Characteristics of the Physicochemical Aloe Vera Gel as Edible Coating on Strowberry Fruit

By

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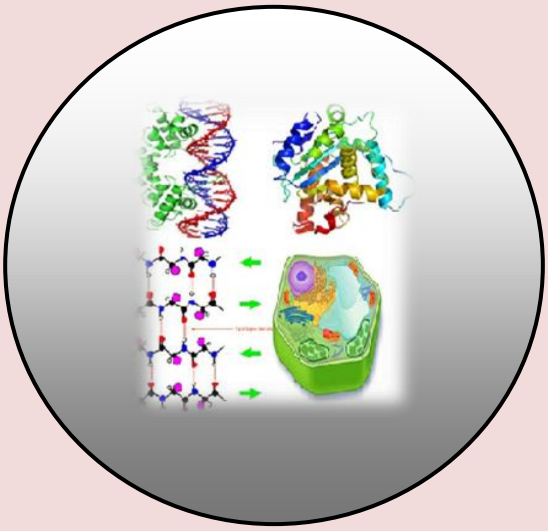

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RESEARCH PAPER

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Assessment of Plant Diversity and Structural Analysis of Majang Forest Biosphere Reserve, Majang Zone, Gambella Regional State, Southwest Ethiopia

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ABSTRACT
The study was conducted on Majang Forest Biosphere Reserve in Majang Zone, Gambella Regional State, and southwest Ethiopia with the aim of assessing floristic composition, diversity, and vegetation structure and regeneration status of the forest. A total of 187 plant species belonging to 143 genera and 70 families were recorded and identified. Euphorbiaceae, Fabaceae, Rubiaceae, Moraceae, Asteraceae were the most dominant family representing the highest number of genera and species except Moraceae which is represented by three genus followed by Combretaceae, Rutaceae, Acanthaceae, Poaceae, Sapotaceae with 6-3 genera and 6-5 species. R-software package was used for diversity analysis and six vegetation clusters are produced. The total basal area and IVI value of the Biosphere Reserve was computed to be 74.12 m^2 ha^{-1}, total density of 797.22 and total IVI value of 301.86 individuals' ha^{-1} respectively. The densities for mature plants, saplings and seedlings were (797.22), (1023.8) and (1542.7) individuals' ha^{-1} respectively. The population structure and regeneration status of the forest indicated good regeneration potential there are woody plants with no seedling and sapling at all within sample area showing anthropogenic disturbances and leads to immediate recommendation for conservation actions to be implemented for sustainable utilization and management of the forest.
Key words/phrases: Floristic Composition, Majang Biosphere Reserve and Sustainable Use.

INTRODUCTION
Among a total of 59.7 million ha of woody vegetation resources exist in Ethiopia, 6.8% is forest, 49% is woodland and 44.2% is shrub land. The high forests of the country are shown to be about 4.07M ha (3.6% of the total landmass) whereas, Woodlands and shrublands cover 29.24 and 26.4M hectares or 25.5 and 23.1% of the country's territorial surface, respectively (WBISPP, 2004).
Diverse physiographic, altitudinal, climatic, and edaphic difference enables Ethiopia to have various types of vegetation ranging from alpine to desert plant communities which provide economical, socio-cultural, and environmental benefits.

Most of the remaining forests of Ethiopia are confined to the south and southwest parts of the country are less accessible and less populated (Kumelachew Yeshitela and Tamrat Bekele, 2002). But, nowadays things are completely changed because of legal and illegal settlement and high population flow to these sacred areas in consequence of ever-increasing drought problems in the northern and eastern parts of the country for more than 2 decades.

Despite all their importance, however, the Ethiopian Afromontane forest fragments are continuously shrinking owing to deforestation (Reusing, 2000). To minimize loss of these forest fragments, understanding the ecological and anthropogenic factors involved in the process are highly important. Particularly, studies of plant species diversity have been very important issues for prioritizing conservation activities (Myers et al., 2000). Studying species richness patterns at different scales is very important both for ecological explanations and effective biodiversity conservation design.

The rural people's indigenous institution of the local culture included all ideas, structures, and practices which 'influence' issues such as access to and control over natural resource, and arbitrate contested resources claim. Indigenous or local people's ideas about their relation with environmental and nature practices are argued to be the result of years of experimentation and to be adaptive. In various part of the world traditional farming and natural resource management have been practiced by local communities since time immemorial (Watson, 2006).

MATERIAL AND METHODS

Description of Study Area

The Majang zone is one among the three administrative classes of the Gambella Regional state that borders Sheka and Bench Maji zones of SNNPR in southeastern, Ilu aba bora zone of Oromiya Regional State.This Zone covers the extent of the original special woreda of Godere, that was made to be part of the 2 administrative Zone subsequently between 1994 and 2001, but a number of kebeles were split off to create Mengesh and both woredas became Majang Zone (Gatwech, 2006).

The Majang zone constitutes only 6.62% of the total land area and 19.3%of the total number of regional population with the density of 26.28 persons per square kilometer and implying it the most densely populated zone of the three administrative classes of the regional state. Godere and Mengeshi are the most densely populated woredas with a density of (65.43%) and (17.62%) respectively occupying the first (1st) and fifth (5th) rank relative to all other districts of the region (CSA, 2007).

The Majang Forest Biosphere Reserve is located in Gambella Regional State, Southwest Ethiopia (Figure 1). Based on sample data from current study, Majang Biosphere Reserve is located between 07°08'-07°23' latitude and 035°04'-035°19' longitude. It also has an altitude ranging from 796m to 1335m above sea level. Friis, 1992 stated that the area has an altitude of 500m to 2400m with the natural forest area in the range between 500-1500m above sea level.

Demographic Information

The Majang zone has a total population of 59248, of whom 30567 are men and 28681 women with an area of 2254.65 square kilometers. Majang zone has a population density of 26.28 and 7140 or 12.05% are urban inhabitants. The zonal administration has a total of 15661 households with an average of 3.8 persons per household and 15242 housing units (CSA, 2007).

The main ethnic groups the zone are the Amhara (26.96%), Kafficho (25.17%), Majang (16.86%), Shakacho (11.67%), Oromo (8.84%) and all other ethnic groups 10.5%. The main Languages spoken in this zone include Amharic (37.08%), Kafa (22.89%), Sheko (12.78%) and Afan Oromo 9.91% and only a negligible number of inhabitants speak Majang. The religion with the largest number of follower is Orthodox Christian with 46.5% of the population, while other groups with sizable number of followers including Protestant, 36.4%, and Islam 15.42% (CSA, 2007).

The Majang people are the third largest indigenous ethnic group in the Gambella regional state. Their language is classified under the Nilo-Saharan Surmic African language cluster. As such, it differs considerably from either the Anywa or the Nuer languages (Stauder, 1971). The total population of Majang (native residents of the area) is estimated to be 15341 (CSA, 2007). They live in scattered settlements in the hills and forests between the lowland Gambella region and highland Ethiopia. The Majang zone comprises of two woredas Godere and Mengeshi as administrative clusters (Gatwech, 2006).

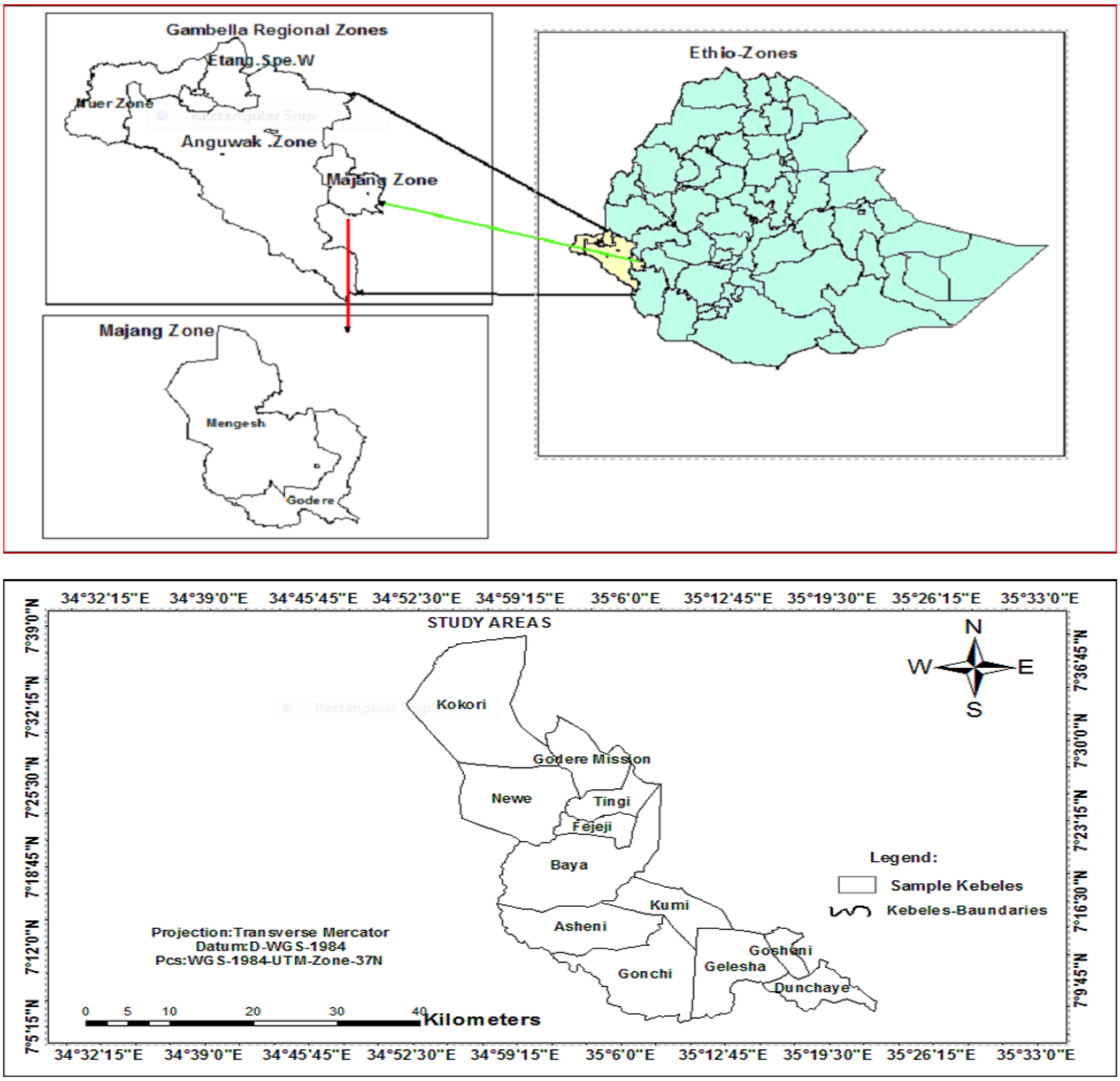

Figure 1. Map of the Study Area.

Climate and Agroclimatic Zones

Temperature and Rainfall

Based on 10 years data, the mean annual rainfall in the study area is about 1566 mm, rainfall peak period between May to October, and decreasing in November and December with little or no rainfall in January and February. The mean annual temperature is about 16.6^{0}C and the mean minimum temperature is 10.78^{0}C whereas the mean maximum temperature is 22.32^{0}C. There is slight temperature difference throughout the year. The hottest months are from February to May maximum temperature recorded is about 24.6^{0}C (in April/May) and the coldest months are from July to December with the mean minimum temperature 9.8^{0}C.

The climate of the area is a hot and humid type (Tadesse Woldemariam and Feyera Senbeta 2006), and Meteorological data obtained from National Meteorology Service Agency (Addis Ababa) indicate that Godare district receives high rainfall between mid-March to October and low rainfall from November to February. The highest annual mean rainfall of the study area within twelve years (1998-2009) is 2726.7mm. The lowest mean monthly temperature is 13.2°C and the highest mean monthly temperature is 33.1°C with an average temperature of 22.2°C (Bilew Alemu *et.a.l*, (2015).

On the basis of altitudinal variations, agroclimatic zones Majang zone is characterized by dry and moist Woinadega, moist and wet Kolla with an altitude of 1500-2300m and 500-1500m above sea level (Azene Bekele, 2007). But nowadays, these situations are slightly changing because of population and investment pressure that resulted in fast deforestation particularly in forest area and micro-agroclimates are transforming into dry Kolla and moist Bereha with annual rainfall less than 900mm and with an altitude ranging between 500m-1500m and less than 500m respectively above sea level.

Topography and Drainage System

The Majang Forest Biosphere Reserve has an altitudinal range between 500m and 2400m and with the natural forest area in the range between 500-1500m above sea level (Friis, 1992). The forest biosphere endowed with various topographic land forms and several streams and rivers such as Tenshu-Elewero, Guchi, Elewero, Choshi, Biza, Shisha, Sulin, Kawi, Gondere, Gebuy, Waki, Fejeji, Kati, Gemadero, Gonji, Yeri, Gonchi, Gilo, Tingi, Yobi, and Dunchay are permanently flowing throughout the year. These all rivers and streams that are crossing and bordering the biosphere highly guaranty the future fate and overall survival of the forests. Others also provide the surrounding people with drinking water and other small scale services.

Agriculture and Livelihood Activities

The majorities of Majang people live in Godere and Mengeshi woredas and in some pocket areas of Gambella and Abobo. The Ethnic group is mostly residing in the forest areas of the region in which there are also dozens of untapped natural resources and for this reason their livelihood is associated with forest resources.

The Majang economy heavily relies on hunting and gathering forest products. Although farming has recently also been an important source of livelihood. For most, still agriculture plays only a supplementary role in their livelihoods (Kurimoto, 1996). The majang people mostly depend on beekeeping and also practice some cultivation in settlement areas (Abraham, 2002). The majang native dwellers represent approximately 5% of the total regional populations.

Evidences showed that in typical settlements from January-April, Majang would be out in the forests collecting honey from hives consisting of hollowed logs placed in branches of tall trees. During the rainy season that lasts probably from May-August, they usually practicing agriculture and from October-December they mainly rely on collecting wild roots, fruits and occasionally eat them together with farm products. Generally speaking, in the majority of Majang settlements, agriculture seems to cover only 1/3 of their annual livelihood needs; the rest being covered by the forest in particular and other natural environment products (Ojulu, 2013).

Reconnaissance Survey

Reconnaissance survey was made during the second half of October 2017 few days before the actual data gathering in order to obtain an impression and accessibility of the study site and make justifiable decision in selecting representative sample size of the forest biosphere reserve.

Sampling Design

Systematic sampling technique was used to collect vegetation data (Kent and Coker, 1992). Sampling sites were arranged along transects and sample plots of 25 m x 25 m were taken at distance of 200m interval from each other. A total of 46 quadrats were laid for vegetation data collection. Five 2m x 2m and 1m x1m subplots were laid down; one at each corner and one at the centre of the main plot was used to collect seedling and sapling and herbaceous data respectively.

Plant community structure, species composition and diversity analysis of Majang Forest Biosphere Reserve (MFBR) was conducted for seven line transects were laid down starting from the bottom valley to the top of the ridge. Sample quadrats of 25m x 25m ($625m^2$) were considered for trees, shrubs and lianas whereas 2m x 2m ($4m^2$) and 1m x 1m ($1m^2$) were laid down for herb species and sapling and seedling respectively within the main sample quadrats. Every quadrats were laid down with an interval of 200m distance between each plots along one transect line.

Floristic Data Collection

A total of 46 quadrats were sampled and a complete list of trees, shrubs, lianas and herbs was made in each plots. Every plant species encountered in each quadrat was recorded using their vernacular names and plant specimen were collected, pressed, identified and some complicated specimens were taken to the national herbarium of Ethiopian, Addis Ababa University for taxonomic identification by expertise using published volume of flora of Ethiopia and Eritrea, authenticated herbarium specimens and (Azene Bekele, 2007). Plant species occurring outside the plot were also collected and identified to produce a comprehensive list of the plant species diversity of the study area. All individuals of trees and shrubs with a diameter at breast height (DBH) ≥2.5m were measured to estimate basal area of overall biosphere reserve. The circumferences of all woody plants were measured and recorded using meter tape later converted to DBH in meter.

Floristic Data Analysis

A hierarchical cluster analysis was performed using R-Software to classify the vegetation into plant community types based on cover abundance data of the species. The data matrix contained 46 quadrats and 187 species. The indicator species in each community type were determined using Indicator Species Analysis (ISA) (Dufre´ne and Legendre, 1997). A species is considered as an indicator of a group when its indicator value is significantly higher in relation to others. The clusters were designated as plant community types and a name is given after two or three dominant or characteristic species.

Forest Regeneration Status

Regeneration status of the forest was analyzed by comparing saplings and seedlings with the matured trees, i.e., 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 = mature individuals); and if a species is present only in an adult form it is considered as not regenerating (Dhaulkhandi *et al*., 2008).

Vegetation Structural Analysis

Structural analysis of species can be done on the basis of frequency, density, abundance, basal area, and importance value index (IVI) of trees and shrub species. Importance value index was calculated by summing up relative frequency (RF), relative density (RD) and relative dominance (RDO) values for each species.

Plant Community Classification

Hierarchical cluster analysis was conducted to identify vegetation samples that are similar in terms of their woody species composition. The cover abundance data of species were used for the analysis. The plant community types were named after two or three dominant species selected using the relative magnitude of their mean cover abundance value.

RESULTS AND DISCUSSION

Floristic composition

A total of 187 plants species belonging to 143 genera and 70 families were recorded from the study area. Trees and shrubs together contribute 101species (54%) while herbs alone contribute 55 species (30%) and lianas and vines jointly contribute 26 species (14%) of the overall floristic composition of the Majang Forest Biosphere is respectively (Table 2). The most characteristic families dominating the area are Euphorbiaceae, Fabaceae, Rubiaceae, Moraceae, Asteraceae, Combretaceae, Rutaceae, Acanthaceae, Poaceae, Sapotaceae, Solanceae, Celastraceae, Commelinaceae, Meliaceae, and Ulmaceae. The family Sapindaceae, Dioscoreaceae, Vitaceae, Urticaceae, Tiliaceae and Asplinacae are each represented by three species and Oleaceae, Cucurbitaceae, Asparagaceae, Menispermaceae, Malvaceae, Violaceae, Apocynaceae, Balsaminaceae, Dracaenaceae, Boraginaceae, Amaranthaceae, and Araceae each contributing two species. Euphorbiaceae and Fabaceae are the most abundant family with (15) and (12) species followed by Rubiaceae and Moraceae each with 11 species whereas Asteraceae (9) and Combretaceae, Rutaceae, and Acanthaceae each with 6 species ranking 4th and 5th position.

Family Importance Value (FIV)

Family importance value for each family is given in Table 5. The current study revealed that the first four families (Euphorbiaceae, Fabaceae, Rubiaceae, Moraceae, Asteraceae, Combretaceae, Rutaceae, Acanthaceae, Poaceae, Sapotaceae, Solanceae, Celastraceae, Commelinaceae, Meliaceae, and Ulmaceae) together contributed about 57% to the FIV. Euphorbiaceae was recorded for its highest FIV (8%) followed by Fabaceae, Rubiaceae, Moraceae, Asteraceae, Combretaceae, Rutaceae, Acanthaceae toping 1-5 ranks. The family Euphorbiaceae, Fabaceae, Rubiaceae, Asteraceae, Acanthaceae and Poaceae contributes the highest number of genera.

Thirty six (36) plant families each contribute a single species to the Family Importance Value. In terms of life forms, Majang Forest Biosphere Reserve has normal distribution patterns of flora as displayed in (fig.2). The graph shows trees, herbs and shrubs followed by lianas, vines and ferns comprise the highest and lowest number of plant composition across the whole biosphere reserve.

Table 1.Total Number of Species Contributed by each Family.

	Families	No of Genera	No of Species
1	Euphorbiaceae	10	15
2	Fabaceae	9	12
3	Rubiaceae	10	11
4	Moraceae	3	11
5	Asteraceae	6	9
6	Combretaceae	3	6
7	Rutaceae	5	6
8	Acanthaceae	6	6
9	Poaceae	5	5
10	Sapotaceae	3	5
11	Solanaceae	2	5
12	Celastraceae	2	4
12	Commelinaceae	1	4
13	Meliaceae	3	4
14	Ulmaceae	1	4
15	Vitaceae	3	3
16	Aspleniaceae	1	3
17	Urticaceae	2	3
18	Tiliaceae	2	3
19	Asclepiadaceae	1	3
20	Sapindaceae	2	3
21	Dioscoreaceae	1	3
22	Oleaceae	2	2
23	Cucurbitaceae	2	2
24	Asparagaceae	1	2
25	Menispermaceae	2	2
26	Malvaceae	2	2
27	Violaceae	1	2
28	Apocynaceae	2	2
29	Balsaminaceae	1	2
30	Dracaenaceae	1	2
31	Boraginaceae	2	2
32	Amaranthaceae	2	2
33	Araceae	2	2
34	Families with single species	36	36

From the pairs of bar-graphs (fig.3) representing plant families, the 1st of each stands for genera and the 2nd of each stands for species. Accordingly, plant family with the highest number of genera and species are Euphorbiaceae, Fabaceae, Rubiaceae followed by Asteraceae while Moraceae is represented by only three genera and 11 species. The rest families are represented by almost equivalent number of genus and species.

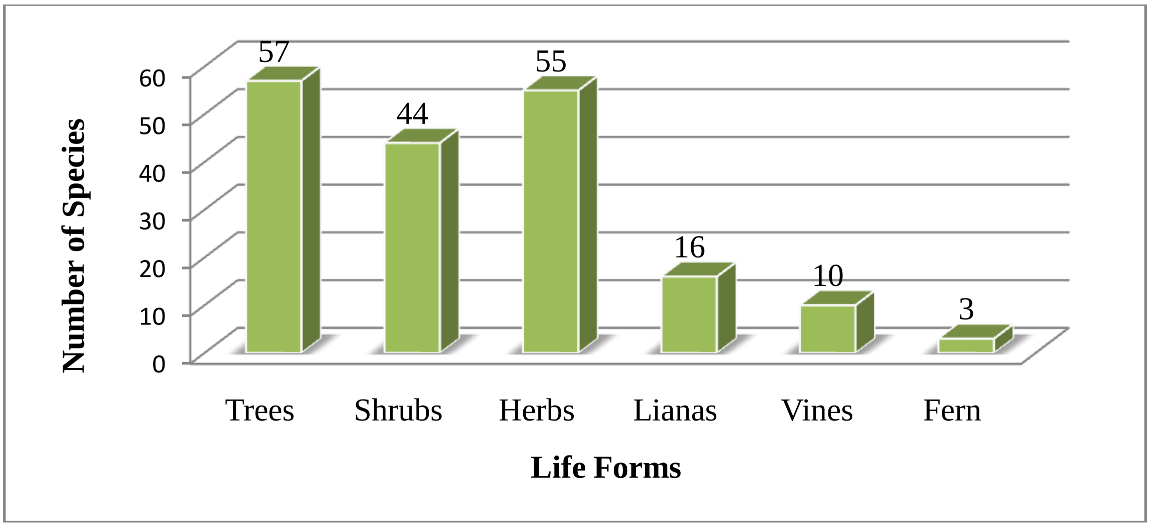

Figure 2. Floral distribution in terms of life forms.

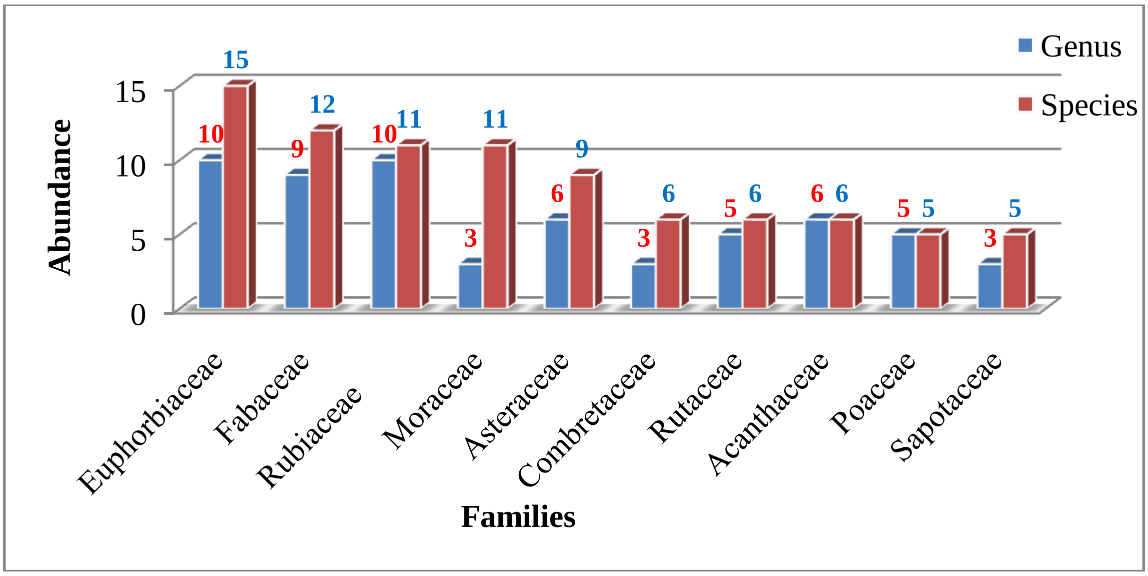

Figure 3. Distribution of plant genera and species in families.

Structural Analysis of Vegetation

Density

It is a count of the numbers of individuals of a species within the quadrat (Kent and Coker, 1992). It is closely related to abundance but more useful in estimating the importance of a species. Counting is usually done in quadrats placed several times in vegetation communities under study. Afterwards, the sum of individuals per species is calculated in terms of species density per convenient area unit such as a hectare (Mueller-Dombois and Ellenberg, 1974).

The density of trees and shrubs is expressed as the number of tree or shrub individuals per unit area. Density parameter is an important parameter for forest evaluation and also helpful for determining regeneration status of a forest. The total density of individual woody plants with DBH ≥2.5m is computed for all woody plant species. The total density of the forest is calculated as 797.22 individuals' ha^{-1}. Rinorea friisii, Pouteria altissima, Baphia abyssinica, Argomuellera macrophylla, Ficus vallis, Alchornea laxiflora, Dracaena fragrans, Blighia unijugata, Acalypha acrogyna, Erythrococca trichogyne, Pisonia aculeate, Pouteria alnifoia, Antiaris toxicaria and Landolphia buchananii are the most common woody plants with high density values.

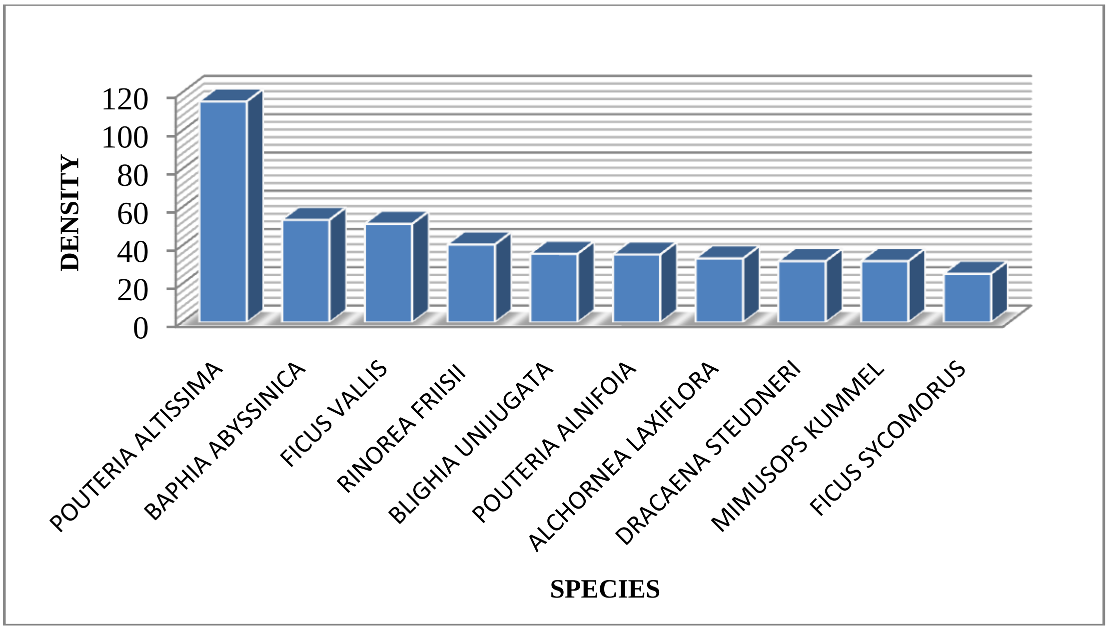

Figure 4. Density Distribution of Top-10 Woody Plants.

Frequency

It is defined as the probability or chance of finding a species in a given sample area or quadrat. Frequencyis dependent on quadrat size, plant size and patterning in the vegetation (Kent and Coker, 1992).Frequency is an indicator of homogeneity and heterogeneity of a given vegetation type (Lamprecht, 1989). The higher number of species in higher frequency classes and lower number of species in lower frequency classes show homogeneity and high number of species in lower frequency classes and low number of species in higher frequency classes show heterogeneity of species. The total frequency of individual woody plants with DBH ≥2.5m is computed for all woody plant species and the overall frequency of forest is calculated as 16.26 individuals ha $^{-1}$. *Pouteria altissima, Ficus vallis, Rinorea friisii, Argomuellera macrophylla, Baphia abyssinica, Blighia unijugata, Erythrococca trichogyne,Ficus exasperate, Erythrococca trichogyne, Ritchiea albersii, Alchornea laxiflora, Dracaena fragrans, Antiaris toxicaria Pouteria alnifoia and Erythroxylum fischeri are the most frequently occurring woody plant species in the area.*

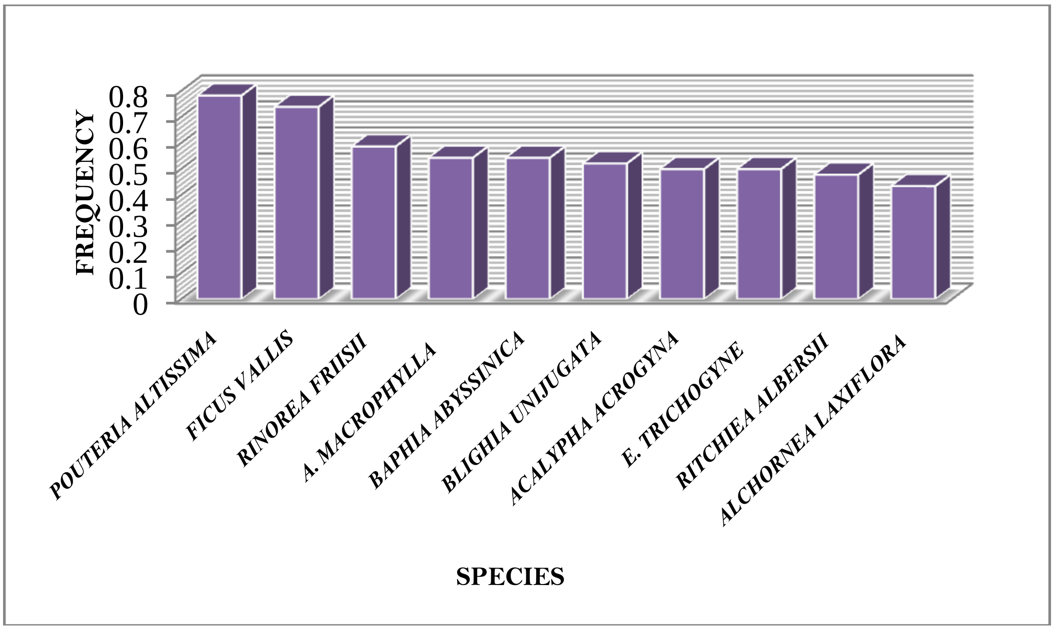

Figure 5. Frequency distribution of Top-10 Woody Plants.

Abundance

Abundance is an ecological concept referring to the relative representation of a species in a particular ecosystem. It is usually measured as the number of individuals found per sample. How species abundances are distributed within an ecosystem is referred to as relative species abundances.Therefore with regard to species abundance,*Rinorea friisii, Pouteria altissima, Baphia abyssinica, Argomuellera macrophylla, Ficus vallis, Alchornea laxiflora, Dracaena fragrans, Blighia unijugata, Acalypha acrogyna, Erythrococca trichogyne, Pisonia aculeate, Pouteria alnifoia,Antiaris toxicaria and Landolphia buchananii are the most abundant species of within majang Forest biosphere reserve.*

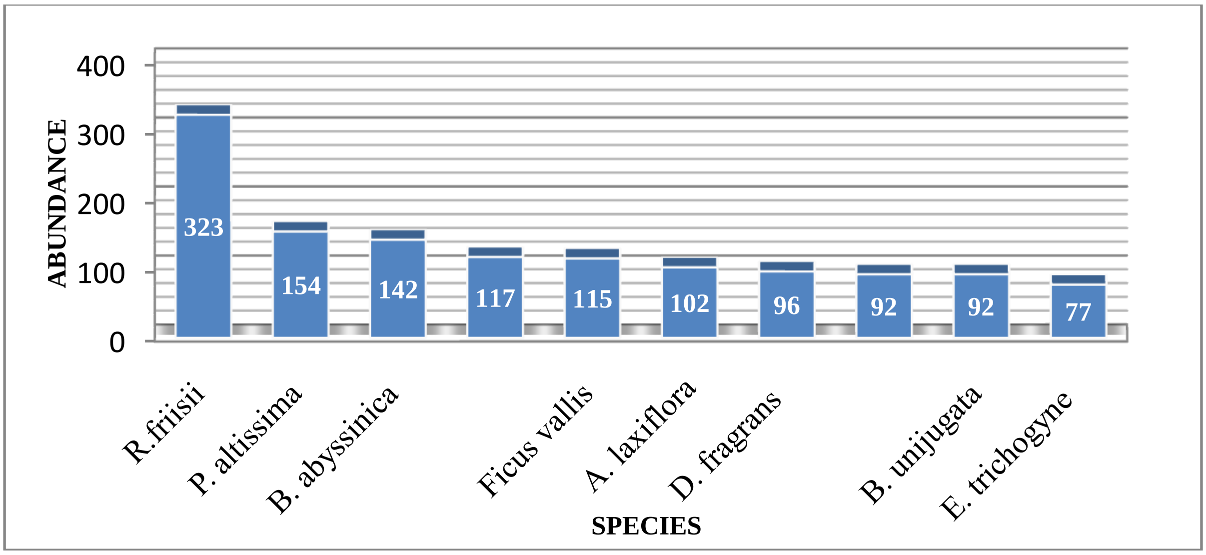

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Figure 6.The most abundant woody plant species.

Dominance

Dominance is woody plant species is calculated by the basal area of species divided by the sample plots taken for each. Hence, Majang Forest Biosphere reserve is dominated by *Pouteria altissima, Baphia abyssinica, Ficus vallis, Rinorea friisii, Blighia unijugata, Pouteria alnifoia, Alchornea laxiflora, Dracaena steudneri, Mimusops kummel, Ficus sycomorus, Manilkara butugi, Erythrococca trichogyne, Breonadia salicina, Lannea welwitschii, Erythroxylum fischeri and others (fig. 7).*

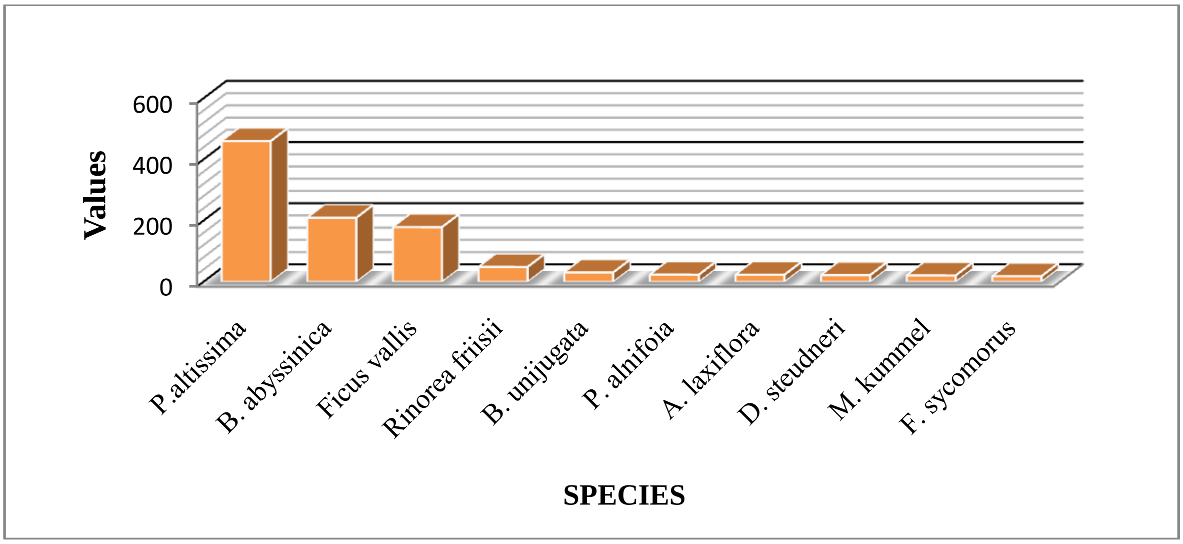

Figure 7. Dominant woody plants with their respective values.

Diameter at Breast Height (DBH)

A total of 2292 individuals of woody plant species whose DBH and height is ≥2.5m were recorded from Majang Forest Biosphere Reserve. The DBH was classified in to nine classes. The general pattern of DBH class distribution of the forest showed an inverted J-shaped distribution (Fig. 8). *Pouteria altissima, Baphia abyssinica, Ficus vallis, Rinorea friisii, Blighia unijugata, Pouteria alnifoia, Alchornea laxiflora, Dracaena steudneri, Mimusops kummel, Manilkara butugi, Erythrococca trichogyne, Breonadia salicina, Lannea welwitschii and Erythroxylum fischeri* plays a key role in characterizing the basal area of each trees and overall forests. They occupy the first 15th to-ranks with the DBH value ranging in between 41.05m-6.13m respectively.

The distribution of all individuals in different DBH size classes showed an inverted J-shaped distribution. This pattern indicates that the majority of the species had the highest number of individuals in lower DBH class implying that the forest vegetation has good reproduction and recruitment potential. The DBH analysis also revealed that individuals of woody plant species decrease significantly from the lower size classes to the higher size class in which slight increase of individuals was seen (Figure 8). This pattern of DBH classes indicates a good potential of reproduction and recruitment of the forest.

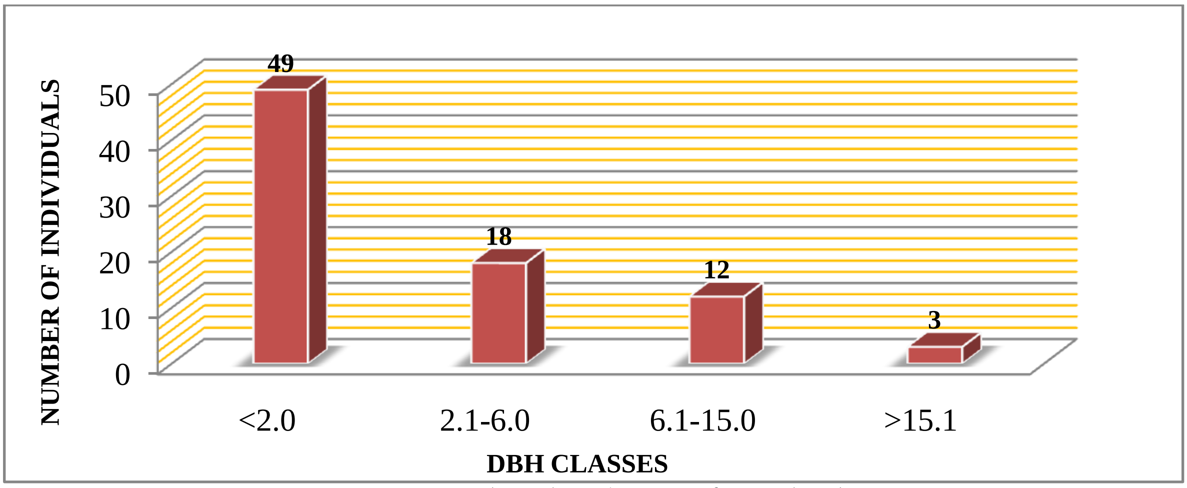

Figure 8. DBH class distribution of Woody plants

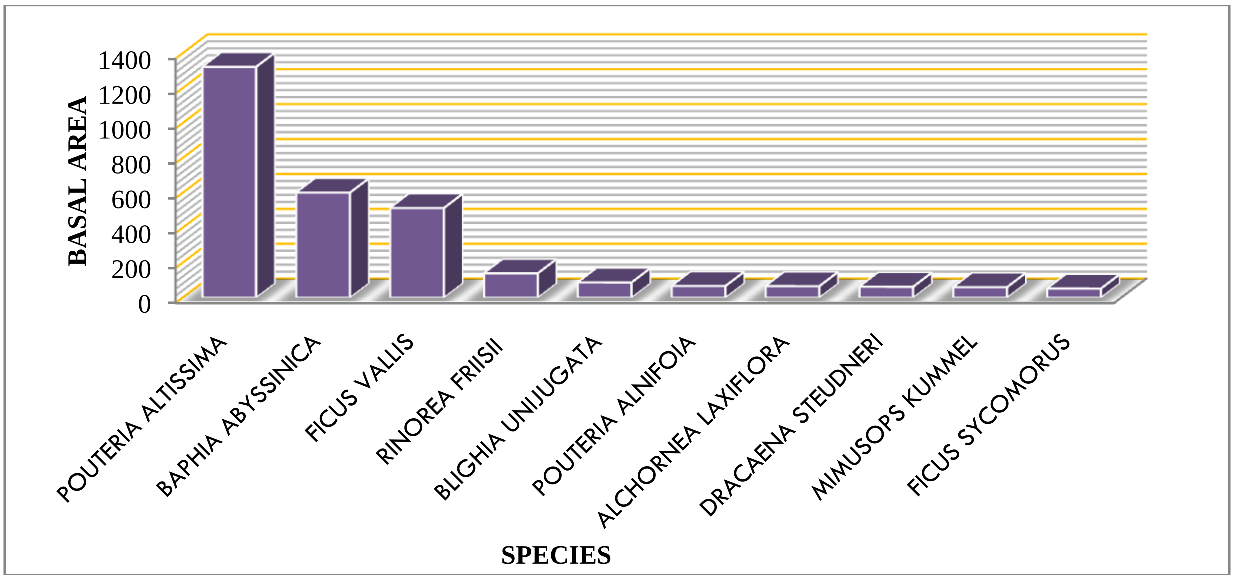

Figure 9. Basal area of top-10 woody plant species.

Basal Area

The total basal area of Majang Forest Biosphere Reserve was computed to be 74.12 $m^2 ha^{-1}$for woody plant species with DBH≥2.5m. There is a considerable decrease in number of individuals of woody plants as DBH increase. Basal area is an important parameter to measure relative importance of plant species (Tamirat Bekele, 1994). Hence, plant species, with large basal area in a forest is considered as the most important species of forest. Depending on the results of basal area values, *Pouteria altissima, Baphia abyssinica, Ficus vallis, Rinorea friisii, Blighia unijugata, Pouteria alnifoia, Alchornea laxiflora, Dracaena steudneri, Mimusops kummel,Ficus sycomorus, Manilkara butugi, Erythrococca trichogyne, Breonadia salicina, Lannea welwitschii and Erythroxylum fischeri* are the most characteristic species.

Important Value Index (IVI)

High IVI of species indicates its structural significance among other species of a given forest and computed by summation of the relative frequency, relative density and relative dominance of a species. Lamprecht (1989) stated that the Important Value Index is used to compare the ecological significance of each species. High IVI value of species indicates excellent sociological structure of species in a in that given forest. In contrast, the highest IVI of a species indicates that the species is most dominant in an area. The total Important Value Index of Biosphere Reserve was computed to be 301.86 individuals ha^{-1}.

Accordingly, *Pouteria altissima, Baphia abyssinica, Ficus vallis, Rinorea friisii, Blighia unijugata, Alchornea laxiflora, Argomuellera macrophylla, Ritchiea albersii, Erythrococca trichogyne, Dracaena fragrans, Acalypha acrogyna, Pouteria alnifoia, Antiaris toxicaria, Dracaena steudneri and Mimusops kummel* are the most significant woody plants species within the higher IVI classes.

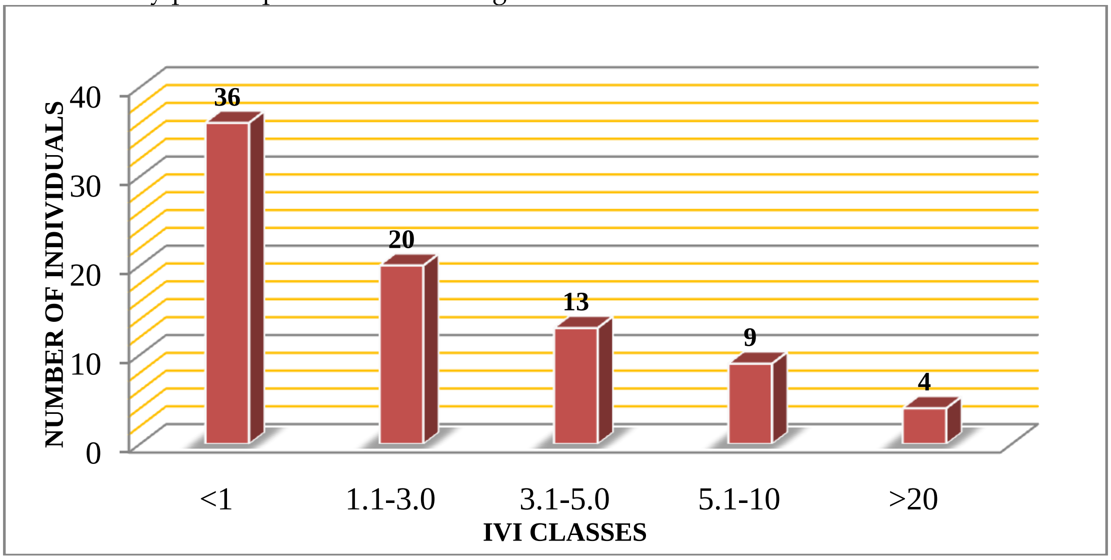

Figure 10. Distribution of woody plants within IVI category

Vertical Structure Analysis

The height of woody plants in the area was classified into five height classes as in between 2.5-10m, 10-20m, 20-30m and greater than 30m (Fig. 10). The overall height of plant species in the forest has normal distribution pattern. The occurrence of high number of plant species in the, middle and higher height classes in a given natural forest indicates a very good distribution of adult and mature generations with an excellent reproduction potential.

The general pattern of height class distribution if the forest is reversed J-shaped which in turn indicate the stable population structure. Different height of trees in a forest is an indicator of role of species and determines structure of a forest (Pascal and Pelissier, 1996). Height variation of trees plays a significant role in ecological phenomenon deciding the distribution of parasitic plants and affecting the microclimate of a forest (Tamirat Bekele, 1993).

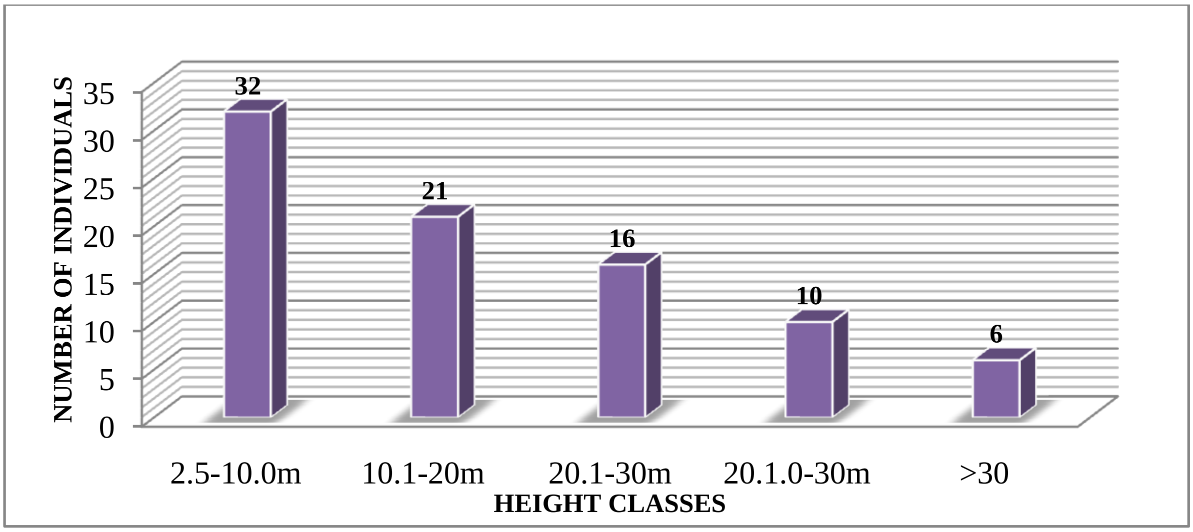

Figure 11. Height classes woody plants.

Vegetation Regeneration

Of 82 woody species recorded from the area, seedling covers about 37% and sapling covers about 33%. However, 30% of the species have neither seedling nor saplings. Therefore, management and conservation priority should be given for the species with no seedling and sapling in the forest.

Regeneration Status of Majang Forest Biosphere Reserve Floristic composition, number of seedlings, saplings and analysis of densities of a forest has an implication regarding regeneration status and management of a natural forest. The density data analysis indicated that total of 1236.7 ha^{-1} seedlings, 823.8 ha^{-1} saplings and 425.2 $ha^{-1}$of mature individuals of woody plant species of was computed (Fig. 12).

The density of seedlings and saplings is considered as a key factor for determination of regeneration potential of a given forest (Dhaulkhandi *et al.*, 2008). Presence of sufficient number of seedlings, saplings and adult plant species shows good regeneration status of a forest and forecasts the future floristic composition of that forest. Forest regeneration is poor, if number of seedlings and saplings are much less than the number mature individuals.

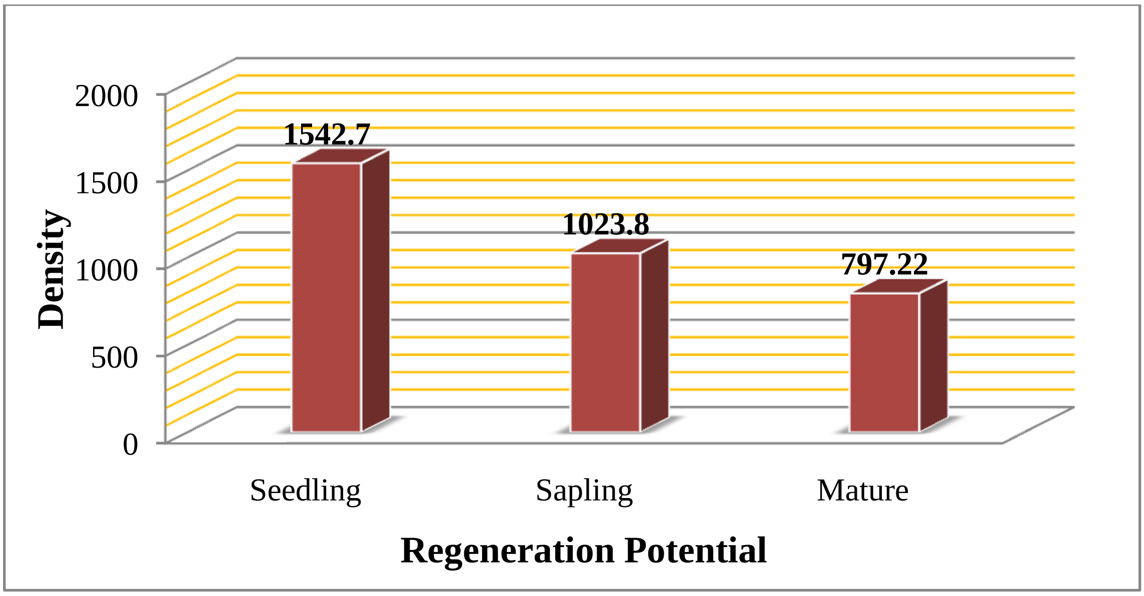

Figure 12. Density of seedling, sapling, and mature woody plants.

Plant Community Classification

Hierarchical cluster analysis was conducted to identify vegetation samples that are similar in terms of their species composition. The cover abundance data of species were used for the analysis. Six clusters of plant community were produced using the most recommended and recent ecological software package (R-Software). The clustered plant community types were named after two or three dominant species selected using the relative magnitude of their mean cover abundance values.

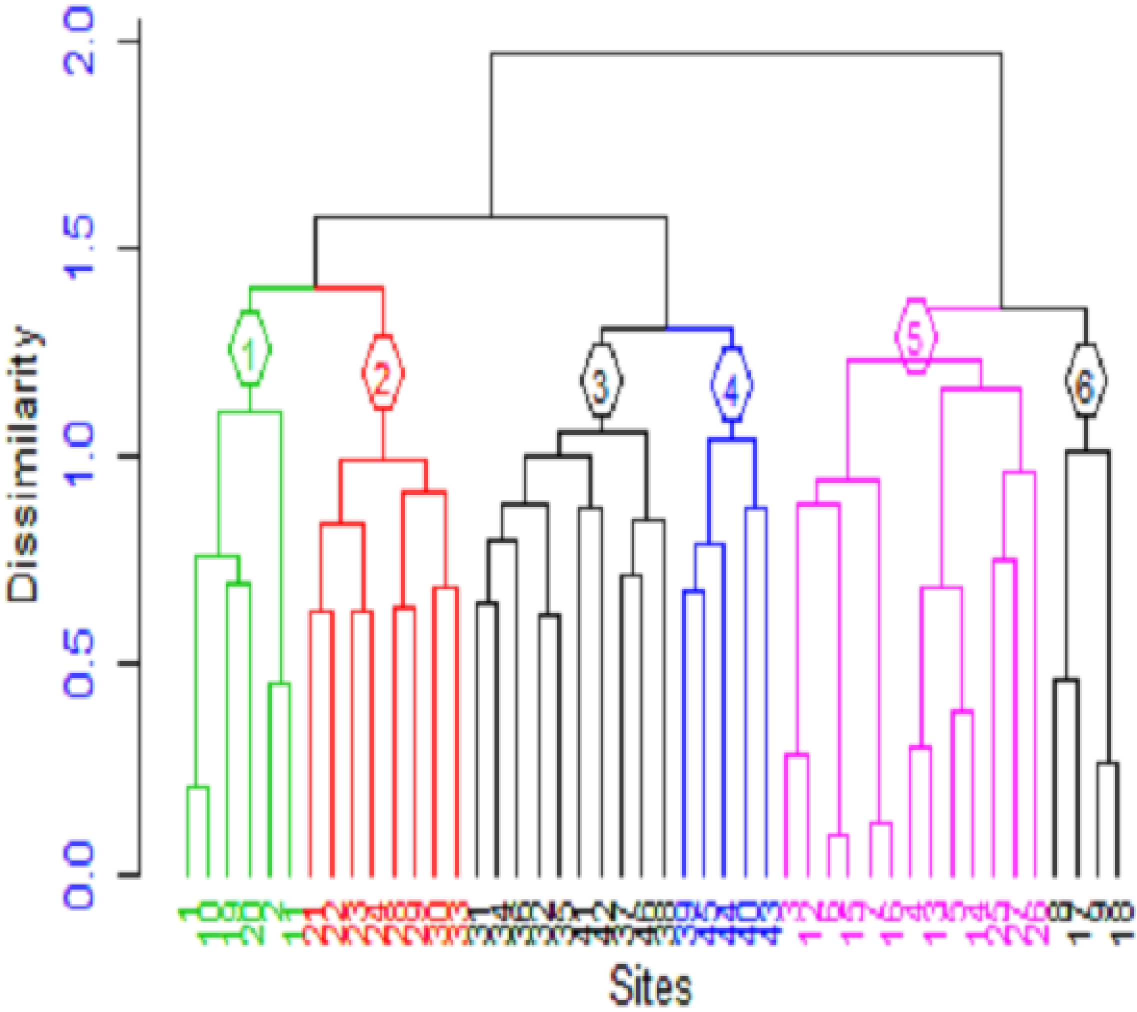

Figure 13. Shows Dendrogram of Vegetation Clusters.

Antiaris toxicaria-Acalypha acrogyna-Alchornea laxiflora Community Type

This community type was represented by 6 quadrats and 61 plant species. The most common indicator plant species in community are trees *(Baphia abyssinica, Blighia unijugata, Ficus vallis,Lannea welwitschii, Sterculia africana, Pouteria altissima, Pouteria alnifoia, Prunus africanus, andFicus sycomorus), shrubs (Ritchiea albersii, Argomuellera macrophylla, Psychotria orophila, Dracaena steudneri and Rinorea friisii)* and herbs such as *Olyra latifolia,and Oplismenus hirtellus)* with significant indicator values.

Bersama abyssinica-Pouteria altissima-Alstonia boonei Community Type

This community type encompasses 8 plots and 95 plant species with a characterized trees such as *Ficus vallis, Cordia africana, Ficus sycomorus, Ficus thonningii, Croton sylvaticus, Antiaris toxicaria, Syzygium guineense subsp.afromontanum, and Bridelia micrantha), shrubs like Acalypha acrogyna, Alchornea laxiflora, Argomuellera macrophylla, Erythrococca trichogyne, Ficus exasperata, Ritchiea albersii, Rinorea friisii, Pavetta oliveriana) and herbs (Hibiscus calyphyllus), and lianas including Albizia grandjbracteata Combretum poniculatum, Hippocratea pallens and Cissus populnea are indicators of the community.*

Antiaris toxicaria-Pouteria altissima Community Type

This community type comprises 10 plots and 45 plant species. (*Ficus thonningii,Prunus africanus,Trichilia dregeana, Ficus sycomorus, Ficus mucuso, Bridelia micrantha, Pouteria alnifoia), (Bersama abyssinica, Oncoba spinosa, Erythrococca trichogyne, Elaeodendron aquifolium, Acalypha ornata, Argomuellera macrophylla), (Commeuna latifolia, Achyrospermum schimperi) and Rhoicissus revoilii are the most important characteristic trees, shrubs, herbs and climbers respectively.*

Dracaena fragrans-Baphia abyssinica Community Type

This community represents 5 plots and 88 plant species and Blighia unijugata,Celtis zenkeri,Cordia africana,Celtis africana, Ficus thonningii, Prunus africanus,Trichilia dregeana, Ficus sycomorus, Pouteria alnifoia, Lannea welwitschii, Bridelia micrantha, Milicia excels,Trilepisium madagascariense,Trichilia dregeana, Erythrococca uniflora, Lepidotrichilia volkensii, Pavetta oliveriana, *Dracaena steudneri and Ziziphus pubescens are charateristic trees where as Acalypha acrogyna, Argomuellera macrophylla, Ficus mucuso, Bersama abyssinica, Oncoba spinosa, Erythrococca trichogyne, Diospyros abyssinica, Erythroxylum fischeri are indicator shrubs and Rhoicissus revoilii, Ampelocissus bombycina, Combretum poniculatum, Hippocratea pallens and Cissus petiolata are characteristic vines and lianas and Asplenium elliottii is the most important characteristic plant species in the community.*

Manilkara butugi-Lepidotrichilia volkensii Community Type

This community constitutes 13 plots and 81 plant species and characteristic plant species includes (Baphia abyssinica, Blighia unijugata, Celtis africana, Cordia africana, Croton sylvaticus, Dracaena steudneri, Erythroxylum fischeri) trees, (Diospyros abyssinica, Lannea welwitschii, Rinorea ilicifolia, Vepris dainellii, Maesa lanceolata, Ficus umbellata) shrubs and (Rhoicissus revoilii,Cissus petiolata) climbers.

Celtis zenkeri-Albizia schimperiana Community Type

This community is composed of 4 plots and 44 plant species and the characteristic plant species are Argomuellera macrophylla, Blighia unijugata, Cissus petiolata, Cordia africana, Lannea welwitschii, Milicia excels, Oncoba spinosa, Pavetta oliveriana, Syzygium guineense subsp.afromontanum with least species composition comparative to other communities.

Species Diversity, Richness and Evenness

Species diversity and evenness are often calculated using Shannon-Wiener diversity index. This diversity index is the most popular measure of species diversity because it accounts both for species richness and evenness, and it is not affected by samplesize (Kent and Coker, 1992). The value of Shannon diversity index is usually between 1.5 and 3.5 and only rarely exceeds 4.5 (Magurran, 1988)

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

.

Where H=Shannon-Wiener diversity index,

S=the number of species,

Pi=the proportion of individuals or the abundance of ith specie and

ln=log base

Shannon equitability (J) or evenness is the degree of association between species and level of similarity between quadrats or samples. The value of evenness index falls between 0 and 1. The higher the value of evenness index, the more even the species is in their distribution and calculated as **J=H/HMAX=H/lnS**,

Where, J=evenness,

H=Shannon-wiener diversity index,

H max=lnS=the natural logarithm of the total number of species and

S=total number of species in the sample.

Table 2. Species Richness, Diversity and Evenness of Community Types.

Community Type	Species Richness	Diversity (H)	Species Evenness	
1	63	3.67483	0.46551	
2	96	3.95484	0.39689	
3	47	3.35756	0.45187	
4	90	3.93595	0.38833	
5	82	3.8838	0.423	
6	47	3.4089	0.42132	

The highest species richness were oserved in community type II, IV and V respectively where as the least species richness were observed in community type III and VI followed by community type I. The decrease in species richness is probably of rapid agricultural expansion particularly because growing needs coffee plantation in buffer and core zones of the biosphere by local people, illegal investment activities and selective plant hantings primarily for their multipurpose importance (for instance, *Antiaris toxicaria, Cordia africana, Prunus africana* etc.).

The highest species diversity was observed in community type II (3.95) and IV (3.94) follwed by V (3.88) and I (3.67) and the lowest species diversty value was observed in community type III (3.36) and VI (3.41) respectively. Regarding equitability in species distribution, community type I and III followed by community type V and VI exhibits the highest species evenness and The lowest species equitability were observed in community type IV and II respctively. Overall, the value deviation in species evenness of the whole biosphere is relatively equitable (table 2).

Similarity among Plant Communities

Sorensen`s similarity was used to determine the pattern of species turnover among successive communities. The coefficient value ranges from 0 (complete dissimilarity) to 1 (total similarity). The similarity coefficient (Sc) was used to measure similarities between two habitats. Sorensen's coefficient is calculated using the following formula.

Sc =2a / 2a + b + c

Where: Ss=Sorensen's similarity coefficient,

a=Number of species common to both samples,

b=Number of species present in sample one and absent in sample two,

c=Number of species present in sample two and absent in sample one.

Table 3. Sorensen's Similarity Coefficient among Communities.

Community Type	I	II	III	IV	V	VI
I		0.43	0.44	0.49	0.42	0.31
II			0.39	0.57	0.48	0.41
III				0.26	0.27	0.20
IV					0.50	0.01
V						0.40
VI						

The similarities in plant species composition were compared among the six community types in the study forest (Table 3). The similarity coefficient value for all community type ranges from 10% to 57%. The highest Sorenson similarity coefficient values indicate higher similarity in species composition in between community types.The finding shows that there were high species overlaps between community type II and IV (57%) followed by community type IV and V (50%). The lowest similarity coefficient was recorded between community types IV and VI (10%) followed by III and VI, III and IV and III and V respectively indicating the lowest species overlap among these communities.

CONCLUSION AND RECOMMENDATION

A total of 187 plants species belonging to 143 genera and 70 families were recorded from the study area. Trees and shrubs together contribute 101species (54%) while herbs alone contribute 55 species (30%) and lianas and vines jointly contribute 26 species (14%) of the overall floristic composition of the Majang Forest Biosphere is respectively.

The most characteristic families dominating the area are Euphorbiaceae, Fabaceae, Rubiaceae, Moraceae, Asteraceae, Combretaceae, Rutaceae, Acanthaceae, Poaceae, Sapotaceae, Solanceae, Celastraceae, Commelinaceae, Meliaceae, and Ulmaceae together contributed about 57% to the FIV. Euphorbiaceae was recorded for its highest FIV (8%) followed by Fabaceae, Rubiaceae, Moraceae, Asteraceae, Combretaceae, Rutaceae, Acanthaceae toping 1-5 ranks.

Structural analysis of species was done by calculating frequency, density, abundance, basal area, and importance value index (IVI) of trees and shrub species. Importance value index (IVI) was calculated by summing up relative frequency (RF), relative density (RD) and relative dominance (RDO) values.

Of 82 woody species recorded from the area, seedling covers about 37% and sapling covers about 33%. However, 30% of the species have neither seedling nor saplings. Therefore, management and conservation priority should be given for the species with no seedling and sapling in the forest (Photo 1-4). Six clusters of plant community were produced using the most recommended and recent ecological software package (R-Software). The clustered plant community types were named after two or three dominant species selected using the relative magnitude of their mean cover abundance values. The highest species richness were oserved in community type II, IV and V respectively where as the least species richness were observed in community type III and VI followed by community type I. Regarding equitability in species distribution, community type I and III followed by community type V and VI exhibits the highest species evenness and The lowest species equitability were observed in community type IV and II respctively.

The finding shows that there were high species overlaps between community type II and IV (57%) followed by community type IV and V (50%). The lowest similarity coefficient was recorded between community types IV and VI (10%) respectively indicating the lowest species overlap among these communities (Table 3).

The Majang Forest Biosphere Reserve affords great economic socio-cultural and overall survival value for the whole communities living in and around the forest being as a source of non-timber products. The forest biosphere reserve is among few of the remnant Afromontane forests of southwest Ethiopia with varying natural landscape, microclimate, vegetation diversity, untouched indigenous knowledge, biocultural diversity that are critically important in sustainable use, management and conservation of biological resources.

Despite these facts, recently the wild forests are under tremendous human pressures derived from multiple dimensions such as lack of good governance in controlling illegal settlement, rapidly growing needs of wild forest destruction for coffee plantation and selective hunting of some indigenous plants for their multipurpose advantages (Photo 1-4).

Therefore, to meet the agendas of Millennium development goals in a way that brings sustainable development and mitigates the impacts of global climate changes through the implementation of convention on biological diversity through declaration of an area as Biosphere Reserves. Therefore, to meet the intended goals, ensure sustainable development and brings rational use of resources, the following recommendations are forwarded:

It is better to make participatory forest management programs (PFM) more functional through community mobilization by developing environmental club at all levels of GOs, NGOs and curriculum revision, practical implementation of investment policy in and around protected areas with the outcome of creating sense of resource ownership among resource users or local communities.

Creating public awareness, through extension programs, on the multiple uses of forest resources and ecosystems is essential to safeguard the biodiversity of the forest.

Needs further investigation on the patterns of ecosystem functioning, the soil seed banks, germination performance of seeds, establishment of seedlings and studies on the role of gap dynamics for suggested species.

Promotes multiple-use conservation approach as management strategy that focus on For example, undisturbed areas of the forest can be designated for strict conservation so that they may act as repositories of biodiversity and possibly as a source of forest genetic resources while the peripheral areas could be utilized on a sustainable basis. To promote the sustainable use of the forest and its products, ethnobotanical studies and exploration of indigenous knowledge on the diverse uses of plants should be carried out.

The planning and management of the Forest has to be assisted by research findings, such as detail ecological studies in relation to various environmental factors like the physico-chemical properties of soil.

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