

An Overview of the Major Vegetation Classification in Africa and the New Vegetation Classification in Ethiopia

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To cite this article:

Wondimagegn Mengist. An Overview of the Major Vegetation Classification in Africa and the New Vegetation Classification in Ethiopia. *American Journal of Zoology*. Vol. 2, No. 4, 2019, pp. 51-62. doi: 10.11648/j.ajz.20190204.12

Received: July 31, 2019; **Accepted:** September 27, 2019; **Published:** January 7, 2020

Abstract: Vegetation is classified using life forms, density, and seasonality. The objective of this review work was to list the vegetation classification, major plant species and geographic distribution in Africa, and the recent vegetation category in Ethiopia. The review search was focused on English-language and peer-reviewed literature. The vegetation types in Africa were classified into various groups using various criteria of categorization. It was grouped into 24 types, 16 types, and even five groups. Though the vegetation categorization in Africa was varied, this work focuses on the five major groups of vegetation that is forest, woodlands and shrub lands, grass lands, agricultural land, and swampy and mangrove vegetation. The vegetation types in Ethiopia were also grouped in different types across time. However, recently, the vegetation was classified into 12 major and 12 sub-types of vegetation. The major vegetation types are desert and semi-desert scrubland, Acacia-Commiphora woodland and bushland, wooded grassland of the western Gambella region, Combretum-Terminalia woodland and wooded grassland, dry evergreen Afromontane forest and grassland complex, moist evergreen Afromontane forest, transitional rainforest, ericaceous belt, afro-alpine belt, riverine vegetation, fresh-water lakes, marsh and floodplain vegetation and salt lakes, marsh and pan vegetation. The total number of higher plant species was expected to be between 6500-7000. Out of them, about 10-12% are endemic species in Ethiopia. This shows that still, lot of work is remaining to fully assess the types of plant species that are available in the country. These big vegetation variations both in the continent and in Ethiopia was associated with the existence of variation in climate, geology, and altitude. These again favor the existence of diverse plant species.

Keywords: Vegetation in Africa, Vegetation in Ethiopia, Vegetation Classification, Major Plant Species, Geographical Distribution

1. Background

The vegetation type is classified based on their life forms, density, and a seasonality which is evergreen and deciduous in association with altitude, climate, and vegetation architecture [1]. Vegetation classification appeared to consider the existence of spatial variation and to formulate commencement for silvicultural management [2]. Therefore, the main purposes of vegetation classification are to identify as well as to delineate vegetation patterns for vegetation monitoring; to explain vegetation patterns using the causal link with the environment, and to conclude field observations and measurements of vegetation to a relevant level of geographic or ecological generalization [3]. Besides, vegetation classification can help to understand the spatial and temporal variation of vegetation [4].

The natural vegetation types in Africa are diverse and previously classified into sixteen vegetation types mainly using their physiognomy characters. Physiognomic characters cover all aspects of the vegetation structures like height, density, thorniness, deciduousness and soon [5]. These vegetation types were the forest, woodland, bushland and thicket, shrub land, grassland, wooded grassland, desert, Afro-alpine vegetation, scrub forest, transition woodland, scrub woodland, mangrove, herbaceous fresh-water swamp and aquatic vegetation, halophytic vegetation, bamboo, and anthropic landscape. These sixteen vegetation types are varied and their formations are very unequal in the size of the area they occupy and degree of physiognomic distinctiveness [5]. However, there are vegetation changes across time and space due to the effects of ecological processes on plant population and communities. In addition, new vegetation

data is available. These two conditions have significant implications for the stability of vegetation classification [4]. Thus, the vegetation types in Africa were again sub-grouped into five main types. The five major vegetation types in Africa are the forest, woodlands and shrublands, grasslands, swamp and mangrove vegetation, and agricultural lands [6]. Therefore, this review work addresses the vegetation classification of Mayaux, Bartholomé [6], however, the agricultural land, that includes croplands, croplands with open woody vegetation, irrigated croplands, and tree crops are not included in this paperwork.

Ethiopia has various ecological zones that range from arid and semi-arid to wet areas and high land zones. This is emanated from diversity in its climate, vegetation and landforms/altitudes [7]. This results in heterogeneous flora and this puts the country at the fifth level from Africa. From these rich flora species, most of them are endemic and that ranges from arid/semi-desert to tropical and mountainous forests. The total number of the flora of Ethiopia constitutes 6500-7000 species of higher plants out of which 10-12% are endemic [8-10]. Referring to many sources, the natural vegetation types of Ethiopia classified into various groups. For example, Woldu, Edward [11] and Sebsebe and Friis [12], they grouped the vegetation into nine types including the coastal vegetation of Eritrea. According to Pichi-Sermolli [13], the vegetation types in Ethiopia were divided into twenty-four types using physiognomic discussion with little phytogeographical consideration. Recently, the study by Ib, Sebsebe [8] using climate and altitude, the natural vegetation is grouped into 12 major types and 12 subtypes. These are (1) Desert and semi-desert scrub-land, (2) *Acacia-Commiphora* woodland and bushland which has two subtypes (a) *Acacia-Commiphora* woodland and bushland proper and (b) *Acacia* wooded grassland of the Rift Valley, (3) Wooded grassland of the western Gambella region, (4) *Combretum-Terminalia* woodland and wooded grassland, (5) Dry evergreen Afromontane forest and grassland complex that has four subtypes (a) Undifferentiated Afromontane forest, (b) Dry single-dominant Afromontane forest of the Ethiopian high lands, (c) Afromontane woodland, wooded grassland and grassland, and (d) Transition between Afromontane vegetation and *Acacia-Commiphora* bushland on the Eastern escarpment. (6) Moist evergreen Afromontane forest constitutes two subtypes (a) Primary or mature secondary moist evergreen Afromontane forest, and (b) Edges of the moist evergreen Afromontane forest, bushland, woodland and wooded grassland. The others are (7) Transitional rainforest, (8) Ericaceous belt and (9) Afro-alpine belt. The rest three types are vegetation categories that encompass (i) Riverine vegetation, (ii) Fresh-water lakes, etc. followed by two subtypes (a) Fresh-water lake vegetation (open water) and (b) Freshwater marshes and swamps, floodplains and lakeshore vegetation) and (iii) Salt lakes, etc. with the subtypes (a) Salt Lake vegetation (open-water) and (b) Saltpans, saline/brackish and intermittent wetlands and salt-lake shore vegetation [8]. From these vegetation types, seven of them are considered as typical of dryland areas. These are Desert

and semi-desert scrubland; *Acacia-Commiphora* woodlands and bushlands; Wooded grasslands of the Western Gambella region; *Combretum-Terminalia* woodland and wooded grassland; Dry evergreen Afromontane forest and grassland complex; Freshwater lakes, lakeshores, marshes, swamps (wetlands) and floodplains vegetation, and Salt-water lakes, lakeshores, salt marshes and pan vegetation. Among these vegetation ecosystems, the two most dominant vegetation categories are *Combretum-Terminalia* and *Acacia-Commiphora* woodland and shrub lands [14].

As a result, the main purpose of the review is to discuss the major vegetation types in Africa in general and Ethiopia in particular. It covers their general characteristics, species composition, and geographic location. The review emphasized the new vegetation categories of Ethiopia. Therefore, the specific objectives of the review work are (i) to summarize the major vegetation types in Africa with their main characteristics and geographical sites, and (ii) to discuss the recent vegetation classification in Ethiopia with their common plant species, geographical sites and the number of total available species.

2. Literature Search and Study Selection

The search was conducted within the peer-reviewed literature on the science direct, google scholar and Scopus databases spanning any years of study up to 2019. A combination of the search terms and keywords “Vegetation”, “new vegetation categories” and “Vegetation types” were used, with the results further refined with keywords such as “Africa”, and “Ethiopia”. In addition, “vegetation map”, and also keywords representing “Africa”, and “Ethiopia” were used to broaden the search and its inclusiveness.

The inclusion and exclusion criteria used to select articles for this review were: (i) English-language publications, (ii). published in peer-reviewed scientific journals, and (iii) scientific report, maps and books on vegetation types and distribution in Africa and Ethiopia. All the selected literature on Africa's and Ethiopia's vegetation types and classification was examined to extract meaningful information to achieve the review objective. Further studies were added by reviewing the literature found in the reference lists of already included papers through backward reference list checking [15] which evaluated Africa's and Ethiopia's vegetation that also conformed to the criteria listed above.

3. Major Vegetation Types in Africa

Even if various vegetation types and classifications are existing in the continent of Africa; however, the paper covers the major vegetation types with their subdivision of Mayaux, Bartholomé [6] classification.

3.1. Forest

Forest is a continuous stand of trees that constitute several layers. The canopy varies in height from 10 to 50 meters or 150 feet and above. The crowns of individual trees overlap

each other and are often interlaced with lianas and created various thicknesses in the canopy [5, 16]. In terms of physiognomic criteria, a forest has a canopy cover of 80% and above. However, it is not only the vegetation cover that distinguishes the forest from woodland vegetation, but the floristic composition in forests differs from woodland vegetation types [17].

However, there is no universally agreed definition of forest. The UN Food and Agriculture Organization (FAO) has given various definitions. For example, in 2001 defined a forest as “land with a tree crown cover (or equivalent stocking level) of more than 10% and an area of more than 0.5 hectare; the trees should be able to reach a minimum height of 5 m at maturity in situ”. Again after five years, FAO defined a forest as a minimum land area of 0.05–1 ha with tree crown cover more than 10–30% and tree height of 2–5 m at maturity [18, 19].

Forests in the wet area constitute epiphytic plants including ferns, orchids, and large mosses are characteristic of the moister tropical and subtropical forest types. This forest can include the tropical moist and dry forests and lichens are common in forests located in the upland area. A shrub layer is normally present. It usually ranges from densest to those types of a forest with a more open canopy. The ground layer is often sparse and may be absent or consist only of bryophytes. In tropical and subtropical types grasses, if present, are comparatively localized and inconspicuous, though lianas are usually well represented [5, 16]. Forest vegetation group of Mayaux, Bartholomé [6] includes closed evergreen lowland forest, degraded evergreen lowland forest, montane evergreen forest (> 1500m), sub-montane forest (>900m), swamp forest mangrove, mosaic forest/croplands, mosaic forest/savanna and closed deciduous forest (Miombo). The classification is based on percentage of vegetation cover (open/closed), seasonality, flooding regime, climate, and altitude, and it is grouped into the following subgroups.

3.1.1. The Closed Tropical Rain Forest of Lowlands

This includes “Forest classes on land up to 1000masl with tree canopy cover is greater than 70% and height greater than 5 meters”[6]. The Tropical rain forests of Africa cover areas having a favorable climate. The rainfall spread evenly over the year, except for an occasional short period of drought lasting at most three months; the temperature remains at an average of 25° to 26°C and humidity is very high. Such conditions certainly afford the most suitable environment for forest growth [20]. It covers 2.5 million km² area and it shares 15% of the world’s forest [21]. Central Africa shares 89.3% cover, West Africa 6%, East Africa 2.4% and Madagascar 2%. In terms of countries, the largest size is in Democratic Republic of Congo (53.6%), and followed by Gabon (11.2%), the Republic of Congo (10.4%), Cameroon (10.0%) and the remaining 14.8% of the lowland rainforest is distributed to the rest countries [22]. The forest in central Africa is a closed evergreen forest that has upper strata from 35–45 meters. Grass and shrubs at a lower layer are not

developed well due to canopy prevention but favor the epiphytes. This forest area has no marked seasonal variation in temperature and rainfall [6]. Moving far from the center, the density of the forest changes and the closed semi-deciduous forest forms at the climax. Compared to the evergreen forest, the semi-deciduous forest is richer in floristic composition [6].

3.1.2. Closed evergreen Montane and Sub-montane Forests

Refers forests found at the mountainous area of an altitude from 1000 meters above mean sea level (masl) [6]. According to White [5], these forests occur on mountain areas range from 1200 and 2500 meters. Altitudinal variation may exist concerning distance from the equator, nearness to the ocean, and the size and shape of the massif where these forests happen [5]. The plant's floristic composition and structure tend to change along gradients. This vegetation is characterized by the vegetation of smaller size trees, more in number, less diversity and a reduction in total volume. Such vegetation in Africa is commonly found in Ethiopia, in coastal Central Africa (Mount Cameroon and insular Equatorial Guinea) and Madagascar [6].

The Afromontane rainforest has a structural resemblance to many types of Guineo-Congolian rainforest. However, these forest types differ from the tropical rainforest in its species composition, the existence of a greater degree of bud protection, a lower rate of developing drip tips of leaves, the existence of tree ferns like *Cyathea* and conifer species like *Podocarpus falcatus* [17].

3.1.3. Mosaic Forest

Mosaic forest with croplands is the vegetation types formed by a complex of secondary regrowth, fallow, home gardens, food crops, and village plantations. The secondary regrowth has features like continuous and homogenous upper layer from the same tree composition. “This pioneer species, strictly helophyte, shows a rapid height growth in the clearings (up to 15 meters in 3 years). Its large leaves (25–30 cm of radius) are continuously replaced by young ones. Their water content and photosynthetic activity are permanently high”. Knowing the patterns of secondary forest distribution in a region helps to make analysis concerning human activities, carbon sequestration potential, its floristic and faunistic characteristics [6].

Mosaic Forest / Savanna includes vegetation formations both forest elements and savanna elements [6]. It is the central biome found between forest and grasslands. It constitutes both woody vegetation and grass and herbs. These two vegetation coexist even if they compete for water resources [23]. Savanna grasslands are commonly existing in areas where there is moisture, soil texture, nutrients, herbivory and fire that allow codominance of grasses and trees. “When the main agent in their maintenance disappears, savanna gives way to the forest. The main enclosed savannas (Lopé, Odzala...) are maintained by repeated burning. Large savannas of the plateaux Bateke (Gabon, Congo-Brazzaville, Congo-Kinshasa) extend on sandy soils developed from decomposed sandstone” [6]. Savanna grasslands in Central Africa are likely sustained by a combination of

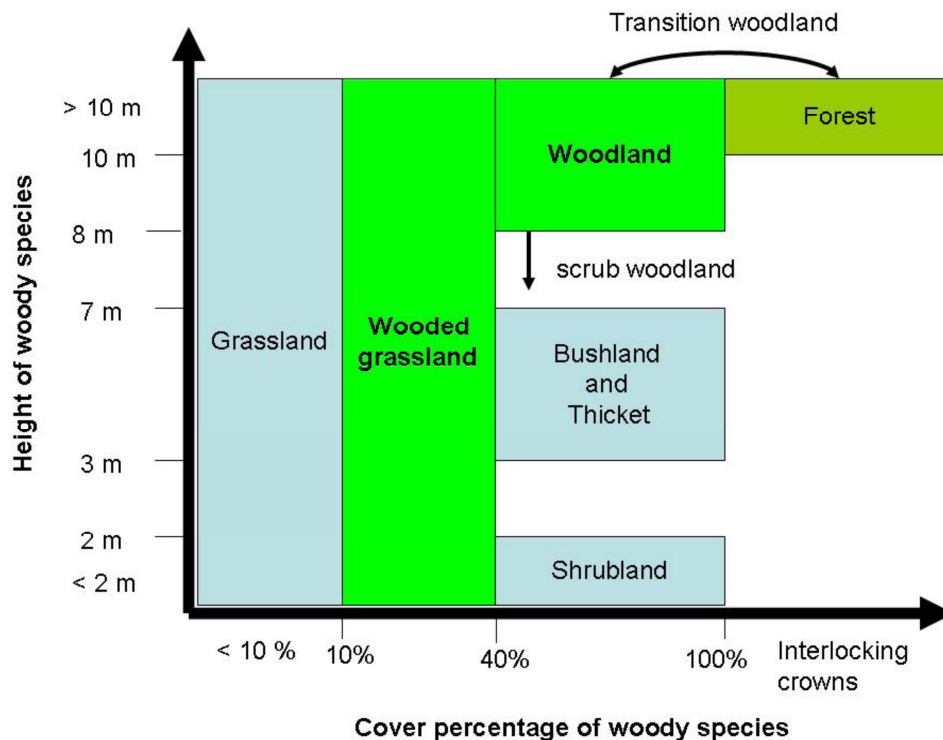
precipitation, soil characteristics and anthropogenic disturbance such as fire and clearance for grazing, agriculture and timber production [24].

3.2. Woodlands and Shrublands

Broadly, it is defined as vegetation dominated by woody plants mainly trees and the canopy cover is more than 10 percent of the ground surface which experience climates with a dry season of three months or more. This broad definition incorporates diverse vegetation types commonly termed woodland, shrub land, thicket, savanna, and wooded grassland, as well as a dry forest in its strict sense. However, it does not include a moist evergreen forest (rainforest), grasslands and dwarf shrub land, like heathlands and fynbos.

Hence, the woodland is a land that has open space that is not fully covered with a canopy and most of the trees have dropped their leaves during the dry season of the year. It constitutes scattered evergreen trees, perennial grass species, and herbs [16]. Based on height, however, woodland vegetation cannot be easily differentiated from forest vegetation, but woodland vegetation never have densely interlocking crowns [17].

As Figure 1 shows, the vegetation types based on percentage of woody species coverage and its height, the major types of vegetation can be grouped in to grasslands, wooded grasslands, wooded land (that constitutes scrub woodland, bushland, and thicket land) and forest from lower height and crown area coverage to highest, respectively.



Source:[25]

Figure 1. Height and cover percentage limits for major physiognomic types. Transition woodland is woodland that reverts to the forest under certain conditions. Scrub woodland is a stunted variant of typical woodland formations such as “scrub Miombo woodland”.

Where more specific vegetation types are being described, the appropriate term is dense woodland or wooded grassland. Dry tropical forests or woodlands initially covered over 40% of tropical forest areas at the global level and 14% from the total African land surfaces and constitutes about 25% of the natural vegetation in Africa [26, 27]. In Africa, this dry forest covers an area between rainforests in the Congo basin and open woodlands of western and southern Africa. The vegetation exists in 31 sub-Saharan Africa countries in western, eastern and southern Africa and is the dominant vegetation in 63 percent of these countries. Based on the 2003 report, approximately it covers 17.3 million km² area and is inhabited by nearly 505 million people [28].

According to Mayaux, Bartholomé [6], this vegetation type is sub-grouped into three based on canopy height and

cover. When the canopy cover is between 15 to 40% with tree height greater than five meters, it is deciduous open woodlands. It has a feature like a spare tree layer and their floristic composition differs from forest vegetation but has richness in diversity. When the shrub canopy cover is greater than 15% and canopy height less than 5 meters, it is deciduous shrub lands with sparse trees. The tree layer is gradually replaced by a dense shrub layer. The third category is deciduous shrub lands with no trees. This category has shrub canopy cover greater than 15% and canopy height less than 5 meters but no tree layer due to the scarcity of rainfall [6]. These vegetation types, however, in the continent is under human population pressure. Woody vegetation cover loss is serious in parts of the Sahel, East Africa, and Madagascar. Woody plant encroachment is dominant in the

central interior of Africa such as Cameroon, Central Africa Republic, South Sudan and Uganda [29].

3.3. Grasslands

“Grasslands are the most extensive, arguably the most useful to human society, yet the most threatened biome on the planet. Nevertheless, it is surprisingly difficult to unambiguously define grassland” [30]. Some of grasses definitions as cited in [30] are: ‘... a plant community in which the *Gramineae* are dominants and trees absent.’ Milner and Hughes (1968) cited in [30]. “[Grasslands]... are dominated primarily by grasses (*Gramineae*) and grass-like plants (mostly *Cyperaceae*) and the climates generally have distinct wet and dry seasons and are noted for temperature and precipitation extremes.” A region with sufficient average annual precipitation (25–75 cm) to support grass but not trees. The central point of the definition is that the prevalence of grasses, no or less availability of woody vegetation and the climate condition is less favor tree growth due to the scarcity of rainfall.

According to Mayaux, Bartholomé [6], grassland in Africa can range from areas where herbaceous vegetation cover is high up to less with no tree cover at all. This idea is further explained by Greenway [16] as “land covered with grasses and other herbs, generally perennial; sometimes with evergreen or deciduous trees or shrubs, either very scattered or in small isolated groups, in either case not covering more than 10 percent, of the ground”. The grasses may form a dense or thin cover on the ground, closer space or far apart; or they may be perennial and forming a permanent ground cover. It includes grasses with a height of one inch to nearly six feet length, but giant grasses like Bamboos, Elephant and Thatching Grasses are categorized under the Main Type Bushland, Thickets and Scrub [16]. Closed grassland vegetation is covered by herbaceous above 40% and tree/shrub with less than 20%. In this ecoclimatic zone, although trees/shrubs exist, more size of the savanna grass is located within the forest category either by surrounding the large forest patches or as a small island encircled by forests. Thus, the Savanna ecosystems have a mix of trees and grasses, cover one-fifth of the world's land surface and are of great ecological and socio-economic importance and are also home to most of the world's rangelands, livestock, and large wild herbivores [6, 31]. Compared to trees/shrubs with savanna at the edge of forests, grass forms a continuous layer. According to Riginos [31], the existence of grass competition can significantly reduce the growth and demographic transition probability of trees besides of demographic stage or rainfall. Therefore, grass competition may be far more important in limiting the availability of savanna trees. However, when there is overgrazing, over time the tree species become dominant as they are more tolerant of over story shading and water scarcity by their longer roots [32].

When the dry land condition is appearing, the herbaceous cover declined from 40% up to 15% due to the scarcity of rainfall which is less than 200mm/year. The shrub layer

declined and the area is dominated by grass which is open grassland with sparse shrubs. Getting farther from the moist area, the rainfall amount is reduced to 100-50 mm/year. The condition less favor even grasses and the herbaceous cover is ranges from 5-15%. The eco-climate is devoid of shrubs, but have perennial grass species like *Stipagrostis sp.*, *Monsonia ignorata*, *Eragrostis sp.*, *Aristida*. The area at the edge of the desert has herbaceous vegetation cover less than 5% and this reflects the absence of rainfall for grass species. The herbaceous species include perennial grass and succulent species [6].

3.4. Swampy and Mangrove Vegetation

i. Swamp and mangroves forests

The swampy forest is formed by the permanent or periodic influence of freshwater. The vegetation structure and its species types are associated with the flood frequency and drainage. These conditions created forests like riparian forests, periodically inundated forests and swamp forests. The Congolian swamp forest is intact and one of the largest swamp forests in the continent and on the planet [6].

Mangrove species according to White [5] grouped as one major vegetation type than subgrouping under forests even if many mangrove vegetation has similarities with bushland and thickets. The formation of mangrove forests is permanently under the influence of saltwater and it is linked with marine alluvium. The environment has more salt and it reduced the species types and their floristic compassion. This vegetation is frequently flooded by sea-water and thus, their leaves are succulent and their roots are capable to desalinate the saltwater. In Africa, such a forest type is found along with the coastal areas [6, 25]. Except for *Avicennia* species, which avoid salt from their leaves, in most species salt is accumulated in their tissues [25].

ii. Swampy shrub lands and grasslands

The swamps can be permanent or seasonal depending on the duration of surface water flow in the area. Most of the freshwater shallow lakes in Africa have reed-swamp vegetation where they rooted in the soil and their stems rise above the water surface. The most available swamp vegetation in East Africa is *Cyperus papyrus* with *Miscanthus violaceus*, *Phragmites australis* and *Phragmites mauritianus* grasses. Aquatic species are common in deeper water beyond the reed-swamp vegetation by having floating leaves or underwater [25].

In Africa, large swampy areas are formed along the lower course of rivers due to the plain land formation. The most common areas are in Sudan along River Nile, in Botswana in River Okavango, Lake Chad, and River Niger in Mali. Such a swampy site favors both forest and grassland vegetation. Large swamp grasslands appear between Rivers Oubangui and Congo, in the Likouala region in Congo-Brazzaville, along with the Nyong in Cameroon and the Upemba region in Katanga. “These grasslands are low formations dominated by grasses (*Vossia*, *Echnichloea*....) or by *Cyperus papyrus*” [6].

4. Major Vegetation Types of Ethiopia

The various vegetation types in Ethiopia are dependent on factors like topographic features (i.e., altitudinal variation and aspect), climate (i.e., mainly precipitation and temperature), geology and soil types [33]. The ecosystem types of the country were grouped into various types, however, this work depends on the recent 12 major vegetation classification types that have further subdivided into 12 [8].

4.1. Desert and Semi-desert Scrubland Vegetation

This vegetation is common in areas having an elevation below 400masl. It is found in the northwestern and northeastern, southern, southeastern and eastern (Somali) parts of Ethiopia. The northern Afar and northeastern Tigray are predominantly desert areas. The vegetation types are composed of small trees, shrubs and herbs, which may be succulent, geophytic or annual and they are drought-tolerant species. Floristically this vegetation type is not well-defined and has very scarce plant cover [8]. This ecosystem is ranges from areas devoid of vegetation like for example, the Danakil depression to areas moderately vegetated with shrubs with a rare number of trees, bush/shrub-steppe, grass steppe and a variety of annual plants and succulents [34].

The common trees and shrubs species are *Acacia ehrenbergiana*, *Boswellia ogadensis*, *Commiphora erosa*, *C. longipedicellata*, *Gyrocarpus hababensis*, *Kissenia arabica*, *Ochradenus baccatus*, *Diceratella revollii*, *Cadaba barbigera*, *C. divaricata*, and *Ziziphus hamur*. Some woody species are available like *Acacia oliveri*, *Acridocarpus glaucescens* var. *forrugineus*, *Commiphora guidottii*, *C. longipedicellata*, *C. samharensis*, *C. sphaerocarpa*, *C. staphyleifolia* and *C. unilobata*. Succulents are also characteristic, including *Euphorbia doloensis* (endemic), *E. ogadenensis*, *E. quadrispina*, *Aloe bertemariae*, and *A. citrina*. There are drought-tolerant grass species like such as *Dactyloctenium aegyptium*, and *Panicum turgidum* [8]. According to Berhanu and Tesfaye [34], there are additional plant species that are not included in *Atlas of the potential vegetation of Ethiopia* by Ib, Sebsebe [8]. These are *Acacia nilotica*, *A. senegal*, *A. etbaica*, *A. tortilis*, *A. brevispica*, *A. zanzibarica*, *A. oerfota*, *Balanites aegyptiaca*, *B. rotundifolia*, *Calotropis* sp., *Atriplex* sp., *Boscia angustifolia*, *Tamarix nilotica*, *Phoenix reclinata*, *Ficus* sp., *Cadaba rotundifolia*, *Capparis tomentosa*, *Terminalia brevipes* and *Phyllanthus* sp. Among the grasses are *Setaria*, *Hyparrhenia*, *Eragrostis*, *Cenchrus*, *Sorghum*, *Ochtochloa*, *Dactyloctenium* and members of the *Aristidae*.

4.2. Acacia-Commiphora Woodland and Bushland Vegetation

This vegetation type is common in dry lowland areas. It covers a larger area, has complex and many vegetation types. This ecosystem is found within an altitudinal range of 900 and 1,900 masl, but according to Ib, Sebsebe [8], the vegetation type can stretch up to 400 masl. It covers part of

the southern and eastern lowlands and the rift valley areas of Ethiopia (Ethiopian Biodiversity Institute 2015). As a result of its diverse vegetation and location, the vegetation is divided into two subtypes: those vegetation located in the rift valley areas as one group and the other found in lowlands of eastern and southern Ethiopia as another category. The second subtype covers large areas and it lets to constitute varied vegetation types [8].

This vegetation type has a total of 565 species, subspecies and varieties of vegetation and 286 of them are exclusively found in this ecosystem. However, the rest species are shared with another ecosystem such as desert and semi-desert scrublands, dry evergreen Afromontane forest and grasslands, Combretum-Terminalia woodland and wooded grassland, riverine vegetation, salt-water lakes, salt-lake shores, marsh, and pan vegetation. In terms of its floristic, *Acacia-Commiphora woodland and bushland* is the most diverse vegetation among all vegetation types in Ethiopia [8]. It is characterized by large variations in soil, topography, and diverse biotic and ecological elements. Most of the plant species have small deciduous or leathery evergreen leaves [35].

According to Ib, Sebsebe [8], the vegetation is broadly sub-grouped into two vegetation categories with known geographic areas. These are *Acacia-Commiphora woodland and bushland proper*, and *Acacia wooded grassland of the Rift Valley*.

I. Acacia-Commiphora woodland and bushland proper subtypes are drought-resistant trees and shrubs either deciduous or small evergreen leaves, or lianas are not common species. The most common species are *Acacia bussei*, *A. drepanolobium*, *A. hamulosa*, *A. ogadensis*, *A. prasinata* (endemic), *A. reficiens*, *A. tortilis*, *A. zizyphispina*, *Boswellia microphylla*, *B. neglecta*, *Commiphora alaticaulis*, *C. albiflora*, *C. ancistrophora*, and soon. Succulents are prominent and all of the followings are endemic species, such as *Euphorbia awashensis*, *E. monacantha*, *E. burger*, *E. cyptocaulis*, *E. dalettiensis*, *E. gymnocalycioides*, *E. longispina*, etc. [8, 32].

This sub vegetation type is found in areas with an elevation range from 400-1900masl in the lowlands of southern, southeastern and western part of Ethiopia [8]. According to Song, Nigatu [36], bushland often occurs in areas with shallow soil and steep sloppy areas like hills, escarpments, mountains, and gorge slopes. At the bottom, the vegetation is dominantly grass and it created bush-grass complex. The dominant woody species of bushland are *Maytenus senegalensis*, *Carissa spinarum*, *Clausena anisata*, *Clerodendrum myricoides*, *Grewia ferruginea*, *Caesalpinia decapetala*, *Ficus verruculosa*, *Calpurnia aurea*, *Erica arborea*, *Hypericum revolutum*, *Vernonia* spp., *Senna* spp., *Cordia* spp., *Acacia* spp., *Commiphora Africana*, and *Indigofera* spp.

II. Acacia wooded grassland of the Rift Valley

It extends from an upper part of the Awash River in the north and extends up to the town Konso in the south by including the Rift Valley lakes. This category of the

ecosystem has dominantly acacia species. It is resembling with acacia dominated wooded grasslands of Gambella area. The rift valley vegetation is differed from Gambella vegetation by the absence of flooding and grass fire, and have tree composition from *Acacia albida* and *Acacia tortilis* [8].

The tree layer mainly composed of *Acacia* species of *A. etbaica*, *A. seyal*, *A. albida*, *A. tortilis*, *A. Senegal*, etc. The other species types are *Croton dichogamus*, *Euphorbia*, and grasses like *Heteropogon*, *Setaria*, *Sporobolus*, and *Panicum*. There are also the some succulents *Aloe trichosantha*, *A. gilbertii* subsp. *Gilbertii* and *Euphorbia nigrispinioides* [8].

4.3. Wooded Grassland of the Western Gambella Region

It is characterized by a tall grass layer and tree canopy that resist fire burning and temporary flooding. In terms of species diversity, the ecoregion has less diversity. The total number of species recorded is about seven varieties and of which only one species exclusively exist in the site. All the rest varieties are also recorded and exist with the nearby another ecoregion. The authors suspected that the low number of species varieties may be due to lack of detail study because most types of species that knew in the area are herbaceous flora particularly grass species [8]. According to Awas, Bekele [37], the common grass species are *Loudetia arundinacea* (Hochst. Ex A. Rich), *Hyparrhenia pilgeriana* C. E. Hub., *H. filipendula* (Hochst.) Stapf, *Andropogon schirensis* Hochst. Ex A. Rich, *Rottboellia cochinchinensis* (Lour.) Clayton and *Panicum maximum* Jacq. However, the recent report by Ib, Sebsebe [8], mentioned only *Hyparrhenia* from the common grass species listed by Awas and other in 2001 and list other grass species types as common like *Echinochloa*, *Setaria*, *Cymbopogon*, and *Sorghum*. The ecology has fire resistance deciduous woodland tree species of *Combretum collinum*, *Lonchocarpus laxiflorus* Guill. & Perr., *Pterocarpus lucens* Guill. & Perr. *Sterculia Africana* (Lour.) Fiori and *Entada Africana* Guill. & Perr. Ib, Sebsebe [8] listed acacia species like *A. seyal* and *A. nilotica* are the most dominant woody species in the area, which the previous study by Awas, Bekele [37] did not mention. The area has lands covered with river water flooding which is harbor water-loving species like *Caperonia serrata* and *Thalia geniculata* [8].

4.4. Combretum-Terminalia Woodland and Wooded Grassland

This ecosystem constitutes species from the genera of *Combretum* and *Terminalia* (Combretaceae) and woody species from Fabaceae of *Lonchocarpus laxiflorus*, *Pterocarpus lucens*, *Dalbergia melanoxylon* and *Piliostigma thonningii* as an example, but no from *Acacia* species. *Acacia* species are observed in areas that have vertisols. They are usually located in humid lowland areas or river valleys of the country. The understory is a mixture of herbs and grasses and the vegetation is characterized by small to moderate-sized

trees and they are large of deciduous leaves. Many grass species are well developed and many of them *Hyparrhenia*, *Panicum* and *Pennisetum* genera are tall grass. However, during the dry season, the grasses are burnt to sprout new grasses [8, 36].

This ecosystem has a total of 199 species, subspecies, and varieties of woody plants, of which 81 of them is recorded only in *Combretum-Terminalia* woodland, and wooded grassland ecosystem. Floristically, it is relatively diverse with a high amount of unique subspecies, species, and varieties. The rest 118 species, subspecies and varieties are shared with other ecosystem groups and the highest amount is shared with *Dry evergreen Afromontane forest and grassland complex* (74 species). The remaining are shared with *Acacia-Commiphora* woodland and bushland (50 species), with *Riverine vegetation* (13 species), with *Wooded grassland of the western Gambella region* (five species); three species are commonly recorded with *Desert and semi-desert scrubland*, *Moist evergreen Afromontane forest*, *Transitional rain forest*, and *Ericaceous belt*. The non-adjacent *Afro-alpine belt* shares one species in common [8].

This vegetation type constitutes a lot of species, but the most common species are *Cussonia arborea*, *Boswellia papyrifera*, *Anogeissus leiocarpa*, *Combretum adenogonium*, *C. hartmannianum* (near endemic), *C. molle*, *C. rochetianum* (near-endemic), and *C. collinum*. There are species type from *Terminalia*: *Terminalia laxiflora*, *T. macroptera*, and *T. schimperiana*; *Lonchocarpus laxiflorus*, *Pterocarpus lucens*, *Dalbergia melanoxylon*, *Piliostigma thonningii*, *Balanites aegyptiaca*, *Stereospermum kunthianum*, *Lannea barteri*, *L. ruticosa*, *L. schimperi* and *L. schweinfurthii*; *Ozoroa pulcherrima*, *Sclerocaryabirrea* subsp. *birrea*, *Vitexdoniana*, *Acacia hockii*, and *Grewia mollis*. The number of woody species recorded in this vegetation type is less than 100 types, even it is lower than the species recorded in *Acacia-Commiphora* woodland and bush land. The shrubby-herb species found in the group are less common in other vegetation categories. These species include *Clerodendrum alatum*, *Dicoma sessiliflora* and *Ochrocephala imatongensis* [8]. According to Ib, Sebsebe [8] the vegetation type found in the western escarpment of the Ethiopian plateau stretches from the Ethio-Eritrea border to western Kefa and the Omo Zone. It also found in Benshangul-Gumuz, and Gambela Regions, and the Didesa valley. It also found in central, northern, south-western and eastern part of the country.

4.5. Dry Evergreen Afromontane Forest and Grassland Complex

One of the complex vegetation types in Ethiopia that constitute grasslands, shrubs, various sized trees and a closed canopy forest that composed various strata. However, the agricultural practices in Ethiopia seriously affected this ecosystem mainly in the northern part of the country and most of the bushlands area now were part of this group. Similarly, the southwestern forest and grassland complex are also affected by human activities such as clearing the forest for coffee and tea plantation, expansion of subsistence

farming and resettlement program expansion in the area reduced the forest coverage of the area [8, 38].

The total plant variety recorded is 460 species and of these 128 have only been recorded from this vegetation type. The rest is shared with adjacent and non-adjacent vegetation types. It shares highest species with Riverine vegetation and Acacia-Commiphora woodland and bush land (102 species); with Moist evergreen Afromontane forest (89 species), 74 species with Combretum-Terminalia woodland and wooded grassland, 56 with Ericaceous belt; 20 are shared Afro-alpine belt, 15 with Transitional rainforest, three are shared with Desert and semi-desert scrubland, two are shared with Wooded grassland of the western Gambella region (WGG); one species is shared with Fresh-water lakes, lakeshores, marsh and floodplain vegetation [8]. Based on floristic diversity, it is the second diverse vegetation after Acacia-Commiphora woodland and bushland.

Geographically, these vegetation types are distributed in highland areas with an elevation between 1800 and 3000 masl, except in the high rainfall areas like in western and south-eastern parts of the country- where it is a moist Afromontane forest. Most of the vegetation canopy is dominated by *Juniperus procera*, followed by *Olea europaea* subsp. *Cuspidate* and *Podocarpus falcatus*. The vegetation is subdivided into distinct groups. These are: Undifferentiated Afromontane forest, (which is either *Juniperus-Podocarpus* forests, or tend towards single dominant *Podocarpus* or *Juniperus* forests, both with an aggregate of broad-leaved species), Dry single-dominant Afromontane forest of the Ethiopian highlands, Afromontane woodland, wooded grassland and grassland, Transition between Afromontane vegetation and Acacia-Commiphora bushland on the Eastern escarpment [8].

Forests are classified as moist or dry using climatic limits. A forest is grouped as dry when the drought period is about half the year in one or two periods and annual precipitation of between 400 - 1700 mm. The moist forests delimited when the climate has a period of at least six months of rainfall in one period and annual precipitation of at least 1700 mm [39]. Dry Evergreen Montane Forests occur in a wide range of altitude and is designated as a very complex vegetation type. These types of forests develop in areas of relatively high humidity, but not much rain ranging from 4-8 months and have inconsistent rainy periods. Both moisture stress and temperature increase in the ecology are common during the dry season [18].

4.6. Moist Evergreen Afromontane Forest

It is characterized by the existence of strata of the highest rich up to 40 meters long and evergreen trees. Before the 2010 vegetation classification in Ethiopia, this vegetation constitutes two subtypes: the Afromontane rainforest and the transitional rainforest [8]. The moist evergreen Afromontane forest found in the southwestern highlands between an elevation of (1500-) -1800 and 2600 (-3000) meters and an annual rainfall of 700-2000 millimeters and above. It also comprises Haremma forest on the southern slopes of the Bale

Mountains and a patch of forest in Wembera and around Wendo Genet. The dominant tree species are *Podocarpus falcatus*, *Pouteria (Aningerid) adolfriederid* and the mountain bamboo - *Arundinaria alpina* and many other medium-sized trees are common. It is an important source of timber and non-forest timber products [8, 40].

The total number of woody plant species recorded in this vegetation type are 135. However, only 18 of them are only recorded, but the rest 117 species are shared with the rest vegetation groups. The first highest species share is with Dry evergreen Afromontane forest and grassland complex (89 species), with Riverine vegetation (56 species), 36 species are shared with Transitional rainforest, seven species types with other non-adjacent species and three with Combretum-Terminalia woodland and wooded grassland. The moist evergreen Afromontane forest is moderately diverse, but a small number of unique woody species are existed [8].

The vegetation contains broad-leaved evergreen species in the multilayered canopy: upper, middle and lower layer. The upper layer has big sized trees like *Podocarpus falcatus*, *Pouteria (Aningerid) adolfriederid*. The middle layer has consisted of *Albizia gummifera*, *A. schimperiana*, *A. grandibracteata*, *Celtis africana*, *Sapium ellipticum*, *Macaranga capensis* var. *kilimandscharica*, *Croton macrostachyus*, *Euphorbia ampliphylla*, *Ekebergia capensis*, *Ficus sur*, *F. ovata*, *F. thonningii*, *Ilexmitis*, *Ocotea kenyensis*, *Olea welwitschii*, *Polyscias fulva*, *Schefflera abyssinica*, *Prunus africana*, and *Syzygium guineense* subsp. *afromontanum*. The lower layer is possessed by canopy of smaller trees of less than 10 meters high that includes *Allophylusabyssinicus*, *Deinbollia kilimandscharica*, *Apodytes dimidiata*, *Bersama abyssinica*, *Bucea antidysenterica*, *Erythrina brucei*, *Calpurnia area*, *Millettia ferruginea*, *Galiniera saxifraga*, *Canthium oligocarpon*, *Coffea arabica*, *Rothmannia urcelliformis*, *Chionanthus mildbraedii*, *Clausena anisata*, *Teclea nobilis*, *Vepris dainellii*, *Cyathea manniana*, *Dracaena afromontana*, *D. fragrans*, *D. steudneri*, and soon. This vegetation also constitutes Lianas and epiphytes. About 25 Liana species have been recorded. Many types of Epiphytes are that includes many species of ferns are common. The ground cover is rich with herbs where sunlight is sufficient [8].

According to Ib, Sebsebe [8], this vegetation type can be subdivided into two of which they are distinct subtypes. The first is Primary or mature secondary moist evergreen Afromontane forest which is then closed and mature forest. The second is Edges of the moist evergreen Afromontane forest, bushland, woodland and wooded grassland. The second type is represented in climax vegetation forest margins, clearings and areas where local edaphic or topographic conditions have favored the development of evergreen bushland, woodland, wooded grassland and grassland.

4.7. Transitional Rainforest

This vegetation type was recognized as independent vegetation in the 1970s by Chaffey and it was named by

“Lowland broadleaved forest”. However, it was merged under the moist Afromontane forest when the vegetation types of Ethiopia were grouped into nine types. Later when the vegetation types of Ethiopia were categorized into twelve types, the transitional rainforest stand as an independent vegetation type. This vegetation has 101 species type and varieties and 47 of them are recorded only in this vegetation type. The rest species were commonly recorded from the moist evergreen Afromontane forest (36 species), riverine vegetation (30 species), with dry evergreen Afromontane forest and grassland complex (15 species), three species are in common with Combretum-Terminalia woodland and wooded grassland.

Floristically, the Transitional rainforest constitutes more amount of unique plant species than moist evergreen Afromontane forest, which is the second next to Acacia-Commiphora woodland and bush land. The common species are *Manilkara butugi*, *Pouteria (Aningeria) altissima*, *Pouteria (Malacantha) alnifolia*, *Anthocleista schweinfurthii*, *Antiaristoxicaria*, *Ficus mucoso*, *F. exasperata*, *Milicia excelsa*, *Morus mesozygia*, *Trilepisium madagascariense*, *Alstonia boonei*, *Croton sylvaticus*, *Celtis toka*, *C. zenkeri*, *C. gomphophylla*, *Diospyros abyssinica*, *Lecaniodiscus fraxinifolius*, *Strychnosmitis* and others [8].

These forests are existing between 500 and 1500 meters altitude, common in the western lowlands, semi-deciduous of 15-20 meters height and similar in physiognomy and composition to the moist Afromontane forest. Epiphytic species are not common, but lianas are prominent in the lower strata of the forest.

4.8. Ericaceous Belt

An Ericaceous belt is developed on all high mountains of eastern Africa. The ericaceous belt is found in most mountainous areas of Ethiopia. Although the altitude range is varying from one mountain to another, mostly the ericaceous species exist between 3000-3200 meters. This vegetation type is found in between the montane forest and the alpine vegetation [8].

A total of 56 number of species, subspecies, and varieties of woody plants have been recorded in this vegetation types and none of them are exclusively found in the Ericaceous belt. All the species types are also commonly found with Dry evergreen Afromontane forest and grassland complex, 21 types with Afro-alpine belt; seven species types are found with moist evergreen Afromontane forest; three have been recorded from both this vegetation type and *Combretum-Terminalia* woodland and wooded grassland. Therefore, the Ericaceous belt has a low diversity, with no unique woody species, subspecies and varieties and all of them are shared with the adjacent vegetation types [8].

Physiognomically, these vegetation types are known by the existence of shrubs and shrubby trees like *Erica arborea*, *Erica (Phillipia) trimera*, *Hypericum revolutum*, and *Myrsine melanophloeos*. Perennial subshrubs or herbs are common. For instance, *Alchemilla haumannii*, *Geranium arabicum*, *Anthemis tigrensensis*, *Erigeron afroalpinum*, *Haplocarpha*

rueppellii, *Helichrysum citrispinum*, *H. splendidum*, *H. gofense*, *H. formosissimum*, *Senecio schultzii*, *Romulea fscheri*, *Satureja biflora*, *Thymus schimperii*, *Trifolium acaule*, and *T burchellianum*. Ferns are common particularly belonging to the genus *Polystichum* [8]. This vegetation is common in highlands parts of Ethiopia such as Semien mountains, Choke mountains, Gurage mountains, Guge highlands and Gara Muleta mountain [8].

4.9. Afroalpine Belt

This vegetation type is found next to an ericaceous belt towards the peak of gigantic mountains and comprises of the Ethiopian massifs which have been dominated by mountain grasslands and scattered shrubs such as *Helichrysum* and *Alchemilla* species with scatter stands of the endemic giant lobelia (*Lobelia rhynchopetalum*) [8, 40]. The belt is characterized by five distinct life forms: “giant rosette plants, tussock grasses (and sedges), acaulescent rosette plants, cushion plants, and sclerophyllous shrubs (and dwarf-shrubs)”. Immediately after the Ericaceous belt, small-sized trees, shrubby herbs are abundant. Moving far to the upper part of the mountains, the vegetation is dominated by giant herbs, small herbs, and grasses. It is commonly found in areas above 3200 meters, however, it is not common in all mountainous areas with elevation above that [8].

The number of species is too small, which is 22 types of which only single species are recorded, but the rest is shared with other vegetation types. For instance, 21 species are also recorded from the Ericaceous belt and 20 types found commonly with Dry evergreen Afromontane forest and grassland complex. The most common vegetation types are giant Lobelias, *Helichrysum*, *Alchemilla*, and *Festuca*, *Poa*, *Deschampsia*, etc grass types which are common in the temperate region. *Maytenus cortii* woody species are found in areas with elevation above 3500masl, which is above the boundary limit of the Afroalpine vegetation types [8].

4.10. Others

Riverine vegetation

This vegetation is commonly found in riversides. Ethiopia has a large number of rivers and tributaries. All the rivers and their tributaries have riverine forests in areas below approximately 1800 meters altitude. The vegetation constitutes tall trees and riparian woodlands. The total number of vegetation types recorded in this group are 242 varieties and 64 of them are only available in riverine vegetation. A large number of vegetation types, 102 vegetation types, are shared with dry evergreen Afromontane forest and grassland complex, 56 species are commonly shared with Moist Afromontane forest, 32 species types with Acacia-Commiphora woodland and bushland, 30 with Transitional rainforest, 13 with Combretum-Terminalia woodland and wooded grassland, 10 with desert and semi-desert vegetation, and three vegetation types with Ericaceous belt. Floristically, it is moderately diverse, but with a relatively low number of unique woody species [8]. The

vegetation type is highly variable in structure and density, which is linked to altitude and geographical location. The woody species common in riverine forests are *Acacia polyacantha*, *Celtis Africana*, *Ficus sycomorus*, *Mimusops kummel*, *Mimusops laurifolia* and *Breonadia salicina*. There are many types of species that is found in this vegetation types like *Lepisanthessen-egalensis*, *Salix subserrata*, *Trichilia emetica*, *Diospyros mespiliformis*, *Syzygium guineense subsp. Guineense*, *Phoenix reclinata*, and others. Some of the known species in riverine vegetation are *Abrus canescens*; *Abutilon mauritianum*; *Acacia robusta*; *Acalypha Jruticosa* var. *eglandulosa*; *A. Jruticosa* var. *Jruticosa*; *Acridocarpus ugandensis*; *Antidesma venosum*; *Artabotrys monteiroae*; *Breonadia salicina*; *Bridelia atroviridis*; *Cocculispendulus*; *Combretum capituliflorum*; *Diospyros scabra*; *Dregea abyssinica*; *Euphorbia goetzei*; *Feretia apodanthera*; *Ficus capreaejolia*; *F. vallis choudae*; *Garcinia livingstonei*; *Gomphocarpus semilunatus*; *Gymnema sylvestre*; *Hibiscus diversifolius*; *H. rostellatus*; *Hypericum gnidifolium*; *Kanahia carlsbergiana* [8].

The most types of riverine forests, mainly along the rivers running to the west, have a ground-cover includes grasses, ferns, and a few herbaceous dicotyledons. The rivers running to the east have a very sparse or no ground cover, except for annual species germinating during the rains.

Freshwater lakes, lake shores, marsh, and floodplain vegetation

Freshwater lakes refer when the salt concentration is below 1000 parts per million, however, in this vegetation group, lakes that have below 3000 parts per million is used as fresh lakes although the salt concentration is high. Lakes such as Langanoo (1800 parts per million) and Rudolf (Lake Turkana) has 2800 parts per million, grouped as fresh lakes and they have green algae and cyanobacteria. Floristically, this vegetation type has eight species and all of them are also available in the riverine forest. One species is commonly available with Dry evergreen Afromontane forest and grassland complex. It has low species diversity and none of them are exclusively restricted to this vegetation type.

This vegetation type refers to vegetation that is found in fresh-water lakes with open water, on lakeshores, in marshes and floodplains. As a result, it is subdivided into two: freshwater lakes-open water vegetation and freshwater marshes and swamps, floodplains and lakeshore vegetation.

Open fresh water lakes vegetation is found in the open water in lakes with an extensive water surface. Aquatic and phytoplankton species are common. This vegetation is found in major freshwater lakes of Ethiopia: Lake Tana, Ashenge, Hayk and Ardibo, Langano, Ziway, Hawassa, Abaya, Chamo, Turkana and the crater lakes in Bishoftu town, Lake Ziquala, Hareshetan, and Zengena. It includes reservoirs of Koka, Fincha, Gilgel Gibe I and Melka Wakena [8]. The second subgroup is freshwater marshes and swamps, floodplains and lakeshore vegetation. Marshes and swamps have a slight variation in vegetation types, marsh includes vegetation on wetlands dominated by grass, rushes, reeds, *Typha* spp. and other herbaceous plants. However, swampy vegetation

includes shrubs and trees together with herbs. This vegetation type is common in the western and central Ethiopia [8].

Along the sides of rivers, the flatlands are affected by river water during the summer season and it favors the growth of vegetation which may be riverine vegetation or swampy and marsh vegetation. Mainly in the western and southwestern part of Ethiopia, the river may develop seasonal wetlands. Such an area is covered with grass and leaf-rosettes of *Lannea edulis*.

The dominant species in this vegetation types are sedges like *Cyperus digitatus*, *C. denudatus*, *C. dichroostachys*, *C. elegantulus*, *C. latifolius*, *Ascolepis capensis*, herbs like *Juncus dregeanus*, *Floscopa glomerata*, *Syngonanthus wahlbergii*, *Persicaria decipiens* and other *Persicaria* spp. (*Polygonaceae*), *Ludwigia abyssinica*, *Chenopodium album*, *Ranunculus multibus*, and many others. The woody species are *Phoenix reclinata* and various *Sesbania* types [8].

Salt lakes, salt-lake shores, marsh, and pan vegetation

This includes vegetation that can adapt salt concentration in water. Only one woody plant species are recorded, which is called *Suaeda monoica*. But, no species, subspecies, and variety of woody species have been recorded from both this vegetation type and other adjacent vegetation types. Floristically, among all vegetation types in Ethiopia, it has very low species diversity. This vegetation type is divided into two subtypes. (1) Salt lakes - open water vegetation. This includes saline lakes which have no outlet, rather the water is evaporated and resulted in more salt concentration. Such an area is possessed by the family of *Chenopodiaceae* and cyanobacteria. The lakes are Abijata, Shalla, and Chitu. They have more sodium amounts; the temperature is high and leads to lake water evaporation. (2). Saltpans, saline Arackish, and intermittent wetlands and salt-lake shore vegetation. The common vegetation types are *Suaeda monoica* woody species and *Chenopodiaceae* herbaceous species. Such vegetation is restricted to the Danakil Depression in the Afar region, some lakes in the central and southern part of the Rift Valley areas and along the River Wabishebele [8].

5. Summary

Vegetation types in Africa are diverse and it can be grouped into different categories. Based on the physiognomic characters, the vegetation is grouped at the highest rank into sixteen types. These were classified using physiognomy characters like height, density, thorniness, deciduousness and soon. Recently, these are minimized into five major vegetation category that constitutes all the vegetation types of the continent. These were forest which constitutes closed tropical rainforest of lowlands, closed evergreen montane and sub-montane forests and mosaic forest/savanna. The second group was the woodland and shrubland vegetation that is diverse in its types. It includes the woodland, shrubland, thicket, savanna and dry forest. The vegetation has deciduous species, shorter height than moist forest trees experiences the climate of the dry season and canopy cover of less than 10%. The grasslands, the third group, is the most extensive biome and has dominantly grasses and grass-like plants or herbs

with less or no woody plants, and dominantly perennial species. The other is swamp and mangrove vegetation. This vegetation is linked with water influences. They are developed along the side of rivers and at the coastal lands due to the existence of flooding impacts. It is sub grouped into the swamp and mangrove forest- where the forest is formed, and swampy and mangrove shrub and grasslands.

The vegetation types in Ethiopia were grouped into various category by different authors at different times. It was grouped into 24 types in 1957 by Pichi Sermolli using their physiognomic criteria, later grouped into nine by Sebsebe Demsew and others in the 1990s. After the 1990s the vegetation has a new classification that has 12 major and 12 subgroup types. From the category, Acacia-Commiphora woodland and bush land have the largest number of species of which about 286 species are not available in other categories. The salt-water lakes, shores, and salt marshes and pan vegetation category have only single species, *Suaeda monoica*, which is absent in the rest category.

Acknowledgements

The author would like to thank Debre-Berhan and Addis Ababa University for the facilities provided to the author during this review work write-up.

References

- [1] Matthews, E., *Global vegetation and land use: New high-resolution data bases for climate studies*. Journal of climate and applied Meteorology, 1983. 22 (3): p. 474-487.
- [2] Wong, T., C. O. Delang, and D. J. G. Schmidt-Vogt, What is a forest? Competing meanings and the politics of forest classification in Thung Yai Naresuan Wildlife Sanctuary, Thailand. 2007. 38 (4): p. 643-654.
- [3] Mueller-Dombois D. Classification and mapping of plant communities: a review with emphasis on tropical vegetation. The role of terrestrial vegetation in the global carbon cycle: Measurement by remote sensing. 1984: 19-88.
- [4] De Cáceres, M., et al., A comparative framework for broad - scale plot - based vegetation classification. 2015. 18 (4): p. 543-560.
- [5] White, F., UNESCO/AETFAT/UNSO Vegetation Map of Africa, Scale 1: 5 000 000. 1981: UNESCO.
- [6] Mayaux, P., et al., A land cover map of Africa. Carte de l'occupation du sol de l'Afrique. European Commission, Joint Research Center, EUR, 2003. 20665.
- [7] Soromessa, T., D. Teketay, and S. Demissew, Ecological study of the vegetation in Gamo Gofa zone, southern Ethiopia. Tropical Ecology, 2004. 45 (2): p. 209-222.
- [8] Ib, F., D. Sebsebe, and P. v. Breugel, Atlas of the potential vegetation of Ethiopia. 2010: Det Kongelige Danske Videnskabernes Selskab.
- [9] Tadesse, W., G. Desalegn, and R. Alia, Natural gum and resin bearing species of Ethiopia and their potential applications. Forest Systems, 2007. 16 (3): p. 211-221.
- [10] Dibaba, A., et al., Diversity, structure and regeneration status of the woodland and riverine vegetation of Sire Beggo in Gololcha District, Eastern Ethiopia. Momona Ethiopian Journal of Science, 2014. 6 (1): p. 70-96.
- [11] Woldu, Z., et al., Forests in the vegetation types of Ethiopia and their status in the geographical context. 1999.
- [12] Demissew, S., I. J. F. o. E. Friis, and Eritrea, Natural vegetation of the Flora area. 2009. 8: p. 1-7.
- [13] Pichi-Sermolli, R. E., Una carta geobotanica dell'Africa Orientale (Eritrea, Etiopia, Somalia). Webbia, 1957. 13 (1): p. 15-132.
- [14] Ethiopian Panel on Climate Change (EPCC). 2015. First Assessment Report, working Group II Biodiversity and Ecosystems, Published by the Ethiopian Academy of Sciences <EPCC_First_Assesment_Reports_English_EAS.pdf>.
- [15] Gough, D., S. Oliver, and J. Thomas, An introduction to systematic reviews. 2017: Sage.
- [16] Greenway, P. J., A classification of the vegetation of East Africa. Kirkia, 1973. 9 (1): p. 1-68.
- [17] Kindt, R., et al., Potential natural vegetation of eastern Africa. Volume 2: Description. and no. Forest & Landscape Working Paper 62-2011, 2011.
- [18] Wassie, A., Forest Resources in Amhara: Brief Description, Distribution and Status, in Social and Ecological System Dynamics. 2017, Springer. p. 231-243.
- [19] Neeff, T., H. Von Luepke, and D. Schoene, Choosing a forest definition for the Clean Development Mechanism. 2006.
- [20] Cochrane, Mark A. "Introduction to AMA Aubréville's Article." *Fire Ecology* 9, no. 2 (2013): 1-2.
- [21] Fisher, J. B., et al., African tropical rainforest net carbon dioxide fluxes in the twentieth century. Phil. Trans. R. Soc. B, 2013. 368 (1625): p. 20120376.
- [22] Malhi, Y., et al., African rainforests: past, present and future. Phil. Trans. R. Soc. B, 2013. 368 (1625): p. 20120312.
- [23] Baudena, M., et al., Forests, savannas and grasslands: bridging the knowledge gap between ecology and Dynamic Global Vegetation Models. Biogeosciences, 2015. 12: p. 1833-1848.
- [24] Cuni-Sanchez, A., et al., African savanna-forest boundary dynamics: a 20-year study. 2016. 11 (6): p. e0156934.
- [25] Kindt, R., et al., Potential natural vegetation of Eastern Africa (Ethiopia, Kenya, Malawi, Rwanda, Tanzania, Uganda and Zambia): Volume 5: Description and tree species composition for other potential natural vegetation types (vegetation types other than forests, woodlands, wooded grasslands, bushlands and thickets). 2011.
- [26] Eshete, A., F. Sterck, and F. Bongers, Diversity and production of Ethiopian dry woodlands explained by climate- and soil-stress gradients. Forest Ecology and Management, 2011. 261 (9): p. 1499-1509.
- [27] Kiruki, H. M., et al., The effect of charcoal production and other land uses on diversity, structure and regeneration of woodlands in a semi-arid area in Kenya. Forest ecology and management, 2017. 391: p. 282-295.

- [28] Chidumayo, E. N. and D. J. Gumbo, The dry forests and woodlands of Africa: managing for products and services. 2010: Earthscan.
- [29] Venter ZS, Cramer MD, Hawkins HJ. Drivers of woody plant encroachment over Africa. *Nature communications*. 2018 Jun 11; 9 (1): 2272.
- [30] Gibson, D. J., Grasses and grassland ecology. 2009: Oxford University Press.
- [31] Riginos, C. J. E., Grass competition suppresses savanna tree growth across multiple demographic stages. 2009. 90 (2): p. 335-340.
- [32] Liao C, Clark PE. Rangeland vegetation diversity and transition pathways under indigenous pastoralist management regimes in southern Ethiopia. *Agriculture, ecosystems & environment*. 2018 Jan 15; 252: 105-13.
- [33] Lemessa D, Teka Y. Patterns of the Diversity of Characteristic Species Across Vegetation Ecosystems of Ethiopia. *Ecology and Evolutionary Biology*. 2017 May 27; 2 (3): 34.
- [34] Berhanu, A. and G. Tesfaye, The Prosopis dilemma, impacts on dryland biodiversity and some controlling methods. *Journal of the Drylands*, 2006. 1 (2): p. 158-164.
- [35] Li, F., et al., Assessing the changes in land use and ecosystem services in Changzhou municipality, Peoples' Republic of China, 1991–2006. *Ecological Indicators*, 2014. 42: p. 95-103.
- [36] Song, C., et al., Mapping the vegetation of the Lake Tana basin, Ethiopia, using Google Earth images. 2018. 10 (4): p. 2033-2041.
- [37] Awas, T., T. Bekele, and S. Demissew, An ecological study of the vegetation of Gambella region, southwestern Ethiopia. *SINET: Ethiopian Journal of Science*, 2001. 24 (2): p. 213-228.
- [38] Addi A, Soromessa T, Kelbessa E, Dibaba A, Kefalew A. Floristic composition and plant community types of Agama Forest, an Afromontane Forest in Southwest Ethiopia. *J. Ecol. Nat. Environ*. 2016 May 31; 8 (5): 55-69.
- [39] Bekele, T., Vegetation ecology of remnant Afromontane forests on the Central Plateau of Shewa, Ethiopia. 1993: Sv. växtgeografiska sällsk.
- [40] Workie TG, Debella HJ. Climate change and its effects on vegetation phenology across ecoregions of Ethiopia. *Global Ecology and Conservation*. 2018 Jan 1; 13: e00366.