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LUMBER RECOVERY EFFICIENCY OF SOME SELECTED SAWMILLS IN ISHIAGU, EBONYI STATE, NIGERIA

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ABSTRACT
This study was carried out to investigate the lumber recovery efficiency among selected sawmills in Ishiagu, Ivo Local Government Area of Ebonyi State, Nigeria. The main sawing method used during the log conversion was the live-swing method. Before, during and after the sawing operations, parameter measurements were generated and documented. Data were analyzed using descriptive statistics such as frequency distribution, percentage distribution and bar chart. The results generated from the log conversion were used to estimate the percentages of lumber recovered and the wastes produced. The study revealed a lumber recovery efficiency ranging from 50.16% to 58.81%, with 3.31% to 10.02% of the log generated as sawdust and 32.38% to 40.8% of the log generated as wood wastes in form of slabs, shavings and off-cuts. Optimal volume yield and optimal sawing pattern is important for considerable reduction of wood-wastes generated in sawmills cognate experience should be a major determinant in the appointment of head rig operators.-Routine maintenance of machines especially the saw blades are essential.

Key words: Lumber recovery, Log conversion, live-sawing, sawing methods, sawmills, lumber.

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INTRODUCTION

Forests in Nigeria are made up of many forest resources with timber as the major interest to Nigerian forest consumers (Adewole and Onilude.2011, Rotowa *et al*. 2017). Woods harvested for both domestic and commercial usage from natural and reserved area is a major part of forestry in Nigeria. Sawmilling has been defined as a process of converting round wood from the forest into lumber by using a variety of processing machines (Kukogho *et al*, 2011; Izekor *et al*, 2016).

In Nigeria, sawmilling industry has played an important role in the wood products industries over the past few decades (Ogunwusi and Jolaoso, 2012). The forestry sector is seen as underperforming in terms of resource management and the competitive wood processing industry (Ogle and Nhantumbo, 2006). The high rate of forest loss in Africa is a major problem. Between 1990 and 2000, the continent lost about 5.2 million ha of forest, accounting for about 56 percent of the global reduction in forest cover. Although other products from the natural environment have been exploited, rate of timber harvesting has accelerated significantly since the turn of the century. In central and west Africa, the tropical rain forest has been an important source of timber, as well as other valuable non-timber product (Keegan, 2011). The increased demand of timber and method of extraction has caused severe depletion of forest resources.

An estimated 420 million hectares of forest has been lost worldwide through deforestation since 1990. Africa had the highest annual rate of net forest loss in 2010 –2020, at 3.9 million ha (FAO, 2020). In recent times, the ever-increasing demand of wood-based products and continuous harvesting of logs for various domestic and industrial applications has led to the reduction in forms and sizes of log available for conversion in forests, consequently leading to smaller sizes of marketable lumber generated from the sawmills. To meet this growing demand, suitable sawmilling practices that encourage high lumber recovery rate are essential (Olufemi *et al*, 2012). Numerous research works have thus been geared towards improving the lumber recovery efficiency during log conversion so as to effectively utilize this now limitedly available forest resource.

Lumber recovery ratio refers to the volume of lumber generated during conversion in relation to the volume of log converted; and is widely used as a means of assessing the efficiency of sawmills. In Nigeria, the lumber recovery efficiencies of sawmills have been estimated to range between 45–50%, with 50–55% of wastes generated in form of sawdust, edgings, slabs and shavings (Egbewole *et al*, 2011; Omoniyi and Fatoki, 2013).

The recovery efficiency has become increasingly significant with increasing logs price and transportation cost, and decreasing volume of standing timbers. Subsequently, the technological improvement of wood products industries has steadily increased the recovery efficiency. The limber recovery efficiency of sawmill may be influenced by many variables such as unconventional way of log conversion, sewing machines, log diameter and length (In Yang *et al* 2007). The loss of timber resources beyond sustainable limit is a serious issue in Nigeria. Consequently, the need for a study on the lumber recovery efficiency so as to reduce the severe degradation and wastage of forest resources. This study therefore seeks to investigate the lumber recovery efficiency in Ebonyi State.

MATERIALS AND METHODS

Study Area

This study was carried out at Ishiagu, Ivo Local Government of Ebonyi State in 2021. Ishiagu is a town located at longitude 07^0 33’ 59.99’’E and Latitude 05^0 56’ 32.99’’N with a mean annual temperature of 29^0 C and mean annual rainfall of 1350 mm. The town lies within derived savannah vegetation zone of South Eastern Nigeria with grassland and shrub tree combined together (Adekoya *et al*., 2020). There are two reported distinct seasons, the dry season which spans November to March, a times extend to April and the rainy season which spans April to October (Nwite *et al*., 2008). It is made up of ten (10) autonomous communities: Amaeke, Amaeze, Amagu, Amata, Ihie, Okue, Amaonye, Amaokwe, Ngwogwo, Ogwor. Ishiagu is an agrarian town like most places in Ebonyi State.

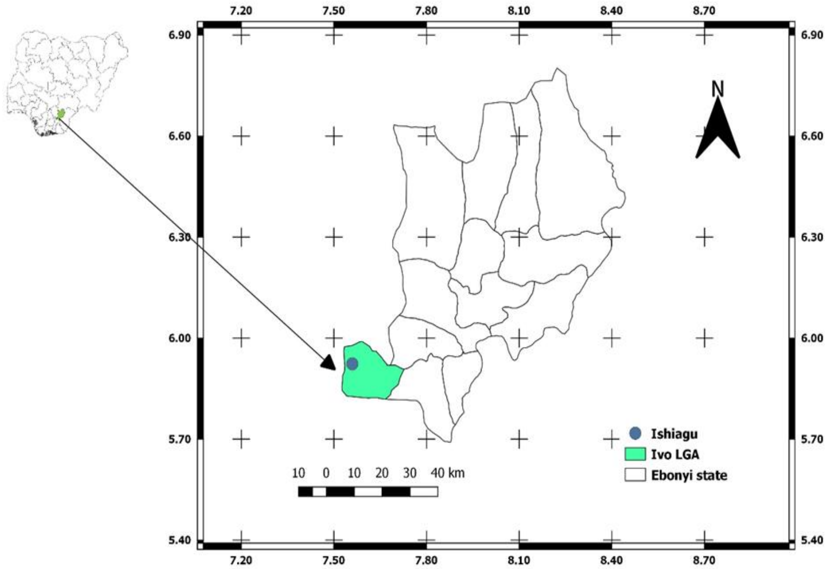

Figure 1: Map of Ebonyi state showing Ishiagu in Ivo Local Government Area of the state.

Experimental Design

Data was collected on 10 logs per species selected at 10 different sawmills for each wood specie. A total of 100 logs of varying sizes and shapes was sourced from each of the 10 sawmills visited. Hence a total of 1000 logs were used for this study.

Ten sawmills were purposively selected and visited within the town based on availability of logs of different species and regular conversion operations, while investigations and analyses were conducted to obtain necessary data before, during and after the conversion processes. The mills selected were Ogbuefi Ventures Sawmill, Geohaiz Sawmill, Eni Agha and Associate Sawmill, Agu and Sons Sawmill, Jerry Oko Sawmill, Jax Obis Agency Sawmill, Eluu ohia and Associate Sawmill, Augustine Oko sawmill, Enyi and Sons Sawmill and Zentus Sawmill.

All the mills visited use locally fabricated CD horizontal band saws with 1600 mm wheel diameter, 200 mm blade width, 3 mm blade thickness and 125 KW power input. After sawing using the band saw, a table circular saw was employed for other primary operations of edging, ripping, crosscutting and trimming. The ten common wood species – *Melicia excelsa*, *Terminalia Ivorensis*, *Khaya ivorensis*, *Cordia milenii*, *Triplochiton scleroxylon*, *Ceiba pentandra*, *Gmelina arborea*, *Mansonia altissima*, *Nuclea diderrichii*. - usually converted in these sawmills were used for the study. The formula used to estimate the volume of log converted, the volume of lumber generated, the volume of sawdust produced, the volume of solid wastes (in form of slabs and edgings) and conversion efficiency as shown in the formulae below:

1. **Volume of Log:** The volume of each log before conversion is estimated according to Omoniyi and Fatoki, (2013) using Newton's formula given by:

$$V_{log} = \frac{xl}{24} (D_b^2 + 4D_m^2 + D_t^2) \ \ldots\ldots (1)$$

Where: V_{log} = volume of log (m^3)
D_b = diameter of the base (large end) of the log (m)
D_m = diameter at the middle of the log (m)
D_t = diameter at the top (small end) of the log (m)
L = length of log (m)
π = 3.142 or 22⁄7

2. **Volume of Lumber**: The total volume of sawn lumber (planks) produced after conversion calculated by:

$V_{sl} = n\,(l \times b \times h)$ ……. (2) (Olufemi, *et al*, 2012)

Where: V_{sl} = volume of the sawn lumber (m)
l = length of lumber produced (m)
b = width of the lumber produced (m)
h = thickness of the lumber produced (m)
n = number of lumbers obtained from a log conversion

3. **Volume of Sawdust**: The approximate volume of sawdust generated from each log conversion was estimated using:

$V_{sd} = t \times l \times \int w$ …… (3) (Olufemi *et al*, 2012)

Where: V_{sd} = volume of sawdust (m)
t = kerf of the sawblade (m)
l = length of the log (m)
w = width of each lumber (plank) at the point of cut (m)

4. **Volume of Solid Wastes**: The combined volume of the slabs, off-cuts and waning edges (V_{sw}) generated during a log conversion is estimated by:

$V_{sw} = V_{log} - (V_{sl} + V_{sd})$ ……. (4) (Olufemi *et al*, 2012)

5. **Conversion Efficiency**: The lumber recovery efficiency as expressed in percentage is estimated using:

$C_r = = \frac{Vsl}{Vlog} \times 100\%$ …….. (5)

(Kukogho *et al*, 2011)

`Where: C_r = lumber recovery ratio of log conversion
V_{sl} = total volume of sawn lumber (planks) produced after conversion
V_{log} = volume of each log before conversion

Data were analyzed using descriptive statistics such as frequency distribution, percentage distribution and bar chart.

RESULTS

The volume of log, lumber and wastes generated by all the sawmills during the whole duration of the study are shown in Table 1. It is apparent that Iroko (*Milicia excelsa*) is the most converted wood species while Apkarata (*Afzellia africana*) is the least converted in all the sawmills. The lumber recovery ratio in Figure 1 shows that *Gmelina arborea* had the highest ratio (67.80%) during conversion process followed by *Cordia milenii*; 65.13%, *Ceiba pentandra;*62.92%, *Triplochiton scleroxylon;* 61.17% while *Melicia excelsa* gave the least value (53.75%).

Table 1: Volume of tree log converted in the sawmills and the resulting volumes of lumber and wood residues generated.

Wood species (Common Name)	**Wood species (Scientific Name)**	**Vol. of log(m^3)**	**Vol. of lumber(m^3)**	**Vol. of Sawdust(m^3)**	**Vol. of solid waste (m^3)**
Iroko/Oji	*Melicia excelsa*	11.87	6.38	0.63	4.72
Mansonia	*Mansonia altissima*	11.54	6.78	0.32	4.44
Obeche	*Triplochiton scleroxylon*	11.41	6.98	0.61	3.82
Mahogany	*Khaya ivorensis*	8.48	4.82	0.79	2.87
Black Afara	*Terminalia ivorensis*	8.24	4.98	0.32	2.94
Ceiba/akpu	*Ceiba pentandra*	7.82	4.92	0.58	2.32
Gmelina	*Gmelina arborea*	7.05	4.78	0.31	1.98
Opepe	*Nuclea diderrichii*	7.05	3.80	0.33	2.93
Omo	*Cordia milenii*	6.94	4.52	0.38	2.02
Apkarata	*Afzellia africana*	5.91	3.54	0.43	1.92

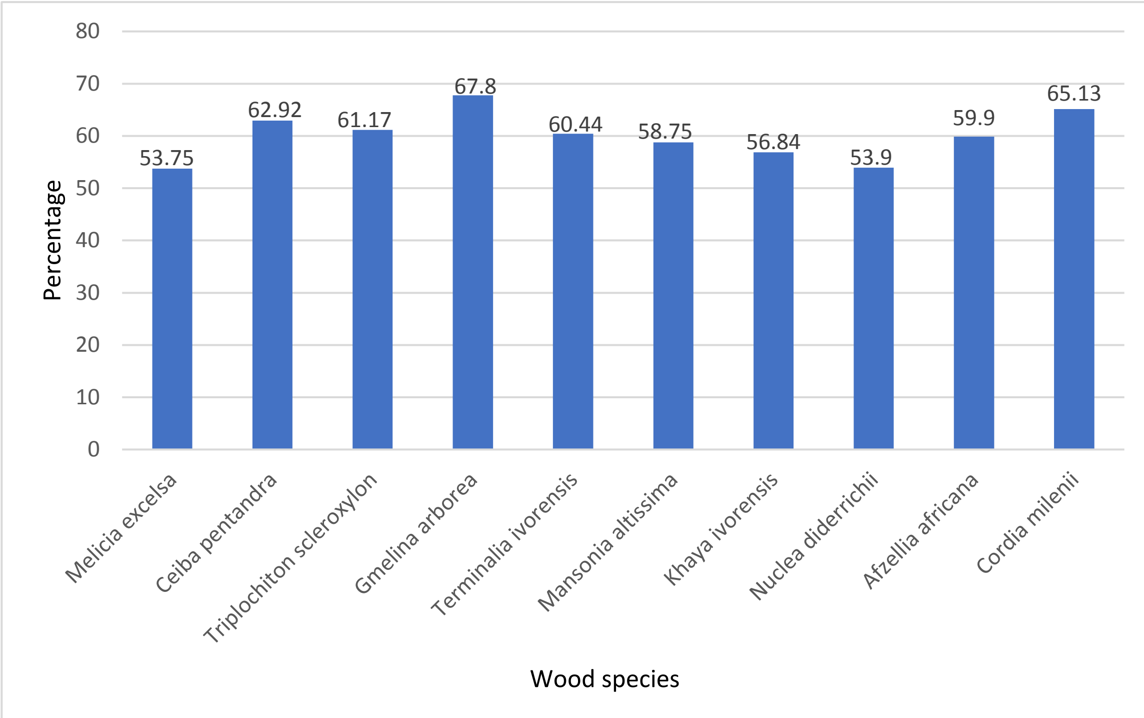

Figure 1: Percentage of Lumber Recovered for Each Species in Ishiagu LGA of Ebonyi State.

Plate 1: One of the sawmills visited in Ishiagu Ivo LGA of Ebonyi State

Table 2: Percentages of Lumber, Sawdust and Solid Wastes Generated during Conversion in each Selected Sawmills.

Name of Sawmill	Lumber (%)	Sawdust (%)	Solid Waste (%)
Zentus sawmill	58.81	8.29	32.9
Enyi and Sons	57.60	10.02	32.38
Jerry Oko sawmill	57.46	3.31	39.23
Eni Agha and associate	56.06	5.39	38.55
Ogbuefi ventures	54.12	7.67	38.21
Geohaiz sawmill	53.82	7.02	39.16
Jax Obis Agency	53.55	8.43	38.02
Eluu ohia and Associate	53.42	8.63	37.95
Augustine Oko	53.11	9.04	37.85
Agu and Sons sawmill	50.16	9.04	40.8
Mean Value	**54.81**	**7.68**	**37.51**

Table 2 below shows the mean lumber recovery of each sawmills including the percentages of sawdust and solid wastes generated during conversion. The total average recovery efficiency of the selected sawmills was 54.81% of the total log converted, with 45.19% of wood residue, with 7.68% of sawdust and 37.51% of solid wastes in form of slabs, off-cuts, shavings among others. From the table, Zentus Sawmill had the highest recovery of 58.81% while Agu and Sons Sawmills had the lowest value (50.16%), respectively

DISCUSSION

The availability of wood species in the forest and the need for a particular wood species for production of wood-based products by wood users is an important factor in the selection of wood species. The thickness of the blade, the number of times the saw blade passes through the log are the factors which determine volume of sawdust generated during conversion process. The slightly higher conversion ratio in some sawmills may be attributed to better technical know-how of personnel, newer equipment, proper maintenance of saw blade and detailed attentiveness of the sawyer during operation (Omoniyi and Fatoki,2013).Higher lumber recovery efficiency can be achieved when logs with good quality and good form (in terms of size and shape). Proper positioning of the logs on the carriage so as to display the best face of cut is also necessary. Although, this finding when compared with the similar works carried out in previous years in Nigeria showed a slight increase in lumber recovery efficiency. Numerous factors influence lumber recovery efficiency; grades and species of trees of the machine operators to types of saw used, log sizes, and log form. Low recovery rates and lack of capacity to process small diameter logs from tree plantation by sawmills can pose a significant threat to efforts to curb deforestation and forestry degradation in Nigeria (Ogunwusi and Jolaoso, 2012). Defects in woods such as splits, checks, spiral grains, decay, curvature borers holes and wane edges also lead to reduction in wood quality and thereby affects its lumber recovery. The result of this study showed a small increase in the lumber recovery efficiency when compared to similar works done in the past (Aviar, 1993; Aina, 2006; Egbewole *et al*., 2011; Olufemi *et al*,2012; Ogunwusi and Jolaoso, 2012 Omoniyi and Fatoki,2013; Rotowa *et al*,.2017). This increase can be due to better maintenance of saw blade of the mills, good grades and forms of logs being converted and improved skills and techniques used by the sawyers during conversion process. The sawyers should make efforts to try other means of log conversion methods aside from the usual through-and-through method, so as to determine the best opening face of cut that will guarantee higher volume of lumber and reduced solid wastes. Reduced lumber recovery efficiency can be attributed to sawmills having oversized logs and product-size variation in producing the products. Oversizing entails products having more thickness or width needed to compensate for reductions from shrinkage, variation, or planing. These oversized logs usually end up as planer shaving. Also, reduced recovery can be attributed to the ease with which the band sawmill blade moves through the log during conversion and the hardness of various wood species. Lumber recovery efficiency is known to increase with bigger log, short log length and narrower taper. Hence, log size, taper and log length have positive relationship on lumber recovery efficiency (Izekor *et al*, 2016).The mechanical hardness of the wood in relation to the species of wood being converted also reduce the lumber recovery of conversion as higher volume of solid wastes are usually generated from such logs (Omoniyi and Fatoki,2013). The technical know-how of the sawyers and the shape of the logs being converted can affect these results.

Conclusion and Recommendation

The findings from the study have shown that the type of wood species, the type of wood conversion method used to process it and the expertise of operator who manned these machines, contributes to lumber recovery efficiency in the sawmills visited. Also, volume of generated wood waste can be drastically reduced with better lumber recovery.

The sustainable forest management and profitable production of the sawmills is essential; In order to increase the lumber recovery efficiency of sawmills and reduce volume of wood wastes in the log conversion operations. Some of the sawmills visited with obsolete sawing machines should endeavor to replace them with new technologically advanced machines so as to increase lumber recovery ratio. Trees with larger size diameter should be harvested to reduce wastages during conversion. Also, live-sawing method should not be used for all types of logs being converted; this is because converting logs of different forms, sizes and shapes with a single sawing method tends to waste wood. Sorting of logs according to their diameters (girths) range for precise sawing should be done so as to improve Lumber yield and sawing efficiency. Well trained sawyer or sawmill operators should always to carry out log conversion in order to minimize wastage from inappropriate sawing. Effective and efficient timber harvesting methods should be done in the forest at all time so as to reduce wastes. Maintenance culture should be encouraged in sawmills as expected in a well-managed sawmill. Implementations of these approaches will certainly result in high level of performance in sawmilling industry.

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