Recovery Efficiency of Lumber/Sawnwood from Prioritised Wood Species in Selected Sawmills Within Egor Local Government Area, Edo State, Nigeria

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Abstract

Past studies concerning the efficiency of sawmills are limited by location specification and are not current. This study examines the interplay of sawmill activities with the socio-economic and resource base of stakeholders. The volume of log inputs for four prioritised wood species namely: Blighia sapida, Lophira alata, Baphia nitida and Bombax buonopozense were measured using Newton and Smalian formulae. The volume of lumber/sawnwood obtained from the four species were also calculated and based on these, percentage cubic lumber recovery (CLR) were obtained for the four species taking into consideration the two formulae. Data obtained were descriptively analysed and also subjected to Analyses of Variance (ANOVA) and Fisher's Least Significant Difference (LSD). Results showed that mean log input volume for the four species of logs ranged between 1.12±0.06m^3 and 2.35±0.03m^3 using Newton formula and from 1.15±0.22m^3 to 2.40±0.05m^3 based on Smalian formula. The volume of lumber/sawnwood obtained ranged from 0.59±0.13m^3 to 1.33±0.17m^3. Based on these values, percentage CLR for the four species ranged from 50.57±0.60% to 59.36±0.82% and 42.22±0.88% to 65.99±0.44% for log input based on Newton and Smalian formulae respectively. Significant variation did not occur in pooled data for log input volume obtained using the two formulae although variation exist in data for individual formula. Similarly, significant variation exists in data obtained for output volume of lumber/sawnwood. Furthermore, it was also observed that significant variation did not exist in data jointly analysed for the two formulae while significant variation was observed in data obtained for individual formula.

Keywords: Band saw, cubic lumber recovery, log conversion, sawmilling, sawnwood volume

Introduction

Wood and its products are still in high demand in Nigeria for both local and export consumption. For instance, volume estimates of total wood removed from Nigeria's forests increased from 69.12 million m^3 in 2001 to 72.63 million m^3 in 2011 (FAO, 2015). This is a challenge in Nigeria, which has been reported as suffering declining quantity and quality of forest resources, owing partly to this high wood demand. This reality has led to recommendations from studies and other informed sources that planting and replanting of forests should be sustainably intensified in order to meet the demand for harvestable resources and environmental services provided by both natural and planted forests (Erakhrumen, 2011; 2012; 2014). However, these efforts may not achieve their objectives, for example, in cases where harvested wood are processed with outdated and/or inefficient technologies.

One of the implications of applying outdated and/or inefficient technologies in this regard is that more than necessary resources are likely lost as waste/residues, which on the long run have negative impacts on the resource base. Presently, Nigeria's technological advancement is low and this impacts on her industries including those of sawmilling. A sawmill can be briefly described as a wood processing industry that uses machines. The bulk of wood conversion done in most sawmills in the country are achieved using band and circular saw machines whose output is dependent on factors like species' types, shape and size of logs, condition of machine, and experience of machine handlers.

Earlier studies such as Badejo and Giwa (1985) and Wade *et al*. (1992) were carried out to evaluate some parameters relating to volume of lumber or sawnwood recovered from different species of logs, with a view to having an indication of the operating efficiency of those sawmills. An example of these past studies is the one that has to do with cubic lumber recovery (CLR). This CLR is the cubic volume of lumber manufactured per cubic volume of logs processed (Keegan *et al*., 2010). It is assumed that the higher this ratio, the lower the waste/residues generated during log conversion process. However, the outcomes of these earlier studies might not be in tune with the present state of sawmills, their machines, emerging wood species presently converted, increase in quantity of small-diameter logs from the forests, increasing variations in log form, among others.

In addition, recent similar studies of this kind such as those by Wade *et al*., (1992), Egbewole *et al*. (2011) and Olufemi *et al*. (2012) that are to serve as means of update concerning scenarios in sawmills within Edo State, Nigeria, are scarce in literature. Also, it is imperative to note that apart from Edo State possessing part of the country's rainforest, which is under pressure of exploitation, the State also has appreciable number of functional sawmills in Nigeria. Therefore, an update study of this type is apt to make comparison with earlier studies. Consequently, this study was designed to assess the efficiency of selected sawmills within Egor Local Government Area, Edo State, Nigeria based on CLR of converted stakeholder prioritised wood species. Newton and Smalian formulae were used to calculate CLR for comparison as there are instances when logs are stacked in ways that prevent mid-point diameter measurement needed for Newton formula application.

Materials and Methods

Study area

The data for this study was obtained from six operational sawmills located within Egor Local Government Area (LGA), located on the southern part of Edo State, Nigeria. Egor LGA has an estimated land area of 93km^2 and a population size of 340,470 (NPC, 2006). The topography is flat with gentle slope. It is located within the latitude 06°15´N and 06°27´N and longitude 05°30´E and 05°40´E. It has an annual rainfall of between 1500 and 2000 mm with an average temperature of 25°C in the rainy season and 28°C in the dry season. It is part of a low lying plain covered with porous sand that rises gently North–Eastward, with soils derived from sand stones and shades and very recent deposits susceptible to leaching (Egbe *et al*., 1989; Kalu and Anigbere, 2011). These conditions are favourable for fauna and flora diversity and by extension tree growth, which favour the supply of raw materials for the sawmilling industries (FORMECU, 1999; Kalu and Decoco, 2013).

Data collection

Data collection was done in six operational sawmills within the study area in two months (February and March of 2015), that form a part of the dry season of that year, the season mostly associated with higher sawmilling activities. These sawmills were: Ogbebor 2, Ogbebor 3, Ogbebor 4, Mrs. Enabulele, Grace Onwiobo and Mrs. Omorodion sawmills. Questionnaire survey was carried out within and around these six sawmills where subsequent measurements of logs from prioritised species were carried out. The data obtained from these sawmills were pooled together for analyses.

Questionnaire survey

In order to select species that were commonly converted in these sawmills, a set of questionnaire was administered to sawmill owners, managers, machine operators and other stakeholders, responsible for wood supply to and their conversion in these sawmills. A total of one hundred and twenty (120) copies of the questionnaire were administered in all, although, ninety six (96) were retrieved. This was used to compile a list and prioritise all the identified wood species. In order to prioritise the species, respondents listed the woody species in order of conversion priority from 1 to 10. Based on the ranking order described by Erakhrumen (2009), four (4) species that had the highest cumulative values among all the listed species were selected for measurements.

Volume measurements for log input and lumber/sawnwood output

The mean log volume for the four mostly converted wood species was calculated with the use of Newton and Smalian formulae (Equations 1 and 3, respectively). All measurements were made over-bark for straight logs that had their top, middle and basal diameters ranging between 0.51m and 0.74m before they were converted to lumber/sawnwood. The cumulative volume of lumber/sawnwood obtained from each log was calculated by adding up the volume of all the different dimensions of individual lumber/sawnwood from each log (Equation 4).

$$V_{\log 1} = \{L \cdot (A_b + 4A_m + A_t) \cdot 6^{-1}\} m^3 \text{ -- (Equation 1)}$$

Where: $V_{\log 1}$ = Volume of log obtained over-bark (m^3)

L = Total length of log (m)

A_b = Cross sectional area at the basal part of the log (m^2)

A_m = Cross sectional area at the middle pat of the log (m^2)

A_t = Cross sectional area at the uppermost part of the log (m^2)

Cross sectional area was calculated as follows:

$$A = \{l^2 \cdot (4\pi)^{-1}\} m^2 \text{ -- (Equation 2)}$$

Where: A = Cross sectional areas at the basal, middle and uppermost parts of the log (m)

l = Circumferential lengths at the basal, middle and uppermost parts of the log (m)

p = 3.14

$$V_{\log 2} = \{\pi \cdot L \cdot (D_b^{\ 2} + D_t^{\ 2}) \cdot 8^{-1}\} m^3 \text{ ----- (Equation 3)}$$

Where: $V_{\log 2}$ = Volume of log obtained over-bark (m^3)

L = Total length of log (m)

D_b = Diameter at the basal part of the log (m)

D_t = Diameter at the uppermost part of the log (m)

p = 3.14

Total volume of recovered lumber/sawnwood was calculated as follows:

$$V_{sw} = \sum n \cdot (\alpha \cdot \beta \cdot \gamma) m^3 \text{ ----- (Equation 4)}$$

Where: V_{sw} = Total volume of lumber/sawnwood obtained from each log (m^3)

a = Length of lumber and other sawnwood dimensions (m)

β = Breadth of lumber and other sawnwood dimensions (m)

γ = Thickness of lumber and other sawnwood dimensions (m)

n = Number of lumber and other sawnwood dimensions from each log

Percentage lumber/sawnwood volume obtained from logs

The following equation 5 was used to calculate, in percentage, the ratio of recovered lumber/sawnwood volume to corresponding volume of converted logs:

$$(Lumber + sawnwood\ \ recovered)\ \ x\,(Log\ converted)^{-1}\ \%$$

$$= \frac{(Total\ \ volume\ \ of\ lumber\ + sawnwood\ \ obtained\ \ from\, each\ \log)\, x\, 100}{(Over\!-\!bark\ \ volume\ \ of\ \ each\ \log)} \text{ ----- (Equation 5)}$$

Statistical analyses

Data obtained for the calculated input log volume, output lumber/sawnwood volume and percentage cubic lumber recovery were subjected to basic descriptive statistical analyses such as mean and standard deviation (SD). Analysis of variance (ANOVA) was also employed in analysing the data for statistical significant variation ($P \leq 0.05$). In addition, Fishers' Least Significant Difference (LSD) was applied for the separation of significantly different means ($P \leq 0.05$).

Results

During the study, logs from different types of wood species were brought from different sources for conversion to different lumber/sawnwood dimensions based on demand specifications and market requirements. However, Tables 1 and 2 contain the results from statistically analysed data obtained from measurements made on logs from some prioritised species. The mean length of all the logs used for this study was observed to be 5.49m. It was also observed that out of all the species of logs converted in the visited sawmills and prioritised by the respondents through questionnaires, *Blighia sapida*, *Lophira alata*, *Baphia nitida* and *Bombax buonopozense* were ranked the top most favoured. The mean log input volume for *B. sapida*, *L. alata*, *B. nitida* and *B. buonopozense* were found to be $1.12\pm0.06m^3$, $2.19\pm0.05m^3$, $2.35\pm0.03m^3$ and $1.50\pm0.04m^3$ as well as $1.15\pm0.22m^3$, 1.97±0.02m^3, 2.40±0.05m^3 and 1.80±0.06m^3 using Newton and Smalian formulae, respectively (Table 1).

The ANOVA (Table 2) showed that there was no significant variation when the data obtained for input log volume obtained for the four species using the two formulae were pooled together and jointly analysed. However, significant variation was observed in data for input log volume of individual species using the two formulae when analysed differently (Table 2). Further, it was found that the mean input log volume of *L. alata* and *B. nitida* were not significantly different while those for *B. sapida* and *B. buonopozense* were significantly different from each other and from those for *L. alata* and *B. nitida*, using the two formulae (Table 1). Furthermore, the mean calculated volume for lumber/sawnwood obtained from individual logs after their conversion were 0.59±0.13m^3, 1.30±0.14m^3, 1.33±0.17m^3 and 0.76±0.10m^3 for *B. sapida*, *L. alata*, *B. nitida* and *B. Buonopozense*, respectively (Table 1).

Further, significant variation was observed to exist in the pooled data for output volume for lumber/sawnwood obtained from the four species (Table 2). Similarly, the mean data for *L. alata* and *B. nitida* were not significantly different, although those for *B. sapida* and *B. buonopozense* were significantly different from each other and from those for *L. alata* and *B. nitida* (Table 1). In addition, the mean CLR for *B. sapida*, *L. alata*, *B. nitida* and *B. buonopozense* were 52.68±0.66%, 59.36±0.82%, 56.60±0.37% and 50.67±0.60% while they were

Table 1: Mean log input volume (over-bark), output lumber/sawnwood volume and cubic lumber recovery for the four prioritised wood species in the study area

Species	****Mean log input volume and SD (over-bark) (m^3)***		***Mean output volume and SD for lumber/sawnwood (m^3)***	***Cubic Lumber Recovery (CLR) and SD (%)***	
	Newton formula	Smalian formula		Newton formula	Smalian formula
Blighia sapida	1.12^a±0.06	1.15^a±0.22	0.59^a±0.13	52.68^a±0.66	51.30^a±0.33
Lophira alata	2.19^b±0.05	1.97^b±0.02	1.30^b±0.14	59.36^b±0.82	65.99^b±0.44
Baphia nitida	2.35^b±0.03	2.40^b±0.05	1.33^b±0.17	56.60^b±0.37	55.42^a±0.42
Bombax buonopozense	1.50^c±0.04	1.80^c±0.06	0.76^c±0.10	50.67^a±0.60	42.22^c±0.88

*The mean values for input log volume are for six (6) logs per species
Means with the same superscripts in the same column are not significantly different (p =0.05)

Table 2: Analysis of Variance (ANOVA) for the analysed data

Source of variation	***Log input volume***		***Cubic Lumber Recovery***	
	f-calculated	p-value	f-calculated	p-value
Formulae for estimations	0.010582^{ns}	0.921419^{ns}	0.042679^{ns}	0.843164^{ns}
Species (Newton formula)	1417.652*	1.86E-23*	172.0715*	1.9E-14*
Species (Smalian formula)	69.55335*	9.3E-11*	1670.37*	3.64E-24*

*denotes significance (p = 0.05); ^{ns} denotes not significant (p = 0.05)

51.30±0.33%, 65.99±0.44%, 55.42±0.42% and 42.22±0.88% for log input calculated using Newton and Smalian formulae, respectively (Table 1).

The results of ANOVA (Table 2) also showed that there was no significant variation when the data for CLR obtained for the four species, using the two formulae, were pooled together and jointly analysed. Also, significant variation exist in data for CLR obtained for individual species analysed differently using the two formulae (Table 2). Mean CLR for *B. sapida* and *B. buonopozense* were not significantly different from each other while though that of *L. alata* and *B. nitida* were not significantly different from each other, they were different for those for *B. sapida* and *B. buonopozense* using Newton formula (Table 1). Nevertheless, mean CLR for *B. sapida* and *B. nitida* were not significantly different while those for *L. alata* and *B. buonopozense* were significantly different from each other and from those for *B. sapida* and *B. nitida* using Smalian formula (Table 1).

Discussion

The logs that were converted using mainly the available CD Series of horizontal band saw headrig machine had mean diameter lengths that ranged between 0.51m and 0.74m thereby making them not to be considered as small-diameter logs. This is because small-diameter logs, according to Wolfe and Moseley (2000) are defined as trees with diameter at breast height under 0.230m (9inches), a definition also reinforced by FPL (2004). However, the range of diameter of the converted logs might have reduced compared to what used to be converted in the past considering the submission of Lucas (1990) that noted that form and sizes of available logs for conversion have been reducing considerably. This may imply that there is the likelihood that large-diameter logs (logs with diameter greater than 0.55m) are becoming difficult to come by in the country's forests and this is a reflection of the prevalent pressure on our forests owing partly to increasing demand for logs.

Whatever the diameter length of a stem/log, in standing trees or harvested logs, there are instances when there are needs for their volume to be estimated. In doing this using known methods of elementary forest measurement, tree stem shape, for stems of average circular cross-sections, is modelled by longitudinal sections using the solids of revolution: cylinder, paraboloid, cone, and neilod (Cruz deLeón and Uranga-Valencia, 2013) referred to as classical geometries (Diéguez-Aranda *et al.,* 2003). The most widely known methods for stem/log volume estimation, based on these geometries, with assumption that cross-sectional areas are circular, are: Huber, Newton and Smalian methods. The three methods give exact results for cylinder and paraboloid while the Newton method gives exact results for all the classical geometries (Diéguez-Aranda *et al*., 2003).

However, Smalian and Huber methods are preferred in the field because they are easier to apply than the Newton method (Cruz de León and Uranga-Valencia, 2013). Compared with Newton formula for the same log, the Smalian formula overestimates by about 10% while Huber formula underestimates by about 3% (Wenger, 1984). Opinion may be divided on the accuracy of these stem/log volume estimation methods but it is believed that Newton method is more accurate than that of Smalian. Nonetheless, since significant variation did not exist in the data obtained from this research for log input volume using the two methods of estimation, it could be safely stated within the context of this study, that both log volume estimation methods (Newton and Smalian) can be used for these species' log volume estimation if the need to choose from either exists.

For instance, choosing between Newton and Smalian formulae for log volume estimation might be necessary when logs are stacked in piles where the mid-point diameter is not available for measurement. The observation of significant variation in data obtained for the four species when considering individual method of volume estimation might not be unexpected since these values are dependent on size, shape, form, among other factors, peculiar to individual log species in question. The species that have similar input log volume (*L. alata* and *B. nitida*) using Newton and Smalian formulae are so, perhaps, owing to the fact that they belong to same diameter range and not necessarily because of the types of species they are. This implies that different results concerning this parameter will be obtained in other studies once the sizes of the logs for the species are varied.

The variability experienced in the data obtained for the total output volume of lumber and sawnwood among the four species should also not be unexpected as measures of the volume of lumber/sawnwood produced per unit of log input can be influenced by a range of factors in addition to log scale. These factors include types of wood species, level of conversion technology, log size, shape and form, lumber size, lumber grade, market conditions for lumber, among others (Keegan *et al*., 1998; Keegan *et al*., 2010). In addition, some other factors that are mostly not within the control of sawmill machine operators, such as wood defects, also influence the output volume of lumber and sawnwood from round logs. Therefore, if the only positive output of interest expected from round logs in sawmills is the lumber/sawnwood, then maximising their output volume should also be of interest owing to their various economic and environmental implications.

The CLR values obtained for logs of the four wood species using both Newton and Smalian formulae in this study fall within the range of values obtained from other similar studies such as Byers (1960), Fahey (1974), Alviar (1983), Badejo and Giwa (1985), Rappold *et al*. (2007), Okunomo *et al*. (2008) and Egbewole *et al*. (2011), thereby giving an impression that there has not been significant improvement in sawmilling operations and activities concerning log conversion to lumber/sawnwood based on prevalent CLR values obtained from this and other recent similar studies in developing countries like Nigeria. This is not to overlook the efforts in some other climes that have led to increase in their percentage CLR over the years. Examples of such are the reports by Keegan *et al*., (2010) and Blatner *et al*., (2012) where percentage CLR increased between 1970s and 2000s within the US.

The reason(s) behind the non significance in data variation for percentage CLR obtained for logs from the four wood species when the data obtained using Newton and Smalian formulae were pooled together may be difficult to explain since significant variation exist in the data obtained for output lumber/sawnwood volume for logs from the four species, however, it might not be far from the results obtained when data for log input volume for the two formulae were pooled together and analysed giving a non significance in data variation as stated earlier. In addition, as noted for input log volume, the observed significant variation in data for CLR when values for individual method of estimation was considered, might also be related to the highlighted factors and others influencing log input volume for the individual formula for the estimation. Similarly, the mean CLR values that are or not significantly different are likely so owing to the ranges of their log diameter noted earlier.

Conclusion and Recommendation

The outcomes of this study still appear to suggest that the mean percentage cubic lumber recovery for logs in sawmills located within the study area are still within the range earlier published for other similar studies in Nigeria. The likely implication of this observation is that, technologically, Nigeria and many other developing countries are still lagging behind as compared to many other countries where technology and machines for wood conversion have been improved upon while residues generated are further converted in such ways as to obtain more sawnwood from them. Therefore, efforts toward improvement in technology in this regard, are necessary in Nigeria, in order to maximise wood output from harvested logs of these and other species, considering the informed projections that there will be increase in the supply of small-diameter logs from tropical forests.

References

Alviar, G.O. (1983). Sawmilling Industry in Nigeria. Field Documents No. 17. Food and Agricultural Organization (FAO) Rome. 53pp.

Badejo, S.O.O and Giwa, S.A. (1985). Volume Assessment and Economic Importance of Wood Waste Utilization in Nigeria. Forestry Research Institute of Nigeria (FRIN) Technical Report Number 50: 15-31.

Blatner, K.A., Keegan III, C.E., Daniels, J.M. and Morgan, T.A. (2012). Trends in Lumber Processing in the Western United States. Part III: Residue Recovered versus Lumber Produced. *Forest Products Journal*, 62(6): 429-433.

Byers, A.M. (1960). The Timber Industry and Industrial Forestry in Alaska. *Journal of Forestry* 58(6): 474- 477.

Cruz de León, G. and Uranga-Valencia, L.P. (2013). Theoretical Evaluation of Huber and Smalian Methods Applied to Tree Stem Classical Geometries. *BOSQUE*, 34(3): 311-317.

Diéguez-Aranda, U., Barrio-Anta, M., Castedo-Dorado, F., Ruíz-González, A.D., Álvarez-Taboada, M.F., Álvarez-González, J.G. and Rojo-Albareca, A. (2003). Dendrometría. Madrid, España. Mundi-Prensa. 327pp.

Egbe, N.E., Ayodele, E.A. and Obatotu, C.R. (1989). Soil Nutrition of Cocoa, Kola, Cashew and Trees: Progress in Tree Crop Research (2nd Edition): Ibadan, Nigeria. Pp. 28-30.

Egbewole, Z.T., Ogunsanwo, O.Y. and Omole, A.O. (2011). Technical Efficiency of Lumber Recovery from High Forest Tree Species in Selected Sawmills of Southwestern Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 7(1): 34-41.

Erakhrumen, A.A. (2009). Energy Value as a Factor of Agroforestry Wood Species Selectivity in Akinyele and Ido Local Government Areas of Oyo State, Nigeria. *Biomass and Bioenergy*, 33(10): 1428-1434.

Erakhrumen, A.A. (2011). Recent Trends in Global and Regional Forest Cover Changes: Continuously Increasing Forest Size and Quality are Crucial Steps toward Environmental Sustainability. In the Proceedings Entitled "Forestry in the Context of the Millennium Development Goals" Edited by L. Popoola, K. Ogunsanwo and F. Idumah, for the 34th Annual Conference of the Forestry Association of Nigeria held in Osogbo, Nigeria, from the 5th

to 10th December, 2011, 1:476-496.

Erakhrumen, A.A. (2012). Recent Estimations of Net Forest Cover Changes in Nigeria and their likely Implications on Efforts toward Carbon Emission Reduction. In the Proceedings Entitled *"De-reservation, Encroachment and Deforestation: Implications for the Future of Nigerian Forest Estate and Carbon Emission Reduction"* Edited by J.C. Onyekwelu, B.O. Agbeja, V.A.J. Adekunle, G.A. Lameed, P.O. Adesoye and A.O. Omole, for the Third Biennial National Conference of the Forests and Forest Products Society held in Ibadan, Nigeria, from the 3rd to 6th April, 2012. Pp. 582-590.

Erakhrumen, A.A. (2014). Declining Tropical Forests: A Challenge to Sustainability of Forest-Dependent Industries and Climatic Stability. In the Proceedings Entitled "Forests and Forest Products: Key to Sustainable Livelihood" Edited by M.O. Adedire, J.C., Onyekwelu, D.O. Oke, V.A.J. Adekunle, O.A. Jayeola and A.O. Oladoye, for the Fourth Biennial National Conference of the Forests and Forest Products Society held in Abeokuta, Nigeria, from the 22nd to 26th April, 2014. Pp. 26-34.

Fahey, T. D. (1974). Lumber Recovery from Second-Growth Douglas-Fir. USDA Forestry Service Research Paper PNW-177. Pacific Northwest Forestry and Range Experimental Station, Portland Oregon, USA. 20pp.

FAO, (2015). Global Forest Resources Assessment 2015: Desk Reference. Food and Agriculture Organization of the United Nations (FAO), Rome, 2015. ISBN 978-92-5-108826-5. 253pp.

FORMECU, (1999). Forest Resources Study: Revised Forest Management Plan of Edo State. Forestry Management Evaluation and Coordinating Unit (FORMECU), Federal Ministry of Agriculture and Natural Resources, Abuja, Nigeria. 126pp.

FPL, (2004). Structural Grading of Logs from Small-Diameter Trees. Paper GR-1 published by Forest Products Laboratory (FPL), One Gifford Pinchot Drive, Madison, WI 53726-2398. 2pp. Available at: http://www.fpl.fs.fed.us/documnts/techline/structural-grading-logs-from-small-diameter-trees.pdf

Kalu, C. and Anigbere, R.F. (2011). Social Benefits of Non-Timber Forest Products (NTFPS): An Assessment of Employment Generation from NTFPS Enterprises in Benin Metropolis, Edo State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 7(2): 30-35.

Kalu, P.C. and Decoco, I.M. (2013). Economic Evaluation of Bench Mill Enterprises in Benin Metropolis, Edo State. *Nigerian Journal of Agriculture, Food and Environment*, 9(4):70-75.

Keegan, C.E., Wichman, D.P., Blatner, K.A., Van Hooser, D.D. and Willits, S.A. (1998). Mill Residue Volume Factor Changes in Idaho and Montana. *Forest Products Journal*, *48(3): 73-75.*

Keegan III, C.E., Morgan, T.A., Blatner, K.A. and Daniels, J.M. (2010). Trends in Lumber Processing in the Western United States. Part II: Overrun and Lumber Recovery Factors. *Forest Products Journal*, 60(2): 140-143.

Lucas, E.B. (1990). Wasted Tree Products in Nigeria and their Potentials as Industrial Raw Materials. Proceedings of the National Conference of the Forestry Association of Nigeria, Hosted by FRIN, Ibadan. Pp. 13.

NPC, (2006). Population Distribution by Sex, State, Local Government Areas and Senatorial Districts: 2006 Census Priority Tables Vol. 3: Published by National Population Commission (NPC). Available at: http://www.population.gov.ng/index.php/censuses

Okunomo, K., Achoja, F.O., Agbogidi, O.M. and Onosode, A.T. (2008). Economics of Wood Conversion Efficiency and Plank Yield Estimation Among Different Wood Species. *African Journal of General Agriculture*, 4(1): 7-12.

Olufemi, B., Akindeni, J.O. and Olaniran, S.O. (2012). Lumber Recovery Efficiency among Selected Sawmills in Akure, Nigeria. *Drvna*

Industrija, 63(1): 15-18.

Rappold, P.M., Bond, B.H., Wiedenbeck, J.K. and Ese-Etame, R. (2007). Impact of Elliptical Shaped Red Oak Logs on Lumber Grade and Volume Recovery. *Forest Products Journal,* 59: 29-34.

Wade, M.W., Bullard, S.H., Steele, P. and Araman, P.A. (1992). Estimating Hardwood Sawmill Conversion Efficiency based on Sawing Machine and Log Characteristics. *Forest Products Journal*, 42(11&12): 21-26.

Wenger, K.F. (Ed.) (1984). Forestry Handbook. Second Edition Edited by K.F. Wenger for the Society of American Foresters. Published by John Wiley & Sons, Inc. ISBN 978-0-471-06227-1. 1360pp.

Wolfe, R. and Moseley, C. (2000). Small-Diameter Log Evaluation for Value-Added Structural Applications. *Forest Products Journal*, 50 (10): 48-58.