International Journal of Agriculture Innovations and Research
Volume 9, Issue 3, ISSN (Online) 2319-1473
Manuscript Processing Details (dd/mm/yyyy):
Received: 18/11/2020 | Accepted on: 12/12/2020 | Published: 23/12/2020

Assessment of Woody Species Diversity, Structure and Regeneration Status of Setema Natural Forest, Setema District, Southwest Ethiopia

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Abstract **– This study was conducted on Setema Natural Forest, located in Setema District, Jimma Zone, Oromia National Regional State in Southwestern Ethiopia. The objective of the study was to assess the woody species diversity, structure and regeneration status of the forest. To collect the vegetation data, eight transects were laid with regular interval of 200m distance. Along each transect, plots of 20×20 (400m2) were systematically established at 25m interval (elevation). A total of 47 species belonging to 44 genera and 31 families were recorded and identified. Fabaceae was the most dominant family represented by six species followed by Rubaceae represented by five species and Euphourbaceae represented by three species. The basal area of the forest was 50.7 m 2ha-1. The total IVI of all woody trees/shrubs in the forest was 295.57, of which; *Cordia africana* contributed 43.85 IVI (14.8%) making it the most ecologically important species in the forest. Six plant communities namely: - *Schefflera abyssinica – Podocarpus falcatus* Community type, *Ficus sur* – Syzium guinensee Community type, *Cordia africana – Albizia schimperiana* Community type, *Clausena anisata – Apodytes* dimidiate Community type, *Prunus Africana Millettia ferruginea* Community type and *Polyscias fulva - Ficus sycomorus* Community type were identified. The densities for seedlings, saplings and mature woody tree/shrub were 1713.95, 1166.42 and 1628 individual's ha-1 respectively. The regeneration status and population structure of the forest indicated that there are human-induced disturbances in the area and immediate conservation actions should be implemented.**

Keywords **– Setema Natural Forest, Woody Species Composition, Regeneration.**

I. INTRODUCTION

Biodiversity of various ecosystems of the globe is not equally distributed (Gibert and Deharveng, 2002). Some regions of the world like that of tropics have higher biodiversity as compared to other places. Most of the countries in the tropics that are endowed with such huge biodiversity have poor economies, which is the major challenge to conserve their biodiversity. Ethiopia is one of the top 25 richest countries in the world in terms of biodiversity (Feyera etal, 2014). Ethiopia is one of the few countries in Africa where virtually all major types of naturally diversified vegetations are represented, ranging from thorny bushes and tropical forests to mountain grasslands due to its wide variation in climate, topography and soils (Badege, 2001). The flora of Ethiopia is very heterogeneous and has rich endemic taxa. Forest serves as a source of food, household energy, construction and agricultural material, tourism and recreation values and medicines for both people and livestock (Mamo et al., 2007). Forests are important habitats in terms of the biological diversity they contain and the ecological functions they serve (SCBD, 2001). Although Forests have crucial ecosystem service in soil and biodiversity conservation and mitigation of climate change, they are being destroyed at an alarming rate largely due to human-related disturbances. Ethiopians, particularly in the rural areas of the country, are highly dependent on forest resources to fulfill their basic needs such as fuel wood for cooking, heating, foliage for livestock, and timber for shelter and non-timber products including medicine. Environmental degradation and deforestation have been taking place for many years in the country. Especially during the last century, Ethiopia's forest has

been declining both in size (due to deforestation) and quality (due to degradation) (Gebrehiwot, 2003.). The clear-felling accelerates the loss of seedlings and saplings as well as disturbs the natural condition of the natural forests and hence the ecosystem. Assessments on floristic composition, species diversity and structural analysis studies are essential for providing information on species richness of forests. It is useful for forest management purpose and helps in understanding forest ecology and ecosystem functions (Burju et al., 2013). Knowledge of floristic composition and structure of forest is also useful in identifying ecologically and economically important plants, their diversities and protection measures (Addo-Fordjour et al., 2009). Setema natural forest is one of the National forest priority areas of Ethiopia under Sigmo-Setema forest and it is one of the remnant moist afromontane forests in the country. Ecological assessments of this forest would serve as a base for the planning, sustainable utilization and conservation of this valuable natural resource. The general biodiversity, floristic composition, regeneration and structural analysis of Setema natural forest have not yet been investigated. Thus, the current work on woody species diversity, structural analysis and regeneration of the vegetation in the area is believed to contribute a lot for the effective conservation and management of the forest. Therefore, the objective of this study was to assess the woody species diversity, structure and regeneration status of the species in the forest.

II. Materials and Methods

Description of the Study Area

The study was conducted on Setema block of Sigmo-Setema Natural Forest, located in Setema district, Jimma zone, Oromia Regional State, Ethiopia. Setema Forest is one of the Natural forests within Sigmo-Setema forest priority area. The study was conducted only on Setema block of Sigmo-Setema forest priority which is found in Setema district. The size of the forest is about 10,000 ha (OFWE, 2018). Setema district is bordered on the south by Gera distrcit, on the west by Sigmo district, on the north by Illubabor Zone and on the southeast by Gomma district (SDA, 20017). The administrative center of the woreda is Gatira. The altitude of this woreda ranges from 1,580 to 3,010 meters (7,380 to 9,880 ft.) above sea level. The highest points are in the Damu Siga mountain range. Perennial rivers include the Onja, Salako, Gidache and Gebba. A survey of the land in this woreda shows that 27.2% is arable or cultivable (20.8% was under annual crops), 13.1% pasture, 55.1% forest and the remaining 4.6% is considered degraded, built-up and unusable.

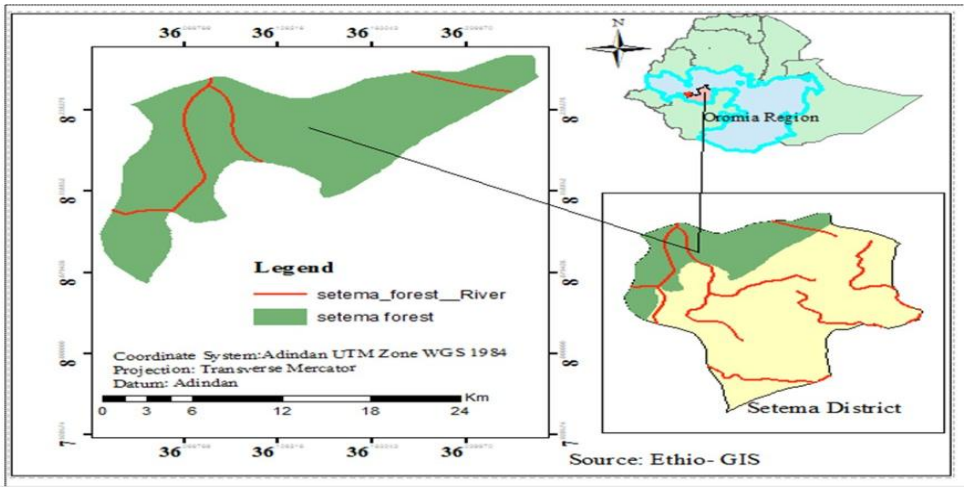


Fig. 1. Map of study area showing Ethiopia, Oromia, Setema District and Setema Natural Forest.

Sampling Design

Eight transects were laid with regular interval of 200m distance. Plots of 20 m x 20 m (400 m2) were placed along each transect at 25m elevation gradient. Five sub-plots (one at each corner and one at the center) with area of 3m × 3m (9m2) were laid in the main plots. Another five sub-plots with the size of 1m × 1m (1m2) were established at each corner and at the center of the large plot. A total of 10 plots were laid along each transect.

Vegetation Data Collection

Data on woody species including DBH and height were collected from 20m × 20m plots. Regeneration data were collected from the 3m × 3m (Sapling) and 1m × 1m (seedling) sub-plots. The data collection was a full inventory of all woody species with a diameter at breast height (DBH) of 2.7 cm and above. The DBH of woody plants were calculated from the circumference measured using measuring tape. The height of all trees were measured using Suunto clinometers. Density, frequencies, basal area, dominance and IVI of trees and shrubs were calculated after individual woody plant species were measured and counted.

Species Identification

Plant identification was carried out by using Botanical keys from published volumes of Flora of Ethiopia and Eritrea, volume 1-8 and Useful trees and shrubs for Ethiopia (Azene Bekele, 1993). Fresh specimens were collected and taken to Jimma University Herbarium. The voucher specimens were deposited at Jimma University Herbarium.

III. DATA ANALYSIS

Species Diversity Analysis

Species diversity and evenness were calculated using Shannon Weiner diversity index. It is the most applicable index of diversity (Greig-Smith, 1983). Shannon's Index accounts for both abundance and evenness of the species present. The Shannon Diversity Index (H') was calculated using the following formula:

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

Where, S = the total number of species, Pi = the proportion of individuals or the ith species expressed as a proportion of total cover. ln = Natural logarism.

Equitability

Equitability or Evenness was calculated from the ratio of the observed diversity to maximum diversity using the equation: - EH = H/Hmax = H/lns.

Equitability assumes a value between 0 and 1 with 1being complete evenness. The higher the value of evenness index, the more even the species is in their distribution within the given area.

Measurement of Similarity

Similarity indices measure the degree to which the species composition of quadrants or samples is alike. Sorensen is one of the most common binary similarity coefficients which rely on presence or absence of data (Xia *et al*., 2018).

Sorensen's coefficient is expressed as: Ss = 2a/ (2a + b + c) Where,

a = number of species common to both sites.

b = number of species unique to site 1.

c = number of species unique to site 2.

Often, the coefficient is multiplied by 100 to give a percentage similarity index.

Important Value Index (IVI)

Important Value Index (IVI) is useful to compare the ecological significance of a species (Dereje Denu, 2006). The high value of IVI indicates that the species sociological structure in the community is high. Importance value index combines data from three parameters (relative frequency, relative density and relative dominance).

IVI = Relative Density + Relative Frequency + Relative Dominance.

Density : - is the count of individuals per unit area (ha).

Relative Frequency: - Is obtained by comparing the frequency of occurrences of all of the tree species present. Relative frequency is calculated as follows.

$$\text{Relative Density} = \frac{Density\ of\ a\ species\ \times 100}{Total\ density\ of\ all\ species}$$

$$\text{Relative Basal Area} = \frac{Dominance\ of\ a\ species\ \times 100}{Total\ dominance\ of\ all\ species}$$

Basal Area

The DBH of all woody species in Setema Natural forest was measured at 1.3m above the ground. The basal area for the woody species was determined from the DBH measurement. Basal area is calculated from the following formula.

BA = $\frac{\pi D^2}{4}$, Where BA = Basal area in m2 per hectare,

D = Diameter at breast height (cm) and $\pi = 3.14$

Vertical Stratification of Vegetation

The vertical structure of vegetation is categorized following Lamprecht (1989).

1. Upper storey: the layer comprising the tree species which attain a height >2/3 of the top height of a given forest.
2. Middle storey: When the stratum is formed by individual tree/shrub species with a height >1/3 of the top height in a given forest.
3. Lower storey: When the stratum is formed by individual tree/shrub species with a height <1/3 of the top height in a given forest.

Plant Community Classification

Plant community types were determined using PC-ORD version 5.3 for windows (McCune and Mefford, 2006). Hierarchical cluster analysis was done to classify plants into different community types. The distance measure used in this analysis was Euclidean distance.

Regeneration Status

The number of individuals of each tree, sapling and seedling per hectare were calculated from the total number of individual species recorded from the sampled area. The regeneration status of Setema Natural Forest was assessed and categorized as follows:

'Good', if the presence of seedling > sapling > mature strata;

'Fair', if the presence of seedling > sapling < mature strata;

'Poor', if a species present only in the sapling stage, but not as seedlings (even though saplings may be less than, more than, or equal to mature);

'None', if a species is absent both in sapling and seedling stages, but present as mature; and 'New', if a species has no mature, but only sapling and/or seedling stage (Chauhan *et al.*, 2008).

IV. RESULT AND DISCUSSION

Floristic Composition

Overall, a total of 47 woody plant species belong to 43 genera and 31 families (See Annex 1) were collected and identified. The most frequent families in the area were Fabaceae (*Albizia schimperiana, Acacia abyssinica, Acacia etbaica, Calpurina aurea, Lonchocarpus laxiflorus, Millettia ferruginea*) and Rubiaceae (*Ehretia cymosa, Galiniera saxifraga, Psychotria orophila and Rytigynia neglecta*) followed by Euphorbiaceae *(Croton macrostachyus, Phyllanthus ovalifolius and Ricinus communis)*. Rutaceae, Myrsinaceae, Asteraceae and Araliacieae were medium in their frequency of occurrences (two species each) in the study area. On the other hand, Rosaceae, Melianthaceae, Acanthaceae, Podocarpaceae, Myrtaceae, Celasteraceae, Verbenaceae, Oleaceae, Sterculiaceae, Moraceae, Sapindaceae, Arecaceae, Ulmaceae, Pittosporaceae, Icacianaceae, Anacardaceae, Simarobaceae, Tiliaceae, Rhamnaceae Ebenaceae, Meliaceae, Burseraceae and Boraginaceae were the least frequent Families (one species each) in the area. The distribution of the plant species in terms of the growth forms were trees, 33 species and Shrubs, 14 species (Figure 3). Two woody plant species were observed out of quadrats in the study area. These were *Hagenia abyssinica* and *Juniperus procera* (at 100m distance from the quadrat).

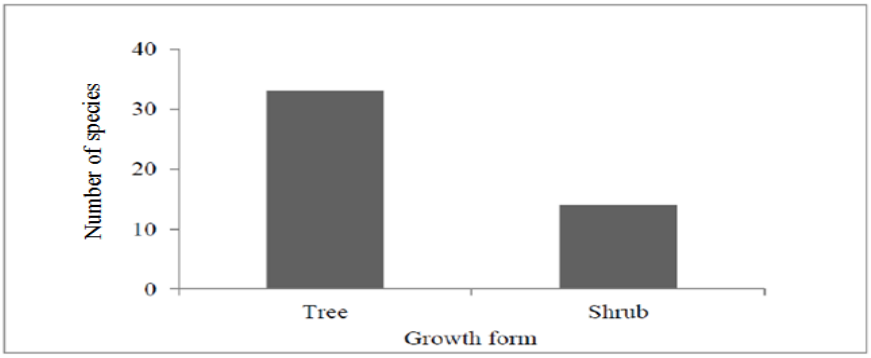


Fig. 2. Growth form of Woody species in Setema Natural Forest.

Endemism

Among the species collected from Setema Natural Forest, two plant species (*Millettia ferruginea* and *Vepris dainellii)* are endemic to Ethiopia. They constitute 4.2% of the total species recorded from the study area.

Vertical Structure

The vertical structure of the woody species of Setema Natural forest generally categorized as shown in annex 3. Hence, in this case, the tree/shrub species exceeding a height of 24m belong to the upper storey comprising about 18.55% of the floristic composition; those tree/shrub species with height ranging between 13-24 m were categorized to the middle stratum consisting of about 33.91% of the floristic composition and those tree/shrub species with height ranging between 3-12m were classified to the lower layer consisting of about 47.54% in proportion from the woody plant species inventoried in Setema Natural forest (Tabe 1). Despite that, species like *Cordia africana, Prunus africana, Ficus sur* and *Croton macrostachyus* were not specific to each vertical structure. They appeared in each stratum. According to Debissa (2009), such kinds of species are called species with regular vertical distribution. In general, the analysis of the vertical structure of Setema Natural forest reveals that the majority of the floristic composition is found in the lower stratum of the vegetation. The species with the highest height in Setema Natural forest was *Prunus africana* with a height of 38 m.

Table 1. Vertical stratification of woody species of setema natural forest in density ha-1.

Storey	**Height (m)**	**Density (No of stems/ha)**	**(%)**
Lower	3-12	774	47.54
Middle	13-24	552	33.91
Upper	>24	302	18.55
Total	1628		100

The most dominant tree species in the upper storey of the study forest were *Prunus africana, Schefflera abyssinica, Croton macrostachyus, Podocarpus falcatus, Albizia schimperiana, Polyscias fulva, Cordia africana; Ficus sur and Millettia ferruginea* (annex 3). This storey constitutes about 18.55% of the density of tree/shrub. Trees in the height range between 13-24 m represented the middle storey. The most dominant species in this storey were *Prunus africana, Cordia africana, Schefflera abyssinica, Croton macrostachyus, Albizia schimperiana, Allophylus abyssinicus, Ekebergia capensis, Ficus sycomorus, Celtis africana, Apodytes dimidiate, Olea capensis, Acacia abyssinica, Syzygium guineense, Pittosporum viridiflorum, Vepris dainellii, Dracaena steudneri, Brucea antidysentrica* and *Clausena anisata.* This storey constitutes about 33.91% of the density of tree/shrub. Some species found in the upper storey were also found in middle storey. The lower storey contains about 47.54% of the density with the dominancy of *Galiniera saxifraga, Lonchocarpus laxiflorus, Rhus glutinosa, Vernonia turbinate, Acacia etbaica, Phoenix reclinata, Vernonia amygdalina, Phyllanthus ovalifolius, Maytenus senegalensis, Vernonia auriculifera, Premna schimperi, Grewia ferruginea , Embelia schimperi, Rhamnus prinoides , Bersama abyssinica, Calpurina aurea, Oxyanthus speciosus, Ricinus communis, Maesa lanceolata, Psychotria orophila, Rytigynia neglecta, Justicia schimperiana, Euclea racemosa* and *Ehretia cymosa.* In general tree densities in lower, middle and upper storey were found to be 774/ha, 552/ha and 302/ha respectively.

Frequency

The result of the study showed that the variation of the species frequency ranges between 0.4 – 4.9% (Figure 4). This implies that there is high homogeneity in species distribution in the area. The species" frequency classes were; class A (0.4-1.3%), class B (1.4-2.3%), class C (2.4 -3.3%), class D (3.4-4.3%) and class E (4.4-5.3%). Among these, *Syzygium guineense* (4.9%) was the most frequently appearing or the most widely distributed woody plant species in the area (class E). Moreover, *Bersama abyssinica, Albizia schimperiana, Prunus africana, Cordia africana, Galiniera saxifraga, Maytenus senegalensis and Vernonia auriculifera* were the second most frequent species in the area (class D*). Maesa lanceolata, Croton macrostachyus, Polyscias fulva, Clausena anisata, Psychotria orophila, Premna schimperi, Rytigynia neglecta, Vepris dainellii, Ficus sur, Apodytes dimidiata and Ehretia cymosa* were relatively the third most frequent (Class C) woody species in the area. *Dombeya torrida, Vernonia turbinate, Ficus sycomorus, Lonchocarpus laxiflorus, Rhus glutinosa, Schefflera abyssinica, Justicia schimperiana, Pittosporum viridiflorum, Brucea antidysentrica and Celtis africana were the fourth rank in their frequency (Class B).* On the other hand, *Allophylus abysinicus, Millettia ferruginea, Rhamnus prinoides, Calpurina aurea, Embelia schimperi, Ekebergia capensis,* Oxyanthus *speciosus, Euclea racemosa, Phoenix reclinata, Olea capensis, Grewia ferruginea, Dracaena steudneri, Ricinus communis, Acacia etbaica, Vernonia amygdalina* and *Phyllanthus ovalifolius* were the least frequent woody species in the area (class A). Hence, there is a low variation in species distribution between the above mentioned class of species that showed the highest and the lowest frequency. Nevertheless, the majority of the species fall between the frequency range of 0.4-1.3 % (Class A). In other words, when the distributions of species were interpreted in terms of frequency classes, it is only one species, *Syzygium guineense,* which belonged to the E frequency class (4.4-5.3%). Further, as illustrated in Figure 3, 7 species were included under frequency class D (3.4-4.3%), 11 species were categorized under frequency class C (2.4-3.3%) and 12 species were under frequency class B (1.4-2.3%). Therefore, the falling of highest percentage (or number of species) under low value frequency class implies that the distribution of species in the area is not generally high.

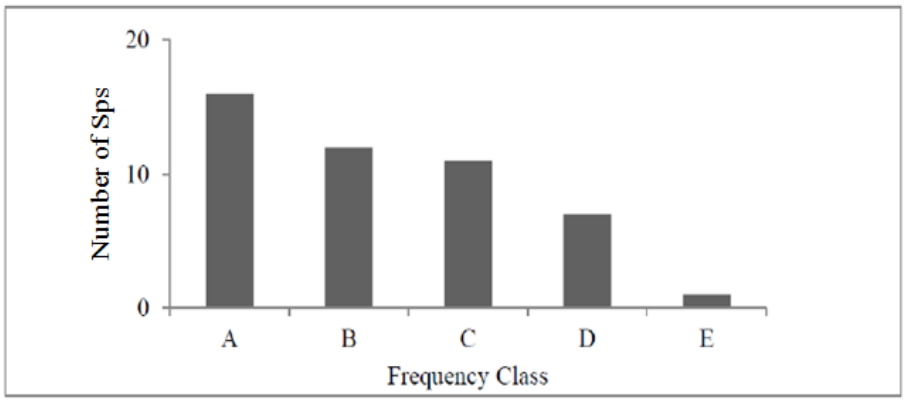


Fig. 3. Number of species by frequency class.

Density

Density is an important parameter for determining regeneration status of a forest. The species density in the area ranges between 7-77 stem per ha. The range of the relative density of the species is also between 0.41-4.56%. The least species density was for *Dracaena steudneri* (7) while the highest species density was for *Syzygium guineense* (77). This result Pointed out that there is little variation among the individual tree/shrub

species in density per ha. In the study area, the total species density per ha was 1628. To summarize, the density and Species density class of each species was organized in figure 5. Here, the majority of the species (31.91%) belonged to the first density class (A (7-21)).

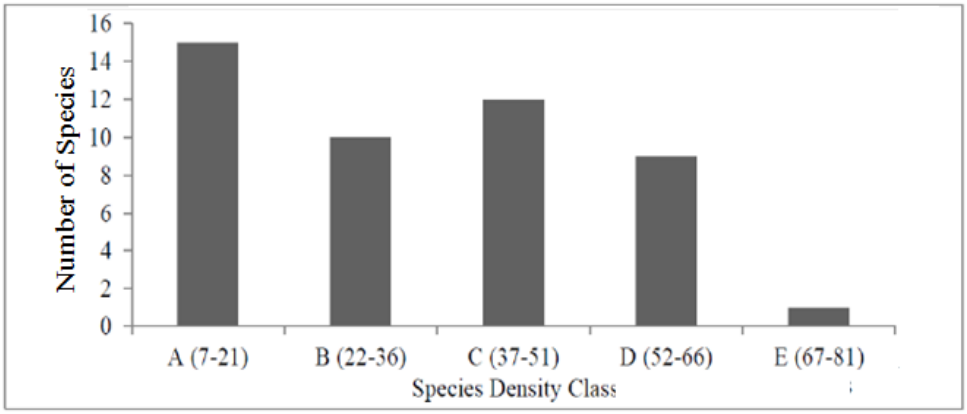


Fig. 4. Species density class.

Diameter at Breast Height (DBH)

For ease of the comparison and interpretation, the diameter class was formed in to seven groups as: I (2.7-7.6 cm); II (7.7-12.6cm); III (12.7-17.6 cm); IV (17.7-22.6 cm); V (22.7-27.6 cm); VI (27.7-32.6 cm) and VII (>32.6 cm). The minimum DBH of trees and shrubs found in the area was 2.7cm. The result of the analysis of the diameter data indicated that about 44.68% (21 species) of the tree/shrub species were those species which have fallen in diameter class I, followed by diameter class II, while the least number of species were found in the diameter class of VII (1 species (Fig. 6)). It is only one species (*Cordia africana*) that appeared in Diameter class VII. The low number of woody species in higher diameter class might be due to selective use of the mature trees in the higher DBH class for different purposes like house construction, timber and charcoal making.

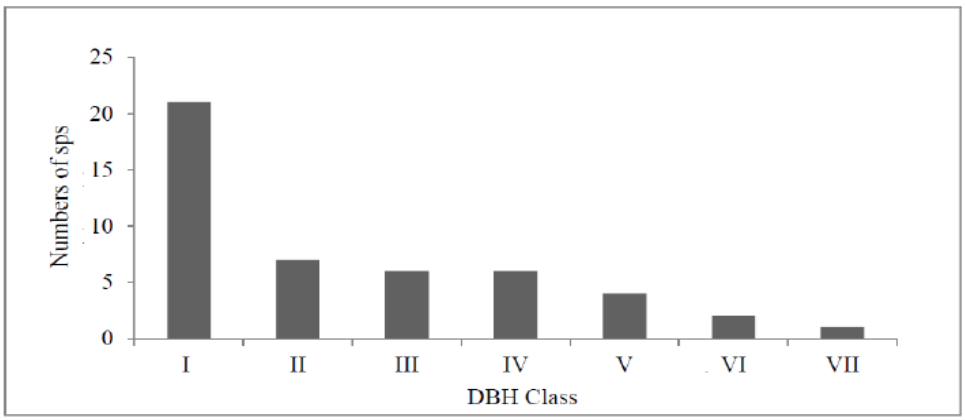


Fig. 5. Species DBH class.

Species Population Structure

The pattern of diameter size-class distribution has been used to represent the population structure of a forest (Debissa, 2009). This is because the pattern of diameter class distribution connotes the general trends of population dynamics and recruitment process of a given species.

The vegetation structure of the study area reveals five (5) patterns, depending on DBH Class: These are : -

1. *Inverted J-shape (A):*

This shows a pattern where species frequency distribution has the highest frequency starting from lower diameter classes and gradually decrease towards the higher DBH classes in case of A (*Millettia ferruginea*).

2. *Irregular (B):*

This type of frequency distribution was shown by Schefflera abyssinica. Vegetation structure of this species does not show any regularity in density across different DBH classes.

3. *J-shape (C and F):*

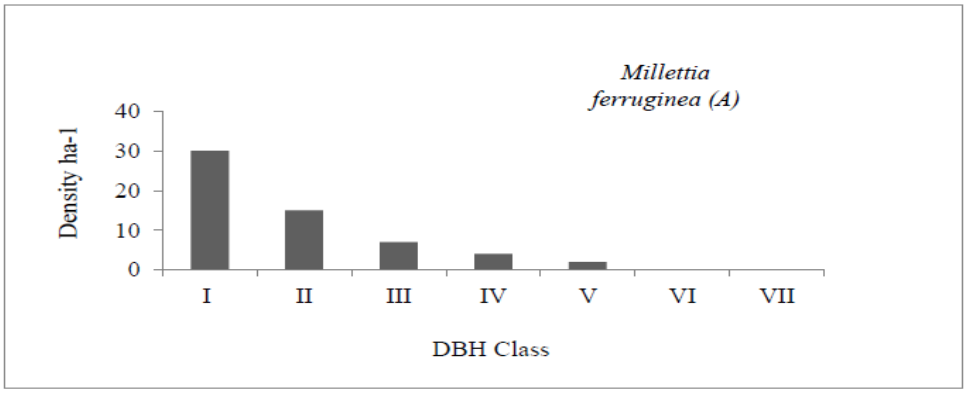
Density of Podocarpus falcatus and Croton machrostachyus increase with DBH class showing a J-shape pattern and there is no species in Class VI and VII. This might be due to closed canopy of the forest that reduces the amount of rainfall and solar radiation that reaches the forest floor to induce germination of the seeds and recruitment into mature trees.

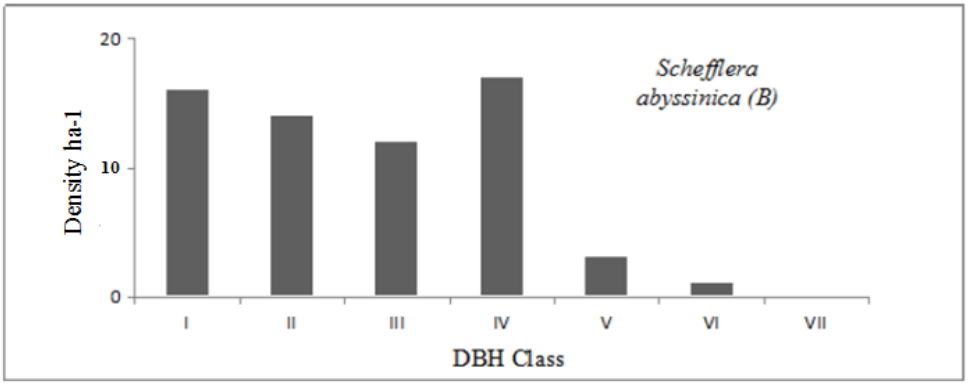
4. *U-shape (D):*

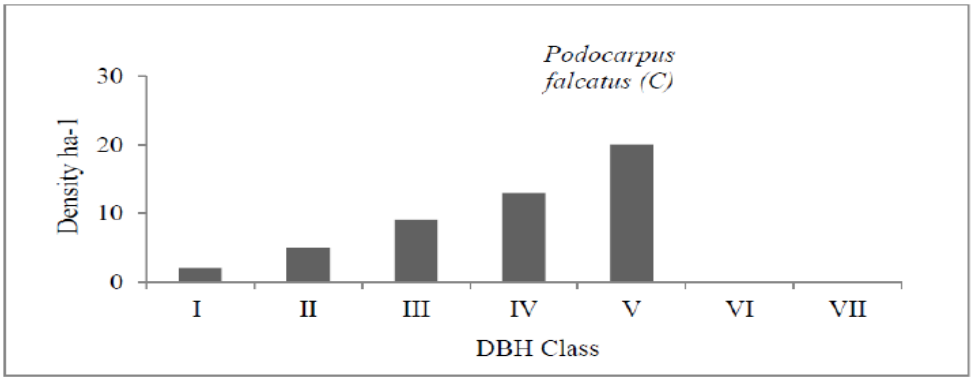
This pattern of frequency distribution was a high DBH class in the first and decreases in the middle classes and then eventually increases in the next DBH class as shown in Cordia africana. This type of distribution class may be because of the removal of the oldest DBH for construction, charcoal and other purposes.

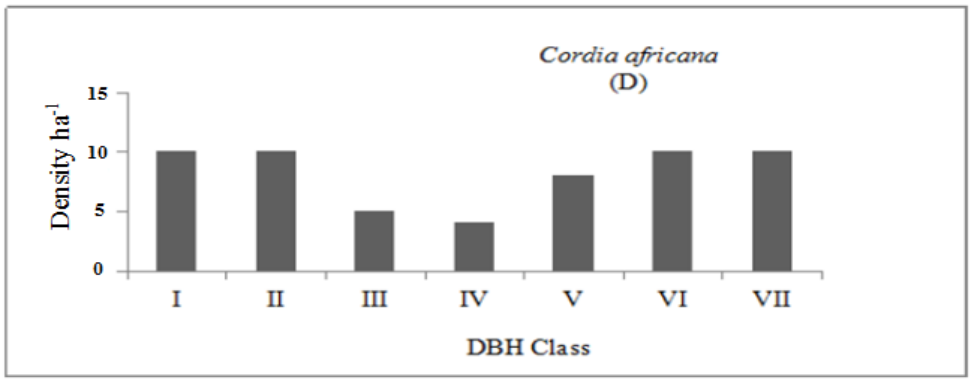
5. *Bell-shape (E):*

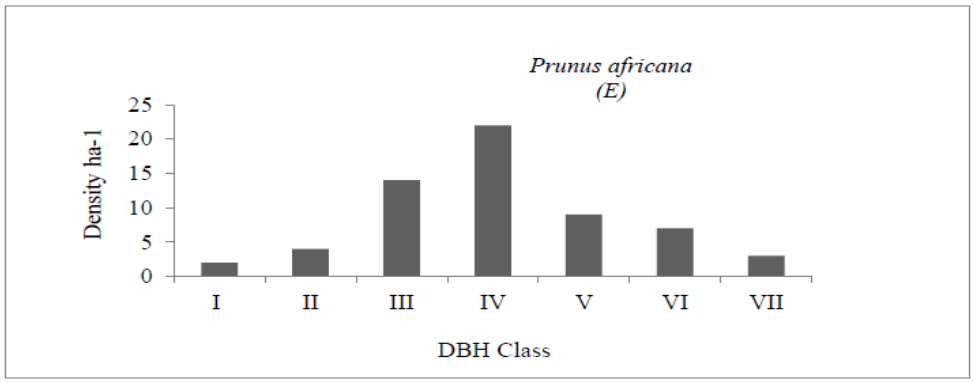
This pattern of frequency distribution is low in low DBH classes, and shows some increment starting from class I to IV (middle) and again shows some decrement in some middle classes to high DBH classes *(Prunus africana).*











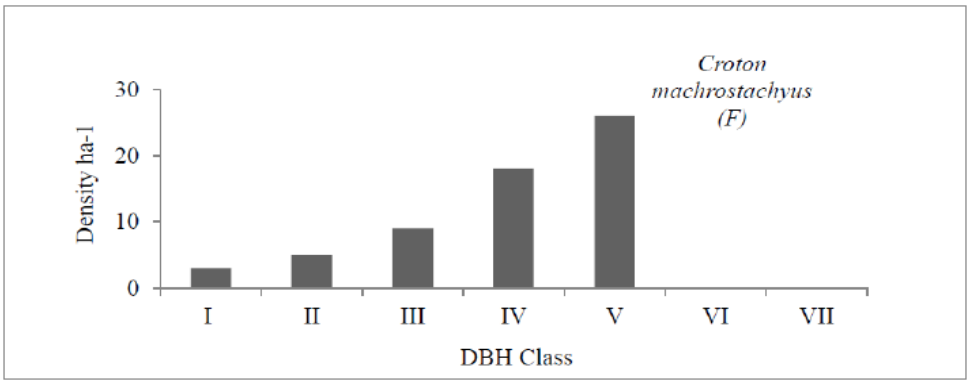


Fig. 6. Density per hectare of 6 selected plant species across different DBH Classes in Setema Natural Forest (DBH Class: - I (2.7-7.6cm); II (7.7-12.6cm); III (12.7-17.6 cm); VI (17.7-22.6cm); V (22.7-27.6 cm); VI (27.7-32.6cm) and VII (>32.6cm)).

Stand Height Profile

In determining the stand height profile, the height class was formed in to six groups as: A (3-8m); B (9-14 m); C (15-20 m); D (21-26 m); E (27-32 m) and F (33-38 m). The result of the analysis of the height profile data

indicated that about 44.68% of the tree/shrub species are those species which have fallen in height class A; 6.38% in height class B; 21.28% in height class C; 10.64% in height class D ; 14.89% in height class E and 2.13% in height class F (Figure 9). This depicts that the majority of the species belonged to the lower height class.

The possible reason could be selective use of the mature trees in the higher height class for different purposes like house construction and timber.

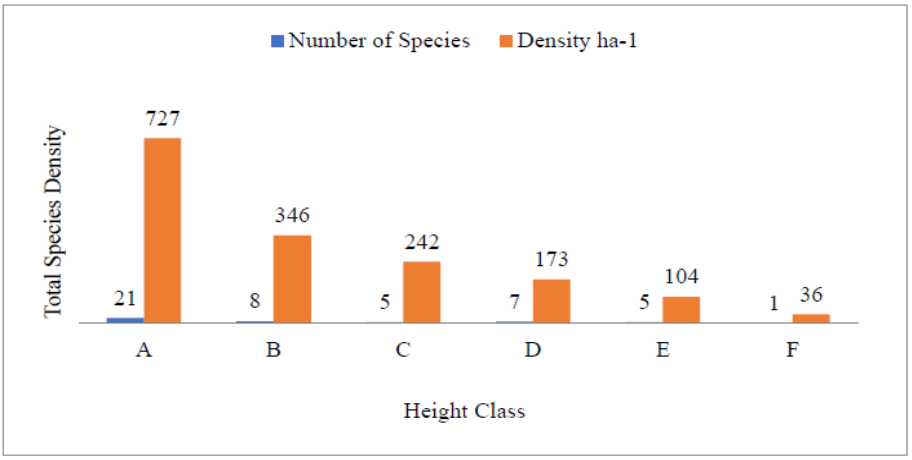


Fig. **7**. Number of species and density per hectare by height class.

Basal Area

Basal area provides a better measure of the relative importance of the species than simple stem count. Therefore, species with the largest basal area can be considered as the most important woody species in the forest (Lamprecht, 1989). The total basal area calculated for the study area was 50.741m2/ha for woody plants ≥2.7 cm in DBH (annex 4). Accordingly, *Cordia africana* is the species with higher basal area (18.7m2/ha) due to its higher DBH size and *Dracaena steudneri* is the species with lower basal area (0.005m2/ha) due to its lower DBH size relatively. The second most important plant species is *Prunus Africana*, with a basal area of 4.72 m2/ha (Table 2). Others top ten plant species are Podocarpus *falcatus* with 2.82 m2/ha, *Albizia schimperiana* with 2.6m2/ha, *Ficus sur* with 2.5m2/ha, *Millettia ferruginea* with 2.34m2/ha, *Polyscias fulva* with 2.06m2/ha, *Croton macrostachyus with* 1.73m2/ha, *Apodytes dimidiate* with 1.64m2/ha and *Schefflera abyssinica* with 1.6m2/ha.

Table 2. Basal area of top ten woody species in setema natural forest.

No.	Species	Density/ha	BA (m^2/ha)	RBA (%)
1	*Cordia africana*	57	18.7	45.94
2	*Prunus africana*	61	4.72	11.6
3	*Podocarpus falcatus*	49	2.82	6.93
4	*Albizia schimperiana*	61	2.6	6.39
5	*Ficus sur*	40	2.5	6.14
6	*Millettia ferruginea*	20	2.34	5.75
7	*Polyscias fulva*	48	2.06	5.06

No.	Species	Density/ha	BA (m^2/ha)	RBA (%)
8	*Croton macrostachyus*	49	1.73	4.25
9	*Apodytes dimidiata*	41	1.64	4.03

The basal area of Setema Natural forest is the eighth of the twelve basal areas of the forests under comparison. Kimphe Lafa (114.4m2/ha), Wof-Washa (64.32m2/ha), Menna Angetu (94.22m2/ha, Menagesha Amba Mariam (84.17m2/ha), Masha Anderacha (81.9m2/ha, Bibita (69.9m2/ha) and Aleta-Bolale (53.33m2/ha) have higher basal area than Setema natural forest (Table 3). On the other hand, all the rest forests under comparison; Gole (49.2m2/ha), Bonga (45.20m2/ha), Denkoro (45.00m2/ha) and Menagesha–Suba (36.10m2/ ha) have basal area lower than Setema natural forest. The result revealed that the Basal area of the woody species in Setema Natural Forest is relatively medium. This may be due to the presence of plant species with lower stems than the mentioned forests.

Table 3. Basal area comparison.

No.	Forest	BA	Source
1	Kimphe Lafa	114.40	Kadir Aliyi *et al.* (2015)
2	Wof-Washa	64.32	Gebremikael Fisaha *et al* (2013)
3	Menna Angetu	94.22	Ermias Lulekal *et al.* (2008)
4	Menagesha Amba Mariam	84.17	Abiyou Tilahun *et al.* (2011)
5	Masha Anderacha	81.9	Kumelachew Yeshitela and Taye Bekele (2003)
6	Bibita	69.90	Dereje Denu (2006)
7	Aleta-Bolale	53.33	Woldeyohanne Enkossa (2008)
8	Gole	49.20	Mesfin Belete and Tamiru Demis (2018)
9	Bonga	45.20	Abayneh Derrero (2003)
10	Denkoro	45.00	Ayalew *et al*. (2006)
11	Menagesha–Suba	36.10	Tamrat Bekele
12	**Setema**	**50.741**	**Current study**

Important Value Index (IVI)

The important value index of the species indicates how dominant is the species in a certain area and hence helps to compare ecological importance of the species in vegetation (Curtis and McIntosh, 1951). This index generally combines three parameters or is the sum of the Relative density, Relative frequency and Relative basal area (relative dominance) for each woody species. In the study area, the species IVI varies between 0.85 - 43.85 as shown in table below (Table 4). It is lowest for *Dracaena steudneri* and highest for *Cordia africana*. This reveals that in this natural forest, the species relative frequency, density and dominance differ accordingly. In principle, when a certain species receives the lowest IVI, it entails as it requires high priority for conservation while those species with the highest IVI require only monitoring and management priority for conservation. As

a result, species like *Dracaena steudneri, Phoenix reclinata, Olea capensis, Grewia ferruginea, Euclea racemosa, Ricinus communis, Vernonia amygdalina, Phyllanthus ovalifolius and Rhamnus prinoides* require high priority for conservation. The remaining 38 species need management and monitoring efforts.

Table 4. IVI of top ten woody species in Setema natural forest.

No.	Species	RD	RDO (RBA)	RF	IVI
1	*Cordia africana*	3.37	36.88	3.6	43.85
2	*Prunus africana*	3.61	9.31	3.85	16.77
3	*Syzygium guineense*	4.56	4.62	4.9	14.08
4	*Albizia schimperiana*	3.61	5.13	3.9	12.64
5	*Podocarpus falcatus*	2.9	5.57	3	11.47
6	*Croton macrostachyus*	2.9	4.7	3.1	10.7
7	*Polyscias fulva*	2.84	4.07	3	9.91
8	*Ficus sur*	2.37	4.92	2.54	9.83
9	*Bersama abyssinica*	3.73	1.41	4	9.14
10	*Apodytes dimidiata*	2.4	3.24	2.6	8.26

RDO = Relative dominance, RD = Relative Density, RF = Relative Frequency, IVI = Important Value Index, RBA = Relative Basal Area.

Regeneration Status

The density and composition of seedlings and saplings indicate the status of regeneration of the forest. The regeneration status was recorded for 42 woody species in the area. No regeneration (both seedling and sapling) was found for *Phoenix reclinata, Grewia ferruginea, Dracaena steudneri, Vernonia amygdalina and Embelia schimperi* in the area. Moreover, the seedlings density was 1713.95/ha, the sapling was 1166.42/ha and the density of mature tree/shrub was 1628/ha (Table 5). The ratio of seedling and sapling to mature tree/shrub is 1.05 and 0.71 respectively. The result reveals the presence of more seedlings than mature trees/shrubs and saplings. The finding of this study reveals that the regeneration status of woody species of Setema natural forest is fair since the density of seedlings > saplings < Mature trees/shrubs. Two species; *Croton macrostachyus* and *Rytigynia neglecta* have high regeneration potential with 11.67% and 8.75% seedlings count respectively. On the other hand, *Oxyanthus speciosus* has the least regeneration potential of all species with 0.15% seedlings count.

Table 5. Density ha-1 of seedling, sapling and mature tree/shrub species in Setema Natural Forest.

No.	Species Name	Habitat	T/S D/ha	Sd D/ha	Sp D/ha
1	*Bersama abyssinica*	Tree	63	100	50.31
2	*Clausena anisata*	shrub	49	30.31	20.31
3	*Vernonia auriculifera*	tree	54	75	44.69
4	*Croton macrostachyus*	tree	49	200	38.75

No.	Species Name	Habitat	T/S D/ha	Sd D/ha	Sp D/ha
5	*Maesa lanceolata*	shrub	52	38.12	41.88
6	*Premna schimperi*	shrub	42	23.75	14.06
7	*Rytigynia neglecta*	shrub	41	150	10.62
8	*Podocarpus falcatus*	Tree	49	14.67	3.44
9	*Albizia schimperiana*	Tree	61	44.67	0.94
10	*Syzygium guineense*	Tree	77	80.32	52.19
11	*Maytenus senegalensis*	shrub	54	62.81	5.6
12	*Galiniera saxifraga*	Tree	58	48.12	23.12
13	*Dombeya torrida*	Tree	35	41.25	20.94
14	*Vepris dainellii*	Tree	39	42.81	49.69
15	*Ficus sur*	Tree	40	54.67	39.06
16	*Allophylus abyssinicus*	Tree	21	15.94	10
17	*Calpurina aurea*	shrub	18	23.75	0
18	*Polyscias fulva*	Tree	48	45.94	41.25
19	*Phoenix reclinata*	Tree	12	0	0
20	*Justicia schimperiana*	shrub	29	20.31	6.88
21	*Oxyanthus speciosus*	shrub	17	2.5	24.34
22	*Olea capensis*	shrub	13	4.38	35.31
23	*Celtis africana*	Tree	22	19.69	27.19
24	*Grewia ferruginea*	shrub	9	0	0
25	*Euclea racemosa*	shrub	14	3.75	0
26	*Dracaena steudneri*	shrub	7	0	0
27	*Schefflera abyssinica*	Tree	29	41.25	27.19
28	*Pittosporum viridiflorum*	Tree	24	6.56	30.62
29	*Vernonia turbinata*	shrub	37	42.81	4.34
30	*Apodytes dimidiata*	Tree	41	42.81	45
31	*Psychotria orophila*	shrub	48	114	30.62
32	*Rhus glutinosa*	Tree	32	10.94	12.81
33	*Ricinus communis*	shrub	13	16.25	0

No.	Species Name	Habitat	T/S D/ha	Sd D/ha	Sp D/ha
34	*Millettia ferruginea*	Tree	20	10.94	35
35	*Brucea antidysentrica*	Tree	23	30.31	14.34
36	*Ekebergia capensis*	shrub	19	7.19	0
37	*Acacia etbaica*	Tree	14	14.69	16.88
38	*Acacia abyssinica*	Tree	26	20.31	23.12
39	*Vernonia amygdalina*	shrub	11	0	0
40	*Phyllanthus ovalifolius*	shrub	15	3.44	7.19
41	*Rhamnus prinoides*	shrub	14	12.19	16.56
42	*Ficus sycomorus*	Tree	33	35	65.31
43	*Cordia africana*	Tree	57	60.94	121.56
44	*Embelia schimperi*	Tree	62	0	0
45	*Lonchocarpus laxiflorus*	Tree	34	10.31	48.75
46	*Prunus africana*	tree	61	77.19	82.81
47	*Ehretia cymosa*	Tree	42	14.06	23.75
Total	1628		1713.95		1166.42

T = Tree, S = Shrub, D = Density, Ha = Hectare, Sd = Seedling, Sp = Sapling.

Woody Plant Species Diversity and Equitability

The woody plant species diversity and equitability in the study forest was analyzed by Shannon-Weiner diversity index and equitability (evenness) index. The overall Shannon Weiner diversity index of the study forest is 1.99 (annex 7). The diversity analysis indicates that Setema natural forest has medium diversity of woody species. The species evenness value ranges between 0 and 1. When it is 0, the area is dominated by single species and when it is 1, the species are evenly distributed in the area. The analysis result also indicated that the average evenness value of the study forest is 0.52; showing more or less even representation of individuals of most woody species in the sampled plots.

Vegetation Community Classification

Six plant community types were distinguished from data matrix of 47 species and 80 sample plots using hierarchical cluster analysis of PC-ORD 5.31 window versions based on their similarity values. The name for each community type was given based on high synoptic values of the tree and/or shrub species of cover estimate. Accordingly, the following community types were identified.

1. *Schefflera abyssinica - Podocarpus falcatus Community type*

This community type was found at altitude ranging between 2000-2250 m.a.s.l. It was resulted from 18 plots and 42 species. *Schefflera abyssinica and Podocarpus falcatus* were the dominant species. Plant species found

in this community were *Cordia africana, Apodytes dimidiata, Croton macrostachyus, Albizia schimperiana, Bersama abyssinica, Galiniera saxifraga, Ficus sur, Celtis africana, Prunus africana, Syzygium guineense, Vepris dainellii, Allophylus abyssinicus, Polyscias fulva, Dombeya torrida, Millettia ferruginea, Brucea antidysentrica, Ficus sycomorus, Lonchocarpus laxiflorus, Embelia schimperi, Ehretia cymosa, Pittosporum viridiflorum, Rhus glutinosa, Acacia abyssinica, Olea capensis, Clausena anisata, Vernonia turbinate, Acacia etbaica, Premna schimperi, Vernonia auriculifera, Grewia ferruginea, Maesa lanceolata, Phoenix reclinata, Ricinus communis, Dracaena steudneri, Euclea racemosa, Rytigynia neglecta, Vernonia amygdalina, Phyllanthus ovalifolius, Rhamnus prinoides, Calpurina aurea, Ekebergia capensis, Oxyanthus speciosus, Justicia schimperiana, Maytenus senegalensis and Psychotria orophila.*

2. *Ficus sur - Syzygium guineense Community Type*

This community type was found between altitudes of 2182-2249 m.a.s.l. and represented by 7 plots and 35 species. *Ficus sur and Syzygium guineense* were the dominant in the tree layer of the community type. Species found in this community were *Cordia africana, Croton macrostachyus, Albizia schimperiana, Bersama abyssinica, Galiniera saxifraga, Celtis africana, Prunus africana, Allophylus abysinicus, Polyscias fulva, Dombeya torrida, Millettia ferruginea, Brucea antidysentrica, Ficus sycomorus, Schefflera abyssinica, Podocarpus falcatus, Ehretia cymosa, Pittosporum viridiflorum, Rhus glutinosa, Acacia abyssinica, Clausena anisata, Premna schimperi, Vernonia auriculifera, Phoenix reclinata, Ricinus communis, Euclea racemosa, Rytigynia neglecta, Vernonia amygdalina, Rhamnus prinoides, Calpurina aurea, Ekebergia capensis, Oxyanthus speciosus, Justicia schimperiana and Psychotria orophila.*

3. *Cordia africana - Albizia schimperiana Community Type*

This community was distributed between altitudes of 2174-2244 m.a.s.l and contained 21 plots and 44 species. *Cordia africana* and *Albizia schimperiana* were the dominant tree species of the community. Species found in this community were *Croton macrostachyus, Bersama abyssinica, Galiniera saxifraga, Ficus sur, Celtis africana, Prunus africana, Syzygium guineense, Vepris dainellii, Allophylus abyssinicus, Polyscias fulva, Dombeya torrida, Millettia ferruginea, Brucea antidysentrica, Ficus sycomorus, Lonchocarpus laxiflorus, Embelia schimperi, Ehretia cymosa, Pittosporum viridiflorum, Rhus glutinosa, Acacia abyssinica, Olea capensis, Clausena anisata, Schefflera abyssinica, Podocarpus falcatus, Vernonia turbinate, Acacia etbaica, Vernonia auriculifera, Grewia ferruginea, Maesa lanceolata, Phoenix reclinata, Ricinus communis, Dracaena steudneri, Euclea racemosa, Rytigynia neglecta, Phyllanthus ovalifolius, Rhamnus prinoides, Calpurina aurea, Ekebergia capensis, Oxyanthus speciosus, Justicia schimperiana, Maytenus senegalensis and Psychotria orophila.*

4. *Clausena anisata - Apodytes dimidiata Community Type*

This community was distributed between 2190-2245m.a.s.l and represented by 5 plots and 27 species. *Clausena anisata and Apodytes dimidiata* were the dominant tree species of this 39 community. *Cordia africana, Apodytes dimidiata, Croton macrostachyus, Albizia schimperiana, Bersama abyssinica, Prunus africana , Syzygium guineense , Vepris dainellii, Allophylus abyssinicus, Polyscias fulva, Schefflera abyssinica, Podocarpus falcatus, Millettia ferruginea, Brucea antidysentrica, Ficus sycomorus, Lonchocarpus laxiflorus, Embelia schimperi, Ehretia cymosa, Pittosporum viridiflorum, Acacia abyssinica, Olea capensis, Clausena*

anisata, Vernonia turbinate, Premna schimperi, Vernonia auriculifera, Vernonia amygdalina and Maytenus senegalensis were species found in this community.

5. *Prunus africana – Millettia ferruginea Community Type*

This community was distributed between 2197-2238 m.a.s.l. and represented by 21 plots and 42 species. *Prunus africana and Millettia ferruginea* were the dominant tree layers of this community. *Cordia africana, Apodytes dimidiata, Croton macrostachyus, Albizia schimperiana, Bersama abyssinica, Galiniera saxifraga, Ficus sur, Celtis africana, Prunus africana, Syzygium guineense , Vepris dainellii, Allophylus abyssinicus, Polyscias fulva, Dombeya torrida, Ficus sycomorus, Lonchocarpus laxiflorus, Ehretia cymosa, Rhus glutinosa, Acacia abyssinica, Olea capensis, Clausena anisata, Vernonia turbinate, Schefflera abyssinica, Podocarpus falcatus Acacia etbaica, Premna schimperi, Vernonia auriculifera, Grewia ferruginea, Maesa lanceolata, Phoenix reclinata, Ricinus communis, Dracaena steudneri, Euclea racemosa, Rytigynia neglecta, Vernonia amygdalina, Phyllanthus ovalifolius, Rhamnus prinoides, Calpurina aurea, Oxyanthus speciosus, Justicia schimperiana, Maytenus senegalensis and Psychotria orophila* were the tree/shrub species found in this community type.

6. *Polyscias fulva – Ficus sycomorus Community Type*

This community was found between 2092- 2241 m.a.s.l and contained 8 plots and 33 species. *Polyscias fulva and Ficus sycomorus* were the dominant tree species of this community. Species found in this community were *Cordia africana, Apodytes dimidiata, Ficus sur, Celtis africana, Prunus africana, Syzygium guineense, Dombeya torrida, Brucea antidysitrica, Podocarpus falcatus, Lonchocarpus laxiflorus, Embelia schimperi, Ehretia cymosa, Pittosporum viridiflorum, Rhus glutinosa, Clausena anisata, Vernonia turbinate, Premna schimperi, Vernonia auriculifera, Grewia ferruginea, Maesa lanceolata, Phoenix reclinata, Euclea racemosa, Rytigynia neglecta, Vernonia amygdalina, Phyllanthus ovalifolius, Rhamnus prinoides, Calpurina aurea, Ekebergia capensis, Justicia schimperiana, Maytenus senegalensis and Psychotria orophila.*

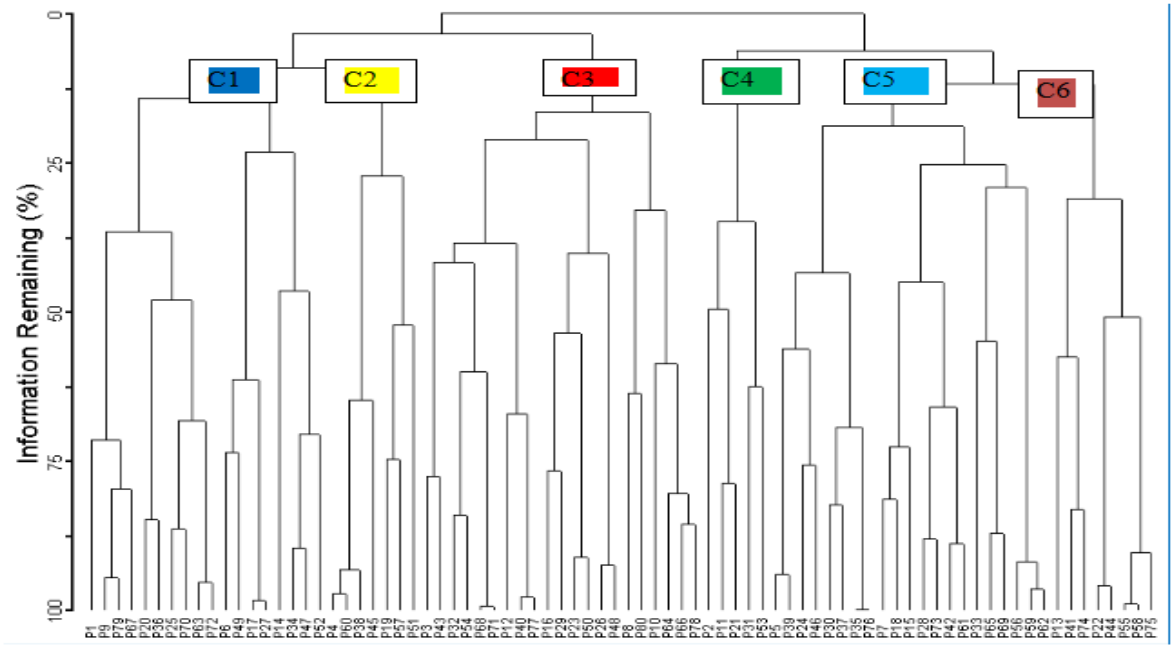


Fig. 8. Dendrogram showing six plant communities in Setema natural forest.

Species Diversity in Each Plant Community

The highest species richness was recorded from community 3 (44) followed by community 1 (42), while the least species richness was recorded from community 4 (Table 7). Low level of disturbance has contributed to the highest species richness in community three. It is mainly covered with shrubs and less needed trees for construction and commercial purposes. On the other hand, the reason for the lowest species richness in community 4 was due to human disturbances. Specially, *Prunus africana* in this community was non-selectively harvested for construction. The species evenness was also greater in community 3 followed by community 5, while community 6 has relatively the least evenness value. Accordingly, the analysis result revealed that the numbers of each species in community 4 were closer to each other than the rest communities whereas the closeness of the numbers of each species in community 6 was relatively less.

Table **7**. Comparison of diversity indices in six communities of Setema natural forest.

Communities						
Diversity indices	C1	C2	C3	C4	C5	C6
Taxa	42	35	44	27	42	33
Individuals	1053	534	1242	395	1392	422
Shannon	2.07	1.98	2.16	1.72	2.25	1.76
Evenness	0.83	0.83	0.88	0.82	0.84	0.80

Community's Similarity

The similarity of community 1 with community 2 was 88%, with community 3 it was 82%, but relatively shared a smaller number of species with community 4 (72%), community 5 (71%) and community six (72%). The result of similarity analysis between communities revealed that the species in Setema natural forest are more or less homogeneously distributed in the forest.

Table 8. Sorensen's coefficient of similarity between the plant communities of Setema natural forest.

Community	**1**	**2**	**3**	**4**	**5**	**6**
1	1	_	_	_	_	_
2	0.88	1	_	_	_	_
3	0.82	0.5	1	_	_	_
4	0.72	0.48	0.67	1	_	_
5	0.71	0.57	0.72	0.60	1	_
6	0.72	0.76	0.54	0.53	0.69	1

V. RECOMMENDATION

Setema Forest is one of the Natural forests within Sigmo-Setema forest priority area in Ethiopia. Appropriate management strategy is Essential to conserve this natural forest. This study was conducted only on one block of Sigmo-Setema Forest priority area. The study of the whole Sigmo-Setema forest is recommended to know the current status of the vegetation of the area.

Further studies like diversity of herbaceous plants and lianas and analysis of soil sampling are needed to fill the gap of this work since it was only on woody species.

Vegetation of Setema Natural forest was disturbed through selective cutting, browsing and grazing. These factors further affect the forest regeneration status and thereby the ecosystem of the forest as a whole. Therefore, this forest needs to be conserved and utilized in sustainable way.

Different programs like Participatory Forest management programs should be hosted and applied so that local communities and concerned government offices adopt responsibility for the management and conservation of the forest and become the user of the economic profit of the forest.

Government should address Capacity-building and awareness creation on forest conservation for local community.

Finally, though it is not part of this study, local community use the forest for different purposes like cutting trees to make traditional hives and hunging hives again on branches of trees in the forest, for medicinal values, for home construction, for timber and for home furnitures. Thus, further ethno-botanical study on Setema Natural Forest is highly recommended.

Appendix 1. woody species collected from setema natural forest (t = tree, s = shrub).

No.	Scientific Name	Family Name	Vernacular Name (A/O)	Habit	Remark
1	*Acacia abyssinica* Hochst.ex Benth	Fabaceae	Laaftoo	T	
2	*Acacia etbaica* Schweinf.	Fabaceae	Dodota	T	
3	*Albizia schimperiana* Oliv.	Fabaceae	Ambabesa	T	
4	*Allophylus abyssinicus* (Hochst.) Radlkofer	Sapindaceae	Seo	T	
5	*Apodytes dimidiate* E. Mey. ex Arn.	Icacianaceae	Wandabiyo	T	
6	*Bersama abyssinica* Fresen	Melianthaceae	Lolchisa	T	
7	*Brucea antidysentrica* J.F Mill	Simarobiacee	Komanyo	T	
8	*Calpurina aurea* (Lam.) Benth	Fabaceae	Cheka	S	
9	*Celtis africana* Burm.f.	Ulmaceae	Qayi	T	
10	*Clausena anisate* (Willd.) Benth.	Rutaceae	Ulumayi	T	
11	*Cordia africana Lam*	Boraginaceae	Waddeessaa	T	
12	*Croton macrostachyus* Del.	Euphorbiacee	Bakkanniisaa	T	
13	*Dracaena steudneri* Engl.	Dracaenaceae	Lankuso (Showiye)	S	
14	*Dombeya torrida* (J. F. Gmel.) P. Bamps	Sterculiaceae	Adaannisa	T	
15	*Ehretia cymosa Thonn.* Thonn.	Rubiaceae	Ulaga	T	
16	Ekebergia capensis Sparm	Meliaceae	sombo	T	
17	*Embelia schimperi* Vatke	Myrsinaceae	Hanqu	T	
18	Euclea racemosa	Ebenaceae	miessa	S	
19	*Ficus sur* Forssk.	Moraceae	Harbuu	T	

No.	Scientific Name	Family Name	Vernacular Name (A/O)	Habit	Remark
20	*Ficus sycomorus*	Moraceae	Lugo	T	
21	*Galiniera saxifraga* (Hochst.) Bridson	Rubiaceae	Mito	T	
22	*Grewia ferruginea* A.Rich.	Tiliaceae	Tumane (lankisa)	S	
23	*Hagenea abyssinica* (Bruce) J. F. Gmel.	Rosaceae	Heto	T	++
24	*Juniperus procera*	Cupressaceae	Gatira	T	++

++ represents species out of sample plots. *** represents Endemic Species.

REFERENCES

[1] Addo-Fordjour, P., Obeng, S., Anning, A.K. and Addo, M.G., (2009). Floristic composition, structure and natural regeneration in a moist semi-deciduous forest following anthropogenic disturbances and plant invasion. *International journal of biodiversity and conservation*, **1(2)**: 021-037.
[2] Alemu, M and Bluffstone, R. (2007). Lesson from economics and international experience. In: polices to increase forest cover in Ethiopia: proceeding environmental economics policy forum for Ethiopia. Addis Ababa, Pp. 23-28.
[3] Aliyi, K., Hundera, K. and Dalle, G., 2015. Floristic composition, vegetation structure and regeneration status of Kimphe Lafa natural forest, Oromia Regional State, West Arsi, Ethiopia. *Research & Reviews: Journal of Life Sciences*, **5(1)**, Pp. 19-32.
[4] Badege B., 2001. Deforestation and land degradation in the Ethiopian highlands: a strategy for physical recovery. *Northeast African Studies, pp. 7-25.*
[5] Bekele-Tesemma, A., (1993). Useful Trees and Shrubs for Ethiopia Identification, Propagation and Management for Agricultural and Pastoral Communities.
[6] Bekele, M., (2008). Ethiopia's environmental policies, strategies and programs. Digest of Ethiopia's national policies, strategies and programs. FSS, Addis Ababa, Ethiopia, pp. 337-69.
[7] Birhanu, K., Soromessa, T. and Kelbessa, E., (2014). Structure and regeneration status of Gedo dry evergreen montane forest, West Shewa Zone of Oromia national regional State, central Ethiopia. *Science, technology and Arts Research journal*, **3(2)**: 119-131.
[8] Bishaw, B. (2001). Deforestation and land degradation in the Ethiopian highlands: a strategy for physical recovery. Northeast African Studies, pp. 7-25.
[9] Boyle, T.J. and Boontawee, B. eds. (1995). *Measuring and monitoring biodiversity in tropical and temperate forests: proceedings of a IUFRO symposium held at Chiang Mai, Thailand, August 27th-September 2nd, 1994*. CIFOR.
[10] Burju, T., Kitessa, H. and Ensermu, K., (2013). Floristic composition and structural analysis of Jibat humid afromontane forest, West Shewa zone, Oromia national regional state, Ethiopia. *Ethiopian Journal of Education and Sciences*, **8(2)**: 11-34.49.
[11] CBD (1992). Importance of forests for maintaining biodiversity CBD (2009). Definition of Biodiversity.
[12] Chauhan, B.S. and Johnson, D.E., 2008. Germination ecology of two troublesome Asteraceae species of rainfed rice: Siam weed (Chromolaena odorata) and coat buttons (Tridax procumbens). *Weed Science*, ***56*(4)**, pp. 567-573.
[13] Dail, G. (1997). What are ecosystem services? In: nature's services societal dependence. Daily on Natural Ecosystem (Daily, G.ed.) Island Press, Washington, pp1-10.
[14] Debisa, L.., 2009. Woody plant species Diversity of Taltalle woodland.
[15] Demel, T. (2002). Forest research in Ethiopia: past, present and future. In proceedings of a national conference on forest resource of Ethiopia: status, challenges and opportunities, Addis Ababa.
[16] Denslow, J.S. (1987). Tropical rainforest gaps and tree species diversity. *Annual review of ecology and systematics*, **18(1):** 431-451.
[17] Denu, D.., 2006. Floristic Composition and Ecological Study of Bibita (Gura-Ferda) Forest, Southwest Ethiopia (Doctoral dissertation, M. Sc. thesis).
[18] Dieler, J., Uhl, E., Biber, P., Müller, J., Rotzer, T. and Pretzsch, H. (2017). Effect of forest stand management on species composition, structural diversity, and productivity in the temperate zone of Europe. *European Journal of Forest Research*, **136(4)**:739-766.
[19] EFAP (1994). The relationship between vegetation cover and the quantity of carbon that can be sequestered from the atmosphere.
[20] Enkosa, W., (2008). Floristic Analysis of Alata-Bolale Forest in Gudaya Bila Wereda, East Wollega Zone in Oromia Regional State. AAU, School of Graduate Studies, Unpublishe Msc, Thesis.
[21] FAO (1996). Ethiopia"s biodiversity in both domesticated and wild plant and animal species that occur in variable and unique micro and macro-ecosystems.
[22] Ferreira, M.C. and Vieira, D.L.M. (2017). Topsoil for restoration: Resprouting of root fragments and germination of pioneers trigger tropical dry forest regeneration. *Ecological Engineering*, **103***: 1-12.*
[23] Feyera, S., Schmitt, C., Woldemariam, T., Boehmer, H.J. and Denich, M., 2014. Plant diversity, vegetation structure and relationship between plant communities and environmental variables in the Afromontane Forests of Ethiopia. *SINET: Ethiopian Journal of Science*, ***37*(2)**, pp.113-130.
[24] Friis, I. (1986). The forest vegetation of Ethiopia. *Acta Universtalisis Upsaliensis Symbolae Botanicae Upsaliensis (Symbolic Botaniee done Universtalisis Uppsala Uppsala)* **26**:31-47.
[25] Gebrehiwot, K., (2003). *Ecology and management of Boswellia papyrifera (Del.) Hochst. dry forests in Tigray, Northern Ethiopia*. Georg- August-University of Gottingen.
[26] Gennene, A., Berhe, L. and Teklay, T., 2013.Vegetation data sampling methods.
[27] Gibert, J. and Deharveng, L., 2002. Subterranean Ecosystems: A Truncated Functional Biodiversity: *Bio Science*, ***52*(6)**, pp.473-481. Girma, A. (2005). Rehabilitation and sustainable use of degraded community forests in the Bale Mountains of Ethiopia. Ph.D. Thesis report, Albert-Ludwigs University Freiburgin Breisgau.
[28] Gotelli, N.J. and Colwell, R.K. (2001). Quantifying biodiversity: procedures and pitfalls in the measurement and comparison of species richness. *Ecology letters*, **4(4)**:*379-391.*
[29] Gurmessa, F., Soromessa, T. and Kelbessa, E. (2012). Structure and regeneration status of Komto Afromontane moist forest, East Wollega Zone, west Ethiopia. *Journal of Forestry Research*, **23(2)**: 205-216.
[30] Hamilton, A.J., (2005). Species diversity or biodiversity. *Journal of Environmental Management*, **75(1)**: 89-92. Hubbell, S.P., (1979).

Tree dispersion, abundance and diversity in a tropical dry forest. *Science*, **203(4387)***:1299-1309.*
[31] Kelbessa, E., and Teshome, S. (2008). Interference of regeneration, structure, diversity and use of some woody species in Bonga forest. Unique gene reserve for wild coffee. SINET: *Ethiopia Journal of Sciences* **31' (2)***:121-134.*
[32] LaManna, J.A. and Martin, T.E. (2017). Logging impacts on avian species richness and composition differ across latitudes and foraging and breeding habitat preferences. *Biological Reviews*, **92(3)**: 1657-1674.
[33] Lamprecht, H. (1989). Silviculture on the Tropics. Tropical forest ecosystems and their tree species – Possibilities and methods for their long term utilizations.
[34] Lawton, R.O. (1990) Canopy gaps and light penetration into a wind-exposed tropical lower montane rain forest. *Canadian Journal of Forest Research*, **20(5)**: 659-667. 51.
[35] Le Prestre, P.G. (2017). Governing global biodiversity: The evolution and implementation of the convention on biological diversity. Routledge.
[36] Lemenih, M. and Kassa, H., 2014. Re-greening Ethiopia: history, challenges and lessons. Forests, **5(8)**, pp.1896-1909.
[37] Keenan, R.J., 2015. Climate change impacts and adaptation in forest management: a review. *Annals of Forest Science*, **72(2)**: 145-167.
[38] Masresha, G., Soromessa, T. and Kelbessa, E., (2015) Status and Species Diversity of Alemsaga Forest, Northwestern Ethiopia.
[39] Mamo, G., Sjaastad, E. and Vedeld, P. (2007). Economic dependence on forest resources: A case from Dendi District, Ethiopia. *Forest Policy and Economics*, **9(8)**: 916-927.
[40] McCune, B., 2006. Non-parametric habitat models with automatic interactions. *Journal of Vegetation Science*, ***17***(**6**), pp.819-830.
[41] Mersha Gebrehiwot, M. (2003). Assessment of Natural Regeneration Diversity and Distribution of Forest Tree Species. Geo-information science and earth observation present for degree of Master.
[42] Muthy, I.K., Murali, H.S, Hegde, G.I., Bhat, P.R. and Ravindranth, N.H. (2002). Comparative analysis of regeneration in natural forest and joint forest management plantation. *Current Science*, **83**: 1358-1364.

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