

# Medicinal Plant Composition, Distribution, Usage and Conservation Status in Nole Kaba District, West Wollega, West Ethiopia

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## Research Article

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# Abstract

## Background

Many Ethiopians have practiced and still practice home-based medications using various medicinal plants. This research was aimed to study the composition, distribution, and usage and conservation status of medicinal plants in the Nole Kaba District.

## Methods

Data were gathered through semi-structured interviews, group discussions, and field observations. The analysis employed descriptive statistics and quantitative indices including Factor of Informant Consensus (Fic), Fidelity Level (FL), and Sorenson's Similarity.

## Results

One hundred sixty-two medicinal plants that belong to 65 families, and 135 genera were documented for use in the treatment of 45 human and 31 animal health problems. The growth forms that comprise high proportions of the medicinal flora were herbs (76, 46.9%) and shrubs (45, 27.8%). Most of the species were distributed in forests and farmlands. *Ehretia cymosa* (FL = 100%), *Pentas schimperiana* (FL = 100%), *Buddleja polystachya* (FL = 100%) *Schefflera abyssinica* (FL = 100%) and *Loxogramme abyssinica* (FL = 94%) were among medicinal plants showing high informant consensus. Pairwise comparisons identified the expansion of agriculture, deforestation, and over-grazing as principal threats to most medicinal plants.

## Conclusions

Medicinal plants showing high informant consensus are recommended for further evaluation of efficacy, safety, and other product quality requirements. Medicinal plants such as *Echinops longisetus*, *Ocimum urticifolium*, *Pentas schimperiana*, *Securidaca longepedunculata* and *Warburgia ugandensis* are threatened mainly due to over exploitation. These and other similarly affected species should be given top priority for in-situ and ex-situ conservation jointly by the community, the relevant administrative bodies, and development partners.

## Background

Ancient medical manuscripts written by Ethiopian churchmen and Muslim scholars revealed that medicinal plants have long been playing an important role in human healthcare in Ethiopia [1]. The knowledge and skills associated with the use of medicinal plants have been passed on orally to their family members by healers, knowledgeable elders, religious leaders, and other members of the clergy for most of the centuries [2]. In addition to renowned traditional healers, many Ethiopians have practiced and still practice home-based medications using various herbs such as ginger, garlic, and eucalyptus leaves to treat health problems such as colds, fevers, and headaches. Although current estimates are lacking, previous estimates indicate that the use of plant-based traditional medicine meets up to 70% of human health needs in Ethiopia and understandably the proportion that goes to traditional herbal medicine use is a little less than this figure. Regarding medicinal plant richness, the flora of Ethiopia comprises over 1500 medicinal plants (Ongoing review) which are used by ethnic communities in different parts of the country. Most of these medicinal plants are harvested from the wild, while few are cultivated/or grown as crops in homegardens and farmlands.

Despite the richness, the natural vegetation and associated medicinal plants are declining in area coverage and species abundance in many parts of the country, including the present study area. Remnant tree/shrub stands in farmland and many parts of the study area are a testimony to vegetation shrinkage or deterioration. Assessments of threatened plant species by [3] found an increasing number of threatened plants over the years. Among these, *Echinops ellenbeckii* and *Taverneia abyssinica* are endangered and critically endangered, respectively. Equally, species such as *Echinops kebericho* and *Securidaca longepedunculata* are highly declined and endangered in the wild due to overexploitation and habitat destruction. The latter two species did not appear on the IUCN RED List of threatened species yet. However, field observations clearly show that these species are becoming rare in most parts of Ethiopia due to unsustainable use and other pressures. The decline of such medicinal plants inevitably leads to the erosion and/ or loss of ethnomedicinal knowledge and this consequently is an important public health concern. Given growing pressures on medicinal plant diversity and associated knowledge, ethnobotanical documentation and identification of potentially useful and threatened species are essential for development and conservation planning. This study was, therefore, aimed to identify medicinal plants and their distribution; assess the health problems, analyze medicinal plants usage consensus, and identify threats to medicinal plants. The findings of this study are believed to contribute to the conservation and sustainable use of medicinal plants; and enrichment of the Flora database of the National Herbarium.

## Materials And Methods

The study area, Nole Kaba District is geographically located in west Ethiopia between 8°39'45"N and 8°58'10"N latitude and 35°34'41" E and 35°58'49" E longitude in west Wollega, Oromia Region, at about 491 km west of Addis Ababa (Figure1). According to the 2007 national census report, the total human population of Nole Kaba District is 60,793, consisting of 29,667 men and 31,126 women, largely (97%) belonging to the Oromo ethnic group. The people have settled in different agroecological settings namely, highland (above 2100 m asl.), midland (1900-2100 m asl.), and lowland (1500 - 1900 m asl.) which show variations in temperature. According to the rainfall and temperature data collected by the National Meteorological Service Agency for the years between (1990-2015), the mean monthly temperature is 21.4°C with mean minimum and maximum monthly temperatures of 14.3°C and 30.5°C, respectively. The mean annual rainfall is 1610 mm with a unimodal distribution. The soils are well drained, strong to moderately acidic, deep, and reddish-brown in color. The natural vegetation towards the higher altitudes (>1900 m asl.) belongs to moist Afromontane forests while those towards the lower (<1500 m asl.) altitudes belong to *Combretum-Terminalia* woodlands.

### Selection of study sites and informants

The study areas were stratified into three agroecological settings namely, highland, midland, and lowland. These agroecological settings have somehow varied in temperatures, altitudes, and vegetation assemblages. Within each agroecological setting, representative study sites were identified proportionally based on area coverage/proportion of the agroecological zones in the study district. Accordingly, six from midland, four from highland, and two from lowland agroecological zones were selected. Informants were sampled randomly at each village following [4]. However, traditional healers were sampled purposively. The sample size was determined following [5] from 11,386 households. Overall, 371 informants (197 men and 174 women) aged between 13-90 years were involved in the interviews. In the course of interviews, 12 more knowledgeable informants (8 men and 4 women) were considered as key informants for group discussions. The research obtained formal research

permit from Addis Ababa University, Ethiopian Biodiversity Institute and the local administration of the study area. Each informant gave oral informed consent prior to data collection.

## Data collection and analysis

Data was gathered using semi-structured interviews, group discussions, and field observations. Herbarium specimens of all recorded medicinal plants were collected, pressed, dried, and identified by using Ethiopian Flora Books and by cross-checking with authenticated herbarium specimens at National Herbarium, Addis Ababa University.

The data were analyzed using both descriptive and inferential statistics. Furthermore, the following indices were employed to analyze the quantitative data. *Factor of Informant Consensus (Fic)* adopted by [6] was employed to see the degree of agreement among informants interviewed concerning the use of plant species within a given ailment category.

$$Fic = \frac{n_{ur} - n_t}{n_{ur} - 1}$$

Where,  $n_{ur}$  is the number of use reports for a particular disease category and  $n_t$  is the number of different plants (taxa) that are reported to treat this disease category.

*Fidelity Level (FL)* was computed following [7] to estimate the relative importance of medicinal plants reported for treating particular disease categories.

$$\text{Fidelity level (FL)} = \left(\frac{I_p}{I_u}\right) \times 100 \text{ [7]}$$

Where  $I_p$  = number of informants that use a species for principal disease;  $I_u$  = total number of informants that cited the species to treat any other disease. Sorensen's (Ss) similarity index was computed using R software version 3.41[8] to determine medicinal plants similarity between different study sites. Furthermore, pairwise comparison was conducted to prioritize factors threatening medicinal plants [4]. The number of pairs for pairwise comparison was determined using  $N(N-1)/2$  relationships, where N is the number of threat factors.

## Results

### Medicinal plants composition and distribution

The study found a total of 162 medicinal plant species belonging to 65 families and 135 genera. Of the total, 43.8% were reported only for human health problems, 35.8% for both human and animal and 20.4% only for animal. In total, the ethnomedicinal plants comprises 129 species belong to 108 genera and 60 families (see additional file 1), while the ethnoveterinary comprises 91 species belonging to 84 genera and 49 families (see additional file2). The families that contributed high proportion of medicinal plants were Asteraceae (65%), Fabaceae (20%), Solanaceae (15.4%) and Lamiaceae (13.8%). The majority (55.8%) of the families were represented by one species. The composition of the medicinal plants indicate the predominance (47.5%) of

herbs, followed by shrubs (27.8%), trees (16.7%) and lianas (8%). Of the documented medicinal plants, six species including *Echinops longisetus*, *Lippia adoensis*, and *Solanecio gigas* are endemic to Ethiopia. Plant parts used for preparation of remedies for both human and animal health problems were largely leaves and roots (Figure 2).

The medicinal plants were distributed across seven habitat types which were classified based on land use (farmland/border, homegardens, pasture lands, roadsides) and physiognomy of the vegetation (forest, woodland, riverine vegetation). The habitats harboring high proportion of medicinal plants were forests (34%), followed by farmlands/borders (33%), roadsides (10%) and homegardens (9%) (Figure 3). Some medicinal plants were distributed across more than one habitat some others were restricted to a particular habitat type. Species such as *Ageratum conyzoides*, *Bersama abyssinica*, *Croton macrostachyus*, *Justicia schimperiana* and *Salvia nilotica* were distributed across multiple habitat types while others confined to habitat characterized by *Comberetum-Terminalia* woodland (e.g *Capparis tomentosa*, *Combretum molle*, *Echinops amplexicaulis*, *Hymenodictyon floribundum*, *Securidaca longepedunculata*, *Stereospermum kunthianum*, *Warburgia ugandensis*, and *Ximenia americana*) and moist Afromontane vegetation (e.g *Adiantum poiretii*, *Chionanthus mildbraedii*, *Cyperus fischerianus*, *Galiniera saxifraga*, *Pavetta oliveriana*, and *Vepris dainellii*). In terms of altitudinal distributions, the occurrence of many medicinal plants was between 2000-2200 m asl. This altitudinal range is characterized by a moist and warm climate, which also includes Jorgo Wato Forest (JWF).

## Medicinal plants similarity

The number of medicinal plants reported in the sampled study sites varied between 46 and 75 species. Many of the medicinal plants were shared and used commonly in these sites. The highest similarity ( $S_s = 0.70$ ) was observed between Siba Silase and Hrbu Abagada, while the least ( $S_s = 0.31$ ) was observed between Shimala Illu and Aydobi (Table 1). The highest medicinal plant similarity value suggests more number of shared medicinal plants and associated knowledge. The sites that shared a greater number of medicinal plants are geographically located closer to each other and found within the same agroecological settings. These sites are bordered by JWF, which was the source of many medicinal plants reported in this study. This finding suggested that there is an intra-cultural exchange of medicinal plant knowledge between these sites. On the other hand, the low medicinal plants use similarity between some sites may be due to variation in environmental settings (relief, climate, and altitude), which may influence the availability and utility of medicinal plants. It may also be due to less opportunity for exchange of ethnomedicinal knowledge which in turn due to greater distance between the sites. Medicinal plants shared commonly across most study sites were *Brucea antidysentrica*, *Capparis tomentosa*, *Croton macrostachyus*, *Datura stramonium*, *Dracaena steudneri*, *Drymaria cordata*, *Justicia schimperiana*, *Ocimum lamiifolium*, and *O. urticifolium*. The use of these species over wider localities may be due to their adaptability to and availability in broader altitudinal and habitat ranges.

Table 1 Sorensen's similarity index showing medicinal plants use similarity among study sites

	AB	AD	AL	DQ	GR	AA	HC	HT	SD	SI	SK	SS
AB	X											
AD	0.48	X										
AL	0.50	0.51	X									
DQ	0.55	0.55	0.56	X								
GR	0.56	0.54	0.59	0.64	X							
AA	0.47	0.47	0.56	0.60	0.59	X						
HC	0.48	0.50	0.45	0.53	0.55	0.48	X					
HT	0.51	0.49	0.53	0.55	0.50	0.53	0.39	X				
SD	0.59	0.52	0.55	0.62	0.67	0.57	0.58	0.55	X			
SI	0.32	0.31	0.37	0.37	0.35	0.41	0.51	0.33	0.42	X		
SK	0.42	0.38	0.50	0.47	0.47	0.67	0.46	0.41	0.49	0.40	X	
SS	0.46	0.50	0.56	0.58	0.62	0.70	0.58	0.56	0.62	0.49	0.56	X

NB: (AB = Aybeda; AD = Aydobi; AL = Aleku; DQ = Didu Qoce; GR = Gaba Robi; AA = Aarbu Abagada; HC = Haro Coroqa; HT = Haro Tumsa; SD = Siba Dalo; SI = Shimela Ilu; SK = Siba Kopi; SS = Siba Silase

### Health problems and medicinal plant usage consensus

The study documented with a total of 45 human and 31 animal health problems. In both human and animal cases, the health problems are grouped into eleven major categories based on affected organs or features of the health problems. The human health problem categories are general malaise, dermatological, auricular, dental, neck and optical, antidote, liver and kidney, reproductive, respiratory, burning in the chest, and thoracic problems. Most of these categories are also considered in grouping animal health problems. Of the animal health problems, 18 (58 %) were affecting cattle, while the remaining 13 (42%) were affecting sheep, equines, and dogs.

In the case of humans, the factor of informant consensus analysis revealed the highest values for treatment of bone fracture ( $Fic = 1.00$ ) and stomachache ( $Fic = 0.94$ ) (Table 2). The study found that multiple plants were reported for the treatment of a single health problem. The health problems treated with the highest number of medicinal plants were toothache (20 species), followed by rabies (18 species), migraine (16 species), and febrile (15 species). The study also found multiple therapeutic uses of a single medicinal plant. Among these, *Echinops longisetus* was reported to have eight different therapeutic uses, while *Croton macrostachyus* and *Capparis tomentosa* reported having seven therapeutic uses each (Table 2).

Table 2 Human health problems with high informant consensus values

Health problems	Nur	Nt	Nur-1	Nur - Nt	Fic
Bone fracture	49	1	48	48	1.00
Stomachache	177	11	176	166	0.94
Rabies	187	18	186	169	0.91
Bleeding wound	63	8	62	55	0.89
Migraine	120	16	119	104	0.87
Febrile	110	15	109	95	0.87
Circling sickness	44	6	43	38	0.88
Snakebite	70	13	69	57	0.83
Toothache	106	20	105	86	0.82
Spider poison	57	11	56	46	0.82

Besides, fidelity level analysis showed that *Pentas schimperiana* with the highest fidelity level (FL = 100%) was reported for the treatment of a human bone fracture. This species is the only medicinal plant widely used for the maintenance of bone fracture. *Ehretia cymosa* and *Loxogramme abyssinica* showed the highest fidelity level values for the treatment of toothache (Table 3).

Table 3 Ethnomedicinal plants with high fidelity values on specific health problems

Specific health problem	Medicinal plant	Np	Nt	FL (%)
Toothache	<i>Ehretia cymosa</i> Thonn.	18	18	100
Bone fracture	<i>Pentas schimperiana</i> (A. Rich.) Vatke	49	49	100
Toothache	<i>Loxogramme abyssinica</i> (Baker) M. G. Price	17	18	94
Febrile	<i>Ocimum urticifolium</i> Roth	32	37	86
Migraine	<i>Ocimum lamiifolium</i> Hochst. ex Benth.	49	57	86
Rabies	<i>Phytolacca dodecandra</i> L'Hérit.	36	43	84
Migraine	<i>Echinops longisetus</i> A. Rich.	57	70	81
Rabies	<i>Datura stramonium</i> L.	17	21	81
Stomachache	<i>Clerodendrum myricoides</i> (Hochst.) Vatke	15	19	79
Febrile	<i>Salvia nilotica</i> Jacq.	18	23	78
Stomachache	<i>Securidaca longepedunculata</i> Fresen.	16	21	76
Taeniasis	<i>Embelia schimperi</i> Vatke	13	17	76
Bleeding wound	<i>Croton macrostachyus</i> Del.	63	84	75
Rabies	<i>Justicia schimperiana</i> (Hochst. ex Nees) T. Anders.	22	33	67
Rabies	<i>Dracaena steudneri</i> Engler	31	52	60

Concerning animal health problems, high factors of informant consensus (*Fic*) values were recorded for bone fracture, eye problem, rabies, and babesiosis. The ethnoveterinary health problems treated with the high number of medicinal plants were rabies (23 species), snakebite (18 species), and blackleg (16 species) (Table 4).

Table 4 Animal health problems with high factor of informant consensus

Health problem	Major categories	N <sub>t</sub>	N <sub>ur</sub>	N <sub>ur-1</sub>	N <sub>ur</sub> -N <sub>t</sub>	<i>Fic</i>
Bone fracture	Skeletal	1	49	48	48	1.00
Eye problem	Optical	4	29	28	25	0.89
Rabies	Neurological	23	187	186	164	0.88
Babesiosis	General	13	82	81	69	0.85
Blackleg	General	16	58	57	42	0.74
Snakebite	Antidote	18	67	66	49	0.74

Most of (58, 64%) of the ethnoveterinary plants had single therapeutic values while some (33, 36%) have multiple therapeutic uses. Among those with multiple therapeutic uses, *Dracaena steudneri* was reported to have four therapeutic uses, while *Albizia schimperiana*, and *Croton macrostachyus* have three therapeutic uses each.

Fidelity level analysis of ethnoveterinary plants revealed the highest fidelity value of *Buddleja polystachya* (FL = 100%) for a treatment eye problem and *Pentas schimperiana* (FL = 100%) for bone fracture (Table 5).

Table 5 Fidelity level values of ethnoveterinary plants commonly reported against specific health problems

Scientific name	Diseases treated	N0 of report	Report frequency	FL (%)
<i>Buddleja polystachya</i>	Eye disease	20	20	100
<i>Schefflera abyssinica</i>	Blackleg	11	11	100
<i>Mucuna melanocarpa</i>	Emaciation	20	22	91
<i>Phytolacca dodecandra</i>	Rabies	36	43	84
<i>Piper capense</i>	Emaciation	10	12	83
<i>Datura stramonium</i>	Rabies	17	21	81
<i>Justicia schimperiana</i>	Rabies	22	33	67

## Dosage forms and application of remedies

Herbal remedies were prepared from fresh (64%), fresh or dried (34%), and dried (2%) plant materials for humans. For animals, 62% of the remedies were prepared from fresh, while 38% were from either fresh or dried materials. Informants thought that fresh plant materials were more effective in healing than dried materials. In many cases, dried remedies are applied as smoke and or fumigant. Scarce medicinal plants that may not be locally available are often dried and preserved for future use. The majority (87%) of human remedies were prepared from single species or plant parts. In several instances, more than one plant part of the same species was used in the preparation of various remedies. Drinking (44%) was the most common method of applying the treatments, followed by crushing/smashing and inhaling or adding drops (14%). Smoke inhalation and steam bath were the least reported applications (Figure 4).

The main ingredient used along with or added to remedies was salt, followed by butter, coffee, milk, honey, garlic, and ginger. Other ingredients like barley soup/gruel, sugar, pancake, lemon, yogurt, hot pepper, vaseline, sugar cane, and ash were used rarely for the preparation of remedies.

The plant remedies were applied largely (60%) through the oral application, while some were applied through nasal (16%), dermal (15%), optical (6%), and auricular (3%). In the case of animals, remedies are prepared mainly by crushing and soaking in water in the form of infusion (57%), followed by concoction (30%), sap or juice (12%), and latex (1%). The most (82%) frequent method of application of remedies is drenching, followed by dropping (7%), painting or tie on (6%), and feeding (5%). Oral (90%), Nasal (5%), dermal (3%), and optical (2%) are the routes used for the application of ethnoveterinary remedies.

## Factors affecting the availability of medicinal plants and management status

Analysis of threat factors identified five principal factors responsible for the declining availability or scarcity of medicinal plants, namely agricultural expansion, deforestation, overharvesting, overgrazing, and drought/climate

change. Pairwise comparison prioritized the first two factors as top factors that have contributed to the declining availability and loss of medicinal plants (Table 6). These factors have together altered the habitats of many wild plants, including that of medicinal species.

Table 6 Pair-wise ranking of threat factors

Factors	I <sub>1</sub>	I <sub>2</sub>	I <sub>3</sub>	I <sub>4</sub>	I <sub>5</sub>	I <sub>6</sub>	I <sub>7</sub>	I <sub>8</sub>	I <sub>9</sub>	I <sub>10</sub>	I <sub>11</sub>	I <sub>12</sub>	Total score	Rank
Agricultural expansion	3	4	3	4	4	4	4	4	2	3	4	3	42	1
Deforestation	2	1	3	3	1	3	2	2	3	4	3	4	31	2
Over-grazing	3	2	0	2	3	0	3	3	3	2	2	1	24	3
Over-harvesting	2	2	2	1	2	2	1	1	1	1	1	1	17	4
Drought	0	1	2	0	0	1	0	0	1	0	0	1	6	5

Loss of habitats such as shrinkage of forests and pasture lands has had a direct impact on the abundance and availability of many medicinal plants. Interviewed informants reported the need to conserve *Datura metel*, *Dracaena steudneri*, *Echinops longisetus*, *Euphorbia schimperiana*, *Gomphocarpus semilunatus*, *Olea europaea* subsp. *cuspidata*, *Passiflora caerulea*, *Pentas schimperiana*, *Phytolacca dodecandra*, *Pittosporum viridiflorum*, *Podocarpus falcatus*, *Salvia nilotica*, *Securidaca longepedunculata*, and *Warburgia ugandensis* as these species were found to be rare or scarce in abundance in areas where they were recorded. In addition, over-harvesting of some medicinal plants such as *Echinops longisetus*, *Pentas schimperiana*, and *Securidaca longepedunculata* have seriously affected their availability as explained by informants and verified the rarity/scarcity by onsite field observations. In particular, uprooting makes the worst condition for *Echinops longisetus* and *Securidaca longepedunculata*. Efforts made to collect samples of these rare species demanded special searching in secluded habitats of the study area.

Regarding management, 54 (33%) medicinal plants were managed traditionally by informants on farmlands (58%) and in homegardens (42%). These medicinal plants include shrubs (16 species), trees, and herbs (14 species each). Of the managed species, 14 (26.9%) were reported to be locally threatened or rare. These species include *Datura metel*, *Dracaena steudneri*, *Echinops longisetus*, *Ocimum lamiifolium*, *Ocimum urticifolium*, *Olea europaea* subsp. *cuspidata*, *Phytolacca dodecandra*, and *Pittosporum viridiflorum*. This suggests that increasing the participation of farmers in the management may have a significant contribution to the conservation, sustainable use as well as rescuing of the rare medicinal plants.

## Discussion

### Composition and distribution of medicinal plants

The flora of the study area is rich in medicinal plants that are used for the treatment of a wide range of human and animal health problems. The families shown to be richest in medicinal plant species are Asteraceae, Fabaceae, Solanaceae, and Lamiaceae, which are also among the dominant flowering plant families in Ethiopia [9] and in the world [10]. Furthermore, these families are known to constitute secondary metabolites like essential oils, antibacterial, and antifungal products [11]. This result suggests that families represented by the highest

number of medicinal plants can be considered as a target group in the search of/bioprospecting of drug compounds. The composition of medicinal plants includes endemic species among which, *Echinops longisetus*, *Lippia adoensis*, and *Solanecio gigas* are reported on IUCN Red List as threatened species [3]. In terms of habitat distribution, a large proportion of medicinal plants were distributed in the forest, followed by farmland/borders and roadsides. The high species diversity in forests is possibly due to structural complexity, heterogeneous niche, micro-habitats created by trees, bushes, and variable topographic locations where forests occur, and often forests get some level of protection from anthropogenic factors. This is in agreement with previous studies [12] who reported that tropical forests are home to a large number of medicinal plants, most of which remain undiscovered. Similarly, the high medicinal plant diversity in farmland/borders may be attributed to human activities, which could favor the dispersal of propagule, especially of weedy and herbaceous medicinal plants. This observation agrees with [13], who found many medicinal plants in farmlands. Thus, the findings suggest that habitats such as forest/forest margins and farmlands/farm borders could be target areas during the collection of medicinal plants germ-plasms for ex-situ conservation. Regarding species distribution, the results showed that many medicinal plants distributed in more than one habitat type. Wider habitat distribution of species could increase the availability and accessibility of the species for public use. From a conservation point of view, however, species found in different habitats are under less harvesting pressure compared to those that are locally restricted.

### **Medicinal plants growth forms and parts**

The results showed that the growth forms of the documented medicinal plants were predominantly composed of herbs and shrubs. These could possibly be due to the fact that herbaceous plants are available in many habitats, including agricultural fields. It is expected that the more accessible a plant taxon is in an area, the more the likelihood of being used by or interacting with local people [14]. In addition, ease of harvest may also contribute to the preference and predominant use of herbs in traditional medicine.

Regarding medicinal plant parts, leaves and roots were the most commonly used for the preparation of the remedies. Several medicinal plants or parts are sometimes used for the same medicinal purposes. In such a case, users may choose the most readily available, easily harvestable, and applicable parts. These may contribute to the increased use of a particular part. For example, the most frequent use of parts such as leaves may be related to ease of harvesting, preparation, and application as well as their efficacy because, particularly actively growing young leaves are accumulation centers of secondary metabolites known to contain higher amounts of healing compounds. [15] argued that the most frequent use of a plant or a plant part might rather suggest that this plant or plant part is not toxic to human health.

In view of conservation, the most frequent use of roots is a concern because it is considered to be destructive; it could threaten and endangered species' survival. Species such as *Echinops longisetus*, *Securidaca longepedunculata*, and *Warburgia ugandensis* were harvested for their roots in the present study area and have become vulnerable to extinction locally. *Echinops longisetus* is already reported in IUCN Red List of threatened species under Least Concerned (LC) threat category [3] but locally threatened as seen in the present study area. Although further assessment and evaluations are required, *Securidaca longepedunculata* and *Warburgia ugandensis* are under threat and need conservation attention.

### **Informant consensus and applications of medicinal plant remedies**

The results revealed that medicinal plants are used by the majority of the rural people even today. The medicinal plants documented in this study were reported to treat a wide range of health problems. Among the human health problems, bone fracture, wound, rabies, febrile, migraine, stomachache, and toothache showed high informant consensus values. Bone fracture, eye problem, rabies, and babesiosis were among animal health problems that showed a high factor of informant consensus. High informant consensus values may indicate a more prevalence of these health problems in the area. A high informant consensus value may also indicate more agreement among informants on the medicinal plants reported for treatments of health problems. Some of the health problems are treated by different medicinal plants. The use of different plants for the same application might increase treatment options and contributes to healthcare security. For example, when a particular plant is not available due to various reasons such as seasonality or inaccessibility, alternative species could be used as a remedy. The presence of alternative remedies might also reduce harvesting pressure, particularly on rare medicinal plants.

High informant consensus may also imply more shared knowledge on the reported medicinal plants. Most of the medicinal plants that showed high informant consensus have been used as remedies in other parts of Ethiopia. For example, *Phytolacca dodecandra* has long been used in Ethiopia for numerous ailments; anti helminths, eczema, gonorrhoea, abortion, malaria, rabies, skin disease, gonorrhoea, and liver disease [1, 16]. *Brucea antidysenterica* was reported for the treatment of cancer, diarrhea, evil eye, leishmaniasis, rabies, wound, skin disease, dysentery, hemorrhoids, weight loss, fever, and diarrhea [1, 17]. Another most frequently used species was *Embelia schimperi*, which was reported for the treatment of tapeworms and roundworms for gastrointestinal complaints [13]. In line with this, [6] suggested that medicinal plants with high informant consensus values can be considered as culturally significant species.

Furthermore, many of the medicinal plants documented in this study, including those that showed high informant consensus values, were found to possess phytochemical and pharmacological properties. For example, phytochemical screening of plant parts of *Stereospermum kunthianum* confirmed the presence of flavonoids, tannins, saponins, terpenoids, glycosides, sterols, coumarins, quinones, and higher fatty acids [18]. These phytochemical compounds provide various therapeutic properties [15]. Phytochemical screening of leaf extracts of *Ocimum lamiifolium* confirmed the presence of tannins, sterols, flavonoids, saponins, terpenoids, and alkaloids [19]. Aqueous extracts of leaves, fruits, and stems of *Phytolacca dodecandra* are known to contain alkaloids, steroids, phenols, triterpenoids in its leaves [19]. The berries of *P. dodecandra* are known to contain saponins, a compound showing molluscicidal properties [1]. A crude leaf extract of *Brucea antidysenterica* and *Croton macrostachyus* showed the presence of flavonoids, saponins [17] alkaloids, phenols, triterpenoids, and steroids [20]. The phytochemicals present in these plants are known to exhibit biological activities [1,17] such as effects on the central nervous system, anti-microbial, stimulants, pain killer, anti-tumor, fungicidal, anti-helminthic activity, antioxidant, anti-viral, hepato-protective, anti-inflammatory, cardiovascular, and anti-hypertensive therapeutic effects [21].

More importantly, pharmacological evidence showed that the medicinal plants with high informant consensus in this study were reported to demonstrate pharmacological effects against harmful microbes. For example, crude extract of *Buddleja polystachya* leaf has shown anti-inflammatory [22], cytotoxic potentials, and anti-microbial effects [23]. Leaf extracts of *Croton macrostachyus* showed antibacterial activities against *Staphylococcus aureus* and *Shigella sonnei* [24]. Extracts of *Ocimum lamiifolium* leaves demonstrated anti-plasmodial and anti-bacterial effects [25]. The crude extract of *Phytolacca dodecandra* had shown inhibition against bacterial growth

[26]; seed extracts of *Brucea antidysenterica* showed a significant effect against plasmodium parasite [25]; leaf and seed extracts of *Datura stromonium* revealed anti-microbial activities [27]; crude extracts of *Dracaena steudneri* and *Capparis erythrocarpos* [28] portrayed the most significant anti-fungal activity; extracts from *Echinops longisetus* leaf and stem showed strong inhibitory activity against *Staphylococcus aureus*; root and flower extracts showed lethal activity against earthworms and molluscicidal activity [29]. *Embelia schimperi*, *Ocimum lamiifolium* and *Vernonia amygdalina* were reported to possess antimicrobial effects against different microbial strains [30]. Embelin compounds found in the berries had shown lethal activity against hookworm larvae and anti-microbial effect against *Staphylococcus aureus* strains [31]. The crude extract of *Millettia ferruginea* seed and *Warburgia ugandensis* leaves demonstrate the stronger larvicidal effect [32]. The anti-bacterial, anti-plasmodial, analgesic, anti-inflammatory, anti-diarrhoeal and anti-oxidant effects of *Stereospermum kunthianum* extract have been experimentally demonstrated [18]. The leaf extract of *Pentas schimperiana* was found to exhibit anti-microbial, anti-fungal, and diabetic activities [33].

Indeed, the presence of diverse chemical compounds in different parts of the reported medicinal plants and antimicrobial activity testing all give significant credibility to the usage of documented medicinal plants. Overall, these findings suggest that medicinal plants with high use reports and high informant consensus can be used for further phytochemical and pharmacological evaluations against a wide range of diseases and disease-causing organisms.

### **Forms of plant materials and preparation of remedies**

The plant remedies were prepared mainly from fresh plant parts, while the use of dried plant parts was less common. Informants thought that medicinal plants might lose or reduce medicinal values upon drying. Indeed, such information needs further investigation to see the effect of drying on the bioactive contents of the plants. Other studies in Ethiopia [13, 34] found the use of fresh materials for most of the herbal preparations. Several factors including plants' growth stage and storage period are believed to influence the phytochemical constituents of plants. Many unstable secondary metabolites are copiously available in fresh materials. A study by [35] revealed a higher quantity of phytochemical compounds in young plant parts than in mature parts. The same source further reported that prolonged storage of plant parts reduces their phytochemical contents and supports the use of fresh material in most traditional medicine. Thus, although further investigations on different parts of the species are needed, the use of fresh materials in the traditional herbal preparations has possible scientific evidence. The results further showed that various ingredients, mainly salt, butter, coffee, and milk, were used together with herbal remedies. The use of these additive substances in herbal remedies could improve the healing potential, the taste, and/or flavor and reduce the possible side effects of the remedies.

### **Factors affecting availability of medicinal plants and management efforts**

In many places, the natural vegetation cover of the study area is deteriorating. Factors reported in this study are generally considered to be the principal factors for the loss of wild plant resources including those found in forests, woodlands, and pasture lands in Ethiopia [3]. Furthermore, multiple uses, over-exploitation, and destructive harvesting contributed to the decline or local loss of certain medicinal plants. For instance, *Echinops longisetus* and *Securidaca longepedunculata* are declined/or lost from the wild due to over-harvesting of roots for sale. *Echinops longisetus* is already reported in the IUCN Red List of threatened species [3]. These species are restricted in habitat distribution and were not available where they were previously growing, they also have a low number of individuals in their natural habitats. In many cases, slow-growing, slow-reproducing, and rare species

with specific habitat requirements are the most vulnerable group [36, 37]. To this end, the protection of natural vegetation favors the coexistence of different biodiversity components, maintains evolutionary processes of the species, and protects rare and threatened species [37].

## Conclusions

The study found rich medicinal plant resources in the Nole Kaba District. The majority of rural people depend on these resources for the management of health problems. The medicinal species are composed largely of herbs and shrubs. Most of the plant remedies are prepared from fresh leaves and roots, which are processed in the form of infusions. Of the documented medicinal plants, *Croton macrostachyus*, *Datura stramonium*, *Dracaena steudneri*, *Echinops longisetus*, *Justicia schimperiana*, *Loxogramme abyssinica*, *Ocimum urticifolium*, *Pentas schimperiana*, *Phytolacca dodecandra*, and *Securidaca longepedunculata* showed a high informant consensus and could, therefore, be considered for further evaluation of efficacy, safety, and other quality requirements of medicinal plant products. Declining or rare medicinal plants such as *Echinops longisetus*, *Ocimum urticifolium*, *Pentas schimperiana*, *Securidaca longepedunculata*, and *Warburgia ugandensis* should get conservation priority in protected areas (in situ), field gene bank, and other appropriate means that are suitable to the particular species. In addition, sensitization about the need for sustainable use of medicinal plants is required to stakeholders at different administrative levels to contribute to the long-term availability of this resource.

## Declarations

### Ethics approval and consent to participate

“Not applicable”

### Availability of Data and Materials

The data supporting their findings can be found in additional file 1 and 2

### Competing interests

“The authors declare that they have no competing interests”

### Consent for publication

Verbal consent obtained from local governments and informants

### Authors' contributions

The first authors had significant intellectual contribution towards the design of the study, data collection and analysis and write-up of the manuscript. The co-authors made substantial contributions to the revision and finalization of the manuscript. The authors read and approved the final manuscript.

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## Figures

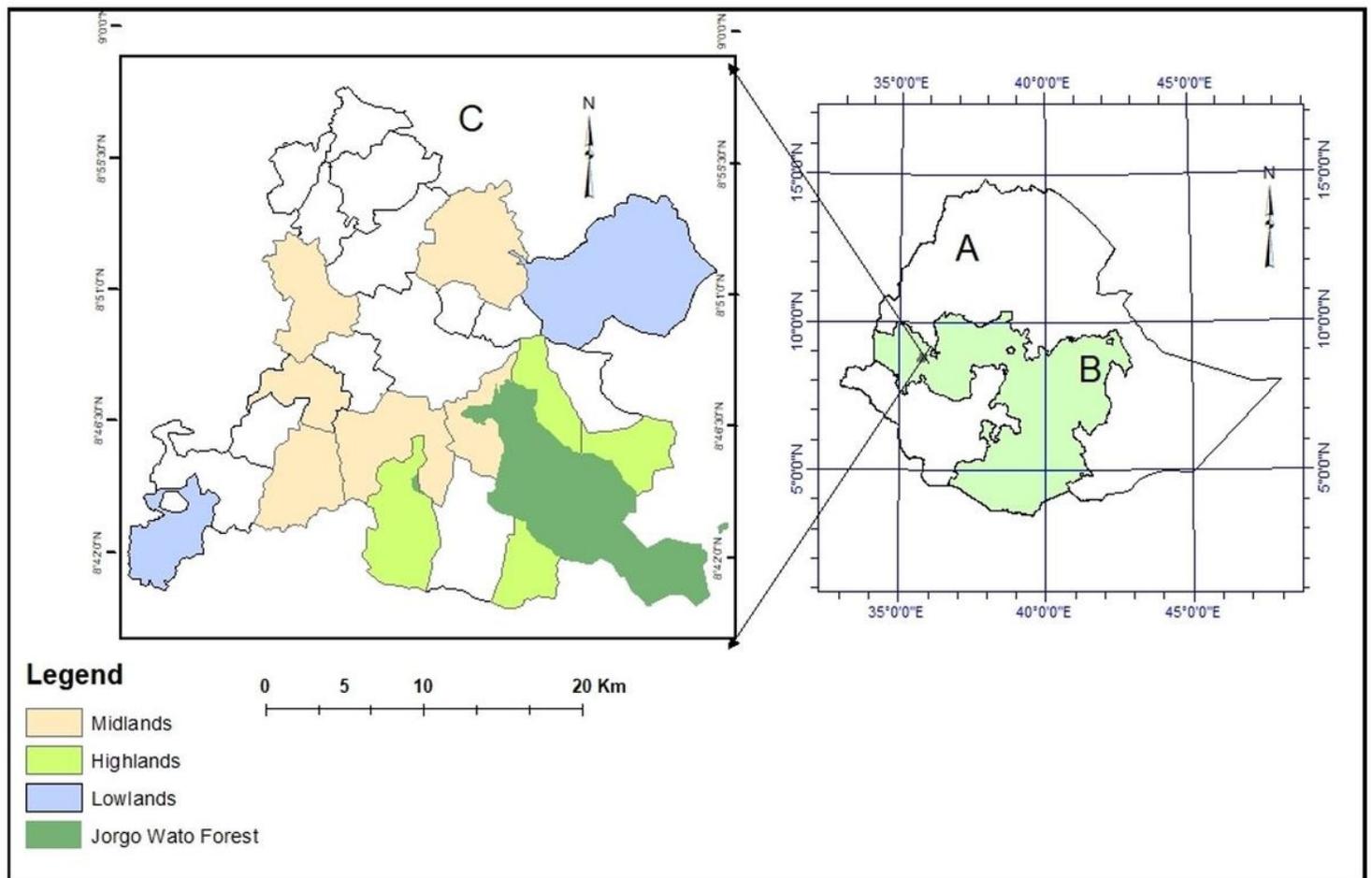


Figure 1

Map of Ethiopia showing the study area: (A) Ethiopia and Oromia Region (B) Nole Kaba District and sampled sites (C). Note: The designations employed and the presentation of the material on this map do not imply the expression of any opinion whatsoever on the part of Research Square concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. This map has been provided by the authors.

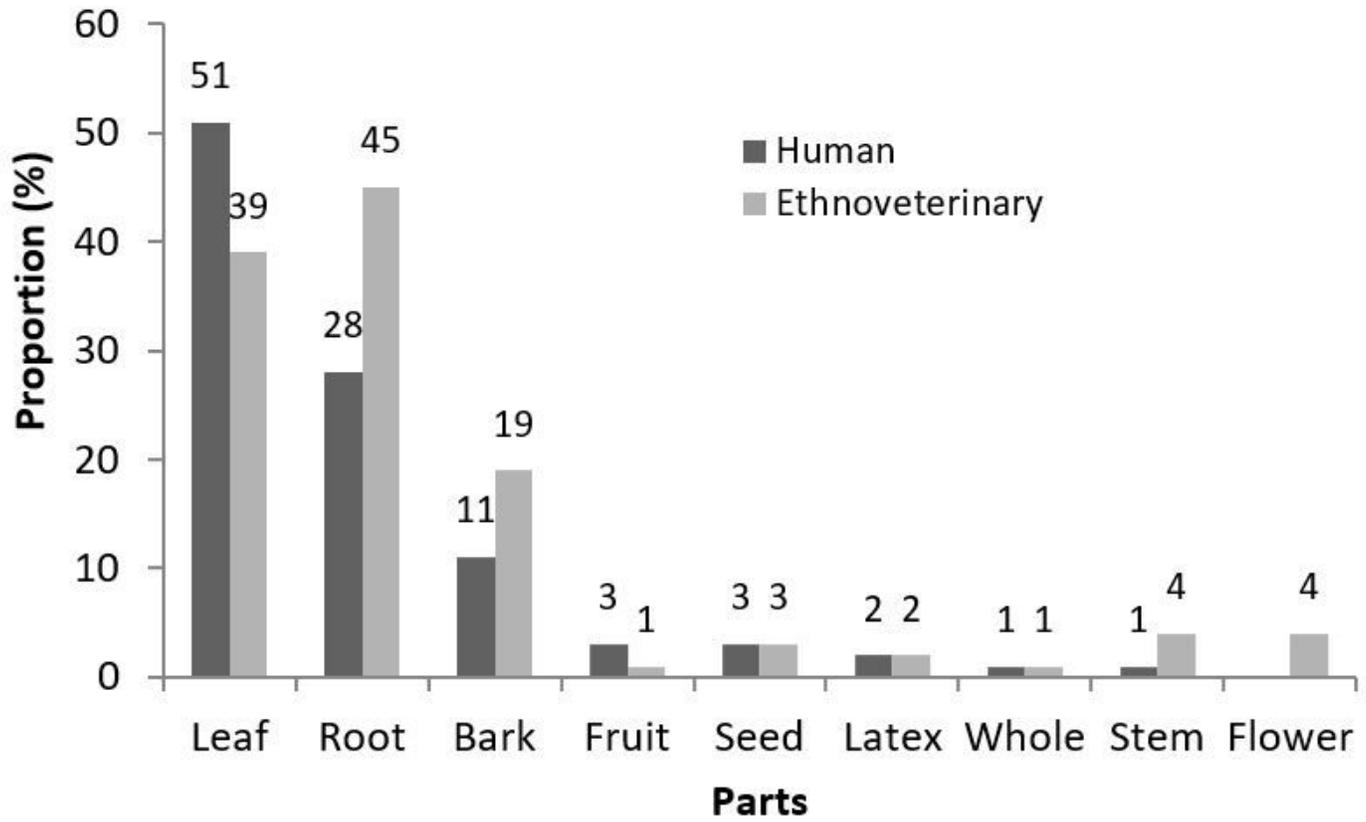
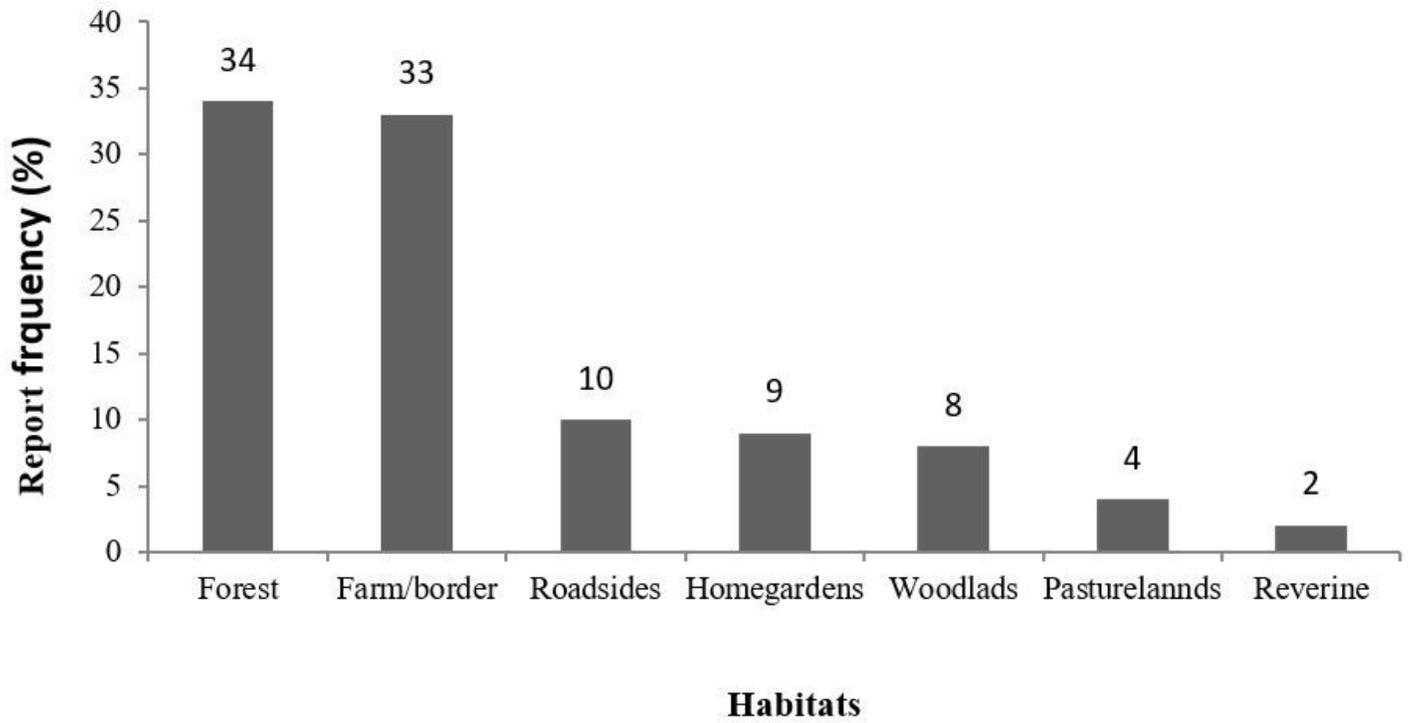


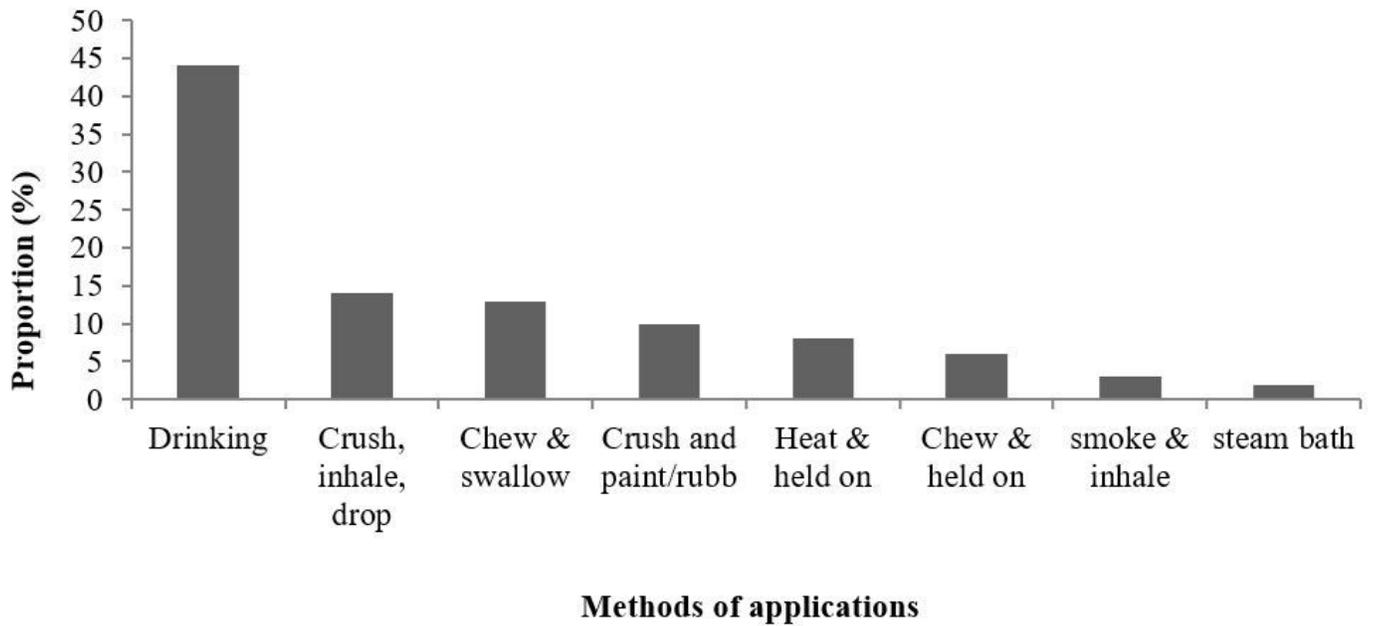
Figure 2

Proportion of medicinal plant parts used as remedies



**Figure 3**

Proportion of medicinal plants habitats



**Figure 4**

Mode of application of remedies