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The Use of Forest Inventory in Estimating Illegally Felled Trees of Tectonagrandis Plantation in Agudu Forest Reserve,Lafia, Nasarawa State, Nigeria

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ABSTRACT

*The aim of this study is to evaluate the Use of Forest Inventory in Estimating Illegally Felled Trees of Tectonagrandis Plantation in Agudu Forest Reserve. Seven (7)plots were randomly selected from different area of the whole plantation. Perimeter measurement for each plot were; Permanent Sample Plot 1 (PSP1) to (PSP3) and Temporary Sample Plot 4 (TSP4) to Temporary Sample Plot 7(TSP7) with size 30m by 30m each totaling 0.63ha. Six (6) mean trees in respect of girth class and height class and 1 plus tree were identified and the stumps of felled trees were measured in each of the 7plots. The study was laid out in a 7 x 6 x 6 factorial experiment in a Randomized Complete Block Design (RCBD) with a total of 252 treatment combinations in order to facilitate the interpretation of the main and the evolving interaction effect. Treatments were analyzed with respect to 7 Sample plots, 6 girth classes and 6 height classes. It was observed that a total of 640 Teak stand and 250 stumps of felled trees on 7plots of size 30m by 30m each totaling 0.63ha.The average tree height was 14.56m, average merchantable height was 11.56m, total basal area (BA) for the 7plots was 48.15m^2 and the mean BA was 0.08m^2. Total tree Volume (using Newton's fomular) was 147.69m^3 and the mean volume/tree was 0.23m^3. The average stump girth (SG) was 30.54cm, 0.09m^2 Stump Basal area, the estimated mean tree height was 14.34m while the average Estimated Stump Volume (ESvol) was 0.62m^3. The Total Stump Basal area for the whole 250 felled tree stumps was 21.44m^2 on the 0.63ha sampled plots, this will amount to 34.03m^2/ha while the Total Estimated Stump Volume (ESvol) was 154.18m^3 on 0.63ha sampled plots, this will amount to 244.73m^3/ha. Based on 'International prices for teak: Historical and current, and price forecasts' the World Market Price of Teak as at 2018 is put at 1221.31USD/m^3at ₦355/USD, this will amount to (₦433565.1/m^3x 244.73m^3/ha x 161.28ha) the sum of ₦17,112,838,083.00 equivalent to a total loss of about **(48,205,177.70USD)**of felled Teakat 2018 year ending.Comparing all the models tried in this study using the fit statistics, model2: **ESV = -0.26 – 1.71BD + 11.38BAs + 0.03MeanTHp ……Eq23.**With basal diameter (BD), Basal area and mean Tree Height as the independent variables which had (R^2 = 99.80, SEE = 0.02, with a negative intercept of -0.26) is the most appropriate prediction model. For predicting tree stump volume of Teak in Agudu Forest Reserve, the 5 ranked models are considered fit because they meet the basic requirement of a good fit model having negative intercept whereas the rest model with positive intercept may be discarded. The stand volume equations, which incorporated various tree growth variables, will enhance future yield prediction of the trees in the study areas since they provide quantitative basis for estimating stand growth parameters. It is believed that these models and volume prediction equations will enhance sound and informed management decisions and conservation measures for the remaining Tectonagrandis stands.*

Keywords: *Inventory, Estimating, Illegal Tree Felling, Prediction Equations, Forest Reserve*

INTRODUCTION

The forest reserve in Nigeria is estimated to cover about 10 million hectares which accounts for more than 10% of land area, of approximately 96.2 million hectares; 923,768 km square with a population of about 170,790 in 2006 (National Directorate of Employment, 2012). Ikuomola *et al.*, (2016) observed that, in recent times the area marked as forest lands have been decreasing steadily due to the indiscriminate felling of trees and activities of

illegal loggers which have continued in virtually every part of the country. For instance, the Federal Department of Forestry (2010) estimated that Nigerian forests are being depleted at an annual rate of 3.5%. Nigeria used to have about 20% of its area covered with natural forests but, this has been reduced to about 10%. It lost about 60% of its natural forests to agricultural encroachment, excessive logging and urbanization between the 1960s and the year 2000 (FAO 2001; SFM Tropics. 2005). Ikuomola *et al.,* (2016) opined that industrial and social development which competes for the same pieces of land upon which the forest stands has not been commendable.

The need to adequately quantify the rate of forest depletion across Nigeria annually necessities the use of forest inventory as an appropriate tool and procedure for obtaining information on the quantity and quality of forest resources and many of the characteristics of the land area upon which the treesare growing. Husch *et al*, (2003)simply defined Forest inventory as taking the stock of the forest. A forest inventory determines the locations of timber and estimates its quantity by species, product potential, size, quality, or other characteristics. An inventory may be conducted for land acquisition or sale, a timber sale, or other objectives (Avery and Burkhart, 2002). Forest Inventory also deals with measurement of trees and seeds, the estimation of their volume, the prediction of growth and sampling problems involved inits design. Necessary information such as total forest area or volume on a national or regional basis, the description of the topography of the area, the ownership pattern, accessibility and transportation facilities, growth and drainage creation facilities are provided by a complete forest inventory (Grosenbaugh, 1952). Without forest mensuration, adequate and proper research is highly impossible Afuwape *et al,.* (2007).

It is worthy of note that timber harvesting and general forest depletion across Nigeria is done through indiscriminate and illegal timber harvesting annually probably owing to inconsistent government policies and lack of proper monitoring of human activities as it relates to forest management, this therefore calls for a need to beam a searchlight on illegal timber harvesting as it relates to forest reserves as the case is in Agudu hence the need to evaluate the use of Forest Inventory in Estimating Illegally Felled Trees of *Tectonagrandis* Plantation in Agudu Forest Reserve, Nasarawa State. Illegal felling refers to what in forestry is called timber theft, it can also refer to the harvesting, transportation, purchase or sale of timber in violation of law. The harvesting procedure itself may be illegal, including using corrupt means to gain access to forests; extraction without permission or from a protected area. The cutting of protected species or the extraction of timber in excess of agreed limits Ola-A dams, (1983). Illegal felling is the lead cause of degradation of the world's forests. It includes the harvesting, transporting, processing, buying and selling of timbers in violation of national laws. According to Patterson *et al.,* (2006), some examples include. Trees are harvested from protected areas and then traded illegally, trees are extracted at volumes significantly higher than are permitted and licenses to cut down trees are falsified.

As a result of its large land area, the country covers different and favorable climatic and ecological zones. The size and its diverse population coupled with the socio-political and economic challenges have put much pressure on the forest belts as increasing number of unemployed youths have come to realize that there are opportunities in looting Forest products for survival(Ola-A dams, 1983; Patterson *et al.,* 2006).Thus unemployment as one of the developmental challenges in Nigeria has wide ranging negative impacts, on environmental crime, which is often treated as a low-priority crime in most developing countries, with the belief that the forest belongs to everyone in the community (Mason *et al.,* 2012; South and Wyatt 2011).The impressively fast urbanization process experienced in Nigeria together with the increasing rate of unemployment, persistent poverty, inequality, inadequacy of social services, the consolidation of trans-national crime organizations, the wide spread drug use arid drug trafficking, ill equipped security officials and forest guards to combat illegal logging and lumbering cartel cum clandestine markets and saw malls for rare forest products, have led a lot of youths to seeking for opportunities in forest businesses (Pretty *et al.,* 2013).Illegal logging, lumbering and sawmilling can be described as a system and as a system with various persons and institutions involved in the supply and demand needs of the industry, be it legitimate or illegitimate. It is a common fact that human activities do have either negative or positive

effects on the growth rate and yield of a forest estate since, forest measuration facilitates the sense and idea of knowing the progress in a forest as regards the growth and yield of forest crops according to Avery and Burkhart, 2002. It is of note that indigenous agro-forestry practices are not new in Agudu community just like any other agrarian communities in Nigeria because they offer potentials for sustainable development (Baumer, 1990). Therefore, it is importance to assessthe peculiarities of human agro-forestry activities in and around Agudu forest estate so as to ascertain the effect of human activities of agrarian communities in Agudu as a follow up to Egbewole and Alao, 2013. Hence, the reason for assessing the Use of Forest Inventory in Estimating illegally felled trees in Agudu forest reserve and develop volume models for Tectonagrandis plantation in Agudu Forest Reserve Lafia, Nasarawa State, Nigeria, with a view to provide information for stakeholders in forestry for sustainable management.

MATERIALS AND METHODS

The inventory was carried out in Teakplantation (*Tectonagrandis*) established between 1981-1982 in Lafia Local Government Area, Nasarawa State, located between latitude 08°N and longitude 09°E by March 2018. The total area covered by the *Tectonagrandis* plantation was 161.28ha (Fig.1). The original Teak trees were harvested for export between 1995 and 1998 now left with the coppices that lived through the "survival of the fittest" which are today being harvested and sold either as transmission poles or thinning by the Nasarawa State Government and private individuals (Alao, 2009). Egbewole and Alao, (2013) observed that large proportion of the forest estate has been encroached by various human activities of the neighboring villagers who have converted parts of the Reserve to agricultural and non-agricultural purposes. Lafia Lacal Government Area is located in the Guinea Savannah zone of North Central Nigeria at an altitude of about 177m above the sea level. The mean monthly maximum and minimum temperature range is between 35.06^{0}C to 36.40^{0}C and 20.16^{0}C to 20.50^{0}C respectively while the mean monthly relative humidity and rainfall are 74.67% and 168.90mm respectively (Jayeoba, 2013). Agudu Village that host Agudu Forest Reserve shares common boundary with Obi Local Government in Nasarawa State. The area is predominantly inhabited by Koro (Migili), Alago, Gwandara and other tribes like Eggon, Hausa, and Fulani. The loamy soil and clay with some areas swampy and water logged, used as Fadama. The climate is characterized by warm and humid with two seasons namely dry and wet seasons. The raining season start from April through November and dry season start from part of November through March. Agriculture is the main stay of Agudu Villagers. The vast land couple with good quality soil which makes it possible for about 80-90% of the inhabitants to engage in food and cash crop production, Egbewole and Alao, (2013). The major crops produced in the areas are cassava, yam, millet, beans, maize and groundnut. The local Government Areas has a total population of about 103,253 people and land area of about 599km² (National population census, 1991.

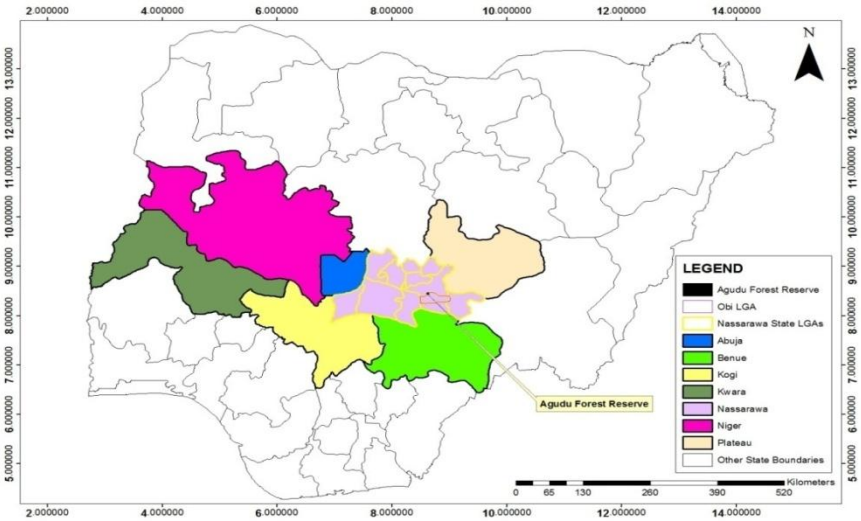

Fig1. *Map of Nigeria showing the North Central States with focus on Agudu Forest Reserve, Obi LGA of Nasarawa State*

DATA COLLECTION

Seven plots were randomly selected from different area of the whole plantation. Perimeter measurement for each plot were; Permanent Sample Plot 1 (PSP1) to (PSP3) and Temporary Sample Plot 4 (TSP4) to Temporary Sample Plot 7(TSP7) with size 30m by 30m each totaling 0.63ha. Six (6) mean trees in respect of girth class and height class and 1 plus tree were identified and stumps of felled trees were measured in each of the 7plots and Geo-referenced using Global positioning system using (eTrex H) to measure their elevation (m) and their bearings (Table 1, Plate 1,2, 3, 5 & 6).

The study was laid out in a 7 x 6 x 6 factorial experiment in a Randomized Complete Block Design (RCBD) with a total of 252 treatment combinations in order to facilitate the interpretation of the main and the evolving interaction effect. Treatments were analyzed with respect to 7 Sample plots, 6 girth classes and 6 height classes. Parameters measured included: Plots perimeter and area, Total height, Merchantable height, Girth at base, Diameter at base, Diameter at breast height, Basal area, Clear bole height, Crown height, Girth at breast height, form factor, form quotient, stump count, stump height, stump girth.

Plate1. *Permanent Sample Plot 1 (PSP1) of Agudu Forest Reserve*

Plate2. *Part of Agudu Forest Reserve with less Encroachment (TSP5)*

Plate3. *Cattle rearing and other human activities within the forest area.*

Plate4. *Harvested trees for yam staking and fuelwood*

Plate5. *Spiegel relascope*

Plate6. *Hand held GPS (eTrex H)*

Plate7. *Encroached part of the Reserve tuned to farmland*

Table1. *30mx 30m Sample Plot Layout of Teak plantation in Agudu Forest Reserve*

		Sample Size (Standing trees)	Stumps	Observation/plot description
Plots				
	Permanent sample plot 1	117	46	Near farmland
	Permanent sample plot 2	99	42	Near farmland
	Temporary sample plot 3	76	29	Near farmland
	Temporary sample plot 4	85	26	Close to waterlogged area
	Temporary sample plot 5	105	20	Near farmland
	Temporary sample plot 6	65	33	Near farmland
	Temporary sample plot 7	93	54	Near farmland
	Total	**640**	**250**	
Girth class				
	<30cm	51	4	Recessive class
	31-50cm	73	29	Middle class
	51-70cm	82	87	Middle class
	71-90cm	53	100	Dominant class
	91-110	20	27	Dominant class
	> 111cm	13	3	Dominant class
	Total	640	**250**	
Height class				
	<3m	-	-	Recessive class
	3.01-5m	6	-	Middle class
	5.01-10m	34	-	Middle class
	10.01-15m	66	-	Dominant class
	15.01-20m	160	-	Dominant class
	> 20.01m	26	-	Dominant class
	Total	**640**		

Basal area of a cylinder is measured in terms of radius. The basal area of the tree is not the same with that of a cylinder. Thus, the basal area of a tree is measured in terms of diameter.

Basal Area of a cylinder $=\pi r^2 h$ (1)

Basal Area of a tree $= \pi d^2/4$ (2)

Where: π = pie = 3.142, d = diameter at breast height, h = height

Stem Volume was estimated using the Newton's formula as adopted by Egbewole *et al*,. (2011): Egbewole, 2017 expressed thus:

$V = h/6 (Ab + 4Am + At)$ (3)

Ab, Am and, At = tree cross-sectional area at the base, middle and top of merchantable height, respectively (m^2) and h = total height (m). Following the computation of tree basal area and volumes, the data were summarized by computing simple descriptive statistics for each growth variable. This study was laid in a 7 x 6 x 6 factorial experiment in a Randomized Complete Block Design (RCBD) with a total of 252 treatment combinations in order to facilitate the interpretation of the main and the evolving interaction effect. Treatments were analyzed

with respect to 7 Sample plots, 6 girth classes and 6 height classes (Table 1). Analysis of variance was performed on the data to show the comparative performance of each treatment with others, where significant difference was found, Duncan's Multiple Range Test (DMRT) was applied for mean separation and in locating where the significant differences occurred among treatment means of selected variables as prescribed by Akindele, (2004); Adesoye, (2004).

In attempt to achieve the major objective of this study which aimed to evaluate the use of Forest Inventory in Estimating Illegally Felled Trees of *Tectonagrandis* Plantation in Agudu Forest Reserve, Lafia, Nasarawa State, Nigeria. A set of 130 structured questionnaire and interview schedule was drawn and administered to respondents living in and around Agudu Forest Reserve to obtain information on their educational status, occupation, income status, reasons and purposes for cutting Teak trees and timber sizes mostly preferred. Both descriptive statistics were used such as frequency, percentage, charts and 4 points Likert Scale Ranking. Seven plots randomly selected from different area of the whole plantation. Stumps of felled trees were identified, marked, tagged and measured in each of the 7plots as laid out in Table 1. The stumps were classified in 6 girth classes while the mean height of trees within

each girth class was used to estimate the volumes of stumps in each girth class.Correlation and Regression analysis Correlation coefficient (r) was used to investigate the strength and direction of association between the selected variables such as; Total height, Merchantable height, Crown height, Clear bole height, Diameter at breast height and Diameter at the base. While Volume prediction model Equations ware developed for modeling the volume growth of Agudu Forest Reserve. Volume model developed by Schumacher and Hall (1933) was used for modeling process in this study. However, several forms of this model, using height with the introduction of other variable was considered and tried for *Tectonagrandis.* This is because height is the major determinant variable if stem volume of tree is considered Schumacher and Hall, (1933). Consequently, the generalized logarithmic model consisting of height and diameter at the middle as the independent variable was the most appropriate for the species in the study area. The coefficient of determination (R^2) and standard error (SEE) of estimation, mean square error (MSE) was also determined to know the proportion of variation explained by the regression equation. The model was therefore selected for the modeling of Tectonagrandis plantation in Agudu Forest Reserve, Nasarawa State, Nigeria. The model in its original form is expressed as:

$$LogV = bo + b1Log(MH) + b2\ Log(Dbh) \quad (4)$$

Where: V = tree volume (Dependent variable, Newton's volume) (m3) Dbh = diameter at breast height (cm); MH = merchantable height (m); b0, b1 and b2 are the regression parameters.

RESULTS AND DISCUSSION

Sample trees planted in a 3*x*3 spaceman were systematically numbered for easy enumeration. Six (6) mean trees in respect of girth classes, 6 mean trees in respect of height class and 1 plus tree were identified in each of the 7 plots. It was observed that a total of 640 Teak stand and 250 stumps of felled trees on 7plots of size 30m by 30m each totaling 0.63ha. Permanent Sample Plot 1 (PSP1) had 117 Teak stand and 46 stumps of felled trees, Permanent Sample Plot 2 (PSP2) had 99trees and 42 stumps, Permanent Sample Plot 3 (PSP3) with 76trees, 29 stumps. While Temporary Sample Plot 4 (PSP4) had 85 tress and 26 stumps, Temporary Sample Plot 5 (PSP5) had 105 tress and 20 stumps, Temporary Sample Plot 6 (PSP6) had 65 tress and 33 stumps, Temporary Sample Plot 7 (PSP7) had 93 tress and 26 stumps of felled trees (Table 1). The result of the tree distribution among the girth classes revealed that Girth class of <30cm had 51trees, 73 trees belong to 31-50cm girth class, 51- 70cm had 82 trees, 71-90cm had 53 trees, 91-110cm had 20tress, While the remaining 13 trees belonged to Girth class above > 111cm. There was no tree observed in height class of <3m, 3.01-5m had 6trees, 5.01-10m had 34 trees, 10.01-15m had 66trees, 15.01-20m had 160 and height class of >20.01m had 26trees (Table 1).

Estimated Tree Stand Volume of Tectonagrandis Plantation in Agudu Forest Reserve

The result revealed that the average Girth at breast height (Gbh) was 62.91cm, TSP 6 had the highest Gbh of 73.92cm while PSP 2 had the least Gbh of 54.82cm. The highest Gbh of 126.44cm was observed in >111cm girth class. While the least Gbh of 23.29cm was observed in <30cm Girth class. The mean Diameter at breast height (Dbh) was 0.15m, 0.10m Diameter at middle and 0.07m Diameter at top. The mean Form quotient (Fq)was 0.73 while the mean tree Form factor (FF) was 0.41, PSP 3 had the highest mean tree Form factor (FF) of 0.43 while TSP 6 had the least FF of 0.31(Table 2). The 0.41 mean Form factor (FF) observed in the Agudu Forest Reserve is on the low side based on Averyand Burkhart (2002), it is an indication of poor tree bole formation probably resulting from poor plantation management which might have led to about 41% bole quality. The result revealed that, the average tree height was 14.56m, PSP 3 had the highest mean Height of 16.96m while the least height of 11.91m was observed in TSP 7. Tree height as influenced by Girth class showed that, the highest tree height of 17.20m was observed in >111cm Girth class while the least mean height of 10.81m was observed in <30cm Girth class. The result also revealed that, the average merchantable height was 11.56m. PSP 3 had the highest tree merchantable height of 13.54m while the least merchantable height of 8.39m was observed in TSP 6. The tree total basal area (BA) for the 7plots was 48.15m^2 and the mean BA was 0.08m^2. Total crown area (CA) for the 7plots was 75394.97m^2 and the mean CA was 117.80m^2. Total tree Volume (using Newton's fomular) for the 7plots was 147.69m^3 and the mean volume was 0.23m^3, PSP 1 had the

highest mean volume of 0.27m^3, while the least mean volume of 0.16m^3 was observed in TSP 7(Table 3). Since the Estimated tree Volume (ETvol) was 147.69m^3 on 0.63ha.sampled plots, this will amount to 234.43m^3/ha.Based on 'International prices for teak: Historical and Current, and Price Forecasts' by Guillermo *et al*,. (2009), the World Market Price of Teak as at 2018 is put at 1221.31USD/m^3 at ₦355/USD, this will amount to (₦433,565.1 /m^3*x*234.43 m^3/ ha *x* 161.28ha) the sum of ₦16,392,606,676.00 equivalent to a total value of about (46,176,357USD) of standing trees of *Tectonagrandis* at 2018 year ending.

Table2. *Mean value of variable measured at different parts of the tree bole on the bases of sample plot, girth class and diameter class.*

Sample plot	Sample size(N)	Girth at base (cm)	Diameter at Breast height (m)	Diameter at middle (m)	Diameterat top(m)	Form factor	Form quotient
Permanent sample plot 1 (PSP 1)	117	61.23±34.06c	0.14±0.08a	0.11±0.06ab	0.08±0.05a	0.41±0.12a	0.78±0.13a
Permanent sample plot 2 (PSP 2)	99	54.82±25.11a	0.13±0.07a	0.10±0.05a	0.07±0.04a	0.43±0.11a	0.77±0.08a
Temporary sample plot 3 (TSP 3)	76	58.55±22.95b	0.15±0.07b	0.11±0.05b	0.08±0.03b	0.48±0.14b	0.76±0.10a
Temporary sample plot 4 (TSP 4)	85	66.76±29.44b	0.16±0.07a	0.12±0.06a	0.09±0.04a	0.45±0.12ab	0.78±0.12a
Temporary sample plot 5(TSP 5)	105	60.74±24.88c	0.14±0.06b	0.11±0.05bc	0.08±0.04bc	0.44±0.34ab	0.76±0.01a
Temporary sample plot 6 (TSP 6)	65	73.92±26.23a	0.16±0.06a	0.09±0.03d	0.05±0.02d	0.31±0.11c	0.61±0.16b
Temporary sample plot 7 (TSP 7)	93	68.40±24.84b	0.15±0.06a	0.09±0.04d	0.05±0.02d	0.32±0.11c	0.63±0.14b
Grand mean	**640**	**62.91±27.82**	**0.15±0.07**	**0.10±0.05**	**0.07±0.04**	**0.41±0.18**	**0.73±0.13**
Girth class							
<30cm	51	23.29±4.53a	0.06±0.02a	0.05±0.02a	0.04±0.02a	0.50±0.40b	0.81±0.11b
31 - 50cm	73	40.90±5.83b	0.10±0.03b	0.07±0.02b	0.05±0.02b	0.41±0.14b	0.75±0.12ab
51 - 70cm	82	61.34±6.31c	0.15±0.04c	0.11±0.03c	0.07±0.03c	0.40±0.13b	0.72±0.13ab
71 - 90cm	53	80.77±6.00d	0.20±0.04d	0.14±0.04d	0.10±0.04d	0.40±0.12b	0.71±0.15ab
91 - 110cm	20	99.30±5.26e	0.23±0.04e	0.16±0.05e	0.11±0.05e	0.37±0.11b	0.69±0.14a
>111cm	13	126.44±17.82f	0.23±0.07e	0.16±0.05e	0.11±0.05e	0.31±0.08a	0.71±0.14ab
Grand mean	**640**	**62.91±27.82**	**0.15±0.07**	**0.10±0.05**	**0.07±0.04**	**0.41±0.19**	**0.73±0.14**
Height class							
<3m		25.33±3.51	0.06±0.01	0.05±0.01	0.04±0.01	0.49±0.14	0.84±0.05
3.01 – 5m	6	41.25±23.00a	0.08±0.06a	0.06±0.04a	0.04±0.02a	0.36±0.15ab	0.77±0.13a
5.01 – 10m	34	36.27±16.59a	0.08±0.05a	0.06±0.04a	0.04±0.03a	0.41±0.42a	0.76±0.13a
10.01 – 15m	66	60.24±25.52b	0.14±0.06b	0.09±0.04b	0.06±0.03b	0.37±0.13ab	0.70±0.15a
15.01 – 20m	160	73.38±25.92c	0.18±0.06c	0.13±0.05c	0.10±0.04c	0.44±0.12b	0.77±0.11a
>20.01m	26	84.96±29.45d	0.21±0.05d	0.15±0.04d	0.11±0.04d	0.44±0.10b	0.74±0.08a
Grand mean	**640**	**62.91±27.82**	**0.15±0.07**	**0.10±0.05**	**0.07±0.04**	**0.41±0.19**	**0.73±0.14**

Note: *Figure with the same alphabet in the same column are not significant different from each other. P>0.05*

Table3. *Mean value of variable measured at different part of the tree on the bases of sample plot, Girth classes and height classes.*

Sample plot	Sample Size(N)	Total Height(m)	Merchantable Height (m)	Clear bole Height (m)	Basal area (m^2)	Crown area (m^2)	Humber volume(m3)	Newtons volume(m3)
(PSP 1)	117	15.73±4.40b	11.87±2.20a	7.88±2.44b	0.08±0.09c	157.33±76.61a	0.20±0.21b	0.27±0.28b
(PSP 2)	99	15.04±4.85a	12.81±1.65b	4.81±2.31a	0.06±0.06e	178.95±100.22b	0.17±0.16a	0.21±0.21a
(TSP 3)	76	16.96±3.60c	13.54±1.63c	13.54±1.63c	0.06±0.05e	251.00±134.33c	0.22±0.19b	0.26±0.20b
(TSP 4)	85	14.98±2.87c	12.38±1.81bc	11.76±2.55a	0.08±0.07b	129.15±88.57d	0.24±0.22a	0.21±0.27a
(TSP 5)	105	14.09±2.04d	12.34±1.65bc	10.91±1.78b	0.07±0.06d	43.73±19.31e	0.17±0.18c	0.22±0.22c
(TSP 6)	65	12.87±1.71e	8.39±1.99e	8.45±1.77c	0.01±0.06a	22.34±9.43f	0.10±0.08d	0.18±0.12d
(TSP 7)	93	11.91±2.13f	9.06±1.81d	8.85±1.72c	0.08±0.06b	34.12±27.68ef	0.10±0.09d	0.16±0.13d
Grand mean	**640**	**14.56±3.70**	**11.37±2.57**	**8.16±3.32**	**0.08±0.07**	**117.80±108.51**	**0.17±0.18**	**0.23±0.22**

Girth class								
<30cm	51	10.81±3.60a	11.50±3.31a	5.67±2.99a	0.01±0.003	93.04±75.30a	0.02±0.03a	0.03±0.02a
31- 50cm	73	12.87±3.36b	10.85±3.02a	6.97±2.95a	0.03±0.01	97.92±78.54a	0.06±0.05b	0.07±0.04b
51- 70cm	82	15.29±3.21c	10.98±2.54a	8.16±2.81b	0.06±0.01	127.06±112.77b	0.15±0.11c	0.20±0.10c
71- 90cm	53	16.17±2.79d	11.54±2.47a	9.15±3.08b	0.10±0.02	144.22±143.81c	0.27±0.16d	0.35±0.14d
91-110cm	20	16.52±2.77d	11.83±2.47a	10.65±2.83c	0.16±0.02	122.12±105.64b	0.37±0.22e	0.50±0.20e
>111cm	13	17.20±2.76d	12.17±2.35a	10.74±3.58d	0.26±0.08	128.00±98.27bc	0.42±0.28f	0.69±0.32f
Grand mean	**640**	**14.56±3.70**	**11.37±2.57**	**8.16±3.32**	**0.08±0.07**	**117.80±108.51**	**0.17±0.18**	**0.23±0.22**
Height class								
<3m		6.93±3.58	-	4.70±2.25	0.01±0.003	18.23±7.08	0.01±0.01	0.02±0.01
3.01– 5m	6	7.91±3.33a	7.90±1.45	5.98±2.87a	0.04±0.04	28.88±16.39a	0.04±0.07a	0.06±0.09a
5.01– 10m	34	8.93±1.85b	7.74±4.23	6.01±2.49b	0.03±0.03	79.05±70.44b	0.04±0.06a	0.05±0.06a
10.01– 15m	66	13.06±1.50c	9.43±1.99a	8.59±2.84b	0.07±0.06	68.29±67.78c	0.10±0.10b	0.15±0.13b
15.01– 20m	160	17.92±1.62d	12.61±1.80b	8.58±3.81c	0.10±0.07	172.52±100.83d	0.29±0.20c	0.36±0.24c
>20.01m	26	20.31±0.44e	14.10±1.56c	6.72±2.59c	0.13±0.11	344.09±137.80e	0.40±0.22d	0.52±0.32d
Grand mean	640	14.56±3.70	11.37±2.57	8.16±3.32	0.08±0.07	117.80±108.51	0.17±0.18	0.23±0.22
Grand Total		-	-	-	**48.15**	**75394.97**	**110.93**	**147.69**

Note: *Permanent Sample Plot (PSP 1-3), Temporary Sample Plot (TSP 4-7), Figure with the same alphabet in the same column are not significant different from each other. P>0.05*

However the analysis of variance showed that the effects of plot location, girth class and height class had significant influence on accessed variables: Total height, Merchantable height, Crown height, Diameter at breast height, Diameter at base, Crown height, Form factor and tree volume both within and between sample plots on growth variables of *Tectonagrandis* plantation in Agudu Forest Reserve at $p<0.05$ (Table 4).The results indicated that the Models generated for tree volume estimation in Agudu Forest Reserve had highly significant coefficient of determination (R^2) at ($p<0.05$) as could be observed from the selected prediction models (Table 5).Comparing all the models tried in this study using the fit statistics, model 12:

Table4. *Analysis of variance for measured parameters of Tectonagrandisat Agudu forest*

Sources of variation	Total Height (m)			Clear Bole Height(m)			Merchantable Height (m)			Newton volume (m^3)			Form Factor (Ff)		
	Df	F	Sig.	Df	F	Sig	Df	F	Sig	Df	F	Sig.	Df	F	Sig.
Plot	6	13.65	.00**	6	89.94	0.00**	6	14.760	0.00**	6	8.39	0.00**	6	8.25	0.00**
Girthclass	5	10.31	.00**	5	9.47	0.00**	5	2.160	0.06ns	5	161.4	0.00**	5	15.71	0.00**
Heightclass	5	194.78	.00**	5	3.37	0.01**	4	7.476	0.00**	5	12.79	0.00**	5	1.75	0.12ns
plot * Girthclass	30	3.09	.00**	30	1.18	0.24ns	24	1.541	0.05**	30	4.60	0.00**	30	3.68	0.00**
plot * Heightclass	17	14.59	.00**	17	0.68	0.83ns	8	2.092	0.04**	17	1.59	0.06ns	17	3.93	0.00**
Girthclass * Heightclass	15	3.09	.00**	15	0.77	0.73ns	9	0.499	0.88ns	15	2.73	0.00**	15	2.69	0.00**
plot * Girthclass * Heightclass	25	2.35	.00**	23	1.01	0.45ns	11	0.62	0.81ns	25	1.91	0.01**	25	3.39	0.00**
Error	536			531			327			536			536		
Total	640			633			397			640			640		
R^2	0.928			0.806			0.866			0.883			0.46		

Note:=** *highly significant at 1% probability level, * = significant at p<0.05, ns = not significant*

$$lnNV = -0.77 + 8.08DM + 0.81lnBA + 0.84FF \ldots\ldots\ldots\ldots\ldots\ldots Eq12$$

Which had diameter at the middle and Basal area and form factor as the independent variables which had (R^2 = 94.2, R^2 –Adjusted = 94.2, SEE = 0.28, f-ratio = 3448.0, Double Watson value =1.61, sig. =0.000**, with a negative intercept of -0.77) is the most appropriate yield model(Table 5).In other words, diameter at the middle is the best predictor of *Tectonagrandis* stem volume among all the tested predictor models. For

predicting tree volume of Teak in Agudu Forest Reserve, the 8 ranked models are considered fit because they all meet the basic requirement of a good fit mode having negative intercept whereas the rest models with positive intercept may be discarded(Table 5). This is in line with the report by Avery and Burkhart (2002) who opined that tree volume prediction usually gives negative intercept. The model prediction and selection was done in compliance with Aigbe and Omokhua (2014) in modeling diameter distribution of the tropical rainforest in Oban Forest Reserve. It is also in agreement with the method used by Akinyemi, *et al.*, (2012) in Evaluating Crown-diameter prediction models for *Terminaliasuperba* in Onigambari Forest Reserve, Nigeria.

Table5. *Models generated for tree volume estimation in Agudu Forest Reserve*

s/n	Equations	N	R^2	R^2 (adjusted)	SEE	F	Sig.	Double Watson	Model Rank
6	logNV = -1.02 + 1.36logTH + 1.53logDbh + (-0.07FF	640	91.8	91.8	0.14	2385.0	0.000**	1.62	3
7	lnNV = -9.87+ 10.17lnTDia + 1.69lnBD + 0.46FF	640	91.8	91.8	0.33	2387.0	0.000**	1.59	5
9	lnNV = 1.19 + 0.18lnCH + 1.92lnDBH	640	86.8	86.8	0.42	2103.0	0.000**	1.66	*X*
10	lnNV = 2.75 + 0.78lnDbh + 1.31lnDM	640	89.2	89.2	0.38	2638.0	0.000**	1.67	*X*
11	lnNV = 0.58 + 1.89lnDbh + 3.13lnDT + 1.50Fq	640	89.3	89.3	0.38	1777.0	0.000**	1.68	*X*
12	***lnNV = -0.77 + 8.08DM + 0.81lnBA + 0.84FF***	***640***	***94.2***	***94.2***	***0.28***	***3448.0***	***0.000****	***1.61***	***1***
13	lnNV = -2.43 + 1.52lnDbh + 1.35lnTH	640	91.8	91.7	0.33	3548.0	0.000**	1.61	4
14	lnNV = -10.43+ (-0.00)lnCArea + 3.25lnTH	640	60.4	60.2	0.73	485.03	0.000**	1.68	8
15	lnNV = -8.40 + 1.81lnTH + 0.03BG	640	89.6	89.5	0.37	2735.0	0.000**	1.79	6
16	lnNV = -4.88 + 0.17lnCArea + 14.89DBH	640	80.7	80.7	0.51	1336.0	0.000**	1.77	7
17	lnNV = -1.22 + 0.65lnBA + 11.22DM	640	93.3	93.3	0.31	4437.0	0.000**	1.63	2
18	lnNV = 2.91 + 2.06lnMD + 0.02DT	640	87.4	87.3	0.41	2200.0	0.000**	1.68	*X*
19	lnNV = 2.10 + 1.97lnDBH+ (-0.11)FF	640	84.3	84.2	0.46	1709.0	0.000**	1.55	*X*
20	logNV = 0.73 + 1.69lnMdia + 2.01BArea	640	91.6	91.6	0.15	3488.0	0.000**	1.78	*X*
21	NV = 0.54 + 0.44lnMdia + 1.91BArea	640	84.6	84.6	0.09	1751.0	0.000**	1.36	*X*
Dbh = Diameter at breast height, BG = Basal girth, DM = Diameter at middle, DT = Diameter at top, TH = Total height, BA = Basal area, CA = Crown area, NV = Newton's volume, FF = form factor, Fq = form quotient , CH= Crown Height, *x* = discarded models for having positive intercept									

The good fit models obtained may be attributed to the better tree growth variables obtained from the plots as indicated in Table 2 &3, which may also be related to site factors. This is in conformity with Brandel, (1990), who discovered that site determines the fit ability of tree volume functions, similar trend was observed in the studies carried out byEgbewole (2017) in his work on 'Application of Tree Growth Models for Inventory of Plantation–grown *Tectonagrandis* in Agudu Forest Reserve, Nasarawa, Nigeria',this is similar to Aigbe and Omokhua, (2014) in Oban Forest Reserve, Port-Harcourt, Nigeria. The trend is also in accordance with Ige and Erhabor, (2013) on Crown-Diameter Prediction Models for *TriplochitonScleroxylon* in Onigambari Forest Reserve, Oyo State, Nigeria.

Estimated Tree Stump Volume of Felled Tectonagrandis Trees in Agudu Forest Reserve

It was observed that a total of 250 stump of felled trees on the 7plots of sizes 30m by 30m. Permanent Sample Plot 1 (PSP1) had 46 stumps of felled trees, Permanent Sample Plot 2 (PSP2) 42 stumps, Permanent Sample Plot 3 (PSP3) had 29 stumps. While Temporary Sample Plot 4

(PSP4) had 26 stumps, Temporary Sample Plot 5 (PSP5) had 20 stumps, Temporary Sample Plot 6 (PSP6) had 33 stumps, Temporary Sample Plot 7 (PSP7) had 26 stumps of felled trees (Table 1). The result revealed that the average stump girth (SG) was 30.54cm; TSP 4 had the highest SG of 34.15cm while TSP 6 had the least SG of 25.18cm. The highest SG of 117.67cm was observed in >111cm girth class. While the least SG of 31.50cm was observed in <30cm Girth class. The mean Stump height was 30.54cm, mean Stump Diameter (SD) was 0.23m, 0.09m^2 Stump Basal area, the estimated mean tree height was 14.34m while the average Estimated Stump Volume (ESvol) was 0.62m^3, PSP 3 had the highest average Estimated Stump Volume (ESvol) of 0.62m^3 while TSP 5 had the least mean Estimated Stump Volume (ESvol) of 0.44m^3. The Total Stump Basal area for the whole 250 harvested stumps was 21.44m^2 on the 0.63ha sampled plots, this will amount to Total Stump Basal area of 34.03m^2/ha while the Total Estimated Stump Volume (ESvol) was 154.18m^3 on 0.63ha sampled plots, this will amount to 244.73m^3/ha.(Table 6& 7). Based on 'International prices for teak: Historical and current, and price forecasts' by Guillermo *et al*,. (2009), the World Market Price of Teak as at 2018 is put at 1221.31USD/m^3 at ₦355/USD, this will amount to (₦433,565.1/m^3*x* 244.73m^3/ha *x* 161.28ha) the sum of ₦17,112,838.083.00 equivalent to a total loss of about (48,205,177.70USD) of felled *Tectonagrandis* at 2018 year ending.

Table6. *Mean value of variable measured on felled tree stumps on the bases of sample plots and Girth classes*

PLOT	Stumps	StumpHeight (cm)	Stump girth (cm)	SumpDiameter(m)	Stump Vol(m^3)	Stump Basal area(m^2)	Mean tree height/plot(m)	(Felled trees)Estimated StumpVolume(m^3)
(PSP 1)	46	30.15±12.67abc	68.17±19.17bc	0.22±0.06a	0.01±0.01a	0.06±0.04b	15.73±1.84b	**0.63±0.34bc**
(PSP 2)	42	34.05±11.33a	76.62±14.91a	0.24±0.05c	0.01±0.01a	0.01±0.04a	15.04±0.97c	**0.73±0.27ab**
(TSP 3)	29	32.93±11.87a	73.07±18.87ab	0.23±0.06b	0.02±0.01b	0.09±0.05d	16.96±1.46a	**0.77±0.40a**
(TSP 4)	26	34.15±13.09a	75.08±21.45ab	0.24±0.68c	0.02±0.01b	0.01±0.05a	14.98±1.81d	**0.72±0.37ab**
(TSP 5)	20	33.05±8.93ab	60.15±19.13c	0.19±0.06d	0.01±0.01a	0.06±0.04b	14.09±1.98e	**0.44±0.29d**
(TSP 6)	33	25.18±12.72c	69.88±15.49ab	0.22±0.05a	0.01±0.01a	0.08±0.03c	12.87±1.57f	**0.52±0.20cd**
(TSP 7)	54	27.48±9.17bc	71.89±14.92ab	0.23±0.47b	0.01±0.01a	0.09±0.03d	11.91±1.21g	**0.51±0.19d**
Grand Mean	-	**30.54±11.77**	**71.26±17.73**	**0.023±0.06**	**0.01±0.01**	**0.09±0.31**	**14.34±1.58**	**0.62±0.39**
Sum Total	**250**	-	-	-	-	**21.44**		**154.18**
Girth Class								
<3m	4	29.75±7.14	31.50±20.98	0.10±0.07	0.00±0.00	0.02±0.03	10.88±0.00	**0.11±0.15**
3.01–5m	29	29.67±12.43	46.83±11.01	0.15±0.04	0.01±0.00	0.04±0.02	11.16±0.00	**0.26±0.15**
5.01–10m	87	30.26±12.26	63.57±9.64	0.20±0.03	0.01±0.00	0.07±0.02	13.53±0.00	**0.57±0.16**
10.01–15m	100	29.88±11.49	78.89±7.43	0.25±0.02	0.02±0.01	0.01±0.02	14.41±0.00	**0.92±0.17**
15.01–20m	27	34.89±11.11	94.74±12.57	0.30±0..4	0.03±0.01	0.15±0.03	16.66±0.00	**1.35±0.32**
>20.01m	3	31.54±11.77	117.67±3.21	0.37±0.01	0.03±0.01	0.22±0.02	17.67±0.00	**2.07±0.11**
Grand Mean	-	**30.54±1.77**	**71.26±17.73**	**0.23±0.06**	**0.01±0.01**	**0.09±0.04**	**14.52±1.58**	**0.77±0.39**
Sum Total	**250**	-	-	-	-	**21.44**	-	**154.18**

Note: *Figure with the same alphabet in the same column is not significantly different from each other. P>0.05*

Table7. *Quantitative summary of Timber stock in a 161.28ha Agudu Forest Reserve and its cost implication*

	N	Sampled Plot(ha.)	Estimated tree/stump Volume (m^3)	Estimated tree/stump Volume (m^3/ha)	World Market Price of Teak as at 2018(USD/m^3)	Nairaequivalent of stock/felled trees (₦)	Dollar equivalent of stock/felled trees (USD)
Standing trees	640	0.63	147.69	234.43	1221.31	16,392,606,676	**46,176,357USD**

Stump (felled trees)	250	0.63	154.18	244.73	1221.31	17,112,838.083	**48,205,177.7USD**

Note: *World Market Price of Teak as at 2018 is put at 1221.31USD/m^3 at ₦355/USD,*

Models Generated for Felled Tree (Stumps) Volume Estimation in Agudu Forest Reserve

The results indicated that the Models generated for felled tree stump volume estimation in Agudu Forest Reserve had highly significant coefficient of determination (R^2) at ($p<0.05$) as could be observed from the selected prediction models (Table 8). Comparing all the models tried in this study using the fit statistics, model 23,

ESV = -0.26 – 1.71BD + 11.38BAs + 0.03MeanTHp……Eq23

Table8. *Models Equation generated for estimation the stump volume of felled Teak in Agudu Forest*

s/n	Equations	Stumps	R^2	R^2 (adjusted)	SEE	F	Sig	Double atson
22	ESV = -0.30 +9.25BAs + 0.016MeanTHp	**250**	99.66	99.65	0.02	35822.68	0.000**	1.69
23*	***ESV = -0.26 – 1.71BD + 11.38BAs + 0.03MeanTHp***	***250***	***99.80***	***99.80***	***0.02***	***41386.74***	***0.000****	***1.55***
24	logESV = -2.19 +10.13BD – 8.25BAs + 0.02MeanTHp	**250**	99.17	99.16	0.03	9855.72	0.000**	1.62
25	LnESV = -5.06 +23.33BD - 19.0BAs + 0.06MeanTHp	**250**	99.17	99.16	0.06	9855.72	0.000**	1.62
26	LnESV = 1.54 + 4.66LogBD – 0.21BAs + 0.06MeanTHp	**250**	99.99	99.99	0.01	903738.9	0.000**	1.62
MHp =Mean Height/plot, BD = Basal girth, BAs = Basal area, ESV = Estimated Stump volume (Humbers)								

Which hadbasal diameter (BD),Basal area and mean Tree Height as the independent variables which had (R^2 = 99.80, R^2 –Adjusted = 99.65, SEE = 0.02, f-ratio = 41386.74, Double Watson value =1.55, sig. =0.000**, with a negative intercept of -0.26) is the most appropriate prediction model (Table 8). Diameter at the middle is the best predictor of *Tectonagrandis* stem volume among all the tested predictor models, though stump volume is to be estimated here. For predicting tree stump volume of Teak in Agudu Forest Reserve, the 5 ranked models are considered fit because they all meet the basic requirement of a good fit model having negative intercept whereas the rest model with positive intercept may be discarded. This is in line with the report by Avery and Burkhart (2002) that tree volume prediction usually gives negative intercept.

However, these models can be applied in determining the volume of Teak trees volume of felled Teak stumps in these locations based on the statistical significance and closeness of the fit statistics of the 7 plot models. This suggests that any of these variables can be substituted for one another as a predictor of stem volume. Similar results have been reported in tropical rain forest area of Nigeria for plantation-grown *Tectonagrandis* by (Osho, 1983) and in *Gmelinaarborea* (Akindele, 2003). It is also in line with Borokini, *et al.*, (2013) on Inventory Analysis of *Miliciaexcelsa* in Ibadan, Nigeria. The linear relationships betweenMerchantable height, form factor, Crown height, Crown diameter, and stem volume (V) did not depict a reasonable pattern as indicated by the low coefficient of determination (R^2). In Agudu Teak Plantation, most of the 15 model prediction equations generated have negative intercepts. This is as a result of the logarithmic transformation of the variables utilized in the models, thereby leading to value reduction vis-à-vis tilting of the variable values towards negativity (Schumacher & Hall, 1933). This is also in line with the report by Avery and Burkhart (2002) that tree volume prediction usually gives negative intercept. The standard error of estimate (SEE), which measures the overall predictive value of regression models (Adekunle, *et al.*, 2004), and which is a common measure of goodness of fit in nonlinear regression models (Ige and Erhabor, (2013), with low value indicates better fit.

Reasons and Purposes for cutting Teak trees in Agudu Forest Reserve

The results of the Reasons and Purposes for cutting Teak trees in Agudu Forest Reserve showed that 52.73% of the respondents do harvest the trees for sales to earn income,

20.34% do cut down the teak trees to reduce shade on their farmland, while the remaining 16.36% of them do cut down the trees to reclaim the reserved forest land from Government and turn it back to their arable farmland. The results of the Purposes for cutting Teak trees showed that 28.46% of the respondents do harvest the trees for sales as transmission poles to earn income, 18.46% do use the trees cut as roofing members, 17.69% do use the cut trees for fuel/firewood for sale, 10.77% do cut tree branches for leaf harvesting for preservation and rapping food/ items, 15.38% do cut tree branches for staking yam/beans and other climbing crops, while the remaining 9.23% of them do use the trees cut as fencing poles(Table 9, Plate 3, 4& 7).Poverty was observed to be a major threat to the existence of Teakplantation in Agudu. Acute shortage of firewood continues to adversely affect families which rely on firewood for cooking. Most families are now lamenting the rising cost of firewood which has become a scarce commodity due to the indiscriminate felling of trees and deforestation of the Forest Reserve.

Table9. *Reasons and Purposes for cutting Teak trees in Agudu Forest Reserve*

s/n	Item	Frequency	Percentage(%)
a	**Reasons for cutting Teak trees**		
1	Harvest the trees for sales to earn income	72	68.42
2	Cut down the teak trees to reduce shade on their farmland	35	20.34
3	Cut down the trees to reclaim the reserved forest land from Government and turn it back to their arable farmland	23	11.24
	Sub total	**130**	**100.00**
b	**Purposes for cutting Teak trees**		
1	Harvest trees for sales as transmission poles	37	28.46
2	Use the trees cut as roofing members	24	18.46
3	For fuel/firewood for sale	23	17.69
4	Cut tree branches for leaf harvesting for preservation and rapping food/ items	14	10.77
5	Cut tree branches for staking yam/beans and other climbing crops	20	15.38
6	Use the trees cut as fencing poles	12	9.23
	Sub total	**130**	**100.00**

CONCLUSION AND RECOMMENDATIONS

This project was carried out to evaluate the use of Forest Inventory in Estimating Illegally Felled Trees of *Tectonagrandis* Plantation in Agudu Forest Reserve, Lafia, Nasarawa State, Nigeria. It also drew conclusion equivalent to the volume estimated for each tree per plot and for each plot mean for exploitation. In order to achieve sustainability in forest management, Palmer and Synnott (1991) identified that there should be: Adequate information about the forest stock, Security of land use, Suitable financial and political environment.It is known fact that the stand volume equations, which incorporated various tree growth variables, will enhance future yield prediction of the study area since they provide quantitative basis for estimating stand growth parameters. For instance, those growth variables that have very strong relationships, depicted by their high coefficient of determinations (R^2) and low standard error of estimate (SEE) with tree stem volume could be regarded as important determinants to be considered in stand volume assessment in Agudu Forest Reserve. The models generated were screened, those having negative intercepts are adequate and are recommended for stand volume assessment in the study area. The volume prediction equations provide the means through which the production potential of both the existing stands and illegally felled Trees of *Tectonagrandis* can be estimated in the study area. It is believed that the equations obtained in this study will enhance sound and informed management decisions and conservation measures for the remaining stands. Also, It is concluded that there was linear relationship existing between the growth of Teak (*Tectonalgrandis)* and the selected parameters used to estimate the volume of the trees.

- The Estimated tree Volume (ETvol) was 147.69m^3 on 0.63ha sampled plots, this will amount to 234.43m^3/ha. If the World Market Price of Teak as at 2018 is put at 1221.31USD/m^3 at ₦355/USD, this will amount to the sum of ₦16,392,606,676.00 equivalent to a total value of about

(46,176,357USD) of standing trees of *Tectonagrandis* at 2018 year ending.

- While, the Total Estimated Stump Volume (ESvol) was 154.18m^3 on 0.63ha sampled plots, this will amount to 244.73m^3/ha. (Table 6). Based on 'International prices for teak: Historical and current, and price forecasts' by Guillermo *et al*,. (2009), the World Market Price of Teak as at 2018 is put at 1221.31USD/m^3 at ₦355/USD, this will amount to (₦433,565.1/m^3*x* 244.73m^3/ha *x* 161.28ha) the sum of ₦17,112,838.083.00 equivalent to a total loss of about (48,205,177.70USD) of felled *Tectonagrandis* at 2018 year ending.

It is recommended that forest inventory should be done at a regular interval in order to be able to manage, maintain and to know the growth rate of the plantation maybe is due for harvest or not.Also to be able to ascertain the extent of damages caused by human activities such as fuel wood fetching, leaves and herbs collection, hunting that usually leads tobush burning, in and around Agudu Forest Reserve areas as the case of human interference is pronounced in the area. If this is done, it will enable sustainable management, maintenance of the plantation. Furthermore, comprehensive study in this area is recommended.

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