge to researchers and readers. It may be because plants accumulate energy and water for the dry season growth and development and become ready for flowering and fruiting after the main and short rainy seasons. About 15 species (44%) of the plant species were ripe in the spring season while seven species (20.6%) were found in all seasons and only eight species (23.6%) were able to reach maturity in autumn and winter (Fig. 3).

Preference ranking of edible plants

The species preference is almost similar throughout the kebele and there is no significant difference among the eight kebeles. This may be due to similarity in ethnic composition and sharing of the same culture of wild edible plant utilization as well as living in the same woreda. *Rosa abyssinica* is the most preferred edible plant, cited by most respondents in all kebeles, while *Rubus steudneri* got the last position. The preference of wild food plant species varied within the study area. For example, plants consumed during famine were not consumed during normal periods. The fruits of *Ficus sur* were the most preferred wild food fruits because of its good taste (pairwise ranking; Table 6). All species that are edible are not equally attractive for consumption. Some of the species are considered to have good palatability, while others are medium or low grade.

Multipurpose use of WSWEPs

Apart from their food values, the reported WEPs are used also for other purposes. Direct matrix ranking was undertaken in order to evaluate the multipurpose use of plant species and their relative importance to the local people, and also the extent of existing threats related to their use values. The result of use diversity indicates that *Cordia africana* was ranked first because it is used for different purposes such as construction, firewood, fencing and so forth (Table 7). This shows that the local people harvest the WEPsnot only for food but also for construction, firewood and furniture.

Abundance and coverage of WSWEPs in the study area

Abundance of the edible plants varied from site to site with altitudinal differences, as recorded using the Braun-Blanquet cover-abundance scale. The distribution of plants varied between kebeles. The kebele Tabo had the highest abundance and cover of WSWEPs. Overall, trees and shrubs were more abundant than herbs. Two tree species, *Acacia abyssinica* and *Rosa abyssinica* had

Table 5 List of plants collected with the season they reach maturity, parts used and mode of preparation

S/no.	Scientific name	Time to reach maturity	Parts used	Mode of preparation
1	*Acacia abyssinica* Hochst ex Benth	All time	Gum and bark	Gum and bark chewed by children
2	*Acanthus sennii* Chiov	Spring	Nectar	Absorb liquid from nectar
3	*Brassica carinata* A.Braun	Winter and spring	Leaf and fruit	Cooked and roasted
4	*Carissa spinarum* L.	Spring	Fruit	Ripe fruit eaten fresh
5	*Catha edulis* Forssk. ex Endl	All time	Leaf	Chewing leaf
6	*Citrus simensis* (L.) Osbeck	Winter	Fruit	Fruit eaten
7	*Cordia africana* Lam	Winter	Fruit	Raw, ripen, eaten
8	*Cucurbita pepo* L.	Autumn	Fruit	Cooking, eaten by injera (local flatbread) as wot
9	*Dovyalis abyssinica* E.Mey. ex Arn	Spring	Fruit	Fruit eaten
10	*Ensete ventricosum* (Welw.) Cheesman	All time	Young stem and Fruit	Fruit eaten and stem with other food
11	*Ficus sur* Forssk	Spring	Fruit	Ripen eaten
12	*Ficus sycomorus* L.	Spring	Fruit	Fruit eaten when ripe
13	*Grewia ferruginea* Hochst. ex A.Rich	Spring	Fruit	Ripen eaten
14	*Hagenia abyssinica* (Bruce) JF.Gmel	Spring	Leaf and fruit	Raw, ripen, eaten and chew leaf
15	*Impatiens paucidentata* De Wild	Summer	Nectar	Absorb liquid from nectar
16	*Lippia adoensis* Hochst. ex Walp	All time	Leaf and young stem	As condiments in spice preparation
17	*Nicotiana tabacum* L.	Autumn	Leaf	Leaf chew and grinding of it
18	*Ocimum lamifolium* Hochst. ex Benth	All time	Leaf	Chewing leaf or liquid with water
19	*Opuntia ficus-indica* (L.) Miller	Winter and spring	Fruit	Ripe fruit eaten
20	*Persea americana* Mill	Spring	Fruit	Fruit eaten
21	*Phoenix reclinata* Jacq	Spring	Fruit	Fruit eaten
22	*Physalis peruviana* L.	Winter	Fruit	Ripen eaten
23	Prunus africana (Hook.f.) Kalkman	Winter	Fruit	Ripen eaten
24	*Rhus glutinosa* A.Rich	Spring	Fruit	Raw, ripen, eaten
25	*Rhus natalensis* Berh. ex Krauss	Spring	Fruit	Raw, ripen, eaten
26	*Rosa abyssinica* R.Br. ex Lindl	Spring	Fruit	Raw, ripen, eaten
27	*Rubus apetalus* Poir	Winter	Fruit	Ripen, eaten
28	*Rubus steudneri* Schweinf	Autumn	Fruit	Ripen eaten
29	*Rumex nervosus* Vahl	All time	Young shoot	Pilled stem
30	*Schinus molle* L.	Autumn	Fruit	Use as spice and pepper
31	*Solanum indicum* L.	Spring	Fruit	ripen eaten
32	*Thymus schimperi* Ronn	Summer	Leaf and young stem	Use as spice and for tea
33	*Urtica simensis* Steudel	All time	Leaf	Roasting and eaten by injera
34	*Ximenia americana* L.	Spring	Fruit	Ripen and un ripen eaten

highest abundance and cover, while *Catha edulis* was less abundant. Among the herbaceous species, *Thymus schimperi* was more abundant than the others.

Traditional knowledge associated with WSWEPs

Most of the people living around the study area directly or indirectly depend on WSWEPs. Social norms, beliefs and taboos have their own merits and demerits in biodiversity conservation. The people perceive that *Ficus sur* brings ground water to the surface area and *Acacia abyssinica* is considered spiritual to the environment. Due to this perception, people in the Berek area have developed positive attitudes towards the plant (*Ficus sur)* which in turn contributes to its conservation. Anyone who is found cutting *Ficus sur* is socially outcast and sometimes punished, both in physical and monetary forms, by the leaders of the kebele and woreda. Also, elders bless their adored ones under acacia trees, while then the person to be blessed listen more sincerely to the idea transferred from the elders.

People around the forest have developed knowledge of wild plant food, its collection and consumption. Most local communities have positive attitudes towards WSWEPs as being easily accessible, safe, organically produced and gives a higher dietary variety. Regarding

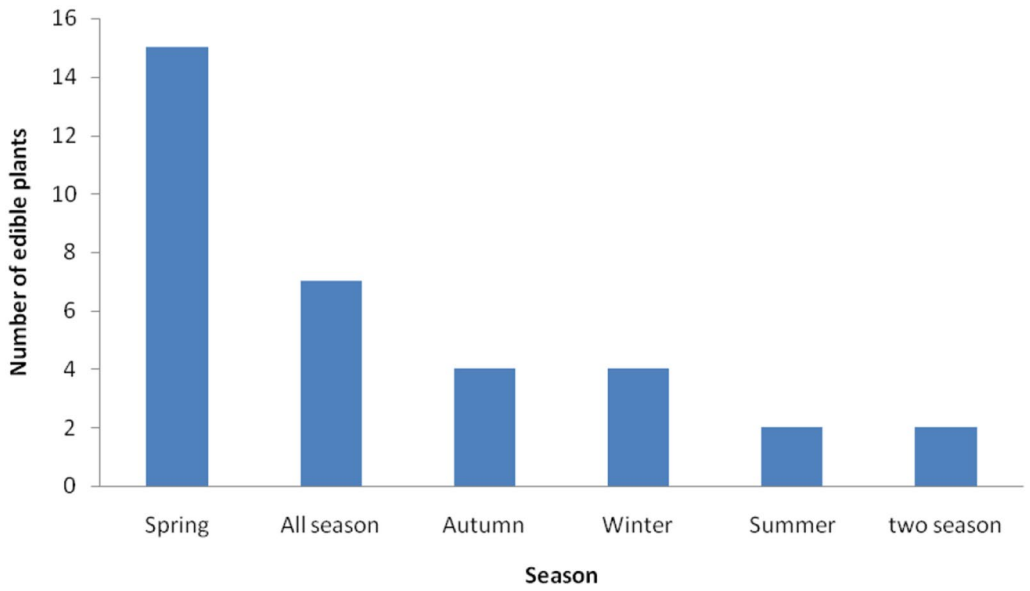

Fig. 3 The number of edible plants becoming mature and available at different season

Table 6 Results of preference ranking of top five WSWEPs fruits by their taste quality (1 = least, 2 = less, 3 = good, 4 = very good, and 5 = excellent

Edible fruits	Key informants (K1 to K7)								
	K1	K2	K3	K4	K5	K6	K7	Total	
								Score	Rank
Ficus sur	4	3	3	2	3	3	3	21	1st
Ximenia americana	2	1	4	3	5	3	2	19	2nd
Physalis peruviana	3	1	1	3	3	4	2	17	3rd
Rubus apetalus	1	5	1	3	1	1	3	15	4th
Cordia africana	2	3	1	1	2	1	4	14	5th

Table 7 Direct ranking of five WEPs by five informants based on five use criteria (5 = best; 4 = very good; 3 = good; 2 = less used plant species and 1 = least used)

Key informants (K1–K5)	WSWEPs				
	Acacia abyssinica	*Carissa spinarum*	*Cordia africana*	*Ficus sur*	*Hagenia abyssinica*
K1	5	3	5	5	4
K2	4	2	4	4	5
K3	5	2	5	3	4
K4	2	3	5	3	3
K5	3	4	4	2	4
Total	19	14	23	17	20
Rank	3rd	5th	1st	4th	2nd

the knowledge associated with WEPs, the older people could tell the uses of plants as food than for other uses.

The knowledge of wild food plants has been transferred through songs, folklore and riddles in local languages at different times especially when people are at rest during night time. The general public consumes wild edibles as snacks, supplement or refreshments. Fruit is found to be the most edible plant part and mostly eaten raw. The knowledge associated with edibility and related information on WSWEPs is general knowledge that is transferred directly or indirectly orally to next generation. The knowledge flow from elders to children and its enrichment thereafter is directly conveyed through observation, imitation and

free flow of information among community members, through oral history telling and myths.

Informants told that some of the WEPs are consumed only during famine or in times of food shortages as it was also shown by Balemie and Kebebew [31]. But, youngsters (mostly male cattle herders) also took relatively higher quantities of edible wild plant parts (mainly fruits) even in times of food availability when they were with their livestock.

Informants said that there was seasonal variation in the availability of WSWEPs. Some of the annual herbs such as *Brassica carinata* become scarce during the dry seasons and their spatial distribution is restricted to near shades of trees making their collection and use difficult. Elderly key informants said, that 25–40 years ago they were using many WEPs for food, medicine and other uses. Collecting edible wild plants nearby was very easy at that time. In recent years, because of degradation by deforestation to expand agriculture and settlements, fire wood collection and commercial charcoal production, encroachment by invasive alien species like eucalypts, cutting trees for construction, overgrazing and browsing and other development activities, some WEPs were no longer easily available and accessible.

Threats to WSWEPs and their habitats

According to the respondents from all kebeles, a number of factors threatened the useful plants in their area. Today these wild and semi-wild edible plant species are not easily available in the area due to both natural and anthropogenic causes. Increase in the population numbers in the study area and lack of awareness, deforestation, expansion of agricultural activities, firewood collection, charcoal preparation, grazing, planting of eucalypts around or in the forest, insect infection and selective cutting for house construction were severely depleting wild edible plant species. Among these problems, most informants perceived that agricultural expansion, that includes both land cultivation and livestock production, was the main factor that threaten wild food plants.

Anthropogenic factors played the main role for the survival of plant species in the study site. Human demands for sources of food, medicine, shelter, cosmetics, construction, charcoal production and forage for livestock resulted in overexploitation and overgrazing of plants. Most plants used for livestock feed suffered mainly from overgrazing in the study areas. The habitats of these valuable WEPs were increasingly threatened by continued destruction of indigenous vegetation. The fact that most WEPs have multipurpose uses, posed a big threat to their existence due to destruction of their habitats and over-harvesting. As a result, most edible wild plants have become rare.

Therefore, we were informed during semi-structured interviews and group discussions that plant species, such as *Ximenia americana* and *Rubus steudneri*, were rarely encountered. Nutraceutical plant species like *Hagenia abyssinca, Ocimum lamifolium, Acacia abyssinica* and *Urtica simensis* might in the future be restricted to the vicinity of settlement areas (Fig. 4), in or borders of farms, relic forests, rocky hillsides and spiritually protected and secluded areas.

During group discussions, key informants identified five major threats to WEPs by priority. Agricultural

Fig. 4 *Hagenia abyssinica* planting for multipurpose role in the study area. Source: own survey (March 2018)

Table 8 Result of priority ranking of factors threatening edible plants by eight respondents (1 = least destructive, 2 = less, 3 = medium, 4 = more and 5 = most destructive)

Threats	Key informants (K1–K8)								Total	
	K1	K2	K3	K4	K5	K6	K7	K8	Score	Rank
Agriculture	4	3	4	5	3	4	5	3	31	1st
Introducing exotic species	3	3	3	4	4	5	3	3	28	2nd
Overgrazing	3	2	4	1	2	3	3	5	23	3rd
Construction	2	3	2	3	3	4	2	1	20	4th
Charcoal making	2	1	2	4	2	1	3	4	19	5th
Extended dry seasons	2	2	2	3	2	3	1	2	17	6th

expansion was identified as a major threat followed by introduction of exotic species like eucalypts (Table 8). As a result, WEPs are left to widely grow in farmlands (e.g., *Acacia abyssinica* and *Carissa spinarum*), farm boundaries and watershed areas. Others are frequently used for shade (*Ficus sur).*

The threats were also exacerbated by climate variability and change in the region. Hence, all socio-economic and environmental problems are exacerbated by climate change events. In spite of population pressure people of the study area have knowledge of how to prevent lasting threats to WEPs. People said that they have ways to mitigate changes in the plant communities in the study area within their community norms such as strict prohibition of cutting of valuable shrubs and trees, particularly for charcoal production. Besides, the people perceive that some plants, such as *Ficus sur*, bring ground water to the surface area, and *Acacia abyssinica* is used as spiritual to the environment. Such perceptions towards plants have helped the people in Berek areas to develop positive attitudes towards conservation.

Discussion

The WSWEPs recorded were used for many purposes. Most of the identified trees and shrubs are also reported to be edible elsewhere in Ethiopia and other parts of Africa. A fairly high number of WSWEP species were recorded in the study area compared to other areas. For example, 15 wild edible trees and shrubs were identified by Addis et al. [36], 22 wild species by Atinafu et al. [40] and 33 WSWEPs in Chilga District Northwestern Ethiopia by Tebkew [55]. But Ayele [41] in Ethiopia and Rajeswar et al. [56] in India were reported higher diversity of WSWEPs than the current study.

Most edible plants are documented elsewhere in Ethiopia: 16 species of WSWEPs were recorded in Berehet District, North Shewa Zone of Amhara Region with emphasis on WEPs [57]. 10 potential but underutilized fruit trees and vegetables were found in Tigray, northern Ethiopia [58]. 10 species were found in an ethnobotanical survey of WEPs and their contribution for food security used by the Gumuz people in Kamash woreda, Benishangul Gumuz Regional State [41]. Finally, nine species were found in Chilga district, Northwestern Ethiopia [55]. All informants almost similarly reported that agricultural expansions stood first. Similar results are also reported in other areas [31, 59, 60].

Trees followed by shrubs and herbs were the dominant growth forms of WSWEPs in the study area. The report by Fantahun and Herbert [61] in Amhara region and Teklehaymanot and Giday [34] in the lower river valley of Debub Omo Zone were consistent with the present finding that trees were the most important growth form. On the other hand, Lulekal [62] reported that shrubs were the dominant growth forms in Ethiopia followed by trees, herbs and climbers. Similar findings have also been reported from Uganda [7]. On the other hand, Li et al. [63] among Lhoba people in Milin County, Tibet and Ashagre et al. [39] in Burji District, Segan Area Zone of Southern Nations, Nationalities and Peoples Region (SNNPR), Ethiopia, found herbs and shrubs to be the dominant growth form.

In the present study, WSWEPs were collected from a variety of environments such as natural forest, agricultural fields and home gardens. Also Ashagre et al. [39] found most wild and semi-wild plants in wild habitats. Most of the WSWEPs were collected from wild habitats also in Central East Shewa of Ethiopia according to Feyssa et al. [64]. Similar results were reported from southern Ethiopia by Balmie and Kebebew [31].

Plant parts of the WSWEPs regularly utilized by the local community of the study area include fruits and leaves (Table 5). The most palatable fruits are usually consumed raw as snacks and between meals while collecting fuelwood or herding. Similar results were reported by Ojelel et al. [7]; Ayele [41] and Lulekal [62]. On the other hand, Łuczaj and Szymański [65] and Lentini and Venza [66] reported that fruits are the second most important

plant part used in Poland and Sicily, respectively. Besides, Pegu et al. [67] in Poba Reserved Forest, Assam, India found almost all parts of the plants (roots, stem, flowers, leaves, tubers, fruits) to be palatable. Furthermore, young leaves or enrolled fronds, are the primary pteridophyte food sources in sub-Saharan Africa, followed by leaves and rhizomes [68].

WSWEPs in the study area are mainly consumed as raw (Table 5) without any processing. About 80% of the recorded edible plants were consumed fresh without additional processing and most of them are fruits as it is reported by [31] in Derashe and Kucha Districts, South Ethiopia and other places [29, 34, 39, 63].

Field observations and discussions with key informants have shown that the last 15 years have been very detrimental to the natural vegetation of the area. Hence, the vegetation is degrading by natural and anthropogenic factors. This is partly associated with the recent adoption of genetically modified crop production by most of the population as well as livestock pressure. Following the change in land use, environmental degradation has accelerated and this was further aggravated and reinforced by climate change as it is indicated by Nkrumah [69]. Key informants said, that increased collection of fuel wood and construction material cannot be secure unless other energy source is designed and put in action with apt technology. This will lessen the severe consequences of anthropogenic activities on nutraceutical wild plants and consequently maintain their abundance for food, medicine and other multipurpose uses [60].

The multiple use of several species were recorded as one of the threatening factors for the plant species in areas that have been facing lack of priorities for conservation, especially of useful plants (medicinal, edible, forage plants). However, some farmers have started management of some few species, such as *Hagenia abyssinica* and *Ficus sur* in their farmlands (Fig. 4). Such management and acquisition of economic benefits from species might promote local people's interest in conservation and maintenance of such local important plants. Such experiences should be exchanged with other local people to motivate conservation and management habit in the area. Once again, most of WSWEPs provide various services in addition to food value. Researchers elsewhere in Ethiopia also noted multiple purposes such as preparation of remedies, fuel wood, fencing, construction, timber, farm and house hold implements and livestock fodder [31, 34, 61].

The majority of the respondents across the study areas also complained that most of the edible plants are trees and some are thorny which are difficult to climb to reach the edible parts. Cultural ignorance was also mentioned as a problem for obtaining WSWEPs, given that most of the fruits and leaves, which are eaten raw and fresh, are becoming perishable and deteriorate easily and cannot be stored for a long time. Besides, local taboos also seem to depress the consumption of WSWEPs. Studies elsewhere in Ethiopia also show that utilization of WSWEPs is coupled to similar problems [61].

Generally, elder informants indicated that plant diversity decrease for various reasons compared with the last 10 years. Mainly, some WSWEPs in the area are becoming locally extinct and difficult to get. On the other hand, there are fragmented and disorganized conservation activities by the community at present which is much reduced in its extent compared to the past time, similar to the findings of Addis et al. [29]. Such a problem was also recorded in other parts of the country [5, 31, 32, 70, 71].

As described by Cotton [44] and Cunningham [72], this might be due to declining indigenous management and conservation practices, slowly eroded and even lost forever by cultural deviations and human interest shifting towards financial aspects. Industrial development as well as movement of youth from rural areas could be other factors [73] as well as fast socio-economic changes of the community [32].

Local communities in the study area have various indigenous management strategies for conservation and management of their natural resources. These includes planting in the home garden, pruning, pollarding, use of indigenous trees such as *Hagenia abysinica* for fencing and preventing cutting of some plants in the local culture like *Acacia* and *Ficus* species that they used for various purposes in relation to their daily life. The home gardens and their surroundings are strategic and ideal habitats for the in situ conservation of biodiversity, production and enhancement of wild food plants and for preservation of the associated valuable indigenous knowledge of the local community. Likewise, WEPs which have additional uses in the area, such as livestock fodder, medicine, construction, spice, fuel and forage were planted in home gardens and farmlands of the households. According to Feyssa et al. [64], lessening of deforestation, protection of plants and traditional agroforestry activities are the best conservation practices suggested by local people in Central East Shewa of Ethiopia.

As local people, especially elder informants, reported, before the past ten to 15 years, the area was full of natural vegetation around the farm land, in forests and along rivers, and there was a wealth of plant species. Although the local people understand the importance of conserving the WEPs, only a few in situ (in original/natural habitat) conservation measures like planting in the form of fences and protected pasture land in different worship areas (churches, mosques) and in their farm field/farm margins are being practiced. These are sustainable modes

of resource use that need to be encouraged and applied by blending them with standard modern management practices.

Conclusions and recommendations

The study area is rich in WSWEPs, with high diversity and with associated indigenous information. Forty three WSWEPs were documented, most of which were trees. Besides, indigenous knowledge about the edibility, habitat distribution, harvesting time and uses of most WSWEP species is still maintained among the communities in the study area. The knowledge of wild food plants has been transferred through songs, folklore and riddles at different times especially when people are at rest during the night time. Moreover, all household members of the study area were involved in the collection and consumption of WSWEPs. This helps to ensure the maintenance of indigenous knowledge associated with WEP species. The local people harvest the WEPs not only for food but also for construction, fire wood, livestock fodder and furniture. Particularly, WSWEPs such as *Hagenia abyssinica* and *Cordia africana* have multipurpose use within the local communities.

However, there is a decline in the consumption of some WSWEP species that were used during periods of food shortage such as the foliage of *Brassica carinata* and *Urtica simensis* which slowly lead to the fading away of the indigenous knowledge associated with them. The local knowledge about the nutritive composition and side effects of the WEPs is very scanty and little is known about adverse side effects such as toxicity originating from the WEPs. In general, diversity of WEPs and the associate indigenous knowledge in the area is declining gradually by different factors (including agricultural expansion, overgrazing and poor management, and lower emphasis towards safeguarding of indigenous knowledge) leading to local extinction of the species and the valuable knowledge. Therefore, to improve the natural diversity and to minimize the influence of the surrounding communities and to use the forest resources sustainably, public awareness and participatory community based management need to be encouraged by government and non-government organizations at all levels with urgent collection of germplasm by the professionals. At large, the plant species and the traditional culture of the community shall be preserved and acknowledged. Almost all WSWEPs are found in the natural forest, along river sides and in range land areas. Thus, local communities should be encouraged to cultivate multipurpose and widely used WSWEPs on their own land in the home gardens, mixing with crops in farmlands and live fences and promoting the establishment of local botanical gardens starting at least at the kebele level.

Abbreviations

GPS: Geographic Positioning System; Kebele: Which is an Amharic term, is part of a wereda (district) and the smallest administrative division or structure in Ethiopia; Key informants: Refer to informants having better indigenous knowledge regarding WEPs than general informants; m.a.s.l.: Meters above sea level; ETH: National Herbarium of Ethiopia; OAFD: Office of Agriculture and Forest Development; WEPs: Wild edible plants; WSWEPs: Wild and semi-wild edible plants.

Supplementary Information

The online version contains supplementary material available at https://doi.org/10.1186/s40066-021-00308-7.

Additional file 1: Appendix S1. Partial view of the study area. Source: own survey (March 2018).

Additional file 2: Appendix S2. Ethnobotanical data collection sheet.

Additional file 3: Appendix S3. Photographs showing the major edible plants found in the study area. Source: own survey (March 2018).

Additional file 4: Appendix S4. List of plants collected from the study area with average altitude, latitude and longitude.

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Authors' contributions

AK collected and analyzed the data and was the major contributor of the study; LK performed organization of the paper, analyzed some of the data, critically revised the paper and has done the write-up of the article. All authors read and approved the final manuscript.

Authors' information

Leul Kidane (PhD) Associate Professor and researcher in Plant Ecology and Biodiversity Conservation, currently works at the Department of Biology, Mekelle University, Mekelle, Ethiopia. Alemu Kejela, MSc graduate from the Department of Biology, College of Natural and Computational Sciences, Mekelle University, Mekelle, Ethiopia.

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Availability of data and materials

All data collected and analyzed in this paper are included within the article and attached in the form of "Appendices" as additional files. Voucher plant specimens are deposited in Mekelle University, Mekelle, Ethiopia. Besides, datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate

The ethical approvals were approved from Mekelle University; Berek District Administrative office; Berek District Agricultural and Rural Development offices, prior to the data collections. Written consent was obtained from participants by performing group discussions about the objectives of the study prior to the interviews, and all data were collected through their consents. Besides, participants were asked their view if their name is openly accessed and they have clearly agreed to have their names and personal data to be published. Finally, Mekelle University certified the research finding after it was presented for public defense. Accordingly, ethnobotanical data were collected based on a comprehensive participation, friendly interactions and the willingness of informants.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

Author details

[1]Department of Biology, College of Natural and Computational Sciences, Mekelle University, Mekelle, Ethiopia. [2]Present Address: Beke Secondary High School, Sendafa, Ethiopia.

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