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ORIGINAL ARTICLE

Woody species structure and regeneration status of shoti forest, Essera district Dawro zone, SNNPRG, Ethiopia

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Woody species in Shoti forest were assessed. Systematic sampling method was used to collect vegetation data. Ninety 20 m ×20 m sample plots were used for mature trees of woody species and five 2 m × 2 m subplots within each main plot for seedling and sapling study to know regeneration of woody plants. The sample plots were laid at every 100 m interval along transects at 400 m apart. The composition and population structure of the woody species and their regeneration were recorded in each plot. Environmental variables (altitude and aspect,) were recorded in each sample plot and tree height was measured. Woody species densities for mature individuals were 3516 stems ha^{-1}, for saplings 2544 stems ha^{-1} and for seedlings 1177 stems ha^{-1} which indicates the study forest is declining. The total basal area of the forest was 77.32 m^2 ha^{-1}. Management like enrichment plantation is recommended.

Keywords: Woody species, Structure, Regeneration, Forest.

Introduction

A woody plant is a plant that produces wood as its structural tissue. Woody plants are usually trees, shrubs, or lianas. These are usually perennial plants whose stems and larger roots are reinforced or strengthened with wood produced from secondary xylem. The main stem, larger branches, and roots of these plants are usually covered by a layer of bark. Wood is a structural cellular adaptation that allows woody plants to grow from above ground stems year after year, thus making some woody plants the largest and tallest terrestrial plants. Wood is primarily composed of xylem cells with cell walls made of cellulose and lignin. Xylem is a vascular tissue which moves water and nutrients from the roots to the leaves. Most woody plants form new layers of woody tissue each year, and so increase their stem diameter from year to year, with new wood deposited on the inner side of a cambium layer located immediately beneath the bark. However, in some monocotyledons such as palms and dracaenas, the wood is formed in bundles scattered through the interior of the trunk. Woody plant differs from herbaceous plants in having an aerial stem, which persists for more than one season and in most cases a cambium layer for periodic growth in diameter (FAO, 2007).

Regeneration refers to the natural process by which plants replace or re-establish themselves, usually from an abundant production of seeds. The concept of regeneration includes: reforestation, harvesting of old timbers, seeding depleted range and reintroduction of wild species. Seedlings represent the final stage in the process of regeneration from seeds. Recruitment is a transition from juvenile stage to the seeds or seedlings and then to vegetative plant parts. It is a multiphase process involving several sequential life history stages (i.e., seeds, seedlings and saplings) connected by transitional processes (i.e., dispersal, emergence and survival) (Oldeland, et al., 2010).

The recruitment of a seedling population from the available seeds relies on environment sieve. Hence, a good understanding of natural regeneration in any plant community requires information on the presence and absence of persistent soil seed banks or seedling banks, quantity and quality of seed rain, durability of seeds in the soil, losses of seeds to predation and deterioration, triggers for germination of seeds in the soil and sources of regrowth after disturbances (Kotwal, et al., 2008).

Environmental factors such as soil moisture, temperature, canopy cover (light conditions), deep leaf layers and micro scale disturbances affect tree seedling dynamics. Seedling may fail to occupy a particular site because seeds do not arrive at the site (dispersal limitation) or because the site is not a suitable environment for establishment (establishment limitation). Hence, the availability of seeds and the lack of suitable microsite for seedling recruitments are increasingly identified as major constraints governing species diversity (Woldemariam, 2016).

Following the germination of seeds, the next phase in the process of regeneration by seeds is the development of seedlings. Vulnerability of seedlings to hazards from environmental and biotic factors is higher at the early stages of seedling establishment. Some species are unable to establish in the under storey environment while other seedlings and saplings are favoured by herbivores. A tree species with no seedling and sapling in a forest is under a threat of local extinction. Moreover, Tree species that have been over utilized and lack replacement would eventually disappear from the forest. One of the most effective adaptations for ensuring successful seedling establishment is, therefore, possession of a large seed, which provides an ample reserve of nutrients during the period immediately after germination (Oldeland, et al., 2010).

They are usually much more sensitive to both harsh abiotic conditions and competitions from neighbouring plants. In general, a tree species with no seedling and sapling in a forest is under risky condition and it is suggested that these species are under threat of local extinction. Hence, for a successful regeneration and establishment of seedlings, a sufficient volume of viable seeds, appropriate climatic and edaphic conditions are indispensible. In addition, vegetative regeneration of forest gap can be affected by size, shape and orientation of gap to the sun, soil type, topography, soil seed bank. Height and species composition of the surrounding vegetation, extent of damage to vegetation upon formation of the gap, temperature aspect of the gap and its spatial disturbances can also affect vegetative regeneration (Tajebe, 2017).
Diameter of a stem is a length from the outside of the bole through the centre to the opposite side of it. Usually diameter is measured with bark so that a reduction needs to be applied if only the wood is of interest.
Sometimes instead of diameter tree girth is measured. It is the circumference/perimeter of the stem.
Tree diameter and girth measurement are the most important tree variables because:

- They are in most cases easily and directly measured.
- From the diameter the basal area (which is closely correlated to tree volume) is directly calculated.
- The diameter distribution of a stand gives a good insight to the stands structure and potentially necessary silvicultural treatments.

The standard position for diameter measurement at standing tree is at breast height. It is defined at 1.30 meter above ground in most countries, but there are some countries where diameter at breast height is measured at different heights because trees vary in height (Asrat and Tesfaye, 2013).
At breast height the instrument is easily handled (convenience and ease). Also on most trees the influence of buttress on the stem form is already much reduced at the diameter at breast height (DBH).

Calipers and diameter tape are the most commonly used instruments.

Caliper

Is the most efficient to measure dbh directly whenever there is direct access to the tree. It can be made of wood, metal or aluminium. It has two arms one fixed and a graduated bar/beam on which the second arm slides.
To measure with a caliper, hold it firmly and horizontally as well as perpendicular to stem axis at the same time. Usually two readings are taken perpendicular to each other rat breast height and then the average value will be recorded.

Diameter tape

There are diameter tapes from which the tree diameter can be directly read. Tree diameter can also be determined from circumference measurement which can be done by diameter tape or any tape since circular tree stem shape is assumed.
Tapes are easy to carry than calipers (especially in dense forest). Measuring with caliper is faster than with tape. Bigger trees can be measured with tapes easily (calipers have an upper bound) tapes can be extended by joining them. Tapes are good to maintain consistency in measuring diameter regularly (Dinkissa, 2011).
If the cross-section of a tree is determined using the diameter at breast height, then it is called basal area. It is denoted by "g".
Basal area is commonly expressed in square meter (m^2).
Importance of basal area measurement:

- The sum of the basal areas of all trees in crop is a useful measure of stocking.
- In a uniform plantation of a single species volume is closely related to basal area.

Height is a tree variable that is used to estimate or determine the volume of a tree. Dominant height also helps to deal with the issues of site classification.
Tree height Vs tree length.
Tree height is defined to be the perpendicular distance between the ground level and the top of the tree. While, Tree length is the distance between the stem foot and the top along the stem (Dinkissa, 2011).

Types of tree height

- **Total height:** the distance between the ground and top of the tree.
- **Bole height:** the distance between the ground and the Crown Point.
- **Merchantable height:** the distance between the ground and the terminal position of the last useable portion of the tree stem.
- **Stump height:** the distance between the ground and the position where a tree is cut.
- **Merchantable length:** is the distance between the top of the stump and the terminal position of the last useable portion of the tree stem.
- **Dominant height:** is the average height of 100 thickest trees per hectare.

Shoti forest is one of the protected forest areas in Dawro zone, currently it is under severe anthropogenic impacts like agricultural land expansion, charcoal extraction, illegal logging for construction and timber and etc. Hence, there is a need of sound conservation and sustainable use of this forest. This necessitates perceiving the nature of its plant community, species diversity and its linkage to the local communities. Lack of such basic information is one of the serious problems that hampered the conservation and rational utilization of the forest resources of the area. Thus, species documentation, community identification and description of this forest are important and this study is initiated to provide primary information about woody plant composition, species diversity and population structure of Shoti natural forest in Essera district. Further, the aim of this study on vegetation management is for proper utilization of the resource and it will play pivotal role in avoiding environmental degradation for the local communities and for others who rely on the forest as well as for local government that nearly follows and manages the forest resource of the area.

The main objective of this project is to assess woody species structure and regeneration status of Shoti forest and to recommend the way of sustainable forest management.

Materials and Methods

Description of study area

Dawuro is one of the 13 zones in SNNPR. It is situated 7°14' North latitude and 37°5' East longitude. The Zone has 5 districts *woredas*: Loma, Mareka, Essera, Gena Bosa and Tocha, its capital, is located about 438 kilometers south West of Addis Ababa. Essera district, which is purposefully selected for study, is rich in forest resource. Essera districts lies in three agro-ecological regions: *Kola* region which is within 500-1500 meters above sea level (masl) and receives 500-1,500 milimeters (mm) of rainfall; *Woyina Dega* within 1501-2500 masl and receives 1281501-2500 mm; and *Dega* at above 2500 m.a.s.l and receives more than 2500 mm (Zeleke, 2014) (Fig. 1).

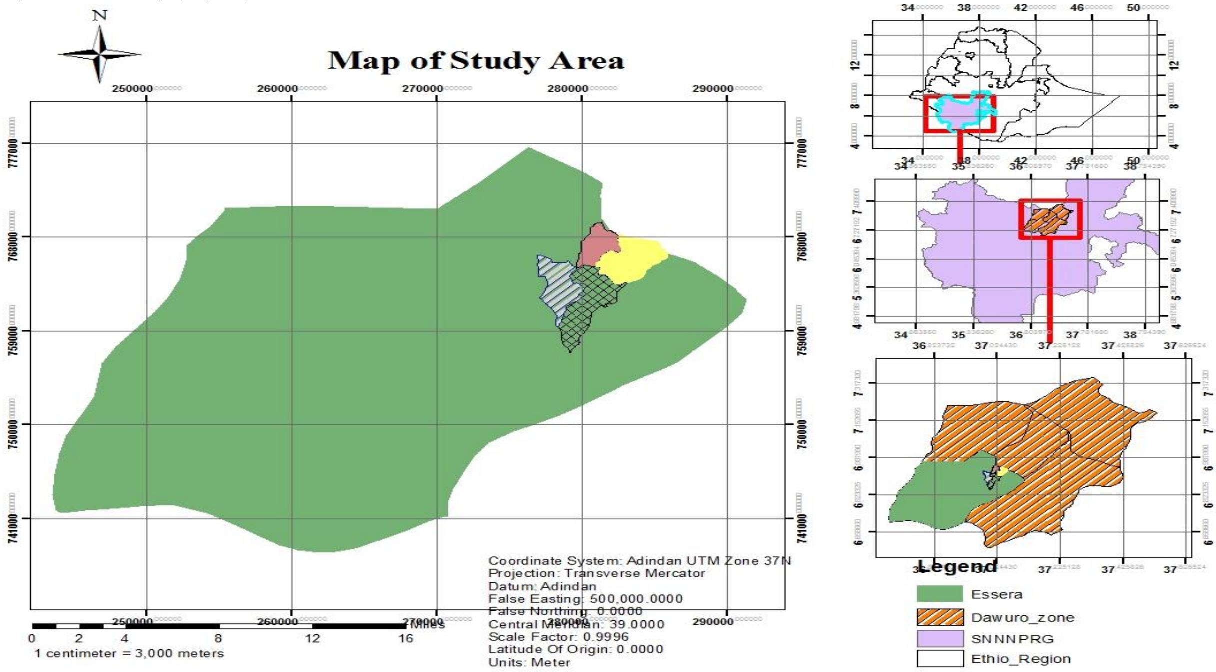

Fig. 1. Map of study area.

Sampling design

A systematic sampling technique was used to collect vegetation data in the forest. Plots of size 20 m × 20 m (400 m^2) was used for trees and shrubs, and subplots of 2 m × 2 m for plants at sapling stage at the four corners and one at the centre of the large quadrate. Plots were laid systematically at every 200 m along transect lines, which was 400m apart from each other.

Establishments of quadrates

A reconnaissance survey of study area was undertaken first. During that period, overall information on the study site was obtained and representative sampling sites were identified. Three representative sampling sites were selected based on altitudinal gradients. Sites that are relatively better protected and with relatively less extent of human disturbance than in the other areas were selected. At each site, two lines transects were laid at 400 m apart and quadrates of size 20 m × 20 m were established systematically at every 200 m interval along these lines transects following altitudinal gradient at appropriate direction. Sampling plots were systematically established for the documentation of trees, shrubs and lianas following the Braun-Blanguet approach (Mueller-Dombois and Ellenberge, 1974; Kent and Coker, 1992; DesalegnWana and Zerihun Woldu, 2005). For the ground flora (seedlings and saplings), a 2 m × 2 m subplot were established within the main sampling plot.

Vegetation data collection

Vegetation data was collected between in sunny season. All the woody plant species encountered in each sample plot were recorded using vernacular or local names. In each plot, trees and shrubs with DBH >2.50 cm was measured and recorded for height and diameter at breast height (DBH). At each of the plots established, diameter of trees and shrubs with Diameter at Breast Height (DBH) >2.5 cm was measured using a diameter tape. Counting of trees, and shrubs with DBH >2.5 cm and conversion of Diameter at Breast Height (DBH) to basal area was made later. The measurement was taken for trees and shrubs with the height >2 m and

DBH >2.5 cm. For trees and shrubs that are leaning, the study was conducted at standing on up slope side of the tree and wrapping the tape at 1.3 m at right angle to lean of the bole. When trees with swelling, bumping and branch at 1.3 m above the ground, DBH was measured at equal distance above and below 1.3 m and two measures was averaged. For trees and shrubs that are forking branched above the breast height, branches were measured separately and were averaged, forking below breast height, was measured separately and was considered as two trees. In each plot, the number and height of seedlings and saplings was recorded to determine the status of their regeneration. The undergrowth of woody species with the height less than 1 m was considered as seedlings, single-stemmed individuals with the height of greater than 2 m was considered as trees and those in between the seedling and trees/shrubs (with height of 1-2 m) was considered as sapling (Hundera, 2008). The height of these species were taken by using clinometers, for some short trees calibrated bamboo stick was used and visual estimation was applied. All individuals of each study species were then categorized into DBH and Height classes.

Physiographic variables such as altitude, aspect, slope and UTM was recorded for each sampling plots using GPS of model Garmin 72H. Species composition and cover value (the area of ground within a sampling plot occupied by the above-ground parts of each species) was recorded for each species to determine the plant community types.

The identification was done using the Flora of Ethiopia and Eritrea. The nomenclature of plant species follows the Flora of Ethiopia and Eritrea.

Structural analysis

The structure of the vegetation was described based on the analysis of species density, DBH, height, basal area, frequency and Important value Index (IVI). The regeneration status of the trees, shrubs and lianas was also determined by computing density ratios between seedlings and mature individuals, seedlings and saplings, and sapling and mature individuals. The Diameter at Breast Height (DBH) and tree height was classified in to DBH classes and height classes. The percentage frequency distribution of individuals in each class was calculated. The tree or shrub density and basal area, values was computed on hectare basis. These vegetation data was computed and summarized using Microsoft Office Excel spread sheet using the following formulae.

The frequency distribution of tree species was calculated as:

Frequency (F): Is the chance of finding a species in a particular area in a particular trial samples.

F=[Number of plots in which a species occur/total number of plots laid out in the study site] × 100

Relative Frequency (RF): It is the frequency of species A/sum of frequencies of all species x 100.

Density of a species=the number of individuals of that species/area sampled.

D=Number of above ground stems of a species countered/sampled area in hectare (ha)]

Relative density=Density of species A/total density of all species x 100.

Basal area (BA): It is the area outline of a plant near ground surface for trees. It is measured through diameter, usually at breast height (DBH) that is 1.3 m above ground level. The analysis of species dominance was be made using basal area measurements.

$$BA = \frac{\Pi d^2}{4}$$

Where BA=Basal area in m^2 per hectare.

D=diameter at breast height in meter.

$$\Pi = 3.14$$

Dominance: It is the mean basal area per species times number of the species.

Relative dominance (RDO): It is basal area of a species/total basal area of all species x 100.

Important values index (IVI) was analyzed for woody species. IVI of a species was calculated from the sum of relative dominance (RDO), relative density (RD) and relative frequency (RF) (Kent and Coker, 1992).

IVI=RDO+RD+RF.

Results and Discussion

Analysis of vegetation structure

To analyse the vegetative structure of woody species, all individuals of each species encountered in the quadrat were grouped into diameter and height classes. Information on population structure of a tree species indicates the history of the past disturbance to that species and the environment and hence, used to forecast the future trend of the population of that particular species.

Diameter at Breast Height (DBH)

The result indicated that, the DBH of trees were classified into seven classes: a) <20 cm, b) 20.01-40 cm, c) 40.01-60 cm, d) 60.01-80 cm, 5) 80.01-100 cm, e) 100.01-120 cm and f) >120 cm (Fig. 2).

The majority of trees were distributed in the in third, fourth and fifth class and the oldest trees of species such as *Ficus elastic*, *Schefflera abyssinica*, *Prunus africana*, *Syzygium guineense*, *Ficus vasta*, *Ficus sycomorus* and other few largest trees found in sixth class. Small woody plants like *Maesa lanceolata*, *Vernonia karaguensis* and others found in first and second classes in large amount.
The distribution of trees in DBH class <20 cm was 3292 individuals (26%) are found in plot and 914 individual ha^{-1}; in this class small trees are found. Here many trees occupy small land. In second class (20.01-40 cm), 19% or 2405 individuals found in plots and 688 individuals per hectare. In this class species like *Myrica salicifolia*, some *Millettia ferruginea* species, some of *Croton macrostachyus*, small amount of *Albizia schimperiana* are found. In third class (40.01-60 cm) 2025 individuals or 16% are found in plot and 563 individuals ha^{-1}. In fourth class (60.01-80 cm) 15% or 1899 individuals are found in plots and 528 individuals ha^{-1}. In fifth class (80.01-100 cm), 1645 individuals or 13% found in plots and 457 individuals ha^{-1}. In sixth 1392 individuals or 11% of the woody plants are found in plot and 387 individuals ha^{-1}. From the DBH class distributions of the species, two types of regeneration status were determined, i.e., good and poor regeneration. Some species like *Maytenus arbutifolia* possessed high number of individuals in the lower DBH classes, particularly in the first class, which suggests that they have good regeneration potential. Other species such as *Syzygium guineense* possessed either no or few number of individuals in the lower DBH classes, particularly in the first class, which indicates that the species are in poor regeneration status. Total number of trees in each DBH class decreased with and increasing tree diameter classes. Result showed that, the majority of the species had the highest number of individuals in the lower DBH and low in the high DBH classes.
But as the DBH class distribution of some tree species had irregular pattern result with total DBH of the study forest shown in Fig. 3. That the number of individuals was low at lower class than higher class, some species had high number of individual at lower, still the others are high at middle class. That means such woody plant species were being finished because there was no substitution at seedling/sapling stage. This may be due to free grazing and selective cutting of individuals at specific size for different purposes (Table 1).

Table 1. DBH classes and density of woody plants in each DBH class.

DBH classes	Class intervals	Density	Percent (%)
1.	<20 cm	914	26
2.	20.01-40 cm	688	19
3.	40.01-60 cm	563	16
4.	60.01-80 cm	528	15
5.	80.01-100 cm	457	13
6.	100.01-120 cm	387	11
7.	>120 cm	0	0

Source: Inventory, 2021.

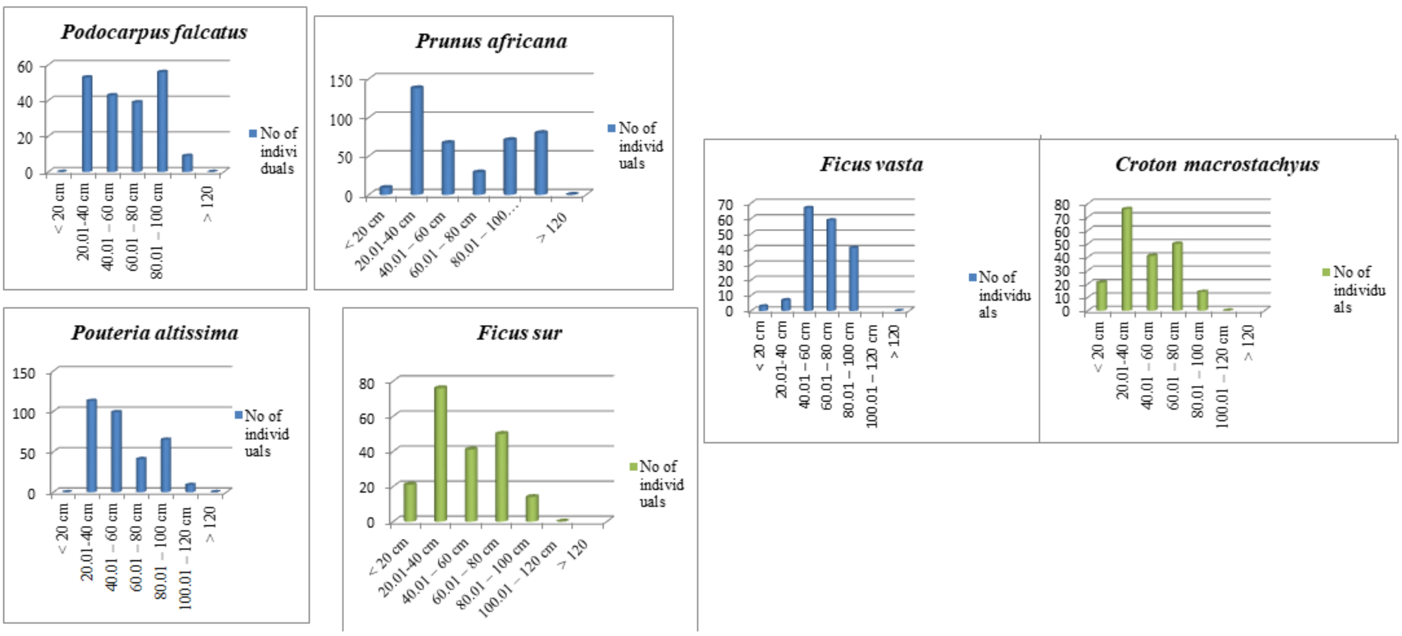

Fig. 2. DBH of selected tree species of Shoti forest.

As it can be seen from above graphs DBH distribution of selected trees from Shoti forest had Irregular shape; in which woody plants are distributed differently in almost all classes.

Tree height distribution of Shoti forest

Twenty seven (27) woody species having 2,917 individuals were selected to describe the height of Shoti forest plant communities. Nine height classes, class 1) 2.0-5.0 m, 2) 5.01-10.0 m, 3) 10.01-15.0 m, 4) 15.01-20.0 m, 5) 20.01-25.0 m, 6) 25.01-30.0 m, 7) 30.01-35.0 m, 8) 35.01-40 m 9) >40.01 were established.

As shown in Table 2, the number of individuals in each successive height class has almost decreasing situation beginning from the first lower height class to the highest height class. The majority of individuals contributing to the first height class came from trees such as *Maesa lanceolata*, *Myrica salicifolia*, and some of *Euphorbia candelabrum.* The percent of woody species decreased with increasing height classes from third to fifth class, increased from first to third class and again decreased from sixth to ninth class.

Table 2. Height class distribution.

Height classes	Class intervals	Density	Percent
1.	2-5 m	47	6
2.	5.01-10 m	73	9
3.	10.01-15 m	170	21
4.	15.01-20 m	73	9
5.	20.01-25 m	65	8
6.	25.01-30 m	235	29
7.	30.01-35 m	57	7
8.	35.01-40 m	65	8
9.	>40 m	25	3
Total		810	100

Source: Inventory, 2021.

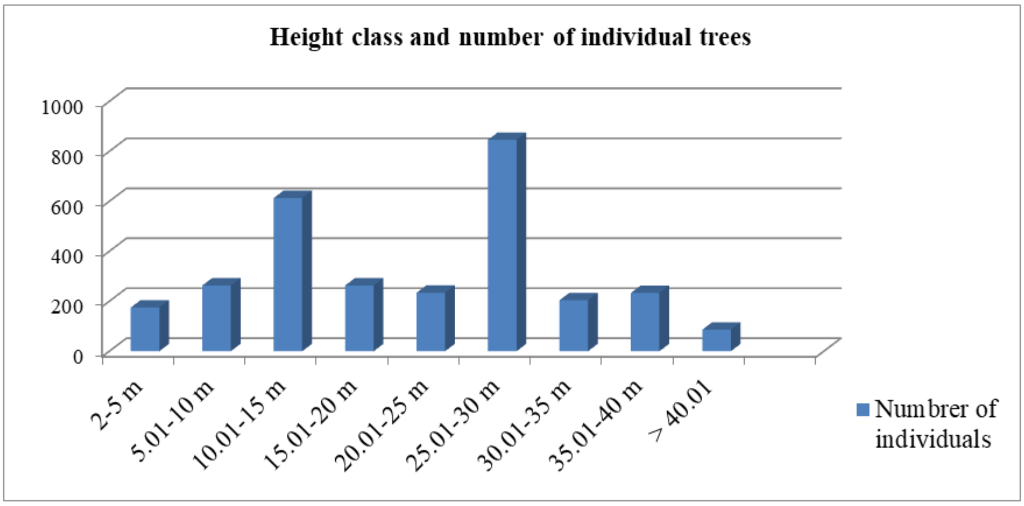

Fig. 3. Height class frequency distribution of woody species.

Starting from second height class, tress species such as *Juniperus procera, Cordia africana and Hagenia abyssinica.* Such irregular height distribution was due to selective cutting of some species for example local saw mile workers strongly prefer woody species like *Cordia africana, Syzygium guineense and Podocarphus falcatus* and some height class. The decrease in number of each height class towards the highest classes showed that the dominance of small-sized individuals in the Forest, which was the characteristic of high rate of regeneration. Height class from third to fifth and sixth to ninth showed such pattern.

Basal area of Shoti forest

The cross sectional area of a tree estimated at breast height is called the tree basal (symbol g) and expressed in (m^2). The sum of the basal areas of all trees on an area of one hectare is symbolized by G-m^2/ha. Basal area is a useful measure by which to compare the stocking of two stands of the same species height. Basal area provides the measure of the relative importance of the species than simple stem count. Species with largest contribution in dominance value through higher basal area could be considered as the most important species in the study vegetation. Otherwise, in most cases shrubs could be the dominant species if only we consider density as a measure to indicate the overall dominance of the species (Weber, E., and Gut, D., 2004). In Shoti forest, large amount of basal area was determined from large DBH classes as indicated in following Table 3 in average 59.83 m^2 basal area was determined from 6th DBH class followed by 5th DBH class. In lower DBH classes, low basal area was determined even-though there were many individuals per plot.

Table 3. DBH and basal area.

DBH classes	Class intervals	Basal area in m^2 per Ha
1.	<20 cm	10.29
2.	20.01-40 cm	11.028
3.	40.01-60 cm	13.34
4.	60.01-80 cm	12.4
5.	80.01-100 cm	13.65
6.	100.01-120 cm	16.62
7.	>120 cm	0

Total	77.32

Source: Inventory, 2021.

This was due to the presence of very large and old aged tree species which contain very large DBH and basal area per individual tree. For instance tree species like *Syzygium guineense*, *Schefflera abyssinica*, *Prunus africana*, *Ficus vasta*, *and Ficus sycomorus* had very huge diameter at breast height per individuals. Consequently, the DBH class where such trees found had large basal area. In study forest total basal area was 77.32 m^2/Ha.

Frequency

The frequency and percentage frequency values of each woody species in Essera high forest was determined based on the number of plots in which a particular woody plant found.

Frequency reflects the pattern of distribution and gives an approximate indication of the heterogeneity of a stand. The highest relative frequency was scored by *Syzygium guineense* was the most frequent species followed by *Prunus africana* which has relatively highest relative density and the highest relative basal area. These may be due to the fact that these species might have a wide range of seed dispersal mechanisms like by wind, livestock, wild animal, birds and the like. Following Table 4 shows the most frequent woody plant species in Essera high forest.

Table 4. Frequency of woody plants of study forest.

Scientific name	No of quadrats present in	Total quadrats Sampled	% Frequency	Relative Frequency
Syzygium guineense	87	90	96.7	10.03
Prunus africana	83	90	92.2	9.56
Schefflera abyssinica	79	90	87.8	9.1
Ficus sur	74	90	82.2	8.52
Erythrina abyssinica	72	90	80	8.29
Cordia africana	60	90	66.7	6.92
Croton macrostachyus	53	90	58.9	6.1
Pouteria altissima	51	90	56.67	5.88
Dracaena steudneri	48	90	53.33	5.53
Podocarphus falcatus	44	90	48.9	5.07
Acacia lahai	41	90	45.55	4.72
Hagenia abyssinica	37	90	41.11	4.26
Eucalyptus camaldulensis	36	90	40	4.15
Juniperus procera	33	90	36.66	3.8
Phoenix reclinata	31	90	34.44	3.57
Ficus sycomorus	26	90	28.88	2.99
Ficus vasta	13	90	14.4	1.49
Total			964.44	100

Source: Survey, 2021.

Important Value Index (IVI)

Important Value index combines data from three parameters, which include Relative Frequency, Relative Density and Relative Basal area (Kent and Coker, 1992). IVI is ecologically important and a key structural parameter in vegetation study. It is the most realistic aspect in vegetation study and used to compare the ecological significance of species. For all individuals of tree having >2.5 cm DBH, Relative density, Relative frequency, Relative basal and Importance Value Indices (IVI) were calculated.

Importance Value Index (IVI) indicates the importance of individual tree/shrub species in the land use systems. It is a composite index based on the Relative density+Relative frequency+Relative Basal area. This index is used to determine the overall importance of each species in the community structure (relative density, relative dominance and relative frequency) which describes the structural role of a species in a stand.

Importance value index indicates the structural importance of a species within a stand of mixed species and it is calculated by summing up the relative percentages of basal area, density and frequency of species in the study area. As indicated by (Abunie, 2016), it is used for comparison of ecological significance of species in which high IVI value indicates that the species sociological structure in the community is high. Importance Value Index combines data from three parameters which include RF, RD and RDO (Kent and Coker, 1992). It is crucial to compare the ecological significance of species. It was also stated that species with the greatest importance value are the leading dominant of specified vegetation.

Thus IVI is the most reasonable aspect in the vegetation study. Moreover, species with the greatest importance value are the most dominant of particular vegetation (Abunie, 2016).

Following tree species were selected for important value determination because of their high basal area, frequency and density. The following basal area was calculated for most determinant tree species to important value index starting from DBH class 3 up to DBH class 7.

The most important vegetation type was the dominant tree *Prunus africana, Cordia africana, Schefflera abyssinica, Syzygium guineense, Pouteria altissima* in their descending order of IVI (Table 5,6).

Table 5. Relative basal area, DBH, Relative density.

Scientific name	DBH (m)	Basal area (m^2)	Relative basal area	Density	Relative Density
Schefflera abyssinica	5.64	25	11.23	71	5.58
Prunus africana	5.29	22	9.92	109	8.57
Syzygium guineense	4.92	19.1	8.62	55	4.32
Pouteria altissima	4.79	18	8.12	90	7.08
Podocarphus falcatus	4.65	17	7.67	56	4.4
Ficus sur	4.27	14.3	6.45	56	4.4
Erythrina abyssinica	4.07	13	5.86	84	6.6
Cordia africana	4	12.14	5.48	178	14
Croton macrostachyus	3.63	10.32	4.65	62	4.87
Acacia lahai	3.6	10.12	4.56	117	9.2
Phoenix reclinata	3.51	9.89	4.46	43	3.38
Dracaena steudneri	3.49	9.54	4.3	90	7.08
Juniperus procera	3.42	9.23	4.16	61	4.8
Ficus vasta	*3.3*	8.53	3.85	49	3.86
Hagenia abyssinica	*3.21*	8.2	3.8	56	4.4
Ficus sycomorus	*3.19*	8	3.6	35	2.76
Eucalyptus camaldulensis	*3.06*	7.28	3.29	60	4.72
Total density		221.65	100	1272	100
Source: Inventory, 2021.					

Table 6. Important value index.

Species	Relative Basal area	Relative Frequency	Relative Density	IVI	%IVI	Priority
Prunus africana	9.92	9.56	8.57	28.05	9.35	1
Cordia africana	5.48	6.92	14	26.4	8.8	2
Schefflera abyssinica	11.23	9.1	5.58	25.91	8.64	3
Syzygium guineense	8.62	10.03	4.32	22.97	7.66	4
Pouteria altissima	8.12	5.88	7.08	21.08	7.03	5
Erythrina abyssinica	5.86	8.29	6.6	20.75	6.9	6
Ficus sur	6.45	8.52	4.4	19.37	6.46	7
Acacia lahai	4.56	4.72	9.2	18.48	6.16	8
Podocarphus falcatus	7.67	5.07	4.4	17.14	5.71	9
Dracaena steudneri	4.3	5.53	7.08	16.91	5.64	10
Croton macrostachyus	4.65	6.1	4.87	15.62	5.2	11
Juniperus procera	4.16	3.8	4.8	12.76	4.25	12
Hagenia abyssinica	3.8	4.26	4.4	12.46	4.15	13
Eucalyptus camaldulensis	3.29	4.15	4.72	12.16	4.05	14
Phoenix reclinata	4.46	3.57	3.38	11.41	3.8	15
Ficus sycomorus	3.6	2.99	2.76	9.35	3.11	16
Ficus vasta	3.85	1.49	3.86	9.2	3.07	17
Total				300.02	100	
Source: Inventory, 2021.						

Regeneration status

The population structure of a species in a forest can convey its regeneration behavior. The population structure characterized by the presence of sufficient population of seedlings, saplings and adults, indicates successful regeneration of forest species and the presence of saplings under the canopies of adult trees also indicates the future composition of a community. Regeneration status of trees can be predicted by the growth structure of their populations. Regeneration of a particular species is poor if seedlings and saplings are much less than the mature trees. The study of regeneration of forest trees has important implications for the management of natural forests. Composition and density of seedlings and saplings would indicate the status of regeneration in the study area. The population structure helps to study the regeneration pattern of a species. In this study 2 m by 2 m sized plots within large plots (20 m × 20 m) were developed at four corners and one at the middle that means totally five (5) small plots whose totally area 2m*2m*5=20m^2.

From total 90 main plots 1800 m^2 or 0.18 ha sized sub plots were taken total collect seedling and sapling data. From the analysis of seedlings and saplings data, the total seedling density of the woody species in Shoti forest was 10339 or 2872 ha^{-1}, the densities of tree, shrub and liana species seedlings were 41% 4239 individuals or 1177 individuals per hectare, 32% 3308 individual trees or 919 individuals per hectare and 27% 2792 individual trees from sample plot or 775 per hectare respectively. Similarly, the total density of saplings accounts 9159 or 2544 per hectare and that of mature tree was 12656 or 3516 ha^{-1}. The distribution of mature individuals is greater than seedlings and sapling indicates that the regeneration status of the forest is at low state.

According to (Alemu et al., 2011), the density values of seedlings and saplings are considered regeneration potential of the species. Good regeneration, if seedlings >saplings >adults; Fair regeneration, if seedlings> or ≤ saplings ≤ adults; Poor regeneration, if the species survives only in sapling stage, but no seedlings (saplings may be <,> or=adults); and if a species is present only in an adult form it is considered as not regenerating (Hundera, 2008). The presence of good regeneration potential shows stability of the species to the environment. Climatic factors and biotic interferences influence the regeneration of different species in vegetation. Higher seedling density values get reduced to sapling due to biotic disturbances and competition for space and nutrients. Regeneration status of study forest was seedling (4239 or 1177 ha^{-1})<sapling (9159 or 2544 ha^{-1})<mature tree (12656 or 3516 ha^{-1}). The result shows as the study forest was very poor in regeneration. The data analysis revealed that the density values for seedlings and saplings of the population structure of the Forest are low and deviates from the normal patters of the population. This might be due to high disturbances existing in the Forest as it could be directly observed in forest during the study problems such as free grazing, illegal logging for different purposes (construction, timber production, charcoal production etc.). Especially, illegal timber production has had very strong influences on some tree species due to their quality timber and their convenience to be produced by hand saws. Tree species in this category from study forest were *Cordia africana, Pouteria altissima*, *Podocarphus falcatus*. This implies a need to develop and implement effective forest management regimes in the area to promote healthy regeneration and the sustainable use of these species.

Conclusion and Recommendation

From the structural analysis, the density of tree species in the forest decreases with increasing DBH and Height classes, or which implied the predominance of small-sized individuals in the lower classes than in the higher classes, indicating good recruitment of the forest and rare occurrence of large individuals. DBH of some selected woody species have had irregular shape. This is an implication for the occurrence of excessive cutting of selected size classes.

The analysis of frequency classes for woody species revealed that *Syzygium guineense* was the most frequent species followed by *Prunus africana* which has relatively highest relative density and the highest relative basal area.

Regeneration status of study forest was seedling (4239 or 1177 ha^{-1})<sapling (9159 or 2544 ha^{-1})<mature tree (12656 or 3516 $ha^{-1)}$. The result shows as the study forest was very poor in regeneration. The data analysis revealed that the density values for seedlings and saplings of the population structure of the Forest are low and deviates from the normal patters of the population.

Even though many struggles and motions are there to conserve forest in study area it still wrong in right sense of conservation because, currently Essera forest is experiencing high rate of destruction because of the unwise use of the people from nearby villages for their requirements. This has resulted in the depletion of the forest, thereby causing damage to both plant and animal diversity of the area. As well there is expansion of exotic tree in very alarming rate. For instance *Grevillea robusta* is one that got great issue of extension work and consequently it is being planted as enrichment plantation.

Creating mechanisms such as participatory forest management by which human impacts can be minimized through discussion and consultation with the local communities to make the sense of ownership.Tree planting by the local community has to be encouraged to reduce the pressure on the natural forests and to create buffer zones because as the result of regeneration status indicated, the forest is declining in regeneration.

Conflicts of Interest

The authors declare no conflicts of interest.

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