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Species Size Distribution and Site Status Assessment of *Gmelina Arborea* Plantation

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ABSTRACT

The research work on size distribution of tree species in *Gmelina arborea* plantation was conducted to assess the volume of primary tree species, Gmelina and other secondary species identified in the plot and to relate the present site status with the afore stated objectives of the plantation. It was carried out in the *Gmelina arborea* plantation of Federal College of Forestry, Ibadan, Nigeria. Total enumeration method was employed to achieve the set objectives. Total number of 108 trees was assessed among which 90 were *Gmelina arborea*, 5 *Tectona grandis*, 6 *Delonix regia*, 2 *Mangifera indica* while others in Table 4.0 had one appease. Parameters assessed were Diameter at Breast Height (DBH)(cm) and Total Height (TH)(m) through which Basal Area(m^2) and Volume(m^3) were deduced. DBH was measured at 1.3m above the ground level using diameter tape while Total Height was measured with the use of Haga altimeter and measuring tape. The result showed that *Gmelina arborea* had the highest species composition of 83.33%, followed by *Delonix regia* with 5.55% and *Triplochiton sceleroxylon*, *Cedrela odorata*, *Milicia excelsa*, *Elaeis guineensis* and *Securidaca longipedunculata* which had the least species composition of 0.93% appease. Also, *Gmelina arborea* had the highest total DBH of 8172cm

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followed by *Tectona grandis* with DBH of 1072cm and *Securidaca longipedunculata*, 81cm. *Gmelina arborea* has the highest total height of 1945m followed by *Tectona grandis* with 118m and *Milicia excelsa* 13m. *Gmelina arborea* had the highest Basal area (BA) of 76.772m^2 followed by *Tectona grandis* with 18.411m^2 and *Securidaca longipedunculata* 0.515m^2.*Gmelina arborea* has the highest volume of 1,4931.54m^3 followed by *Tectona grandis* with 2,172.498m^3 and *Securidaca longipediculata* with 7.21m^3. Furthermore, the on-site inventory on the plantation showed that other tree species apart from the main Gmelina species identified was as a result of poor silvicultural practices such as poor weeding culture and primary objective deviation. This was seen bastardized the laid down spacing of 3m x 3m. Overall assessment of this research reveals that the study area was dominated by *Gmelina arborea* species while other tree species grown as a result of poor silvicultural management. It is thereby recommended that proper silvicultural management such as weeding, pruning, selective felling and coppice management should be embraced for stable and sustainable plantation.

Key words: DBH, BA, Size distribution, Plantation, Forest mensuration.

INTRODUCTION

Meaning, Importance and Objectives of Plantation

FAO, (2000) reported that there is no internationally agreed definition of forest plantations, although the expression “planted forest” is now widely used to embrace the continuum of forest types where forest origin is known to be by planting. The International Experts Meeting on The Role of Planted Forests in Sustainable Forest Management in Chile recommended that the question of definition be considered by the UN Food and Agriculture Organization (FAO), the principal body responsible for forestry, since the boundary between planted and natural forests is often indistinct, and among countries there are different degrees of management and different objectives for planted forests. Forest plantations are taken to be those planted forests by origin which still possess features of uniformity, shape, and often intensity of management, which

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readily distinguish them as artificial, often, although not always, they will have been established on land devoid of tree cover, at least in the previous 50 years.

Plantation forests are a type of managed forest in which the trees are planted (as opposed to naturally regenerate), of the same age and generally of the same species, and are intended to maximize the production of wood fiber. Trees in a plantation forest are usually planted uniformly in rows to maximize the site's growing space and resources, to ensure uniform growth, and to facilitate the use of mechanized harvesting equipment (Grotta *et a*l., 2015)

Ajani, (2018) defined plantation as a piece of land cultivated with trees in a regular pattern of spacing and for specific purpose(s). It may be agricultural plantation or forest plantation. Agricultural plantation is the one comprising only agricultural trees such as Cocoa, Kolanut, Cashew, Oil Palm, Coconut etc while Forest plantation refers to the one cultivated with forest trees such as *Terminalia* spps, *Detarium microcarpum, Afzelia africana, Milicia excelsa, Triplochyton scleroxylon, Nesorgodonia papaverifera, Nauclea didderichi* etc. Plantation is of less species diversity. Mostly, plantation is mono cultivated area.

From the above assertions, plantation is deliberate cultivation of land with trees to meet specific objectives which can be mono or multiple in objective(s).

Ajani, (2018) further reported "plantation serves various importance forest serves apart from the fact that its cultivation is not natural, it is of lesser diversity, it follows regular spacing etc. All the benefits derived from plantation are purpose dependent, that is, the benefits follow the achievement of the reason for establishing the plantation at the first instance. Among the importance of plantation are socio-economical, environmental and ecological benefits. Plantation establishment is objective-dependent, among which are; timber production, fuel wood production, charcoal production (not environmentally friendly), land reclamation, soil & water conservation, park & recreation, weather amelioration, mitigation to climate change, landscape & beautification, windbreaks & shelterbelt management, electric pole production and research purpose. Each objective dictates the silvicultural procedures started from spacing. For example,

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the spacing for plantation of timber production objective will be wider than that of windbreaks while that of pole production will be less spacious than park and recreation spacing".

Forest/Plantation Mensuration and Inventory

For any reason of establishment, plantation assessment needs to be carried-out in term of inventory to estimate the size distribution for a particular period of time. Forest inventory is the systematic collection of data and forest information for assessment or analysis. Forest inventory is the procedure of obtaining information on the quantity and quality of the forest resources and many characteristics of the land area on which trees are growing (Husch *et al*., 2003). Harvesting and processing of forest product provides numerous jobs as well as needed raw materials used in a variety of industries. They also have many recreation uses and contribute to noise pollution control and report rephrase of tree decline and mortality in Europe and other part of the world (Hibeman, 2009).

Tree volume is the amount of wood in a tree. These may be gross or net. Tree volume is one of many parameters that are measured to document the size of individual trees (Kumar, 2005). Tree volume measurements serve a variety of purposes. These could be economic, scientific, and sometimes sporting competitions. Measurements may include just the volume of the trunk, or the volume of branches depending on the details needed and the sophistication of the measurement methodology (Blozan, 2004). Other commonly used parameters outline in tree measurement includes; the height, girth, and crown spread (Blozan, 2004).The tree is subdivided into smaller section in each method. The dimension of each section is measured and the corresponding volume calculated (Blozan and Riddle, 2006). In general, most sections are treated as frustum of cone, parabolic, or noiloid where the diameter at each end and length of each section is determined to calculate volume. Direct measurement are obtained by a tree climber who uses a tape to measure the girth at each end of a segment along electronic surveying equipment to remotely measure the end diameter and the length of each section (Blozan and Riddle, 2006). ISFR *et al.,* (2013) reported that *Gmelina arborea* is commonly known as white Teak/Gama, a fast growing tree species, used for timber, furniture wood, paper and pulp making and other

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forest based industries. It is a most promising multipurpose tree which is able to fulfill the need of fuel, fodder, wood, medicinal products, other domestic needs etc. *G. arborea* belongs to the family of *Liminaceae* an associate of *Tectona grandis* as it possesses equally good quality wood and native tree. *G. arborea* is light demanding and an ideal choice for Farm forestry and large-scale afforestation / reforestation. The species grows up to 30 m in height and over 80 cm diameters and is widely grown as a component of agroforestry system in humid tropics. It performs best on fresh, well-drained, fertile alluvial soils where rainfall varies from 1200 to 4500mm, temperature ranges from 20 to 45°C, and elevation ranges from sea level to 1000 m (Tewari *et a*l., 2009). Adopting an economically important tree species (Ujjwala and Rambabu, 2017) under various agroforestry systems could upsurge the productivity and contribute considerably in narrowing the gap between demand and supply of wood. The light-weighted wood is used in light construction, packaging, furniture, artificial limbs, particle board, plywood, wooden handicrafts, matches, etc. The wood is relatively light with a density of 420 to 640 kg/m^3 and a calorific value of about 4800 kcal/kg (Gonzalez *et al.*, 2009). The wood creates the average yields of paper with superior properties than from other hardwood pulps. Its leaves can be used as fodder, and its flowers produce abundant nectar from which good quality honey is produced (Kijkar *et al*., 2004).

Forest menstruation and inventory is a major concept of silvicultural operation used to determine volume and sustainability of forest. An estimate of the value and possible uses of timber is an important part of the broader information required to sustain ecosystems (Abraham and Wyss, 2010). When taking forest inventory the followings are important things to measure and note: species Diameter at Breast Height (DBH), Height, Site quality, Age, and Defects. From the data collected one can calculate the number of trees per acre, the basal area, the volume of trees in an area, and the value of the timber. Inventories can be done for other reasons than just calculating the value. A forest can be cruised to visually assess timber and determine potential fire hazards and the risk of fire (Pennamen, 2002). The results of this type of inventory can be used in preventive actions and also awareness. Wildlife surveys can be undertaken in conjunction with timber inventory to determine the number and type of wildlife within a forest. The aim of the

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statistical forest inventory is to provide comprehensive information about the state and dynamics of forests for strategic and management planning. Merely looking at the forest for assessment is called taxation. Forest mensuration is the science of forest growth and yield emphasizes the construction of models describing the relationship between growth parameters and influential predictor variables, and is based on forest botany, ecology, climatology, and soil science. It makes extensive use of forest mensuration techniques and inferential statistics to model tree and forest growth. To a large extent, these studies are of a phonological nature, indispensable to the forest manager in observing and quantifying growth phenomena in relation to time, site, genetic factors, and stand treatment. Gadow *et al.,* (2000) reported that forest mensuration deals with the measurement of trees and stands. They are mathematical variables representing different physical entities, and statistical variables with a probability distribution. Processing information about these variables requires the application of statistics and computer technology. Some characteristics are continuous variables, which imply that they can theoretically take on infinitely many values. The diameter of the bole, for example, may be measured in millimeters but continuity implies that a further sub- division can continue indefinitely, although it makes no sense to measure the diameter in 1/10 mm. Discrete variables can assume a countable number of values. The number of trees within fixed-radius sample plots, the number of branches within a tree and the number of needles within a branch are discrete variables.

A forest inventory does not only record the trees height, DBH and number for tree yield calculations. It also records the conditions of the forest, which might include (for example) geology, site conditions, tree health and other forest factors. The aggregate of individuals (trees, stands forests), for which information is required, is denoted as population.

Many forests are deficient of this importance operation thereby making the forest/plantation unstable and non-sustainable. The *Gmelina arborea* plantation at the Federal College of Forestry, Ibadan faces a lot of management challenges in the area of sustainable weeding, thinning, pruning and harvesting since its establishment in 1981 which resulted to the natural regeneration of other tree species. It has then been observed that the identified management problems have direct or indirect effects on the plantation volume status.

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MATERIALS AND METHODS

Study Area.

The research work was carried out at *Gmelina* plantation of Federal College of Forestry, (FCF) Ibadan, Nigeria. The plantation was established in 1981 as a Forestry Course Practical Plot. FCF, Ibadan was located at Jericho area in Ibadan North West Local Government of Oyo State, The area lies on Latitude 7° 23^1 N and Longitude 3° 51^1 E. The climate condition of the area is tropically dominated by average annual rainfall of 1200mm to1250mm. The average temperature is about 32°C, with average relative humidity of 80 to 85% and the climate ecology of the area experience rainfall with two distinct seasons, dry season usually from November-March and raining season usually from April-October (FRIN, 2015).

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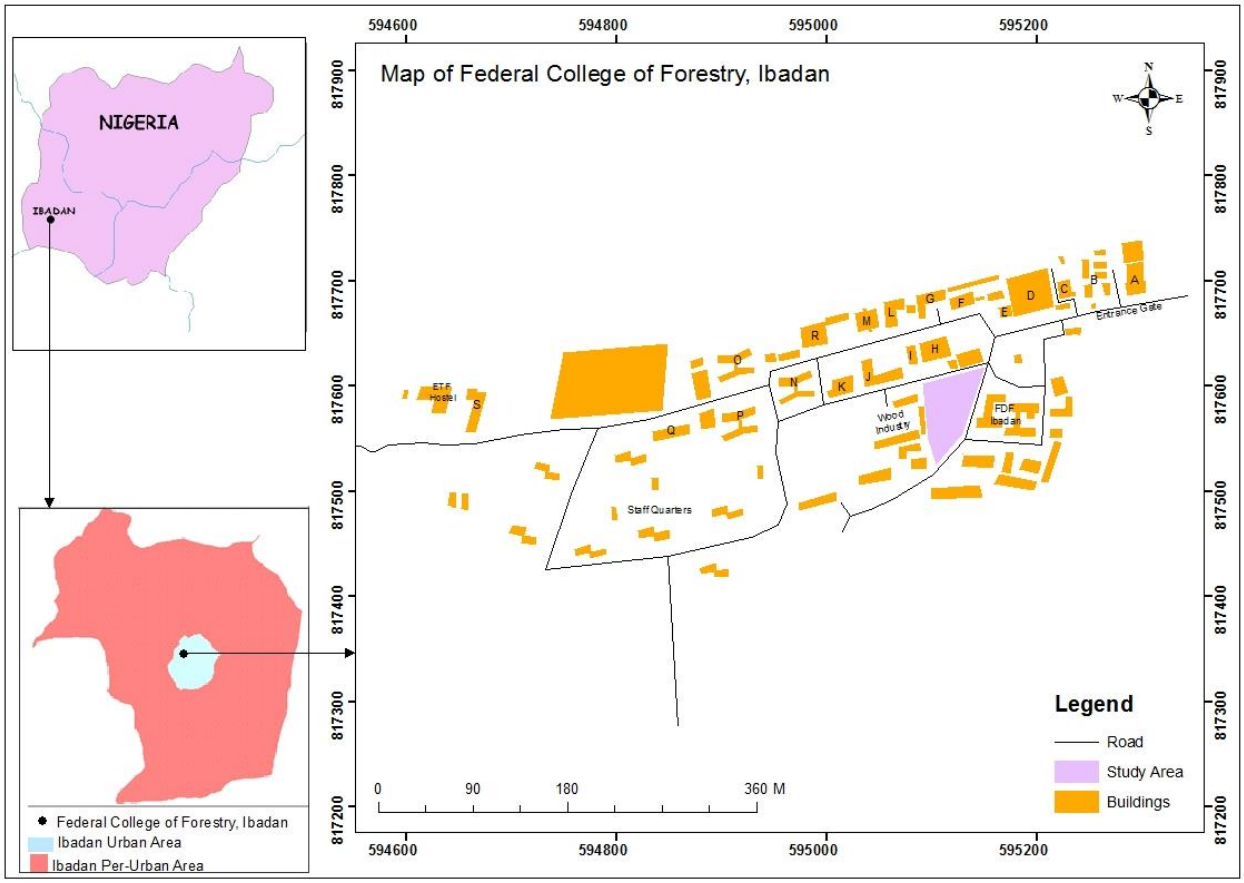

MATERIALS USED

The following materials were used in the course of this work:

MATERIAL	USES
• Haga altimeter	for measuring tree height.
• Diameter tape	for measuring the diameter at breast height.
• Estimation note	for recording the measurement data collected.
• Cutlass	for demarcation and clearing the plot land.
• Ranging pole	for alignment of point.

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- Linen rope for connecting alignment point.
- Rain-boots. For protecting the foot against injury.

METHODS OF DATA COLLECTION

Plantation Splitting and Assessment

Complete enumeration method was adopted in carrying out the stand structure assessment. The study area was divided into four plots in accordance to the shape of the study area for the purpose of easy enumeration and organization. The population of the trees in each of the plots was determined by numbering and counting the entire trees each plot accordingly. Trees were presented in their various Families, Botanical and common name and percentage represented (Table 4.1).

Diameter at Breast Height

Diameter at Breast Height is a standard method of expressing diameter of the trunk or bole of a standing tree. DBH is one of the most common dendrometry measurements.

Tree trunks are measured at the height of an adult's breast. However, this is defined in different countries and situations. The convention meter is now 1.3metre above ground level. In many countries the diameter has been measured at 1.3meter above ground (Feldspausch *et al.*, 2011). In some countries such as Australia, New Zealand, Burma, India, Malaysia and South Africa breast height diameter has been measured at a height of 1.4metres, but because of allometrics that are being applied to trees and forests, the convention of 1.3 m is more appropriate. Previously 4.5ft (1.37 m) was used.

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Tree Total Height (TTH)

The height measurement was taken using Haga altimeter. The Haga altimeter is a measuring instrument that enables the user to estimate total tree height by standing at a predetermined distance and measured out distance from it and see the base of and top/tip of the tree which is the apex, at the same time conveniently. Distance measurement of 15m, 20m, 25m, and 30m, was made with measuring tape away from the base of each tree species to the Total Height viewing point depending on the position of the tree species for clear visibility. A calibration of 15m, 20m or 25m was chosen on the Haga altimeter for the total tree height (TTH) measurement for easy height visibility according to the position of each tree. After which the Haga-altimeter's periscope is then aimed at the base of the tree and traced to the last part of the tree within the trunk before the shooting knob was pressed. The reading needle situated by the opaque side of the measuring instrument indicates it's reading by veering either left or right in a 180° line on either positive or negative decoding values.

When the reading has been recorded, the shooting knob was simply pressed in order to unlock the reading needle (gauge) for fresh readings.

Tree Basal Area

The tree basal area was computed using the formula;

$$\mathbf{BA} = \frac{\boldsymbol{\pi}\mathbf{D}^2}{\mathbf{4}}$$

Where; **BA** = Basal area (m^2) $\boldsymbol{\pi}$ **= 3.14**

D = Diameter at breast height i.e 1.3m above the ground level.

Tree Volume

Volume was estimated from both basal area and total height of the tree. Based on the data collection from this study, the height volume was estimated using Huber's formula (Husch, 2003).

$$\mathbf{V = H.Ab}$$

Where; **V** = Tree volume (m^3)

Ab = basal area respectively (m^2)

H = Total height (m)

Data Analysis

The data collected from the study area were analyzed using SPSS & Microsoft Excel

The statistical tools used were frequency percentage such as mean, median and mode.

RESULTS AND DISCUSSION

Table (i) showed that there are 8 prominent tree Families in the study area, these are; *Anacardiaceae* , *Arecaceae, Fabaceae, Lamiaceae, Malvaceae, Meliaceae, Moraceae* and the Polygalaceae,of which the *Lamiaceae* family which is *Gmelina arborea* had the highest species composition of 83.33%, followed by the *Fabaceae* family with 5.55% while the *Arecaceae, Malvaceae, Meliaceae, Moraceae* and the *Polygalaceae* family had the least composition with 0.93%.

A total number of 108 trees were assessed in the study area. And it was partitioned into four plot consist of the following species *Mangifera indica,* Elaeis guineensis, *Delonix regia, Gmelina arborea (roxb), Tectona grandis, Triplochiton sceleroxylon, Cedrela odorata,* Milicia excelsa, *Securidaca longipedunculata*

It was also observed that the highest tree species in the study area was *Gmelina arborea* and this recorded 83.33%, this was followed by *Delonix regia* (5.55%). However, the least tree species (0.93%) recorded was the *Cedrela odorata*.

Furthermore, with *Gmelina arborea* dominating the study area, this could serve as a seed source for plantation establishment. It also suggest that *Gmelina arborea* tree species could be an effective, efficient and suitable tree in regulating stream flow by ensuring that lands on lower slopes are protected from erosion and flooding and protecting/conserving watershed at large. According to Bharati *et al.,* (2002), forest around watershed filter and regulate the flow of water, in large part due to their leafy canopy that intercepts rainfall, slowing its fall to the ground and the forest floor, which acts like an enormous sponge, typically absorbing up to 18 inches of precipitation (depending on soil composition) before gradually releasing it to natural channels and recharging ground water. Mcpherson, (2000) also reported that trees and forests around watershed absorb and use tremendous amounts of water for growth, thereby consuming storm water. Stream health is dependent on the presence of woody vegetation along its banks.

From Table (ii), it shows that *Gmelina arborea* have highest value in height (m) of 1945, follow by Tectona grandis with the value of 118, *and Delonix regia* with value of 71, *Triplochiton sceleroxylon* with value of 32 and the least value is *milicia excelsa* with 13. *Gmelina arborea* have the highest DBH with 8172cm followed by *tectona grandis* with 1072, and *delonix regia* with 430cm, followed by *longipedunculata* .

Table (iii) showed the total basal area (BA) and total volume (V) of trees species encountered. Furthermore, the total BA of the tree species observed was 113.998m^2. *Gmelina arborea* has the highest BA with (76,772m^2), followed by *Tectona grandis* (18.411m^2), *Cederela odorata* (8.044m^2), *Mangifera indica* (3.495m^2), *Delonix regia* (2.474m^2), *Triplochiton sceleroxylon* (2.324m^2), *Elaeis guineensis* (1.327m^2), *Milicia excelsa* (0.636m^2), while *Securidaca longipedunculata* has the least (0.515m^2).

The total volume of the tree species observed was 151,949.304m^3. *Gmelina arborea* has the highest volume with (149,321.54$m^{3)}$ followed by *Tectona grandis* (2,172.498m^3), *Delonix regia*

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(175.652m^3), *Cederela odorata* (112.616m^3), *Triplochiton sceleroxylon* (74.368m^3), *Mangifera indica* (55.92m^3), *Elaeis guineensis* (21.232m^3), *Milicia excels* (8.268m^3) while *Securidaca slongipedunculata* has the least (7.21m^3). This supported the work of Naidu and Kumar, (2016) that the differences in the basal area of tree layers among the study area may be due to differences in altitude, species composition, age of trees, and extent of disturbances and successional strategies of the stands

On-site Status Assessment of the Plantation

The *Gmelina arborea* plantation was established in 1981 by Mr Adebayo (now Dr Adebayo) as an experimental plot in one of the forestry courses with the objective of research and training, and long term objective of pole production. The site was cleared, surveyed and planted solely with *Gmelina arborea* which earned the plot Gmelina plantation. It was gathered based on the sight-seeing that silvicultural practices were neglected. Such practices like prompt weeding, pruning, coppice management and other related operations that were lacked in the plantation gave rise to objectives deviation and natural regeneration of other tree species that made the plantation objective defeated. In line with this, many individual stands of Gmelina and other tree species were seen forked and not suitable for pole production which was the secondary objective of the plantation apart from research purpose.

CONCLUSION

The research concluded that 8 families were identified with Lamiaceae having the highest frequency percentage of 87.96%. It further showed that *Gmelina arborea* was having the highest frequency of 83.33% while *Triplochiton scleroxylon, Cedrela odorata, Milicia excelsa* and *Securidaca longipedunculata* had the least frequency percentage of 0.93% appease.

The size distribution of the plantation concluded that the highest DBH of 8,172cm and Height 1,945m followed by *Tectona grandis* with DBH 1,072cm and Height 118m while *Milicia excelsa* had the least of DBH 90cm and Height 13m. In the area of Basal Area, Gmelina arborea had the

highest BA 76.772m^2 and Volume 1,4931.54m^3 while *Securidaca longipedunculata* had the least BA and Volume of 0.515m^2 and 7.,21m^3 respectively.

It was concluded also that silvicultural operations were not performed sustainably on the plantation such as non-weeding, no pruning, lack of coppice management which gave rise to objective deviation and natural regeneration of other tree species beside the major and primary *Gmelina arborea* species.

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Table (i) Species Composition in the Study Area

S/N	Family	Species	Common name	Freq.	%Freq.
1	Anacardiaceae	*Mangifera indica*	Mango	2	1.85
2	Arecaceae	*Elaeis guineensis*	African oil palm	1	0.93
3	Fabaceae	*Delonix regia*	Flame of the forest	6	5.55
4	Lamiaceae	*Gmelina arborea*	Beech wood	90	83.33
	Lamiaceae	*Tectona grandis*	Teak	5	4.63
5	Malvaceae	*Triplochiton*	Obeche	1	0.93

		sceleroxylon			
6	Meliaceae	*Cedrela odorata*	Cedar tree	1	0.93
7	Moraceae	*Milicia excels*	Iroko	1	0.93
8	Polygalaceae	*Securidaca longipedunculata*	Violet tree	1	0.93
Total	**8 Families**	**9 Species**		**108**	**100**

Source: Field Survey, 2018

Table (ii): Diameter at Breast Height (DBH) and Total Height (TH) of classed tree species in the Study Area.

S/N	Species	Common names	DBH (cm)	DBH (m)	H (m)
1	*Cedrela odorata*	Cedar tree	320	3.2	14
2	*Delonix regia*	Flame of the forest	430	4.3	71
3	*Elaeis guineensis*	African oil palm	130	1.3	16

4	*Gmelina arborea*	Beech wood	8172	81.72	1945
5	*Magnifera indica*	Mango	290	2.9	16
6	*Milicia excels*	Iroko	90	.90	13
7	*Securidaca longipedunculata*	Violet tree	81	.81	14
8	*Tectona grandis*	Teak	1072	10.72	118
9	*Triplochiton sceleroxylon*	Obeche	172	1.72	32
	Total		**10757**	**1067600**	**2239**

Source: Field Survey, 2018

Table (iii): Basal Area and Volume of *Gmelina arborea* and other trees species

S/N	Species	BA (m^2)	H (m)	Volume (m^3)
1	*Cedrela odorata*	8.044	14	112.616
2	*Delonix regia*	2.474	71	175.652
3	*Elaeis guineensis*	1.327	16	21.232

4	*Gmelina arborea*	76.772	1945	1,4931.54
5	*Magnifera indica*	3.495	16	55.92
6	*Milicia excels*	0.636	13	8.268
7	*Securidaca longipedunculata*	0.515	14	7.21
8	*Tectona grandis*	18.411	118	2,172.498
9	*Triplochiton sceleroxylon*	2.324	32	74.368
	Total	**113.998**	**2239**	**151,949.304**

Source: Field Survey, 2018