



Ethnobotanical Study of Medicinal Plants Traditionally Used by Local People of Amaya District in Oromia Region, Central Ethiopia

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Abstract

*The purpose of the study was to identify and document medicinal plants and associated indigenous knowledge of the Amaya District's people mainly focusing on the parts of medicinal plants, their modes of preparation and administration; and rating and evaluating the efficiency and preference of medicinal plants (MPs) by locals to treat human and livestock diseases in South West Ethiopia. A total of 112 medicinal plant species belonging to 96 genera and 56 families were identified and documented. Most of the medicinal plants were herbs, followed by trees. Leaves were the most frequently used medicinal plant part, followed by seeds and roots to prepare traditional remedies. Pounding was the most widely used mode of preparation in the study area. The most commonly used route of administration during the treatment of patients was oral. Many medicinal plants were used in fresh conditions while treating diseases. The species *Ocimum lamiifolium* was cited by the highest proportion of informants and ranked first in treating febrile illness of human disease in Amaya District. Malaria disease category scored the highest number of informant consensus factor values. *Acmella caulirhiaz* ranked the first to treat tonsillitis infection. The first ranked medicinal plant used as a multipurpose tree was *Cordia africana*. Hence, the identification and documentation of MPs and the knowledge of the local people on how to prepare and use them are so vital for conserving them. Human induced factors are, however, the main threats to medicinal plants. Community based cultivation in home gardens and farmlands as well as conservation of them in the wild (by using a closure areas and establishing wild nurseries) were common conservation practices made by local communities to minimize the loss of those medicinal plants.*

Keywords: Aliments, Ethiopia, Ethnobotany, Indigenous knowledge, Medicinal plants

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1. Introduction

From ancient times, plants have been rich sources of effective and safe medicines for treating, humans and other animals. Hence, the world's primary means of treating diseases and fighting infections have been based on the use of medicinal plant species (MPs). The local people of different localities have also advanced their own specific knowledge on plant resource use, management, and conservation [1]. Such indigenous knowledge (IK) of MPs and their use by indigenous cultures are beneficial for the conservation of cultural traditions and biodiversity, besides healthcare and drug development in the present and upcoming days [2]. Accordingly, globally, about 64% of the total world population is reliant on traditional medicine (TM) for their healthcare needs [3]. Nearly 3.5 billion people in developing countries believe in the efficiency of plant remedies and use them regularly [4]. In Ethiopia, over 80% of the population has been relying on TM [5, 6] for the past several years. The major reasons why MPs are demanded in Ethiopia are due to culturally associated traditions, the trust of communities in the medicinal values of TM, and the relatively low cost of using them [5, 7]. However, in the country, TM

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has faced the problem of sustainability and continuity mainly due to the loss of taxa of MPs [8, 9] which is, in turn, caused by natural and anthropogenic factors [10]. Hence, there exists an accelerated destruction of plant resources with loss of indigenous (IK). Besides, among 85 diverse ethnolinguistic Ethiopian communities, most of them are uninvestigated [11]. Hence, documentation of the traditional uses of MPs is critical to preserve the knowledge [12]. Overutilization of wild plants in the District, particularly from Tulu Roge and Gefersa forests, and the lack of knowledge about proper conservation practices also lead to the loss of biodiversity. As a result, there is a greater danger for the loss of MPs together with IK. Despite the problems that are urgent and critical, there is not any ethnobotanical study conducted to document the MPs and associated IK of the people in the District. Lack of integration of IK with modern science for continuity and the transfer of IK from elder to young generation also needs due attention. The researchers were, thus, motivated to conduct this study in the District to: (1) identify and document medicinal plants and their parts used for medicinal purposes to treat human and livestock ailments, (2) examine the

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modes of preparation, and routes of administration of the remedies being prepared by the local healers for treating the local people in the study area, and (3) rank and evaluate the MPs for their degree of effectiveness and being preferred in curing diseases based on the respondents' experiences, and (4) assess the threats to MPs and indigenous knowledge of the local community and practices for conserving MPs.

2. Materials and Methods

2.1. Description of the Study Area

2.1.1. Geographical location

The study was conducted in the Amaya District, which is one of the 12 districts of South West Shewa Zone of Oromia Regional State, Ethiopia (Figure 1). The capital of the district is Gindo, which is 30 km away from the Zonal Capital, Waliso, and 144 km South West of Addis Ababa, the capital of the country. The District is divided into 40 kebeles (where “kebele” is the proportionate of a county in Amharic, the national language of the country, or the smallest administrative unit of the country), where 36 of them are rural and four of them are urban kebeles. Based on the Amaya District Agricultural Office report of 2017

(unpublished document), the total land area size of the district is about 93,279 ha. The district is located between 8° 29'59, 99” northing and 37° 44'59, 99” easting latitude and longitude, respectively. The altitude of the study area ranges between 1500-3240 m above sea level.

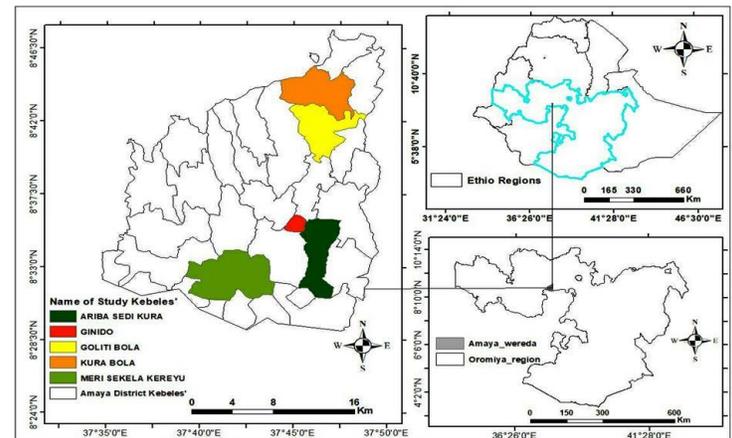


Figure 1: A map illustrating the study District in Oromia Regional State, Southwest Ethiopia

2.1.2. Agro-ecological zones and climate of the District

The District is classified into three agro-climatic zones: 1) highlands, ranging from 2,700m to 3,240m; 2) midlands, ranging from 1,500m to 2,600m, and 3) lowlands, below 1,500m above sea level (the Amaya District Agricultural Office report of 2017). The climate data were obtained from the Metrological Station of the study District

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(Figure 2). Accordingly, the rainfall pattern of the study area is unimodal, where the heavy rainy season ranges from April to September, whereas the dry season extends from October 15 to March 15, but still there is intermittent rainfall in October, March and April. The maximum and minimum mean annual rainfalls of the area were 1127 mm and 8.38 mm, respectively. The highest and lowest mean temperatures were also 28.4°C and 12.3°C, recorded in February and December, respectively. The mean annual temperature and rainfall of the study area is 19.6°C and 1127mm, respectively

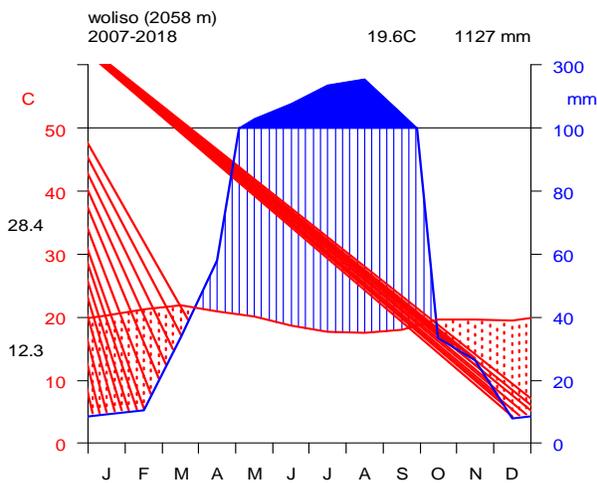


Figure 2: A climate diagram developed from 2007-2018 climate data of Woliso Station (Source: National Meteorological Service Agency, 2019)

2.1.3. Population and health services provided in Amaya District

Regarding the populations and health services of human and livestock in the study area is also described briefly here below. Accordingly, based on the projection report of Central Statistics Agency (CSA) of Ethiopia, the total population of the Amaya District in 2018 was 122,056 (61,578 males and 60,478 females; out of the total population, 5.13% is urban dwellers [13]. In this district, there was one hospital, eight clinics and 34 health posts under governmental ownership (personal communication with the expert of Amaya District Health Office). Based on the Amaya Agricultural and Natural Resources Office report of 2017, the District had also a livestock population of 345,600; out of this, 160,600 were cattle, 35,400 were goats, 32,600 were sheep, 15,200 were donkeys, 3,300 were mules, 8,500 were horse and 99,000 were poultry. The major livestock feeds on natural grazing, hay, crop residues and local beverage by-products. Concerning to the availability of veterinary services, there were eight clinic and 15 health posts in the district. There were various diseases, such as fever, malaria, tonsil, cancer,

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anthrax, and skin related diseases affecting the health of both humans and/or livestock in the District.

2.2. Study Design

Descriptive survey methods were employed to collect data from the respondents and field visits, and to analyze them. Hence, both qualitative and quantitative data were collected and analyzed for this study. As the data were collected more than once using household and plant surveys to assure the accuracy of the data collected from the respondents, a longitudinal survey design was, therefore, applied.

2.3. Study site selection and sampling techniques

Before starting the actual field study, a one-week reconnaissance survey was conducted to select sample kebeles, and obtain preliminary information about agro-climatic zones, availability of both medicinal plants and local traditional healers in these selected kebeles of the district. Thus, the whole kebeles (40) of Amaya District were already stratified into three agro-climatic zones (highland, midland, and lowland); of which, five kebeles, representing the three agro-climatic zones, were selected

purposively depending upon their proximity to forest areas, having different altitudinal ranges, and availability of both MPs and traditional healers. Therefore, one Kebele named by Marii Saqalaa Karrayyuu, from lowland; two Kebeles named by Arba Sadden Kuraa and Gindoo town from midland, and two Kebele named by Guultii Bolaa and Kuraa Bolaa from highland agroclimatic zones were selected using both stratified and purposive sampling techniques.

2.4. Informant Selection and their sampling techniques

For ethnobotanical data collection, due to the budget and time constraints the researchers had, in total only 70 participants were selected from the representative sample Kebeles. Out of the total, 60 informants (12 per Kebele) were household respondents, who were ordinary residents, and selected randomly. Based on the Kebele administrative bodies, development agents, local authorities, and religious leaders' recommendations [14] of the study area, the remaining 10 key informants (two persons per Kebele), who were knowledgeable elders and traditional healers, were selected purposively for the interview.

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2.5. Data collection methods

2.5.1. Structured and semi structured interviews and focus group discussion

Ethnobotanical data were collected from February 15, 2019 to March 30, 2019 during two field trips to the study area. The first field trip was conducted to collect primary data from respondents regarding ethnobotanical data. The second field trip was conducted to confirm ethnobotanical information and to request people participate in this study to show us the wild medicinal plants they used to treat human and livestock ailments [1, 14]. However, in the first and second round data collection periods, the respondents' consents were asked and even informed as they could cut off the interview meanwhile if they did not feel comfort. Then after, structured and semistructured interviews, focus group discussions, and guided field walks with informants were employed to obtain IK of the local people on health, plant parts, modes of preparation and administration.

Structured and semi-structured interviews were conducted with both household respondents and key informants, respectively, based on the items prepared

beforehand in English, and translated into the local language, 'Afaan Oromoo', later on. Then, the interviews were held in 'Afaan Oromoo' directly. Information regarding the local names of MPs, plant parts used, methods and condition of preparation, disease treated, routes of administration, and uses other than medicinal values, threats, and conservation practices of MPs was recorded. Field observation was also made on the morphological features and habitats of MPs in the guided field walk.

2.5.2. Market survey

Market survey was also made to record the name and availability of MPs and mixture used in the preparation of drugs sold in the local markets of the study area. The market survey was conducted two times for each open market found in Gindoo and Qotaa towns via observation and using semi-structured questionnaire interviews with drug producers and sellers.

2.5. 3. Field survey for plant specimens' collection and identification

At the end of the interviews, the reported MPs were collected from the natural vegetation in the wild and home garden.

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Plant identification was performed both in the field and in Debre Berhan University. The specimens collected were numbered, pressed, and dried for further identification. Further identification of all specimens was done by comparison with authentic specimens, illustration and taxonomic keys from the flora books of Ethiopia and Eritrea (Volumes 1-8). Finally, the identified specimens were deposited in the Botanical Herbarium Room of Debre Berhan University.

2.6. Data Analysis

2.6.1. Descriptive statistics

Descriptive statistics, such as percentage and frequency were employed to summarize the data on the MPs use. The information gathered from local people, such as medicinal values, application, methods of preparation, routes of administration, disease treated, parts used, and growth form of MPs and other associated IK were summarized using descriptive statistics. To make summary calculations, to draw bar graphs, scatter graph, and pie-charts, MS Excel spreadsheet 2010 was used.

2.6.2. Informant consensus factor

Informant consensus factor (ICF) was calculated for each category to identify the agreement of the informants on the reported cures for the group of ailments. The ICF was calculated as follows: number of use citation in each category (nur) minus the total number of species used (ns), divided by the number of use citation in each category minus one [15].

$$ICF = \frac{Nur - Ns}{Nur - 1}, \text{ where,}$$

IFC = Informant consensus, Nur = number of use citation and Ns = number of species used. The ICF values range from 0.00 to 1.00. High ICF values are obtained when only one or a few plant species are reported to be used by a high proportion of informant to treat a particular ailment. The low ICF values indicate that informants disagree with the plant species to be used to treat a category of ailments.

2.6.3. Preference Ranking

Preference ranking was conducted to rank some selected MPs based on the degree of their effectiveness in treating a particular disease. Following the methods of Martin [14], key informants were asked to think, order, and rank the MPs based on their personal preference, community importance,

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or any other criteria set by him /her, and this may help to indicate the most effective MPs used by the community to treat a disease.

2.3.4. Direct matrix ranking

Direct matrix ranking was conducted to compare multipurpose MPs commonly reported by informants following Cotton [1]. Based on the relative benefits obtained from each MPs, multipurpose MPs species were selected out of the total MPs, and the use diversities of these plants were also listed. Key informants were chosen to assign the use values to each attribute (5=best, 4=very good, 3=good, 2=less used, 1=least used and 0=not used). Based on the information gathered from key informants, the average value of each use-diversity for a species was taken and the value of each species was summed up and ranked.

3. Results and Discussion

3.1. Sample respondents' characteristics

To represent the whole agro-climatic zones of the Amaya District, 70 sample respondents were selected from five sample Kebeles (14 respondents from each), which were distributed in three agro-climatic zones: highland, midland, and lowland of the district. Regarding the ages of the respondents, most of them were above 40

years old (~63%). This shows as the ages of the respondents' increases, they become more knowledgeable due to the experience they gain in their life. This was also reported by other authors [10, 11].

3.2. Composition and growth form of MPs in Amaya District

A total of 112 MP species belonging to 96 genera and 54 families were identified to this study area (Supplementary files 1 and 2). Regarding plant families, Fabaceae and Asteraceae were the most popular plants to the area and both were represented by nine species (8.03%), followed by Solanaceae with eight species (7.145%); Lamiaceae, seven species (6.25%), and Euphorbiaceae, six species (5.35%) (Supplementary file 1). This result indicated that the two dominant families were frequently used for medicinal purposes since they are largely available, which might be due to the good agroclimatic (Figure 2) and soil conditions. This finding agrees with other studies in Ethiopia and other countries [10, 15, 16].

Regarding their growth forms, among the 112 MPs recorded from the study area, the highest representation was for herbs (51 species, 45.5%), followed by trees (25,

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28.57%), and shrubs (5, 22%). The least was liana (4 species, 3.57%) (Figure 3). This could be related to the fact that these species exhibit a high level of richness and easy to obtain them because the herbs were easily available in home gardens and forest patches. This finding agrees with previous studies conducted by some researchers [11, 17, 18, 20, 21].

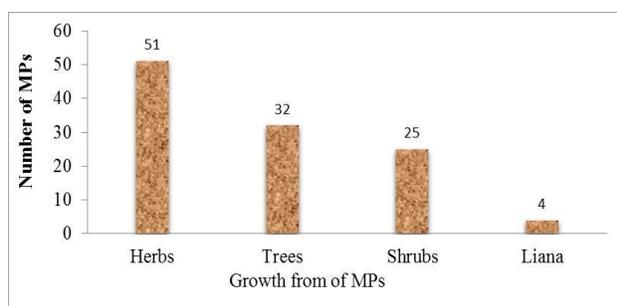


Figure 3: Growth form of MPs in the study area

Out of the total identified MPs, 72 species (64.28%) were reported to be used to treat human ailments only, 14 species (12.5%) for livestock ailments only and 26 species (23.27%) for both human and livestock (Supplementary file 2). This result indicated that most of MPs were used for treating human ailments. Other ethnobotanical studies carried out elsewhere by different researchers [8, 19, 22, 23, 24] also indicated that the majority of MPs were used for treating human diseases, which implies that

the local healers give more focus to human than livestock disease treatments.

3.3. Habitat of MPs

As depicted in Figure 4, of the total, 65 species (58.03%) were collected from wild alone; 27 species (24%), from both home garden and wild; 11 species (9.82%), from home gardens alone and nine species (8.03%), from farmland. This finding shows that local people in the study area mostly depended on wild sources than home gardens and farmland to obtain the MPs. It is also reported by Lulekal et al. [11], Kassa et al. [24] and Fenetahun and Eshetu [25], and A. Moges and Y. Moges [21] as wild is the main habitat for the majority of MPs. However, the collection of MPs was not limited to the kebeles of traditional healers, where they live in, rather the healers also harvested from other kebeles in the district. The collection of MPs from the wild was mainly carried out in the morning because, firstly, those plants were mostly obtained far away from their residents, and secondly, the traditional healers believe that those medicinal plants would be effective only when they are collected in the morning. Despite the available MPs in the wild, the

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study and our field observation showed that these wild habitats are subjected to human factors, leading to the loss of habitat.

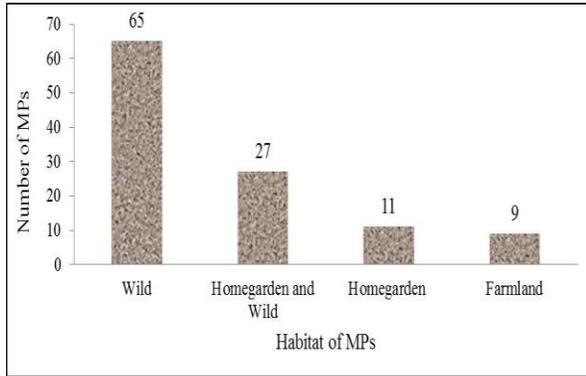


Figure 4: Habitats of MPs in the study area

3.4. Parts used, modes of preparation and administration of MPs

3.4.1 Medicinal plant parts used

People in Amaya District used different parts of MPs for the preparation of traditional medicines to treat human and livestock ailments. Leaf (37 species) of MPs was the most frequently reported part to be used in the study area, followed by seeds (15 species) (Figure 5). This is a good practice and even be promoted as a more sustainable method because leaves are many per tree so that using leaf rather than the other parts (particularly the root, including the bark, stem parts) of the MPs may not have a significant impact on the survival of the mother plants. However, using the root of

the MPs through uprooting of the whole plant is causing total death of the mother MPs. In fact, excessive use of leaves has also a negative effect on the survival and regeneration of MPs, but not as such serious as that of damaging the root, bulbs, stem, and bark parts. Many authors [26-28] also confirmed that the leaf of MPs is mostly used for TM preparation, which might also be due to its containing many chemical ingredients and simplicity in collecting and preparing it for medicine used for treating diseases.

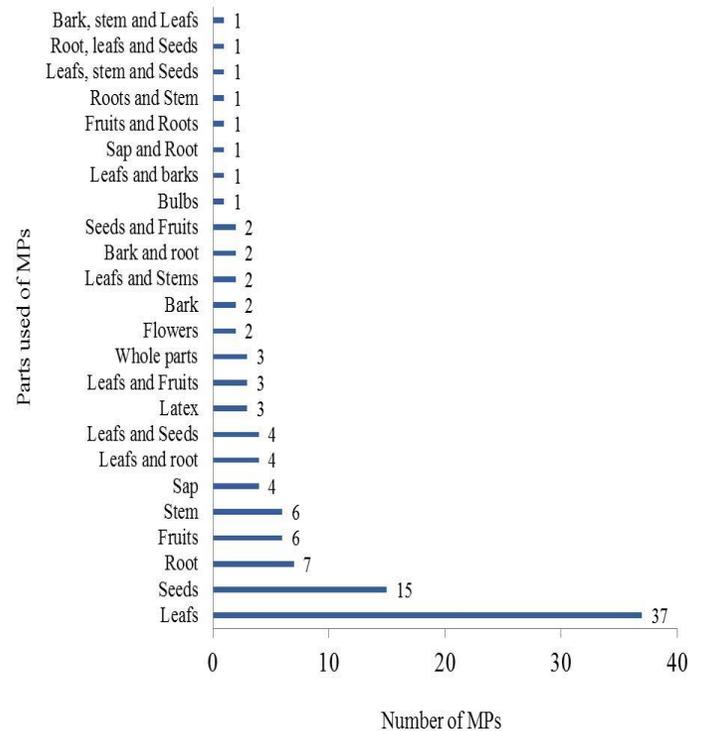


Figure 5: Plant parts used for preparation of medicine in the study area

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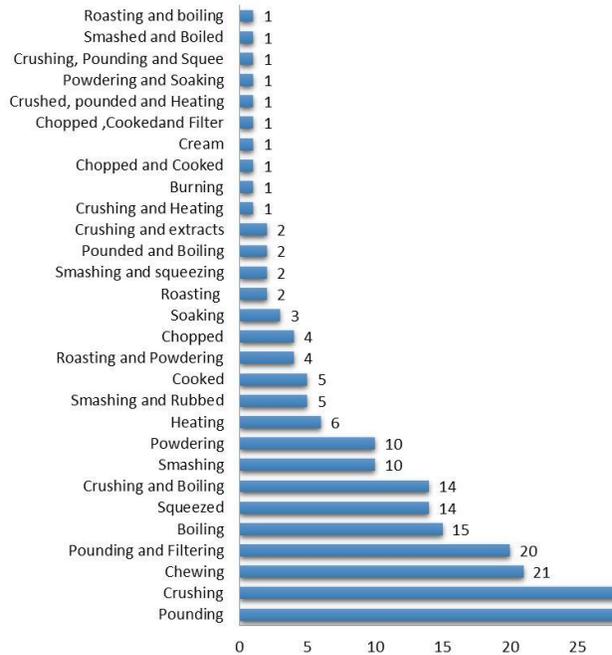
3.4.2. Modes of preparation

In Amaya District, different modes of preparation were used to treat human and livestock ailments. As portrayed in Figure 6, the major modes of preparation were pounding (30 species), crushing (29 species), pounding, and filtering (20 species). This indicated that the people of the study area use different ways of preparation, based on the types of disease treated and the actual site of ailments. The majority of the preparations were made from mixtures of different plant species with water and different additive substances. Amenu [26] also reported that most of the preparation was done by pounding.

Figure 6: Modes of preparation of medicines from MPs used to treat both human and livestock

3.4.3. Routes of administration

The prepared traditional medicines are applied in a number of methods. Hence, based on the report of the respondents of the study area, the major routes of administration used were oral only (36), dermal only (28), oral and dermal (19), nasal only (7), anal (3), nasal and oral (3) (Figure 7). This result indicated that both oral and dermal routes permit a quick physiological reaction of the prepared medicines with the pathogens; thereby they increase the curative power of the infected ones. Hence, oral application of remedies was popular as also reported by many other authors [16, 29, 30].



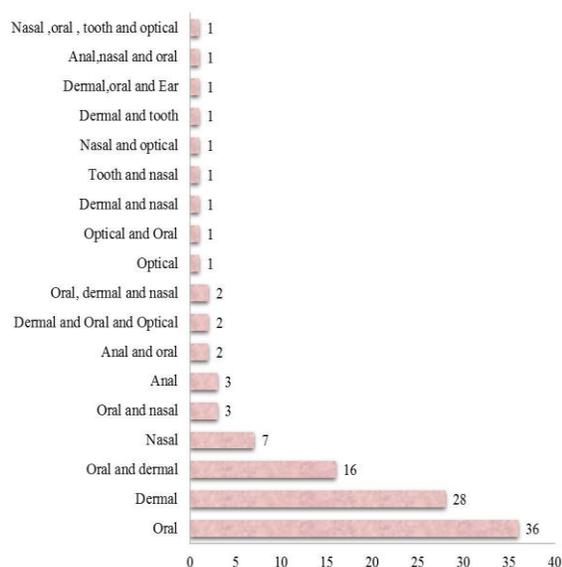


Figure 7: Routes of application of remedies in treating ailments in the study area

3.4.4. Conditions of preparation and dosage of medicinal plants

As also illustrated in Figure 8, the preparations of the MPs identified for remedies in the study area were in fresh (76 species), dry (23 species), and fresh or dry (8 species) conditions. This finding showed that most of the species are prepared for remedies in their fresh conditions. The frequent use of freshly processed remedies could also imply the accessibility of MPs in the locality and their high curative power while preparing in fresh conditions. Getaneh and Girma [23] and Yineger [28] also reported that most of TMs are prepared from the fresh parts of MPs.

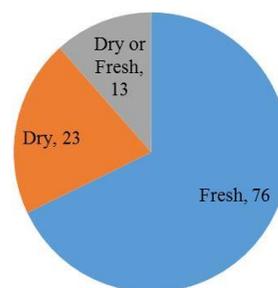


Figure 8: Conditions of preparation of medicine to treat human and livestock in the study area

In the study area, to determine the dosage, different units of measurement and duration of administration were used. In fact, there is no uniformity with regard the dosage of the medicine between the different traditional healers and local people (used by them) for the same disease, although all traditional healers and local people agree on the point that the dosages given to patients varies with age and physical strength. As also reported by key informants, the dosages of TM to be administered for certain duration were given by estimating the age, physical strength of the patient and the severity of the disease. They also reported that some medicines were not allowed to be taken by women when pregnant. Accordingly, as reported by the respondents, the amounts to be administered were estimated using

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measurements such as length of a finger (for bark, root, and stem), coffee, and/or tea cup (for powdered plant material) and number count (for sap/latex drops, leaves, seeds, fruits, and bulbs). Recovery from the disease, which is usually determined by the disappearance of disease symptoms, is a criterion that the local people of the study area consider to determine the duration of using medicine. Lack of precision and standardization is, therefore, the major drawback in practicing MPs for treatment of human besides livestock aliments, which are also reported by other ethnobotanical studies carried out in different regions of Ethiopia [10, 31], and Thulamela and JS Moroka municipalities of South Africa [32].

3.5. Marketed Medicinal plants

As represented in Table 1, market survey results obtained from Gindoo and Qotaa markets indicated that MPs sold at market were not widely used for medicinal values, rather for other purposes such as food, spices and psychoactive. This shows that the local people prefer either immediately to collect these plants by themselves from the available area in the District so as to prepare traditional medicine or directly go to traditional healer in order to get treatments

instead of buying the MPs from the market. This finding is also reported by Giday *et al.* [33] and Mesfin *et al.* [22], who stated that most of the MPs are not traded at market rather collected from environment when needed.

Table 1: List of MPs reported marketability with their local names and uses

Botanical name	Local name	use
<i>Aframomum corrorima</i>	Korarimaa	spices
<i>Allium sativum</i>	Qullubbi adii	Spice and food
<i>Brassica carinata</i>	Raaffuu	food
<i>Vacia faba</i>	Baaqelaa	Food
<i>Carica papaya</i>	Paapayya	Food
<i>Catha edulis</i>	jimaa	psychoactive
<i>Guizotia abyssinica</i>	Nuugii	food
<i>Hardeum vulgare</i>	Garbuu	food
<i>Allium cepa</i>	Qullubbi dimaa	food
<i>Coffea arabica</i>	Buna	psychoactive
<i>Eragrostis tef</i>	xaaffii	Food
<i>Ensete ventricosum</i>	Warqee	Food
<i>Eucalyptus globulus</i>	Bahargamoo adii	Firewood construction
<i>Lepidium sativum</i>	Feexoo	Medicine
<i>Linum usitatissimum</i>	Talbaa	Food and income
<i>Ruta chalepensis</i>	Ciraakoota	Spices and medicine
<i>Echinops kebericho</i>	korabichoo	Spices
<i>Zingiber officinale</i>	Ginjinbila	Spices

3.6. Ranking of medicinal plants

3.6.1. Informant consensus

In Amaya District, MPs, which were popular due to the wide range of diseases they treat and commonly used, are well known by the local peoples and traditional healers. Certain species were independently cited by many of the informants for their medicinal uses to

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treat human and livestock ailments. The results of the study showed that some MPs were popular than others. Accordingly, the highest informant consensus goes to *Ocimum lamiifolium*, which was cited by 32 informants (45.71%), followed by *Allium sativum* (38.57%), *Linum usitatissimum* (34.28%), *Croton macrostachyus* (28.57%), *Citrus limon* (27.14), and *Aloe kefaensis* (25.35) (Table 2). The popularity of *Ocimum lamiifolium* was due to the preference of the species for treating febrile illness in the community rather than going to modern medication for the disease and its easy access in the home gardens of many people, everybody had the chance to see the treatment with minimum secrecy of plants. The finding is line with the finding of Getaneh and Girma [23], who conducted their study in Debre Libanos District, Central Ethiopia, and reported as *Ocimum lamiifolium* is the best MPs, selected by the local community for remedy preparation.

Table 2: List of MPs corresponding to informants (cited by ≥15 informants)

Botanical name of MPs	Informants in:	
	Number	Percentage
<i>Ocimum lamiifolium</i>	32	45.71
<i>Allium sativum</i>	27	38.57

<i>Linum usitatissimum</i>	24	34.28
<i>Croton macrostachyus</i>	20	28.57
<i>Citrus limon</i>	19	27.14
<i>Aloe kefaensis</i>	17	25.35
<i>Datura stramonium</i>	16	22.85
<i>Platostoma rotundifolium</i>	15	21.42
<i>Lepidium sativum</i>	15	21.42
<i>Phytolacca dodecandra</i>	15	21.42
<i>Vernonia amygdalina</i>	15	21.42
<i>Ruta chalepensis</i>	15	21.42

3.6.2. Informant consensus factors (ICF)

Diseases treated by MPs reported in the study area were grouped into different categories based on the site of occurrence of the disease, condition of the disease as well as treatment resemblance of the disease. The informant consensus factors were calculated for each category (Table 3). In this study, the informant consensus on MPs usage resulted in ICF values ranging from 0.42 to 0.87 per disease category. As shown in Table 3, the ailment Malaria scored the highest value (0.87) followed by internal and external parasitic diseases (0.83). This indicates that informants use relatively few taxa to manage specific disease conditions as well as consistency in the use of plant species. MPs used to treat those ailments were more popular and effective to cure the ailments, and the ailments were more

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common than the others in the area. Low value of ICF indicates that the informants disagree on taxa to be used in the treatment within a category of illness. In this study, the lower ICF value was scored (0.42) for the category of diseases like sensor organ related diseases. This category may be indicative for lack of consistency in the use of MPs in study area.

Table 3: Informants consensus factors (ICF) values based on the disease category citation

Disease Category	Number of MPs	Use citation	ICF
Gastric and stomach related disease	26	75	0.67
Febrile illness and cough	23	99	0.77
Cattle disease	18	96	0.80
Reproductive organ disease	4	10	0.67
Wound and bleeding	35	98	0.64
Anemia and blood pressure	5	9	0.5
Internal and external parasitic problem	12	54	0.83
Evil	4	14	0.76
Malaria	3	17	0.87
Skin affecting disease	11	30	0.65
Sensor organ related disease	12	20	0.42
Disease affecting both human and livestock	10	36	0.74

3.6.3. Preference ranking of human disease

When there are different species prescribed for the same health problem, people show preference of one over the other. Preference ranking of seven MPs that were reported for treating febrile illness human disease was

conducted after selecting 10 key informants separately. Febrile illness was the most frequently reported human disease in the study area. The key informants were asked to compare the given MPs based on their efficacy, and to give the highest number (7) for the MPs that they believed most effective in treating febrile illness and the lowest number (1) for the least effective MPs in treating febrile illness. Accordingly, as presented in Table 4, *Ocimum lamiifolium* and *Croton macrostachyus* were stood the 1st and 2nd preferences of the informants, respectively, to treat the febrile illness, whereas *Solanecio gigas* was the least preference. This indicated that *Ocimum lamiifolium* was the most effective in treating febrile illness. Similar finding was reported by Kassa *et al.* [24] as *Ocimum lamiifolium* ranked first to treat fever human disease in Tulu Korma and its surroundings in Ejere District, Western Shewa Zone of Oromia Regional State.

Table 4: Preference ranking of MPs used to treat human febrile illness disease in the study area (T = total, R = Rank)

MP species	Key informants labeled 1-10										T	R
	I	I	I	I	I	I	I	I	I	I		
	1	2	3	4	5	6	7	8	9	1		

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<i>Allium sativum</i>	1	3	4	5	2	2	4	5	1	3	27	6 th
<i>Croton macrostachyus</i>	5	5	6	4	6	5	6	5	3	4	49	2 nd
<i>Eucalyptus globulus</i>	3	5	4	5	4	2	1	2	3	2	31	5 th
<i>Ocimum lamiifolium</i>	7	6	6	5	4	6	6	7	5	6	58	1 st
<i>Platostoma rotundifolium</i>	5	3	6	7	2	3	4	5	6	5	46	3 rd
<i>Solanecio gigas</i>	3	2	2	1	4	2	3	1	4	3	25	7 th
<i>Withania somnifera</i>	4	3	2	2	4	3	4	2	4	4	34	4 th

3.6.5. Direct matrix ranking

In this study area, the majority of the people rely on wild plants for various purposes, such as construction, charcoal, firewood, furniture, and fencing besides medicine. To evaluate the relative importance and check the major impact on such multipurpose plants, direct matrix ranking was performed. In the area, several MPs were found to be multipurpose species being utilized for a variety of uses. The seven most reported multipurpose species and six use categories were involved in direct matrix ranking with 10 key informants, who were requested to give value, from 5 to the most used plants for particular purposes, up to 0 (zero) to the least ones. Respondents evaluated the relative importance of these MPs to the local people and the extent of the existing threats related to their use values. The values for use reports across the selected key

informants were summed up and ranked for each species.

Based on this, the results of the direct matrix ranking revealed that *Cordia africana* ranked first followed by *Eucalyptus globulus*, *Hagenia abyssinica*, *Croton macrostachyus*, *Ficus vasta*, *Juniperus procera* and *Podocarpus falcatus*, which ranked 2nd, 3rd, 4th, 5th, 6th and 7th (Table 5), respectively. Hence, *Cordia Africana* was the most preferred multipurpose plant and over harvested for not only medicinal purpose, but also for other uses such as furniture and construction largely. Therefore, it was the most preferred plant by local people for various uses, the most threatened species; which was evidently shown by its scarce distribution in the area. From this, one could conclude that the top-ranked species were highly threatened as there was high rate of loss of *Cordia africana* in the study area. Even though the rank was given, all of the species particularly the top ranked ones were under question in their long-term survival since the livelihoods of some people in the study area directly depended on these species. This finding is in line with Teklay [34] that *Cordia africana* was the most preferred

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multipurpose plants in Kilde Awulaelo District of Tigray Regional State, Northern Ethiopia.

Table 5: Average direct matrix ranking of seven commonly used species in the study area (Ch=charcoal, Fw=Firewood, Fe=Fencing Co=Construction, , Me=Medicine, T=Total, R=Rank)

Scientific name	Use category						T	R
	Ch	Fw	Co	Fe	Fu	Me		
<i>Cordia africana</i>	10	13	20	12	20	12	87	1 st
<i>Podocarpus falcatus</i>	12	10	3	4	17	2	48	7 th
<i>Eucalyptus globulus</i>	5	22	20	23	5	10	82	2 nd
<i>Hagenia abyssinica</i>	0	5	20	10	22	20	77	3 rd
<i>Juniperus procera</i>	0	5	18	5	20	2	50	6 th
<i>Ficus vasta</i>	15	10	15	5	12	1	58	5 th
<i>Croton macrostachyus</i>	15	10	0	8	10	20	63	4 th
Total	57	75	96	67	10	87		
Rank	6 th	4 th	2 nd	5 th	1 st	3 rd		

3.7. Factors threatening MPs

Threatening factors to MPs are anthropogenic and natural factors. Based on the respondents' perception, farm expansion (cited by 20 informants) stood first, followed by firewood and charcoal (18), and furniture (10) producing activities in the study area. The least threatening factor was

plant harvesting for medicine (1) (Figure 8). This study indicated that farm expansion was found to be the highest threatening factor to MPs which might be due to an increase in population. Balemie and Seid [31], Bekele and Reddy [35] and Birhanu *et al.* [6] from Ethiopia and Heneidy *et al.* [36] from Egypt also reported similar findings as human induced factors are the main threats to MPs. Generally, MPs are mainly threatened by human induced factors, such as agriculture and urbanization, overgrazing or overharvesting of MPs, firewood collection, furniture, and introduction of exotic plants (such as *Eucalyptus globules*). Natural factors such as droughts are also the other challenges to MPs.

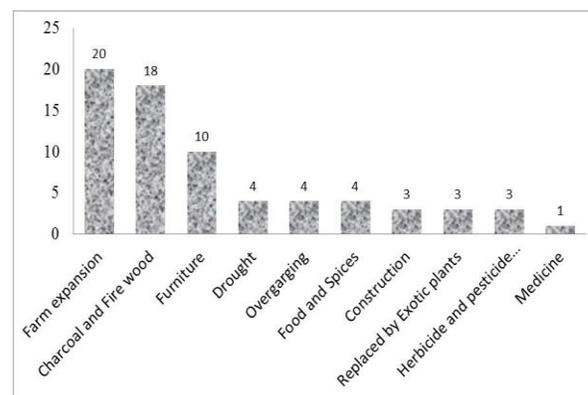


Figure 8: Factors threating MPs and number of respondents in the study area

3.8. Conservation of Medicinal Plants

Different conservation practices were reported to be practiced by local peoples in

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the study area aiding for continuity of MPs and associated IK. *Ex-situ* conservation such as plantation of MPs in home garden by collecting threatened wild MPs, bulbs and seeds stored for annual crop was one of the conservation practice strategies in the study area. Additionally, the annual and perennial MPs were being grown in the farmlands of the local people. According to Swarts and Dixon [37], the main purpose of *ex-situ* conservation is to cultivate and/or naturalize threatened species out of their natural habitats (like botanical gardens, farm lands and home guards) besides seed banks, to guarantee their continual survival and producing large quantities of planting material used in drug preparation. *In-situ* conservation practices were also implemented by local peoples. For instance, using closure areas, the local people allow the MPs to regenerate by themselves (e.g. *Podocarpus falcatus*) by pruning the branches of them and restricting grazing by their livestock. Moreover, forests are currently being conserved by efforts of the community and the local government around the Asasa forest, Roge forest and Karsa Kile forests, thereby, wild MPs are conserved. Hence, *in-situ* conservation practices such as natural reserves (closure areas) and wild

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nurseries preserve the medicinal effectiveness of plants in their natural habitats [38].

4. Conclusion

As compared to other studies, many MPs and associated IK were reported to be used for treating human and livestock ailments in study area, implying that the District is rich in MPs. Leaf parts of MPs were highly harvested for remedy preparations; such use of the leaf parts reduces the removal of the mother trees, but rather maximizing the sustainable use of medicinal plants. Among others, the pounding mode of preparation and oral route of application are the most widely used indigenous knowledge for treating and curing patients in the local healthcare systems compared to the modern ones, particularly in rural areas, where modern healthcare systems are not yet established well. In the study area, elders have better knowledge of medicinal plant than both younger and scholars; while people are more educated and young, they do not prefer to use MPs as their parents and grandparents did due to their modernization, immaturity, religion and absence of interest from traditional healers and elders to transfer their IK to other persons. Still,

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agriculture, collection of woods for firewood and charcoal, drought, overgrazing, and over harvesting for medicine, food and spices, were the other threats to MPs in the study area, leading to the loss of both MPs and their habitats. Hence, for mitigating the loss of MPs with their habitats in the study area, *ex-situ* (in botanical/home gardens, seed banks, cultivation on farmlands) and *in-situ* conservation activities (like closure area) are the most frequent practices made by the local communities.

Data availability

All data generated or analyzed during this study are included in this published article [and its supplementary files] except the list of respondents.

Conflicts of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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Ethics approval and consent to participate

Before data collection, the authors got an ethical letter from the Ethical Board of Debre Berhan University, and consent from each participant of the data collection.

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