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Richness, distribution and conservation status of medicinal plants in Tiyo District, Arsi Zone, Oromia, Ethiopia

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Abstract
This study was conducted to document species diversity and conservation status of medicinal plants in Tiyo District, Arsi, Ethiopia. The study involved 153 informants from nine kebeles, comprising traditional healers, knowledgeable elders and local user communities. Semi- structured interview, guided field walk and group discussion were used for data collection on indigenous knowledge of local communities. Vegetation data was collected from 90 sample plots (45 in home gardens and 45 in the wild). Plot size of 25 m^2 (5 m × 5 m) in each home garden and 400 m^2 (20 m x 20 m) were used to collect vegetation data in the wild. Data was analyzed using descriptive statistics. A total of 83 medicinal plants belonging to 74 genera and 45 families were collected and identified. Almost all medicinal plants were multipurpose. Lamiaceae had the highest number of medicinal plants followed by Euphorbiaceae. Fabaceae, Cucurbitaceae and Solanaceae were also important families with many medicinal plants. Herbs constituted 47.0% of the total collected medicinal plants, followed by shrubs, (25.3%), and trees (19.3%). About 69% of the total medicinal plants were harvested from wild ecosystems. Compared with other districts in similar agroecology in Ethiopia, species richness of medicinal plants in the study area was low. Major threatening factors included unregulated agricultural expansion for cereal cultivation, deforestation, over utilization, over grazing and expansion of settlements. Integrated implementation of both *in-situ* and *ex-situ* conservation measures were identified to be critical. Environmental law enforcement and public awareness raising were recommended.

Keywords: Agricultural expansion, conservation status, deforestation, distribution, growth forms

Introduction
Natural resources including plant biodiversity are fundamental to ensure sustainable development. The livelihoods of 70 per cent of people living in poverty directly depend on natural resources (IRP 2019) for diverse needs such as food and herbal medicines. Nature and nature's contributions to people (e.g., food, medicine, building materials, etc.) are vital for human existence and good quality of life (Díaz *et al*. 2015) [7]. Review of studies (IPBES 2016) showed nearly 90 per cent of wild flowering plant species depend on the transfer of pollen by animals and these pollinators are responsible for the productivity of many of the world's crops that contribute to healthy diets.

In addition to providing foods and medicines, biodiversity helps to regulate climate, filters air and water, enables soil formation and mitigates the impact of natural disasters. It also provides timber, ecotourism, and physical and mental health benefits.

Ethiopia is a megadiverse country with rich plant biodiversity. It has diverse climatic and landscape and these varied macro and micro-climatic conditions have contributed to the formation of diverse ecosystems inhabited with a great diversity of life forms of both plants and animals. So far about 6000 species of vascular plants have been identified and documented in the country out of which 10% are reported to be endemic (EBI 2015) [8]. Plant diversity remains indispensable for human wellbeing in providing a significant number of traditional and modern remedies required in healthcare.

However, many plants in general and medicinal plants in particular are being lost as a result of many driving factors. At global level, major drivers of environmental change include (UNEP, 2019): (i) Human population pressure, and economic development have been identified as the primary drivers of environmental change; (ii) Urbanization that most rapidly happening especially in Africa; (iii) "Grow now, clean up later" economic approach used in certain regions; and (iv) Climate change affecting both human systems (including human health), and natural systems.

According to the SCBD (2014) [34], there are underlying (indirect) and direct drivers causing biodiversity loss. The underlying causes or indirect drivers of biodiversity loss include lack of awareness on biodiversity and its values; lack of incorporation of those values into accounting systems and decisions on economic development and planning; presence of subsidies and financial incentives that influence decisions affecting biodiversity. Habitat loss, degradation and fragmentation; overexploitation of biological resources, unsustainable forms of production in key activities such as agriculture, aquaculture and forestry; pollution; the introduction and establishment of invasive alien species are some of the major direct drivers causing biodiversity loss (SCBD 2014; IRP 2019) [34, 24].

Similar threating factors have been identified in the Ethiopian context. Major threats to Ethiopian ecosystems and biodiversity include population growth, agricultural land expansion, land degradation, deforestation and forest degradation, overgrazing, timber extraction, settlements, shifting cultivation, habitat fragmentation, bush encroachment and invasive alien species (EBI 2015) [8]. Many developing countries such as Ethiopia may be losing its biodiversity even before describing and using these precious resources.

Medicinal plants play a significant role in Ethiopia as more than 70% human and 90% livestock populations depend on herbal medicine (EBI 2015) [8]. Availability of plants in general and medicinal plants in particular has been affected by a dramatic decrease in areas of native vegetation due to agricultural expansion, deforestation and development of urban centers (Cunninghum 1996) [6]. Almost all threats to Ethiopian biodiversity listed above are direct threats to medicinal plants as most medicinal plants are found in wild ecosystems. This challenge calls for proper documentation of medicinal plants, identification of threats and proposal on conservation interventions at local levels.

Data on the species diversity and conservation status medicinal plants in the study District were limited in Tiyo Distrcit of Arsi zone, Oromia. Furthermore, extent of ecosystem degradation and perception of communities on major drivers that caused degradation were not documented and reported. Therefore, this study aimed at determining medicinal species richness, documenting medicinal plants and their conservation status and identifying threats to medicinal plants in the study area with focus on the following specific objectives: (i) collect and identify medicinal plants and describe distribution of these plants in the study area; (ii) document perceived threats to medicinal plants in the study area; and (iii) document the management and conservation techniques practiced by the local people.

Methods

Geographic Location and Description of the Study Area

The study was conducted in Tiyo District of East Arsi Administrative Zone, Oromia National Regional State of Ethiopia (Figure 1).

The area is located at about 175 Km southeast of Addis Ababa. The Addis Ababa-Asela all-weather road provides the primary access to the District. Geographically, Tiyo District is found approximately between 7^0 45' 55" and 8^0 02' 02" N latitude and 38° 56' 42" to 39° 18' 31" E longitude. It is located just on the top of the eastern edge of the Ethiopian Rift Valley. Topography of the District is a part of the Arsi-Bale Mountains chain in general and Chilalo-Galama Mountains in particular. The District is characterized by flat (0^0) to very steeply topographic features (58.6^0). Its altitude ranges from 1850 to 4050 m.a.s.l. The District is characterized by three agroecological zones: Dega (highland) is about 52%; Woyenadega (middle land) about 37% and Kola (lowland) is 11%.

Climate

According to the records of the National Meteorological Agency of Ethiopia, the mean annual rainfall of the District is 1100 mm. Distribution of the rainfall is bimodal, which occurs in the major rainy season (Kiremt) and the short rainy season is (belg). The major rainy season occurs from June to October and the short rainy season occurs in March, April and May. The dry season extends from November to February. According to ten years data from the National Meteorological Agency of Ethiopia (2004 to 2013), the mean annual maximum temperature is 23.1^oC and the mean monthly maximum values ranged from 21.1 to 25°c. The mean annual minimum temperature was 9.1°c and the mean monthly minimum values ranges from 7.1 to 11°c. The coldest months was October, November and December whereas March, April and May were the hottest months of the years.

Data collection methods

Data were collected from October 1/2013 to January 30/2014 in several field trips. For data collection on perception of local communities, semi-structured interview, focus group discussion and guided field walk were used for collecting data as described below.

Semi-structured interview

Semi-structured interview was conducted using prepared questions in Afaan Oromo following Martin (1995) and Cotton (1996) [5]. During interview, issues regarding name, age, sex, level of education, occupation, religion and ethnicity of the informants were included. Moreover, informants were asked about the local name of the medicinal plants used, habitats of species and extent of change, drivers of the change, degree of management both in wild and cultivation, abundance and existing threat to conservation and sustainable use of medicinal plants.

Focus group discussion

Discussion with knowledgeable informants over all kebeles were also designed and performed so as to gather further information on medicinal plants, to evaluate traditional knowledge of the respondents on conservation practices, management systems, threats to medicinal plants, causes of the threat and in general to prove reliability of information gathered during semi-structured interview.

Guided field walk

Two to three field walks were made as necessary with knowledgeable informants and this provided an opportunity for more discussion and the practical identification of traditionally used medicinal plants in their natural environment. It also helps to obtain firsthand impression on the abundance, habit and habitat characteristics of the plant species mentioned during interviews. During this observation medicinal plant species were identified, specimens collected and photographs were taken.

Vegetation data collection

To assess the distribution of reported medicinal plants, vegetation survey was carried out both in home garden and wild areas based on a modified Whittaker Nested-Quadrat sampling method (Stohlgren *et al*., 1994). A total of 90

sample plots were established, 45 of which were in home garden (five plots in each study kebele) and 45 plots in the wild (five plots in each study kebele). The size of the plots in home gardens were 5×5 m, in each home garden five plots were taken from all possible directions of the home garden in order to assess the whole plant species and averages of the five sample plots were considered for the data analysis. The homogeneity of each stand was checked through observation before laying down a sample plot. The plots taken in the natural vegetation (wild) were along a transect line, the size of the plot for tree species was 20 × 20 m, for shrubs 5 m x 5 m, for herbs 2 m x 2 m size. The sample plots used to assess the distribution of wild medicinal plants were established systematically in order to cover all habitat types occurring in the area (rocky areas, hilly areas, top mountain/plateaus, and valleys, riverine and plain areas). Then, counts of each species (presence or absence) were conducted within each plot and plant number and species cover were estimated

Voucher specimen collection was carried out with the help of traditional healers and local field assistants. The specimens were air-dried, numbered, labelled, pressed, heater-dried, deep-frozen, identified and deposited at the National Herbarium (ETH) in Addis Ababa University. Identification of specimens were performed both in the field and later at ETH using taxonomic keys and the relevant volumes of the Flora of Ethiopia and Eritrea (Hedberg and Edwards 1989, 1995; Edwards *et al*. 1995, 1997, 2000; Hedberg *et al*. 2004, 2006) [19, 9, 26, 11, 22].

Data Analysis

Descriptive statistical methods were used for data analysis. Data on management systems, use and conservation status were entered in Excel spread sheet software and organized for statistical analysis.

Frequency and Relative frequency were used for the most commonly reported medicinal plant species in the study area following Martin (1995) and Jha (1997) [26].

$$\text{Frequency (\%)} = \frac{\text{Number of plots with individual species x100}}{\text{Total number of plots studied}}$$

$$\text{Relative frequency (\%)} = \frac{\text{Frequency of any species x 100}}{\text{Total frequency of all species}}$$

Results

Diversity of medicinal plants in the study area

A total of 83 medicinal plant species belonging to 74 genera and 45 families were identified and documented from the study area (Table 1). Lamiaceae had the highest number of medicinal plants (11 species comprising of 13.2% of total species). Euphorbiaceae had five species (6.0% of total species) and Asteraceae Fabaceae, Cucurbitaceae and Solanaceae had 4 medicinal plants each (Table 2).

Diversity of growth forms (growth habits) of medicinal plants

The analysis of growth forms showed that among the total medicinal plants collected, herbs were represented by 39 species, shrubs by 21 species and trees by 16 species (Table 1 and Figure 2).

Local/emic and etic vegetation classification/categorization

The community of the study area traditionally classified vegetation of their surroundings based on the dominating vegetation types and density of plants that cover the land.

Biqiltoota lafa qonnaa: means farm land vegetation. It refers to type of vegetation growing on farm lands and mostly includes crops, weeds and some scattered trees and shrubs on the farmland.

Biqiltoota lafa margaa: this refers to plants on grazing lands reserved for pasture and mostly covered with grass, shrubs, herbs and trees.

Bosona: refers to forest vegetation and this is the type of vegetation with populated plant species and composed of a range of larger trees. In the study area this type of vegetation was found at the middle and bottom edge of Chilalo Mountain and lowland study site.

Shaatoo/Saatoo represents: refers to the Afro-alpine vegetation dominated by *Erica arborea* found at the middle and top of Chilalo Mountain where the ecological factors limit the distribution of other vegetation types.

Naannawa lagaa: refers to the riverine vegetation constituting the range of plant species that vary based on the interference of both humans and livestock. In areas beyond this interface good vegetation distribution was observed.

Hurufa: is open woody and shrub land with patches of trees, bushes, shrubs and herbaceous species. It is common near agricultural margins, along main asphalt roads and mountain escarpments.

Distribution of medicinal plants in different agroecology and land use types

Survey of species distribution in the agroecologies showed uneven distribution of medicinal plants in the different land use types and agroecologies. The highest numbers of medicinal plants (32.53%) were recorded from the community of moist kola vegetation dominated by *Acacia seyal* followed by mixed forest dominated by *Podocarpus falcatus* that accounted for 20.48% (Figure 3). Furthermore, survey of indigenous knowledge associated with medicinal plants across different agroecologies showed that large number of medicinal plant species 40 (48.19%) were reported from lowland area (Table 3). Based on this result, it was also noted that traditional healers from lowlands had more indigenous knowledge compared to others from highland or mid altitudinal areas following number of medicinal plants in their respective agroecologies.

The majority of the reported medicinal plants were found in wild habitats. It was documented that 63 medicinal species (75.9% of the total species) were encountered in wild out of which 11 species were also found in home gardens. A total of 31 medicinal plants (37.3% of the total species) were recorded from home gardens. In other words, species found only in wild, home gardens and both in wild and homegardens were 52 (62.6%), 20 (24.1%) and 11 (13.3%), respectively (Table 1).

The frequency and relative frequency of the plant species recorded in 45 quadrats in the wild ecosystems showed variations in spatial distribution of species. *Cordia africana* was the most frequent tree species occurring in 35 of the total quadrats surveyed, followed by *Hagenia abyssinica* occurring in 33 quadrats (Table 4).

Survey of vegetation distribution in the 45 quadrats at home gardens showed that *Satureja paradoxa* was the most frequent

(95.6%) followed by *Nicotiana tabacum*, *Carissa spinarum* and *Allium sativum* with 73.3%, 71.1% and 64.4%, respectively (Table 5).

During this study, it was noted that the people in the study area plant perennial species such as *Azadirachta indica*, *Ocimum lamiifolium*, *Leonotis ocimifolia* next to their fence and/or mixed with the live fence whereas annual plants such as *Allium sativum*, *Nicotiana tabacum*, *Rosmarinus officinalis* and *Satureja paradoxa* were cultivated closer to the houses.

Other Ecosystem services of home garden plants

It was observed and documented that various home garden plant species were used for different services by the local community (Table 6). About 14 (53.8%) species were identified to be used for medicine and other purposes, 4 (15.4%) species provide the service of live fencing, wind break and medicine, 5 (19.2%) species were used for medicine and construction purpose and 3 (11.5%) species provide medicinal and food service. It is worth noting that only 2 species were solely used for medicinal value.

According to the home garden owners, managing home garden plants has been their long years of experience. They perceived that home gardens have been very important for them as source of income to improve their livelihoods. Home gardens are useful in all the time in a year but particularly important during the off set of the rainy season.

Threats to medicinal plants

There are several human induced and natural factors that were found to be contributing to the degradation of ecosystems and loss of medicinal plants in the study area. The major factors reported included agricultural expansion, deforestation, over utilization, over grazing and expansion of settlements. Agricultural expansion was cited to be the most important factor that have been threatening medicinal plants (Table 7). Deforestation, overutilization and overgrazing were also among top major factors causing degradation and loss of medicinal plants.

Local medicinal plants conservation practices

In the study area, there are various local beliefs and cultural traditions that have contributed to the conservation of medicinal plants. During the field work, it was observed that communities care for medicinal plants using different approaches. For example, while collecting the part(s) of the medicinal plants, various careful actions were taken to save the life of the mother plant: (i). collecting leaf and lateral roots without damaging the main root; (ii) re-planting and/or transplanting the parts (root and stem) after taking the required amount. Some traditional medicines are collected and administered only by selected families or tribes known as warra tuftoo. Thus, not all healers harvest such medicinal plants. The informants perceived that such approach would reduce the rate of plant exploitation. It was also noted that vegetation on certain places like special place for worship (abdaarii), cemetery, Mosques, Churches and other areas have been culturally protected and no one would cut any plant from such sacred sites for personal use such as construction material and firewood. They believed that such practices had contributed to conservation and management of plant resources. The informants also pointed out that it was illegal to harvest healthy and reproductive plants in the presence of another deformed and non-fruiting (seeding) plant.

Discussion

Richness and uses medicinal plants

A total of 83 medicinal plants belonging to 74 genera and 45 families were documented from the study area. It was noted that there were rich species in the area. These species were used not only for medicinal values but also for many other local level other ecosystem services. It is worth noting that almost all medicinal plants were multipurpose used for live fences, wind break, construction, spices, food, clothing, cash income, for making household materials, shade and spiritual practices.

Lamiaceae, Euphorbiaceae, Asteraceace, Fabaceae, Cucurbitaceae and Solanaceae were important families with many medicinal plants in agreement with many study reports (Gijan and Dalle 2019; Kidane *et al*. 2018; Lulekal *et al*. 2008; Lulekal *et al*. 2013; Yineger 2005) [18, 29, 31, 30, 39].

Herbs constituted 47.0% of the total collected medicinal plants, followed by shrubs, (25.3%), and trees (19.3%). This finding was in agreement with some previous reports (Isa *et al*. 2018; Mesfin *et al*. 2009; Teklehymanot *et al*. 2007) [25, 33, 37] but disagreed with others (for example, Belayneh *et al*. 2012; Gemedo- Dalle *et al*. 2005; Eshete *et al*. 2016; Tolossa *et al*. 2013) [3, 16, 38]. Tolossa *et al*. (2013) [38] reported trees as the most dominant followed by shrubs and herbs. Another study reported shrubs as the most commonly used followed by herbs and trees (Belayneh *et al*. 2012) [3]. These differences could be due to environmental factors in agroecologies. For example, the dominance of woody species in the moisture stressed lowland ecosystems such as Borana (Gemedo- Dalle *et al*. 2005) [6] and South Omo (Tolossa *et al*. 2013) [38] could be related to the competitive advantage of woody species over herbs for the most limiting resource (moisture) in the area. The other reason for the dominance of herbs in highlands could be due to presence of home gardens where herbs are commonly cultivated for medicinal and other purposes.

Distribution of medicinal plants

The traditional healthcare practice in Ethiopia is mainly dependent on medicinal plants collected from wild. Similarly, traditional practitioners and local communities of the study area confirmed that they mainly depend on the wild vegetation for collecting and using medicinal plants for treating both human and livestock ailments. It was documented that 75.9% of the total medicinal plants were harvested from the wild in Tiyo District in agreement with many previous reports (Awas and Demissew 2009; Eshete *et al*. 2016; Estrada-Castillon *et al*. 2012; Gebrehiwot 2010; Giday *et al*. 2003; Issa *et al*. 2018; Kidane *et al*. 2018; Lulekal *et al*. 2008; Yineger 2005) [25, 29, 31, 39]. Based on these study results, it can be concluded that most medicinal plants used in different parts of Ethiopia and in other African and Latin American countries are harvested from the wild or natural ecosystems. This in turn indicates the high need to conserve and sustainably manage habitats of these medicinal plants which include forests, grasslands, wetlands and riverine ecosystems.

Medicinal plants in the study area were unevenly distributed in different land use types and agroecologies. In some areas, they are clumped together and in other places evenly distributed in agreement with previous reports. For example, Martin (1995) [32] and Jha (1997) [26] who observed that there is a chance of finding a plant species either clumped together

in one spot or evenly distributed in a given area.

This study also documented distribution of these species across three different agroecologies. The result showed that large number of medicinal plants were documented from lowland area followed by highlands. In the middle agro-ecological zone, it was observed that there was high population pressure on the land and the plant resources mainly due to the unregulated and extensive cereal cultivation. Most natural habitats of medicinal plants in in this agroecology were converted into farm fields for crop cultivation. It was expected that informants in lowland could identify more medicinal plants than the other two groups as loss of species is related to loss of associated indigenous knowledge. Loss of medicinal plants links with the gradual displacement of indigenous knowledge associated with these plants (Sofowora 1982) [35].

Comparison of medicinal plants richness and major threats to species

The total number of medicinal plants documented during this study was much less that study reports from other districts in more or less similar ecosystems in Ethiopia (Table 8). The finding showed that a smaller number of medicinal plants in Tiyo Diistrict was due to unregulated agricultural expansion into forest and grasslands, deforestation, overutilization, overgrazing, settlements and frequent droughts. Because of the high number of population increment and agricultural land expansion in the study area, forests were cleared and converted into farmland even on a very steeply slope. Such a threatening factors pose significant challenge to the current and future wellbeing of human and animal populations that rely on these resources to combat various ailments. Furthermore, the area has high annual rainfall records (about 1100 mm), the fertile top soil has been washed out and the land is left bare even without providing one season harvest properly directly challenging sustainable production of food in the district.

The local perception of communities was in agreement with global established facts. For example, global assessment by United nations Environment Program (UNEP) has identified habitat change, loss and degradation, unsustainable agricultural practices, spread of invasive species pollution and overexploitation as threats to biodiversity (IRP 2019) [24]. At national level, the Ethiopian Biodiversity Institute had identified population growth, agricultural land expansion, land degradation, deforestation and forest degradation, overgrazing and habitat conversions as major threats for biodiversity in Dry Evergreen Montane Forest and Evergreen Scrubland and Afroalpine and Subafroalpine Ecosystems of Ethiopia (EBI 2015) [8].

Global demand for herbal medicines is accompanied by dwindling supply of medicinal plants due to these degrading factors including overharvesting, habitat loss and agricultural encroachment. Review of different data in in the major primary sectors indicates that drivers linked to agriculture account for 70% of the projected loss of terrestrial biodiversity (SCBD 2014) [34].

Deforestation and agricultural expansion remain major principal threatening factors for medicinal plants in many parts of Ethiopia. As a result, traditional medicine has faced with problem of sustainability mainly due to the loss of taxa of medicinal plants (Kelbessa *et al*. 1992) [28]; as well as habitats destructions and cultures (Asfaw 2001) [2]. Human and natural factors heavily contribute to the loss of medicinal plants, which links with the gradual displacement of indigenous knowledge associated with these plants (Sofowora 1982) [35].

Call for integrated conservation approach

This study showed that most medicinal plants were multipurpose and found in the wild habitats of forests, grasslands and riverine ecosystems. Anthropogenic activities such as deforestation, unregulated expansion of crop fields into forest and grasslands have been threatening these medicinal plants in the wild ecosystems calling for immediate conservation measures. To save the remaining medicinal plants and minimize genetic erosion in the study area, integrated implementation of both *in-situ* and *ex-situ* conservation methods is critical. However, it was observed that there was no practical intervention on the ground.

In addition to government's efforts, participation of local communities in the planning and implementation of conservation activities is important. Community involvement in monitoring the use and status medicinal plants can contribute to effective conservation and sustainable use (Bodeker, 2005) [4]. To protect biodiversity in general and threatened medicinal plants in particular, both *in-situ* and *ex-situ* conservation actions have been adopted and implemented in many countries including Ethiopia (Cunninghum 1996; EBI 2015) [6, 8].

For conservation and sustainable use of medicinal plants, *in-situ* is much better than the *ex-situ* conservation method. Therefore, it is important to integrate on-farm conservation (home gardens) and conservation in natural environment in the different natural ecosystems (forest, grasslands, wetlands, etc.). The *in-situ* conservation is easily practiced with the support of farmer-based conservation (Akerele *et al*. 1991) [1] and therefore, active participation of the local communities in the conservation interventions would be critical.

Furthermore, monitoring and evaluation of conservation measures need to be in place to determine impacts of interventions and to promote sustainable use of these resources.

Table 1: List of medicinal plants encountered and their growth habit in Tiyo District, Arsi zone, Oromia, Ethiopia

Scientific Name	Family	Local Name (Afan Oromo)	Habit
Acacia seyal Delile	Fabaceae	Waaccuu	T
Achyrospermum schimperi (Hochst.) Perkins.	Lamiaceae	Bala Diimessa	H
Acokanthera schimperi (A.DC) Schweinf. L	Apocynaceae	Qaraaruu	Sh
Agave sisalina perrine ex. Engl.	Agavaceae	Algee/Qaaccaa	H
Ajuga integrifolia Buch.-Ham. ex D. Don	Lamiaceae	Harmaguusa	H
Allium sativum L.	Alliaceae	Qullubbii adi	H
Aloe capensis	Aloaceae	Hargiisa	H
Aloe pubescens Reynolds	Aloaceae	Hargiisa	H
Anethum gravelens L.	Apiaceae	Qoricha dhibee sammuu	H
Asparagus africanus Lam.	Asparagaceae	Sariitii	H
*Aspilia mossambicensis (*Oliv.) Wild.	Asteraceae	Hadaa	H

Azadirachta indica	Meliaceae	Niim/Miimoo	T
Calpurnia aurea (Ait.) Benth.	Fabaceae	Cheekataa	Sh
Carissa spinarum L.	Apocynaceae	Agamsa	Sh
Cassipourea malosana (Baker) Alston	Rhizophoraceae	Laalessa	T
Cheilanthus farinosa (Forssk.) Kaulf.	Sinopteridaceae	Ati gubadhu an sii jiraa	H
Chloris virgata Swartz.	Poaceae	Mata bokko	H
Clematis simensis Fresen.	Ranunculaceae	Fitii	Cl
Clerodendrum alatum Guerke	Lamiaceae	Misirich	H
Clerodendrum myricoides (Hochst.) R.Br.ex vatke	Lamiaceae	Maraasisaa	Sh
Coccinia abyssinica (Lam) Cong.	Cucurbitaceae	Hancootee	H
Cordia africana Lam.	Boraginaceae	Woddeessa	T
Croton macrostachyus Hochst.	Eurphorbiaceae	Makkanniisaa	T
Cucumis ficifolius A. Rich.	Cucurbitaceae	Hiddii	Tr
Cucurbita maxima Duchesne ex Lam	Cucurbitaceae	Baasqula	Tr
Cymbopogon citratus (Dc.) Stapf.	Poaceae	Xajjiisaara	H
Cynoglosum amplifolium Hochst ex Dc	Boraginaceae	Qoricha Hadhaa	H
Cyphostemma niveum (Schweinf.) Desc.	Vitaceae	Laaluu	H
Datura stramonium L.	Solanaceae	Banjii	H
Diplolophium africanum Turcz.	Apiaceae	Insilalaa	H
Dodonaea angustifolia L.f	Sapindacae	Dhittacha	Sh
Eucalyptus globulus Labill	Myrtaceae	Baarzaafii	T
Euphorbia abyssinica Gmel	Euphorbiaceae	Hadammii	T
Euphorbia candelabrum Trem. ex Kotschy	Euphorbiaceae	Hadaamii	T
Euphorbia chumalis S. Carter	Euphorbiaceae	Guurii	H
Ficus capreaefolia Del.	Moraceae	Luugoo	T
Gloriosa superba L.	Colchicaceae	Sokorruu	H
Gnidia glauca (Fresen) Gilg.	Thymelaceae	Didiiysaa	Sh
Guizotia seabra (Vis.) Chiov.	Asteraceae	Hadaa	H
Hagenia abyssinica (Bruce) J.F.Gmelin	Rosaceae	Heexoo	T
Helichrysum elephantinum Cufod.	Asteraceae	Holotuu/Araddoo	H
Hypericum revoltum Vahl.	Hypericaceae	Hindhee/Garambaa	Sh
Jasminum abyssinicum Hochst ex Dc.	Oleaceae	Biluu	Sh
Justitia schimperana (Hochst.ex Nees) T.Anders.	Acanthaceae	Dhummuugaa	Sh
Kalanchoe petitiana A.Rich.	Crassulaceae	Bosoqqee	H
Kalanchoe lanceolata A.Rich.	Crassulaceae	Hancuurraa	H
Lagenaria siceraria (Molina) Standl.	Cucurbitaceae	Buqqee	Cl
Leonotis ocimifolia (Burm.f) Iwarsson	Lamiaceae	Bokkolluu	H
Lepidium sativum L.	Brassicaceae	Shuunfaa	H
Lippia adoensis Hochst.ex.Walp. Var. adoensis	Verbenaceae	Sokonota/Sukayee	Sh
Myrsine africana L.	Myrsinaceae	Qamoo	Sh
Nicotiana tabacum L.	Solanaceae	Tamboo	Sh
Ocimum gratissimum L.	Lamiaceae	Damakasee	Sh
Ocimum lamiifolium Hochst.ex Benth.	Lamiaceae	Cabbii	H
Olea europaea subsp. cuspidata (Wall. ex G. Don) Cif.	Oleaceae	Ejersa	T
Olinia rochetiana A. Juss.	Oliniaceae	Gunaa	T
Osyris quadriprtita Decn.	Santalaceae	Waatoo	Sh
Phytolacca dodecandra L Her.	Phytolaccaceae	Andoodee	Sh
Podocarpus falcatus (Thunb.) Mirb.	Podocarpaceae	Birbissa	T
Polystachya tessehata Lindl.	Orchidaceae	Qoricha Bowwoo	H
Prunus africana (Hook.f) Kalkm	Rosaceae	Sukkee	T
Pterolobium stellatum Forssk.) Brenam	Fabaceae	Gorxaa Dimaa	Sh
Ranunculus multifidus Forssk.	Ranunculaceae	Qoricha dhibee Simbiraa	H
Rhus vulgaris Meikle	Anacardiaceae	Qamoo	Sh
Rosmarinus officinalis L.	Lamiaceae	Foon waddittuu	H
Rumex nepalensis Spreng.	Polygonaceae	Shaabee	H
Salix subserrata Willd.	Salicaceae	Alaltuu	T
Sanicula elata Ham. Ex. D.Don	Apiaceae	Xuuxaa	H
Satureja paradoxa (Vatke) Engler ex Seybold	Lamiaceae	Sajjaabii	H
Satureja punctuata (Benth) Bliq.	Lamiaceae	Maxxannee baala bal'aa	H
Senna multiglandulosa (Jacq) Irwin & Barneby	Fabaceae	Birbirraa	Sh
Setaria pumila (Poir.) Roem. & Schult.	Poaceae	Maxxnnee	H
Sida schimperiana Hochst	Malvaceae	Kottee gaangee	H
Sida tenuicarpa Vollesen.	Malvaceae	Camarrii	H
Solanum campylacanthum Hochst. Ex. A. Rich	Solanaceae	Hiddii	Sh
Solanum somalense Franchet	Solanaceae	Hidda bidoo	Sh
Stephania abyssinica Dillon. & A.Rich.	Menispermaceae	Kalaalaa	Cl
Tapinanthus ziziphifolius (Engl.) Dans.	Loranthaceae	Harmoo Doddotii	Cl
Terminalia brownie Fresen.	Combretaceae	Bir'eessa	T
Thymus schimperi Ronn.	Lamiaceae	Xooshinee	H
Tragia cinerea (Pax) Gilbert & Radcl.- Smith	Euphorbiaceae	Laalessaa	Cl
Verbascum sinaiticum Benth.	Scrolophaceae	Gurra Harree	H
Vernonia amygdalina Del.	Asteraceae	Ebicha	Sh

Table 2: Number of species of medicinal plants in different plant families in Tiyo District, Arsi Zone, Oromia, Ethiopia.

No.	Family name	No. of Genera	No of species	% of Total Species
1	Acanthaceae	1	1	1.2
2	Agavaceae	1	1	1.2
3	Alliaceae	1	1	1.2
4	Aloaceae	1	2	2.4
5	Anacardiaceae	1	1	1.2
6	Apiaceae	3	3	3.6
7	Apocynaceae	2	2	2.4
8	Asparagaceae	1	1	1.2
9	Asteraceae	4	4	4.8
10	Boraginaceae	2	2	2.4
11	Brassicaceae	1	1	1.2
12	Colchicaceae	1	1	1.2
13	Combretaceae	1	1	1.2
14	Crassulaceae	1	2	2.4
15	Cucurbitaceae	4	4	4.8
16	Euphorbiaceae	3	5	6.0
17	Fabaceae	4	4	4.8
18	Hypericaceae	1	1	1.2
19	Lamiaceae	8	11	13.2
20	Loranthaceae	1	1	1.2
21	Malvaceae	1	2	2.4
22	Meliaceae	1	1	1.2
23	Menispermaceae	1	1	1.2
24	Moraceae	1	1	1.2
25	Myrsinaceae	1	1	1.2
26	Myrtaceae	1	1	1.2
27	Oleaceae	2	2	2.4
28	Oliniaceae	1	1	1.2
29	Orchidaceae	1	1	1.2
30	Phytolaccaceae	1	1	1.2
31	Poaceae	3	3	3.6
32	Podocarpaceae	1	1	1.2
33	Polygonaceae	1	1	1.2
34	Ranunculaceae	2	2	2.4
35	Rhizophoraceae	1	1	1.2
36	Rosaceae	2	2	2.4
37	Salicaceae	1	1	1.2
38	Santalaceae,	1	1	1.2
39	Sapindaceae	1	1	1.2
40	Schrolophaceae	1	1	1.2
41	Sinopteridaceae	1	1	1.2
42	Solanaceae	3	4	4.8
43	Thymelaceae	1	1	1.2
44	Verbenaceae	1	1	1.2
45	Vitaceae	1	1	1.2
	Total	74	83	

Table 3: Indigenous knowledge on medicinal plants across different agroecology in Tiyo District, Arsi Zone, Oromia, Ethiopia.

Variables	Total respondents	No. of knowledgeable informants	Total plant identified	Percentage of the total
Agro-ecological zone	153	50	83	100.00
Lowland	46	23	40	48.19
Middle	51	9	12	14.46
Highland	56	18	31	37.35

Table 4: List of most frequent trees in the study area of Tiyo District, Arsi Zone of Oromia, Ethiopia (Total No of quadrats = 45)

No.	Plant species	No. of quadrats in which the spp. Was recorded	Frequency (%)	Relative Frequency (%)
1	*Acacia seyal*	31	68.89	0.09
2	*Calpurnia aurea*	14	31.11	0.04
3	*Cordia africana*	35	77.78	0.11
4	*Croton macrostachyus*	18	40.00	0.06
5	*Dodonaea angustifolia*	16	35.56	0.05
6	*Eucalyptus globulus*	11	24.44	0.04
7	*Ficus capreaefolia*	24	53.33	0.08
8	*Hagenia abyssinica*	33	73.33	0.11
9	*Olea europaea* subsp. *cuspidata*	17	37.78	0.05

10	*Podocarpus falcatus*	26	57.78	0.08
12	*Prunus africana*	27	60.00	0.09
13	*Salix mucronata*	12	26.67	0.04
14	*Terminalia brownie*	21	46.67	0.07
15	*Vernonia amygdalina*	29	64.44	0.09

Table 5: Plant species with highest relative frequency of occurrence in home gardens of Tiyo District, Arsi Zone, Oromia, Ethiopia

No.	Plant species	No. of quadrats in which spp. was recorded	Frequency (%)	Relative frequency
1	*Satureja paradoxa*	43	95.56	0.16
2	*Nicotiana tabacum*	33	73.33	0.12
3	*Carissa spinarum*	32	71.11	0.12
4	*Allium sativum*	29	64.44	0.11
5	*Leeyonotis ocimifolia*	25	55.56	0.09
6	*Ocimum lamiifolium*	23	51.11	0.08
7	*Phytolacca dodecandra*	19	42.22	0.07
8	*Podocarpus falcatus*	17	37.78	0.06
9	*Croton macrostachyus*	16	35.56	0.06
10	*Melia azedarach*	16	35.56	0.06
11	*Rosmarinus officinalis*	15	33.33	0.05

Table 6: Ecosystem services of home garden plants in Tiyo District, Arsi Zone of Oromia, Ethiopia

No.	Service categories	No. of plant Species	% of the total Species
1	Live fence and medicine	4	15.40
2	Spice and medicine	3	11.50
3	Food and medicine	3	11.50
4	Clothing, cash income and medicine	3	11.50
5	Medicine only	2	7.69
6	Household material and medicine	2	7.69
7	Utensil wash and medicine	3	11.50
8	Food, shade and medicine	2	7.69
9	Shade, roofing and medicine	1	3.85
10	Alcohol preparation and medicine	1	3.85
11	Cash income, stimulant and medicine	1	3.85
12	Roofing, medicine and spiritual role	1	3.85
	Total	26	100.00

Table 7: Priority ranking of factors threatening medicinal plants in Tiyo District, Arsi Zone, Oromia, Ethiopia.

Factors	Response of informants								Total	Rank
	I_1	I_2	I_3	I_4	I_5	I_6	I_7	I_8		
Agriculture	5	4	5	5	5	4	5	5	38	1st
Deforestation	4	5	4	4	4	5	5	4	35	2nd
Overutilization	5	4	3	4	4	3	3	4	30	3rd
Overgrazing	3	4	3	3	3	5	5	3	29	4th
Residence construction	4	3	3	4	4	3	3	3	27	5th
Drought	3	4	3	3	3	3	3	4	26	6th

Table 8: Comparison of species diversity and of medicinal plants in different districts of Ethiopia

No.	Name of District	Total number of species	Number of Genera	Number of Families	Reference
1	Tiyo, Arsi zone, Oromia, Ethiopia	83	74	45	This study
2	Ganta Afeshum, Tigray, Ethiopia	173	156	77	Kidane et al. (2018)
3	Nagelle Arsi, West Arsi, OromiaEthiopia	102	85	55	Gijan and Dalle (2019)
4	Ada'a, East Shoa, Oromia, Ethiopia	131	109	54	Kefalew et al. (2015)
5	Ankober, North Shoa, Amhara, Ethiopia	135	128	71	Lulekal et al. (2013)
6	Yalo, Afar, Ethiopia	106	79	46	Teklehymanot (2017)
7	Bule Hora, Guji, Oromia, Ethiopia	106	98	46	Eshete et al. (2016)

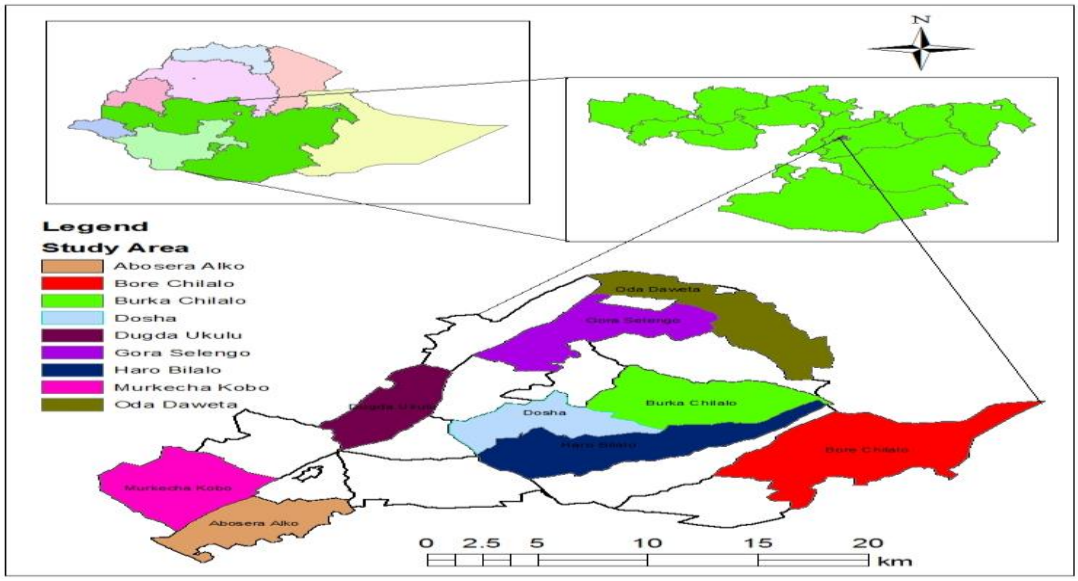

Fig 1: Map of Ethiopia showing the study area and the study sites in Tiyo District, Arsi Zone, Oromia, Ethiopia.

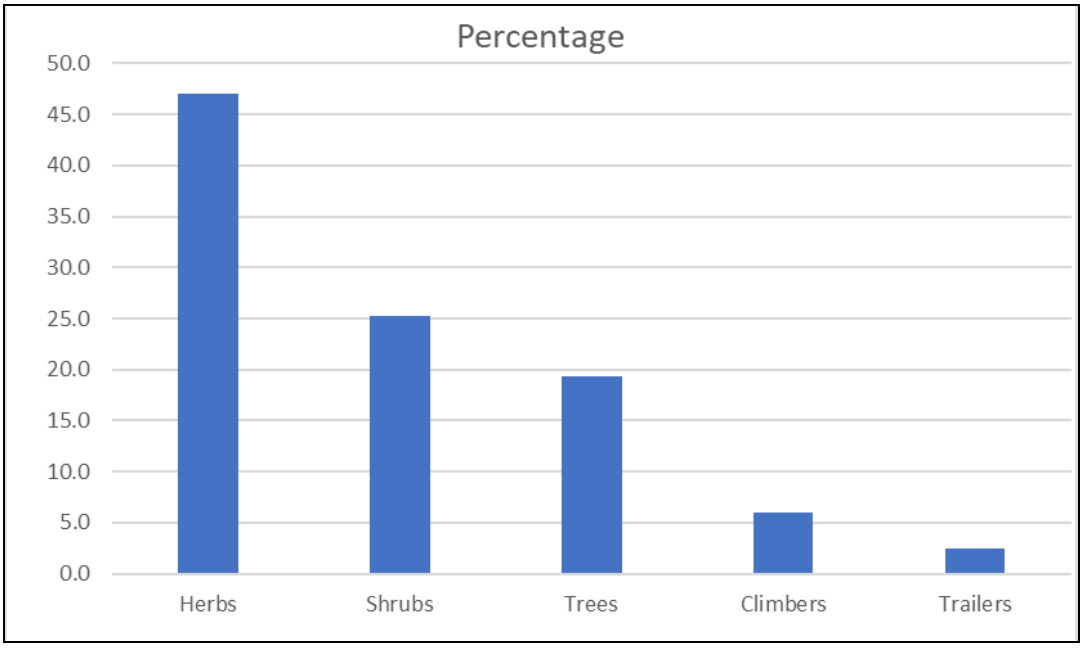

Fig 2: Diversity of growth forms of medicinal plants in Tiyo District, Arsi zone of Oromia, Ethiopia

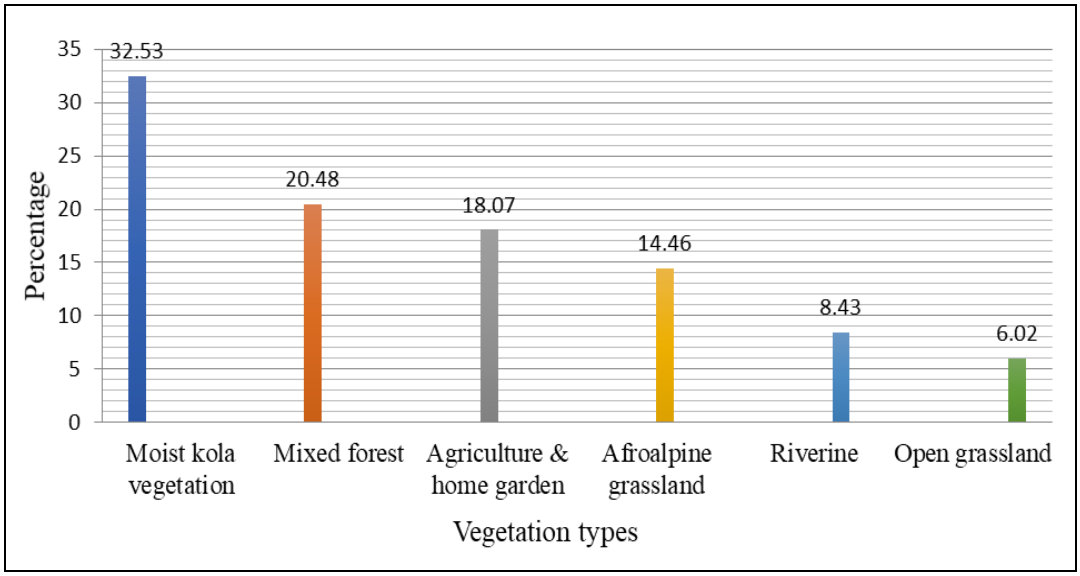

Fig 3: Distribution of medicinal plants in different vegetation types in Tiyo District, Arsi Zone, Oromia, Ethiopia.

Conclusion

Conversion of natural forests, grazing lands, woodlands and wetlands into agricultural lands and settlements have been some of the threats to Ethiopian biodiversity (EBI 2015) [8]. Deforestation and unregulated agricultural expansion were noted to significantly affect the vegetation of the study area. This necessitates putting in place and implementing strategy that promote conservation and sustainable utilization of medicinal plants. Regulating land use and control of deforestation through environmental law enforcement is critical and timely in Tiyo District, Arsi Zone. Furthermore, plantation of other trees (non- medicinal plants) and fast-growing plant species will minimize the negative impacts on existing medicinal plants thereby meeting the needs of local communities.

In the study area most of medicinal plants used by the herbalists were collected from the wild habitats found in different natural ecosystems of the forests, grasslands, riverine and farm lands mainly in the form of herbs and shrubs. Home based medicinal plants use relies on plants of the home gardens those cultivated for medicinal or other primary purposes. There is a need to promote sustainable use of the medicinal plants with measures in place to regulate overutilization. To succeed in efforts of conservation and sustainable use of biodiversity in general and medicinal plants in particular, there should be a mechanism in place for active involvement of various sectors. Federal and regional governments to continuously raise public awareness as clearly indicated in the National Biodiversity Strategy and Action Plan (EBI 2015) [8] thereby ensuring public support for the effective implementation of domestic legislation on the conservation and sustainable utilization of local biodiversity.

There is high need for integrated implementation of both *in-situ* and *ex-situ* conservation methods that would include on-farm conservation of multipurpose species. For that to be effective, further botanical collections and documentation indigenous knowledge associated with these species should be done in a systematic way. Continuous public awareness, further botanical collections and documentation indigenous knowledge associated with these species were recommended as a result of this study.

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