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Table of Content

On farm diversity of barley landraces in North Western Ethiopia

Daniel Tadesse and Tazebachew Asres

Ecological distribution, diversity and use of the genus *Digitaria* Haller (Poaceae) in Senegal

Ablaye Ngom, Mame Samba Mbaye, Adeline Barnaud, Mame Codou Gueye, Abdoul Aziz Camara, Mathieu Gueye, Baye Magatte Diop, Kandioura Noba

Assessment of woody species in agroforestry systems around Jimma Town, Southwestern Ethiopia

Buchura Negesse Wari, Debela Hunde Feyssa and Zerihun Kebebew

The dynamics of medicinal plants utilization practice nexus its health and economic role in Ethiopia: A review paper

Yebirzaf Yeshiwas, Esubalew Tadele and Workinesh Tiruneh

Impacts of human activities on wildlife: The case of Nile Lechwe (*Kobus megaceros*) Gambella National Park, Southwest Ethiopia

Mohammed Seid Legas and Behailu Taye

Full Length Research Paper

On farm diversity of barley landraces in North Western Ethiopia

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Barley is one of the major cereal crops grown in Ethiopia. The diversity of barley landraces kept for generations in Ethiopia is nowadays subject to genetic erosion. This is true in North Gondar highlands of the country as well. This research was therefore initiated with the aim of studying the farm diversity status of barley landraces in Debark, Dabat and Wogera districts. A total of 180 randomly selected farmers from six villages were surveyed with a proportion of 30 farmers/village. Ecological models were employed to analyze the level of diversity. Genetic erosion models were employed to estimate the level of genetic erosion over a ten-year period of time. A total of 24 landraces were described by farmers of the studied sites. Of these, 18 of them are still under cultivation although their area coverage is declining from time to time. The landraces *Abat gebs*, *Nech gebs* and *Tikur gebs* were found to be the most common and widely grown. Debark district was found to have the highest richness (Margalef=2.45; Menhinick=1.43) followed by Wogera and Dabat districts. With regard to evenness as a measure of Shannon diversity index, Wogera district (E=0.85) showed the highest diversity followed by dabat (E=0.83) and debark (E=0.79). Simpson's diversity index (D) also revealed the abundance of *Nech gebs* (0.66), *Abat gebs* (0.6) and *Tikur gebs* (0.52). The landraces *Demo kises*, *Goreneje*, *Chankirme*, *Gabieaswelik*, *Amedo* and *Gero tal* were found to be out of production in the last ten years and probably eroded. Genetic erosion and genetic integrity over ten years (2006-2016) was found to be 25 and 75%, respectively. The name given to landraces studied was found to be associated with certain characteristics or situations. Thus, policy makers and researchers should give attention to conservation of landraces of barley (*Hordeum vulgare* L.) for better use of genetic resources.

Key words: On-farm diversity, genetic erosion, barley, landrace.

INTRODUCTION

Ethiopia is a country renowned for the diversity of its native barley types and is recognized internationally to harbor valuable barley genetic resources. With microsatellites derived from nuclear and chloroplast DNA, a significant genetic diversity and distinctiveness of

Eritrean and Ethiopian barley lines was found (Orabi et al., 2007). Barley (*Hordeum vulgare* L.) is one of the most important cereal crops, mainly grown by smallholder farmers at mid- and high-altitudes in North West Ethiopia, predominantly between 2200-3000 m.a.s.l. (Asmare et

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al., 1998). Hence, there can be a typology of farm cropping systems that may influence conservation of barley landraces.

There is growing interest in conservation of genetic resources in the agro ecosystem in which they have evolved; that is, *in-situ* conservation (FAO, 1996). This is especially important in areas of crop domestication/origin, where diversity of genetic resources is concentrated and where farmers maintain not only the landraces of ancestral crop populations, but also the human knowledge and behavioral practices that have shaped this diversity for generations (Bellon and Taylor, 1993). Understanding the diversity within a crop in an area means understanding the people who grow it, just as much as understanding the climate, the soil of the region and distribution of wild relatives (Guarino, 1995). This is because: the pattern of diversity in crops is the result of an interaction between the genetic make-up of the plants, the abiotic and biotic environmental factors as well as human selection and management. A hypothesis on the local agriculture features and the drivers and mechanisms of differentiation among farming systems, such as biophysical and socio-economic conditions, will be tested with statistics.

The bases for the currently grown improved varieties of crops are landraces well managed by farmers for millennia of generations. These landraces have important traits like resistance to biotic and abiotic stresses, which help to boost production and productivity through direct selection, hybridization with each other as well as gene transfer. Nowadays, the landraces are eroding from time to time and we are losing their diversity especially in crops where Ethiopia is either a center of diversity or origin. One of the crops is barley, which is grown widely by Ethiopian farmers mostly in the mid- and high-land areas.

Although the Northern Gondar highlands are potential barley production areas and harbor great diversity of land races, there is no well-documented study about the diversity of barley landraces. The present study was therefore initiated in order to document the diversity of barley landraces through various diversity index models, and to estimate the extent of genetic erosion through genetic erosion models in the North Gondar highlands of North Western Ethiopia.

MATERIALS AND METHODS

Description of the study areas

Six villages of Debark, Dabat and Wogera, two in each district, were studied. These districts are the major barley producing areas of North Gondar highlands. The villages were *Adisgie Miligebsa* and *Gomia* from Debark, *Woken* and *Talak mesik* from Dabat and *Daber Lideta* and *Kossoye* from Wogera. Although the geographic coordinates, soil physical and chemical characteristics of these villages vary, the agricultural cropping systems and also having

high potential and large area coverage in barley production are marks of similarity among the six villages. There was no similar study that could be used as a baseline in the area.

Research design

The design consisted of three stages. In the first stage, three study districts were purposively selected from the potential barley producing districts of North Gondar zone in consultation with North Gondar Zone department of Agriculture. In the second stage, two villages were purposively selected from each district in consultation with district agricultural experts with the major criteria being higher importance of barley in terms of area coverage. In the third stage, 180 respondent households were selected and interviewed from the six villages, each with 30 farmers. Women household heads and elders were purposely involved to ensure good coverage of diversity in knowledge.

Vernacular names

Farmers in the study area give names to varieties of barley by observing peculiar traits like quality, yield, color of seed, size of seed, number of rows, season of planting, maturity and origin to distinguish one another. The landraces planted were identified, named and described by the farmers.

Ecological models

Ecological models were employed to analyze the level of diversity. The models have been adapted on species diversity (Magurran, 1988). Magurran defined species diversity as consisting of the number of species (richness-R) and how equally abundant the species are (evenness-E). Margalef's, Menhinick's, Shannon and Simpson's diversity indices were employed using landraces as species (Magurran, 1988).

Landrace richness

Landrace richness (inter-varietal diversity) among the three districts was compared by using Margalef's index (D_{Mg}) and Menhinick's index (D_{Mn}) as follows:

$$D_{Mg} = \frac{(L - 1)}{\ln C} \quad D_{Mg} \geq 0$$

$$D_{Mn} = \frac{L}{\sqrt{C}} \quad D_{Mn} \geq 0$$

where L refers to the number of landraces in each district, while C designates the number of citations for each landrace.

Shannon Diversity Index (H)

$$H = - \sum_i^n p_i \ln p_i \quad P_i \geq 0$$

It is estimated as

where p_i , the proportional abundance of the i^{th} landraces = (n_i/N) .

The evenness (E) as measure of the Shannon diversity index is calculated as follows:

$$E = H / \ln L$$

Simpson's diversity index (D)

Simpson's index (D), an index commonly used to measure spatial diversity. The frequency of occurrence of each farmer variety cited in the six villages was calculated and presented as cited by farmers. The index is constructed from the number of varieties occurring in a location, and data was compiled from the households across study villages. Its formula is:

$$D = \sum_{i=1}^s p_i^2$$

The proportion of variety i relative to the total number of varieties (p_i) was calculated and squared. The squared proportions for all the species were summed, and subtracted from 1. The derived statistics $1 - D$ expresses the abundance and represents the probability that two individuals randomly selected from a sample will belong to different genotypes. The value of this index ranges between 0 and 1, the greater the value, the greater the sample diversity.

Genetic erosion models

Temporal diversity (rate of change over time) of barley landraces over a period of ten years were assessed in this study based on farmers interview and focus group discussion between the year 2006 and 2016. Genetic integrity and genetic erosion were calculated to assess the pattern of temporal diversity over 10 years (from 2006-2016) and to estimate the level of genetic erosion. Genetic integrity (GI) and Genetic erosion (GE) was estimated as given by Hammer et al. (1996).

$$GI\% = (C_{Y2}/C_{Y1}) \times 100$$

where $Y1$ refers to number of landraces collected in the initial year (first collection mission) and $Y2$ refers to the number of landraces collected in the second collection (second collection mission).

$$GE\% = 100\% - GI$$

The data collected was analyzed using statistical package for social sciences (SPSS Version 16) computer program and various descriptive statistics and mathematical methods like mean, percentages and various analytical methods were used based on the objectives of the study.

RESULTS AND DISCUSSION

Distribution of barley landraces

Documenting farmer-named varieties is important from the genetic resources conservation and utilization point of view, as the names farmers give to varieties is the unit that farmers manage and select over time. A total of 18 barley landraces were recorded in the study districts, which vary in maturity, yield potential, stress tolerance, end-use qualities, and other agronomic traits. The distribution of these 18 barley landraces varied across the districts; that is, a landrace rare in one village was

popular in another. As a result, a given landrace was registered in more than one distribution class. There were six landraces specific to study sites in each of Wogera and Debark districts, while no single landrace was specific to Dabat district. The most common and widely grown landraces listed by farmers across all study districts were *Abat gebs*, *Nech gebs* and *Tikur gebs* (Table 1).

In Debark district, 11 landraces comprising 59 citations were recorded. In this district, only four landraces out of the eleven landraces recorded were found to be popular among many households (79.7%). These are *Tege die belga*, *Nech gebs*, *Belga* and *Abat gebs*. In this area, three landraces namely *Shewa gebs*, *Tikur gebs* and *Akiya* were cited by one farmer each that showed their rarities in the district. Except *Tikur gebs*, the other two rare landraces were only cited in this district indicating these two landraces are becoming endangered to be lost (Table 1).

In Wogera district, 10 landraces comprising 60 citations, were recorded. In this district, only two landraces (*Abat gebs* and *Andita*) were cited by more than half household members (53.3%) showing the popularity of these landraces in the area. In this area, two landraces namely *Tikur gebs* and *Dinbil nech gebs* were cited by one farmer each showing their rarities. Of these rare varieties, *Dinbil nech gebs* is recorded only in this site. In this area, a variety *Teklie gebs* was named after the selector farmer "Teklie," and it was cited only in this district by six farmers (Table 1).

In Dabat district, 6 landraces comprising 59 citations were recorded. In this district, only two landraces, namely *Netela belga* and *Nech gebs*, were cited by more than half of the household members (66.1%); showing the popularity of these landraces in the area. The landrace *Bozie belga* was only cited by one farmer in this district. All the six landraces found in this district were also cited by other districts showing absence of a specific landrace in this district (Table 1). This district is located between Wogera and Debark districts and is found relatively in a lower altitude than the other two. This might be the reason why a large number of landraces were not recorded, since barley landraces are mainly found in higher altitude areas. The landraces recorded in the study districts are purposely maintained to address various needs of the farming community. Similar results were noted for the reason why farmers kept many landraces of barley by Eticha et al. (2008) and Shewayrga and Sopade (2011) in central Ethiopia and north eastern Ethiopia, respectively.

Area coverage, production and productivity of landraces

The area planted, yield obtained and productivity of

Table 1. List of landraces recorded along with diversity estimate.

Debark		Wogera		Dabat	
Variety	Frequency	Variety	Frequency	Variety	Frequency
Abat gebs	5	Abat gebs	15	Abat gebs	6
Nech gebs	13	Nech gebs	7	Nech gebs	13
Tikur gebs	1	Tikur gebs	1	Tikur gebs	5
Bozie belga	2	Weremenie	4	Weremenie	8
Netela belga	2	Semeno	2	Bozie belga	1
Shewa gebs	1	Andita	17	Netela belga	26
Tege die belga	20	Awura gebs	4		
Shegie gebs	2	Dinbil nech gebs	1		
Akiya	1	Derg gebs	3		
Belga	9	Teklie gebs	6		
Marwey	3				
Diversity Indices					
Number of landraces (L)	11		10		6
Number of citations (C)	59		60		59
Shannon Diversity Index (E)	0.79		0.85		0.83
Margalef's Index (D_{Mg})	2.45		2.20		1.23
Menhinick's Index (D_{Mn})	1.43		1.29		0.78

barley landraces was recorded and presented (Figure 1). The largest area share is covered by *Nech gebs*, followed by *Netela belga*, *Abat gebs* and *Tege die belga* (Figure 1a). However, the yield obtained in *Nech gebs* is lower than *Netela belga* and followed by *Abat gebs* and *Tege die belga* (Figure 1b). With regard to productivity of the barley landraces in a given area, the majority of the landraces have similar results with the more productive landrace being *Shegie gebs* followed by *Dinbil nech gebs*, *Akiya* and *Weremenie* (Figure 1c). This showed landraces with the largest area share were not found to be productive per unit area indicating farmers main criteria to grow certain landraces over others is not solely based on yield advantage rather combination of various attributes.

Variety diversity estimation

Diversity estimates, based on the number of landraces collected (richness), showed Debark area having the highest richness (Margalef = 2.45; Menhinick = 1.43) followed by Wogera (Margalef = 2.20; Menhinick = 1.29). Dabat was found to be less diverse in terms of a number of landraces collected in this study (Margalef = 1.23; Menhinick = 0.78) (Table 1). Diversity estimated based on evenness index (Shannon diversity index) on the other hand showed highest diversity in Wogera district (E=0.85) followed by dabat district (E=0.83) and Debark district (E= 0.79) (Table 1). The highest evenness found in

Wogera and Dabat districts were attributed to the abundance of the majority of landraces across the villages.

Simpson's diversity index

The occurrence of landraces in one or more locations is presented in Table 2. If a landrace is sampled in one site with higher frequency, that variety is locally common and the diversity value will be 0, or near to 0. If a variety exists in two or more sites, even if the frequency is low, the Simpson's index will be higher. The Simpson's diversity index (D) revealed the abundance of *Nech gebs* (0.66), *Abat gebs* (0.6) and *Tikur gebs* (0.52) in the study sites (Table 2). *Nech gebs* and *Abat gebs* were found to be common and widely distributed in all districts and were cited by 33 and 26 farmers, respectively. *Tikur gebs* on the other hand was only cited by seven farmers though it was distributed in the three districts. The landraces *Weremenie* (0.48), *Bozie* (0.33) and *Netela belga* (0.14) were cited by farmers in two districts each. The remaining twelve landraces (66.67%) were reported to be common but specific to only one district each; that is why their Simpson's diversity index was 0 (Table 2).

Temporal diversity pattern and genetic erosion

For the last ten consecutive years, between 2006 and

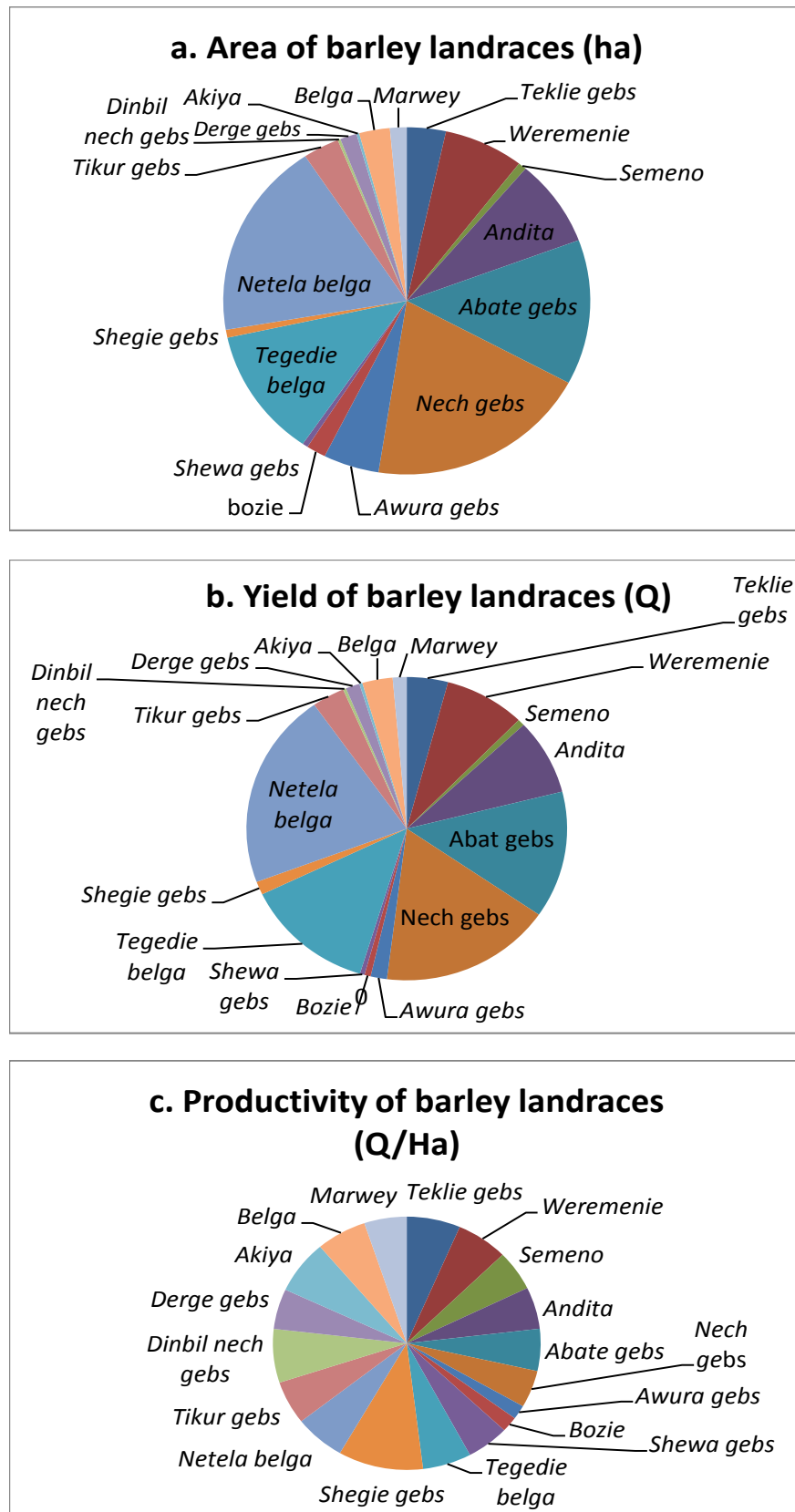


Figure 1. Area, yield and productivity of barley landraces in north Gondar highlands.

Table 2. Occurrence of landraces in each district according to Simpson's Index (D).

Landrace name	No. of farmers who cite the landraces			Cited farmers	Simpson index
	Wogera	Dabat	Debark		
<i>Teklie gebs</i>	6			6	0
<i>Weremenie</i>	4	8		12	0.48
<i>Semeno</i>	2			2	0
<i>Andita</i>	17			17	0
<i>Abat gebs</i>	15	6	5	26	0.6
<i>Nech gebs</i>	7	13	13	33	0.66
<i>Awura gebs</i>	4			4	0
<i>Bozie</i>		1	2	3	0.33
<i>Shewa gebs</i>			1	1	0
<i>Tegedie belga</i>			20	20	0
<i>Shegie gebs</i>			2	2	0
<i>Netela belga</i>		26	2	28	0.14
<i>Tikur gebs</i>	1	5	1	7	0.52
<i>Dinbil nech gebs</i>	1			1	0
<i>Derg gebs</i>	3			3	0
<i>Akiya</i>			1	1	0
<i>Belga</i>			9	9	0
<i>Marwey</i>			3	3	0

2016, it was reported that there were 24 barley landraces in the study districts, which were under production. But during the study time (2016), only 18 landraces were found under production, which means six landraces were missing from the recent study. These missed landraces were named as *Demo kises*, *Goreneje*, *Chankirme*, *Gabie aswelik*, *Amedo* and *Gero tal*. Based on the model of genetic integrity and genetic erosion, the genetic integrity was about 75% and the genetic erosion was 25%. This means 75% of the landraces present in the last ten years are still under production and the remaining ones were lost. Similar results in many other crops have been reported; i.e., farmer varieties are rarely seen in the fields (Girma, 2014).

Vernacular names

The different landraces planted in the study areas were identified, named and described by the farmers. Studies on other crops showed that vernacular names and farmers' descriptions of landraces can relate to formal scientific classifications (Teshome et al., 1997). The varieties *Weremenie*, *Semeno*, *Shewa gebs* and *Tegedie* have got their name based on from where they came from in the country. The varieties *Nech gebs*, *Tikur gebs* and *Shegie gebs* got their name based on the colour of their seed. The variety *Derg gebs* is given its name since it came to the study area during the regime of *Derg*. The

variety *Teklie gebs* has got its name from the farmer selector named '*Teklie*'. The farmer varieties identified, number of rows they have and their meanings are listed in Table 3. The barley landraces studied in the north Gondar highlands were entirely different (at least in name if not genetically) from similar studies made earlier by Eticha et al. (2008) and Shewayrga and Sopade (2011).

Conclusions

This research was conducted to assess on farm diversity status of barley landraces. The numbers of landraces before a decade in the study districts were reported to be 24. However, in 2016 eighteen landraces were being grown on small plots of land. The landraces *Demo kises*, *Goreneje*, *Chankirme*, *Gabieaswelik*, *Amedo* and *Gero tal* were lost. The estimated loss accounts for 25% and the level of genetic integrity (GI) was 75%. Of these 18 cultivated landraces, *Abat gebs*, *Nech gebs* and *Tikur gebs* were found to be the most common and widely grown landraces.

Debark district was found to have the highest richness, followed by Wogera and dabat districts. With regard to evenness on the other hand, Wogera district showed the highest diversity followed by dabat and debark. Simpson's diversity index revealed the abundance of *Nech gebs* (0.66), *Abat gebs* (0.6) and *Tikur gebs* (0.52). The name given to landraces studied was found to be

Table 3. Vernacular names and their meanings of barley landraces grown in North Gondar highlands.

Name	No. of rows	Meaning of variety name
<i>Teklie gebs</i>	Four	Named after the farmer selector, Teklie (probably selected from malt barley)
<i>Derg gebs</i>	Six	Comes during the regime of Derg
<i>Woremenie</i>	Two	Black seeded coming from Wollo
<i>Semeno</i>	Four	Comes from Northern Ethiopia
<i>Andita</i>	Six	Uncomparable in yield and quality /best/
<i>Abat gebs</i>	Six	Comes from early ancestral fathers
<i>Nech gebs</i>	Six	White kernel
<i>Awura gebs</i>	Four/Six	Big seeded and high yielder
<i>Shegie gebs</i>	Six	White kernel and attractive color
<i>Netela belga</i>	Two	It has a single row and grown two times a year
<i>Shewa gebs</i>	Four	Comes from Shewa
<i>Akiya</i>	Two	When touched by both hands after roasted, the cover easily separate from the seed specially used for <i>kolo</i>
<i>Tikur gebs</i>	Four/Six	Black (tikur) color of the barley grain
<i>Bozie belga</i>	Two	Sown lately
<i>Marwey</i>	Six	It is a mixture
<i>Belga</i>	Four	It is mixed and mature early
<i>Tegedie belga</i>	Six	Comes from a place called Tegedie
<i>Dinble nech gebs</i>	Four	Meaning not known

associated with certain characteristics or situations. In conclusion, the genetic resources will be used for meeting future food needs and social benefits for the world's rapidly growing human population. Therefore, attention should be given to on-farm conservation and enhancement of farmers' varieties. Thus, policy makers and researchers should give attention to conservation of landraces for better use of genetic resources.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

- Asmare Y, Alemu H, Alemayehu A, Melkamu A, Tessema Z, Berihane A, Halima H (1998). Barley production practices in Gojam and Gondar. In Chilot Y, Fekadu A, Woldeyesus S (Eds.), Barley based farming system in the high lands of Ethiopia. Ethiopian Agricultural Research Organization. Addis Ababa, Ethiopia pp. 67-89.
- Bellon MR, Taylor JE (1993). Farmer soil taxonomy and technology adoption. *Economic Development and Cultural Change* 41:764-786.
- Eticha F, Berghofer E, Grausgruber H (2008). Utilization of barley (*Hordeum vulgare* L.) landraces in the highlands of West Shewa, Ethiopia. *Plant Genetic Resources: Characterization and Utilization* 7(2):154-162.
- FAO (1996). Global plan of action on the conservation and sustainable utilization of plant genetic resources for food and agriculture. The International Technical Conference on Plant Genetic Resources, Leipzig, Germany P 63.
- Girma M (2014). Genetic erosion of barley in North Shewa Zone of Oromiya Region, Ethiopia. *International Journal of Biodiversity and Conservation* 6(3):280-289.
- Guarino L (1995). Secondary sources on cultures and indigenous knowledge systems. In: Guarino L, Rao VR, Reid R (Eds.), *Collecting Plant Genetic Diversity Technical Guidelines*. CAB International, Wallingford, UK. pp. 195-228.
- Hammer K, Kn puffer H, Xhuveli L, Perrino P (1996). Estimating genetic erosion in FV's – two case studies. *Genetic Resources and Crop Evolution* 43:329-336.
- Magurran AE (1988). *Ecological diversity and its measurements*. Princeton, NJ, USA: Princeton University Press P 192.
- Orabi J, Backes G, Wolday A, Yahyaoui A, Jahour A (2007). The Horn of Africa as a centre of barley diversification and a potential domestication site. *Theoretical and Applied Genetics* 14:1117-1127.
- Shewayrga H, Sopade PA (2011). Ethnobotany, diverse food uses, claimed health benefits and implications on conservation of barley landraces in north eastern Ethiopia highlands. *Journal of Ethno biology and Ethno medicine* 7(19):1-15.
- Teshome A, Baum BR, Fahrigr L, Torrance JK, Arnason JT, Lambert JD (1997). Sorghum [*Sorghum bicolor* (L.) Moench] landrace variation and classification in North Shewa and South Welo, Ethiopia. *Euphytica* 97:255-263.

Full Length Research Paper

Ecological distribution, diversity and use of the genus *Digitaria* Haller (Poaceae) in Senegal

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The genus *Digitaria* Haller is one of the most important of grass flora of Senegal by both its specific richness and the socio-economic value of its species. Despite this importance, no studies have been done specifically on these species. This study aims, therefore, to document the diversity, distribution, ecology and usefulness of the genus of such species for raising public awareness about botanical, ecological distribution, and status of such species and their uses in Senegal. Data collection approach was based on field work conducted in Senegal that has allowed the preparation of distribution maps of species related to ecological factors such as climate, vegetation and soil coupled with a literature review used to determine the use of species. Consequently, literature accessed has revealed that various species of *Digitaria* exist and they consist mainly of weeds, forage or food crops. *Digitaria* spp. has a wider distribution with some species having a broader distribution whereas others are restricted to some African regions. They are generally encountered throughout the tropics including in rainforests, savannas and steppes; wherein soils are sandy and acidic types. In Senegal, most of the species are found in the south under a Sudano-Sahelian zone, growing on almost all vegetation and soil types. This study, which is a contribution to the improvement and preservation of the living environment of these species, is an important step for the facilitation of any conservation action. It also encourages a greater appreciation of the value of these species, which are potential sources of genes from *Digitaria exilis*, the cultivated species.

Key words: *Digitaria*, climatic zones, vegetation types, soil types, conservation, Senegal.

INTRODUCTION

The genus *Digitaria* Haller comprises ca. 220 species distributed in tropical, subtropical, and temperate areas worldwide (Vega et al., 2009; Boonsuk et al., 2014; Okanume et al., 2014; Ngom et al., 2016; Lo Medico et

al., 2017). In tropical Africa, accessible data mentions about sixty species (Robyns, 1931). However, knowledge on current diversity of the genus in this region, including Senegal, is poorly available. In Senegal, the genus

Digitaria is among the most important groups of Poaceae in terms of socio-economic value of the species. It is found in a range of habitats but seems to be most diverse in open areas or grasslands (Boonsuk et al., 2016). Crabgrass species grow in disturbed areas, particularly in gardens and cultivated fields, and are seldom observed in natural veld (Hugo, 2014).

The socio-economic importance of *Digitaria*' species is particularly in their uses as source of human food (Koroch et al., 2013; Ouedraogo et al., 2015; Barnaud et al., 2017), fodder (Beck et al., 2017; Harun et al., 2017) and in pharmacopoeia (Poilecot, 1995, 1999; Pare et al., 2016). Despite the usefulness of this genus, little research has been directed towards studying the botanical and geographical distribution of the genus or of the species in Senegal. The Sudano-Sahelian region has undergone land cover change and land use changes driven by anthropogenic pressures over recent years. The negative impacts of these anthropogenic factors and precarious climatic conditions balance the exploitation and regeneration of resources over time and space, which results in a gradual disappearance of land cover. In Senegal, studies on the distribution of crabgrass are out of date (Berhaut, 1967; Vanden, 1991) and some species such as *Digitaria aristulata*, *Digitaria gentilis* and *Digitaria patagiata* are rare, endemic and endangered, respectively (USAID/Senegal, 2008; Ngom et al., 2016). Therefore, gathering such data could be crucial to determining the current geographical distribution of each species of that genus according to environmental factors.

This paper aims at providing updated knowledge on the botanical and geographical distribution of 19 species of *Digitaria* in Senegal according to the climatic zones, types of vegetation and soil, and to document the usefulness of that species based on available literature on their social and economic importance as a source of animal feed and human consumption.

MATERIALS AND METHODS

Diversity, distribution and ecology of species in Senegal

Senegal, a Western African country, belongs to the Upper Sahelian region. Its geographical position, in a transition zone between the North and the South rainforest, provides to the country a rich ecosystem of high biological diversity (MEPN, 1997). Among the species richness of that ecosystem includes the genus *Digitaria*. The species studied were *D. acuminatissima*, *D. argillacea*, *D. aristulata*, *D. ciliaris*, *D. debilis*, *D. delicatula*, *D. diagonalis*, *D. exilis*, *D. gayana*, *D. gentilis*, *D. horizontalis*, *D. leptorhachis*, *D. longiflora*, *D. nuda*, *D. patagiata*, *D. perrottetii*, *D. sanguinalis*, *D. ternata* and *D. velutina*. For each species studied, the geographical coordinates of herbarium collections (all species studied) of the Herbaria IFAN and DAKAR (Cheikh Anta Diop University) were

recorded. These data were supplemented by those of the Global Biodiversity Information Facility (GBIF) database (all species studied) and those from our collection (specimens of *D. ciliaris*, *D. exilis*, *D. horizontalis*, *D. longiflora* and *D. perrottetii* collected in the regions of Dakar and Ziguinchor). Field work has allowed the collection of data on the species such as *D. acuminatissima*, *D. gentilis* and *D. sanguinalis* in Senegal.

However, geographical coordinates of those species were not initially available in the country's database. As a result, geographical coordinates of these species have been taken into account in the analysis of the country's species distribution maps. In this study, three ecological factors were documented: i) the climate which remains one of the most important factors influencing species distribution, ii) vegetation, and iii) soil. In the analyses applied here, the definition of global climate zones characterizing the distribution of *Digitaria* species was based on the Köppen (1900) classification. Maps of major vegetation and world types of soil were provided by WWF and FAO, respectively. In Senegal, the climate zone map has already been defined by Mbow (2009); whereas, the characteristics of the types of vegetation and soil were provided by the Ecological Monitoring Center (Centre de Suivi Ecologique, 2007).

A georeferencing approach based on cards selection with the QGIS software (version 1.5.0 Tethys, 2010) was used to analyse the species distribution. Such approach has allowed assigning geographic coordinates to these cards in the form of an image file. The projection of geographical coordinates of different samples from geo-referenced maps has allowed the designation of species distribution areas.

Usefulness of species

For ethnobotanical study, information gathered comes from a literature review. Data on different uses of species was obtained from: floras (Vanden, 1991; van der Zon, 1992; Poilecot, 1995, 1999); botanical and agronomy textbooks (Kleinschmidt and Johnson, 1977; Muenscher, 1980; Merlier et al., 1982; Akobundu and Agyakwa, 1989; Le Bourgeois and Merlier 1995; Wilson et al., 1995; Halvorson and Guertin, 2003; Brink and Belay, 2006) and other types of scientific documents (Robyns, 1931; Obizoba and Anyinka, 1994; Lepschi and Macfarlane, 1997; Quattrocchi, 2006).

RESULTS AND DISCUSSION

Diversity, distribution and ecology of species

From this study, it appears that 19 species of *Digitaria* studied are spread over all continents and mainly in tropical and subtropical regions (Figure 1). The wide distribution of these species is in line with those highlighted by Poilecot (1999), Vega and Rúgolo de Agrasar (2002a), and Adoukonou-Sagbadja et al. (2006). Some of these taxa such as *D. acuminatissima*, *D. aristulata*, *D. delicatula*, *D. gayana*, *D. gentilis*, *D. leptorhachis*, *D. patagiata* and *D. perrottetii* are strictly encountered in Africa. Such African distribution of the species has already been indicated by the following

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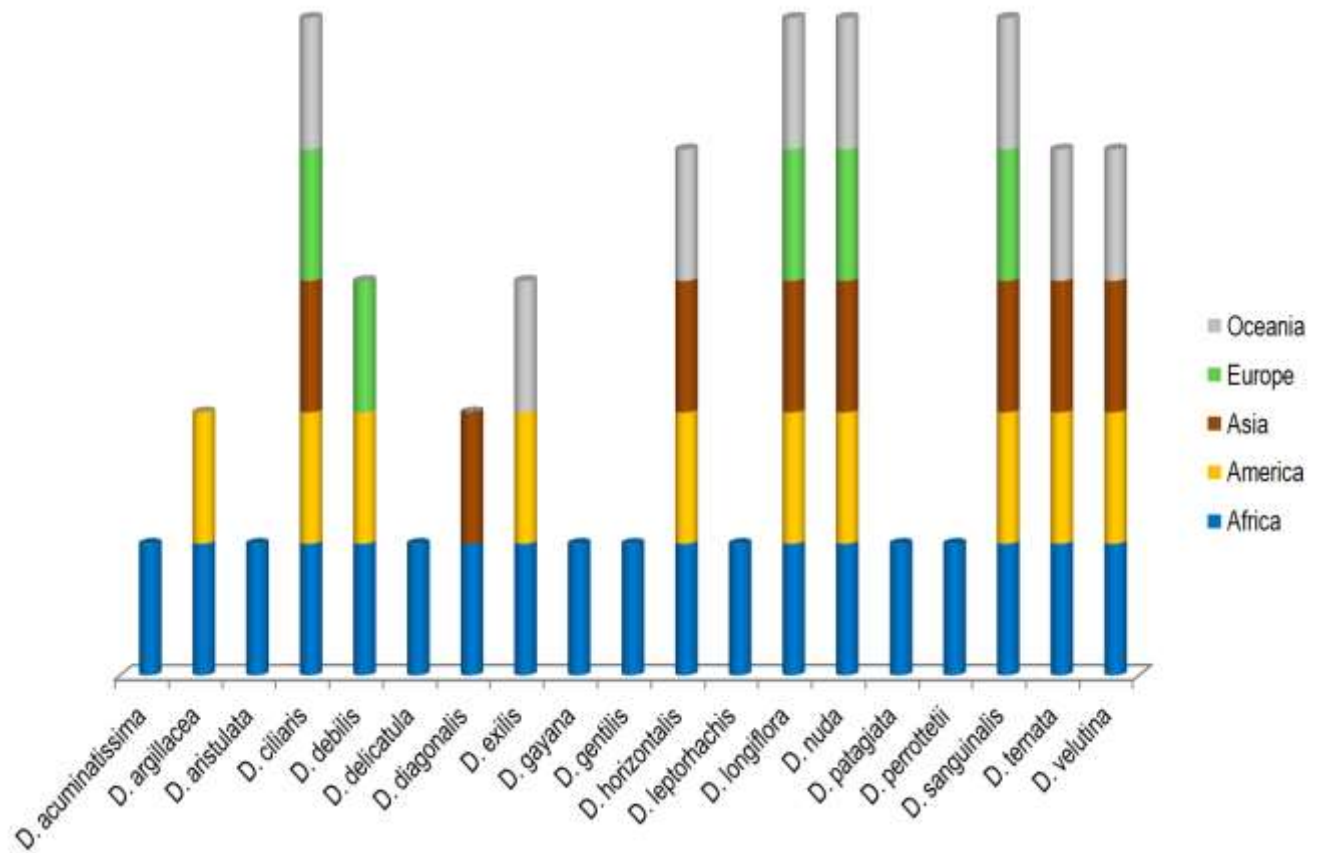


Figure 1. Continents where species of the genus *Digitaria* are encountered.

scholars (Vanden, 1991; van der Zon, 1992; Poilecot, 1995, 1999). On the contrary, other species have wider distribution area (throughout the five continents), such as: *D. ciliaris*, *D. longiflora*, *D. nuda* and *D. sanguinalis*.

In line with the previous result, the continental distribution of *D. ciliaris* has already been highlighted by Poilecot (1995) as well as the distribution of *D. longiflora* distribution. Vanden (1991) reported that *D. longiflora* is mostly distributed in the tropics.

Regarding the geographical distribution of *D. nuda*, the studies of van der Zon (1992) and Poilecot (1999) have reported that such species are encountered in tropical regions including Africa, Mauritius, Brazil, Indonesia, etc. Similarly, *D. sanguinalis* is widely encountered in tropical and warm temperate regions (Clayton, 1989).

The type of climate represents the first factor influencing the species' distribution. There is a worldwide distribution of the species according to the climatic zones (Figure 2), vegetation types (Figure 3) and soil types (Figure 4). The distribution of such species is not accidental. In the African continent, the distribution of species of the genus *Digitaria* is remarkably encountered in tropical rainforests, savannas and steppes; and wherein soils are mostly sandy and acid. Such species

tend to thrive when living under arid climatic zones characterized by a deficiency in rainfall, and in the polar zone or tundra type of areas, wherein the average and annual temperature tend to be below zero. It can be argued that the species of the genus *Digitaria* has developed a substantial ability to adapt to highly variable environmental conditions given that in polar areas often with bare substratum, and formed with ice and rocks; they are not often encountered.

Figures 5 to 8 show the distribution of the genus *Digitaria* according to the climatic zones, vegetation types, and soil types, respectively, covered by each species in Senegal.

In terms of species richness, the Sudan region tends to be more represented. In that region alone, 12 species have been inventoried so far, namely: *D. argillacea*, *D. aristulata*, *D. ciliaris*, *D. diagonalis*, *D. gayana*, *D. nuda*, *D. delicatula*, *D. exilis*, *D. gentilis*, *D. horizontalis*, *D. longiflora* and *D. ternata*. On the contrary, the Sudano-Sahelian zone tends to be the geographical area wherein the richness of the species is the lowest, with five species inventoried so far, such as: *D. aristulata*, *D. ciliaris*, *D. horizontalis*, *D. longiflora* and *D. velutina*.

Although the specific richness is independent from the

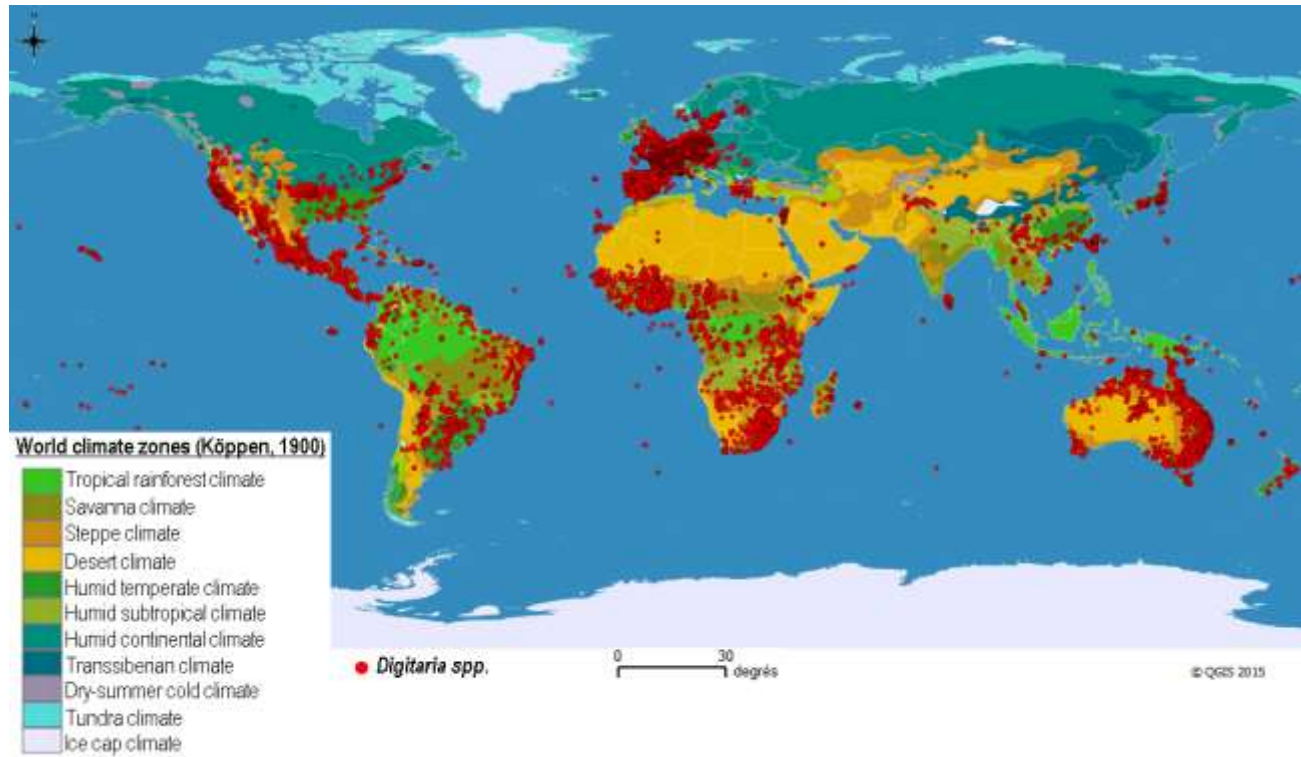


Figure 2. Species' distribution according to the climatic zones in the world.
Source: Wikimedia Commons.

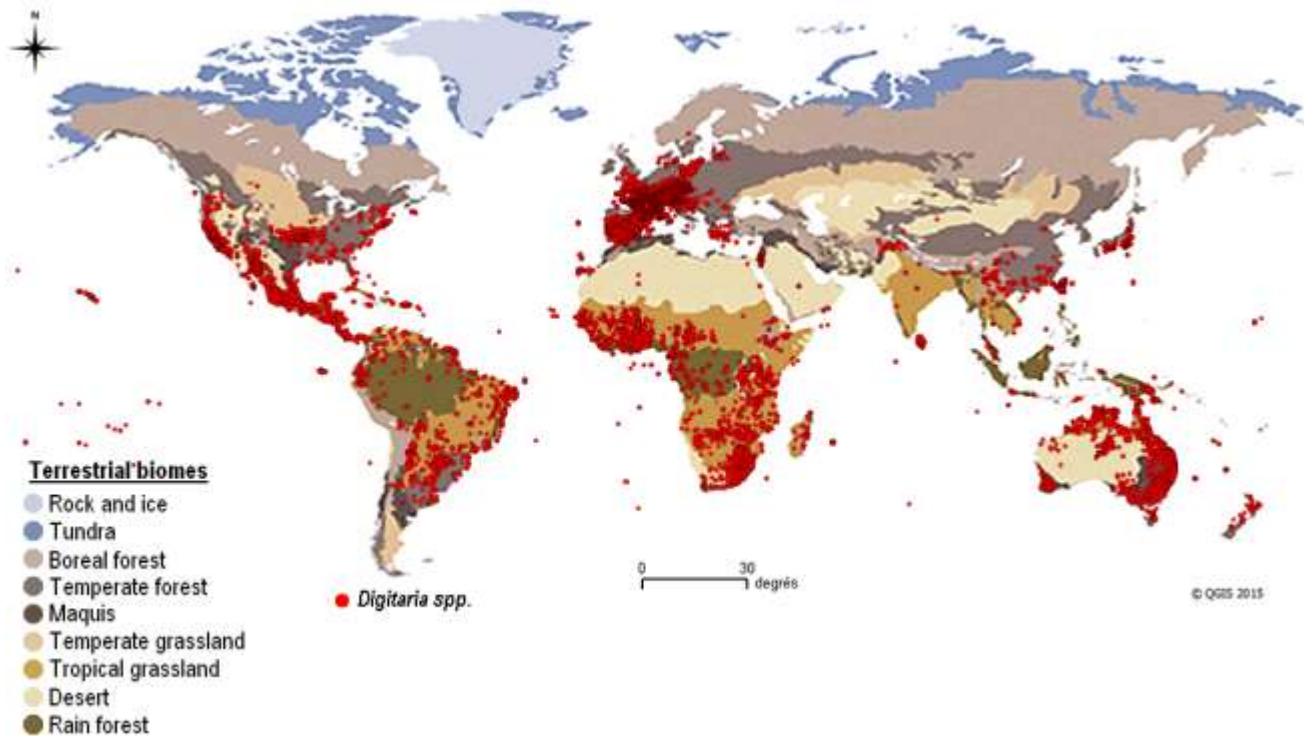


Figure 3. Species' distribution according to the vegetation types in world.
Source: QA International.

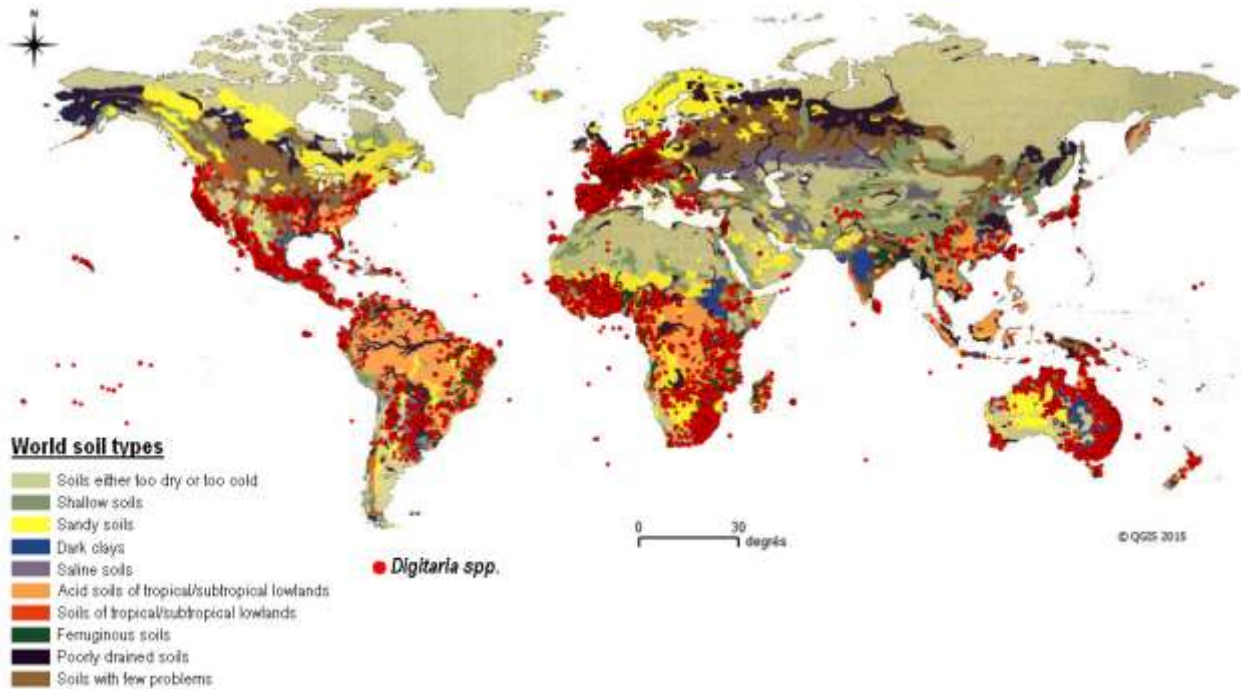


Figure 4. Species' distribution according to the soil types in the world.
Source: FAO.

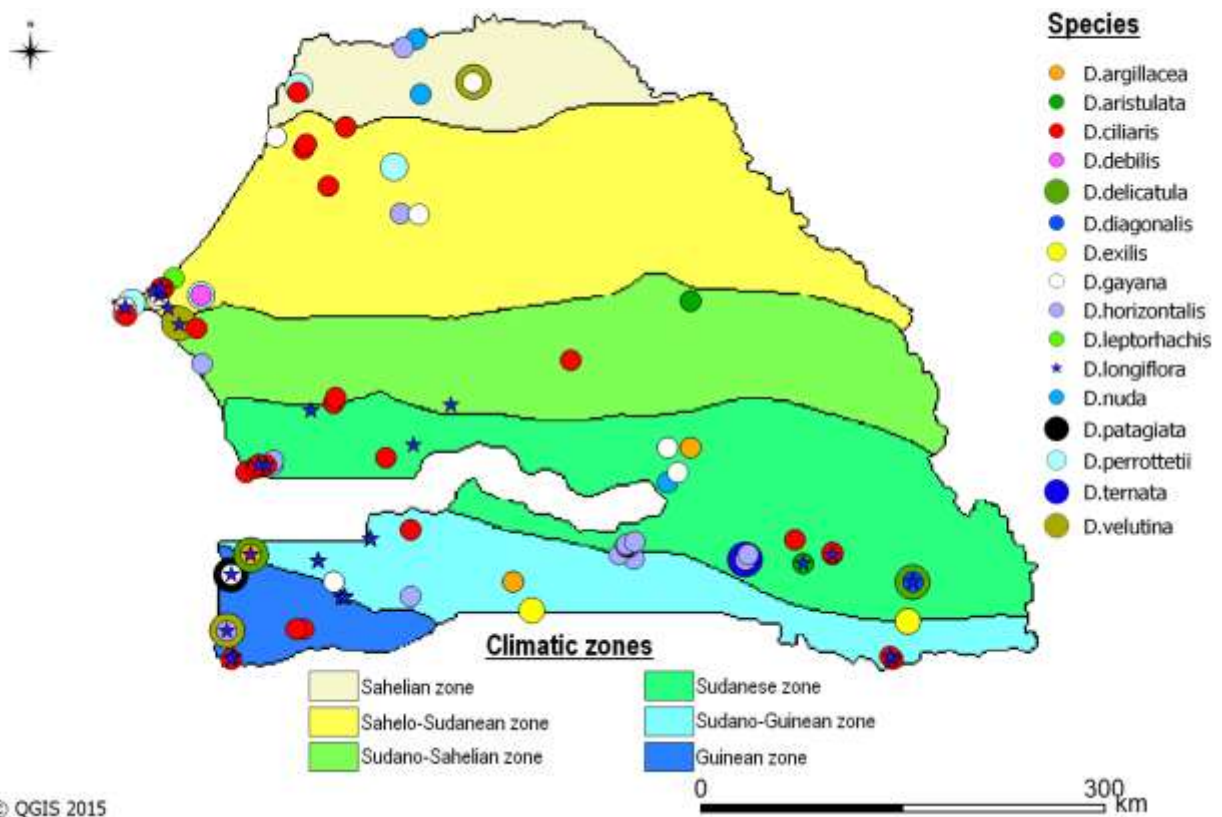


Figure 5. Species' distribution according to the climatic zones in Senegal.
Source: Mbow, 2009.

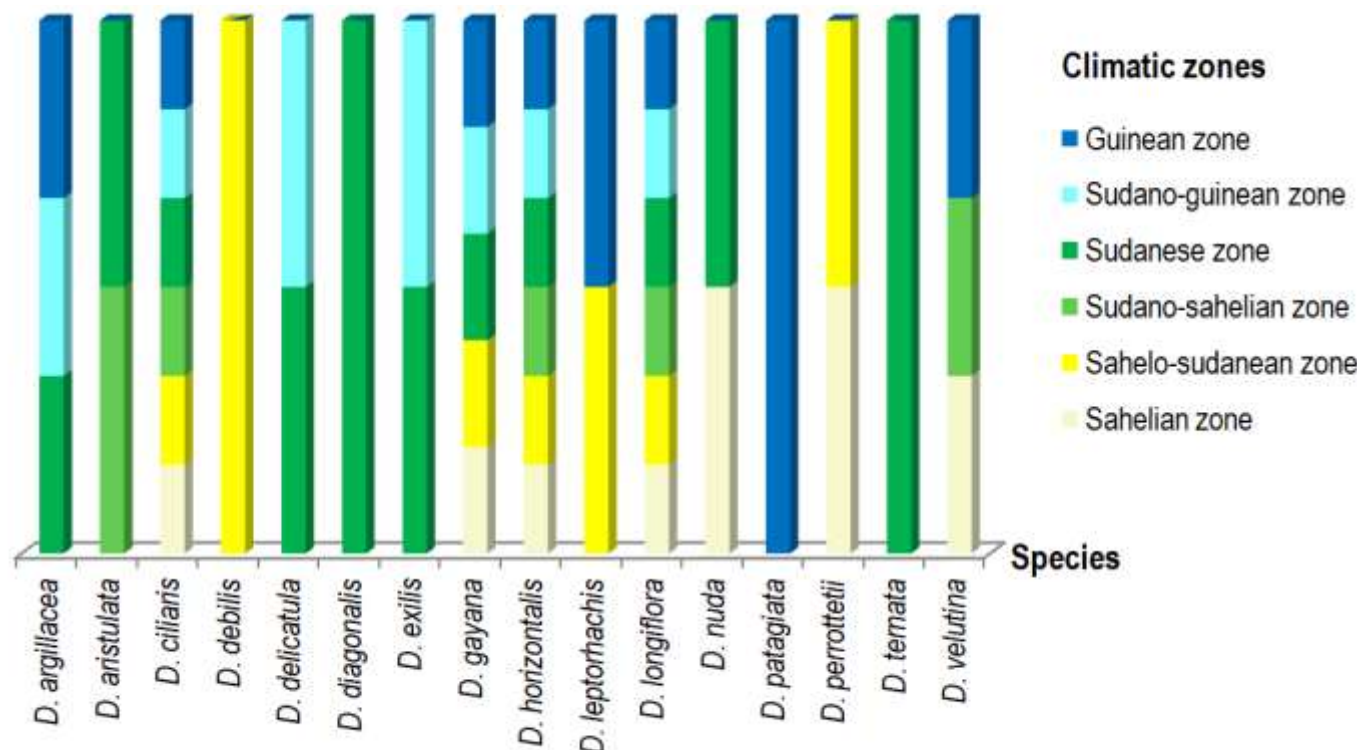


Figure 6. Climatic zones covered by each species encountered in Senegal.

North-South climatic gradient, it is important to note, however, that 15 out of the 19 species found in Senegal (including *D. acuminatissima*, which is not shown on the maps) are encountered in the Guinean areas, Sudano-Guinean and Southern part of the Sudan area. It could be argued that in those geographical and ecological areas, most of the species of *Digitaria* tend to encounter favorable environmental conditions for their growth.

In Africa in general, and in Senegal in particular, although none of the six climate zones is characterized by a particular flora of *Digitaria*, it is remarkable to note that some species have a wide distribution area (Figure 6). That is the case with *D. ciliaris*, *D. horizontalis* and *D. longiflora* that cover all the climatic zones in Senegal. In the case of *D. longiflora*, additional data from non-georeferenced samples of the species confirms its presence in this area, especially in the Senegal River region (Berhaut 5420).

Conversely, other species have a rather narrow distribution in the African continent as is the case of *D. diagonalis*, *D. ternata* (Sudanese zone), *D. patagiata* (Guinean zone), *D. argillacea*, *D. exilis* and *D. delicatula* that appear to be Sudano-Guinean species. Specimens of *D. gentilis* have been inventoried in the Sudan region (National Park of Saloum Delta) by Lykke et al. (1994). But, these specimens (Lykke et al. 309 and Lykke et al. 323) have been confused with *D. longiflora*. Since 1930, *D. gentilis* tends to be only encountered in the Sudano-

Sahelian region by Trochain (Trochain 570), especially along the backwater of Hann in Dakar.

On the other hand, *D. perrottetii* represents the species that has a Sahelian affinity, because this species tends to be encountered in the Sahelian and Sahelo-Sudanean. *D. aristulata* has a Sudano-Sahelian affinity, because it was inventoried in the Sahel and Mali (Vanden, 1991). Although the area of distribution of *D. acuminatissima* and *D. sanguinalis* is not shown on the distribution map, however, these species tend to have a limited distribution, especially encountered broadly in the south (Vanden, 1991) and in Dakar (Berhaut 2824), respectively.

Although many species are also encountered both in the north and in the south of the country, however they are not reported in all climate zones. The presence of species such as *D. debilis*, *D. gayana*, *D. leptorhachis*, *D. nuda* and *D. velutina* in geographical opposite zones (North and South) may tend to reveal their lack of affinity with regards to the given type of climate. On the contrary, they are species that are only encountered in the Sudano-Sahelian region, such as *D. debilis*. However, the geographical area covered by such species tends to be important, because it was found in Sine-Saloum, in Lower Casamance (Vanden, 1991) and in Thies (Berhaut 1080, 2784), respectively.

In Senegal, for example, the different climatic zones of the country are characterized by typical vegetation. This

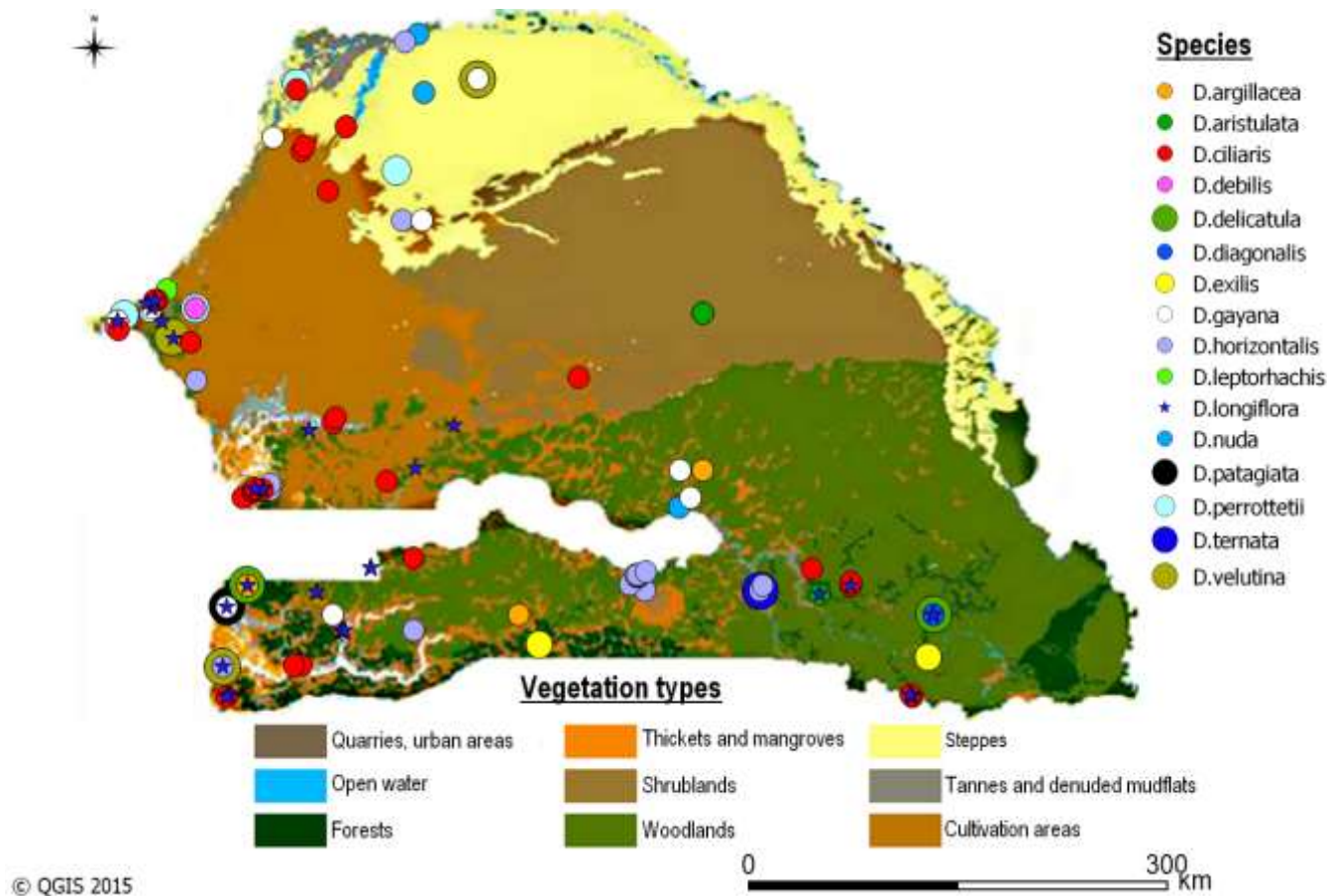


Figure 7. Species distribution according to the vegetation types in Senegal. Source: CSE, 2007.

means that the Sahelian zone is generally composed of steppe-type vegetation; while the Sudanean and Guinean zones are characterized by woodlands and forest-type vegetation. According to the results of the study, the species of the genus *Digitaria* are reported in almost all types of vegetation and soil types in Senegal (Figures 7 and 8). Thus, such species tend to grow on semi-arid (red-brown), ferruginous, ferralitic, hydromorphic, little evolved soils, or on lithosol, regosol or mudflat soil types. Such soils are usually covered by a diversified type of vegetation such as steppes, savannas (wooded and shrub) and forests. If, in their entity, *Digitaria*'s species support a wide range of environmental conditions, it is still worth mentioning that some have outstanding features. Whether they are present in all climate zones or not, these species are encountered both in arid areas where the vegetation is steppe (the North) and wetlands which consist largely of forests and woodlands (south). That is the case of *D. ciliaris*, *D. gayana*, *D. horizontalis*, *D. longiflora*, *D. nuda* and *D. velutina*. With the exception of *D. nuda* and *D. velutina*, these species grow on a variety of soils that spread mainly from North to South, in semiarid soils formed of dunes, ferruginous and ferralitic

soils. These are characteristics of the regions with Guinean or Sudano-Guinean climate (Michel, 1973).

Uses of species

Table 1 shows the worldwide distribution and usefulness of different species of the genus *Digitaria*. As shown in Table 1, the distribution of the *Digitaria* species is wider, because the species have been inventoried throughout the five continents of the world. As expected, usages of the species are of great socio-economic value. Weeds are often source of damage to some crops as it is the case for *D. ciliaris*, *D. horizontalis*, *D. longiflora*, *D. nuda*, etc. (Wiersema et al., 2013). Species such as *D. ciliaris* cause severe infestations and damage to growth of corn (Bassene, 2014) while *D. nuda* has been identified as a troublesome weed in West African countries especially in sugarcane production (Chikoye et al., 2000; Dias et al., 2005) and in crop fields in South Africa, and other countries to the north in Africa (Hugo et al., 2014a; Hugo et al., 2014b).

Despite the damaging role played by weeds in crop

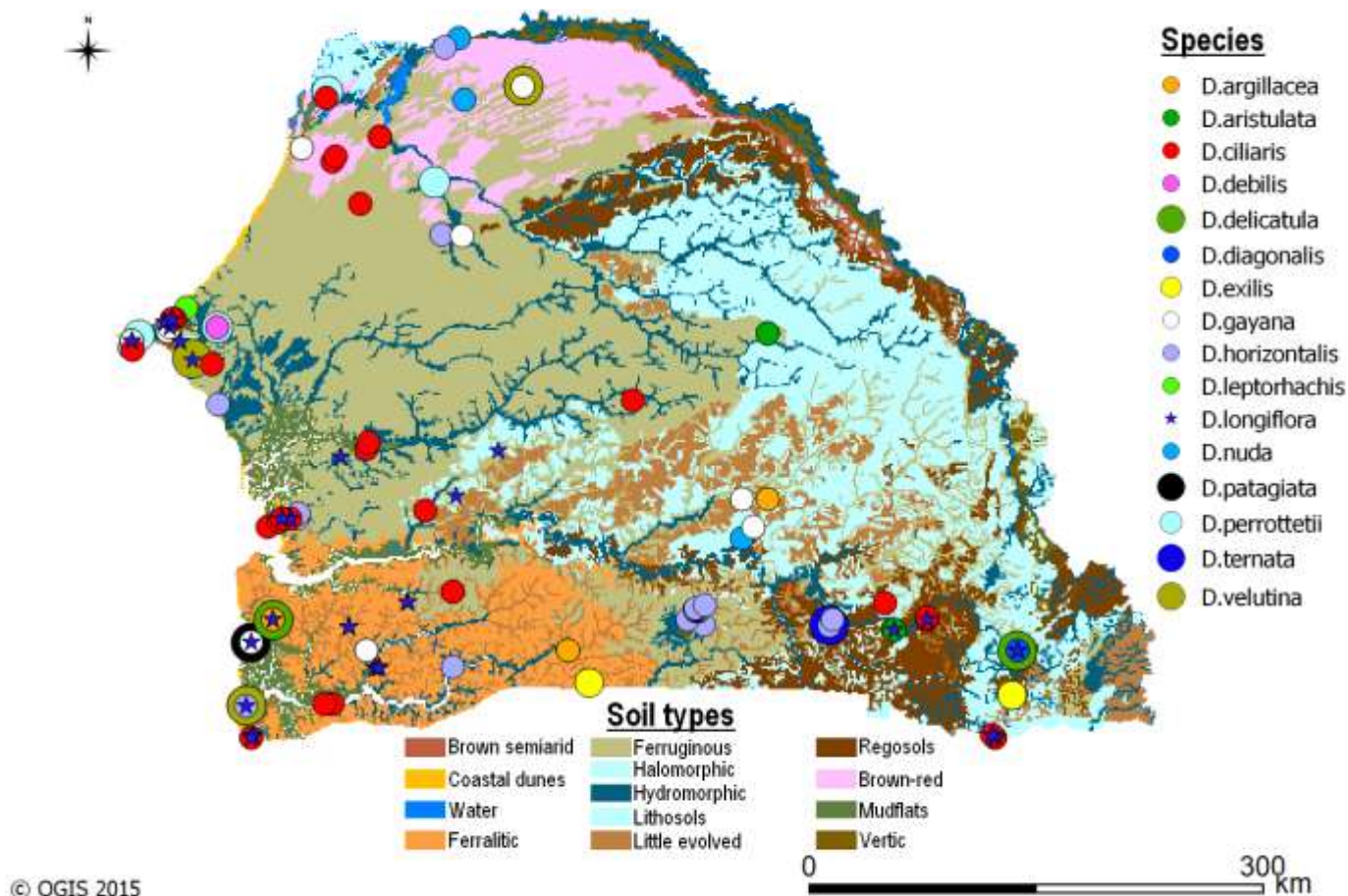


Figure 8. Species distribution according to the soil types in Senegal. Source: CSE, 2007.

growth, such weeds however are often less beneficial to human as a source of food (36.84%), than to livestock as source of feed (68.42%). Other key roles played by weeds include soil conservation. In southern Senegal for example, the only cultivated species of *Digitaria* is *D. exilis*. In the Sahel region, other species are increasingly more consumed; especially in time of environmental crises such as famine, crop failure. This is the case of the species such as *D. ciliaris*, *D. debilis*, *D. horizontalis* (Poilecot, 1999; Sene, 2000; Brink and Belay, 2006; Diarra et al., 2016), *D. longiflora*, *D. nuda* (Quattrocchi, 2006) and *D. sanguinalis* (Portères, 1955; Brink and Belay, 2006). As a result, they tend to play a safety role function, especially in time of household crises. In the Sahel region, the safety role function tends to be widely acknowledged by policy makers.

In traditional medicines such as pharmacopeia, about 15.79% of the species are used for that purpose. In Africa, grain of *D. exilis* is highly used for its therapeutic values (Obizoba and Anyinka, 1994; Poilecot, 1995; Ibrahim and Saidu, 2017). In Togolese traditional medicine for example, the powder obtained from calcined

leafy stems of *D. horizontalis* is used against vomiting in children (Poilecot, 1995, 1999). In Senegal, decoctions of *D. leptorhachis* are used to bathe the children, making them stronger (Poilecot, 1995, 1999). Finally, 10.53% of species are used for the creation of lawns as is the case for *D. ciliaris* and *D. horizontalis*; while 5.26% of the species tend to be used as ornamental plants. That is the case of *D. longiflora*.

Conclusion

The worldwide distribution of the 19 *Digitaria*'s species studied according to climatic zones, vegetation types, and soil types show that *Digitaria*'s species are found in a wide range of environmental conditions.

The distribution of *Digitaria* species in relation to climate zones, vegetation types and soil types in Senegal indicates that the species, taken as a whole, occupy all of the Senegalese territory; and therefore, very varied environments. However, most of them are found in the south of the country where the environmental conditions

Table 1. Worldwide distribution and usefulness of *Digitaria* species.

<i>Digitaria</i> species	Worldwide distribution of species	Uses of species
<i>D. acuminatissima</i>	Africa ^{1, 2}	weed ⁶ , fodder ¹⁷
<i>D. argillacea</i>	Africa ^{1, 2} , America ²	weed ^{6, 18} , fodder ⁴
<i>D. aristulata</i>	Africa ^{1, 2}	-
<i>D. ciliaris</i>	Africa ^{1, 2} , America ² , Asia ² , Europe ² , Oceania ²	weed ^{6, 7, 8, 9, 10} , food ⁶ , fodder ^{5, 6, 7, 8, 9, 10} , pelouse ⁵
<i>D. debilis</i>	Africa ^{1, 2} , America ² , Europe ²	food ^{5, 20} , fodder ⁵
<i>D. delicatula</i>	Africa ^{1, 2}	fodder ⁶
<i>D. diagonalis</i>	Africa ^{1, 2} , Asia ²	fodder ^{6, 11}
<i>D. exilis</i>	Africa ^{1, 2} , America ² , Oceania ²	food ⁶ , weed ⁶ , fodder ^{4, 5, 6} , pharmacopoeia ¹²
<i>D. gayana</i>	Africa ^{1, 2}	weed ⁶ , fodder ^{4, 5}
<i>D. gentilis</i>	Africa ^{1, 2}	-
<i>D. horizontalis</i>	Africa ^{1, 2} , America ² , Asia ² , Oceania ²	weed ^{6, 13, 18, 19} , food ³ , fodder ^{3, 4, 5, 6, 17} , pelouse ^{4, 5} , pharmacopoeia ^{4, 5}
<i>D. leptorhachis</i>	Africa ^{1, 2}	weed ⁶ , fodder ^{3, 4, 5, 6} , pharmacopoeia ^{4, 5}
<i>D. longiflora</i>	Africa ^{1, 2} , America ² , Asia ² , Europe ² , Oceania ²	weed ⁶ , food ⁶ , fodder ^{3, 6, 17} , ornamental ⁶
<i>D. nuda</i>	Africa ^{1, 2} , America ² , Asia ² , Europe ² , Oceania ²	weed ⁶ , food ⁶ , fodder ⁶
<i>D. patagiata</i>	Africa ^{1, 2}	weed ⁶
<i>D. perrottetii</i>	Africa ^{1, 2}	-
<i>D. sanguinalis</i>	Africa ^{1, 2} , America ² , Asia ² , Europe ² , Oceania ²	food ²⁰ , weed ^{14, 15, 16}
<i>D. ternata</i>	Africa ^{1, 2} , America ² , Asia ² , Oceania ²	weed ⁴ , fodder ^{4, 17}
<i>D. velutina</i>	Africa ^{1, 2} , America ² , Asia ² , Oceania ²	weed ¹³

1 : GBIF ; 2 : Herbaria (DAKAR, IFAN) ; 3 : Vanden, 1991 ; 4 : Poilecot, 1995 ; 5 : Poilecot, 1999 ; 6 : Quattrocchi, 2006 ; 7 : Kleinschmidt and Johnson, 1977 ; 8 : Muenscher, 1980 ; 9 : Wilson et al., 1995 ; 10 : Lepschi et Macfarlane, 1997 ; 11 : van der Zon, 1992 ; 12 : Obizoba and Anyinka, 1994 ; 13 : Merlier et al., 1982 ; 14 : Robinson, 1969 ; 15 : Halvorson and Guertin, 2003 ; 16 : Brink and Belay, 2006 ; 17 : Robyns, 1931 ; 18 : Le Bourgeois and Merlier, 1995 ; 19 : Akobundu and Agyakwa, 1989 ; 20 : Portères, 1955.

are more favorable.

The usefulness of such species as a source of food for local populations and feed for animals worldwide is notable, especially with a species focus in Senegal. *D. exilis* or white fonio is a good example, because it is the only cultivated species of the genus in the south of the country and contributes to food security.

This study provides important tools for enhancing the conservation and wise use of *Digitaria* species based on the knowledge of their ecology and biogeographic distribution, especially those that are endemic (*D. gentilis*) or endangered (*D. aristulata* and *D. patagiata*). The information reported here can also serve to strengthen all of the conservation actions in wise use of natural resources, and could be an important step in the process leading to better management of wild species that could potentially be useful to improve crop production.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

- Adoukonou-Sagbadja H, Dansi A, Vodouhè R, Akpagana K (2006). Indigenous knowledge and traditional conservation of fonio millet (*Digitaria exilis*, *Digitaria iburua*) in Togo. Biodiversity and Conservation 15:2379-2395.
- Akobundu OL, Agyakwa E (1989). Guide des adventices d'Afrique de l'Ouest. Institut International d'Agriculture. Ibadan, Nigeria.
- Barnaud A, Vigouroux Y, Diallo MT, Saidou SI, Piquet M, Barry MB, Bakasso Y, Zekraoui L, Rivallan R, Kane NA, Billot C (2017). High selfing rate inferred for white fonio [*Digitaria exilis* (Kippist.) Stapf] reproductive system opens up opportunities for breeding programs. Genetic Resoure Crop Evolution 64:1485.
- Bassene C (2014). La flore adventice dans les cultures de maïs (*Zea mays* L.) dans le sud du Bassin Arachidier : structure, nuisibilité et mise au point d'un itinéraire de désherbage. Thèse Unique. Université Cheikh Anta Diop de Dakar, Sénégal.
- Beck PA, Hutchison S, Stewart CB, Shockey JD, Gunter SA (2017). Effect of crabgrass (*Digitaria ciliaris*) hay harvest interval on forage quality and performance of growing calves fed mixed diets. Journal of Animal Science 85:527-535.
- Berhaut J (1967). Flore du Sénégal (2ème ed.). Dakar, Sénégal: Editions Clairafrique.
- Boonsuk B, Chantaranonthai P, Hodkinson TR (2014). *Digitaria isanensis* sp. nov. and a reinstated taxon of *Digitaria* (Poaceae) from Thailand. Nordic Journal of Botany 32:811-814.
- Boonsuk B, Chantaranonthai P, Hodkinson TR (2016). A new species and two new taxon records of *Digitaria* (Poaceae: Panicoideae) for

- Thailand. *Phytotaxa* 161(4):283-288.
- Brink M, Belay G (2006). *Plant Resources of Tropical Africa 1. Cereals and pulses*. Netherlands: PROTA Foundation, Wageningen.
- Centre de Suivi Ecologique (2007). *Caractérisation des systèmes de production agricole au Sénégal*. Document de synthèse, Sénégal.
- Chikoye D, Manyong VM, Ekeleme F (2000). Characteristics of Speargrass (*Imperata cylindrica*) dominated fields in West Africa: crops, soil properties, farmer perceptions and management strategies. *Crop Protection* 19:481-487.
- Diarra N, Togola A, Denou A, Willcox M, Daou C, Diallo D (2016). Etude ethnobotanique des plantes alimentaires utilisées en période de soudure dans les régions Sud du Mali. *International Journal of Biological and Chemical Sciences* 10(1):184-197.
- Dias NMP, Pereira MRDB, Lopez-Ovejero RF, Christoffoleti PJ, Barela JF, Tornisiello VL (2005). Population dynamics of *Digitaria* spp. submitted to selection pressure by herbicides in sugarcane crop. *Journal of Environmental Science and Health B40*: 21-28.
- Halvorson WL, Guertin P (2003). Factsheet for : *Digitaria sanguinalis* (L.) Scop. USGS Weeds in the west project: status of introduced plants in southern Arizona parks. U.S. Geological Survey, Southwest Biological Science Center, Sonoran Desert Research Station, University of Arizona, Tucson, AZ, p. 32.
- Harun N, Chaudhry AS, Shaheen S, Ullah K, Khan F (2017). Ethnobotanical studies of fodder grass resources for ruminant animals, based on the traditional knowledge of indigenous communities in Central Punjab Pakistan. *Journal of Ethnobiology and Ethnomedicine* 13: 56.
- Hugo E, Saayman-Du Toit AEJ, Reinhardt CF (2014a). Germination characteristics of the grass weed *Digitaria nuda* (Schumach.). *South African Journal of Botany* 90: 52-58.
- Hugo E, Morey L, Saayman-Du Toit AEJ, Reinhardt CF (2014b). Critical Periods of Weed Control for Naked Crabgrass (*Digitaria nuda*), a Grass Weed in Corn in South Africa. *Weed Science* 2014 62: 647-656.
- Hugo E (2014). Growth Responses, Competitiveness and Control of *Digitaria nuda* (Schumach.) in Maize (*Zea mays*). PhD Dissertation. Pretoria, South Africa University of Pretoria.
- Ibrahim HM, Saidu B (2017). Effect of Processed Acha (*Digitaria exilis*) grain on glycemic index of diabetes induced Wistar Rat model. *Scholarly Journal of Biological Science* 6(3): 89-93.
- Kleinschmidt HE, Johnson RW (1977). *Weeds of Queensland (Australia)*: S.R. Hampson. Gov't. Printer.
- Köppen W (1900). Versuch einer Klassifikation der Klimate, vorzugsweise nach ihren Beziehungen zur Pflanzen-welt. *Geogr. Zeitschr* 6: 593-611, 657-679.
- Koroch AR, Juliani HR, Simon JE (2013). Nutritional Value of Fonio (*Digitaria exilis*) from Senegal. In *African Natural Plant Products Volume II: Discoveries and Challenges in Chemistry, Health, and Nutrition*. ACS Symposium Series; American Chemical Society: Washington, DC.
- Le Bourgeois T, Merlier H (1995). *Adventrop - Les adventices d'Afrique soudano-sahélienne*. Montpellier, France, Cirad.
- Lepschi BJ, Macfarlane T (1997). *Digitaria aequiglumis* (Poaceae), a new weed for Western Australia. *Nuytsia* 11(3): 425-427.
- Lo Medico JM, Tosto DS, Rua GH, Rúgolo de Agrasar ZE, Scataglini MA, Vega AS (2017). Phylogeny of *Digitaria* Sections *Trichachne* and *Trichophorae* (Poaceae, Panicoideae, Paniceae): A Morphological and Molecular Analysis. *New Circumscription and Synopsis*. *Systematic Botany* 42(1):37-53.
- Mbow C (2009). Potentiel et dynamique des stocks de carbone des savanes soudaniennes et soudano-guinéennes du Sénégal. Doctorat d'état. Université Cheikh Anta Diop de Dakar.
- MEPN (1997). *Rapport National Biodiversité*. Ministère de l'Environnement et de la Protection de la Nature (MEPN), Dakar, Sénégal. Available at : <https://www.cbd.int/doc/world/sn/sn-nr-01-fr.pdf>.
- Merlier H, Montegut J, Bichat H (1982). *Adventices tropicales : flore aux stades plantule et adulte de 123 espèces africaines ou pantropicales*. Paris: MRE.CODEV.
- Michel P (1973). Les bassins des fleuves Sénégal et Gambie : étude géomorphologique. ORSTOM - IRD - Paris. Mémoires ORSTOM, n°63.
- Muenschler WG (1980). *Weeds*. Second Edition. Cornell University Press, Ithaca and London.
- Ngom A, Mbaye MS, Barnaud A, Kane A, BAN, Gueye M, Camara AA, Ndour YB, Noba K (2016). Révision du genre *Digitaria* Haller (Poaceae) au Sénégal : proposition d'une clé de détermination pour une meilleure identification des espèces. *International Journal of Biological and Chemical Sciences* 10(1):58-86.
- Obizoba IC, Anyinka JU (1994). Nutrient values of baobab milk (gubdi) and mixtures of baobab (*Adansonia digitata*) and hungry rice, acha (*Digitaria exilis*) flours. *Plant foods Human Nutrition* 46(2):157-165.
- Okanume EO, Lawrence DA, Jayeola AA, Agaba OA (2014). Studies on the foliar epidermal tissues of three species of *Digitaria* Haller in Jos, Plateau State Nigeria. *Bayero Journal of Pure and Applied Sciences* 7(2):126-133.
- Ouedraogo I, Hema OS, Sanou A (2015). Inventaire et incidence des insectes inféodes à la culture du fonio (*Digitaria exilis* Stapf) dans la zone ouest du Burkina Faso. *Journal of Applied Biosciences* 94:8880-8889.
- Pare D, Hilou A, Ouedraogo N, Guenne S (2016). Ethnobotanical Study of Medicinal Plants Used as Anti-Obesity Remedies in the Nomad and Hunter Communities of Burkina Faso. *Medicines* 3(2): 9.
- Poilecot P (1995). *Les Poaceae de la Côte d'Ivoire* (Vol. 50). Conservatoire et Jardin Botanique de la Ville de Genève, IUCN, CIRAD: BOISSIERA.
- Poilecot P (1999). *Les Poaceae du Niger* (Vol. 56). Conservatoire et Jardin Botanique de la Ville de Genève, IUCN, CIRAD: BOISSIERA.
- Portères R (1955). Les céréales mineures du genre *Digitaria* en Afrique et en Europe. *Journal d'Agriculture Tropicale et de Botanique Appliquée* 2(7):349-386.
- Quattrocchi U (2006). *CRC World Dictionary of Grasses: Common Names, Scientific Names, Eponyms, Synonyms, and Etymology - Volume 3, Set*. CRC Press.
- Robyns W (1931). *Les espèces congolaises du genre Digitaria Hall*. Bruxelles : G. Van Campenhout.
- Sene EH (2000). Forêts et sécurité alimentaire en Afrique. La place de la foresterie dans le Programme spécial pour la sécurité alimentaire de la FAO. In : *Forêts, sécurité alimentaire et moyens de subsistance durables*, archives documents FAO. Available at : <http://www.fao.org/docrep/x7273f/x7273f00.htm>
- USAID/Sénégal (2008). *Chaîne de valeur fonio – Sénégal : Analyse et cadre stratégique d'initiatives pour la croissance de la filière*. United States Agency for International Development.
- Vanden BC (1991). *Monocotylédones et Ptéridophytes*. In *Flore illustrée du Sénégal* (Vol. X). Dakar, Sénégal: Ministère du Développement rural et de l'Hydraulique, Direction des Eaux et Forêts.
- Vega AS, Rúgolo de Agrasar ZE (2002a). *Novedades taxonómicas y sinopsis del género Digitaria* (Poaceae: Panicoideae: Paniceae) en Bolivia. *Darwiniana* 40:171-190.
- Vega AS, Rua GH, Fabbri LT, Rúgolo de Agrasar ZE (2009). A morphology-based cladistic analysis of *Digitaria* (Poaceae, Panicoideae, Paniceae). *Systematic Botany* 34: 312-323.
- Wiersema JH, León B (2013). *World Economic Plants: A Standard Reference*, Second Edition. CRC Press.
- Wilson BJ, Horton D, Duff A (1995). *Crop Weeds of Northern Australia*. Queensland Dept Primary Industries: Brisbane.
- Zon VD (1992). *Graminées du Cameroun*. Thèse de doctorat, Université agricole Wageningen.

Full Length Research Paper

Assessment of woody species in agroforestry systems around Jimma Town, Southwestern Ethiopia

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Woody species are the major components of traditional agroforestry systems. These species vary across the different types of agroforestry practices in different parts of Ethiopia. This study was conducted to assess woody species across land use in three different sites around Jimma town, Southwest Ethiopia. A total of 100 plots were laid out on six transect lines with sample plot size of 25 m × 25 m for 20 plots of homegarden, 19 plots of coffee farm and 20 plot of grazing land, 40 m × 40 m for 24 plots of crop field and 10 m × 10 m for 17 plots of woodlots and were calculated in hectares. Species diversity, richness, evenness, density and frequency were analyzed between land uses types and sites. The result showed that a total of 60 woody species belonging to 34 families and 54 genera were identified from these three sites. Fabaceae was the most dominant family with 11 (18.3%) species followed by Euphorbiaceae family with 7 (11.7%) species. Out of the identified species, 53.3% were trees, 45% shrubs and 1.67% climbers. In terms of species diversity, grazing lands (3.1) were more diversified than homegardens (2.87), crop field (2.555), coffee farm (0.667) and woodlots (0.643) in the overall study sites. In terms of tree and shrubs density, woodlots were the most dense (9495 stems/ha). Generally, agroforestry systems are conserving several woody species diversity in their systems and woody species varied among land use types in the study area. Practices which aimed at maintaining these woody species should be encouraged and applied to support the conservation of these species in agroforestry systems.

Key words: Agroforestry system, woody species, homegardens, crop field, grazing land, coffee farm, Jimma.

INTRODUCTION

Agroforestry encompasses a wide range and diverse set of practices ranging from trees on croplands to complex production forests (Ogunwusi, 2013). It has been known for its diversity, ecosystem balance, sustainability, household food security and rural development (Tesfaye et al., 2010). Variety of woody species in agricultural

systems supplies products and ecological services (Tesfaye et al., 2010; Mesele et al., 2012; Girmay et al., 2015).

Agroforestry practices including various forms of tree planting and indigenous practices exist (Nyaga et al., 2015) and trees are planted on farms in different niches

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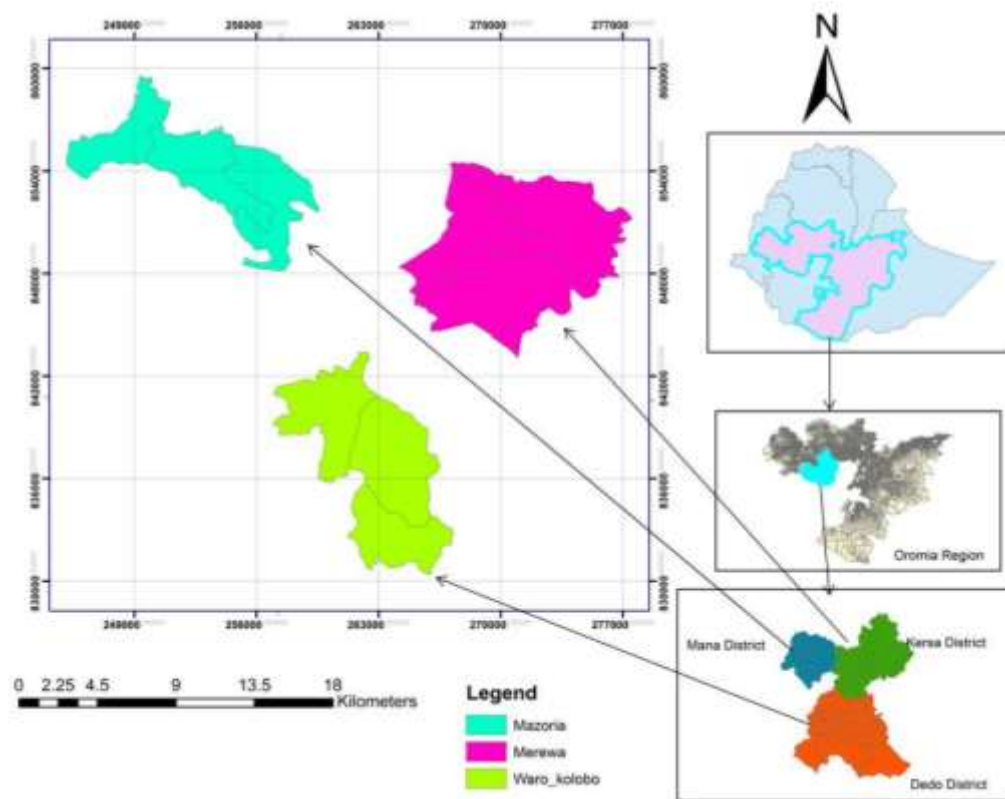


Figure 1. Map of study sites.

(Nair, 1993). Smallholder farmers practice agroforestry in Africa (Mbow et al., 2013) and several types of traditional agroforestry practices exist in different parts of Ethiopia such as: trees on croplands, homegardens, boundary planting, live fencing, and grazing lands (Abreha and Gebrekidan, 2014).

In Ethiopia, inventory and documentation of agroforestry practices are very few and has been concentrated in the southern parts of Ethiopia (Tsfaye et al., 2010; Mathewos et al., 2013; Badege et al., 2013). Even though few agroforestry empirical researches were conducted in the southwestern, it is inadequate from the biophysical point of view to understand the dynamic nature of agroforestry systems in the phase of population growth. Information on agroforestry systems and its potentials have not been evaluated.

Therefore, this study seeks to assess woody species in different types of agroforestry systems across different land use types around Jimma town, Southwest Ethiopia.

MATERIALS AND METHODS

Description of study site

The study was conducted in Mazonia (Mana district), Merewa (Kersa district) and Waro-Kolobo (Dedo district) sites around Jimma town, Oromia National Regional State, Southwestern Ethiopia

(Figure 1). Jimma zone is located in between 7°23' and 8°47' N and 35°52' and 37°30' E and its capital town is Jimma which is located 352 km away from Addis Ababa, the capital city of Ethiopia (BOFED, 2007). The study sites were found within 20 km radius around Jimma town in Mana, Kersa and Dedo districts with their altitudes of 1470-2610, 1740-2660 and 880-2400 m above sea level, respectively (BOFED, 2007). The annual rainfall of Jimma town ranges from 1138 to 1690 mm. The maximum precipitation takes place from the months of June to August, and minimum rainfall in December and January (Abebe et al., 2011). The total population of the study area is 43,486 (Male 22,538 and female 20,948) and the total household is 6671 (Mana WANRO, 2016; Kersa WANRO, 2016; Dedo WANRO, 2016).

Soil

Dystric Nitosol, Orthic Acrisols, Chromic and Pellic Vertisols are the major soil types found in Jimma zone (BOPED, 2000). The dominant soil types in Mana district are Dystric Nitosols and Orthic Acrisols, whereas Orthic Acrisols and Pellic Vertisols are dominant in Kersa and Dedo districts (BOPED, 2000).

Socio-economic activities

Agriculture is the means of the livelihood of the people. Most agricultural producers are subsistence farmers with small land sizes. The major crops grown in the area are maize, teff, sorghum, barley, pulses crops and coffee (BOPED, 2000). Coffee is the most important cash crop in the area (Zerihun et al., 2011). Also, cattle

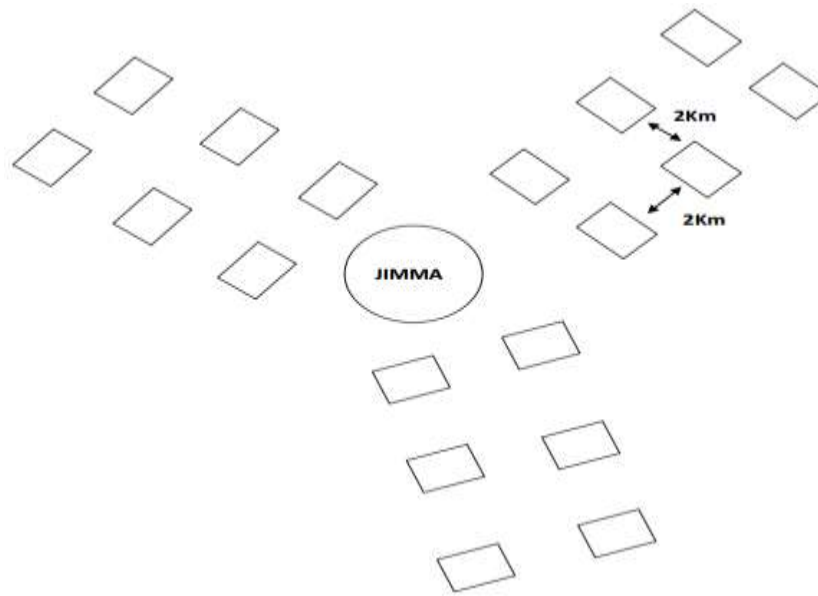


Figure 2. Illustration of plots along transect lines around Jimma town in Mazoria, Merewa and Waro-Kolobo, Southwest Ethiopia.

production is characterized mainly by traditional smallholders that are kept in freely-grazing communal rangelands throughout the year (Yisehak et al., 2013).

Data collection

In this study, both primary and secondary data sources were used. Secondary data were gathered from different sources like journal articles, district documents and regional documents to enrich literatures and knowledge gap.

Quantitative data were collected directly from field survey and field measurement. The primary data includes biophysical information (diameter at breast height (DBH), height and numbers of woody species) in different land use systems. Height and DBH of woody species were measured by using clinometers and diameter tape respectively. In this case, local names, number of all live individuals and DBH of all woody species with DBH ≥ 2.5 cm and height ≥ 2.5 m only were recorded. Trees and shrubs that are branched, along with the circumference was measured separately and average taken.

A total of 10 to 12 key informants (KIs) were selected from each Kebele. They were selected based on their knowledge and experience regarding the identification of woody species. Key informant interview and discussions were carried out at each study sites to obtained more information.

Local names of all woody species present in each site were recorded with the help of KIs and Development agents (Das). Species names were identified using specimen with the help of Useful Trees and Shrubs for Ethiopia (Azene, 2007) and the Honey bee Flora of Ethiopia (Fichtl and Admasu, 1994) at the field. Species that could not be identified in the field were collected, pressed and preserved following the criteria established by published volumes of the Flora of Ethiopia and Eritrea.

Sampling and sample size determination

Mazoria, Merewa and Waro-Kolobo sites were selected purposely

to address the study objectives. Reconnaissance survey was carried out before actual survey and data collection using transect line within 20 km radius of Jimma town. It was done after consultation with expert from zonal office, districts agricultural office and development agents of study areas.

Two transect lines (total of 6 transect lines) were established in each study sites across different land use types. Systematic sampling method was applied to locate the sample plots to study woody species. The first sample plots were assigned randomly and the next sample plots were systematically allocated within 2 km intervals. Inventory of woody species were done using plots size of 25 m \times 25 m (625 m²) for homegardens, coffee farms and pasture land in accordance with Egodawatta and Warnasooriya (2014), 40 m \times 40 m (1600 m²) for crop field as per Nikiema (2005) and 10 m \times 10 m plots size for woodlots following Feyera et al. (2002) (Figure 2). The assessment was carried out in every 2 km intervals with a total of 100 sample plots in six transect lines for all selected land use types. Two transect lines were laid out in each site with 20 plots of homegarden, 24 plots of crop field, 19 plots of coffee farm, 20 plot of grazing lands and 17 plots of woodlots along the transect lines.

Data analysis

The quantitative and qualitative approaches were used to analyze the data. All woody species present in each site were identified and grouped according to their habit and uses.

The population structure of all individuals ≥ 2.5 cm diameter and ≥ 2.5 m height woody species encountered in the field were grouped into diameter and height classes. Frequency tables and histograms were produced using the diameter and height classes versus the number of individuals categorized in each of the classes (Temesgen et al., 2015).

The collected data from the survey were entered into a computer (Microsoft Excel) and computed. The information was used to describe population structure, importance value index (IVI), height, frequency, Density, diameter at breast height (DBH) and basal area. DBH classes were categorized according to its thickness

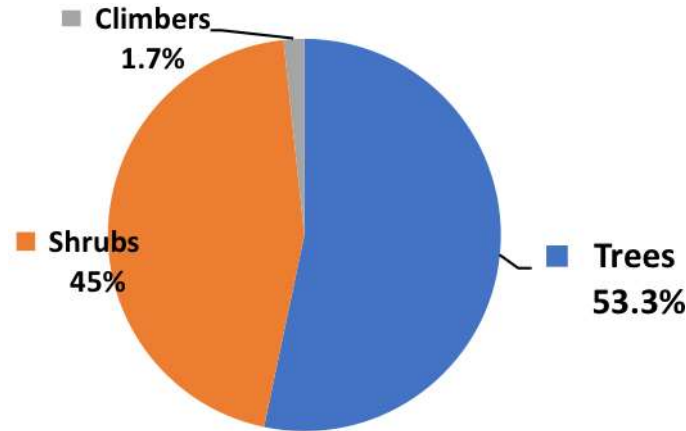


Figure 3. Woody species identified in the land use types.

(Temesgen et al., 2015). DBH is the ratio of circumference to π . The basal area was calculated using the formula: $BA = \pi d^2/4$, where d is diameter at breast height and π is 3.14. Density of the woody species was calculated by converting the total number of individuals of each woody species encountered in the plots to hectare.

Frequency is defined as the probability of chance of finding a species in a given sample area or quadrant (Kent and Coker, 1992). Thus, it shows the presence or absence of a given species within each sample plot.

Importance value indices were computed for all woody species based on their relative density (RD), relative dominance (RDO) and relative frequency (RF) to determine their dominance using the Kent and Coker (1992) formula:

$IVI = \text{Relative Frequency} + \text{Relative Density} + \text{Relative Dominance}$

$$\text{RelativeDensity} = \frac{\text{Total number of stems all of trees}}{\text{sample size in hectare}} \times 100$$

$$\text{RelativeFrequency} = \frac{\text{Number of individuals of tree species}}{\text{Frequency of all species}} \times 100$$

$$\text{Relativedominance} = \frac{\text{Basal Area per species}}{\text{TotalBasalArea}} \times 100$$

Diversity indices provide important information about rarity and commonness of species in a community. The indices can be used to compare diversity between habitat types (Kent and Coker, 1992). The diversity index is the negative sum of all relative abundances multiplied by the natural logarithm of the relative abundance:

$$H' = - \sum_{i=1}^s p_i \ln p_i$$

where H' = the Shannon-Wiener index, S = total number of species, P_i = the proportion of individuals belonging to species i , and \ln = the natural log.

Evenness (E'): is the ratio of H' to natural log of species richness (Magurran, 1988).

$$E = H' / \ln S$$

where E = evenness and S = species richness.

From the analysis of the data from the three sites, similarity index was used with the following formula (Kent and Coker, 1992):

$$S_s = \frac{2a}{2a + b + c}$$

where S_s = Sorensen's similarity coefficient; a = Number of woody species common to both sites/land uses in comparison; b = Number of woody species found only in first site/land use; c = Number of woody species found only in the second site/land use.

RESULTS AND DISCUSSION

Species diversity, richness and evenness

The results showed that a total of 60 woody species belonging to 34 families and 54 genera were identified in the three study sites. Among the identified woody species, 39 species were found in homegardens, 25 in crop fields, 33 in the grazing land, 34 in the coffee farm and 13 in the woodlots. Out of identified woody species 32 (53.3%) species were trees, 27 (45%) species were shrubs and 1(1.7%) species were climbers (Figure 3). This study indicated that the largest proportion of identified woody species were trees followed by shrubs in study sites. This study result is in line with the finding of Tefera et al. (2015), Mekonnen et al. (2014), Abiot and Gonfa (2015) and Motuma et al. (2008) who reported that the identified woody species were dominated by trees.

A total of 39 woody species recorded in homegarden were characterized by a higher numbers of woody species than other land use types. This study result is in line with the finding of Belay et al. (2014), Motuma et al. (2008) and Abiot and Gonfa (2015) who reported that higher number of woody plant species were present in homegardens than most of the other land use types.

A total of 25 woody species were identified from crop field of study sites. It was sparsely distributed in the field and relatively few as compared with homegarden, grazing land and coffee farm in terms of species richness

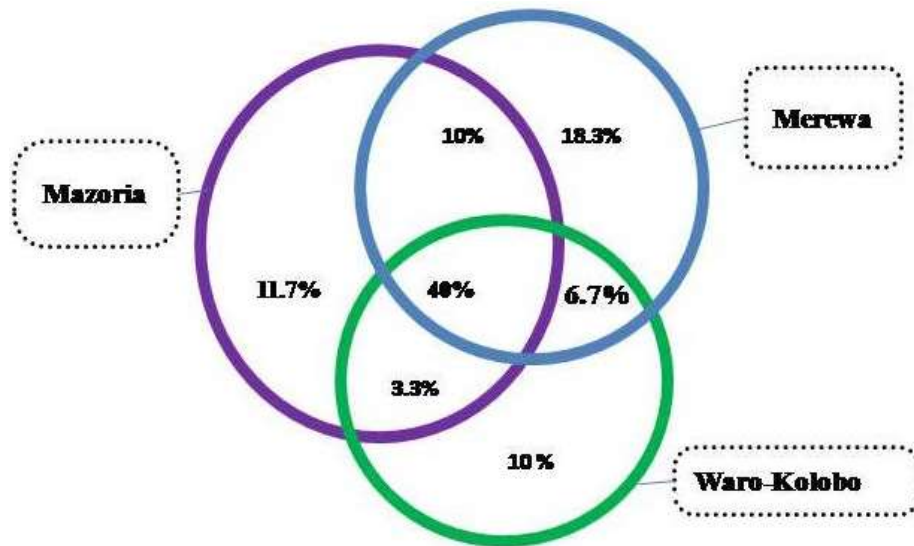


Figure 4. Species richness and number of species overlap between the three study sites.

and individual numbers during inventory whereas higher than woodlots in species richness. In the study sites, the crop fields are owned by small-scale farmers who keep the woody species on their lands randomly in most cases. Woody species were different from site to site in the crop field. This study result is lower than similar study report of Motuma et al. (2008) in South-Central Ethiopia (32) and Tola et al. (2014) in Southern Ethiopia (49), and higher than the study result of Etefa and Raj (2013) in Tigray Region (15). This difference may be due to environmental factors.

In the study area, 33 woody plants species were identified and distributed as the small size of the patches of vegetation remaining in some part of the grazing land. This study result indicated lower number in which system of woody species were identified as compared with similar study reported by Mideksa et al. (2015) in South East Ethiopia and much higher than Belay et al. (2014) in Northern Ethiopia.

A total of 13 woody species were identified in woodlots of the three study sites. The number of species identified in this study was much lower than the result of Shiferaw and Pavlis (2012) in South Western Ethiopia (37) and Tyynelä (2001) in Northeastern Zimbabwe (39). This might be associated with the high relative density of *Eucalyptus camaldulensis*, *Cupressus lusitanica* and *Grevillea robusta* plantation. Light levels are positively associated with plant species richness and permanent open spaces in plantation forests provide an opportunity for enhancing biodiversity in the plantations (Georgie et al., 2007). Also, woodlots are characterized by dominant single species composition.

Species like *E. camaldulensis*, *Ficus vasta*, *Croton macrostachyus*, *Albizia gummifera*, *Cordia africana*, *Millettia ferruginea*, *G. robusta*, *Acacia abyssinica*, *Ficus*

thoningii, *Persea americana*, *C. lusitanica* and *Catha edulis* are the top 12 dominant woody species in the study area.

In terms of woody species distribution across sites, 24 (40%) of woody species are common to all sites, six species (10%) occurred only in Waro-Kolobo whereas seven (11.7%) and eleven (18.3%) species occurred only in Mazoria and Merewa sites, respectively. Again, six species (10%) were found in both Mazoria and Merewa, four (6.67%) species are common in Merewa and Waro-Kolobo, and only two species (3.3%) were found in Mazoria and Waro-Kolobo commonly (Figure 4).

The dominant families were Fabaceae represented by 18.3% of species, Euphorbiaceae 11.7% of total species, Moraceae, Myrtaceae and Rutaceae families each with 5% of total species, Asteraceae, Boraginaceae, Celastraceae and Rubiaceae families each with 3.3% of total species in the study area. The other remaining families (25) were represented by one species.

Fabaceae and Euphorbiaceae were the major woody species in the study area. This study result was in line with the report of Mesele et al. (2012) in south-eastern rift valley escarpment of Ethiopia, Balcha (2013) in Jimma, Belay et al. (2014) in northwestern Ethiopia and Bajigo and Tadesse (2015) in Gununo watershed at Wolayitta zone.

Species diversity of grazing land, homegarden, crop field, woodlots and coffee farm were 3.1, 2.87, 2.555, 0.667 and 0.643, respectively. The grazing land recorded highest species diversity than other land use system in overall study sites whereas species diversity of homegardens in each sites were higher than crop lands, coffee farm, woodlots and grazing land with the exception of Merewa site grazing land and Mazoria site crop field (Table 1). The observed trend might be due to the

Table 1. Species richness, diversity, evenness and density of woody species in study sites.

Land use type/site	Species richness	Species diversity	Species evenness
Home garden	39	2.871	0.784
Mazoria	19	2.320	0.788
Merewa	28	2.577	0.773
Waro-Kolobo	24	2.480	0.780
Crop Field	25	2.555	0.794
Mazoria	13	2.346	0.915
Merewa	16	1.819	0.656
Waro-Kolobo	13	2.253	0.878
Coffee land	34	0.643	0.1823
Mazoria	14	0.661	0.2576
Merewa	22	0.573	0.1855
Waro-Kolobo	15	0.532	0.1964
Grazing land	33	3.100	0.886
Mazoria	17	2.248	0.793
Merewa	18	2.816	0.974
Waro-Kolobo	16	2.249	0.811
Woodlots	13	0.667	0.260
Mazoria	11	0.682	0.285
Merewa	7	0.494	0.254
Waro-Kolobo	2	0.439	0.633

difference in land use types and functions of woody species. Woody species have various functions and purposes in different land use types. This result is in line with Chane et al. (2003) who reported that land use types determine the vegetation attribute of species.

The result indicated that the species diversity was higher in Merewa ($H' = 2.58$) followed by Mazoria ($H' = 2.32$) and Waro-Kolobo ($H' = 2.48$) and species evenness ranged between 0.773 and 0.788 in the homegarden agroforestry of study sites. It was lower in both species Shannon diversity and evenness than traditional agroforestry practice in Dellomenna District, Southeastern Ethiopia (Abiot and Gonfa, 2015) and higher than homegarden in Tigray region northern Ethiopia (Etefa and Raj, 2013).

In crop land, the highest species diversity was recorded in Mazoria ($H' = 2.346$) than Waro-Kolobo ($H' = 2.253$) and Merewa ($H' = 1.819$) sites and the evenness index of woody species ranged between 0.656 and 0.915 (Table 1). This result is similar to those of Mekonnen et al. (2014) who reported that the occurrences of species across crop field land use system of the study sites were variable. Shannon diversity index of woody species was more or less comparable with results reported by Motuma et al. (2008) in South-Central Ethiopia ($H' = 2.22$, $E = 0.64$). The result of Shannon diversity index and evenness

was higher than the study result of Etefa and Raj (2013) in Tigray region, Ethiopia ($H' = 1.12$, $E = 0.41$) and much higher than study result of Belay et al. (2014) in northern Ethiopia ($H' = 0.58$, $E = 0.21$).

The highest species were recorded in Merewa than in Mazoria and Waro-Kolobo sites; and evenness index of woody species ranged between 0.793 and 0.974 in the grazing land. The Shannon diversity index and evenness of this land use type were higher than similar results of Etefa and Raj (2013) in Tigray region, Ethiopia.

In coffee farm agroforestry, the highest species diversity was recorded in Mazoria than Merewa and Waro-Kolobo sites; and evenness index of woody species ranged between 0.186 and 0.258 (Table 1). The results show that single species dominated the coffee farm (*Coffea arabica*), less shade tree species number and not heterogeneous among species. This result is in line with the result of Bikila and Zebene (2016) who reported that due to intensive human interference, selective tree thinning shade tree species diversity are less in number and Belay et al. (2014) also reported low diversity occurring when single or few species dominated the area. The study result indicated lower Shannon diversity and evenness than study result of Dawoe et al. (2016) in West Africa and much lower than smallholder coffee farm (Getachew et al., 2014) in Southwest

Table 2. Sorenson species index of similarity (%) along three sites.

Site	Mazoria (%)	Merewa (%)	Waro-Kolobo (%)
Mazoria	-	72.3	69.33
Merewa	-	-	68.3
Waro-Kolobo	-	-	-

Table 3. Sorenson species index of similarity (%) in three sites land use system.

Land use type	Homegarden (%)	Crop field (%)	Coffee farm (%)	Grazing land (%)	Woodlots (%)
Homegarden	-	-	-	-	-
Crop field	59.38	-	-	-	-
Coffee farm	56.67	52.63	-	-	-
Grazing land	48.72	59.65	60.61	-	-
Woodlots	37.74	42.11	39.13	47.83	-

Table 4. Total density of woody species along sites and slope classes.

Variable	Density per hectare				
	Homegarden	Crop field	Coffee farm	Grazing land	Woodlots
Site	1349	532.1	2485.3	1192	9495
Mazoria	1603.2	181.3	2021.2	520.0	7170.0
Merewa	917.9	400	2135.73	809.3	5725.00
Waro-Kolobo	1470.67	157.5	1616.00	512	8833.33

Ethiopia.

In woodlots, relatively higher levels of diversity were identified in Mazoria (0.682), followed by Merewa (0.494) and Waro-Kolobo (0.439). Woodlots composed of some woody species, and the diversity index was relatively lower in all sites than other land use types. The highest species number was recorded in Mazoria than Merewa and Waro-Kolobo sites.

Generally, this study showed that species richness, diversity and evenness varied with land use type and sites. Homegardens were more diversified followed by crop lands and grazing land in Waro-Kolobo site. Abreha and Gebrekidan (2014), Motuma et al. (2008) and Belay et al. (2014) reported that homegardens were more diversified than crop land and grazing land. Grazing land of Merewa was more diversified than other land use types. This result is in line with Abreha and Gebrekidan (2014) in Andabet Woreda and Etefa and Raj (2013) who reported that grazing land diversified than cropland and homegardens.

Key informants who participated in the discussion also reported that woody species cultivated in different land use types are more or less similar to the result obtained with the survey result. Farmers hang traditional beehives on larger trees in coffee farm, homegarden and grazing land. Key informants also articulated that woodlots of *Eucalyptus* increase onward due to a necessity of wood

product (construction, fuel wood, etc), income and fast growing nature of the tree. This explanation is in agreement with Tola et al. (2014) who reported that the expansion of woodlots is due to increasing demand for various wood products.

Similarities index between sites

Sorenson's index of similarity of Merewa and Mazoria sites showed the highest similarity (72.3%) followed by Mazoria and Waro-Kolobo sites (69.33%). Merewa and Waro-Kolobo sites had lowest similarity index (68.3%) as compared with other sites (Table 2). The similarity indexes of species showed the highest similarity (60.61%) between coffee farm and grazing land. Whereas woodlots and homegardens agroforestry systems had a lowest similarity index (37.74%) as compared with other agroforestry systems (Table 3).

Density

Comparatively, overall densities of woodlots were higher than other land use types followed by coffee farm and homegarden in all study sites (Table 4). Generally, in the homegarden agroforestry system of three study sites,

Table 5. Percentage of woody species in different land use system frequency class.

Land use type	Frequency Class				
	A (0-20%)	B (20-40%)	C (40-60%)	D (60-80%)	E (80-100%)
Homegarden	64.10	25.64	5.13	5.13	0
Crop field	84	12	4	0	0
Coffee farm	79.41	5.88	2.94	8.82	2.94
Grazing land	81.82	15.15	3.03	0	0
Woodlots	69.23	23.08	0	0	7.69

(*E. camaldulensis*, *Erythrina brucei*, *Euphorbia tirucalli*, *C. lusitanica*, *G. robusta*, *C. arabica* and *P. americana*) have the highest density (77 to 352 individuals per hectare) and other species were ranging from 16-72 individuals per hectare. During the vegetation survey, *E. tirucalli* had by far the highest density (269 individuals/ha) while others were much less dense, ranging from 6.25 to 25 individuals/ha in the crop field. *C. arabica* and *Arundinaria alpina* were densely populated (1401 and 224 individuals/ha, respectively) in the coffee farm agroforestry. In grazing land agroforestry system, *C. lusitanica*, *Acacia mearnsii* and *G. robusta* species were densely populated (144, 128 and 91 individuals/ha, respectively) and in woodlots, *E. camaldulensis* with 4250 individuals/ha and *C. lusitanica* with 2650 individuals/ha were much higher in density; while others also ranged between 100 and 600 individuals of woody species per hectare. Generally, *E. camaldulensis* were densely planted species in woodlots. Because *E. camaldulensis* is planted mostly with narrow spacing, *E. brucei*, *E. tirucalli* and *Euphorbia cotinifolia* species were commonly planted as a life fence for protection purposes.

The inventory results of this study also revealed that there was variation in woody species density across the land use of study sites. This result coincides with Aklilu et al. (2013) in terms of density in homegarden agroforestry; however, the density is higher in woodlots and farmland. The density of woody species in woodlots result was much higher than a similar study report of Shiferaw and Pavlis (2012) in South Western Ethiopia, Tyynelä (2001) in Northeastern Zimbabwe, and Abyot et al. (2014) in Gololcha District, Eastern Ethiopia (1845 stems/ha).

Frequency

Frequency was the number of plots in which a specific species occurred per the total plots number of land use in the study area. Species were grouped into A (0-20%), B (20-40%), C (40-60%), D (60-80%) and E (80-100%) frequency classes in each land use type. No species were recorded in D and E frequency class of crop field and grazing land and frequency class C and D in woodlots (Table 5).

The most frequently observed woody species in

homegarden agroforestry system were *P. americana* and *C. edulis* (75 and 60%, respectively) in the overall study site. Whereas, *P. americana* (83.33%), *Sesbania sesban* (66.67%) and *C. edulis* (50%) were in the Mazoria site; *P. americana* (75%), *C. edulis* (75%), *M. ferruginea* (75%) and *C. macrostachyus* (62.50%) were in Merewa; and in Waro-Kolobo, *P. americana* (83.33%), *Mangifera indica* (83.33%), *C. edulis* (66.67%), *C. arabica* (66.67%) and *A. abyssinica* (50.00%) were the most frequented woody species in homegarden agroforestry system. Most of the species were frequently cited in another homegarden (Abreha and Gebrekidan, 2014; Ewuketu et al., 2014).

C. africana (41.67%) was observed in the overall sites of crop fields. *A. gummifera* (42.86%) in Mazoria, *A. gummifera* (50%) and *C. africana* (50%) in Merewa and *C. africana* (55.56%) were more frequently observed than other woody species. The least frequently observed woody species in class 'C' and most species (84%) fall between 0-20% (Class 'A') frequency class in this land use type than others.

The most frequently observed woody species were *C. arabica* (100%), *C. macrostachyus* (78.95%), *A. gummifera* (73.68%), *C. africana* (63.16%) and *A. abyssinica* (52.63%) in the study coffee farm agroforestry. *E. camaldulensis* was the most frequently observed species during the survey in woodlots around Jimma town. The frequency of *E. camaldulensis* was about 94.12% in the overall study sites, 100% in Mazoria and Merewa at each site and 85.71% at Waro-Kolobo site. Woodlots of study sites were dominated by single species, that is, *E. camaldulensis* and received relatively more special attention than other woody species in the study area. Tyynelä (2001) also reported that *E. camaldulensis* was found in all wood sample plots; and other species were found in 4.6 to 26% of the total plots number.

The result also indicated that higher percentage of woody species were frequently observed within the frequency classes 'A' in all land use systems (Table 5) which may be due to its greater economic or ecological value or social importance. This study results are in line with Abiot and Gonfa (2015) who reported that the frequency of tree species varied in different farms and Yirefu et al. (2016) reported that most of the trees and shrubs species were recorded in frequency class 'A' (61.5%).

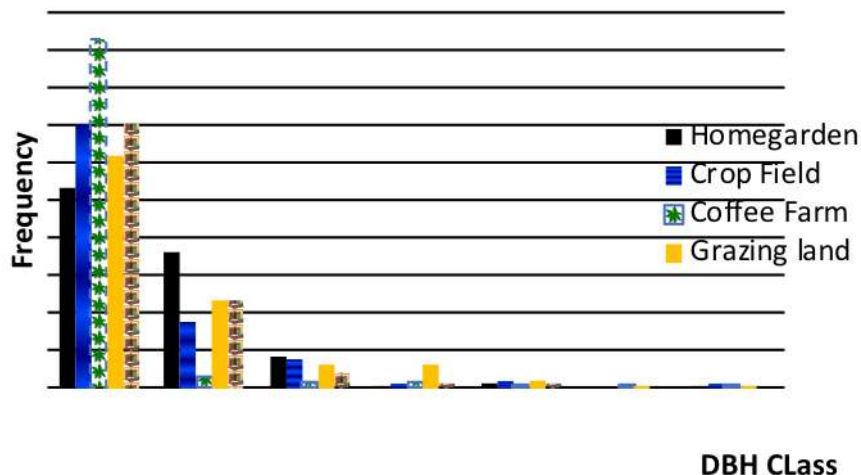


Figure 5. DBH of woody species in homegarden, crop field, coffee farm, grazing land and woodlots of study site.

Diameter at breast height (DBH) distribution

The distribution of woody species in different DBH classes was analyzed and classified into 6 classes: (1) 2.5-10 cm, (2) 10.1-20 cm, (3) 20.1-30 cm, (4) 30.1-50 cm, (5) 50.1-60 cm and (6) >60 cm. DBH class distribution of all individuals in different size classes showed an inverted J- shape in overall land use (Figure 5). The majority of the species had the highest number of individuals in the lowest DBH class distribution with gradual reduction toward high DBH classes. Out of the total woody species, 61.26, 26.50, 6.91 and 2.77% were distributed in the first, second, third and fourth diameter classes, respectively. Whereas about 2.56% of woody species identified in the study area were found under fifth and sixth diameter classes. This study result was similar with the results of Abyot et al. (2014), Temesgen et al. (2015) and Mohammed et al. (2015).

Importance value index (IVI)

The IVI of woody species recorded in each site and land use were estimated to evaluate the importance of each species. The IVI indicates the importance of individual woody species in the land use systems which were associated with farmers' species preference and objectives. The interest of farmers for selection of species is linked with species market demand and service value.

IVI is a composite index based on the relative measures of species frequency, abundance and dominance (Kent and Coker, 1992). The highest basal area of *F. vasta*, *F. thonningii*, *M. ferruginea* and *A. gummifera* made these species have a larger value of relative dominance (34.76, 9.75, 9.48 and 4.16%, respectively); and hence got the highest IVI in the overall study sites. *E. camaldulensis* (38.34%), *G. robusta*

(6.05%), *C. lusitana* (5.83%) and *C. macrostachyus* (4.19%) have higher relative density whereas *C. macrostachyus* (10%), *A. gummifera* (7.8%), *C. africana* (7.8%) and *A. abyssinica* (5.37%) have larger relative frequency values and contributed to the highest IVI. The current result agrees with Aklilu et al. (2013) who reported IVI value determined by density, frequency and basal area. Simon and Girma (2004) also revealed that species with the greatest importance values were the most dominant of particular vegetation.

The most abundant 10 plant species of each land use type were indicated in the report. Accordingly, *P. americana*, *E. brucei*, *C. edulis*, *G. robusta*, *E. tirucalli*, *C. arabica*, *A. abyssinica*, *C. africana*, *M. indica* and *C. lusitana* were the ten top important species among the 39 woody species that were recorded in the homegarden agroforestry system of the study sites (Table 6). This finding is also in line with similar study report of Ewuketu et al. (2014) in Jabithenan district, Northwest Ethiopia

In the crop field, *C. africana*, *A. gummifera*, *E. tirucalli*, *C. arabica*, *C. edulis*, *C. macrostachyus*, *A. abyssinica*, *G. robusta*, *Vernonia auriculifera* and *M. indica* were the top ten important species among the 25 woody species that were recorded in crop field land use system of the study sites.

In the grazing land, woody species recorded were *A. gummifera*, *C. macrostachyus*, *Senna septemtrionali*, *V. auriculifera*, *G. robusta*, *A. abyssinica*, *C. africana*, *A. mearnsii*, *F. vasta*, *Psidium guajava*, *Calpurnia aurea* and *Vernonia amygdalina* were the top twelve important woody species in the study sites.

C. arabica, *A. gummifera*, *A. abyssinica*, *C. macrostachyus*, *C. africana*, *F. vasta*, *M. ferruginea*, *V. auriculifera*, *P. americana* and *C. aurea* were the most important woody species relatively in the coffee farm. Therefore, the species with higher IVI were most important for coffee shade and all woody species

Table 6. Woody species in five land use system and their corresponding importance value index (IVI) of the overall study sites.

S/No	Species name	Importance value index of Species					Average IVI
		Home Garden	Crop field	Grazing land	Coffee-farm	Woodlots	
1	<i>Eucalyptus camaldulensis</i>	6.31	-	8.72	-	125.35	28.08
2	<i>Cordia africana</i>	14.58	53.56	18.03	23.56	15.56	25.06
3	<i>Croton macrostachyus</i>	8.54	14.90	28.46	33.51	24.94	22.07
4	<i>Albizia gummifera</i>	6.62	33.00	32.87	37.03	-	21.91
5	<i>Acacia abyssinica</i>	19.43	20.29	16.11	24.30	-	16.03
6	<i>Ficus vasta</i>	-	-	9.97	68.33	-	15.66
7	<i>Grevillea robusta</i>	16.84	9.21	15.64	5.87	24.89	14.49
8	<i>Cupressus lusitanica</i>	10.35	4.94	6.93	3.97	46.22	14.48
9	<i>Euphorbia tirucalli</i>	15.51	29.89	-	-	-	9.08
10	<i>Ficus thonningii</i>	43.14	-	-	-	-	8.63
11	<i>Catha edulis</i>	18.33	18.98	-	3.38	-	8.14
12	<i>Vernonia auriculifera</i>	7.96	6.78	12.78	11.51	-	7.81
13	<i>Persea Americana</i>	28.26	-	3.31	6.83	-	7.68
14	<i>Ekebergia capensis</i>	-	5.61	3.94	1.59	20.35	6.30
15	<i>Mangifera indica</i>	11.75	10.98	6.35	2.28	-	6.27
16	<i>Maesa lanceolata</i>	5.01	7.16	5.26	-	13.03	6.09
17	<i>Coffea arabica</i>	14.89	15.32	-	-	-	6.04
18	<i>Sapium ellipticum</i>	-	24.38	-	-	-	4.88
19	<i>Psidium guajava</i>	2.53	3.57	11.88	1.63	4.69	4.86
20	<i>Millettia ferruginea</i>	2.52	-	5.44	15.72	-	4.74
21	<i>Erythrina brucei</i>	15.49	4.99	1.99	-	-	4.49
22	<i>Calpurnia aurea</i>	3.07	3.69	8.55	6.62	-	4.39
23	<i>Senna septemtrionali</i>	-	-	11.92	1.60	3.10	3.32
24	<i>Vernonia amygdalina</i>	2.69	-	6.68	3.58	3.62	3.31
25	<i>Syzygium guineense</i>	1.04	2.55	7.83	-	4.67	3.22
26	<i>Premna schimperi</i>	-	-	15.98	-	-	3.20
27	<i>Ficus sur</i>	-	-	-	3.86	8.59	2.49
28	<i>Delonix regia</i>	-	-	11.49	-	-	2.30
29	<i>Citrus sinensis</i>	2.60	-	-	2.09	-	0.94
30	<i>Euphorbia cotinifolia</i>	3.49	5.57	-	1.56	-	2.12
31	<i>Acacia mearnsii</i>	-	-	9.74	-	-	1.95
32	<i>Euphorbia candelabrum</i>	2.21	4.57	2.80	-	-	1.92
33	<i>Sesbania sesban</i>	6.78	-	-	2.23	-	1.80
34	<i>Acacia etbaica</i>	-	-	8.55	-	-	1.71
35	<i>Arundinaria alpine</i>	-	-	-	1.71	-	1.60
36	<i>Maytenus arbutifolia</i>	-	-	6.33	1.56	-	1.58
37	<i>Annona senegalensis</i>	2.77	-	4.79	-	-	1.51
38	<i>Ricinus communis</i>	2.53	-	-	-	5.00	1.51
39	<i>Carissa spinarum</i>	-	3.03	3.79	-	-	1.36
40	<i>Ehretia cymosa</i>	-	-	2.86	3.78	-	1.33
41	<i>Galiniera saxifraga</i>	2.33	-	2.58	1.56	-	1.29
42	<i>Bersama abyssinica</i>	-	-	3.91	2.50	-	1.28
43	<i>Caesalpinia decapetala</i>	1.99	2.38	1.98	-	-	1.27
44	<i>Carica papaya</i>	6.19	-	-	-	-	1.24
45	<i>Flacourtia indica</i>	2.79	-	-	3.35	-	1.23
46	<i>Combretum molle</i>	-	5.74	-	-	-	1.15
47	<i>Clematis hirsute</i>	-	-	-	5.26	-	1.05
48	<i>Brucea antidysenterica</i>	-	2.59	-	2.33	-	0.98
49	<i>Dracaena steudneri</i>	-	-	-	4.84	-	0.97

Table 6. Contd.

50	<i>Prunus persica</i>	3.19	-	-	-	-	0.64
51	<i>Casimiroa edulis</i>	1.03	-	-	1.61	-	0.53
52	<i>Dodonaea angustifolia</i>	-	-	2.54	-	-	0.51
53	<i>Olea welwitschii</i>	-	6.31	-	2.20	-	1.70
54	<i>Jacaranda mimosifolia</i>	-	-	-	1.95	-	0.39
55	<i>Vepris dainellii</i>	1.51	-	-	-	-	0.30
56	<i>Manihot esculenta</i>	1.44	-	-	-	-	0.29
57	<i>Gossypium hirsutum</i>	1.15	-	-	-	-	0.23
58	<i>Ocimum lamifolium</i>	1.03	-	-	-	-	0.21
59	<i>Rhamnus prinoides</i>	1.03	-	-	-	-	0.21
60	<i>Bougainvillea spectabilis</i>	1.06	-	-	-	-	0.21
	Total	300	300	300	300	300	300

identified in study sites were distributed in the coffee farm for the purpose of shade. Bikila and Zebene (2016) stated that woody species with the highest IVI are *C. arabica* and other shade tree species.

Key informants also pointed out that *A. gummifera*, *A. abyssinica* and *M. ferruginea* species were the most preferred species as shade for coffee in their discussions. They stated that the leaves of these woody species are allowed an appropriate amount of light to reach the coffee and other undergrowth species due to leaf structure and size. Tola et al. (2014) also reported that small leaf tree species (*A. gummifera*, *A. abyssinica* and *M. ferruginea*) are most preferred for coffee shade. Small trees and shrubs were used for shade when farmers convert other land use and/or treeless field to coffee farm due to fast growing and soil fertility improvement. This justification also agrees with Tola et al. (2014) who reported that the fast-growing and shorter lived trees provide enough shade to the newly planted coffee until the preferred shade trees have grown big enough.

Most important woody species were *E. camaldulensis*, *C. lusitanica* and *G. robusta* in woodlots. Number of species identified in this study was lower than the study result of Shiferaw and Pavlis (2012). The difference might be associated with the high relative density of *E. camaldulensis* plantation, *C. lusitanica* and *G. robusta*. *E. camaldulensis* was the dominant tree and accounts for most of the woody plants within the study area in woodlots.

Height of woody species in agroforestry system

All individuals with ≥ 2.5 cm diameter at breast height and ≥ 2.5 m height woody species encountered from the fields were categorized into diameter and height classes. Based on height category, woody species was classified into three height classes in different land use type. Woody species individuals recorded in the study area were: (I) 2.5 to 5 m lower class height; (II) 5.01 to 10 m

medium class height; and (III) ≥ 10 m upper class height woody species described as overall land use types and across each land use types with sites.

There was a higher frequency percentage of lower height class distribution of woody species in homegardens, crop field and coffee farm. In case of coffee agroforestry practice, the system is covered by some individual numbers of woody species used for shade and higher coffee shrubs. Due to competition factors with the under growth plants, and use of tree parts in crop field and homegardens, the tree height was managed repeatedly. Most woody species cultivated in homegardens are fruit tree species and their heights are managed to collect fruits. Woodlots are purposely required for woody products and it is dominated by higher height woody plants in overall study sites (Figure 6).

This study result is in agreement with study report of Bikila and Zebene (2016) who reported that repeated management of trees height in homegardens and multi-use of tree species in the farmers' field affects the height growth. Kufa and Burkhardt (2011) also reported that larger tree species, characterized by broad-leaved, dominated upper canopy; and coffee plants and small shrubs were found at the middle and lower height class.

CONCLUSION AND RECOMMENDATIONS

Farmers' were mainly cultivating trees and shrubs on their homegardens, crop fields, coffee farms, grazing lands and woodlots randomly or intentionally in the study area. The type of land use determines the composition and diversity of woody species. Comparatively, the highest diversity was recorded in the grazing land followed by homegardens in the overall study sites; and lowest species richness and diversity were recorded in woodlots. Whereas grazing lands are known in evenly distributed remnants of forest and naturally grown very large size trees, single species dominated in woodlots. Woody species are mainly grown naturally and very

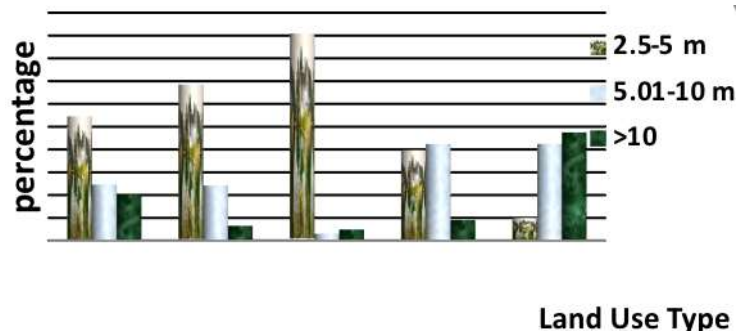


Figure 6. Height class of woody species in land use type of study sites.

scattered in crop field as compared to other land use type. The total density of woodlots were higher than other land use types with *E. camaldulensis* being the most densely populated plant woody species in the area.

This study focused mainly on some biophysical point of view; further studies are advisable on other physical factors (slope aspect, soil and climate) and their interaction in the system. Agroforestry practice should be promoted and encouraged as development and management approach for prevention as well as maintain indigenous plant species within the system.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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REFERENCES

- Abebe A, Gameda A, Wondewossen T, Lemu G (2011). Climatic variables and malaria transmission dynamics in Jimma town, South West Ethiopia. *Parasite and Vectors* 4:30.
- Abiot M, Gonfa K (2015). Woody Species Diversity in Traditional Agroforestry Practices of Dellomena District, Southeastern Ethiopia: Implication for Maintaining Native Woody Species. *International Journal of Biodiversity* pp. 1-13.
- Abreha A, Gebrekidan W (2014). Woody Plant Inventory and Diversity in Traditional Agroforestry of Selected Peasant Association of South Gonder Zone, North West Ethiopia. *Journal of Environment and Earth Science* 4(15):2224-3216.
- Abyot D, Teshome S, Ensermu K, Abiyou T (2014). Diversity, Structure and Regeneration Status of the Woodland and Riverine Vegetation of Sire Beggo in Gololcha District, Eastern Ethiopia. *Momona Ethiopian Journal of Science* 6(1):70-96.
- Aklilu A, Belayneh A, Alemayehu W, Kiros MH, Ermias, Jeremias M (2013). Agroforestry Practices and Farmers' Perception in Koga Watershed, Upper Blue Nile Basin, Ethiopia. *Agriculture and Forestry* 59(3):75-89.
- Azene B (2007). *Usful Trees and Shrubs for Ethiopia, Identification, Propagation and Management for 17 Agro-climatic Zones*. World Agroforestry Center, English Press, Nairobi Kenya P 550.
- Badege B, Henry N, Jeremias M, Abdu A, Jonathan M, Gemedo D, Tewodros A, Kathleen G, Habtemariam K, Ian K Dawson, Eike L, Cheikh M (2013). *Farmers' Strategies for Adapting to and Mitigating Climate Variability and Change through Agroforestry in Ethiopia and Kenya* edited by Caryn MD, Bryan B, Aleksandra D. Forestry Communications Group, Oregon State University, Corvallis, Oregon.
- Bajigo A, Tadesse M (2015). Woody Species Diversity of Traditional Agroforestry Practices in Gununo Watershed in Wolayitta Zone, Ethiopia. *Forest Resource* 4:4.
- Balcha A (2013). Plants used in material culture in Oromo community, Jimma, Southwest Oromia, Ethiopia. *African Journal of Plant Science* 7(7):285-299.
- Belay T, Ruelle ML, Zemedede A, Berhanu AT (2014). Woody plant diversity in an Afromontane agricultural landscape Debark District, northern Ethiopia). *Forests Trees and Livelihoods* 23(4):261-279.
- Bikila M, Zebene A (2016). Woody Species Diversity and Structure of Agroforestry and Adjacent Land Uses in Dallo Mena District, South-East Ethiopia. *Natural Resources* 7:515-534.
- BOFED (2007). Jimma Zone Districts Socio Economic Profile Regional Statistical Available at: https://www.romiabofed.org/regionalstatistics_
- BOPED (2000). Physical and Socio-economic profile of 180 District of Oromia Regional State. Council of The regional State of oromia Bureau of Planning and Economic Development. Finfinne. Available at : www.Physical_and_socio_economic_profiles_of.htm.
- Chane GT, Nashon KRM, Wellington NE, Kassim OF (2003). Land Use and Spatial Distribution of Two Gum and Incense Producing Tree Species. In *The Blue-nile Valley of Wogidi District, Ethiopia*. *Journal of Human Ecology* 14(2):77-87.
- Dawoe E, AsanteW, Acheampong E, Bosu P (2016). Shade tree diversity and aboveground carbon stocks in Theobroma cacao agroforestry systems: implications for REDD+ implementation in a West African cacao landscape. *Carbon Balance and Management* 11(1):17.
- Dedo WANRO (2016). *Agriculture and Natural Resource Management office Annual report*, Sheki, Ethiopia.
- Egodawatta Ch, Warnasooriya R (2014). Diversity of Tree Flora in Homegardens in Urban Proximity of Anuradhapura City, Sri Lanka. *Agriculture, Forestry and Fisheries* 3(1):34-39.

- Etefa G, Raj AJ (2013). Assessment of biodiversity in cropland agroforestry and its role in livelihood development in dryland areas: A case study from Tigray region, Ethiopia. *Journal of Agricultural Technology* 9(4):829-844.
- Ewuketu L M, Zebene A, Solomon Z (2014). Plant species diversity of home garden Agroforestry in Jabithenan District, North-western, Ethiopia. *International Journal of Biodiversity and Conservation* 6(4):301-307.
- Feyera S, Demel T, Bertake N (2002). Native woody species regeneration in exotic tree plantations at Munessa-Shashemene Forest, Southern Ethiopia. *New Forests* 24: 131-145.
- Fichtl R, Admasu A (1994). Honey bee Flora of Ethiopia. Weikersheim (Germany), Margraf Verlag P 519. Available at: <https://www.cabdirect.org/cabdirect/abstract/19946796292>
- Georgie FS, Susan I, Daniel LK, Saoirse O, Fraser JG (2007). Enhancing vegetation diversity in glades, rides and roads in plantation forests. *Biological Conservation* 136:283-294.
- Getachew T, Zavaleta E, Shennan C (2014). Coffee landscapes as refugia for native woody biodiversity as forest loss continues in southwest Ethiopia. *Biological Conservation* 169:384-391.
- Girmay D, Emiru B, Nigussie A (2015). Woody Species Diversity in Oxytenanthera abyssinica Based Homestead Agroforestry Systems of Serako, Northern Ethiopia. *Journal of Natural Sciences Research* 59(9):18-16.
- Kent M, Coker P (1992). *Vegetation Description and Analysis: A practical Approach*. London: Belhaven Press P 263.
- Kersa WANRO (2016). *Agriculture and Natural Resource Management office Annual report*, Serbo, Ethiopia.
- Kufa T, Burkhardt MJ (2011). Plant composition and growth of wild *Coffea arabica*: Implications for management and conservation of natural forest resources. *International Journal of Biodiversity and Conservation* 3:131-141.
- Mana WANRO (2016). *Agriculture and Natural Resource Management office Annual report*, Yebu, Ethiopia.
- Mathewos A, Sebsebe D, Zemedede A (2013). Indigenous knowledge on management of home gardens and plants in Loma and Gena Bosa Districts (Weredas) of Dawro Zone, southern Ethiopia: plant biodiversity conservation, sustainable utilization and environmental protection. *International Journal of Sciences: Basic and Applied Research* 10(1):63-99.
- Mbow Ch, Noordwijk MV, Luedeling E, Neufeldt H, Minang PA, Koworo G (2013). Agroforestry solutions to address food security and climate change challenges in Africa. *Current Opinion in Environmental Sustainability* 6:61-67.
- Mekonnen A, Mekuria A, Zemedede A (2014). The role of homegardens for in situ conservation of plant biodiversity in Holeta Town, Oromia National Regional State, Ethiopia. *International Journal of Biodiversity and Conservation* 6(1):8-16.
- Mesele N, Eshetu Y, Luukkanen O (2012). Potential of indigenous multistrata agroforests for maintaining native floristic diversity in the south-eastern Rift Valley escarpment, Ethiopia. *Agroforestry Systems* 85(1):9-28.
- Mideksa IA, Asfaw AE, Tsegaye A (2015). An assessment of traditional use of woody plants and their relationship with rangeland condition parameters in Southeast Ethiopia. *African Journal of Wood Science and Forestry* 3(5):136-148.
- Mohammed W, Lindner A, Berger U (2015). Management Effects on Woody Species Diversity and Vegetation Structure of Coffee-based Agroforestry Systems in Ethiopia. *Small-scale Forestry* 14:531-551.
- Motuma T, Zebene A, Mulugeta L, Karlun E (2008). Woody species diversity in a changing landscape in the south-central highlands of Ethiopia. *Agriculture, Ecosystems and Environment* 128:52-58.
- Nair PKR (1993). *An Introduction to Agroforestry*, Kluwer Academic Publishers in cooperation with ICRAF, Netherlands. Available at: https://www.worldagroforestry.org/Units/Library/Books/PDFs/32_An_introduction_to_agroforestry.pdf?n=161
- Nikiema A (2005). *Agroforestry parkland species diversity: uses and management in semi-arid West-Africa (Burkina Faso)*; Thesis/dissertation.
- Nyaga J, Barrios E, Muthuri CW, Oborn I, Matiru V, Sinclair FL (2015). Evaluating factors influencing heterogeneity in agroforestry adoption and practices within smallholder farms in Rift Valley, Kenya. *Agriculture, Ecosystems and Environment* 212:106-118.
- Ogunwusi AA (2013). *Green Investments required in the Forest Products Industry in Nigeria*. *Developing Country Studies* 3(3): 51-63.
- Shiferaw A, Pavlis J (2012). Native woody plants diversity and density under *Eucalyptus camaldulensis* plantation, in Gibie Valley, South Western Ethiopia. *Open Journal of Forestry* 2(4):232-239.
- Simon S, Girma B (2004). Composition, structure and regeneration status of woody species in Dindin national forest, south east Ethiopia: implication for conservation. *Ethiopian Journal of Biological Science* 3(1):31-48.
- Tefera M, Mirutse G, Ensermu K (2015). Ethnobotanical study of homegarden plants in Sebeta-Awas District of the Oromia Region of Ethiopia to assess use, species diversity and management practices. *Journal of Ethnobiology and Ethnomedicine* 11(64):1-13.
- Temesgen M, Belayneh A, Yeshanew A (2015). Woody Plant Species Diversity, Structure and Regeneration Status of Woyanwuha Natural Forest, North West Ethiopia. *Asian Journal of Ethnobiology and Medicine Foods* 1(01):03-15.
- Tesfaye A, Wiersum KF, Bongers F (2010). Spatial and temporal variation in crop diversity in agroforestry homegardens of southern Ethiopia. *Agricultural Systems* 78(3):309-322.
- Tola GA, Börjeson L, Feyera S, Hylander K (2014). Balancing ecosystem services and disservices: smallholder farmers' use and management of forest and trees in an agricultural landscape in southwestern Ethiopia. *Ecology and Society* 19(1): 30.
- Tyynelä TM (2001). *Species diversity in Eucalyptus camaldulensis woodlots and miombo woodland in Northeastern Zimbabwe*. *New Forests*, Kluwer Academic Publishers 22:239-257.
- Yisehak K, Taye T, Aynalem H (2013). Characteristics and Determinants of Livestock Production in Jimma Zone/Southwestern Ethiopia. *African Journal of Basic and Applied Sciences* 5(2):69-81.
- Zerihun K, Weyessa G, Adugna D (2011). Understanding Homegarden in household food security strategy, case study around Jimma, Southwestern Ethiopia. *Research Journal of Applied Sciences* 6(1):38-43.

Review

The dynamics of medicinal plants utilization practice nexus its health and economic role in Ethiopia: A review paper

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Medicinal plants play important roles in human and animals disease treatment. 1000 medicinal plant species are identified and reported in the Ethiopian Flora. They contribute and is more preferable for new drug development. Ethiopia has the potential to become an important source country, given the diversity of plants and the rich traditional knowledge regarding their use. The main sources of medicinal plants for utilizers are the wild forests. There is also cultivation practice of medicinal plants in home garden. About 80% of human and 90% of livestock population in Ethiopia depends on utilization of medicinal plants for primary health care. The knowledge transfer of medicinal plants in Ethiopia is largely oral. Most parts of medicinal plants commonly used are leaves and roots. Utilization of leaves for drug preparation is important for conservation of medicinal plants since harvesting leaves may not cause detrimental effect on the plants compared to the root or whole plant collections. Medicinal plants play a crucial role in health care needs in Ethiopia, because modern health care do not have adequate and equitable health service. Moreover, they depend on medicinal plants due to financial limitations related to rapid population growth and poor economic performance. In Ethiopia the market for essential oils of medicinal plants is very high and increasing in alarming rate. In the year 2011, 1,596.5 tons of essential oils of medicinal plants was imported and more than 30 million USD spent. Through increasing production potential and modernizing the sector of medicinal plants, they play a great role to substitute import and export. Medicinal plants have great potential to contribute to economic development and poverty alleviation in Ethiopia. Environmental degradation, deforestation, agricultural expansion over exploitation and population growth is the principal threats to medicinal plants in Ethiopia.

Key words: Medicinal plants, utilization, economic role.

INTRODUCTION

Medicinal plants still play important roles in the daily lives of people living in developing countries of Asia and Africa, including Ethiopia. Medicinal plants not only serve as complements or substitutes for modern medical

treatments, which are often inadequately available, but also enhance the health and security of local people. Thus, these plants play indispensable roles in daily life and are deeply connected to diverse social, cultural, and

economic events associated with life, aging, illness and death (JAICAF, 2008).

Globally, the estimate of medicinal plant species ranges from 35, 000 - 50, 000 species and out of this about 4000 - 6000 species have entered the world market of medicinal plants (Bekele, 2007). There are 6500 species of higher plants in Ethiopia, making the country one of the most diverse floristic regions in the world (Bekele, 2007). The plant kingdom is the most essential to human well-being in providing basic human needs. Human beings used plants for the purpose of disease control and prevention since time immemorial (Yirga et al., 2011). Medicinal plants are important for health care and remedy for diseases and injury. They are also used traditionally for foods and drinks (Bekele, 2007). Early humans acquired knowledge on the utilization of plants for disease prevention and curative purposes through many years' experience, careful observations and trial and error experiments (Martin, 1995).

The common use of medicinal plants has resulted in traditional health care becoming a profitable, multinational business. Billions of US dollars are spent annually on traditional medicine in many developed countries. In 2012, 32 billion dollars were spent in the United States of America on dietary supplements, an amount expected to increase to 60 billion dollars in 2021 (Samuel et al., 2015). The World Health Organization estimates that the global market of traditional medicine is approximately US \$83 billion annually (Robinson and Zhang, 2011). Traditional medicines also contribute to the development of pharmaceutical treatments by providing raw materials derived from plants like digitalis, alkaloids, morphine, quinine, and vinca. According to Samuel et al. (2015) one-third to one-half of pharmaceutical drugs was originally derived from plants. Traditional medicine has contributed and is more preferable for new drug development because Bioactive compounds derived from herbal medicines are more likely to have minimal toxicity, and a long history of clinical use suggests that herbal medicine may be clinically effective (Koehn and Carter, 2005).

About 80% of human and 90% of livestock population in Ethiopia depend on utilization of traditional medicines for primary health care on different types of health problems (Unnikrishnan, 2009; Berhane et al., 2014; Negero et al., 2015). This is because traditional medicines are easily affordable and there are limited modern health care centers (Yirga et al., 2011).

Additionally, according to Bekele (2007), the major reasons why medicinal plants are demanded in Ethiopia are due to culturally linked traditions, the trust the communities have in the medicinal values of traditional

medicine and relatively low cost in using them. Ethiopia has the potential to become an important source country, given the diversity of plants and the rich traditional knowledge regarding their use as medicine. Comprehensive documentation of traditionally written and oral literature pertaining to medicinal plants, herbal drugs, disease entity, drug formulation and dosage regimes need to be practiced.

Demands for medicinal plants in rural parts Ethiopia for human, livestock and plant health, where people do not have access to modern medical services, are increasing due to cultural acceptability of medicinal plants. But medicinal plants and associated knowledge are disappearing at an alarming rate. Despite the wide utilization practice of medicinal plants, the information about their health and economic role in Ethiopia has not been well summarized and documented. Thus, the objective of this paper is to review medicinal plants production, documentation and utilization practices in relation to health and economic role in Ethiopia.

STATUS OF MEDICINAL PLANTS IN ETHIOPIA

Approximately 6,500 higher plant species were obtained in Ethiopia. Of these, 12% are endemic; hence one of the six plant biodiversity rich countries of Africa (UNEP, 1995; Kassaye et al., 2006). The diversity is also considerable in the lower plants, but exact estimates of these have to be made. The genetic diversity contained in the various biotic make up is also high, thus making the country a critical diversity hot spot for plants (Endashaw, 2007). Ethiopia is one of the two world's 25 biodiversity rich area hot spots. Which is the eastern Afromontane Biodiversity Hotspot and the Horn of Africa-Biodiversity Hot Spot (National Herbarium, 2004; Ermias, 2005; Haile, 2005 and Endashaw, 2007). These hotspots house most of the useful wild biodiversity, particularly that of medicinal plants (Thulin, 2004).

Globally, the estimate of medicinal plant species ranges from 35,000 - 50,000 species; and out of this, about 4000 - 6000 species have entered the world market of medicinal plants. However, only about one hundred species have been used as a source of modern drugs (Edwards, 2001). The traditional medicinal plant industry is one of the few industries that have escaped large scale commercialization by both foreign and domestic interest; and consequently it remained as a largely informal industry with virtually no official trade industries in Ethiopia. In developed countries, it is only recently that tremendous interest in bioprospecting, with pharmaceutical companies and universities is moving forward (Endashaw, 2007).

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In Ethiopia, ethno veterinary medicine is also highly practiced by different local communities. The coverage is very high and the National Health Research document emphasized the importance of traditional practices and recommended research undertakings (Endashaw, 2007). In Ethiopia, medicinal plants are widely cultivated and utilized. According to EIAR (2016) a total of 134,541.97 ha areas are covered by herbs and aromatic plants in Oromia region, Amhara and SNNPRS. A large number of medicinal plants was documented and widely used to treat various human and livestock ailments in various parts of the country. However, these resources are under threat due to different reasons. For instance, *Brucea antidysenterica*, *Cordia africana*, *Cucumis ficifolius*, *Euphorbia abyssinica*, *Hagenia abyssinica*, *Ficus sur*, *Olea europaea* subsp. *cuspidata*, *Podocarpus falcatus*, *Millettia ferruginea*, *Myrica salicifolia* and *Withania somnifera*, are highly threatened (Asmamaw and Achamyeleh, 2018; Nigussie et al., 2018).

In Ethiopia, except for a few cases where a few food crops with medicinal value are cultivated, there is no organized cultivation of plant species for medicinal purposes. The reason for this is that the quantities of medicinal plants traded are very small, and there is no organized large-scale value for addition and processing. However, there is a potential in the future for increased demand for some of the species (Bekele, 2007). According to EIAR (2016), more than 80 indigenous and exotic species are conserved in its botanical garden. To develop and enhance production, processing, marketing and utilization technologies of Medicinal Plants, Ethiopian Institute of Agricultural Research, established the Wondo Genet Agricultural Research Centre. Despite availability of diverse favorable climate, ecology, topographic conditions and existence of a conducive investment climate for the development of medicinal plants, this subsector is far from realizing the country's expectations. This is mainly due to prevailing constraints, such as lack of high yielding and quality competitive varieties, unavailability of sufficient horticultural management practices, limited knowledge about pest and disease management, limited level of awareness creation about the sector, limited technologies on post-harvest processing and quality assurance issues, limited information and knowledge about the available genetic resource potentials for proper exploitation, limited knowledge and information on Good Agricultural Practices (GAP) and Good Manufacturing Practices (GMP), and limited effort made for development of the whole value chain integration of the herbs and medicinal plants subsector (EIAR, 2016).

DIVERSITY AND CULTIVATION OF MEDICINAL PLANTS IN ETHIOPIA

Around 1000 identified medicinal plant species are reported in the Ethiopian Flora; however, others are still

not identified. About 300 of these species are frequently mentioned by different authors. Researchers estimated that about 60% of the flora to be medicinal and most sources give about 10% of the vascular flora to be medicinal (Bekele, 2007).

In Ethiopia, the greater concentration of medicinal plants is found in the south and southwestern parts of Ethiopia; following the concentration of biological and cultural diversity (Edwards, 2001). A study at the Bale Mountains National Park in the South East Ethiopia revealed that the area turned out to be a medicinal plant hotspot with 337 identified medicinal species of which 24 are endemic (Haile, 2005). The cultivated medicinal plants are mostly produced in home gardens either for medicinal or primary purposes. Medicinal plants of home gardens are known to the public as the knowledge about them is open or readily available to the public (Zemede, 1999, Feyyesa et al., 2015). Banjaw et al. (2016) carried out a study to assess the Aromatic and Medicinal Plants in Wondogenet Agricultural Research Center Botanical Garden, South Ethiopia. The results showed that twenty-seven plant families, having sixty-one plant species, were identified. The Lamiaceae family contains the greater number of species and is followed by the Asteraceae family.

Asnake et al. (2016) reported that a relative high diversity of plants (94 plant species) which are used to treat malaria came from the South Nations and Nationalities of People region. Assefa et al., (2014) conducted a research study to identify medicinal trees and shrubs, including documentation of local knowledge about their utilization and management in Benna Tsemay district of Southern Ethiopia. The result showed that medicinal trees and shrubs that they collected belonged to 15 families and 20 genera. The plant family with the largest number of trees and shrubs used for medicinal purposes was Fabaceae, which comprised 13% of the medicinal trees and shrubs identified. Similar results were presented by Haile and Delenashaw (2007).

In an ethnobotanical study conducted on medicinal plant species at Menjar shenkora area by Alemayehu et al. (2015), they showed that there was a good number (118) of medicinal plants, and there are people who have the indigenous botanical and medicinal knowledge of the plants to make their use more applicable. Among the plant families that contributed more medicinal species were the Asteraceae (9.3% of the total species), followed by Lamiaceae (8.5%), and Fabaceae (7.6%). This could be an indication that the study area consists of considerable diversity of plant species within these families in the same composition as the flora of the entire country, where these families are among the few with the highest number of species that are widely distributed both in terms of their geographical and habitat spans (Alemayehu et al., 2015).

Berhane et al. (2014) conducted their study to assess use and management of traditional medicinal plants by

Maale and Ari ethnic communities in southern Ethiopia and reported that a total of 128 medicinal plant species, belonging to 111 genera and 49 families, were used as herbal medicine by Maale and Ari communities. In a study conducted at Wolayita zone (Seta et al., 2013), a total of twenty-three plant species with medicinal value were recorded and included in nineteen genera and fourteen families. This accounts for 20.54% of the most useful plant species studied. Species of the family Asteraceae were the most used plants representing about 26.1% of all medicinal plants, followed by the family Lamiaceae (17.4 %). Majority of the medicinal plants were herbs (78.3%), tree species and shrubs accounted for 13.04 % and 8.70 % respectively. The most frequently used plant part in the study area is the leaf with 78.3% (Seta et al., 2013).

Abera (2014) reported that family Asteraceae was represented by 5 species followed by 4 species of Lamiaceae in Ghimbi district. Alemayehu et al., (2015) also reported that Lamiaceae and Solanaceae families were widely distributed in minjar shenkora district. Giday et al. (2006) also reported similar results. According to Zerabruk and Yirga (2011), a total of 26 species of medicinal plants were collected and identified for treating 36 human ailments at Gindberet district, Western Ethiopia. According to Alemayehu et al. (2015), traditional medicinal plants harvested in the study area were from home gardens, crop field and in agricultural margins or fields. Similar results were also reported by Megersa et al. (2013). According to Hunde et al. (2006), medicinal plants utilized by indigenous people of 'Boosat' are collected from the wild, few being under cultivation. They are distributed in woodlands, shrub lands, rocky hillsides, degraded woodlands, grazing and browsing lands, roadsides, in farmlands, farm borders and spiritually protected areas.

In a study conducted in the central zone of Tigray (Yirga, 2010), twelve traditional healers were interviewed to gather information on the knowledge and use of medicinal plants used as a remedy for human ailments and it was reported that 16 plant species were commonly used to treat various human ailments. Most of these species (68.75%) were wild and harvested mainly for their leaves and the remedies were administered through oral and dermal methods. A different study (Pankhurst, 2001) indicated that, the main sources of medicinal plants are the wild forests. However, the increase in population growth rate would result in the intensification of agriculture in marginal areas that would lead to deforestation with a decrease in number, or major loss, of medicinal plants in the wild. According to the socioeconomic survey conducted by Abdulhamid et al. (2004), they showed that most of the respondents expressed willingness to cultivate medicinal plants. The shift from cereal cultivation to medicinal plants could support forest development by changing the livelihood systems from cereal cultivation to alternative income

generation schemes, including medicinal plant cultivation. Plantations of medicinal plants can be made in degraded areas. There are many medicinal plants in Ethiopia that have good properties for land rehabilitation and erosion control, which could be planted in different agro-ecological settings (Bekele, 2007).

Etana (2006) studied the use and conservation of traditional medicinal plants by indigenous people in Gimbi Woreda, Western Wollega. The result showed that 211 species (52%) were collected from home gardens and 168 from the wild, and 9 species were recorded in both areas, of which 85 (40.3%) are medicinal plants. From 52 plant species of the home garden, 30 species (57.7%) are associated with food service, followed by plants that are used for medicinal services, 23 species (44.2%); and among 168 plant species found in the wild, 62 (37%) are medicinal plants. The study conducted by Tadesse et al. (2005) in Seka Chekorsa, Jimma Zone, indicated that among the 39 medicinal plants collected for the treatment of 24 different kinds of diseases, most of them were collected from the wild, while very few are cultivated.

In a study conducted in Kaffa Zone by Tesfaye and Sebsebe, (2009), they reported that the medicinal plants are always cultivated on the upper slope of the home garden, specifically behind the house. The zone of medicinal plant cultivation and collection is always kept clean. Animal wastes or any other garbage are not damped in this zone. Weedy medicinal plants are also collected from this site, even when they occur throughout the garden. Kafficho people give four reasons for this: 1) to prevent contamination by discharge of animal waste in the lower slope of their house, 2) to protect them from livestock, 3) situate them out of human sight, and 4) ensure a continuous supply of medicine for the household. If medicinal plants are grown in a home-garden quarters with high soil nutrient, they grow faster, complete their life cycle within a relatively shorter period and then die; a situation not preferred by farmers. Instead, the farmers want the medicinal plants to remain longer in their gardens so as to ensure a prolonged harvest, and they achieve this by maintaining the plants even under stressed conditions that can subdue plant growth.

Mesfin et al. (2009) carried out a study to assess the ethnobotanical value of medicinal plants in Wonago Woreda, SNNPR, Ethiopia. The results showed that the conservation of medicinal plants in the study area was limited except in *Juniperous* and *Eucalyptus* dominated plantations, which were the only protected natural vegetation areas. Feyessa et al. (2015) assessed the medicinal plants use and conservation practices in Jimma Zone, South West Ethiopia, and they reported that 48.91% of the respondents explained that people cultivated medicinal plants; whereas, 37% collected from wild habitats and less than 20% obtained them from market or from their neighbors. This indicated that medicinal plants need more attention in production, and

Table 1. Source of medicinal plants in Jimma zone Seqa Chekorsa and Kersa woreda.

Medicinal plant cultivation	Frequency	Percentage
Cultivated	112	48.91
Collected at wild habit	85	37.12
Buy in market	17	7.42
From neighbors	14	6.11
Others	1	0.44
Total	229	

Source: Feyyesa et al. (2015).

Table 2. Cultivation status of medicinal plants in Jimma zone Seqa Chekorsa and Kersa Woreda.

Medicinal plant cultivation	Frequency	Percentage
Cultivated	114	59.69
Collected at wild habit	11	5.76
Buy in market	42	21.99
From neighbors	24	12.57
Others	0	0.00
Total	191	100

Source: Feyyesa et al. (2015).

accessibility to the community by minimizing an unstructured production approach. They also reported that 59.69, 5.79, 21.99 and 12.57% respondents commonly cultivate medicinal plants in home gardens, mixing with other crops, maintained in live fences, and in agroforestry respectively (Table 1).

Giday et al. (2006) also conducted a survey to assess medicinal plants in Shinasha, Agew-awi and Amhara peoples in Northwest Ethiopia and reported that major sources of medicinal plants were cultivated in home gardens. In a survey conducted in Hawzen district, Northern Ethiopia, 33 species of medicinal plants were collected and identified for treating 25 human ailments. Most (51.5%) of the traditional medicinal plants were collected from the wild; furthermore, leaves (65%) and roots (17%) were the most commonly used plant parts for herbal preparations. Most (85.7%) of the traditional medicinal plant preparations were used in fresh form. Oral, dermal and nasal were the routes of application of remedies. Squeezing, grinding, boiling, chewing, crushing and tying were the methods of remedy preparation.

In another study conducted in Seka Chekorsa, Jimma Zone, 39 (Tadesse et al., 2005) medicinal plants were collected and identified for the treatment of 24 different kinds of diseases. Thirty-three of them are used as polyherbal prescriptions and 20 are used as a single plant source to treat diseases. The study indicated that leaves are the most commonly used (58%), followed by roots (11%), complete plants and fruits (9%), stem and

bark (2.6%) and (1.3%), respectively. Most of the medicines are taken orally (77%), followed by external application (topically on skin-bandaging or ointment (15.8%) and nasal inhaling (7%) (Tadesse et al., 2005) (Table 2).

MEDICINAL PLANTS UTILIZATION PRACTICE AND PLANT PARTS USED

Before the end of the 19th century, Ethiopia had little knowledge of exercising the modern type of health care practices. People were dependent on natural resources and the various techniques that they had developed to enhance healthcare facilities. Traditional techniques and herbal remedies were widely used by traditional healthcare systems throughout the country. The delivery of the basics of health care services in Ethiopia was started towards the end of the 19th century (Kebede, 2010).

Modern health care has never been, and probably never, provide adequate and equitable health service anywhere in Africa, and Ethiopia in particular, due to financial limitations related to rapid population growth and poor economic performance. Thus, medicinal plants continue to be in high demand in the health care system as compared to the modern medicine (Hunde et al., 2006). Even in modern China alone, some 800 million people use around 5000 species of plants, medicinally.

The annual demand for plant material in China is around 700,000 tonne. A survey conducted by Bekele (2007) indicated that, a total of 56,410 tonne of medicinal plants were demanded by the consumers during the year 2005 in Ethiopia. Of these 42,260 tonne, 75% was traded through different marketing channels while 25% was not traded, i.e. collected and consumed by the consumers.

In Ethiopia, even if there are a large number of herbs and aromatic plant species ranging from 600-1000, it is very hardly possible to get the exact production areas covered by herbs and aromatic plants due to lack of comprehensive assessment studies for estimation of herbs and aromatic plant production potentials. Based on the available data from some parts of Oromia region, Amhara and SNNPRS, there is a total of 134,541.97 ha areas that are covered by herbs and aromatic plants (EIAR, 2016). Between 70 and 95% of citizens in most developing countries, especially those in Asia, Africa, Latin America and the Middle East, use traditional medicines, including traditional and herbal medicines, for the management of health and as primary health care to address their health-care needs and concerns (WHO, 2002).

In an ethnomedical household survey of the Berta ethnic group of Assosa Zone, Benishangul-Gumuz regional state, mid-west Ethiopia, plant roots were the most widely used plant part (46.4%), followed by seed (14.3%), leaf (12.2%), fruit (11.2%), bark (7.7%), and stem (3.6%); while the remaining 4.6%, a combination of one or more plant parts was used. Healers also reported the use of roots in 63.3%, seeds in 17.1% and leaves in 14.6% of the plants (Flatie et al., 2009).

In a similar study conducted on the People of 'Boosat' subdistrict, Central Eastern Ethiopia, fifty-two medicinal plant species were documented, which are used to treat 43 human diseases. The category of medicinal plant species includes shrubs (46%), herbs (25%), trees (19%), climbers (8%) and hemi parasites (2%). Roots (38%) and leaves (23%) are the most frequently used plant parts. The method of preparation is by crushing, pounding and mixing with cold water to serve as a drink and chewing to swallow the juice, which accounted for 17% each (Hunde et al., 2006).

In a study conducted in central Tigray, most of the traditional healers were found to have poor knowledge on the dosage while prescribing remedies to their patients. More than one medicinal plant species was used more frequently than the use of a single species for remedy preparations (Yirga, 2010). Several studies have reported the rich medicinal flora and the knowledge around it (Zemedede, 1999; Mirutse et al., 2003; Balemie et al., 2004; Feyyesa et al., 2015; Alebie (2017), reported that 80% of the Ethiopian population, and 90% of the herbals administered to animals, is composed of traditional herbal medicine in Ethiopia. The wide spread use of traditional medicine could be attributed to cultural acceptability, perceived efficacy against certain types of diseases,

physical accessibility and affordability as compared to modern medicine (Bekele, 2007). Incredibly, most of the urban population also continued to use medicinal plants including in Addis Ababa, where 75% of the population continue to use medicinal plants regardless of access to a modern clinic. It has been documented that some diseases such as tumor "*Almaz balechira*" are well cured by traditional medicine (Bekele, 2007).

Abiyot et al. (2006) in their ethnobotanical studies reported 8 insecticides and 11 species of plants used as anti-malarial agents in one of the districts in West Gojam, Ethiopia. These species of plants are among the widely used plants for medicinal purposes. Since malaria is a serious disease in Ethiopia and many developing countries, the list of traditionally used plants to control it must be backed by phytochemical studies to develop an appropriate phytomedicine. Other studies reported include ethnoveterinary medicine of the Welenchi area presented by Hunde, *et al* (2004). Useful and widely used drugs like Digoxin and Digitoxin, from *Digitalis* leaves; quinine from the cinchona bark; reserpine from *Rauwolfia serpentina*; morphine from *Papaver somniferum*; cocaine from *Erythroxylon coca* and the anti-cancer *Vincristine* and *Viblastine* from *Cartharothus troseus* of Madagascar, and again an anti-cancer compound, bruceatin, from the Ethiopian plant, *Brucea antidysenterica*, just to name a few, are examples of the contributions of traditional pharmacopoeia (Desta., 1988).

According to Zerabruk and Yirga (2011), a total of 26 species of medicinal plants were collected and identified for treating 36 human ailments at gindberet district, Western Ethiopia. The study of Zewdu (2013) at Gonder Zuria District, indicated that forty-two medicinal plant species, representing forty-one genera and thirty-one families, were identified to treat diseases (the highest number of uses mentioned for any disease were general health (sixty-nine), respiratory (fifty-one), and gastrointestinal (twenty-eight).

Alemayehu et al. (2015) conducted research on plant parts used in the Minjar-Shenkora District, North Shewa Zone of Amhara Region, Ethiopia and reported that informants of the study area harvest different plant parts (e.g., leaves, roots, seeds, barks and fruit) for preparation of traditional drugs. The informants reported that more species (54; 45.7%), of medicinal plants were harvested to use their leaves in medicine preparation, and these were followed by roots (17; 18.5%) and fruit parts that accounted for 13.5%. Regarding the plant parts for veterinary uses, leaves are a widely used part for a range of preparations compared to the other parts.

Leaves account for greatest preparations (9.40 %), followed by root (2.56 %), flower (1.70 %), fruit and others preparations (0.85%). They also reported that area included 50.60% liquid forms (liquid obtained after crushing the plant part), exudates (sap and drop form (9.03%), powdered forms (22.28%), smashed, juiced, boiled or filtered forms 12.04 and 6.03% as unprocessed

Table 3. Various categories of ailments treated with medicinal plants as gathered from Southern and Western Ethiopia.

Very commonly mentioned	Fairley commonly mentioned	Occasionally mentioned	Very rarely mentioned (mostly healer Domain)	
Stomach ache	Ascaris	Repelling mosquito	Abortion	Prevention of sterility
Tapeworm	Snake bite	Toothache	Anal tumor	Hemorrhoids
Malaria	Dysentery`	Rheumatism	Animal sickness	Expel placenta in cow
Eye disease	Headache	Gastritis	Asthma	Tongue disease
Wound	Sore	Anemia	Broken bone	Snake bite of domestic animals
Cold	Worms	Constipation	Insect bite	Liver disease
Cough	Hypertension		Insect repellent	Sexual transmitted disease
	Diarrhea	Impotence	Insect born disease	Dandruff
Abdominal pain	Gonorrhea		Insecticide	Lung disease
			Leech	

plus other forms. Most of the medicinal plant preparations involved the use of single plant species or a single plant part (60.24%), while those mixing two plants or plant parts (28.3%) and three plants or plant parts (8.43%) were rarely encountered in the study area.

According to Alebie et al. (2017), the geographic distribution of anti-malarial plants is likely to be predicated on a local trend with regard to disease risk, floral diversity and cultural diversity, including traditional medicinal practices. The western lowlands of Oromia, Amhara, Tigray, Southern Nation and Nationality People (SNNP), and almost the entire areas of Benishangul Gumuz and Gambella regions represent the major malarial hotspots in Ethiopia. According to Assefa et al. (2014), a total of 23 wild medicinal trees and shrubs were identified and documented, of which 56.6% were used to treat human disease, 30.4% to treat livestock disease and 13% for treatment of humans and livestock. Most widely used aromatic and medicinal plants and their parts used were also identified in Wondogenet Agricultural Research Center Botanical Garden. Leaves are the most widely used plant part for aromatic as well as medicinal purposes. Besides, roots, fruits, flower and bark are some important parts of plants used in fresh and dry forms (Banjaw et al., 2016).

Berhane et al. (2014) conducted their study to assess use and management of traditional medicinal plants by Maale and Ari ethnic communities in southern Ethiopia, and reported that predominantly harvested plant parts were leaves, which are known to have relatively low impact on medicinal plant resources. Species with high familiarity indices included *Solanum dasyphyllum*, *Indigofera spicata*, *Ruta chalepensis*, *Plumbago zeylanica* and *Meyna tetraphylla*. Low Jaccards similarity indices (≤ 0.33) indicated little correspondence in medicinal plant use among sites and between ethnic communities (Berhane et al., 2014) (Table 3).

Alemayehu et al. (2015) conducted research on preference ranking of 5 medicinal plants that were reported to be effective for treating skin rash based on

reports provided by 6 key informants. The results showed that *Vernonia amygdalina* scored highest of all and ranked first; indicating that it is the most effective plant in treating skin rash and this is followed by *Rhamnus perinoides*. They also reported that the majority (85%) of these medicinal plants are used for the treatment of human diseases, while about 36 % were used to treat livestock. According to Mekonnen (1990) a majority of indigenous healers and modern health practitioners agree that the integration of indigenous medicines with that of other health care settings would be beneficial. Hunde (2001), Giday (2001), Giday et al.(2006), Amenu (2007), Birhane et al. (2011), Assegid and Tesfaye (2014), Alemayehu et al. (2015), Asmamaw and Achamyeh, (2018), as well as Birhanu and Ayalew (2018) all noted that people in their study areas widely utilize medicinal plants to treat human ailments. Nigusie et al. (2018) conducted a research in gozamen district and reported that ninety-three medicinal plant species were distributed across 51 families and 87 genera. Of the total collected medicinal Plants, 80 plant species were used for the treatment of human ailments and 24 species were used against livestock diseases. Eleven (11) common plants species were listed in both which were used to treat both livestock and human ailments. Asmamaw and Achamyeh (2018) conducted survey in gozamin district to assess medicinal plants utilization practice and reported that medicinal plants were widely utilized to treat human and livestock diseases.

Birhanu and Ayalew (2018) assessed indigenous knowledge on medicinal plants used in and around Robe Town, Bale Zone, Oromia Region, Southeast Ethiopia and the result indicated that 55 medicinally important plants were recorded and most of the medicinal plants documented are used for the treatment of human ailments. They also reported that there is poor indigenous knowledge transfer by elders to younger generations and the knowledge of the traditional medicine is in a verge of disappearing in the near future. Most of the young respondents interviewed in the study know very few, or

even none, of the remedies used by their elders.

Megersa et al. (2013) reported that utilization of leaves for drug preparation is important for conservation of medicinal plants, because harvesting leaves may not cause detrimental effect on the plants compared to the root or whole plant collections. Leaves are the most commonly collected plant parts for medicinal purposes (Zenebe et al., 2012). According to Birhanu and Ayalew (2018) leaf is the most harvested plant part in the Robe Town, Bale Zone, and Oromia Region, Southeast Ethiopia. Wondimu et al. (2007), Yirga (2010); Mesfin et al. (2013), Regassa (2013) also reported that leaves are widely harvested plant parts. Whereas another study by Assefa (2014) in Benna Tsemay district of southern region and a study by Limenih et al. (2015) at Dega Damot district of Amhara region of the Ethiopia reported that root is the dominant plant part collected for medicinal purposes.

Alemayehu et al. (2015) conducted the research on ethnobotanical study of medicinal plants used by local communities of Minjar-Shenkora district and reported that people of the study area prepare remedies for human and livestock ailments, either from a single plant or plant part or by mixing them. The author also indicated that most of the medicinal plant preparations involved the use of a single plant species or a single plant part corresponding to each health problem.

Gender role in utilization of medicinal plants

Men and women differ in terms of their traditional knowledge about medicinal plants for primary health care. Divisions of labour across the traditional societies assign the role of collectors and gatherers in forest, home gardeners, herbalists and custodians of seeds to women. Majority of plant species and varieties used for food and medicine are conserved and managed at the household level by women. Due to social roles assigned to women, the daily work of collecting fuel, fodder, small timber and non-timber forest products like fruits, leaves, seeds, roots, gums and barks require more frequent interaction with forest and nature, resulting in more knowledge. These gender-differentiated local knowledge systems play a decisive role in the conservation and management of medicinal plants and their use for primary healthcare (Singhal, 2005).

On the other hand, Bekele (2007) reported that medicinal plant collectors in Ethiopia (86%) are mostly men than women (14%); while the customers of medicinal plants are equally male and female.

Educational level of users for medicinal plants has little effect. Both rich and poor are equally likely to use medicinal plants. The traditional health care appears to be dominated by men (89%) in some of the study areas. Traditional healers are relatively more educated than the collectors and the traders except in smaller towns and

rural areas.

Building the healthcare treatment knowledge of women would increase access to essential cost-effective rural healthcare services. Because Women have a significant share of the workload in agriculture, household & child care responsibility, women are primary healthcare providers of the family and women have also more access to home gardens where most of the drug plants are conserved or grow. Gender can significantly influence the number of human medicinal plants (Berhane et al., 2014). Zerabruk and Yirga (2011) reported that the gender distribution of traditional healers was 84 (70%) and 36 (30%) for males and females respectively at Gindeberet district, Western Ethiopia.

PREPARATION METHODS, DOSAGE AND ROUTE OF ADMINISTRATION

Medicinal preparations of plants contain many things such as powdered plant materials, extracts and purified active substances isolated from plant materials. The medicinal plant preparation and application are accomplished in various forms. However, according to most literature sources, it has been shown that simple crushing and pounding a particular plant part(s) and homogenizing it in water are the commonly used form of herbal preparation for both human and livestock health problems. An ethnobotanical study of medicinal plants in Fentale area, in Ethiopia by Balemie et al. (2004), revealed that various routes of application are available. Among them oral application accounts for 51.7%, dermal 31%, while nasal and other account for 0.1%, each.

In the same study, Balemie et al. (2004) found that there are variations in amount, and unit of measurement of medicinal plants used by healers for the same kind of health problems. Sofowora (1982) and Dawit (1986) also showed that the lack of precision and standardization is a drawback for the recognition of the traditional healthcare system.

Samuel et al. (2015) reported that the participants in their study area have used many plant products for different disorders and they prepare the plants in different dosage forms (liquid, solid, and gaseous forms) and administer them by mixing with water, tea, egg, and honey or without any mixing. Different studies also reported similar practices (Belayneh, 2012). The plant preparations are mainly used once daily for few days (ranging from 1 day to 6 months). Most commonly used routes of administration are oral, topical, and inhalational routes of administration. Reta (2013) reported that oral, dermal, and nasal routes are the three most commonly used routes of administration.

According to Yirga et al. (2011), leaves were the mainly harvested part for traditional medicine preparation in the area. The practice does not affect the sustainable utilization of the medicinal plants in the area. The findings

Table 4. Major human disease types and number of species used by people of Boosat sub district, Central east Ethiopia.

Disease treated	Total number of species	% of total medicinal plants used by humans
Snake poison	10	19.2
Gonorrhoea	4	7.2
Infected wiund	3	5.8
Malariya	11	21.2
cancer	3	5.8
Febril Illness(mich)	4	7.2
Cough	3	5.8
Evil eye	6	11.5
toothace	4	7.7
Kideny problem	3	5.8
Diarrhoes	3	5.8
Tetanus	4	7.7

Source: (Hunde et al., 2006).

of Mesfin et al. (2009) indicated that roots were the most frequently utilized plant parts. According to Abebe and Ayehu (1993), about 58.3% of traditional medicine is prepared from roots in Ethiopia. Regassa, (2013) reported that 70% of the preparations of traditional medicine by indigenous people of Hawassa city were drawn from mixtures of different plants or plant parts.

The medicinal plant preparations were applied through different routes of administration like oral, topical or dermal and nasal routes. Of these, oral application (54%) was the highest and most commonly used route of application followed by dermal application (29%). Both the dominant routes of administration (oral and dermal) routes permit rapid physiological reaction of the prepared medicines with the pathogens and increase the curative power (Balemie et al., 2004; Alemayehu et al. 2015).

According to Zerabruk and Yirga (2011), in Gindeberet district, Western Ethiopia the medicinal plant preparations were administered through oral, dermal and nasal routes. However, oral application (33 preparations, 67.3%) was the highest and most commonly used route of application followed by dermal application (15 preparations, 30.6%). In addition to these, the most commonly used plant parts for herbal preparations in the area were leaves (28%) and roots (28%) followed by barks (14%) and fruits (14%). In this region, 72.5% of the healers were rural dwellers.

Around Minjar Shenkora area the predominant method of remedy preparation is by crushing the plant parts (Alemayehu et al., 2015). Another ethnobotanical study of medicinal plants in Wonago Distict, SNNPR, indicated that the predominant method of remedy preparation was powdering (Mesfin, 2009). Hunde (2001), Giday (2001), Giday *et al.*(2006), Amenu (2007), Birhane et al. (2011), Assegid and Tesfaye (2014), Alemayehu et al. (2015), Asmamaw and Achamyeleh, (2018), and Birhanu and Ayalew (2018) reported that drinking (oral application)

was the dominant method of administration in different parts of the country. Nigussie et al. (2018) conducted research in Gozamen district and reported that most common route of administration is internal, particularly oral that accounted for 51.61% followed by dermal, 24.73%. Many diseases such as headache, cough, peptic ulcer disease, asthma, cold, skin disease, hypertension, and others are reported to be treated with the different plant preparations. Leaves, stems, and seeds were mainly used for treatment. The plants were obtained from home garden, market, or traditional medicine practitioners. The use of traditional medicine was significantly associated with the age of the population; particularly the age groups of 18–28 and 29–38 were highly associated with the level of traditional medicine use with a statistical significance value of $p < 0.02$ and 0.004 , respectively. Religion, family size, annual income, and marital status were found to have no association with use of traditional medicine (Samuel et al., 2015) (Table 4).

MEDICINAL PLANTS DOCUMENTATION AND INDIGENOUS KNOWLEDGE TRANSFER

The local indigenous knowledge on medicinal plants is being lost at a faster rate with the increase of modern education, which has led the younger generation to underestimate its traditional values (Pankhurst, 2001). This is partially attributed to the fact that most Ethiopian traditional medicinal knowledge is kept in strict secrecy; however, it also is dynamic in that the practitioners make every effort to widen their scope by reciprocal exchange of limited information with each other or through reading the traditional pharmacopeias (Dawit, 1986).

The acquisition and transfer of indigenous knowledge on traditional medicine, in most developing countries

Table 5. The number of human diseases and medicinal plants registered for various Ethiopian kingdoms.

Kingdom	No. of human diseases treated	No. of medicinal plants used
Axumite	1500	800
Zagwe	280	2800
Gondar	305	900
Kaffa	200	596
Libinedengel (Gondar)	800	500
King Hailemeleket of Shoa	500	700

Source: (Bekele, 2007).

including Ethiopia, is passed from one generation to the next by words of mouth. Results of studies by B and M Development Consultants PLC (2001) in the Bale Area, Ethiopia also indicate that 70% of the practitioners have acquired the traditional knowledge either from their parents or close relatives. 65% have reported that they have either already trained a member of their family or that they have plans to do so. Although the majority (70%) believes that oral transfer of indigenous knowledge is effective, they have also expressed their serious concern about future validity of the method. The main reason for this concern is the unwillingness of the young generation to acquire indigenous knowledge. The young generation has other ambitions and priorities than seeking knowledge on traditional practices. As a result, collecting and compiling indigenous knowledge as written accounts seems to be a necessity. The government and, particularly NGOs involved in ethnobotanical studies can play important roles in sponsoring ethnobotanical and ethno-pharmaceutical studies to collect compile and preserve such crucial indigenous knowledge for future generations before it is too late.

According to Berhane et al. (2014), the dominant ways of medicinal plant knowledge acquisition and transfer is vertical: from parents to children through oral means. Zemed (2001) reported that indigenous knowledge of medicinal plants in Ethiopia is unevenly distributed among community members. The knowledge on medicinal plants is largely oral. However, Ethiopia's ancient church practices have documented some of the knowledge as inscribed in Parchments, which partly characterize the traditional medical system usually described as medico religious writings in Geez manuscripts of the 15th Century (Abebe and Ayehu, 1993). Other ancient written sources include the book of remedy (*Metsehafe Fewes*) of the 17th century, which contains a wide range of medicinal plant prescriptions (Fullas, 2001) (Table 5).

In a study conducted in central Tigray (Yirga, 2010), the indigenous knowledge transfer was found to be different. Some traditional healers transfer their indigenous knowledge, while others kept the knowledge with them for the sake of secrecy. The distribution of knowledge

and services are hierarchically placed. Services are obtained from the family, the neighborhood, the village or beyond. A common saying attributed to traditional wisdom goes as follows: 'Leave alone human beings, even a goat knows which twig to nibble when bitten by a snake.' (Fassil, 2005). As a consequence of the pure knowledge transition gap, most of traditional medical practitioners have shifted to the use of conventional medicines that are adulterated with herbal medicines, which may cause high damage to the patient due to antagonistic herbal-drug interactions (WHO, 2002). A study conducted by Debella et al. (2008) to check the presence of active pharmaceutical ingredients (APIs) of conventional drugs in herbal remedies prescribed or supplied by traditional healers, indicates that 51 of 76% samples prescribed for treatment of malaria, gonorrhoea, tuberculosis, tropical ulcer and diabetes and/or hypertension were found to be adulterated with one or more modern drugs. The existence of legal framework is not only intended to the promotion and integration of traditional medicines but also governs the activities of the healers who are doing dangerous practices.

Zemed (1999) studied the ethnobotany of nations, nationalities and peoples in Gambella, Benshangul/Gumuz and Southern regions of Ethiopia. The study targeted Kefficho, Wolaita, Dawro, Gamo, Dizi and Hammar people in Southern Ethiopia, the Anywa, Nuer, Komo Majanger and Opuo people in Gambella and the Mao, Berta, Gumuz, Shinasha, and Komo people in Benshangul and Gumuz region. That study reported that plants used by these people under different categories of food, medicine, craft implements, construction were documented. The study indicated that medicinal plants were important for the health care of the Maale and Ari communities, as they used at least 128 species and traditional medicine was considered as the first line of treatment by 89% of our respondents. Knowledge differed between and within ethnic groups and also among sites. The fact that knowledge transfer was predominantly to family members and in particular to first-born sons may negatively affect its continuity and may result in knowledge loss if medicinal plant resources become scarce in the future (Table 6). There is very little

Table 6. The number of medicinal plants documented for each group.

Group	Number of Medicinal Plants Documented
<i>Anywa</i>	28
<i>Berta</i>	25
<i>Dawro</i>	18
<i>Meinit</i>	65
<i>Bench</i>	35
<i>Sheko</i>	71
<i>Wolaita</i>	13
<i>Shinasha</i>	18
<i>Nuer</i>	21
<i>Majanger</i>	5
<i>Komo</i>	9
<i>Kefficho</i>	20
<i>Gamo</i>	13
<i>Gozamin</i>	93

Source: (Endashaw, 2007).

ethnobotanical documentation on most medicinal species in Ethiopia. The status of phytomedicine, preparation of crude extracts and isolation of active principles is very minimal. There are, however, differences in terms of prevalence of use of species over time; for instance, the use of *T. abyssinica* has now declined mainly because of over-harvesting and degradation of wild bush lands in Shewa and Tigray (Mesfin, 1991). To save indigenous knowledge from disappearing, the young generation has a very crucial role to play. The documentation and preparation of manuals, as a means to preserve local knowledge and experience must be encouraged before they disappear along with dissemination of information on appropriate cultivation methods for scarce medicinal plants in demand. The government also ensures the rights of people to use their traditional practices which are known for their proven safety and effectiveness (Tadesse et al., 2005; Flatie et al., 2009).

Accordingly, it is highly recommended to include in the school curriculum aspects of traditional medicine and medicinal plants. School children should be introduced to the vital role traditional medicine. They have to be instilled that traditional medicine is still valid and important and that medicinal plants have been sources of several important drugs and are still potential sources of more wonder drugs. In addition, students and pupils alike should be encouraged to ask and learn from their parents and community elders about the indigenous knowledge and the practice of traditional medicine (Endashaw, 2007).

MEDICINAL PLANTS MARKETING IN ETHIOPIA

Marketing of medicinal plants harvested from wild and semi-wild stands is not common. Expansion of agricultural land and lack of cultivation efforts by local

communities are mentioned by locals to affect the availability of medicinal plant resources (Berhane et al., 2014). The survey conducted by Alemayehu et al. (2015) in two markets of Minjar-Shenkora area showed that most of the medicinal plants are not widely traded for medicinal purposes, but mostly for other uses. Since the local people prefer either collecting these plants by themselves from the available areas (vegetation's) in the district, to prepare the medicines, or they prefer to go directly to the local healers to get treatments instead of buying the medicinal plants from the market. However, some of the medicinal plants (*Allium sativum*, *Artemisia absinthium* and *Foeniculum vulgare*,) are widely traded and used as spices and others (*Eucalyptus globulus* and *Olea europaea*) are used for firewood, construction, household tools and farming tools other than their medicinal uses.

According to Megersa et al. (2013), medicinal plants are not widely sold in the market. Similar results were reported by Etna (2007) and Berhane et al. (2014). Research studies conducted on marketing of medicinal plants in Ethiopia had provided different conclusions depending on the location of the studies. A market survey of medicinal plants in rural markets around Bahir Dar (North western Ethiopia) came up with no products entirely targeted for medicine but only a collection of food spices and plant products for cosmetics use including many products used as incense or fumigants or steam bath (Hareya, 2005), possibly due to inappropriate seasons for sampling since seasonal variation exists in the products sampled. Most of the local trade of open market is dominated by a few species including *Embelia Schimperi*, *Hagenia abyssinica*, and *Glinus lotides*. The export trade includes *Caltha edulis* and gums from various species of *Boswellia* and *Commiphora*; but these plants are known to be primarily traded for their non-

Table 7. Once purchase and sale price of the most common medicinal plants.

S/No	Species	Purchase price birr/kg	Sale price birr/kg
1	<i>Aloe spp</i>	2.13	27.5
2	<i>Carisa spinarum</i>	0.67	15.67
3	<i>Croton macrostachyus</i>	4.02	262.64
4	<i>Hagenia abyssinina</i>	7.85	47.78
5	<i>Myrsine africana</i>	12.71	35.62
6	<i>Osmium lamifolium</i>	1.11	90.29
7	<i>Rumex absyninica</i>	3.4	93.86

Source: (Berhane et al., 2014).

medicinal uses the former as stimulants or narcotics and the latter species for cosmetics and other industries. Survey on socioeconomic study of medicinal plants by Abdulhamid et al. (2004) compiled various uses of medicinal plants using local names in Bale. The plants include *Allium sativum*, *Ruta chalepensis*, *Zinger officinale*, *Nigella sativa*, and *Artemisia* spp. All these are cultivated plants and households have reported that many of them are maintained regularly at home.

Kloos et al. (1978) reported results from an interview-based survey in 19 markets of towns and villages distributed in the central plateau (including Addis Ababa) and rift valley covering 416 vendors and found that three taenicides: *Embelia Schimperi*, *Glinus lotiodes* and *Hagenia abyssinica* were the most frequently found species on sale WITH 241, 234 and 202 vendors respectively. The plants sold as medicine added to 41 species and these are common in markets to date. A market survey undertaken in Jimma, Bonga, Gambella and Addis Ababa in 1998 reported on some of the common medicinal plants and their trade routes within the country and to external markets indicating that there are no exports particularly for medicinal purposes (Dessalegn, 2001). Marshall (1998) also reported that Ethiopia had no legal export and import of products for medicinal use but plants of medicinal importance are exported to Djibouti and other countries as agricultural products (Table 7). Letchamo and Storck, (2006) conducted a research on medicinal plants marketed in Eastern, Central and Western Ethiopia and reported medicinal plant products that were offered in Dire Dawa, Jimma, Aggaro and Hossaina. For individuals in rural settlements, herbalist's clinics, village markets, town etc. are major retail outlets where people buy their plant medicines.

HEALTH AND ECONOMIC ROLE OF MEDICINAL PLANTS IN ETHIOPIA

Over the past 100 years, the development and mass production of chemically synthesized drugs have revolutionized health care in most parts of the world.

However, large sections of the population in developing countries still rely on traditional practitioners and herbal medicines for their primary care (Negero et al., 2015). Medicinal plants play a crucial role in health care needs of people around the world especially in developing countries (Bekalo et al., 2009). This is because modern health care has never been, and probably never will provide, adequate and equitable health service anywhere in Africa, and Ethiopia in particular, due to financial limitations related to rapid population growth and poor economic performance. Thus, medicinal plants continue to be in high demand in the health care system as compared to the modern medicine (Hunde et al., 2006). About 80% of the populations of most developing countries still depend on the utilization of traditional medicine obtained from plants (Cunningham, 1993). Medicinal plants also play a key role in the development and advancement of modern studies by serving as a starting point for the development of novelties in drugs (Pramono, 2002). Approximately 25% of drugs used in modern Pharmacopoeia are derived from plants (Schippman et al., 2002). It is widely accepted that more than 80% of drug substances are either directly derived from natural products or developed from a natural compound. And, in fact, around 50% of pharmaceuticals are derived from compounds first identified or isolated from herbs/plants (Negero et al., 2015). Thus, in Ethiopia, medicinal plants and knowledge of their use are culturally deep-rooted and contribute greatly to the health care of humans and livestock throughout the country.

An estimated 80 to 90 percent of Ethiopians use herbal medicine as a primary form of health care. Despite significant recent improvements in modern health care, many rural communities continue to have limited access to modern health care due to availability and affordability. It is widely acknowledged that the wisdom of both professional and lay healers in applying traditional medicine to support health and manage illness may be lost to future generations unless urgent efforts. Many medicines widely in use today incorporate ingredients from plants. Medicinal plants have greatly contributed to the development of modern medicines. In many developing countries such as Ethiopia, traditional medicinal plants are still commonly used in daily life and

play important roles as complements to underdeveloped modern health care services.

According to Berhane et al. (2014) herbalists' incomes obtained through giving treatments to local communities of Maale and Ari were not high; the most important aspect observed from traditional healers is local recognition and respect by the community and they also reported that on average they were consulted by patients five times per month. The charges for a treatment depended on the type of health problem treated and on patient/healers' relationships. Payment per treatment ranged from 1-10 Ethiopian Birr (equivalent to 0.05 - 0.5 \$) and sometimes were free of charge, especially in Maale area. However, in the Ari sites, traditional healers believed that whatever relation existed, the patient had to pay money for a consult; otherwise they underlined that the medicine would not be effective. Limited income obtained from marketing of medicinal plants or from treatments given to patients may have negative implications future cultivation, maintenance and conservation of medicinal plants in the landscape.

In Ethiopia the market for essential oils extracted from medicinal plants is very high and increasing in alarming rate from time to time. The country imported 1,596.5 tons of essential oils extracted from medicinal plants spending more than 30 million USD in the year 2011 from countries such as Ireland, Switzerland, South Africa, Spain, United Kingdom, Italy and Germany. The import trend of essential oils during the past 12 years has been consistently rising. The imported quantity which was 375.8 tons in the year 2000 has reached to 1,596.5 tons by the year 2011. The total increment in the past twelve years is more than fourfold, which is equal to an annual average growth rate of 14%, which is really a historic demand growth rate. It was estimated that the demand for essential oil extracted from medicinal plants is projected to reach 3,660 tons and 7,363 tons by the year 2017 and 2022, respectively, requiring a respective amount of 92 and 184 million USD annually. This suggests the existence of huge demand for essential oils locally and knocks the doors of investors to participate in the cultivation, processing and marketing of aromatic plants to get benefited from the sector (EIAR, 2006).

Cultivation of medicinal plants in Ethiopia has remained predominantly traditional over the centuries, being produced mainly by smallholder farmers operating on small plot of land around homestead and in natural forests. Most of the medicinal plants are perennials; their cultivation contributes positively for soil conservation. The processing of medicinal plants doesn't pollute the environment and production and processing of medicinal plants in agreement with green development policy of the government and are contributory to climate change adaptation and mitigation. Hence, the development of medicinal plants subsector has diverse benefits for the environment, additional income generation for the poor and small holder farmers, plays a significant role in import

substitution, contributes for agricultural diversification, for export promotion and creates valuable job opportunities for large number of people (EIAR, 2016). For persons involved in collecting and selling traditional medicinal plants, as well as in providing traditional medical services, these plants are often the most profitable commodity available. Hence, great potential exists for medicinal plants to contribute to economic development and poverty alleviation in Ethiopia. Moreover, appropriate management of these plant resources could contribute to efforts to conserve biodiversity and protect the environment.

The value of both imported and domestically produced pharmaceutical products were about ETB 1.05 billion. During the same year, the value of medicinal plants including traded and non-traded ones was ETB 423 million; making average health coverage by 42% of Ethiopian expenditure on pharmaceutical products. This is a significant saving in terms of foreign currency as well. The economic importance of the trade on medicinal plants was limited: the price of *Embelia shimperii* seeds was only 2 Ethiopian Birr (0.10 \$) per glass (about 250 ml). The product was not always available and marketed in small quantities.

Medicinal plants are widely documented to have a range of health benefits and cultivation can be beneficial to households and the wider community. Health and wealth from medicinal aromatic plants. For example, rosemary is used to treat headaches, poor circulation and as a natural breath freshener. Bay leaves can be made into an infusion to relieve flatulence and bloating and to help with arthritis. African basil (*Ocimum canum*) can be drunk as a refreshing tea and is used to treat diabetes, as an expectorant to clear throat and lungs, and as a mosquito repellent. Antioxidants are found in many spices and herbs which can contribute to the body's defense against cardiovascular disease and intestinal cancers. Roselle (*Hibiscus sabdariffa* L.) red calyces (based on 100 g dry weight) contain 6.4 % protein, 79.3 % carbohydrates, 5.1 % fat, 2.7 % crude fiber, and 6.5 % ash. Its leaves are emollient and are used in Guinea mostly as a diuretic, refrigerant and sedative and used to sour the curry or "dal" preparation in Bangladesh as well as the young leaves is used as a vegetable (JAICAF, 2008).

MAJOR THREATS TO MEDICINAL PLANTS AND ASSOCIATED INDIGENOUS KNOWLEDGE

Home based medicinal plants use relies on plants of the home garden, weeds and that grow wild around human habitation. The cultivated medicinal plants are mostly produced in home gardens, either for medicinal or rather primary purposes. Medicinal plants obtained from wild habitats are found in different natural ecosystems of the forests, grasslands, woodlands, wetlands etc. (Zemede,

1999). The demands of the majority of the people in developing countries for medicinal plants led to over exploitation of wild sources, environmental degradation, agricultural expansion, loss of forests and woodlands, over-harvesting. Consequently, many species are being extinct, threatened or endangered (Omobuwajo et al., 2008).

According to WHO (1986), 90% of plant materials used as medicinal plants are collected from the wild with parallel regeneration programs and as a result many medicinal plant species are driven to extinction or severe genetic loss. However, as observed by WHO (1986), detailed information is not available. When a population may suffer both from heterozygosity and allelic diversity loss and if such threats continue genetic drift can be avoided.

In general, studies in different parts of the country indicated that, medicinal plants were highly threatened by Environmental degradation, deforestation, agricultural expansion over exploitation and population growth is the principal threats to medicinal plants in Ethiopia (Ensermu et al., 1992; Zemedede, 2001; Balemie et al., 2004; Mesfin et al., 2009; Geday, 2001; Alemayehu et al., 2015; Birhanu and Ayalew 2018). Medicinal plants can have uses other than sources of medicines and threats from over harvesting, may be due to or partly due to their collection for purposes other than medicinal uses. Thus, as elsewhere in Africa, in most region of Ethiopia, Ethiopia's plant based traditional medicine is faced with problems of continuity and sustainability (Ensermu et al., 1992; Zemedede, 2001; Abebe, 2001; Balemie et al., 2004). In Ethiopia the traditional medicinal plants and its knowledge which is available in rural communities and perpetuated by word of mouth within families and the communities are fragile traditional skills that are likely to be lost when communities emigrate to towns or to other region with a different flora; and can also be lost by life style changes, by industrialization, rapid loss of natural habitats. Additionally, the expansion of modern health institutions, schools some environmental and cultural modifications were among the reasons for the loss of the knowledge on medicinal plants (Alemayehu et al., 2015).

The study conducted by Etana, (2006) to assess use and conservation of traditional medicinal plants by indigenous people in Gimbi Woreda, Western Wellega reported that several cultural beliefs and traditions were recorded as threatening factors. Sustainable use of medicinal plants has now grown to be a timely issue in Ethiopia because of resource degradation in the lowlands and highlands alike. Ecosystem conservation will ensure in-situ conservation of medicinal plants so as to apply sustainable harvesting methods for collecting medicinal plants from wild habitats.

In an ethnobotanical study conducted on medicinal plant species used to manage human ailments at Bale Mountains National Park, Southeastern Ethiopia, 56 ailments were reported to be managed using 101

different ethno medicinal plant species. Most medicinal plant species reported in this study were found to be under threat and this calls for urgent conservation measures so as to maximize the sustainable use of these vital resources in the study area (Yineger et al., 2008). This is due to those medicinal plants harvesting system and utilization system varied from culture to culture and from place to place. The medicinal plant preparation method and the indication for treating different diseases also varied from place to place based on the legendary knowledge. Many medicinal plants are also harvested for non-medicinal values such as for timber implements, fuel wood and other purposes and hence they are subjected to multiple pressures like *Hagenia abyssinica* (Bekele, 2007).

CONCLUSION

Medicinal plants play important roles in daily life in developing countries of Asia and Africa, including Ethiopia. Medicinal plants were used by human and animals to control and prevent disease for a long period of time; however cultivation practice of medicinal plants for medicinal purposes is not well organized. There is a wide variety of medicinal plants in Ethiopia in different agroecological areas. There is also a huge knowledge about the medicinal plants and their preparation by the different communities of Ethiopia. Medicinal plant harvesting systems and utilization systems varied from culture to culture and from place to place. The medicinal plant preparation method and the indication for treating different diseases also varied from place to place based on the legendary knowledge. Medicinal preparations of plants contain many ingredients such as powdered plant materials, extracts and purified active substances isolated from plant materials. The medicinal plant preparation and application are accomplished in various forms. Most commonly used routes of administration are oral, topical, and inhalational routes of administration.

The acquisition and transfer of indigenous knowledge on traditional medicine, in most developing countries including Ethiopia, is passed from one generation to the next by word of mouth/orally. Also vertically: from parents to children through oral means and is unevenly distributed among community members. To save indigenous knowledge from disappearing, the young generation has a very crucial role to play. The documentation and preparation of manual, as a means to preserve local knowledge and experience must be encouraged before they disappear along with dissemination of information on appropriate cultivation methods for scarce medicinal plants in demand. Traditional medicine has also contributed its own healing remedies, and more preferably can lead to new drug development. Majority of plant species and varieties used for food and medicine are conserved and managed at the

household level by women. Building the healthcare treatment knowledge of women would increase access to essential cost-effective rural healthcare services. Ethiopia has the potential to become an important source country, given the diversity of plants and the rich traditional knowledge regarding their use as medicine. Reports showed that the main sources of medicinal plants for utilizers are the wild forests. There is also cultivation practice of medicinal plants in home garden in different communities of Ethiopia.

About 80% of human and 90% of livestock population in Ethiopia depends on utilization of traditional medicines for primary health care on different types of health problems. The knowledge transfer about medicinal plants in Ethiopia is largely oral. Medicinal plants in Ethiopia were collected for the purpose of treating different kinds of human and animal illnesses. Most of the traditional medicinal plants were collected from the wild stands and leaves and roots were the most commonly used plant parts for traditional medicine preparations. Utilization of leaves for drug preparation is important for conservation of medicinal plants since harvesting leaves may not cause detrimental effect on the plants compared to the root or whole plant collections.

Medicinal plants play a crucial role in health care needs of people around the world especially in developing countries like Ethiopia. Because modern health care has never been and probably never will provide adequate and equitable health service anywhere in Africa, and Ethiopia in particular, due to financial limitations related to rapid population growth and poor economic performance. Despite significant recent improvements in modern health care, many rural communities continue to have limited access to modern health care due to availability and affordability. In Ethiopia the market for essential oils extracted from medicinal plants is very high and is increasing in an alarming rate from time to time. The country imported 1,596.5 tons of essential oils; spending more than 30 million USD in the year 2011 from different countries. Through increasing production potential and modernizing the sector of medicinal plants, they play a great role to substitute importing and exporting them. Great potential exists for medicinal plants to contribute to economic development and poverty alleviation in Ethiopia. Environmental degradation, deforestation, agricultural expansion over exploitation and population growth is the principal threats to medicinal plants in Ethiopia. In general, other areas to look into as regards medicinal plants are:

- (i) Increase cultivation of medicinal plants in home gardens and in farming land for large scale production
- (ii) Preserve local knowledge and experience before they disappear along with dissemination of information on appropriate cultivation methods, for scarce medicinal plants in demand.
- (iii) Establish sustainable harvesting practices in wild areas.

(iv) Establish optional harvesting techniques for cultivated plants.

(v) Provide training for traditional healers for improving their skill on cultivation and harvesting of medicinal plants

(vi) Identify genuinely effective medicinal plants and encourage their production and cultivation.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

- Abdulhamid BK, Belay S, Negatu W and Asmare A (2004). Survey Results. Socioeconomic study of medicinal plants. Institute of Developments Research, Addis Ababa University.
- Abebe D, Ayehu A (1993). Medicinal plants and enigmatic health practices of northern Ethiopia, BSPE, Addis Ababa. Ethiopian traditional medicine. Common medicinal plants in perspective, USA.
- Abebe D (2001). Biodiversity conservation of medicinal plants: Problem and prospects. In: Medhin Zewdu and Abebe Demissie, eds., Conservation and sustainable use of medicinal plants in Ethiopia. IBCR, Addis Ababa.
- Alemayehu G, Asfaw Z, Kelbessa E (2015). Ethnobotanical study of medicinal plants used by local communities of Minjar-Shenkora District, North Shewa Zone of Amhara Region, Ethiopia. *Journal of Medicinal Plants Studies* 3(6):1-11.
- Asmamaw D, Achamyeleh H (2018) Assessment of Medicinal Plants and Their Conservation Status in Case of Daligaw Kebela, Gozamen Werda, East Gojjam Zone. *Journal of Biodiversity, Bioprospecting and Development* 5(1):170.
- Asnake S, Teklehaymanot T, Hymete A, Erko B, Giday M (2016). Survey of medicinal plants used to treat malaria by Sidama People of Boricha District, Sidama Zone, South Region of Ethiopia. Evidence-Based Complementary and Alternative Medicine ID 9690164.
- Assefa A, Abebe T (2014). Ethnobotanical Study of Wild Medicinal Trees and Shrubs in Benna Tsemay District, Southern Ethiopia. *Journal of Science and Development* 2(1):1-17.
- B and M Development Consultants PLC (2001). Socioeconomic and biological survey on the medicinal plants in and around the Bale Mountains National Park, IBCR.
- Balemie K, Kelbessa E, Asfaw Z (2004). Indigenous medicinal plant utilization, management and threats in Fentalle area, Eastern Shewa, Ethiopia. *Ethiopian Journal of Biological Sciences* 3(1):37-58.
- Banjaw DT, Dikir W, Gebre A, Geja W, Tsegaye D (2016). Aromatic and Medicinal Plants in Wondogenet Agricultural Research Center Botanical Garden, South Ethiopia. *Medicinal and Aromatic Plants* 5:278.
- Bekalo TH, Woodmatas SD, Woldemariam ZA (2009). An ethnobotanical study of medicinal plants used by local people in the lowlands of Konta Special Woreda, Southern nations, nationalities and peoples regional state, Ethiopia. *Journal of Ethnobiology and Ethnomedicine* 5:26.
- Bekele E (2007). Study on Actual Situation of Medicinal Plants in Ethiopia. Available at: http://www.jaicaf.or.jp/publications/ethiopia_ac.pdf.
- Belayneh Z, AsfawSD, Bussa NF (2012). "Medicinal plants potential and use by pastoral and agro-pastoral communities in Erer Valley of Babile Wereda, Eastern Ethiopia." *Journal of Ethnobiology and Ethnomedicine* 8:42.
- Birhanu A, Ayalew S (2018). Indigenous knowledge on medicinal plants used in and around Robe Town, Bale Zone, Oromia Region, Southeast Ethiopia. *Journal of Medicinal Plants Research* 12(16):194-202.
- Berhane K, Tinde A, Laurentius J, Gerardus M, Zemedu A (2014). Use and management of traditional medicinal plants by Maale and Ari ethnic communities in southern Ethiopia. *Journal of Ethnobiology and*

- Ethnomedicine 10:46.
- Cunningham AB (1993). African Medicinal Plants: Setting Priorities at the interface between Conservation and Primary Healthcare. People and Plants Working Paper. Paris.
- Dawit A (1986). Traditional medicine in Ethiopia: The Attempts being made to promote it for effective and better Utilization. SINET Ethiopian Journal of Science pp. 62-69.
- Debella A, Abebe D, Mudie KA Tadele A, Gebreegziabher A (2008). Qualitative laboratory analysis for the detection of conventional drugs in herbal preparations supplied by healers in major towns of Ethiopia. Ethiopian Journal of Health Development 22:55-62.
- Desta B (1988). Ethiopian traditional herbal drugs potentiality and appropriate utilization pp. 763-765, In the proceedings of the 8th International Conference of Ethiopian Studies Vol. 1, IES, AAU.
- Edwards S (2001). The ecology and conservation status of medicinal plants on Ethiopia. In: Medhin Z, Abebe D (eds.) Conservation and Sustainable use of medicinal plants in Ethiopia, Proceedings of National Workshop on Biodiversity Conservation and Sustainable use of medicinal plants in Ethiopia, Institute of Biodiversity Conservation and Research, Addis Ababa.
- Ethiopian Institute of Agricultural Research (EIAR) (2016). Medicinal and Aromatic Plants Research Strategy. 2016-2030. Available at: <http://www.eiar.gov.et>.
- Endashaw B (2007). Study on Actual Situation of Medicinal Plants in Ethiopia. Japan Association for International Collaboration of Agriculture and Forestry. Available at: http://www.jaicaf.or.jp/publications/ethiopia_ac.pdf
- Ensermu K, Sebsebe D, Zerihun W, Edwards S (1992). Some threatened endemic plants of Ethiopia. In Sue E, Zemed A (eds.). The status of some plant resources in parts of tropical Africa Botany 2000 East and Central Africa NAPRECA Monograph Series No. 2:35-55.
- Ermias L (2005). Ethnobotanical study of medicinal plants floristic composition of Manna Angetu Moist Montane Forest, Bale, Ethiopia. MSc Thesis. Department of Biology, Addis Ababa University.
- Etana T (2006). Use and Conservation of Traditional Medicinal Plants by Indigenous People in Gimbi Woreda, Western Wellega, M.Sc. Thesis. Addis Ababa University, Addis Ababa.
- Fassil H (2005). Beyond plants, professionals and parchments. The role of home-based medicinal plant use and traditional health knowledge in primary healthcare in Ethiopia. Ethnobotany Research and Applications 3:037-049.
- Flatie T, Gedif T, Asres K, Gebre-Mariam T (2009). Ethnomedical survey of Berta ethnic group Assosa Zone, Benishangul-Gumuz regional state, mid-west Ethiopia. Journal of Ethnobiology and Ethnomedicine 5:14.
- Fullas F (2001). Ethiopian traditional medicine. Common medicinal plants in perspective. USA.
- Giday M (2001). An ethnobotanical study of medicinal plants used by the Zay People in Ethiopia. Skriftserie 3:81-99.
- Giday M (2001). An ethnobotanical study of medicinal plants used by the Zay people in Ethiopia. CBM: Skriftserie 3:81-99.
- Gidey M, Asfaw Z, Woldu Z, Teklehaymanot T (2009). Medicinal plant knowledge of the Bench ethnic group of Ethiopia: Ethnobotanical investigation. Journal of Ethnobiology and Ethnomedicine 5:34.
- Haile Y (2005). A study of Ethnobotany of Medicinal plants and Floristic Composition of the Dry Afromontane Forest at Bale Mountains National Park. M.Sc. Thesis. Addis Ababa, Ethiopia.
- Hareya F (2005). Beyond plants, professionals and parchments. The role of home-based medicinal plant use and traditional health knowledge in primary healthcare in Ethiopia. Ethnobotany Research and Applications 3:037-049.
- Hunde D, Asfaw Z, Kelbessa E (2006). Use of Traditional Medicinal Plants by People of 'Boosat' Sub District, Central Eastern Ethiopia. Ethiopian Journal of Health Sciences 16(2):141-155.
- Hunde D, Zemed A, Ensermu K (2004). Use and Management of Ethnoveterinary Medicinal Plants By Indigenous People of 'Boosat', Welenchiti Area. Ethiopian Journal of Biological Sciences 3(2):113-132.
- Hunde D (2001). Use and Management of Traditional Medicinal Plants by Indigenous People of Boosat Woreda, Wolenchiti Area: An Ethnobotanical Approach. MSc Thesis, Addis Ababa University.
- Japan Association for International Collaboration of Agriculture and Forestry (JAICAF) (2008). "Medicinal crops" in Ethiopia Current status and future potentials. Japan Association for International Collaboration of Agriculture and Forestry. Available at: http://www.jaicaf.or.jp/publications/ethiopia_en.pdf.
- Kassaye KD, Amberbir A, Gatchew B, Mussema Y (2006). A historical overview of traditional medicine practices and policy in Ethiopia. Ethiopian Journal of Health Development 20:127-134.
- Kebede Y (2010). How far have we gone in understanding traditional medicine in Ethiopia? Ethiopian Journal of Health Sciences 2.
- Koehn FE, Carter GT (2005). "The evolving role of natural products in drug discovery," Nature Reviews Drug Discovery 4(3):206-220.
- Kloos H, Tekle A, Yohannes L, Yosef A, Lemma A (1978). Preliminary studies of traditional medicinal plants in nineteen markets in Ethiopia. Ethiopian Medical Journal 16:33-43.
- Limenih Y, Umer S, Wolde-Mariam M (2015). Ethnobotanical study on traditional medicinal plants in Dega damot woreda, Amhara region, North Ethiopia. International Journal of Pharmaceutical Chemistry 5:258-273.
- Marshall NT (1998). Searching for a cure, conservation of medicinal wildlife resources in East and Southern Africa. TRAFFIV network report.
- Martin GJ (1995). Ethnobotany: A method Manual. Chapman and Hall, London pp. 265-270.
- Megersa M, Asfaw Z, Kelbessa E, Beyene A, Woldeab B (2013). An ethnobotanical study of medicinal plants in Wayu Tuka District, East Welega Zone of Oromia Regional State, West Ethiopia. Journal of Ethnobiology and Ethnomedicine 9:68.
- Mekonnen B (1990). Attitudes modern and traditional medical practitioners towards cooperation. Ethiopian Medical Journal 28:63-72.
- Mesfin K, Tekle G, Tesfay T (2013). Ethnobotanical study of traditional medicinal plants used by indigenous people of Gemad District, Northern Ethiopia. Journal of Medicinal Plants Studies 1(4):32-37.
- Mesfin F, Demissew S, Teklehaymanot T (2009). An ethnobotanical study of medicinal plants in Wonago Woreda, SNNPR, Ethiopia. Journal of Ethnobiology and Ethnomedicine 5:28.
- Mirutse G, Gobana A (2003). An Ethnobotanical Survey on Plants of Veterinary Importance in Two Woredas of Southern Tigray, Northern Ethiopia. SINET: Ethiopian Journal of Science 26(2):123-136.
- National Herbarium (2004). Biodiversity assessment of the Bale Mountains National Park and surrounding areas. Conservation and Sustainable Use of Medicinal Plants Project.
- Negero G, Ashenif T, Biruktawit G, Frehiwot T (2015). Proceeding of the Workshop on "Ethiopian Traditional Medicine: Past, Current and Future". Adama, Ethiopia.
- Nigussie A, Yikal B, Mulugeta F, Addisu A, Gashaw A (2018). Use and Conservation of Medicinal Plants by Indigenous People of Gozamin Wereda, East Gojjam Zone of Amhara Region, Ethiopia: An Ethnobotanical Approach Evidence-Based. <https://doi.org/10.1155/2018/2973513>.
- Omobuwajo OR, Alade GO, Sowemimo A (2008). Indigenous Knowledge and practices of women herb sellers of Southwestern. Nigeria. Indian Journal of Traditional Knowledge 7(3):505-510.
- Pankhurst R (2001). The status and Availability of oral and written knowledge on traditional health care in Ethiopia. In Proceedings of the National Workshop on Biodiversity Conservation and Sustainable Use of Medicinal Plants in Ethiopia Addis Ababa: IBCR: 92-106.
- Pramono E (2002). The Commercial use of Traditional knowledge and Medicinal Plants in Indonesia. Multi-stakeholder Dialogue on Trade, Intellectual Property and Biological Resources in Asia, BRAC Rajendrapur, Bangladesh pp. 1-13.
- Regassa R (2013). Assessment of indigenous knowledge of medicinal plant practice and mode of service delivery in Hawassa city, southern Ethiopia Journal of Medicinal Plants Research 7(9):517-535.
- Reta R (2013). Assessment of indigenous knowledge of medicinal plant practice and mode of service delivery in Hawassa city, Southern Ethiopia," Journal of Medicinal Plants Research 7(9):517-535.
- Robinson MM, Zhang X (2011). Traditional Medicines: Global Situation, Issues and Challenges. The World Medicines Situation, WHO, Geneva, Switzerland, 3rd ed.
- Samuel MW, Leul LA, Belaynew WT, Laychiluh BM (2015). Knowledge,

- Attitude, and Utilization of Traditional Medicine among the Communities of Merawi Town, Northwest Ethiopia: A Cross-Sectional Study. Evidence-Based Complementary and Alternative Medicine <http://dx.doi.org/10.1155/2015/138073>
- Schippman U, Leaman DG, Cunningham AB (2002). The impacts of cultivation and gathering of medicinal plants of biodiversity. Global trends and issues, (In) Biodiversity and Ecosystem. Approaches in Agriculture, forestry, and fisheries. 9th regular sessions of the commission on Genetic Resources for food and Agriculture. FAO Rome, Italy pp. 1-21.
- Seta T, Demissew S, Asfaw Z (2013). Home gardens of Wolayta, Southern Ethiopia: An ethnobotanical profile. *Academia Journal of Medicinal Plants* 1(1):014-030.
- Singhal R (2005). Medicinal Plants and Primary Health Care: The Role of Gender *Journal of Health Management* 7:2 DOI: 10.1177/097206340500700208.
- Sofowora A (1993). Medicinal plants and traditional medicine in Africa. 2nd ed. Spectrum Books.
- Tadesse M, Hunde D, Getachew Y (2005). Survey of Medicinal Plants Used to Treat Human Diseases in Seka Chekorsa, Jimma Zone, Ethiopia. *Ethiopian Journal of Health Sciences* 15(2):89-107.
- Tesfaye A, Sebsebe D (2009). Ethnobotanical study of medicinal plants in Kafficho people, southwestern Ethiopia. Proceedings of the 16th International Conference of Ethiopian Studies. Available at: <http://portal.svt.ntnu.no/sites/ices16/Proceedings/Volume%203/Tesfaye%20Awas%20and%20Sebsebe%20Demissew%20-%20Ethnobotanical%20study.pdf>
- Thulin M (2004). Horn of Africa. In: Hotspots Revisited Earth's biologically richest and most endangered terrestrial ecoregions (eds. Russell AM, Patricio RG, Michael H, John P, Thomas B, CGM, John L, Da Fonseca GAB).
- United Nations Environment Programme (UNEP) (1995). Global biodiversity assessment. United Nations Environment Programme.
- Wondimu T, Asfaw Z, Kelbessa E (2007). Ethnobotanical study of medicinal plants around Dheera town. *Journal of Ethnopharmacology* 112(1):152-161.
- World Health Organization (WHO) (1986). Guide Lines on the Conservation of medicinal plants, WHO/IUCN, Gland Switzerland, and Geneva, Switzerland.
- World Health Organization (WHO) (2002). Traditional medicine strategy 2002–2005. Geneva, World Health Organization, (WHO/EDM/TRM/2002.1). Available at: apps.who.int/medicinedocs/en/d/Js2297e/.
- Yineger H, Kelbessa E, Bekele T, Lulekal E (2008). Plants used in traditional management of human ailments at Bale Mountains National Park, Southeastern Ethiopia. *Journal of Medicinal Plants Research* 2(6):132-153.
- Yirga G, Teferi M, Kasaye M (2011). Survey of medicinal plants used to treat human ailments in Hawzen district, Northern Ethiopia. *International Journal of Biodiversity and Conservation* 3(13):709-714.
- Yirga G (2010). Assessment of indigenous knowledge of medicinal plants in Central Zone of Tigray, Northern Ethiopia. *African Journal of Plant Science* 4(1):6-11.
- Zemed A (2001). The role of home gardens in production and conservation of medicinal plants. In: Conservation and Sustainable Use of Medicinal Plants in Ethiopia, Proceeding of The National Work Shop on Biodiversity and Sustainable use of Medicinal Plants In Ethiopia, Medhin Zewdu and Abebe Demissei, (eds). Institute of Biodiversity Conservation and Research, Addis Ababa pp. 76-91.
- Zemed A (1999). Ethnobotany of Nations Nationalities and Peoples in Gabella. benishagul-Gumuz and Southern regions of Ethiopia (A research Report submitted to the Research and Publications Office of Addis Ababa University, Addis Ababa P 172.
- Zenebe G, Zerihun M, Solomon Z (2012). An Ethnobotanical Study of Medicinal Plants in Asgede Tsimbila District, Northwestern Tigray, Northern Ethiopia. Available at: www.ethnobotanyjournal.org/vol10/i1547-3465-10-305.pdf
- Zerabruk S, Yirga G (2011). Traditional knowledge of medicinal plants in Gindeberet district, Western Ethiopia. *South African Journal of Botany* 78:165–169. www.elsevier.com/locate/sajb.
- Zewdu B (2013). Traditional Use of Medicinal Plants by the Ethnic Groups of Gondar Zuria District, North-western Ethiopia. *Journal of Natural Remedies* 13(1).

Full Length Research Paper

Impacts of human activities on wildlife: The case of Nile Lechwe (*Kobus megaceros*) Gambella National Park, Southwest Ethiopia

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Assessing human-induced threatening factors to wildlife is the basis in determining and proposing appropriate conservation measures. The present study was conducted to assess impacts of human activities on wildlife in Gambella National Park, Southwest of Ethiopia, from October 2015 to March 2016, focusing on the case of Nile Lechwe (*Kobus megaceros*). The data in this study were gathered using questionnaires with structured interview and focus group discussion. Data on the threatening factors were compared among villages using chi-square test in SPSS version 20 software. Out of the 384 respondents, 139(36.2), 51(13.2) 49(12.8), 43(11.2) and 41(10.7%) of them informed that agricultural investment, illegal hunting, overgrazing, rice cultivation in the area and habitat loss, respectively, were the most predominant human factors affecting Nile Lechwe. Thus suggests that agricultural expansion and illegal hunting are those human activities with the highest impact on the Nile Lechwe. Before designing and implementing any development investment particularly large scale agricultural expansions, the government and other stakeholders should give consideration and attention to the rapidly declining natural resource beside to the development. Therefore, designing appropriate eco-friendly management with options must be adopted to mediate the effects and minimize future impacts.

Key words: Agriculture, anthropogenic disturbance, habitats, Nile Lechwe, Gambella National park, wildlife.

INTRODUCTION

The impacts of human-induced factors on wildlife need to be understood and has become the controversial issue

and globally recognized (Vitousek et al., 1997). Similarly, the imbalance between the needs of human and the

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needs of wildlife population in basic life supporting systems of the biological environment which have always been resulted in conflict between human and wildlife that affect the lives of both counterparts. Despite the efforts made to conserve biological diversities, our natural ecosystems have been exposed to change significantly by humans at some point in human history (Turner et al., 1990). As a result, biodiversity conservation is achieved through eco-friendly traditional human cultural practices and beliefs (Wuver and Attuquayefio, 2006).

Nowadays, the increase in human population, besides to the question of the better life through improvements in science and technology, the global biodiversity has become easy targets for human over-exploitation. This situation is an indication that global biodiversity is being exploited at an alarming rate than ever before with negative implications for sustainable human livelihood (Mamo and Bekele, 2011). Consequently, it has been suggested that biodiversity is facing a decline of crisis proportions which could ultimately lead to mass extinctions in the very near future. In Ethiopia, increasing evidence indicates that the rate of environmental degradation has increased in recent times, with previously rich forests being converted to arable agriculture and existing lands converted into near desert (Andren, 1994). It has been estimated that forest cover in the country was approximately 40% of the country's total landmass a century ago, but now has shrunken to only 3% (Berry, 2003; Adugnaw, 2014).

To undergo effective conservation measure of wildlife it is very important to understand the interaction among human, wildlife, wildlife and their habitats. Human factors such as illegal hunting, large scale agricultural investment, encroachments of human and livestock particularly the buffer zone of the protected area, result in negative interaction between the wildlife and peoples that reside near the protected area. This situation occurred in the present study area where there are different large scale agricultural investments even when crossing the protected area. Another very important issue in wildlife conservation practice is, understanding the policies existed in a country besides the anthropogenic factors. Weak enforcement of polices and strategies has a negative impacts on natural resource. In Ethiopia, although, there had been conservation attempts since long before, the implementation of wildlife policy is typically underestimated. In addition, several of Ethiopia's protected areas including Gambella National park exist on paper only, while others have declined in size or quality (Schloeder, 1999). The majority of conservation problems, however, can be attributed to Ethiopia's adoption and implementation of an exclusionary

protected area policy and to the causes and consequences of its prolonged engagement in different conflicts.

The Ethiopian Government has designed major developmental activities during the last decade in different regions of the country including Gambella. Such activities, especially large scale agricultural practices, have caused drastic changes in the natural environment in the country. As a result, the natural resources of the country have been depleted alarmingly for over two decades. Such act of leasing lands to private investors for development activities should be encouraged, as it is important for the development and wellbeing of the nation. However, if appropriate environmental impact assessment is not well conducted and risk minimizing strategies are not developed accordingly, it will have tremendous adverse impacts on the wildlife and their habitat (Mann and Smaller, 2010; Mohammed and Afework, 2014). Hence, taking proper care and controlling and managing the activities are mandatory for protection of wildlife and their habitats.

Gambella is one of the regions in Ethiopia where intensive agricultural investments are currently expanding. These investment activities involve conversion of virgin lands to cultivation fields, in which most the sites are concentrated around the Gambella National Park (GNP). As a result, recent observations indicate that extensive wildlife poaching, human and livestock population pressure, and inappropriate land use policy accompanied by extensive investments have resulted in massive destruction of wildlife habitat and severe wildlife population decline in the region (Biodiversity Indicators Development National Task Force [BIDNTF], 2010). Thus, to practice effective conservation of wildlife in the area, it is important to understand existing interactions among human, wildlife, and wildlife habitats. Human factors such as illegal hunting and land use change through agricultural activities, and encroachments of human and livestock in and around protected areas, results to negative interactions between wildlife and local people. Gambella National Park, in the western Ethiopia, is one of the areas where such situations are occurring currently; the extent of large-scale agricultural investment areas, even some of them extending inside the boarder of the park.

GNP was established as a protected area in 1973 to conserve a diverse assemblage of wildlife and unique habitats (EWCA, 2014). Among the key wildlife species protected in the GNP is Nile Lechwe (*Kobus megaceros*), which is uniquely adapted to the wetland habits, including, swamps and marshes. In the National Park, Lechwes inhabit is almost exclusively the flood plains of

Alwero wetlands. The source of this swamp is the Alwero river which is also highly utilized by the large-scale rice cultivation in the area (Rolkier, 2015). This unregulated river water diversion lead to decline in the extent and productivity of the wetland ecosystem, ultimately affecting Nile Lechwes and their habitat.

Furthermore, human and livestock encroachment in the park has been increasing, which is due to weak enforcement of existing wildlife policies. Therefore, improved understanding on the effects of such anthropogenic disturbance to wildlife is needed to guide decision making and mitigate both the threats and their ecological impacts. Hence, the present study was designed to assess the effect of such human activities on wildlife in the Gambella National Park, with special emphasis to Nile Lechwe (*K. megaceros*).

MATERIALS AND METHODS

Description of the study area

In 1944, further legislation was passed to regulate hunting of wildlife and ensure that certain species were not over hunted (Hillman, 1993). Currently the Federal Government of Ethiopia established different protected areas particularly national parks in different regions of the country to conserve wildlife species. One of these parks is Gambella National Park which primarily established to conserve diverse wildlife and their habitats (Figure 1).

Gambella National Park is located at 850 km west of Addis Ababa. It was established as a protected area in 1973 to conserve a diverse assemblage of wildlife and unique habitats. Its location is between 33°45' to 34°15'E and 07°30' to 08°15'N at the west part of Gambella town, in the Gambella National Regional State. The park is located in the centre of Gambella Regional state between the rivers of Baro and Gilo (EWCA, 2014).

The Park is characterized by heavy rainfall during the wet season (May to October) and very little precipitation during the dry season (November to April). The mean annual rainfall of the park is 1400 mm. The mean annual temperature is 27°C but the mean monthly temperature varies significantly. The absolute maximum temperature of 45°C has been recorded in mid-March while the absolute minimum temperature of 10.3°C has been recorded in December (CSG, 2000).

Sample size determination

Since the estimated population around the National Park would be beyond 10,000, hence, by the assumption of normal distribution the sample size was determined as follow:

$$n = \frac{n_0}{1 + \frac{n_0}{N}}$$

Where:

$$n_0 = \frac{Z_{\alpha/2}^2 pq}{d^2}$$

Where: n = sample size; d= margin of error N = total number of house heads near the national parks;
p= proportion of population α = level of significance Z= Score of normal distribution Q = 1-P;
d = 0.05p = 0.5α=0.05.

$$n_0 = \frac{(1.96)^2 \times 0.5 \times 0.5}{0.05^2} = 384$$

Data collection

Data for this study was collected from October to March 2015/16 which involved a sample of 384 local people that include dwellers of six villages, found in the study area (Pochalla, Pokedi and Ollaw from Agnua village and Puldiang, Mun and Gir from Nuer village) and the Gambella National Park staffs. Questioner survey, structured interview and focus group discussion (FGD) were used to collect data. Structured question were administered to members of the household on a random manner (Kumssa and Bekele, 2013). In the household survey, questioner was distributed to the respondents and training was provided for the data collectors prior to data collection. Focus group discussion was held to appropriately clarify validate information obtained through interview. One FGD was conducted in each sampled villages. The group size in each discussion varied from 10 to 15 people.

The questions used for interview and focus group discussion were mostly open-ended which included major human activities that affect wildlife and their habitats in the area, benefits and disadvantages of agricultural investment to the local community, the presence and method of hunting and its impact on wildlife. Finally, they were asked if current Government policies have affected the Nile Lechwe and their habitats in the study area.

Data analysis

Responses to each question were coded priori to analysis. SPSS statistical package (software) version 20 was used to analyze the data. Results expressed in percentage and, for some variables, chi-square test was used to examine whether responses respondents from the six villages were significantly different. Data obtained from focus group discussion was analyzed through content analysis method (Field, 2000).

RESULTS

Socio-demographic characteristics of the respondents

The socio-demographic characteristics of the respondents were summarized and depicted on Table 1. Accordingly, the majority of respondents (252, or 66% of

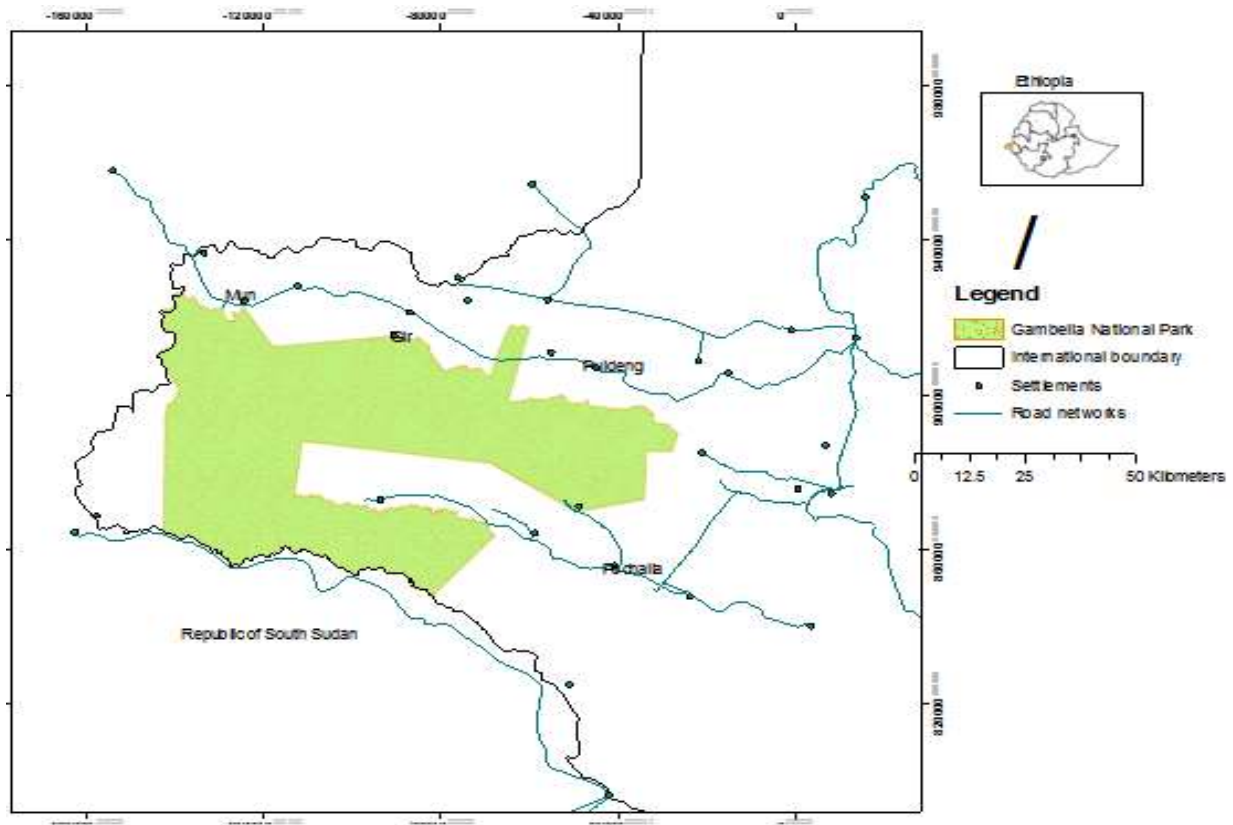


Figure 1. Map of the study area (Source: Extracted from Ethio- GIS).

Table 1. Socio-demographic information of respondents adjacent to Gambella National Park, Southwest of Ethiopia from October 2015 to March 2016.

Category	Frequency	Percent (%)
a) Gender		
Male	252	65.6
Female	132	34.4
Total	384	100
b) Ages in years		
18-27	162	42.2
28-37	83	21.6
38-47	75	19.5
48-57	40	10.4
Above 57	24	6.3
Total	384	100
c) Education level		
Illiteracy	325	84.6

Primary school	37	9.6
Secondary school	16	4.2
Above secondary school	6	1.6
Total	384	100
d) Income source		
Agriculture	217	56.5
Fishing	61	15.9
Employment	27	7
Hunting	35	9.1
Charcoal Making	24	6.3
Livestock keeping	20	5.2
Total	384	100

the total) were males, in the younger age group (i.e. 18 to 27 years old; 42%) and illiterate (85%). The mode of livelihood for most of them (57%) is agriculture, followed by fishing (16%) (Table 1).

Table 2. Habitats and population status (in the last decade) of Nile Lechwe in the study area, Southwest of Ethiopia.

Category	Frequency	Percent
a) Habitats		
Gambella National Park	206	53.6
Baro river basin	12	3.1
Alwero wetland	161	41.9
others	5	1.3
Total	384	100.0
b) Population status		
Decreasing	311	81.0
Increasing	15	3.9
Can't estimate	57	14.8
Stable	1	0.3
Total	384	100.0

Table 3. Factors reported by the respondents that contributed to the decrease in population and habitats of Nile Lechwe in the study area.

Factors	Frequency	Percent
Large scale Agriculture	139	36.2
Illegal hunting	51	13.2
Overgrazing	49	12.8
Habitat loss	41	10.7
Bush fire	23	6.0
Reduced of Alwero river for irrigation	38	9.9
Rice cultivation in the area	43	11.2
Total	384	100.0

Habitat and population status of Nile Lechwe in the study area

Most respondents indicated that preferred habitats of the Nile Lechwe in the study area are Gambella National Park followed by Alwero wetland. Perceptions of the respondents towards trends in population status of the Nile Lechwe within the year 2005 to 2015 indicate that 311(81%) of the respondents responded in decreasing trend (Table 2).

Factors affecting population and habitats of Nile Lichewe in the area

According to the responses of the respondents, the most anthropogenic factor adversely affect habitats and

population of Nile Lichwe in Gambella which is a large scale agricultural investments (36%), followed by illegal hunting/poaching (13%) and livestock overgrazing (13%) (Table 3).

Of the 64 respondents interviewed in each of the six villages in the study area, 94 to 97% of them pointed out that agricultural investment (both small and large scale) have affected both population of the species and its habitats in the study area (Table 4). This result also indicated that, all villages have similar perception ($\chi^2 = 2.133$, $df = 5$, $P = 0.830$).

The present study also assessed the major source of fuel wood consumption in the study area. Source of fuel wood consumption in the study was significant ($p=0.004$) and most of the respondents replied that, they obtained fuel wood by harvesting from wild 268(69.8%) followed by collecting from farm after burning 78(20.3%) (Table 5).

Table 4. The presence and impact of Agricultural investment on Nile Lechwe in the study area.

Response	Villages						Total
	Pokeddi	Puchalla	Olaw	Gir	Puldiang	Mun	
yes	62	60	61	59	59	59	360
no	2	4	3	5	5	5	24
Total	64	64	64	64	64	64	384

$\chi^2 = 0.837$ df = 5 P-value 0.008.

Table 5. Sources of fuel wood in the study area.

Source of fuel wood	Villages						Total
	Pokeddi	Puchalla	Olaw	Gir	Pudiang	Mun	
Harvesting from wild	50	48	47	45	35	43	268
Buying from market	5	9	9	8	3	2	36
Collecting from farm after Burning	9	7	8	11	26	17	78
Others	0	0	0	0	0	2	2
Total	64	64	64	64	64	64	384

$\chi^2 = 41.626$ df = 15 p-value 0.004.

Table 6. Hunted animals in the study area.

Species	Frequency	Percent
Nile Lechwe	191	49.7
African elephant	57	14.8
White ear kob	47	12.2
Bush Buck	39	10.2
Primates	16	4.2
Others	34	8.9
Total	384	100.0

Regarding hunting as threat to Lichwes, half of the respondents indicated that Nile Lichwe the most frequently hunted animal species in the area is followed by the African elephant (as reported by 57(15%) of the respondents (Table 6).

However, the respondents further indicated that hunting, including Lichwe, is practiced as primary economic activities (Table 7), with similar frequency of responses among the study villages ($\chi^2 = 7.696$, df = 5, P = 0.174). Over half (56%) of the respondent mentioned that people use gunshot for hunting (Table 8), with significant difference among villages ($\chi^2 = 25.071$, df = 10, P < 0.05).

RESULTS

Similar to the individual Respondents, about three fourth of the discussant replied that the most devastating human factors to wildlife in the study area were hunting, overgrazing, wildfire, fish hunting, agricultural expansion and habitat loss in order of importance. On the other hand, the most predominant human factors particularly to the population of Nile Lechwe were large scale agricultural expansion in and around the Gambella national park, irrigation for rice cultivation, illegal hunting, overgrazing, charcoal making, wildfire in order of importance in the study area. Moreover, they had

Table 7. Hunting activities across the study villages adjacent to Gambella National Park, Southwest of Ethiopia.

Hunting as an activity	Villages						Total
	Pokeddi	Puchalla	Olaw	Gir	Puldiang	Mun	
Primary activity	10	5	7	14	6	7	49
Secondary activity	54	59	57	50	58	57	335
Total	64	64	64	64	64	64	384

$$\chi^2 = 38.242 \text{ df} = 5 \text{ P} = 0.000.$$

Table 8. Hunting tools adjacent to Gambella National Park, Southwest of Ethiopia.

Hunting tools	Villages						Total
	Pokeddi	Puchalla	Olaw	Gir	Puldiang	Mun	
Shotgun	30	34	30	46	40	35	215
Locally manufactured trap	12	10	18	7	17	18	82
Spear	22	20	16	11	7	11	87
Total	64	64	64	64	64	64	384

informed that the presence of agricultural investment in their locality did not benefit the local people except some employment opportunities, rather this investment activity exploit the natural resource of the area in turn affect the population of wildlife and their habitats.

The village of Pokedi serves as an example of the consequences of Saudi Star's operations. Domestic investors are encroaching on land to its north side while Saudi Star has cleared the land to its south. The damming of the Alwero river will affect the village's local industry just as it receives a population influx from relocated communities. Combined with ongoing raids by neighboring tribes, Pokedi's economic and social future looks bleak.

Almost all the discussant responded that illegal hunting is common in the study area even there were professional hunters whose livelihood mainly relies on hunting and are both individual and group hunters. The majority of hunters use the shotgun for hunting. This is a good indication that, illegal hunting is one of the most anthropogenic factors which affect the wildlife in the study area.

Regarding the effects of government investment policies on the Nile Lechwes and their habitats, one third of the discussants revealed that though the policy dictates, investment activities are sometimes undertaken without considering the side effect of the investment on the environment and the surrounding local communities and even without creating awareness among the local

communities.

Besides they also indicated that the government and other stake holders should create awareness and if possible provide alternative means of income generation to tackle the situation present in the study area.

DISCUSSION

The present study identified that, most predominant human activities which affect wildlife and their habitat in the study area were large scale agricultural expansion, illegal hunting, overgrazing, habitat loss, rice cultivation in the area and bush fire. Similar findings were reported in different corners of Ethiopia (Stephens et al., 2001; Mamo and Bekele, 2014; Tadesse and Kotler 2013) and by Kiringe and Okello (2007) in Kenya in which the major threats to protected area biodiversity were illegal killing of wildlife for bush meat and recent agricultural expansion and other incompatible land use changes.

Large scale Agricultural expansion is the most anthropogenic factor recorded in the present study particularly for Nile Lechwe because large scale rice cultivation resulted in the reduction of the wetland. The Ethiopian Wildlife Conservation Authority (EWCA) estimates that some 438,000 ha of land have been awarded to investors, in early 2008 in the vicinity of the Gambella National Park, all without carrying out Environmental Impact Assessments. Wetlands, with

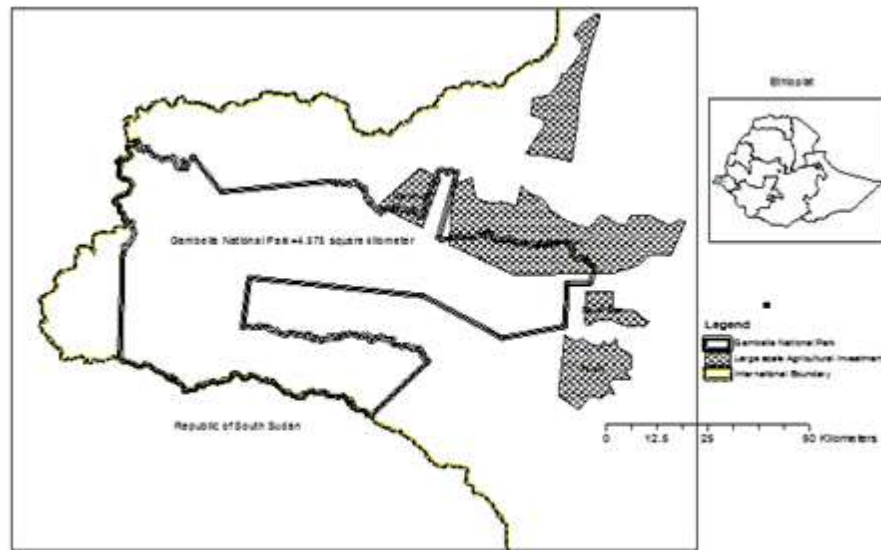


Figure. 2 Large scale agricultural investment in the buffer zone of Gambella national park.

abundant fish populations and birdlife are presently being converted to rice production while extensive forest cover in nearby areas has been completely cleared. The present findings revealed that more than 93% of the respondents replied that the presence of agricultural investment in the study area affected both the habitat and the population of Nile Lechwe.

Figure 2 revealed that the large scale agricultural investment in the buffer zone of Gambella national park tried to engulf the park itself. The finding indicated that the major threat which encountered wildlife by humans were agricultural expansions and illegal hunting. As advocated in the study, the agricultural expansions were due to the large scale agricultural organization at the adjacent part of the national park in the area. Populations of the study area are more of small holder and agro pastoralist which have little experience in agricultural practiced as compared to the highland parts of Ethiopia besides, among six study villages with highest agricultural expansion as indicated in Pokedi village found around Alowero swampy area, which is the key area where Nile Lechwe (*K. megaceros*) is found (Rolkier, 2015). Since Nile Lechwe is a non-migratory and wetland lover antelope, its population has been declining in the meantime.

Hunting for harvesting of bush meat for food and other purpose is one of the foremost issues confronting the management of the protected areas and life in the communities adjacent to the national park. As most this

hunting is illegal, the actors are involved to face a continuous threat of adverse reactions. At the same time, hunting for subsistence and to some extent commercial reasons is a historically important activity to the communities with salient cultural and social dimensions in addition to the direct benefits of providing food or other income for survival reasons. In the present finding from the focus group discussion a clear majority of the discussants reported that, hunting is an important activity in their village. The Findings of the present study also revealed that, more than 12% of the respondents replied that their daily lives are mostly interconnected with hunting which indicate that hunting is one of the most anthropogenic activities which affect the wildlife population in the study area (Table 7). Majority of the respondents in the study area practice group hunters and use shotgun for hunting. As expected, shotgun hunting was the most popular method of hunting, because it enabled the killing of larger game within a shorter period, and was, therefore economically more profitable (more meat with less hunting effort). Another reason for the popularity of shot gun hunting was that, trapping is considered inefficient and dangerous, since the traps sometimes catch non-targeted dangerous animals (e.g. snakes), and the trapped target animals could be stolen, often together with the trap.

Major threats to wildlife by human which occurred in highland part of Ethiopia is habitat shrinkage (fragmentation) and agricultural expansions as reported

by Kumsa and Bekele (2013) and Ashenafi and Leader-Williams (2005) but in contrary to this study, illegal hunting was not reported as a major threat by highland parts of the country, however, in Africa particular Tanzania where Serengeti national park found similar problem was reported by Bitanyi et al. (2012). Gambella national park is one of the protected Areas in Ethiopia where the second highest seasonal migration of large and medium size mammal's population occurred in Africa next to Serengeti National park. Hence the problems such as illegal hunting should not be considered as simple threat because hunting conducted by gun fire (modern fire arms) has a big problem for wildlife existence and conservation management (Tedla, 1995).

Another anthropogenic disturbance of wildlife was wildfire in the study area which is mostly associated with land-use practices and changes. The property, health and welfare of people in these areas are negatively affected by direct and indirect consequences of fire and air pollution. Active involvement of the local people has therefore been recognized as a condition for the successful implementation of fire management programmes, especially at the interfaces between wild lands, managed systems and residential areas (Johann et al., 2002).

Fuel wood plays an important role in human activities like fish smoking and charcoal production in every community. Although, most of the communities obtained energy sources from fuel wood, this situation has many side effects in the destruction of natural resource. In line to this view the present study revealed that majority of the respondent replied that, fuel wood is obtained by collecting from the wild.

CONCLUSION AND RECOMMENDATION

From these findings, the major human activities that impacts on the Nile Lechwe (*K. megaceros*) of the study area were agricultural investment and illegal hunting. The large scale agriculture activities close to the protected area produce effect to the wildlife resource in the area.

Therefore, any development practice should give consideration and attention to the rapidly declining natural resource beside the development. Hence there should be choral relationship between agricultural investments and conservationist as well as finding out possible ways in which both activities go harmonically side by side.

Once more it is the duty of the Government and Developmental Entities of the country to give more attention which further investigate the problems and mitigate the effects of the human factors.

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CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

REFERENCES

- Adugnaw B (2014). Environmental Degradation and Management in Ethiopian Highlands: Review of Lessons Learned. *International Journal of Environmental Protection and Policy* 2(1):24-34.
- Andren H (1994). Effects of habitat fragmentation on birds and mammals in landscapes with different proportions of suitable habitat: a review. *Oikos* 71(3):355-366.
- Ashenafi ZT, Leader-Williams N (2005). Indigenous common property resource management in the Central Highlands of Ethiopia. *Journal of Human Ecology* 33(4):539-563.
- Berry L (2003). Land Degradation in Ethiopia: Its Extent and Impact. Commissioned by the GM with WB support, pp. 2-7.
- Bitanyi S, Nesje M, Kusiluka L, Chenyambuga S, Kaltenborn B (2012). Awareness and perceptions of local people about wildlife hunting in western Serengeti communities. *Tropical Conservation Science* 5(2):208-224.
- Biodiversity Indicators Development National Task Force BIDNTF, (2010). Overview of Selected Biodiversity Indicators. Ethiopia, Addis Ababa. p. 23.
- The conservation strategy of Gambella CSG, (2000). Volume I the resources base. The Gambella peoples' National Regional state. Bureau of planning and Economic Development unpublished report.
- EWCA (2014). About Gambella national park. *Federal Negarit Gazette*, 2015. Council of Ministers Regulation to Provide For the Designation of Gambella National Park Regulation.
- Field AP (2000). *Discovering Statistics Using SPSS for Windows: Advanced Techniques for the Beginner*. Sage Publications, London.
- Hillman JC (1993). *Ethiopia: Compendium of Wildlife Conservation Information 1*. NYZS and EWCO, Addis Ababa.
- Johann GG, Peter GF, Mike J, Evelien MK, Teri K, Soo IM, Manuel P (2002). Community participation in integrated forest fire management: experiences from Africa, Asia and Europe. In *Communities in Flames; Proceedings of an International Conference on Community Involvement in Fire Management*, Balikpapan, Indonesia (25-28 July 2001). Bangkok: FAO Regional Office for Asia and the Pacific. RAP Publication 25:33-52.
- Kiringe JW, Okello MM (2007). Threats and their relative Severity to Wildlife Protected areas of Kenya. *Applied Ecology and Environmental Research* 5(2):49-62.
- Kumssa T, Bekele A (2013). Human-Wildlife Conflict in Senkele Swayne's Hartebeest Sanctuary, Ethiopia. *Journal of Experimental Biology and Agriculture Sciences* 1(1): 33-38.
- Mamo Y, Bekele A (2011). Human and livestock encroachments into the habitat of Mountain Nyala (*Tragelaphus buxtoni*) in the Bale Mountains National Park, Ethiopia. *Journal of Tropical Ecology* 52(3):265-273.
- Mann H, Smaller C (2010). Foreign land purchases for agriculture: What impact on sustainable development? *Sustainable Development Innovation Briefs*. New York, US: United Nations.

- Mohammed K, Afework B (2014). Threats to Mammals on Fragmented Habitats around Asella Town, Central Ethiopia. *International Journal of Biodiversity* 20:1-15.
- Stephens PA, d'Sa CA, Sillero-Zubiri C, Leader-Williams N (2001). Impact of livestock and settlement on the large mammalian wildlife of Bale Mountains National Park, southern Ethiopia. *Biological Conservation*. 100:307-322.
- Rolkier GG, Yehistial K, Prasse R. (2015). Habitate map of distribution of key wild animal species of Gambella national park. *International Journal of Innovative Research and Development* 4(4):240-259.
- Schloeder CA (1999). Investigation of the determinants of African Savanna vegetation distribution: a case study from the lower Omo basin, Ethiopia. PhD. Dissertation, Utah State University, Logan.
- Tadesse SA, Kotler BP (2013). The impacts of humans and livestock encroachments on the habitats of mountain nyala (*Tragelaphus buxtoni*) in Munessa, Ethiopia. *International Journal of Biodiversity and Conservation* 5(9):572-583.
- Turner BL, Clark WC, Kates RW, Richards JF, Matthews JT, Meyers WB (1990). *The earth as transformed by human action*. Cambridge University Press, Cambridge.
- Vitousek PM, Mooney HA, Loobehenco J, Melillo JM (1997). Human domination of Earth's ecosystem. *Science* 277:494-499.
- Wuver AM, Attuquayefio DK (2006). The Impact of Human Activities on Biodiversity Conservation in a Coastal Wetland in Ghana. *West African Journal of Applied Ecology* 9:1.

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