Review on Woody Plant Species of Ethiopian High Forests

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Abstract
Ethiopia is one of the top 25 biodiversity-rich countries in the world, and hosts two of the world's 34 biodiversity hotspots, namely the Eastern Afromontane and the Horn of Africa hotspots. It is also among the countries in the Horn of Africa regarded as major Centre of diversity and endemism for several plant species. The Ethiopian flora is estimated to about 6000 species of higher plants of which 10% are considered to be endemic according to Institute of Biodiversity Conservation (IBC) of Ethiopia, 2012 and woody plants constitute about 1000 species out of which 300 are trees.Forests form the major constituents of vegetation resources and thus conservation of forest genetic resources (FGRs) is among the priority areas of biodiversity conservation in Ethiopia. Forests undergo changes in various ways. Its areas can be reduced either by deforestation or by natural disasters such as volcanic eruptions. As a result, the expanse or vastness of forest areas is declining across the globe, partly through logging activities and also due to conversion of habitats to croplands (agricultural expansion) accounts for up to 40 percent of Ethiopian forest losses. A woody plant is a plant that produces wood as its structural tissue. In Ethiopia, biodiversity varies in space and time, and understanding patterns and drivers of Variation in biodiversity distribution has been a central topic in ecology. A diversity index is a mathematical measure of species diversity in a given Community. Based on the species richness (the number of species present) and species abundance (the number of individuals per species). Limited governmental, institutional, and legal capacity; population growth; land degradation; weak management of protected areas; and deforestation, invasion of exotic species, habitat destruction and fragmentation, over utilization, pollution, climate change, trade and transportation are some of threats and causes for loss to biodiversity of Ethiopia. To identify the richness, evenness, endemism, exoticness, enlargement, extinction rate, and to know appropriate management approach, diversity assessment has indispensable role. And ecologists and other related researchers and scientists use different indices to calculate diversity parameters. Among the indices, Shannon and Simpsons indices are commonly used one. Strong work is required to conserve diversity of Ethiopia.
Keywords: high forest, woody plant, diversity assessment, diversity index, species richness, species evenness

1. Introduction

Throughout history humans have used the environment resources plants, animals and others to gain great economic rewards; however, many of the methods are now being seen as unsustainable. Forests undergo changes in various ways. Its areas can be reduced either by deforestation or by natural disasters such as volcanic eruptions. As a result, the expanse of forest areas are declining across the globe, partly through logging activities and also due to conversion of habitats to croplands (agricultural expansion) accounts for up to 40 percent of Ethiopian forest losses. Especially deforestation is high and severe in the north-eastern Ethiopia. Because of the disappearance of forests, most of the mountainous sides are bare. Valleys have been gullied, striping and streams, which is used to have water the whole year around are now mainly dry in dry season. Particularly some of the current contributory factors accelerated the decline of woody species diversity in Ethiopia are, the size and distribution pattern of human and domestic animal populations, the level of resource consumption, market factors and policies. In addition, understanding of woody plant species conservation in a narrow sense due to low level of awareness, the attention on woody species conservation and sustainable use has so far been inadequate (Journal, Science, Vol, Centre, & Uk, 2013)

Ethiopia is one of the top 25 biodiversity-rich countries in the world, and hosts two of the world's 34 biodiversity hotspots, namely the Eastern Afromontane and the Horn of Africa hotspots. It is also among the countries in the Horn of Africa regarded as major Centre of diversity and endemism for several plant species. The Ethiopian flora is estimated to about 6000 species of higher plants of which 10% are considered to be endemic (Hedberg *et al.*, 2009) as cited by Institute of Biodiversity Conservation (IBC) of Ethiopia, 2012. Woody plants constitute about 1000 species out of which 300 are trees.

Forests form the major constituents of vegetation resources and thus conservation of forest genetic resources (FGRs) is among the priority areas of biodiversity conservation in Ethiopia. Efforts have been made to conserve and sustainably utilize FGRs in the country. Notable examples of such efforts are floristic, structure and socio-economic studies of woody plant species in Afromontane forests of the country; FGR conservation strategies and establishment of *in situ* and *ex situ* conservation sites. The outputs of the study gave way to the development of FGR conservation strategy of Ethiopia that gradually entered into implementation through the establishment of *in situ* and *ex situ* conservation sites. This chapter gives the current state of FGRs in terms of their status, future needs and priorities("Institute Of Biodiversity Conservation of Ethiopia (IBC),2012).

Loss of forest cover and biodiversity due to anthropogenic activities is a growing concern in many parts of the world. This is because of the fact that declining vegetation cover and depletion of natural resources are closely associated with drought and food shortages that have become major threats affecting the life of millions of people. Ethiopia has a wide range of ecological conditions ranging from the arid low lands in the East to wet forests in the Southwest and high altitudes in the central high lands. This wide range of ecological conditions coupled with the corresponding diverse socio-culture has made the country to be one of the internationally recognized major centers for biodiversity. The Ethiopian flora is very heterogeneous and has many endemic species (Dibaba, et al, 2014.). As the same source indicates, Ethiopia possesses about 6000 species of higher plants, of which about 10% are endemic.

The conservation and sustainable use of biological diversity and the eradication of extreme poverty are two of the main global challenges of our time. It has been recognized by the international community that these two challenges are intimately connected, and require a coordinated response. The protection of biodiversity is essential in the fight to reduce poverty and achieve sustainable development. Seventy percent of the world`s poor lives in rural areas depend directly on biodiversity for their survival and well-being(Temesgen et al., 2015).

Ethiopia is one of the countries in the world endowed with rich biological resources. One of these resources is natural vegetation where floristic and faunistic life forms dynamic ecosystems. Vegetation is an assemblage of plants growing together in a particular location and characterized either by its component species or by the combination of structural and functional characters that determine the appearance, or physiognomy of vegetation. The varied topography, the rift valley and the surrounding lowlands have given Ethiopia a wide spectrum of habitats and a large number of endemic plants and animals(Alemu et al., 2011)

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2. Main Body of the Review

2.1Plant diversity of Ethiopia

The diversity of species and the composition of plant communities is significantly respond to elevation. Species richness and diversity show a unimodal, hump shaped relationship with elevation. Decreasing trend with increasing elevation suggesting that restoration is more urgent at the lower elevations. Higher tree dieback at the lower elevation has pushed the tree species to the higher elevation by about 500 m, and this can lead to a shift in the forest-shrub land ecotone to higher elevations. High amounts of dead standing biomass are a particular risk in a fire-prone semi-arid forest environment, and controlling snag densities is of critical concern in the management of the remaining dry Afromontane forests in northern Ethiopia (Vlek & Denich, 2011).

According to Mohammed Gedefaw and Teshome Soromessa,(2014), a total of forty one different species of woody plants were identified in Tara Gedam forest, south Gondar Ethiopia. A total of 7,156 individuals of woody plants from the forty one different species were collected. Among the collected plant species*, Olea europaea*was the dominant one with recorded value of 598. *Allophylus abyssinicus*and *Albizias chimperiana* ranked the second and third in dominance with 556 and 474 numbers respectively. *Acanthus sennii*was the least dominant.

According to Kitessa Hundera, (2010) a total of 60 woody plant species belonging to 50 genera and 31 families were recorded regenerating under the canopy of exotic plantations and a natural forest at Belete forest. Only 40 of the species were found in the plantations while 20 of them found only in the natural forest. The highest density of regeneration was recorded for Pinuspatula followed by *Cuppressus lucitanica*. *Cuppressus lucitanica* plantation stand exhibited the highest value of Shannon diversity and evenness (2.5 and 0.84) followed by Eucalyptus saligna (2.13 and 0.83). Highest similarity index was observed between the plantation stands of *Cuppressus lucitanica* and *Eucalyptus saligna* (0.67). On the other hand, the *Cuppressus lucitanica* and *Eucalyptus camaldulensis* plantation stands showed relatively weak similarity (0.36). *Pinus patula* and *Cuppressus lucitanica* plantations had the highest similarity to the natural forest. The regeneration of native woody species under the canopies of exotic plantations in moist montane forest areas suggests the possibility of restoring degraded areas in southwestern Ethiopia using these exotic plantation stands.

Tree density is expressed as the number of trees per unit area and it is a crucial parameter for sustainable forest management. According to Shembel Alemu,(2011) study in Angada Forest, The total density of mature woody species with DBH> 2.50 cm in Angada Forest was 1,000 individuals per hectare, those with DBH greater than 10 cm was 372.8 individuals per hectare and those with DBH greater than 20 cm was 252.0 individuals per hectare (Table 6). *Podocorpus falcatus* contributed 33.0%, 31.4% and 35.5% for each DBH class respectively followed by *Croton macrostachyus* (12.0%), 6.4% and 8.1% and *Juniperus procera*(8.5%), 16.5% and 9.3% for each DBH class. This indicates that *Podocorpus falcatus*is the most dominant tree species in the forest.

The a/b ratio of Angada Forest is less than all other forests except for Menagesha Amba Mariam Forest. This indicates that there is predominance of large-sized individuals for some species in Angada Forest than other forests which is largely due to the high density of *Podocarpus falcatus, Croton macrostachyus*and *Juniperusprocera.*

Plant biodiversity is one of the major groups of biological diversity. Plant diversity can be affected by different biotic and abiotic factors. The plant communities and their component species are exposed to changes in the environmental, physical, biological, technological, economic or social. Globally, patterns of plant species diversity are influenced by latitudinal, altitudinal and soil gradients (Whittaker, 1975) as cited by (Dinkissa Beche Benti,2011).

Locally in mountainous ecosystems at high rate of change in altitude, slope and moisture gradients, temperature, rainfall and drainage, the diversity of plants may also change within a short distance. The other factors that highly influence plant diversity are human beings, as destructive factor. So, the fate of plant communities in a given area can be determined by these and other different factors. In this case, diversity and distribution patterns of species must be studied to clarify the plant diversity in certain area and to determine major factors influencing the diversity (" Beche," 2011).

Table 1 Number of species, percentage and life forms of Menagesha Suba State Forest

Ser.No	Life forms	Number	Percentage (%)
1	Trees	49	43.8
2	Shrubs	52	46.4
3	Lianas	12	10.7

Source: Dinkissa Beche Benti, (2011)

Table 2the seven most frequently occurring woody plant species in Menagesha Forest

Species	Frequency	Percentage Frequency	Relative Frequency	Priority
Juniperus procera	73	97	5.71	1
Olea europaea subsp. cuspidata	69	92	5.41	1
Dovyalis abyssinica	68	91	5.35	1
Maytenus arbutifolia	63	84	4.94	2
Jasminum abyssinicum	60	80	4.71	2
Pittosporum viridiflorum	54	76	4.47	3
Dovyalis verrucosa	46	61	3.59	4

Source:DinkissaBecheBenti, (2011)

The present day vegetation of Ethiopia physiognomically divided into nine major vegetation types: 1) Desert and semi-desert scrub land; 2) low land (semi-)evergreen forest; 3) Acacia Commiphora small laved deciduous woodland; 4) Combretum-Terminalia broad leaved deciduous woodland and savanna; 5)Evergreen scrub; 6) Moist evergreen montane forest/Afromontanerain forest; 7)Dry evergreen montane forest and grassland ; 8)Afroalpin and sub afroalpin zone; 9)Riparian/ Riverine and swamp vegetation (Awas, 2007).

As ErmiasAynekuluBetemariam, 2011 in Hugumburda forest, northern Ethiopia, a total of 9632 stems belonging to 83 species and 42 families were recorded in the 57 plots. Fabaceae, Lamiaceae, and Asteraceae are the 3 dominant families represented by 7, 6 and 5 species, respectively. *Juniperusprocera*and *O. europaea*subsp. *Cuspidate*are the two-dominant species with relative abundance of 18 and 20 %, respectively.

Table 3 Frequency distribution of woody plant species in Awash National Park, Ethiopia

No.	*Species*	Species	Relative Frequency
1.	*Acacia senegal*	43.75	11.91
2.	*Acacia tortilis*	28.13	7.66
3.	*Acacia oerfota*	20.31	5.53
4.	*Acacia prasinata*	18.75	5.11
5.	*Balanitesrotundifolia*	17.19	4.68
6.	*Ehretiaobtusifolia*	17.19	4.68
7.	*Acacia mellifera*	15.63	4.26
8.	*Grewiavillosa*	14.06	3.83
9.	*Acacia nilotica*	12.50	3.40
10.	*Celtistoka*	12.50	3.40
11.	*Dichrostachyscinerea*	12.50	3.40
12.	*Ficussycomorus*	10.94	2.98
13.	*Tamarindusindica*	10.94	2.98
14.	*Ziziphus sp. (Z. hamur ?)*	10.94	2.98
15.	*Boswelliapapyrifera*	9.38	2.55
16.	*Cordiamonoica*	9.38	2.55
17.	*Grewiatrichocarpa*	7.81	2.13
18.	*Hippocrateaafricana*	7.81	2.13
19.	*Doberaglabra*	7.81	2.13
20.	*Hyphaenethebaica*	7.81	2.13
21.	*Acacia robusta subsp. usambarensis*	6.25	1.70
22.	*Combretummolle*	6.25	1.70
23.	*Commiphoraafricana*	6.25	1.70
24.	*Mimusopslaurifolia*	6.25	1.70
25.	*Diospyrosmespiliformis*	6.25	1.70
26.	*Acacia seyal*	4.69	1.28
27.	*Capparistomentosa*	4.69	1.28
28.	*Maeruaangolensis*	4.69	1.28
29.	*Ozoreainsignis*	4.69	1.28
30.	*Balanitesaegyptiaca*	3.13	0.85
31.	*Berchemia discolor*	3.13	0.85
32.	*Ehretiaobtusifolia*	3.13	0.85
33.	*Prosopisjuliflora*	3.13	0.85
34.	*Terminaliabrownii*	3.13	0.85
35.	*Grewiaerythraea*	3.13	0.85
36.	*Grewiaschweinfurthii*	3.13	0.85
37.	*Ziziphusmucronata*	3.12	1.27
38.	*Cordiamyxa*	1.56	0.43
39.	*Cryptostegiagrandiflora*	1.56	0.43
40.	*Euclearacemosa*	1.56	0.43
41.	*Grewiaflavescens*	1.56	0.43
42.	*Salvadorapersica*	1.56	0.43
43.	*Cadabafarinosa*	1.56	0.42
44.	*Cadabarotundifolia*	1.56	0.42
45.	*Dalbergialactea*	1.56	0.42
46.	*Oleaeuropaea*	1.56	0.42
47.	*Rhusretinorroea*	1.56	0.42
48.	*Sterculiaafricana*	1.56	0.42
49.	*Tamarixnilotica*	1.56	0.42

Source:Tamene Yohannes, Tesfaye Awas1 and SebsebeDemissew, (2013)

2.2 Biodiversity and Its Significance

Diversity in wild plant species is potentially a major medicinal resource, and it is insurance for further food security. It should also be noted that species that might not have known direct economic value today may turn out to be economically important in the future. Biodiversity provides free of charge services worth hundreds of billions of Ethiopian Birr every year that are crucial to the well-being of Ethiopia's society. These services include clean water, pure air, soil formation and protection, pollination, crop pest control, and the provision of foods, fuel, fibers and drugs. As elsewhere, these services are not widely recognized, nor are they properly valued in economic or even social terms. Reduction in biodiversity affects these ecosystem services. The sustainability of ecosystems depends to a large extent on the buffering capacity provided by having a rich and healthy diversity of genes, species and habitats. Losing biodiversity is like losing the life support systems that we, and other species, so desperately depend upon.

The conservation of biodiversity is fundamental to achieving sustainable development. It provides flexibility and options for our current (and future) use of natural resources. Almost 85% of the population in Ethiopia lives in rural areas, and a large part of this population depend directly or indirectly on natural resources. Conservation of biodiversity is crucial to the

Sustainability of sectors as diverse as energy, agriculture, forestry, fisheries, wildlife, industry, health, tourism, commerce, irrigation and power. Ethiopia's development in the future will continue to depend on the foundation provided by living resources and conserving biodiversity(Plant, Diversity, & Forest, 2014).

Various plant species have different use values depending on socio-economic conditions of a given community. Natural forests are important sources of non-timber forest products such as fruits, fodder, honey, herbal medicine, as sources of tools and construction materials, timber and food for local communities. Forests also shelter several animal species including those that are endemic to Ethiopia alone. In Ethiopia, the majority of the woody species have economic uses. This has tended to promote unsustainable utilization of tree and shrub species, such unsustainable utilization of few species, especially timber and fuelwood species put them in the endangered category. Hence, there is less awareness of sustainable forest management in the local community(Federal Democratic Republic of Ethiopia, 2011).

Biodiversity has a number of functions on the Earth. These are as follows;

- **Maintaining balance of the ecosystem:** Recycling and storage of nutrients, combating pollution, and stabilizing climate, protecting water resources, forming and protecting soil and maintaining Eco balance.
- **Provision of biological resources:** Provision of medicines and pharmaceuticals, food for the human population and animals, ornamental plants, wood products, breeding stock and diversity of species, ecosystems and genes.
- **Social benefits:** Recreation and tourism, cultural value and education and research.

The benefits that we gain from biodiversity go far beyond the mere provision of raw materials. Our food and energy security strongly depend on biodiversity and so does our vulnerability to natural hazards such as fires and flooding. Biodiversity loss has negative effects on our health, material wealth and it largely limits our freedom of choice. As all cultures gain inspiration from or attach spiritual and religious values to ecosystems or their components – e.g. landscapes, trees, hills, rivers or particular species - biodiversity loss also strongly influences our social relations (Hertwich, van der Voet, & Tukker, 2010).

2.3Determinants of Biodiversity

Biodiversity varies in space and time, and understanding patterns and drivers of Variation in biodiversity distribution has been a central topic in ecology. The determinants of biodiversity can be seen from both regional and local perspectives. Accordingly, regional biodiversity is determined by the ecological and evolutionary processes of speciation, immigration, and extinction, while local diversity is influenced by random extinction, competition, and adaptation (Vlek & Denich, 2011).

Primary climate and site conditions have influenced and determined biodiversity on a specific site in the long-term development of forest ecosystems. Hence, the actual biodiversity is the result of the adaptation process of species. In the current conditions of climate change the species will have to respond to faster changes. Although the effect of climate change will vary from site to site, it is likely that its impacts on ecosystems will be adverse, as species will have to deal with a variety of new competitors, and biotic factors (diseases, predators), to which they have no natural defense so far (Merganic, Merganicova, Marusak, & Audolenska, 2012).

2.4Threats and Causes to Loss of Ethiopia's Biodiversity

Biodiversity serves as a benchmark for healthy ecosystems. Sadly, many of our ecosystems are in danger because of a tremendous loss of biodiversity. Trees play an important role in preserving biodiversity (Melorose, Perroy, & Careas, 2015).

Threats to Ethiopia's biodiversity, tropical forests, and resource base can be broadly linked to the following categories: limited governmental, institutional, and legal capacity; population growth; land degradation; weak management of protected areas; and deforestation. These threats are largely interrelated and self-reinforcing, and it is therefore important not only to understand the individual threats but also to examine them in a holistic fashion that recognizes their interrelation and can help to propose solutions to decrease the threats and mitigate their effects(Agency, Development, Analysis, & Team, 2008).

Table 4 List of trees and other woody forest species considered to be threatened in Ethiopia

No.	Species	Distribution in the country: widespread (W), Rare (R) or Local (L)	Type of threat (code)	Threat categories
1	*Acacia pseudonigrescens*	R		Low
2	*Acacia venosa*	R	1	Medium
3	*Albizia malacophylla*	R	1, 5	Medium
4	*Arundinaria alpina*	W	5	Medium
5	*Baphia abyssinica*	R	1, 5	
6	*Boswellia papyrifera*	R	1,5	High
7	*Combretum hartmannianum*	R	1,5	
8	*Combretum rochetanum*	R	1, 5	
9	*Cordeauxia edulis*	R	1,13	
10	*Cordia africana*	W	1, 2, 3, 5	High
11	*Dicraeopetalum stipulare*	L	2	High
12	*Dracaena ombet*	R	1	High
13	*Hagenia abyssinica*	W	1, 3,5,7	High
14	*Juniperus procera*	W	1, 3,5	High
15	*Maytenus arbutifolia*	W	1	Medium
16	*Okotea kynensis*	R	1, 3	Medium
17	*Oxytenanthera abyssinica*	W	5, 12	Medium
18	*Podocarpus falcatus*	W	1, 3,	High
19	*Pouteria adolfi-friederici*	R	1, 3, 5	High
20	*Prunus africana*	W	1, 3	High
21	*Teclea borenensis*	W	1	High
22	*Vitellaria paradoxa*	L	1,5	High

Source: Institute Of Biodiversity Conservation (IBC) Country Report Submitted To FAO on the State Of Forest Genetic Resources of Ethiopia August, 2012

Habitat fragmentation often defined as a process during which ‘’a large expanse of habitat is transformed into a number of smaller patches of small total area, isolated from each other by a matrix of habitats unlike the original’’. This definition of habitat fragmentation implies four effects of process of fragmentation on habitat pattern: a) reduction in habitat amount, b) increase in number of habitat patches, c) decrease in sizes of habitat patches, and d) increase in isolation of patches. These four effects form the basis most quantitative measure of habitat fragmentation. However, fragmentation measures vary widely; some include only one effect, whereas others include two or three effects but not all four (Faaborg, et al, 1993).

Habitat loss has large, consistently negative effects on biodiversity, so researchers who conceptualize and measure fragmentation as equivalent to habitat loss typically conclude that fragmentation has large negative effects on biodiversity (Cushman & Huettmann, 2010).

Pollution can affect biodiversity in and around cities. There is significant evidence linking air pollution to the loss of biodiversity. It has been estimated that more than 1300 species were threatened in Europe alone due to acid deposition in 1990s. Water pollution can also significantly affect biodiversity in coastal and inland water ecosystems through toxicity and eutrophication among other processes(Oliveira, 2012).

In certain cases, these non-native species have become invasive after their willing or unwilling introduction in cities. This implies the existence of ‘‘disturbed’’ habitats that provide opportunities for non-native species to find niches and compete with native species potentially turning into invasive species(Weber & Gut, 2004).

Demand associated with the generally higher incomes of urban residents (and not local demand) seems to be driving this wildlife trade in several parts of Asia and possibly around the world(Ethiopia Biodiversity and Tropical ForestsAgency., 2008).

Climate-change ecology is the study of the effects of anthropogenic climate change on any aspect of ecology. It includes the effects of altered temperature and precipitation on the distribution, abundance, behavior and physiology of populations and communities. Climate change over the past ~30 years has produced numerous shifts in the distributions and abundances of species and has been implicated in one species-level extinction (Thomas, 2011)

Urban development brings with it significant conservation challenges and directly affects three of the main drivers of biodiversity loss, namely habitat destruction; overexploitation and; the introduction of invasive species. The continuous expansion of urban areas results in land use and land cover change. Urban development can also induce the extinction of native species and the replacement of native species with alien (non-native) species(McKinney, 2002)

The expansion and growth of urban areas is also considered to be an important factor for the increase of trade and the circulation of commodities. As a result trade and transport is directly linked to biodiversity loss drivers such as GHG induced climate change and the introduction of invasive species, besides direct air pollution (Oliveira, 2012)

2.5 Measuring Species Diversity

A biological community has an attribute which we can call species diversity, and many different ways have been suggested for measuring this concept. Recent interest in conservation biology has generated a strong focus on how to measure biodiversity in plant and animal communities. Different authors have used different indices to measure species diversity and the whole subject area has become confused with poor terminology and an array of possible measures. Measuring diversity enables us to identify which measures are best to use for conservation assessment. Eine and the same source indicates as diversity measures require an estimate of species importance in the community. The simple choices are numbers, biomass, cover, or productivity. The decision in part will depend on the question being asked, and as in all questions about methods in ecology you should begin by asking yourself what the problem is and what hypotheses you are trying to test. Numbers are used by animal ecologists in many cases as a measure of species importance, plant ecologists may use biomass or cover, and limnologists may use productivity.

2.5.1. Relative Abundance: Common Species and Rare Ones

The species that characterize any natural community differ in relative abundance, usually with a few species quite common and most species much less so. Another way of looking at it is that most individuals belong to the few common species in a typical community. One way to plot such species abundance data (an approach originated by R. H. Whittaker) is a rank-abundance curve, in which each species is represented by a vertical bar proportional to its abundance. A community with such striking disparities in abundance among species is said to have low evenness. A rank-abundance plot for a hypothetical community with perfect evenness would be flat instead of declining, indicating that every species had the same abundance(Sileshi & Abraha, 2014).

2.5.2. Measuring and Estimating Species Richness

Measuring species diversity might seem an easy matter: just count the number of species presents in a habitat or study area. In practice, however, complications soon arise. With the exception of very well-known groups in very well-known places (for which we already have good estimates of total richness anyway), species richness must generally be estimated based on samples. Richness estimation offers an alternative to rare-faction for comparing richness among incompletely inventoried communities. Instead of interpolating‘ ‘backward’’ to smaller samples as in rarefaction, richness estimators extrapolate beyond what has been recorded to estimate the unknown asymptote of a species accumulation curve(Sarkar & Devi, 2014).

Species richness is the number of different species present in an area. Richness is an indicator of the relative wealth of species in a community. While the concept is simple, it is almost impossible to provide a formal definition. The difficulty stems from the inherent dependence of any richness measure on sample size; the larger the sample the greater the expected number of species. Because it is virtually impossible to ascertain the complete composition of an ecologic community, richness is often measured as the number of species in samples of an arbitrarily chosen constant size. It would clearly be desirable to have a richness index independent of sample size (Mamo et al., 2015).

The quantification of biodiversity requires some explanation. The concept of diversity has two aspects: the number of species and the relative abundance of species (relative number of individuals of each species). Quantitative approach of interpreting biodiversity data use the first aspect separately or combine the two mathematically in various ways. The simplest measure of biodiversity is species richness(George, Jackson, Boyd, & Tate, 2011).

2.5.3. How to Assess Woody Plant Species Diversity?

Reconnaissance survey, actual sampling of vegetation on homogeneity via preferential sampling method, recording all woody plant species in the plot(20 m X 20m). Height and Diameter at Breast Height (DBH) were measured for any woody plant species with height $\geq$ 2 m and DBH $\geq$ 10 cm thick. Height and DBH measurements were made using Clinometer and diameter tape respectively. Regeneration pattern of study species are assessed by counting of seedlings (woody species of height $\leq$ 50 cm and dbh $\leq$ 10cm) and saplings (woody species of height > 50cm and dbh $\leq$ 10 cm) within the main quadrats. Every plant species encountered in each plot is recorded (Cardelú, 2013).

Good regeneration, if seedlings >saplings >adults; Fair regeneration, if seedlings> or ≤ saplings ≤ adults; Poor regeneration, if the species survives only in sapling stage, but no seedlings (saplings may be <, > or = adults); and if a species is present only in an adult form it is considered as not regenerating according to (Gebrehiwot & Hundera, 2014).

2.5.4. Species Diversity Indices

Floristic description of vegetation community involves the analysis of species diversity, evenness and similarity. Species diversity is one of the most important indices used for evaluating the sustainability of forest communities. Diversity and equitability of species in a given vegetation community is used to interpret the relative variation among and within the community and help to explain the underlying reasons for such a difference (Eroglu S., Toprak S.,et al, 2012)

A diversity index is a mathematical measure of species diversity in a given Community. Based on the species richness (the number of species present) and species abundance (the number of individuals per species). The more species you have, the more diverse the area. However, there are two types of indices, dominance indices and information statistic indices.

The equations for the two indices are:

Shannon Index (H') = -Σ[{ni/N} x ln [{ni/N}]

Simpson Index (D) = $\Sigma (n/N)^2$; $D=\frac{\Sigma n\,(n-1)}{N\,(N-1)}$

Shannon-Wiener diversity index was a commonly used index to measure woody species diversity. The Shannon index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. In the Shannon index,pis the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), lnis the natural log, Σis the sum of the calculations, and s is the number of species. The Simpson index is a dominance index because it gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity. In the Simpson index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), Σ is still the sum of the calculations, and s is the number of species (Mebrat, Molla, & Gashaw, 2014).

2.5.4.1. Shannon Information Index or "Entropy" =-Σ[{ni/N} x ln [{ni/N}]

Interpretation

This measure, which is based on information theory, summarizes the "entropy" of a community. It addresses the following question: if rare species carry more "information" than common species and their information value is proportional to the logarithm of their pi, what is the average amount of "information" in the community? That average amount of "information" is the entropy. H incorporates both richness and evenness– i.e., it increases as both a function of the number of species and the uniformity of their abundance values. Note that H is the absolute value of the mean of ln(pi). This metric is the single most common measure of diversity. It is biased by sample size (N), but the error is on the order of (S-1)/2N (i.e., if this value is much smaller than H calculated using equation (2), then the calculated value is an acceptable estimate of the true value; note that this error estimate is only correct if His calculated using natural logarithms). This metric is the basis for SHE analysis, a means of characterizing a community's diversity using richness (S), entropy (H), and a measure of evenness (E): E= eH/ln(S) (10) (e is the base of the natural logarithm). ln(S) is the maximum value H can have for a sample of given richness (S), so H/ln(S) is a means of removing the influence of richness on the entropy (Olszewski, 2007).

2.5.4.2. Simpson's Evenness

Interpretation

If you pick two specimens from a sample randomly, the probability that they will be two different species is given by PIE, which stands for the Probability of Interspecific Encounter. In theory, this metric ranges from 0 (perfectly uneven) to 1 (perfectly even). It is a true probability value. Simpson index is often used to quantify the woody species diversity of a forest. It measures the evenness ofspecies from 0 to 1. The greater value of "*1-D*" is the greater evenness. Its value increases with increase in the number of species and the distribution of the individuals among the species becomes even(Olszewski, 2007).

According to Shiferaw Alem and Jindrich Pavlis, (2012) the diversity indexes (*H'*) of *E. camaldulensis*plantation and its neighboring native woodland were 1.568 and 2.091, respectively in South western Ethiopia Gibie Valley comparative study between Native Woody Plants Diversity and Density under *Eucalyptus camaldulensis* Plantation.

3. Summary and conclusion

Ethiopia is one of the countries in the world endowed with rich biological resources. The varied topography, the rift valley and the surrounding lowlands have given Ethiopia a wide spectrum of habitats and a large number of endemic plants and animals. Plant biodiversity is one of the major groups of biological diversity. Plant diversity can be affected by different biotic and abiotic factors. The plant communities and their component species are exposed to changes in the environmental, physical, biological, technological, economic or social. High forests have relatively high genetic diversity compared with coppice forests, which develop from vegetative reproduction.

Ethiopia is one of the top 25 biodiversity-rich countries in the world, and hosts two of the world's 34 biodiversity hotspots, namely the Eastern Afromontane and the Horn of Africa hotspots. It is also among the countries in the Horn of Africa regarded as major Centre of diversity and endemism for several plant species. The Ethiopian flora is estimated to about 6000 species of higher plants of which 10% are considered to be endemic. Woody plants constitute about 1000 species out of which 300 are trees.

Limited governmental, institutional, and legal capacity; population growth; land degradation; weak management of protected areas; and deforestation, invasion of exotic species, habitat destruction and fragmentation, over utilization, pollution, climate change, trade and transportation are some of threats and causes for loss to biodiversity of Ethiopia. To conserve biological diversity Ethiopia has strategies and policies.

To identify the richness, evenness, endemism, exoticness, enlargement, extinction rate, and to know appropriate management approach, diversity assessment has indispensable role. And ecologists and other related researchers and scientists use different indices to calculate diversity parameters. Among the indices, Shannon and Simpsons indices are commonly used one.

4. Prospects

Albeit many attempts have been taken to conserve biological diversity in general and woody plant species in particular, still there is unsustainable and destructives activities are taking place. Therefore, actions such as:

- ❖ To conserve the biodiversity, detailed ecological and botanical studies are vital concerning the species composition, diversity and distribution of plant species in relation to the environmental factors such as soil type and properties;
- ❖ Introduced strategies and policies should strictly be applied on place where there is violation;
- ❖ Institutional strength and capacity building work to concerning body starting from local community up to higher governmental organizations and awareness creation;
- ❖ Establishment of local level governmental organization concerning biodiversity and forest for example there is Ministry of environment, Forest and Climate change in Ethiopia now but its corresponding local organization at kebele level is not known;
- ❖ Strong quarantine work to reduce introduction of exotic and invasive species from abroad since some exotic species like *prosopis juliflora* are strongly hurting and competing against indigenous species;
- ❖ Planting trees either invidiously or communally so as to minimize pressure on remnant natural forest and to enhance services from forest;
- ❖ Enrichment plantation in natural forest to assist regeneration and its forest values or tree planting by local people has to be encouraged on already degraded land escapes to create a buffer for the forest;
- ❖ Potential traditional knowledge of the people on the diverse uses of plants should be strengthened for the enrichment of ethnobotanical studies of the area.

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