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Uses of wild edible plants in Quara district, northwest Ethiopia: implication for forest management

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Abstract

Background: Wild edible plants are of crucial importance in all parts of the world in supporting global food basket (about one billion people) on a daily basis. They are means of survival for rural communities, especially during times of drought, famine, shocks and risks. This study assessed wild edible plants, uses, management practices and their threats in Quara district. It further investigates the implication of wild edible plants utilization for forest management.

Methods: Structured and semi-structured questionnaire interview, focus group discussion, rapid market survey and informants guided filed walks were used to collect data in three purposively selected administrative Kebeles. A total of ninety-four randomly selected sample households were interviewed for data collection. Both quantitative and qualitative data analyses were made. Descriptive and regression analysis were made to analyze the data using SPSS version 16.0.

Results: The area harbors a total of 36 wild edible plants. In addition to food values, these plants provide diverse benefits to the local community including income, fuel wood, fencing, construction, medicine and fodder. *Adansonia digitata* L., *Ziziphus spina-christi Willd, Ximenia Americana* L., *Tamarindus indica* L. and *Balanites aegyptiaca* L. were highly cited species by respondents. WEPs were threatened by anthropogenic factors including fire, agricultural expansion, deforestation, free grazing, fuel wood and construction.

Conclusions: Given the number of WEPs resource base, wise utilization and further commercialization of them could support local livelihoods while creating incentive for the management of forests. In addition, value addition could help to link the producers in and around the natural forests to the local, regional and international markets. Doing so will improve the incomes from the WEPs and creates further incentive for domestication. Controlling outsiders/nomads and designing participatory forest management will bring wise utilization of the resource.

Keywords: Consumption, Forest, Management, Wild edible plants

Background

Wild edible plants (WEPs) are all non-domesticated plants species used by people which are a continuum results from co-evolutionary relationships between humans and their environment [1–3]. WEPs are those plants with edible parts which are found growing naturally on forests, farms and fallow or on uncultivated land [3, 4]. Different food types (fresh or dishes, sauces, snacks and juices, carbohydrates and minerals) are obtained from the parts of these plants (leaves, seeds and nuts, fruits, roots, tubers and barks) [4, 5]. Broadly, Guinand and Lemessa [6] distinguished four types of WEPs categories based on the parts of the plants used, consumption circumstances (normal versus famine) and consumer groups (adults, children, women, men). The categories are (a) typical 'famine-food' plants (b) 'wild-food' plants with 'famine-food' components (c) 'wild-food' plants attracting additional consumer categories during food

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shortage periods and (d) on-farm food crops with 'famine-food' components.

Wild edible plants are of crucial importance in all parts of the world in supporting global food basket [7]. It is estimated that one billion people use wild foods (mostly from plants) in the world on a daily basis [8]. They are the means of survival and livelihood strategies for most of the rural people (pastoralists, shifting cultivators, continuous croppers or hunter-gatherers) [1, 9] because of freely and easily accessed [10, 11], their plant use knowledge [10, 11], lack of alternative to secure their food demand [12], and are affordable [13]. Marginalized and poor communities such as women, children are more vulnerable to drought and thus are significantly dependent on these plants [6, 9, 14]. WEPs can improve diets, tide people in times of famine, drought and shocks, supplement income and provide genetic material for experimentation, medicine, cultural and spiritual values of the rural community [1, 2, 9, 15]. Vegetables, fruits and seeds for instance provide vitamins and minerals [7, 9, 16].

Ethiopia is a global biodiversity hot-spot and center of origin for a significant number of food plants [1] and deep traditional knowledge concerning the use of WEPs [6]. Hence, the consumption of WEPs is an integral part of feeding habits of the community [3, 6, 12]. Lulekal et al. [12] noted about 413 WEPs consumed in Ethiopia. They can make supplemental, seasonal and emergency contributions to household food supplies. However, the consumption is more common in food-insecure areas [6, 17]. For example, in southern Ethiopia such as in Konso, Derashe and Burji special Woredas WEPs appears intensified due to the repeated climatic shocks hampering agricultural production and leading to food shortages [6]. Similarly, consumption of WEPs is common in Northern Ethiopia such as *Adansonia digitata, Balanites aegyptiaca, Carissa spinarum, Cordia africana, Tamarindus indica, Ximenia americana and Ziziphus spina-christi* [3]. WEPs are particularly consumed with children [6, 12]. To list a few, fruits from *Ficus* spp*, Carissa edulis and Rosa abyssinica* are plant species consumed by children [6]. However, the consumption of wild foods, their importance for rural community food diet, socioeconomic, cultural and traditional aspects in Ethiopia are under estimated and still lack adequate attention [1, 6].

Quara district, one of the lowland districts of northwestern Ethiopia, is rich in woodland forests and associated WEPs [18, 19]. These woodland forests, also known as the great green wall of the Sahara desert [16], play a crucial role in buffering and checking the expansion of Sahara and Sahel deserts and supply of WEPs products [5, 14]. However, the woodland forests are dwindling with anthropogenic factors such as free grazing, settlement, agricultural expansion and fire.

A few studies have been conducted on WEPs in Ethiopia, to cite a few: Demel and Abeje [3]; Guinand and Lemessa [6]; Fentahun and Hager [11]; Tebkew et al. [14]; Assefa and Abebe [15]; Teklehaymainot and Gidey [17]; Balemie and Kebebew [20]; Asfaw [21] document WEPs; Hunde et al. [22] studied on nutritional value. However, little has been done on the status of WEPs, indigenous knowledge for sustainable development, ecology/habitat/geographical distribution and impact of deforestation on the product [3]. Thus, studying WEPs, their state of use and factors threatening them help to design appropriate interventions for forest management and sustainable utilization. Therefore, this study is initiated with the objectives of (1) identifying WEPs species, (2) assessing their roles for rural community and implication for forest management and (3) identifying the management practices including major threats of WEPs in Quara district.

Methods

Site description

Location

The study was conducted in Quara district, North Gondar Province, northwestern Ethiopia (Fig. 1). Geographically, it is located in 35°18′12″E, and 12°56′18″N [23].

Vegetation cover

The vegetation of the district falls in ecosystem complexes of Combretum–Terminalia Woodland with various habitats such as intact scrublands ecosystem and escarpments. The dominant vegetation type is mixed woodland vegetation where Combretum and Terminalia species are abundant. There are also other vegetation types which include riverine vegetation, seasonal wetland vegetation, open wooded grass land vegetation types and hilly area woodland areas [18].

Population and sociocultural

The total population of the district is estimated at 102,777 [23] and is composed of different ethnic groups: Amhara, Agew, Gumuz, Tigirans and Qimant. The people in the area uses Amharic, Gumuz, Datsien, Agewigna, Arabic and Tigrigna and language, where almost 95% of the residents understand and use Amharic. The population is growing by approximately 2.63% a year naturally and 0.25% of migration rate and total growth rate of 2.92% [18]. People from highland areas (Chilga) descend to the district to graze animals during summer season.

Topography and land use

The general topography of the district is flat to undulating plain with general slope inclination from south to north interrupted by valleys, streams, scattered hills

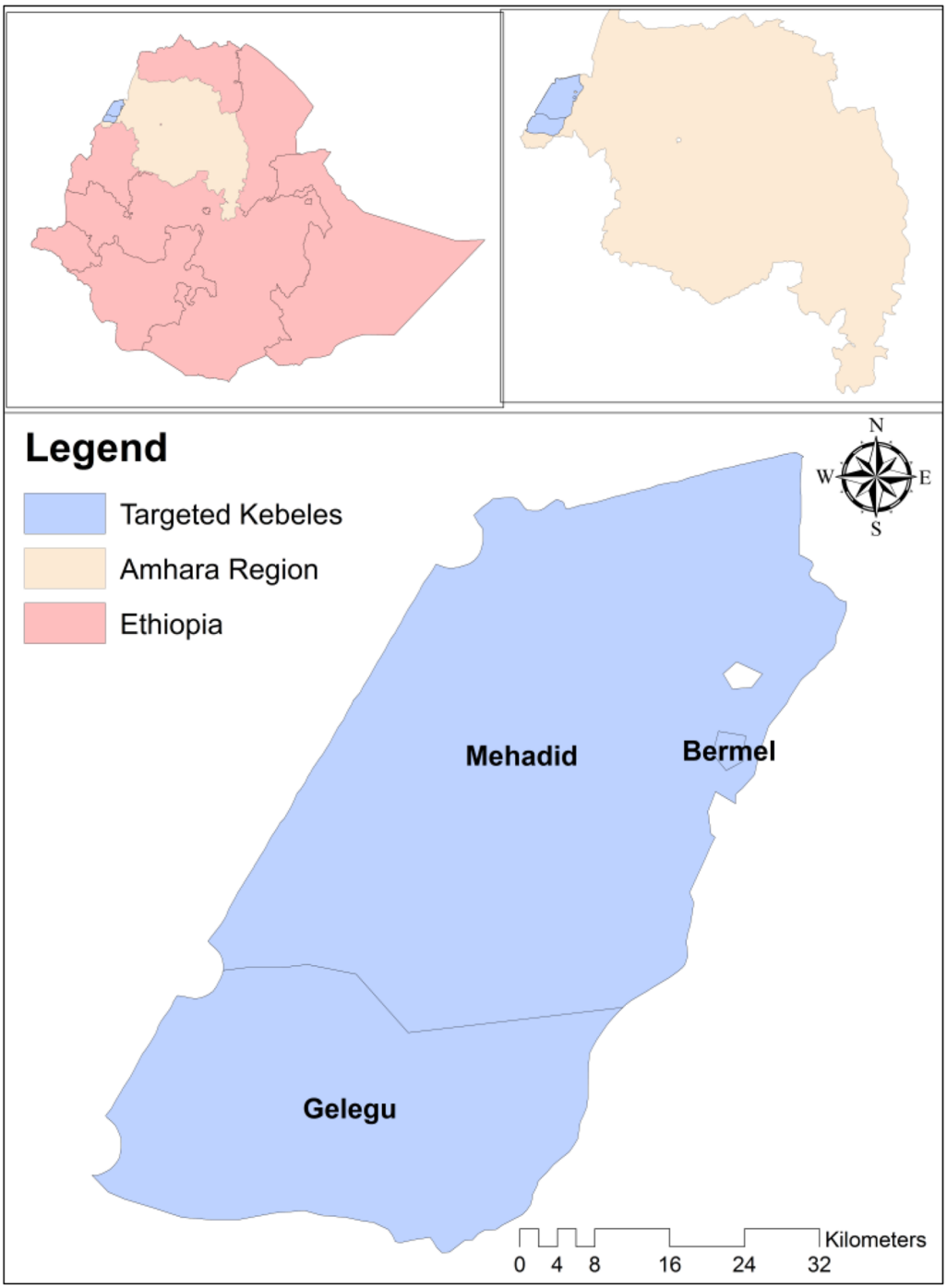

Fig. 1 Map of the study area

and seasonal wetland in the lowland and highly steeply, gorgeous and rugged in the midland agroecology. Agricultural production (sesame, sorghum and cotton) and livestock rearing (cattle, goat and equines) were the main source of income [23].

Climate

The mean annual temperature and rainfall of the area range from 25 to 35 °C and 600 to 1200 mm, respectively. It has midland and lowland agroecologies. The lowland

area of the district is one of the widely used investment corridors of Ethiopia [23].

Research design and sampling techniques

A multistage sampling procedure was followed to select the study areas. First, a discussion was conducted with Agriculture and Environmental Protection Departments of North Gondar Province regarding resource availability and research priority on WEPs. Quara district was recommended for research among the districts of North Gondar Province as: (1) it is rich in wild edible plants, (2) has large national park with high population pressure which need evidence for designing appropriate forest management system and (3) has given lower research attention because of distance and hot climatic condition, especially in lowlands. Then, environmental and Agricultural offices of Quara district, Alitash National Park experts and selected development agents who are working in ANP boundary Kebeles[1] were contacted to get information about wild edible plants and to select study Kebeles. In addition, review of archives was conducted to get additional information. Accordingly, Gelego, Mehadid and Bermile Kebeles that are at the boundary of Alitash national park and sharing similar agroecological condition, were selected based on availability of WEPs, their pressure on Alitash Natioanl Park and accessibility for data collection with the amount of resource available.

Nine key informants[2] (KIs) were selected using snowball survey method to collect preliminary data for questionnaire development following Bernand [24]. Three famers were randomly asked to list five knowledgeable persons in each Kebele. Then, the top three ranked KIs out of the 15 listed informants were selected in each Kebele. Then, structured and semi-structured interview questionnaires were prepared and pre-tested as described in Martin [25] and Cotton [26]. To select interview households, the list of households was collected from each Kebele agricultural office and sample households were estimated using the formula Cochran [27] with 5% sampling intensity. Then, households were selected randomly from the list in each Kebele. Hence, a total of ninety-four households (86 male and 8 female) were selected and interviewed.

Data collection

The data were collected in the selected administrative Kebeles of Quara district from October 2015 to August 2016. All interviewee were met on a one-to-one basis using the local languages (Amharic and Gumuz). Information on local names of WEPs, parts used, their uses, habits, major habitats, management practices and factors threatening them were recorded. In addition, repeated informants guided field observations were made to check species, growth habit, habitat characteristics and collect plant specimen. A focus group discussion composed of 8–10 members who are knowledgeable and familiar to WEPs and local conditions was also conducted at each study site to verify the data collected by household interview. All WEPs listed in the questionnaire survey were verified, and idiosyncratic ideas (data having single respondent and not supported by group discussion) were removed from the data. A repeated market survey (4 times/different season's, i.e., October, March, May and June) of WEPs products was also conducted in Gelego town (the nearest market place) to verify/check the price of marketable products recorded in questionnaire interview. All encountered plants were identified and recorded by their vernacular names and later converted to their botanical names by referring to flora of Ethiopia and Eritrea [28–35], own experience and National herbarium of Addis Ababa.

Data analysis

The data collected using different ethno-botanical methods were entered and analyzed using descriptive statistics (mean and percentage) and regression analysis loaded on Statistical Package for the Social Sciences (SPSS) software version 16.0. It was employed to estimate frequencies of WEPs use, percentage of growth forms, parts used and to see the relation WEPs citation with demographic characteristics. The qualitative data were summarized into groups and explained.

Results

WEPs species composition, growth forms and habitats

A total of 36 WEPs (24 woody and 12 herbaceous) were encountered in the study area composed of 22 families, excluding the three unidentified species (Table 1). The families Moraceae had four species, Fabaceae and Malvaceae three species each, Apocynaceae, Cucurbitaceae, Ebenaceae and Tiliaceae had two species each. The remaining 15 families (Arecaceae, Balanitaceae, Bolentaceae, Capparidaceae, Dioscoreaceae, Meliaceae, Myrtaceae, Ochnaceae, Olacaceae, Pittosporaceae, Plumbaginaceae, Portulacaceae, Rhamnaceae, Rubiaceae and Solanaceae) had 1 species each.

Growth forms of WEPs comprise trees, shrubs, herbs and climbers (Fig. 2). Most (about 44%) have tree growth forms, followed by herbs (about 31%).

WEPs in the study areas were recorded in different habitats (riverine areas, farm lands, natural forests, grazing lands) (Fig. 3). About 36% of WEPs were found in all

[1] Kebeles are the lowest administrative units next to district in Ethiopia.

[2] KIs in this study are knowledgeable persons about wild edible plants and local conditions.

Table 1 List of WEPs plants encountered in the study area in Quara district

Ro.	Scientific name	Vernacular name	Family	PU	HT	Habitat	HB	CT	Mode of use	Added value	FC (%)	VN
1.	*Abelmoschus esculemus* L.	Bamia (Amh)	Malvaccae	F	Jun–Sep	FL	H	DF	Cooked	Fd	10.64	MT-01
2.	*Adansonia digitata* L.	Diza (Amh)	Moraceae	F	Feb–Mar	NF, Riv	T	AI	Dried	M, Bf, HHT	63.83	MT-01
3.	*Balanites aegyptiaca* (L.)	Lalo (Amh)	Balanitaceae	F	Sep–Dec	Valley	T	AI	Dried	Fd, M, Fe, Co, Bf	48.94	MT-02
4.	*Boletus edulis Bull. Ex Fries*	Enguday (Amh)	Bolentaceae	F	Jun–Aug	NF, GL	H	AI	Cooked	–	15.96	MT-03
5.	*Capparis tomentosa Lam*	Gimero (Chiqua- GU)	Capparidaceae	F	Sep–Dec	All site	S	AI	Fresh	Fe, M	5.32	MT-04
6.	*Carissa edulis* L.	Agam (Amh)	Apocynaceae	F	Jun	NF	S	AI	Fresh	F, Fw, Fd	7.45	MT-05
7.	*Corchorus olitorius* L.	Kudera (Amh)	Tiliaceae	L	Jun–Aug	FL (Vertisol)	H	AI	Cooked	Fd	34.04	MT-06
8.	*Cucumis ficifolius A. Rich*	Yebed (gu)- Ye Gurna Matebiya (Amh)	Cucurbitaceae	L	Jun–Aug	All site	H	DFS	Fresh	W	4.26	MT-07
9.	*Dichrostachys cinerea Wight & Am*	Andera (Amh)	Fabaceae	F	Aug–Oct	FL (Vertisol)	T	AI	Fresh	M, T	7.45	MT-08
10.	*Dioscorea prahensilis Benth*	Amejko (GU) Sinsa (Amh)	Dioscoreaceae	R	Jan–Dec	All site	CL	AI	Cooked	–	25.53	MT-09
11.	*Diospyros abyssinica (Hiem) F. Wite*	Serkin (Amh)	Ebenaceae	F	Mar	Riv	T	AI	Fresh	M, Co, Fw	40.43	MT-10
12.	*Diospyros mespliformis (Hiem) F. Wite*	Gurmacha (Amh)	Ebenaceae	F	Nov–Dec	Riv	T	AI	Fresh	Co, Fe, Fw	15.96	MT-11
13.	*Discopodium penninervium Hochst*	Bamlat (gu)-Ameraro, Bolenta	Solanaceae	L	Jun–Aug	All site	H	DFS	Cooked	–	8.51	MT-12
14.	*Ekebergia capensis Sparrm*	Kudekuda (Amh)	Meliaceae	F	Dec–May	FL, Riv	T	AI	Fresh	M, Co, Fw	15.96	MT-13
15.	*Ficus sur Forssk*	Shola (Amh)	Moraceae	F	Feb–Mar	Riv	T	AI	Fresh	Co, HHT, Ft,	5.32	MT-14
16.	*Ficus sycomorus* L.	Bamba (Amh)	Moraceae	F	Nov–Jan	All site	T	AI	Fresh	M, Co, HHT, Bf, Fd	4.26	MT-15
17.	*Ficus thonningii Blume*	Chibeha (Amh)	Moraceae	F	Dec–May	FL, Riv	T	AI	Fresh	M, Fd, Bf	4.26	MT-16
18.	*Gardenia ternifolia Schumach Thonn*	Gambilo (Amh)	Rubiaceae	F	May–Jun	FL, NF, R	T	AI	Fresh	F, Co, Fd	4.26	MT-17
19.	*Grewia mollis Juss*	Betere Mussie (Amh)	Tiliacae	F	Jun–Aug	NF	S	AI	Fresh	Fd, Fe	5.32	MT-19
20.	*Hibiscus cannabinus* L.	Ye Yeberha Wayka (Amh)	Malvaceae	F	Jan–Dec	All site	H	AI	Cooked	Fd	37.23	MT-20
21.	*Hibiscus esculentus L*	Wayka (Amh)	Malvaceae	L	Jun–Aug	FL	H	AI	Cooked	Fd	37.23	MT-21
22.	*Momordica foetida Schum*	Yequra Mechate, Ye jib medihanit (Amh) Shetebigno	Cucurbitaceae	F	Aug–Sep	All site	CL	AI	Fresh	M	3.19	MT-22
23.	*Ochna leucophloeos Hochst. ex A. Rich*	Amedoli (Amh)	Ochnaceae	L	Jun–Aug	All site	H	DFS	Cooked	Fd	4.26	MT-23
24.	*Phoenix reclinata Jacq*	Senel (Amh)	Arecaceae	F	Feb–Mar	R	T	AI	Fresh	M, HHT	13.83	MT-24

Table 1 continued

Ro.	Scientific name	Vernacular name	Family	PU	HT	Habitat	HB	CT	Mode of use	Added value	FC (%)	VN
25.	*Piliostigma thonningii (Schumach.)*	Mijire (GU) Yekola Wanza (Amh)	Fabaceae	R	Jun –July	Riv	T	Al	Cooked	M, FT, HHT	3.19	MT-25
26.	*Pittosporum viridiflorum Sims*	Roha (GU)-Dengay seber, Galazabiya (Amh)	Pittosporaceae	F	Jun–Aug	R, iv	T	DF	Fresh	Fd, Co, M, Ft	6.38	MT-26
27.	*Plumbago zeylanicum* L.	Melekuya (GU), Amera (Amh)	Plumbaginaceae	L	Jun–Aug	All site	H	Al	Cooked	–	3.19	MT-27
28.	*Portulaca oleraceae* L.	Rejila (GU)-(Yenebosa sega-Amh)	Portulacaceae	L	Jun–Aug	Riv	H	Al	Cooked	Fd, M	11.70	MT-28
29.	*Saba comorensis (Bo). Pichon*	Ashama (Amh)	Apocynaceae	F	Jun–Jul	Riv	Cl	Al	Fresh	Fd, Co	44.68	MT-29
30.	*Syzygium guineense (Willd.) DC*	Dokima (Amh)	Myrtaceae	F	May–Jun	Riv	T	Al	Fresh	Fe, Fw	6.38	MT-30
31.	*Tamarindus indica* L. L.	Kumer (Amh)	Fabaceae	F	Dec–Mar	All site	T	Al	Dried	M, Bf, Co, Fe	53.19	MT-31
32.	*Ximenia americana* L.	Enkuay (Amh)	Olacaceae	F	Feb–Mar	All site	S	Al	Fresh	Medicine	59.57	MT-32
33.	*Ziziphus spina-christi Willd*	Serwie (Gu)-Arka	Rhamnaceae	F	Jan–May	FL	T	Al	Dried	M, Co, Fe, Fd	62.77	MT-33
34.	*Unidentified*	Sete (GU)-(Chabilie Amh)	–	R	Jun–Aug	NF, FL	Cl	Al	Cooked	–	15.96	MT-34
35.	*Unidentified*	Seleselo (Amh), (Yageta-Gu)	–	L	Jun–Aug	All site	H	DFS	Cooked	–	5.32	MT-35
36.	*Unidentified*	Yebere Kolet	–	R	Jun–Aug	NF	CL	Al	Fresh	–	5.32	MT-36

NB vernacular names, *GU* Gumuz, *Amh* Amharic, *PU* parts used, *F* fruit, *L* leaf, *R* root, *HT* harvesting time, *Jan* January, *Feb* February, *Mar* March, *Jun* June, *Jul* July, *Aug* August, *Sep* September, *Oct* October, *Nov* November, *Dec* December; Habitat: *Riv* riverine, *NF* natural forest, *FL* farm land, *GL* grazing land, *HB* Habitat, *H* herb, *Cl* climber, *T* tree, *CT* consumption time, *Al* always, *DF* during famine, *DFS* during food shortage; Added value: *M* medicine, *Co* construction, *Fd* fodder, *Fe* fencing, *Bf* bee forage, *Fw* fuel wood, *HHT* household tool, *W* washing, *T* tanning, *FT* farm tool, *FC* frequency of citation, *VN* voucher number

sites, while 28 and 14% in riverine areas and farm land environments, respectively.

WEPs harvesting, utilization and challenges

Fruits, leaves and roots were parts of the plants used for consumption (Fig. 4). Of all, fruits were the most commonly used parts (67%), while leaves were the second (about 22%).

WEPs in the study area were consumed for supplementing staple foods (about 70%) and filling food gaps (drought and famine, about 35%). WEPs were consumed in fresh, dried and cooked or prepared in different forms. Majority (23 plants) were consumed fresh, while nine of them were consumed after dried (Fig. 5).

The result showed that WEPs are harvested and consumed in different months of the year (Fig. 6). Relatively

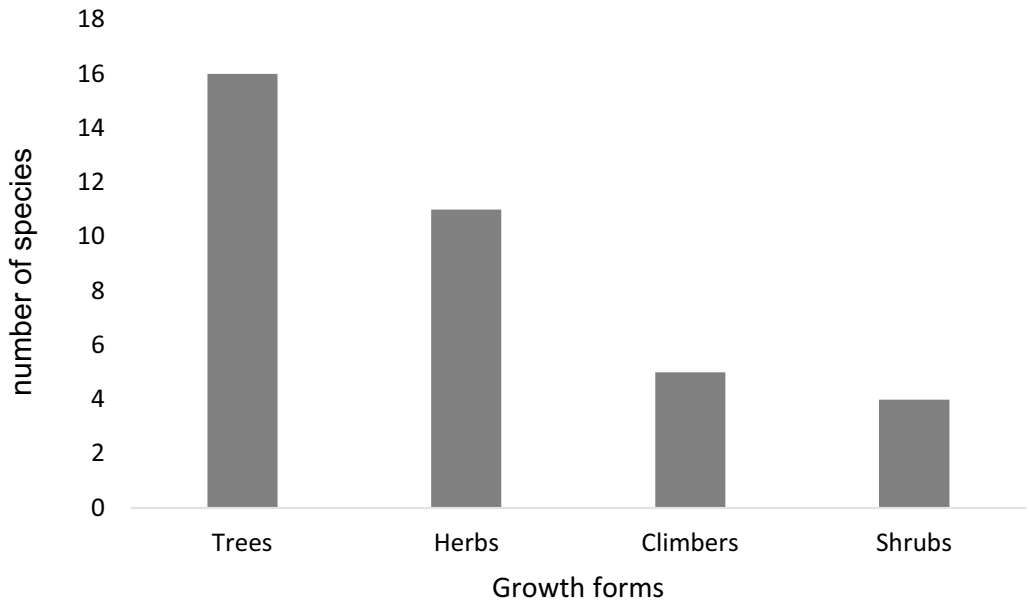

Fig. 2 Growth forms/habits of WEPs in the study areas, Quara district

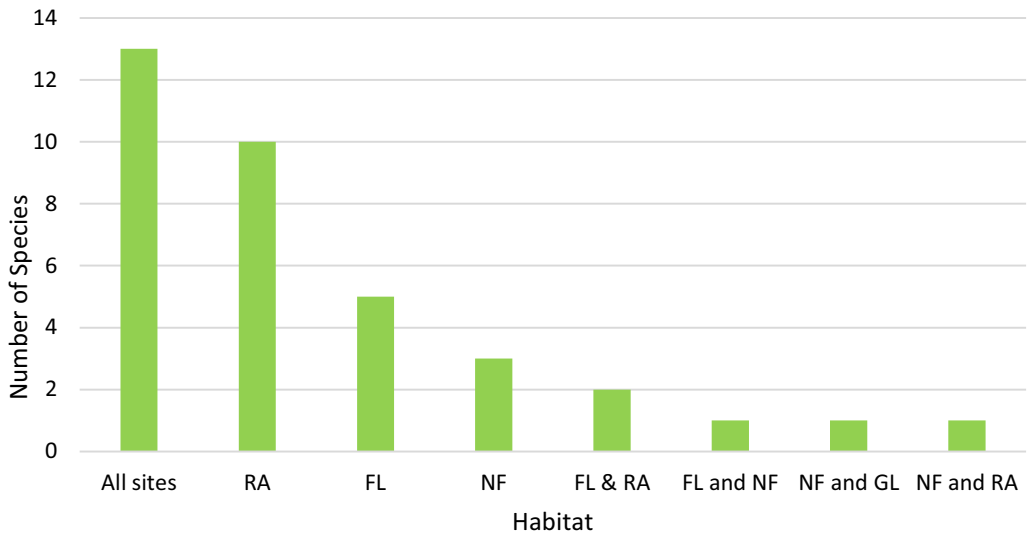

Fig. 3 Habitats of WEPs in the study areas, Quara district

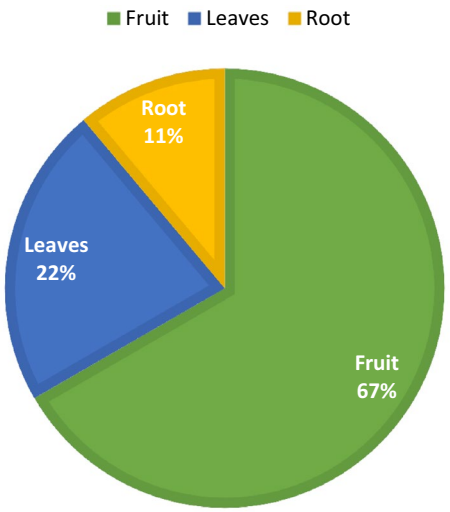

Fig. 4 Parts of WEPs consumed in the study area, Quara district

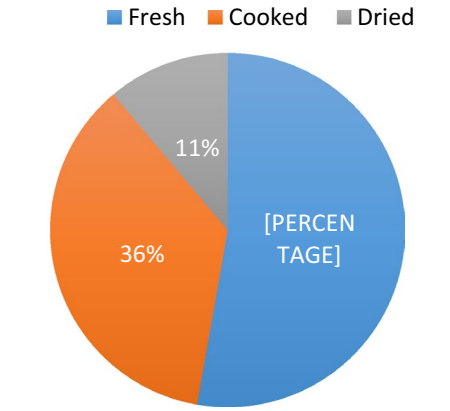

Fig. 5 Consumption mode of WEPs in the study area, Quara district. Legend *RA* riverine areas, *FL* farm lands, *NF* natural forests, *GL* grazing lands

higher numbers of plants were recorded in June, July and August with a frequency of 21, 18 and 18 species, respectively.

The major challenges for utilization of WEPs identified in the study area were difficulty for collection, fast deterioration of products, being choice/alternative food, cultural ignorance and lack of awareness about the nutritional value of the products (Table 2). Of the consumption challenges, using the products as alternative/choice food and ignorance by culture were main challenges about 53 and 44%, respectively.

Informant consensus and popularity

The frequently cited wild edible plants (≥ 24 citation) are presented in Table 3. *A. digitata, Z. spina-christi and X. Americana* were the top three commonly used plants in decreasing order (Table 3).

WEPs and their diversity of uses

Income generation

Households (HHs) generate income by selling products in domestic markets and exporting to neighboring countries, mainly the Sudan (Table 4). Seven WEPs were marketed in local and international market with a mean unit price ranging from 2.00 to 10.00 ETB (Ethiopian Birr). About 57% of them were marketed in domestic/local market.

Other utilities

WEPS are also the main sources of energy (fuel wood and charcoal), construction, fencing, fodder, medicine (Table 1). WEPs also serve as a shade for local community when they fetch water and conduct meeting (Fig. 7). In addition, they protect the soil from erosion through their roots and protection. The rural community in the study area do not have any plantation for use in construction, protection and implements making and other alternative source of energy. They collect from forests and remnant trees in the farms and farm boundaries including WEPs such as *Z. spina-christi, F. thonningi, F. sycomorus, A. digitata and T. indica.*

Traditional knowledge and management practices

The free plant list length of the study area indicated a positive correlation with age of respondents (Fig. 8). The Spearman correlation test has also shown a positive correlation between age and WEPs list ($r = 0.17$, $P < 0.05$). The free plant list length ranges from 1 to 16 WEPs.

Local people practice some traditional management, which includes planting around the home garden, pruning, pollarding, fencing and preventing cutting of some plants by local culture like *B. aegyptiaca* (Fig. 9).

Farmers allow some plants to regenerate and grow in their fields. *B. aegyptiaca* were grown in farmlands because of its role for food (fruit) and shade (both human and livestock) during dry season (Fig. 10).

Threats to WEPs

Fire, agricultural expansion, deforestation, free grazing, cutting for fuel wood, herbicide application (for herbs), cutting for construction and settlement were found to be the major threats for WEPs (Table 5). About 62% of the respondents reported that burning the forests and habitats of WEPs is the major threat followed by agricultural expansion (about 36%). Reportedly local residents, migrants and Felata nomads coming from Sudan and Nigeria set fire to the forest to assist the regeneration of grasses for their livestock. This happens every

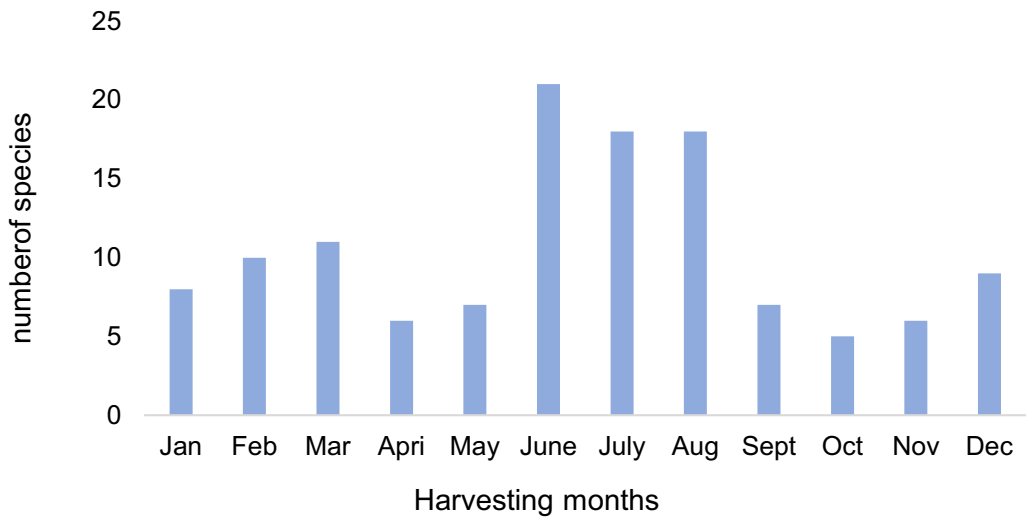

Fig. 6 Harvesting months of WEPs in the study areas, Quara district. Legend: *Jan* January, *Feb* February, *Mar* March, *Jun* June, *Jul* July, *Aug* August, *Sep* September, *Oct* October, *Nov* November, *Dec* December

Table 2 Major consumption challenges of Wild edible plants in the study area, Quara district

Consumption problem ($N = 85$)	Number of respondents
Difficult to collect	10
Fast deterioration	12
Choice food	41
Cultural ignorance	50
lack of knowledge	10

year, especially during the mid-dry season. Freely grazing stray animals do highly affect the growth and regeneration of new WEPs. Besides, farmers peel the barks and part of the stems of standing trees and set beneath the root to get the standing tree dry that affects coppice. For instance, although there exist a high population of lowland bamboo in the study area especially in Alitash National Park, it highly devastated by human induced fire. Some respondents (about 21%) also confirmed the lack of knowledge for management of forests and conflict between locals and migrants.

Discussion

WEPs species diversity, composition and habitat distribution

Fairly high number of WEP species were recorded in the study area which is better than [22, 36] and comparable with [14, 37]. But Balemie and Kebebew [20] in Ethiopia and Kakudidi [38] in Uganda were reported higher WEPs than the current study. Hence, it indicated that the area is rich in plant diversity and indigenous knowledge. Some

Table 3 List of frequently cited edible plants (≥ 24 citation) in the study sites, Quara district

Scientific name	Vernacular name	Family	Habit	Frequency
Adansonia digitata L.	Diza (Amh)	Moraceae	T	60
Ziziphus spina-christi Willd	Serwie (Gu)-Arka	Rhamnaceae	T	59
Ximenia americana L.	Enkuay (Amh)	Olacaceae	S	56
Tamarindus indica L.	Kumer (Amh)	Fabaceae	T	50
Balanites aegyptiaca L.	Lalo (Amh)	Balanitaceae	T	46
Saba comorensis (Bo). Pichon	Ashama (Amh)	Apocynaceae	Cl	42
Diospyros abyssinica (Hiem) F. Wite	Serkin (Amh)	Ebenaceae	T	38
Hibiscus cannabinus L.	Ye Yeberha Wayka (Amh)	Malvaceae	H	35
Hibiscus esculentus L.	Wayka (Amh)	Malvaceae	H	35
Corchorus olitorius L.	Kudera (Amh)	Tiliaceae	H	32
Dioscorea prahensilis Benth	Amejko (GU) Sinsa (Amh)	Dioscoreaceae	CL	24

Table 4 List of marketable wild edible plants in Quara district

Scientific name	Vernacular name	Family	Parts used	Unit	Mean unit price ($US)
Adansonia digitata L.	Diza	Moraceae	Fruit	Kg	0.33
Balanites aegyptiaca L.	Lalo	Meliaceae	Fruit	Kg	0.48
Diospyros abyssinica (Hiem) F. Wite	Serkin	Ebenaceae	Fruit	Kg	0.22
Grewia mollis Juss	Betere Mussie	Tiliacae	Fruit	Kg	0.14
Saba comorensis (Bo). Pichon	Ashama	Apocynaceae	Fruit	Number	0.24
Tamarindus indica L.	Kumer (Degu)	Fabaceae	Fruit	Kg	0.31
Ximenia americana L.	Enkuay	Olacaceae	Fruit	Kg	0.10

Fig. 7 Uses of wild edible plants in the study area, Quara district. Legend: **a** *B. aegyptiaca* braches cut and given for animal to fed; **b** *B. aegyptiaca* serving as shade for local community fetching water; and **c** *T. indica* protecting the soil from erosion

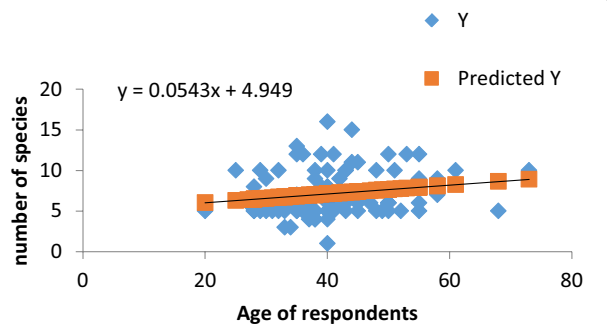

Fig. 8 WEPs free-list exercise of respondents in the study area, Quara district

of the plants recorded in this area were also recorded elsewhere in Ethiopia, to cite a few: 8 species in Derashe and Kucha Districts, southern Ethiopia [20], 16 species in three Districts of Amhara Region (Adiarkay, Debark and Dejen), Northwestern Ethiopia [11]; 9 species in Benna Tsemay District, southern Ethiopia [15]; 11 species in Fantalle and Boosat Districts, East Shewa, semiarid Ethiopia [22]; 9 species in Chelia District, West Central Ethiopia [39]. Hence, recording of plants encountered in our study elsewhere in Ethiopia could be implied by their wider distribution, abundance and popularity [14]. The existence of WEPs in different habitats (natural forests, riverine environments and in farm lands) in the study area indicates the wide-range habitat requirement of the species which is also in agreement with other studies [3, 11, 14, 20]. In addition, the integration of some plants in farmlands shows the promising move of communities toward WEPs conservation. In other words, it indicates their environmental integrity and potential for different land use systems as agroforestry.

WEPs utilization, consumption challenges and knowledge distribution

Trees were the most commonly used growth forms in the study area which is in agreement with Fentahun and Hager [11] and Teklehaymanot and Giday [17]. In contrast, Lulekal et al. [12] in southern Ethiopia and Godfrey et al. [40] in Bunyoro Kitara kingdom of Uganda reported that shrubs and herbs were the dominant growths forms of WEPS consumed, respectively. WEPs products are found to be extracted from the different parts which is in agreement with [11, 12, 17]. Preparation and consumption of WEPs food from different parts showed the diversity of food types. Regarding the proportion of plant parts consumed, fruits were the major parts used in the study. Similarly fruits were reported elsewhere in Ethiopia [14, 20, 39, 41]. On the contrary, leaves and stems are the most widely used parts of WEPs in the West Bank of Palestine [42]. The parts where the WEPs are extracted

Fig. 9 Scattered edible plants in farms (*B. aegyptiaca*) (left) and around the homestead (right) in Mehadid Kebele, Quara district

Fig. 10 Regeneration of scattered edible plants (*B. aegyptiaca*) in Mehadid Kebele, Quara district

Table 5 Major threats of wild edible plants in Quara district

WEPS threats	Percentage of respondents (*N* = 76)
Fire	61.8
Agricultural expansion	35.5
Deforestation	21
Free grazing	18.4
Fuel wood	18.4
Herbicides	7.9
Construction	6.6
Settlement	5.2
Other (farm and household tool)	2.6

are crucial as it determines the possible impacts of the harvesting practice on the wild population. Hence, harvesting mainly fruits in the study area indicates relatively a lower harvesting impact on bearing species and sustainability. Most of the WEPs were consumed fresh without cooking. This indicated that edible plants are not poisonous if consumed raw where comminutes go to forests and distant from houses.

WEPs in the study area were utilized for supplementing staple foods and filling food gaps (drought and famine). In agreement with the present study, other findings elsewhere indicate supplemental role of WEPs [7, 15, 22] and filling food need during food gap and famine [6, 11, 15]. Some species such as *A. digitata, Z. spina-christi, X. americana, T. indica and B. aegyptiaca* were highly cited by respondents which indicate their popularity and relative importance to the local community. Higher frequency of informants was reported for *Z. spina-christi, X. americana* and *T. indica* in other areas of Ethiopia, while it was lower for *B. aegyptiaca* and *A. digitata,* [11]. Other species which had lower informant citation in the current study on the other hand recorded with higher frequency of informant citation in other areas such *F. sycomorus* [11, 43]; *S. guineense* [14, 40], *C. Africana* [11]. The variation in frequency of species citation could be due to cultural and knowledge differences among communities. However, most of the WEPs with high informant citation in the current study are local (*X. americana, A. digitata, B.*

aegyptiaca), national (*Z. spina-christi*) and international (*B. aegyptiaca and T. indica*) priority of Ethiopia for food/nutrition, current socioeconomic importance, market and development of agroindustry [3]. These WEPs are also the priority species of Kenya [44], Sudan [45] and Tanzania [46].

The consumption of WEPs is complained by different problems. The growth of WEPs in natural environment makes them very difficult for collection in the study areas. In agreement with the present study, Fentahun and Hager [11] reported the trouble of WEPs collection natural environment. Deterioration within a short period reduces the quality and value of WEPs which might cause ignoring and shifting to other staple foods. Although not a first problem in this study area, with social problems and lack of knowledge, consumption of WEPs is often considered to be a low-status food and insults [6, 11]. In Jana Mora Woreda, North Gonder, for instance, WEPs called 'wozber,' 'nechelo' and '*Urtica simensis Steudel*' are insults when people quarrel. Similarly in Kayissa Kebele, South Omo Zone, 10 WEPs are not consumed by the majority of the population except when there is a serious shortage of food affecting all strata of the population from the poorest to the richest [6]. In addition, consumption of WEPs is also constrained by deterioration in short period owing to lack of proper harvesting and post-harvest handling [11].

Wild edible plants in the study area also provide other livelihood options in addition to food value. They provide livelihood options in the form of both income generation and subsistence use from different products such as energy construction, shelter/protection and fodder. Different researchers elsewhere in Ethiopia have also noted multiple uses of WEPs such as, fuel wood, fencing, construction and preparation of remedies [6, 17, 20]. WEPs such as *A. digitata, S. comorensis, B. aegyptiaca, T. indica, X. americana and Z. spina-christi* generate income to the community in the study. However, due to illegal/local selling of products and lack of comprehensive global estimation methodology, valuation of economic value of WEPs faces difficulty [47]. Thus, the value of WEPs is underreported. This was observed in the current study area where various WEPs sold at local market and even exported to Sudan but were very difficult to value correctly.

The different products were harvested in different months, especially during the periods of food gap encapsulating the monthly/daily use which is also confirmed by other scholars in Ethiopia [6, 15, 17, 20, 22] and other countries [16, 44]. The year round availability of the WEP products safeguards farmers from any unexpected food shortage which is in line with the finding of Hunde et al. [22]. WEPs such *X. americana, A. digitata and T. indica* are rich in vitamins, carotenoids, iron and other minerals [12, 23, 48]. Hence, the use of WEPs is useful for fighting poor micronutrient intake. Selling WEPs also helps the community to get extra income for saving, exchanging other staple food from the market and acquisition of productive assets.

Knowledge and practice on WEPs varies with demographic and cultural attributes. In a free-list exercise, adults cited a higher number of WEPs than youngster in the study area. Differences in list length and content are measures of intraspecific cultural variation [49]. In the study area, different ethnic groups such as Gaumuz and Agew who are known in consuming WEPs are living for long period. Hence, their interaction with plants in their daily life helps them acquire experience. However, Fentahun and Hager [11] and Tebkew et al. [14] pointed out youngster cited more than adults. Adults avoid eating WEPs because of consumption wild-food plants is seen as a sign of poverty.

Implication of WEPs utilization for forest management

The use of WEPs for supplementing staple food, filling seasonal food shortages/gaps, generating income, securing energy demand, construction, fodder and medicine diversify livelihood outcomes of the community. The increase and diversification of livelihood outcomes contribute a great role in maintaining food security. When communities maintain livelihood outcomes, they create a sense of ownership for the forest and continue strengthening their attachment with the forest. Hence, it can create options for designing forest-based developments and community-based forest management plan, which will bring sustainable forest management. However, care has to be taken during such initiatives for the promotion of WEPs. Because, if the parts where the WEPs collected are roots, and the intensity of utilization is high, it might lead to degradation and extinction of plants.

Management practices and threats

The farmers practice some management activities (growing in farms and homesteads, protecting from livestock) for some WEPs such as *B. aegyptiaca* which is an indication of the community moving toward domesticating WEPs. However, the management practices are limited compared to other staple food plants. The threats of WEPs recorded in the current study (fire, agricultural expansion, deforestation, free grazing, fuel wood, herbicides (for herbs), construction and settlement) are also common problems of non-WEPs that are related to land use change and poor resource utilization systems which are in line with the reports elsewhere in Ethiopia [12, 14, 15, 17, 20]. High population growth, agricultural land demand, lack of alternative energies and plantations,

resource use interest conflict between local community and migrants/nomads are the major root causes for these threats. The nomads and migrants do not worry about resource future fate [18, 19]. So, the entrance and destruction of the forest and surrounding resource with fire by Migrants and Felata nomads push the local community to shift from forest and WEPs land to other economic activity such as agriculture. It was reported that about 300,000 livestock are living in ALNP seasonally specially from October to May [18]. Furthermore, WEPs also gathered in natural environments, which are subjected to less management and exposed to anthropogenic threats [11]. Fast deterioration of products, being choice/alternative food, cultural ignorance and lack of awareness about the nutritional value of the products could make them being ignored for management. In line with this, Fentahun and Hager [11, 14] in semiarid areas of the Amhara region reported a lower level of management.

Conclusion

The study revealed that the Quara district supports a fair number of WEPs and associated use knowledge. The local community support their basic needs by consuming and selling WEPs. The consumption of these plant resources is associated with easy access, economic affordability and their associated use knowledge. WEPs are highly threatened for anthropogenic factors (fire, agricultural expansion, deforestation, free grazing and fuel wood). Therefore, community-based forest management system should be designed. In addition, migrants/nomads, especially who come from other countries, should be controlled. Given the available WEPs resource base, wise utilization and commercialization could support local livelihoods while creating incentive for the conservation and management of the natural forests. Value chain development for the WEPs, especially for species which have high market potential, could help to link the producers in and around the natural forests to the local, regional and international markets and improve their incomes. Growing of some WEPs in farms and homesteads and protecting them from livestock, though challenging, is a great movement toward domestication. Therefore, building on farmers existing practices, measures such as encouraging domestication and in situ conservation through awareness creation, value addition and commercialization of WEPs would help to maximize income and improve the livelihoods of local people while contributing to sustainable forest management. Besides, designing appropriate community-based forest management system would reduce resource conflict and destruction between residents and outsiders.

Authors' contributions

MT was involved in conception and design, data collection and entry and analysis and manuscript writing. YG contributed to design, data collection, data entry and manuscript write-up. TM was involved in design. AA was involved in critical revision. AA contributed to design and data collection. DF was involved in critical revision. All authors read and approved the final manuscript.

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Competing interests

The authors declare that they have no competing interests.

Availability of data and materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

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Not applicable this section.

Ethics approval and consent to participate

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