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Ethiopian Common Medicinal Plants: Their Parts and Uses in Traditional Medicine - Ecology and Quality Control

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Abstract

The main purpose of this review is to document medicinal plants used for traditional treatments with their parts, use, ecology, and quality control. Accordingly, 80 medicinal plant species were reviewed; leaves and roots are the main parts of the plants used for preparation of traditional medicines. The local practitioners provided various traditional medications to their patients' diseases such as stomach-aches, asthma, dysentery, malaria, evil eyes, cancer, skin diseases, and headaches. The uses of medicinal plants for human and animal treatments are practiced from time immemorial. Stream/riverbanks, cultivated lands, disturbed sites, bushlands, forested areas and their margins, woodlands, grasslands, and home gardens are major habitats of medicinal plants. Generally, medicinal plants used for traditional medicine play a significant role in the healthcare of the majority of the people in Ethiopia. The major threats to medicinal plants are habitat destruction, urbanization, agricultural expansion, investment, road construction, and deforestation. Because of these, medicinal plants are being declined and lost with their habitats. Community- and research-based conservation mechanisms could be an appropriate approach for mitigating the problems pertinent to the loss of medicinal plants and their habitats and for documenting medicinal plants. Chromatography; electrophoretic, macroscopic, and microscopic techniques; and pharmaceutical practice are mainly used for quality control of herbal medicines.

Keywords: medicinal plants, herbal medicine, chromatography, histological techniques, pharmaceutical practices, microscopic and macroscopic examination

1. Introduction

Medicinal plants are very vital in their uses for medication, besides providing ecological, economic, and cultural services. The world primary means of treating diseases and fighting infections have been based on the use of medicinal plants. From ancient times, plants have been rich sources of effective and safe medicines [1]. Globally, about 64% of the total world population is reliant on traditional medicine for their healthcare needs [2]. According to the World Health Organization (WHO), nearly 3.5 billion people in developing countries including Ethiopia believe in the efficiency of plant remedies and use them regularly [3].

Ethiopia is located in the Horn of Africa between 3 and 15° northing, latitude, and 33 and 48° easting, longitude, and is also comprised of nine national regional states and two administrative states with varied agroecological zones. Since the country is characterized by a wide range of ecological, edaphic, and climatic condition, Ethiopia is also very diverse in its flora composition [4]. The flora of Ethiopia is estimated to contain close to 6500–7000 species including medicinal plants; of those, 12–19% are endemic to the country [5]. The medicinal plants have been used for various types of human and animal treatments in the country. According to [6, 7], in Ethiopia, about 80% of human population and 90% of livestock rely on traditional medicine. As also stated by many authors (e.g. [6, 7]), the medicinal plants have shown very effective medicinal values for some diseases of humans and livestock.

Even due to the trust of communities on medicinal values of traditional medicines, culturally associated traditions, and their relatively low cost, medicinal plants are highly demanded in Ethiopia [7]. Inadequate health centers and shortage of medicines and personnel in clinics might be the other reasons for driving the people of Ethiopia, in general, and the low-income community and the rural people, in particular, to the traditional health centers, whereby increasing the demand of medicinal plants.

However, these plants have got little attention regarding the documentation of scientific names, uses, ecology, and conservation in Ethiopia, in particular and world-wise, in general. Moreover, in Ethiopia, traditional medicine is faced with a problem of sustainability and continuity mainly due to the loss of taxa of medicinal plants [8, 9] besides having lack of quality control for herbal medicines. The main causes for the loss and decline of diversity of plants in Ethiopia are human-made factors [10–12]. Habitat destruction and deforestation for commercial timber and forest encroachment for urbanization, investment, agriculture, and other land uses are the major causes of the loss of many thousand hectares of forest that harbor medicinal plants yearly for the past several decades. In addition to these, the medicinal plant materials and associated traditional knowledge are being lost due to the lack of systematic conservation, research, proper utilization, and documentation [13]. The knowledge on identifying and managing the medicinal plants with their parts, use, and ecology is mostly associated with local and elder people, who transmitted their knowledge verbally. Such verbal transmissions of knowledge on medicinal plants have thus resulted in eroding and loss of knowledge and the plant materials as well. The quantity and quality of the safety and efficacy data on traditional medicine are also far from sufficient to meet the criteria needed to support its use worldwide [14]. Therefore, assessing and documenting the medicinal plants along with their useful medicinal parts, use, and ecology in Ethiopia, as well as revising the quality control for herbal materials and medicine, are very crucial for giving priority to their conservation and sustainable utilization.

2. Materials and methods

The materials for this review were published documents. However, regarding the screening of medicinal plants, some medicinal plants not yet identified or available in more than one article being revised during this revision time, and published before 2000 with their uses, were not listed and included for this review analysis so as to increase the quality of the present review, provide the current information to the readers, and restrict the revised papers. Based on this, of the total (32) revised documents, 15 articles, which are assessing the different medicinal plants with their uses and parts, were revised for documenting the medicinal plants for this review.

Additionally, the habitats (ecology) of each medicinal plant were assessed from the Flora Volumes of Ethiopia and Eritrea and [15], besides the articles revised for listing the medicinal plants for this review. The data were analyzed and described quantitatively using frequency, percentage, tables, and figures via applying Microsoft Excel Spreadsheet 2010 and SPSS with version 20, as well as qualitatively using content analysis, narrating via drawing sub-contents.

3. Medicinal plants: their parts, uses, and ecology reviewed

Traditional healers in Ethiopia utilize the herbal resources available in nature for various disease treatments. As reported before, approximately 800 species of the medicinal plants grown in Ethiopia are used for treating about 300 medical conditions [16]. However, based on the present review, the number of medicinal plants and the treatments/medications identified and listed are limited as presented here under section by section.

3.1 Medicinal plants and their growth forms and parts used

3.1.1 Composition and growth forms of medicinal plants

As reported by many authors [6, 7, 12, 13, 17–27], there are different types of medicinal plant species with their parts, habitats, and disease types being treated and described here in **Table 1**. Accordingly, as depicted in **Table 1**, there were 80 medicinal plant species with 63 genera, used by the local communities for various human treatments. Among other revised, the common medicinal plants used for treating and curing various diseases are *Aloe* species, *Eucalyptus globulus*, *Hagenia abyssinica*, *Cupressus macrocarpa*, *Buddleja polystachya*, *Acmella caulirhiza*, *Acacia* species, *Citrus* species, *Clematis* species, *Coffee Arabica*, *Croton macrostachyus*, *Euphorbia* species, *Ficus sycomorus*, and *Moringa stenopetala* (**Table 1**).

Based on the review, all plant growth forms were not equally used as remedies, because of the difference in distribution among the growth forms. Accordingly, the life forms of medicinal plants reviewed constituted 18 trees (22.78%), 23 shrubs (29.11%), 29 herbs (36.71%), 3 climbers (3.81%), 4 trees/shrubs (5.06%), and 2 herbs/shrubs (2.53%) (**Figure 1**). Of all life forms, herbs were, thus, the major medicinal plants used by the community for human treatment followed by shrubs and trees.

3.1.2 Medicinal plant parts used for preparation of traditional remedies

The review indicated that the plant parts used for medication preparation by the traditional healers are variables. Healers mostly used fresh specimens from commonly available plants [25] to prepare remedies for their patients; this might be mostly due to the effectiveness of fresh medicinal plant parts in treatment since the contents are not lost before use compared to the dried ones [12]. As also referred from many authors, the traditional healers have harvested leaves, roots, barks, seeds, fruits, stems, flowers, barks, seeds, or latex of medicinal plants (**Figure 2**) to prepare their traditional medicines for their patient treatments. As depicted in **Figure 2**, most remedies were prepared from the leaf (32.98%) and root (29.79%) parts of the medicinal plants to treat the diseases compared to the other parts of them. This finding of the review is in line with the findings of the majority of authors' papers (e.g. [18, 25, 27]). The main reason that many traditional medicine practitioners used the leaf parts compared to others for remedial preparation is due to their accessibility and for preventing them from extinction [25]. In fact,

Scientific names	Local name	Ha.	Habitat	Parts used	Uses [references cited]
<i>Acacia abyssinica</i> Hochst ex. Benth	Qontir	S	Deciduous bushland	Leaves	Used for treating goiter [18, 22]
<i>Acacia nilotica</i> (L.) Del.	Girar	T	Dry bushland	Fruits Leaflets	For treating diarrhea, diabetes, sore gum, hemorrhage, and loose teeth For curing sickness of stomach [19, 21, 27]
<i>Acacia albida</i> Del.	Grar	T	Dry bushland	Latex	Latex from the stem pounded is taken with honey for curing amebiasis; for treating fire wound [13, 27]
<i>Acmella caulirhiza</i> Del.	Yemdir berbere	H	Wetlands, forest floors, stream banks	Leaves Flowers	Used for curing tonsillitis via chewing the flowers and spitted on tonsillitis [18, 22]
<i>Aerva javanica</i> (Burm.f.) Schultes	Nech shinkur	S	Dry sandy plains, dried river course	Root	For treating cancer [20, 24]
<i>Allium sativum</i> L.		H	Irrigable cultivated land, home garden	bulb	For preventing and treating malaria [7, 13, 18, 22, 23, 25]
<i>Amaranthus caudatus</i> L.	Chigogot	H	Roadsides, riverbanks, floodplain	Leaves	Used for curing diarrhea via pounded and boiled leaves [18, 22]
<i>Aloe monticola</i> Reynolds	Eret	H	Steep bare mountain slopes	Root	For also curing anthrax by pounding the root and mixing it with cold water and local alcohol [12, 22]
<i>Aloe macrocarpa</i> Reynolds		H	Rocky slopes	Leaves	For preventing wart by powdering leaf and then mix it with honey [12, 22, 26]
<i>Artemisia abyssinica</i> Sch. Bip. ex. Rich	Chigugn	H	Juniper forest, open grassland, fallow fields	Fresh root	For preventing evil spirit by smelling and drinking after crushing the root and normalizing it in water [7, 22, 25]
<i>Asparagus africanus</i> L.	Yeset qest	H	Acacia woodland Forest margins	Roots	For curing uterine and breast cancer [17, 20, 24]

Scientific names	Local name	Ha.	Habitat	Parts used	Uses [references cited]
<i>Barleria eranthemoides</i> R. Br. ex C. B. Cl	Yeset af	S	Acacia woodland Scrublands	Roots	For curing hear burn [12]
<i>Bersama abyssinica</i> Fresen.	Azamir	T	Riverine forest, rainforest	Leaves- stem	For treating wound by squeezing the leaves and creaming on the wound [22, 24]
<i>Bridelia scleroneura</i> Mul. Arg.		T	Open woodland Dry riverine forest	Seeds	For curing skin diseases by crushing and applying on wound parts [12, 18, 19]
<i>Brucea anti dysenterica</i> Fresen.	Abalo	S/T	Montane, evergreen forest margins	Leaves	For treating cancer, skin problem, leprosy, and external parasites [6, 25]
<i>Buddleja polystachya</i> Fresen.	Anfar	T	Degraded woodland in cultivated fields, around houses	Leaves	For treating the cattle eye diseases by chewing and spitting on the affected area [18, 22]
<i>Calpurnia aurea</i> (Ait.) Benth.	Digita	S	Forest margins, bushland/grassland, favored by over grazing	Leaves Roots Seeds	For preventing poisonous snake bite by boiling the leaves and drinking with honey [12, 24] For curing amebiasis by crushing and boiling with leaf of coffee for drink. The seeds can be used as a fish-poison or as a cure for dysentery [12]
<i>Capparis tomentosa</i> Lam		S	Riverine forest, grassland with scattered trees	Bark	For curing sore, anthrax, and evil eye using the powder of the bark with hot water [18, 20]
<i>Carica papaya</i> L.	papaya	T	Home gardens, small and large plantations	Seeds	Used for treating diarrhea and ascariasis by drinking the ground and boiled seeds with honey [12, 19, 27]
<i>Carissa edulis</i> (Forsk.)	Agam	S	Open <i>Acacia</i> bushland	Root	Used for shorten the labor period just before delivery of women [19, 21]

Scientific names	Local name	Ha.	Habitat	Parts used	Uses [references cited]
<i>Carissa spinarum</i> L.	Agam	S	Disturbed areas, along edges of roads, riverine vegetation	Roots	Used for preventing evil eye by inhaling the smoke of pounded roots. It is also used for treating wounds via applying the powder of the roots [12, 17, 19, 27]
<i>Clausena anisata</i> (Wild.) Benth.	Limich	S	Montane forest margins, moist forest, secondary bushland	Leaves	For treating skin irritation by pounding together the leaf of <i>C. anisata</i> , <i>Solanecio gigas</i> , and <i>Justicia schimperiana</i> [6, 18, 20, 22]
<i>Citrus aurantifolia</i> Swingle	Bahre-Lomi	T	In lowlands, evergreen forest	Fruit	For treating dermatophyte [6, 12, 19]
<i>Citrus sinensis</i> (L.) Engl.	Birtukan	S	Cultivated in irrigable areas	Fruit Bark	Used for treating stomach infection and wound [12, 18]
<i>Clematis hirsuta</i> Per.	Nech Azo hareg	Cl	Edges and remnants of montane forest, roadsides, paths	Leaves/ stems Barks	Used for treating tumor/cancer on the neck [19, 24]
<i>Clematis simensis</i> Fresen.	Hareg	Cl	>>	Leaves Root	Used for curing wound and stomachache [12, 18]
<i>Clerodendrum myricoides</i> (Hochst.)	Misrich	S	Not specified yet	Root	Used for treating earache and headache [12, 20]
<i>Coffea arabica</i> L.	Buna	S	In shaded coffee plantations	Seeds	For curing diarrhea by pounding and mixing with honey [6, 12, 18]
<i>Cordia africana</i> Lam.	Wanza	T	Moist evergreen forest, riverine vegetation, woodland, grassland	Roots	For curing itching via applying the powder of the root on the area [6, 12, 13, 18, 19]
<i>Crinum abyssinicum</i>	Yejb shinkurt	H	Waterlogged valley grasslands, swampy or along stream banks, fallow fields	Leaves	Used as treatment of tumor in general [13, 20, 24, 25]
<i>Croton macrostachyus</i> Hochst. ex Del.	Bisana	T	Forest margin, edges of roads, disturbed areas, woodland	Bark	For curing splenomegaly and gonorrhoea [12, 17, 18, 20, 22, 25]
<i>Croton zambesicus</i>	Bisana	T	Stony streambeds, within broad-leaved deciduous woodland	Bark	Used for treating mental disturbance [21, 27]

Scientific names	Local name	Ha.	Habitat	Parts used	Uses [references cited]
<i>Cucurbita pepo</i> L.	Duba/ Yebarqil	H	Cultivated in home garden, farmland	Leaves	Used as a means of treating gastritis [12, 22]
<i>Datura stramonium</i> L.	Atse-faris	H	Disturbed places, waste ground, near water holes, roadsides	Seed	Used for treating depression [22, 25]
<i>Dodonaea angustifolia</i> (L.fil.) J.G.West		S	Not defined	Root	For curing toothache and wound [6, 7, 12, 18, 23]
<i>Dorstenia barnimiana</i> Schwienf.	Worq-bemeda	H	Woodland bushland, upland grassland, evergreen bushland	Roots/ tubers	For treatment of tumor visible in body surface [20, 24]
<i>Echinops kebericho</i> , Mesfin	Kebericho	H/S	Montane <i>Acacia</i> woodland, disturbed bushland	Root	For treating toothache, vomiting, and headache [22, 27]
<i>Ehretia cymosa</i> Thonn.	Oulaga	H/S	Montane and riverine forest, evergreen bushland, hedgerows around compounds	Leaves	Used for curing bleeding, fibril illness [12, 18]
<i>Eucalyptus globules</i> Labill.	Nech-bahirzaf	T	A wide variety sites (plantations)	Leaves	Used for treating influenza and allergic [7, 13, 18, 22, 23, 26]
<i>Euclea racemosa</i> L.	Dedeho	S	Open montane and bushland; in clearings and along margins	Roots	For treating evil spirit, evil eye, and heartburn [12, 17]
<i>Euphorbia tirucalli</i> L.	Qinchib	S	Live fence of home garden	Roots Latex	Used as treatment of tumor/cancer [7, 12, 23]
<i>Euphorbia abyssinica</i> J. F. Gmel.	Qulkual	T	Steep rocky hillsides, around churches; live fence at higher altitudes	Latex	For treating skin cancer [20, 22]
<i>Rhus natalensis</i> Beru ex Krauss.		H	<i>Acacia-Commiphora</i> woodland, wooded grassland, near rivers on various soil types	Leaves	Used for treating skin wound and boils [12, 21]
<i>Ficus sycomorus</i> L.	Banba	T	River and lake margins, woodland, forest edges and clearings, wooded grassland	Bark	For curing hepatitis [18, 19, 22]
<i>Gladiolus schweinfurthii</i> (Baker) Goldblatt and M.P. de Vos	Milas golgul	H	Open grassland; <i>Acacia</i> woodland; rocky limestone slope	Root	Used for treating headache [12, 22, 24]

Scientific names	Local name	Ha.	Habitat	Parts used	Uses [references cited]
<i>Glinus lotoides</i> L.	Meterie/ Amkin	H	Disturbed sites	Leafy stem	For treating tapeworm
<i>Guizotia scabra</i> (Vis.) Chiov.	Mechi	H	Open wasteland, grassland, weed of cultivation, roadside ditches, riverbanks	Leaves	Used as wound treatment [6, 22]
<i>Justicia schimperiana</i> Hochst. ex A. (Nees) T. Anders	Sensel	S	Open woodland, riverine vegetation, live fence of house	Leaves	For preventing bat urine [6, 7, 12, 18, 20, 26]
<i>Harrisonia abyssinica</i>	Ddugot	S	Montane forest and grassland	Barks	For giving human physical strength [21]
<i>Hagenia abyssinica</i> (Brucce) T.F.Gmel	Kosso	T	Montane forest and grassland Moist evergreen forest	Fruits	Tapeworm [7, 23, 25, 26]
<i>Laggera crispata</i> (Vahl.)	Gemie	S	Cultivation and waste places, grassland, riverbanks	Leaves	For preventing dizziness [12, 20]
<i>Maesa lanceolata</i> Forssk		T/S	Gallery forest, margin of evergreen forest, along river banks and streams, open woodland and valleys	Bark	For curing elephantiasis [6, 18, 26]
<i>Malva verticillata</i> L.	Lut	H	Paths and clearings in upland forest, upland grassland, cultivated areas near houses	Root	For curing cancer/ tumor [6, 18, 24, 25]
<i>Mimusops kummel</i> A. DC.	Safa/kummel	T/S	In gullies, in riverine forest, in riparian woodland, in woody vegetation on lake shores	Root	Used for preventing lung cancer [12, 18]
<i>Moringa stenopetala</i> (E.G. Baker) Cufod.	Shiferaw	T	Cultivated in terraced fields, gardens, small towns, in riverine and woodland	Root	Used for asthma relief [7, 12, 21]
<i>Musa sapientum</i> L.	Koba	H	Cultivated on large irrigated farms and in house gardens	Bulb	It is taken as an abortion medicine [19, 21]
<i>Nicotiana tabacum</i> L.	Timbaho	H	Cultivated in villages, home gardens, tobacco farms	Leaves	For treating snakebite [6, 12, 18]
<i>Nigella sativa</i> L.	Tikur azmud	H	Cultivated in homesteads, in fields; growing in wild	Seed	Used as treatment of headache [18, 22]

Scientific names	Local name	Ha.	Habitat	Parts used	Uses [references cited]
<i>Ocimum lamiifolium</i> Hochst. ex. Benth.	Damakesie	S	<i>Acacia-Commiphora</i> bush- and woodland, limestone slopes, home gardens	Leaves	Fibril illness [7, 12, 18, 20, 22]
<i>Olea europaea</i> L.	Woirra	T	Home garden, monasteries and churches, woody vegetation	Leaves/ roots	For curing dysentery, wound stomachache, bone TB [6, 12, 17, 18, 20, 26]
<i>Opuntia ficus-indica</i> (L.) Miller	Yebereha qulkual	S	Disturbed areas, degraded areas, live fence of houses	Leaves	For killing malaria vectors [22, 25]
<i>Plumbago zeylanica</i> L.	Amira	H	Disturbed habitats by roads and paths, bushland, woodland, savannah	Root	For preventing gonorrhoea and hemorrhoids as well as for toothache [12, 20, 22]
<i>Verbascum sinaiticum</i> Benth.		H	Disturbed sites	Root/ leaves	For treating heart disease, cancer, trypanosomiasis [6, 20, 27]
<i>Premna schimperi</i> Engl.	Chocho	S	Degraded and secondary forests, grassy meadows and along paths in forests	Root Leaves	Used for treating mastitis Used for preventing boils [12, 18]
<i>Solanum nigrum</i>	Embuay	H	In cultivation and ruderal areas, on road-, hill-, river- or streamsides; in bushland areas	Leaves roots, stems	Leaf, root, and stalk are used for cancerous sores and wound treatments. Stems eaten as pot herb for virility in men and for dysmenorrhoea in females, for dysentery, and sore throat [21, 24]
<i>Solanum incanum</i> L.	Tikur awud	H	Cultivated and riverine gallery forest, disturbed habitats	Leaves/ roots	Used for curing bleeding, menstruation, amebiasis [12, 17–20]
<i>Stephania abyssinica</i> (Dill. and A. Rich.) Walp. (Etse Eyesus, Nech- Hareg)	Yayit hareg	Cl	In thickets bordering forest margins, hillsides, cultivated fields, in clearings	Root	For treating external tumor/ cancer and stomachache [6, 12, 8, 24, 25]
<i>Stereospermum kunthianum</i> Cham.	Arziniya	S/T	Open woodland and savanna, widespread in tropical Africa	Bark	Used for treating kidney via drinking the juice crushed from bark [12, 13, 19]

Scientific names	Local name	Ha.	Habitat	Parts used	Uses [references cited]
<i>Tamarindus indica</i> L.	Humer/Roqa	T	Grassland, woodland <i>Combretum</i> bushland, riparian	Fruit	Used for curing stomachache; it is also used for treating bile and intestinal worm using the fruit juice with hot water in the morning before breakfast [12, 19]
<i>Thunbergia ruspolii</i> Lindau	Marte	H	<i>Combretum</i> - <i>Terminalia</i> woodland, grassland, wooded grassland, evergreen forest, seasonally waterlogged	Not reported	For curing poisonous snakebite [21]
<i>Thymus capitatus</i> (L.) Link	Tosign	H	Not reported	Leaves	For curing stomach diseases, cough, and asthma [21, 25]
<i>Tragia cordata</i> Michx.	Alebilabet	H	Among open rock bushlands	Root	For treating urinary tract and external parasite [12, 18, 19]
<i>Tribulus terrestris</i> L.	Kurnchit	H	Open and disturbed places, often on sandy soils	Stem Fruit Seed	For curing scabrous skin diseases For congestion, headache, hepatitis, liver, vertigo, stomatitis, kidneys, liver, and vision For treating anemia, hemorrhoid coughs, fluxes, and stomatitis [21]
<i>Urtica pilulifera</i> L.	Sama	H	Unknown	Leaves	For curing sore joints by mixing the plant juice with oil; provide cure for rheumatism and hemorrhage [18, 21]
<i>Vernonia amygdalina</i> Del.	Girawa	S	Bush/woodland, forest habitats, home gardens	Leaves	For preventing headache and intestinal worm and for treating tumor/cancer in general [6, 7, 12, 18, 20, 22, 24, 26, 27]
<i>Xanthium strumarium</i> L.	Deha nikel	H	Wet forest margins, in riverine vegetation by streamside	Leaves	Used for treating dandruff [12, 27]

Scientific names	Local name	Ha.	Habitat	Parts used	Uses [references cited]
<i>Ximenea americana</i> L.	Enkoy	S	<i>Acacia</i> woodland, <i>Acacia-Ballanites</i> , woodland, <i>Combretum-Terminalia</i> , wooded grassland	Fruit Kernel Root	Oil from the fruit kernel is applied to fresh wounds to prevent infections and also used by some people, who have their ears or lips pierced Used for treating stomachache and tonsillitis [6, 12, 19, 20]
<i>Warburgia ugandensis</i> Sprague		T	Transitional montane forest, adjacent woodland	Stem	Used for treating boils and cough [12, 17]
<i>Withania somnifera</i> L. Dunal	Gizawa	S	In cultivations, disturbed places in the highlands, on lake shores, along riverbanks in disturbed places in open woodland	Leaves	Used for treating malaria [12, 13, 17]
<i>Ziziphus spinachristi</i> (L.) Desf	Qurqura	T	Wooded grassland, along dry riverbeds, edges of cultivations and home gardens	Fruits	Used for treatments of stomachache, tonic, for tooth aches, and tumors [21, 13]

NB: Ha, habits; T, tree; S, shrub; H, herbs; Cl, climbers; T/S, shrubs/trees; H/S, herbs/shrubs.

Table 1.
 List of reviewed Ethiopian medicinal plants used for various traditional disease treatments with their parts and ecology/habitat.

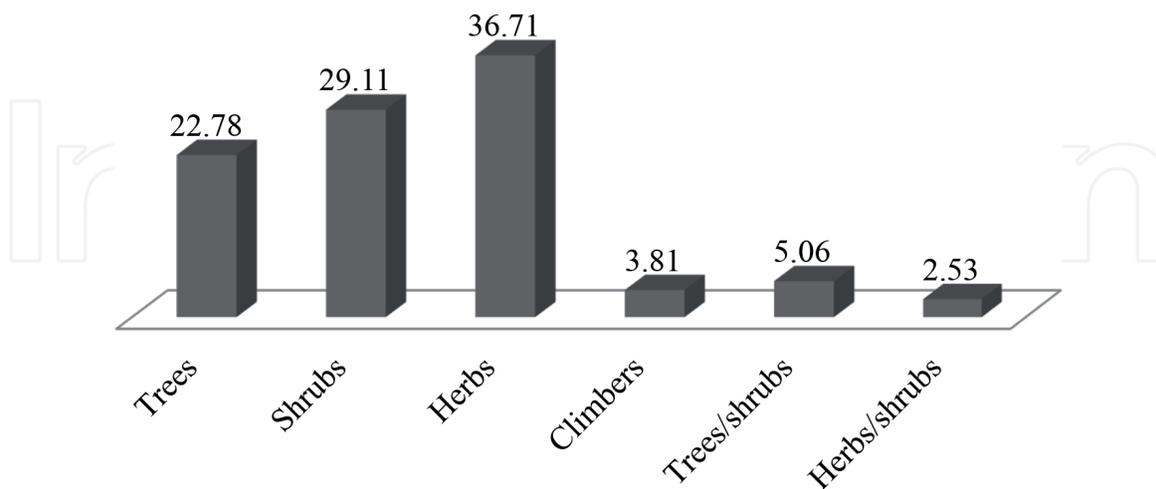


Figure 1.
 Life forms/habits of medicinal plants reviewed with their percentage (%).

harvesting the root parts of the medicinal plant for preparation of traditional medicines has negative consequences on the existence of the plants themselves in the future. That is why most of the medicinal plants are currently at risk, declining highly due to them using their root parts besides other human pressures.

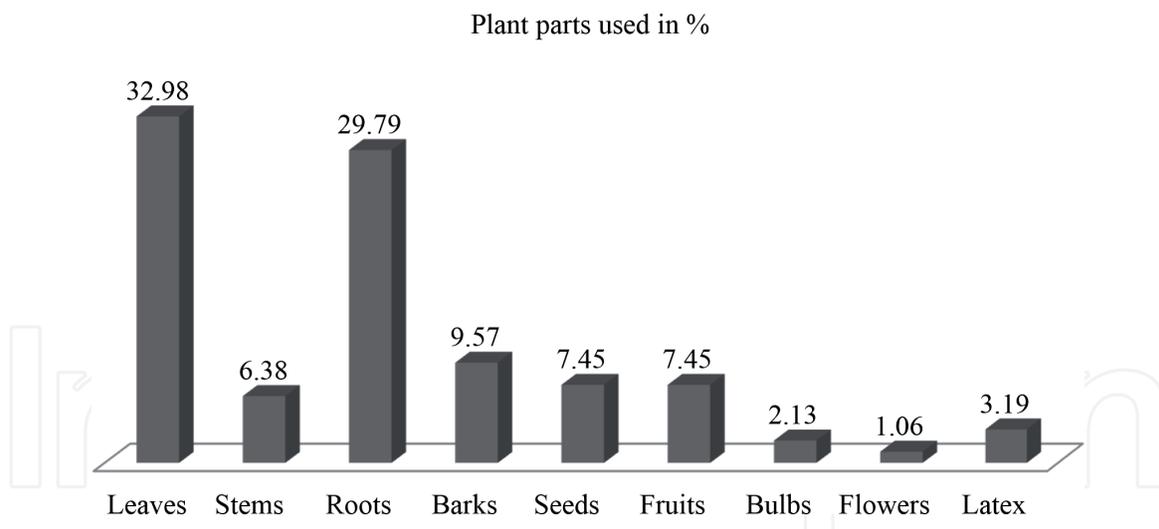


Figure 2.
Distribution of medicinal plant parts used for disease traditional treatments by healers.

3.2 Uses of medicinal plants in treating different disease types

Using these medicinal plants revised in **Table 1**, the local communities could be able to treat about 69 disease types. The disease types treated by these various medicinal plants were skin disease, gonorrhoea, diarrhoea, wound, tapeworm, snake bites, stomachache, headache, evil eye, heartburn, cancer/tumor, and malaria (see **Table 1** for the detail). Particularly, most of the patients (who come from rural areas) with their perspective disease types have been treated by traditional healers, before coming to clinics and/or hospitals located far away by many kilometers from their residential areas. The disease types most frequently treated by traditional medications (traditional healers) provided by those medicinal plants were stomachaches, wounds, cancers/tumors, skin diseases, headaches, toothaches, and coughs and diarrhoea, which took the first, second, third, fourth, fifth, sixth, and seventh ranks, respectively, although the majority of disease types were frequently treated less than four times, ranging from one to three times (**Table 2**). This also points out that one medicinal plant species can be used for treating more than one disease types.

Because of this, medicinal plants are very vital in providing traditional medicines, prepared by local healers, and thereby used for treating and curing different types of diseases that affected the local communities, where they occurred. Even, following the traditional uses and effectiveness of the medicinal plants [23], the traditional healers are also popular by the local societies, providing cultural values. The study of [23] also confirmed that the traditional health practitioners are with a good knowledge of medicinal plants used to treat different diseases of their locals.

In addition to these contributions pertinent to traditional medications and cultural values, the individual medicinal plants could provide regulating, provisioning, and supporting services. For instance, they could provide regulating services via regulating soil erosion, climate change, disease, pollution, and pollination; they also provide provisioning services such as fuel wood, timber for house construction, food (fruits, honey), and fodder and shelter for wild animals [11]. Hence, almost all of the medicinal plants are multipurpose species, providing more than one benefits.

3.3 Ecology and/or habitats of medicinal plants

As referred from the revised documents for this review, the habitat preference of medicinal plants varied from place to place (**Table 1**). As referred in **Table 1** and

No. of disease type	Frequency of treatments	Rank
1 (Stomachaches)	12	1
1 (Wounds)	11	2
1 (Cancer/tumor)	10	3
1 (Skin diseases)	7	4
1 (Headaches)	6	5
1 (Toothaches)	5	6
2 (Cough, diarrhea)	4 (each)	7
8 (Tonsillitis, malaria, evil eye, snakebites, dysentery, boils, throat sore, intestinal worms)	3 (each)	8
10 (Earache, amebiasis, urinary tract, heartburn, external parasites, fibril illness, kidney, liver, hemorrhoids, tapeworms)	2 (each)	9
43 (Elephantiasis, asthma, eye diseases, diabetes, anthrax, leprosy, etc.)	1 (each)	10

Table 2.
Disease type categories and their rank based on their frequency being treated by different medicinal plant species (as described in Table 1).

Figure 3 drawn from the review, the majority of medicinal plants were available along the edges of river/streams and wetlands, disturbed sites, grasslands, cultivated lands, woodlands, bushland, grasslands, and home gardens. Generally, the majority of medicinal plants were found in wild compared to those plants found in cultivated and home gardens together. Many of the authors of the reviewed articles (e.g. [12, 23, 25]) confirmed that the majority of medicinal plants were collected from natural habitats or wild by traditional practitioners compared from home gardens. Among medicinal plants found along stream/riverbanks (**Figure 3**), the majority of them are supposed to be medicinal plants having herbal life forms/habits (**Figure 1**). This could be due to their shallow roots, which cannot bring water from the deep parts of their habitats.

Because of the anthropogenic factors such as over harvesting, fire/deforestation, agricultural expansion, overgrazing, and urbanization [25, 28], most of the medicinal plants have also been lost. This implies that the availability and accessibility of most medicinal plants in Ethiopia are also very difficult [25]. Hence, most of the medicinal plants were restricted to areas (such as cliffs, hills/mountains, gorges, disturbed areas, riverbanks, and valleys of wild) which are not easily accessible to use/harvest them. Not only is this, but also the knowledge of traditional practitioners pertinent to identification of medicinal plants with their parts and ecology and the process of preparation of herbal medicines and medication with their quality/effectiveness are declined/lost since the knowledge is mostly transferred orally from generation to generation, not documented. Therefore, the effects of human on the natural habitat of medicinal plants are the problems for the conservation of medicinal plants and associated knowledge of traditional healers [12]. With the present ecological and socioeconomic changes, medicinal plants together with the associated ethnobotanical knowledge in Ethiopia are under serious threat and may be lost at alarming rate.

Under such circumstances, the use of plants for medicinal purposes will also decline, and consequently the once effective traditional healthcare system will also be lost [19]. Hence, documenting medicinal plants with their uses and ecology as well as the knowledge of traditional practitioners is so vital. Moreover, it is very essential to give conservation priority for those medicinal plants through

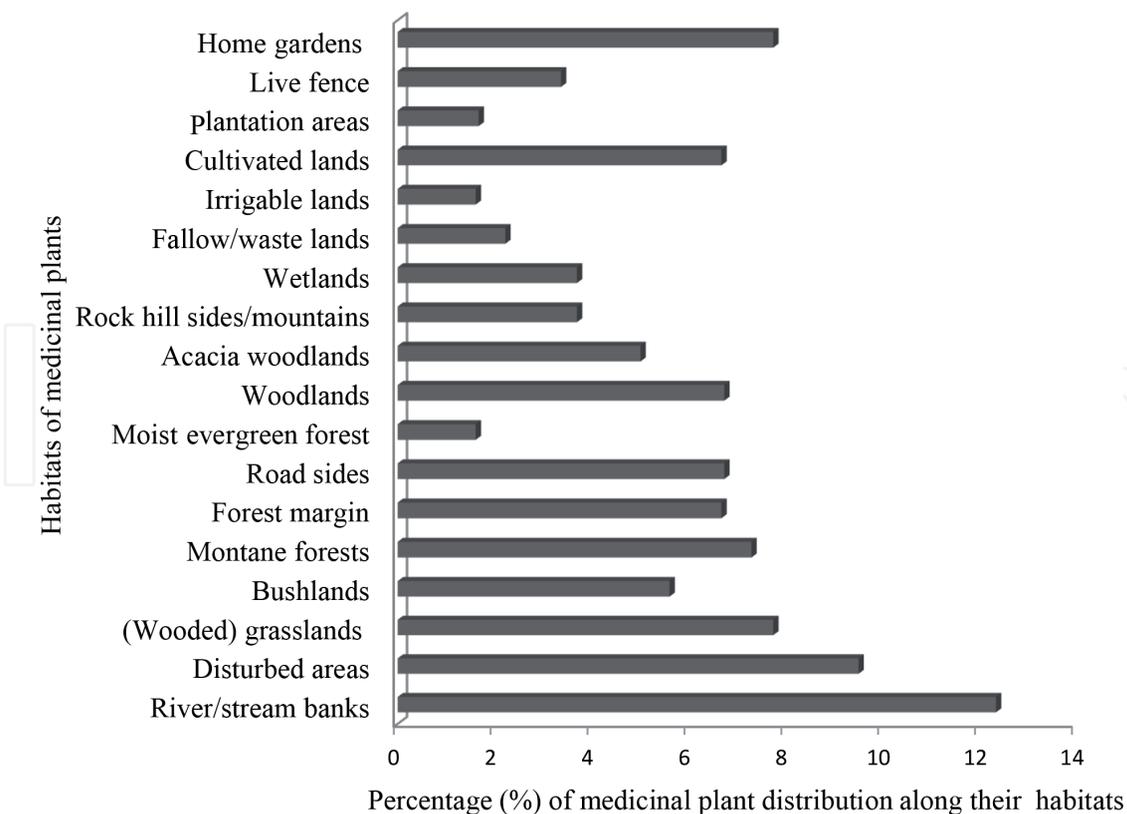


Figure 3. Summary of distributions of medicinal plants along their major habitat categories in Ethiopia.

protecting them where they are found, propagating them in cultivated areas and home gardens, and creating awareness to the locals. Hence, following community and research-based approach is advised to save medicinal plants from their loss and extinction.

4. Applied plant anatomy: quality control of herbal medicine

4.1 General overview

Plant materials are used throughout developed and developing countries as home remedies, as over-the-counter drug products, and as raw materials for the pharmaceutical industry, which represent a substantial proportion of the global drug market [29]. Thus, the traditional herbal medicines and their preparations have been widely used for thousands of years in many countries. Therefore, it is so essential to overview here some modern control histological techniques or tests, suitable standards, and practical experiences used for assessing the quality of medicinal materials and their products. Quality control of herbal medicine using histological techniques and pharmaceutical practices is also very vital for avoiding the risks happened on patients and the beliefs in services provided by traditional healers. According to [30], quality control is a phrase that refers to processes involved in maintaining the quality or validity of the manufactured products. However, the quality control of herbal medicine is beyond this, meaning it is the management of medicinal plants and their products during cultivation, identification process of the plant species with their parts and localities (their being free from polluted environment causing diseases), and medicine preparation including its components, medication processes, storage standards, and dosage; all should be taken into account. This means, without proper all-round quality control,

there is no assurance that the contents of the herbs contained in the package are the same as what are stated outside the package [30]. Climatic factors (prevailing temperature, rainfall, humidity, altitude of the growing region, light), nutritional factors (nutrients, pH, cation exchange capacity), harvesting factors (age, season, collection time, plant organ), and post-harvesting factors (storage hygiene, drying process) are the major factors affecting the contents and composition of medicinal plant raw materials and their products [29, 30]. For these, some of the most important laboratory test methods (histological techniques), common sense, and good pharmaceutical practices are used [29]. Techniques such as thin-layer chromatography and microscopic and electrophoretic techniques are widely used to evaluate the quality of herbal drugs [14, 29, 31] and the content and quality of meats [32] as well. These techniques and good pharmaceutical practices are also used to support the development of national standards based on local market conditions, with due regard to existing national legislation and national and regional norms [29]. Therefore, improved and currently available pharmaceutical analytical methods led to improvements in harvesting schedules, cultivation techniques, storage, product purity, and activity and stability of active compounds [30].

4.2 Major quality control methods for medicinal plant materials and their products

Among others, thin-layer chromatography, macroscopic and microscopic examinations, gas chromatography and volatile components, and electrophoretic techniques [14, 29] are the most important quality control methods for medicinal plant materials and their products, described briefly here below.

4.2.1 Macroscopic and microscopic examinations

Herbal materials are categorized based on sensory, macroscopic, and microscopic characteristics, which are the first steps toward establishing the identity and the degree of purity of such materials, and should be carried out before any further tests undertaken, according to [29]. Therefore, to establish identity, purity, and quality, visual inspection (macroscopic examination) provides the simplest and quickest means. Herbal materials should be entirely free from visible signs of contamination such as insects, molds (fungi), and other animal contamination, including animal excreta; any soil, stones, sand, dust, and other foreign inorganic matter must also be removed before herbal materials are cut or ground for testing [29]. Moreover, plant parts used for medication with abnormal odor, discoloration, slime, or signs of deterioration should be detected to exclude them from being used for medication products.

Moreover, during storage, products should be kept in a clean and hygienic place for avoiding contamination occurring; special care should also be taken to avoid formation of molds, since they may produce aflatoxins [29]. For determination of foreign matter and storage conditions, macroscopic examination can properly be employed for determining the presence of foreign matter in whole or cut plant materials. For these, common sense and good pharmaceutical practices are used. Such common senses and good pharmaceutical practices can, even, be used after laboratory tests since the test procedures cannot take account of all possible impurities in deciding whether an unusual substance not detectable by the prescribed tests can be tolerated [29]. For instance, if a sample is found to be significantly different from the specifications in terms of color, consistency, odor, or taste, it is considered as not fulfilling the requirements. However, such examination may need further microscopic examination for either rejecting or accepting their requirements.

4.2.2 Thin-layer chromatography (TLC)

This technique is simple, can be employed for multiple sample analysis, and so has manifold possibilities of detection in analyzing herbal medicines [14]. The report of [29] also confirmed that TLC is used for evaluating herbal materials and their preparations; particularly, it is valuable for the qualitative determination of small amounts of impurities.

4.2.3 Gas chromatography (GC) and volatile components

Many pharmacologically active components in herbal medicines are volatile chemical compounds; thereby, the analysis of volatile compounds by gas chromatography is very important in the analysis of herbal medicines [14]. GC is a useful analytical tool in the research field of herbal medicines via analyzing their volatile oils, which have a number of advantages: (1) the GC of the volatile oil gives a reasonable “fingerprint” which can be used to identify the plant and to detect the presence of impurities in the volatile oil, and (2) the extraction of the volatile oil is relatively straightforward and can be standardized, and the components can be readily identified using GC analysis [14].

4.2.4 Electrophoretic method

It is a good tool for producing the chemical fingerprints of the herbal medicines and has similar technical characteristics of liquid chromatography [14]. Electrophoretic method, especially capillary electrophoresis (CE), used in the analysis of herbal medicines, is a versatile and powerful separation tool with a high-separation efficiency and selectivity when analyzing mixtures of low-molecular-mass components [14].

5. Conclusions

There are various forms of medicinal plants including trees, shrubs, climbers, and herbs; of those herbal medicinal plants are dominantly used for different human and animal treatments in Ethiopia. These plants are collected mainly from riverbanks, cultivated areas, bushlands, forest, woodlands, and grasslands, among others. They are used for treatments of stomachaches, dysentery, diarrhea, asthma, cancer, evil eyes, earaches, sores of throat and gum, cough, and so on. For such treatments, these medicinal plants have specific parts used for treatment; most of them are leaves and roots. Hence, traditional medicine plays a significant role in the healthcare of the majority of the people in developing countries, including Ethiopia, and medicinal plants provide valuable contribution to this practice. However, the vegetative resources that are unique to the country, particularly used for medication, are dwindling due to continuous exploitation and pressure on the limited resources. Hence, conservation priority should be given to such medicinal plants and their habitats besides the knowledge of traditional practice of medication via designing appropriate strategies, particularly in the rural areas of the country, where there are less accessibility to clinics and hospitals with their medicines and health experts (doctors). Community- and research-based conservation mechanisms could be an appropriate approach for mitigating the problems pertinent to the loss of medicinal plants and their habitats and for documenting medicinal plants and the knowledge of traditional healers on how to prepare and provide the traditional medication to their patients. Medicinal plants should be multiplied

through medicinal gardens, proper handling practices, and scientific development. Moreover, for controlling the quality of medicinal plant materials and their products, chromatography, electrophoretic, macroscopic/microscopic techniques, and pharmaceutical practices are the most important tools.

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Conflict of interest

The authors declare that there is no any conflict of interest between authors and other organizations as well.

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