ECONOMIC ANALYSIS OF SAWMILL WASTE AND ITS IMPLICATION ON SUSTAINABLE FOREST MANAGEMENT IN DELTA STATE.

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ABSTRACT
The high deforestation rate is caused by several factors including the inefficient conversion of logs in sawmill. To maximize the use of wood resource, this study analysed the economic value of wood residues generated in sawmills in Delta State. Forty three percent (43%) sampling intensity was used to obtain information from 32 sawmillers using structured questionnaires. Measuring tape, surrogate and contigent valuation methods were used to obtain log volume before conversion, monetary estimate of wood residues and mean willingness of sawmillers to invest in Forestry respectively. The study revealed that scarcity of log exists and logs were imported from neighboring states to compliment those available in the state. Wood residue of 246.71m^3 was obtained from 549.79m^3 of logs. The monetary value of ₦10,466,425 was estimated for 246.71$m^3$of wood residues. Given the increased revenue from the potential sale of the residues, the respondents were willing to invest ₦193,750 for establishing tree plantation on 0.345 hectares of land. The long gestation period of trees was a major problem to investment. It is recommended that market for wood residues be established to allow for attainment of maximum revenue from logs and policy that encourage the involvement of sawmillers in plantation establishment be intensified.

Keywords: Economic analysis, sawmills, wood residues, optimum utilization

INTRODUCTION
The creation of wealth from waste is of tremendous benefits to forest investors and the environment and it is also needed for sustainable development (SD). This is important considering the high rate of depletion of natural resources with a corresponding carbon footprint. In an attempt to fulfilling the 12th SD goal, it is imperative to ensuring efficient utilization of the wood resources by maximizing recycling and reuse of wood residues in line with indicator 12.5 SDG. Economic study is a logical way to determining the best possible use of scarce resource in-order to maximize the use of timber resources and profit of investors. The utilization of residues generated from wood processing is of key importance to ensuring maximum resource utilization. Waste generation is a concomitant aspect of wood processing (Odewunmi, 2001). Wood processing industries such as sawmill produces different residues like sawdusts, wood off cuts, wood barks, plain shavings and wood cast-off (Dosunmu and Ajayi, 2002; Akinbode and Olujimi, 2014). These residues accounts for about one third of the log involved, and its utilization varies according to the level of technology available (Larinde and Aiyeloja, 2014).

Despite the fact that sawmilling activities sustain livelihood, sawn-wood production activities depends solely on the natural forest for log, a raw material for its production. Most of these log obtained from the forest are small diameter logs which are not suitable for conversion with the available machines. The unsuitability of these machines for the conversion of small diameter log has led to the production of large volume of wood residues leadings to wasteful utilization of timber resources. The unavailability of large diameter logs in the forest is due majorly to unsustainable harvesting and processing over the years without a corresponding afforestation effort. In order to attain efficiency in resource utilization and maintain a stable forest base, it is imperative for sawmills to judiciously utilize the wood residue generated by maximizing reuse and recycling potential of the residues. This can be achieved by integration of sawmills with other wood users such as the furniture industry who utilizes these waste to create various products (Larinde and Aiyeloja, 2014). Efficiency in the utilization of production input determines the output level and subsequently, the level of income. The lower the wood residues in sawmills, the lesser the pressure on the forest to supply logs, greater sawn-wood output and income. Income is further increased when there is added value for any waste produced.

Wood residues in sawmill are extremely burnable especially when dry. The most inflammable wood fuel is charcoal, followed by other dry soft material (e.g sawdust pellets, planer shavings etc). Wood, the major resource of sawmill residues is made up of three basic composite polymers: Cellulose ($C_6H_{10}O_{5)}$, Lignin ($C_8H_{10}O_3$ (OCH^3) 0.9-1.7) and the Hemicelluloses such as xylan ($C_5H_8O_4$). These components of wood make it possible for it to be utilized for manufacturing of various items. Wood

residues are used as compost, mulch and soil conditioners in Nigeria and sub-sahara Africa. Sawmill residues such as sawdust and wood shavings can be used to manufacture chip boards or wood particle board, converted into briquette, and used as domestic source of energy. It can be utilized in various ways such as the production of charcoal (Aina, 2006), production of bio-fuel and pryogas which are use to power turbine for electricity production and are substitute for diesel (Lekan *et al.* 2013), as soveniers such as notepad, key holder, napkin holder, candle holder, bowls, jewelery boxes, (Larinde and Aiyeloja, 2009). Though there is limited utilization of these residues in Nigeria (Atuhe 2005), the availability of technique for the development of the above listed material from wood residues will ensure efficient utilization of timber resources.

The supply of timber to wood base industry is important to ensure that the social aspect of forestry (income and employment generation) is achieved (Akitan *et al.* 2015). Nigeria is presently experiencing shortage in log supply to wood base industry (Babatola *et al*. 2011) as a result of population increase, demand for wood (housing, chairs, furnitures) and income generation (Ohwo *et al*. 2014). The continuous increase in the ordering of wood base product and felling of log has led to rapid depletion of the forest estate thereby affecting the accessibility to large diameter logs by sawmillers. This has constituted a delay to sustainable management and sustainability of forest industries (Bhadmus *et al.* 2013).

The issue of limited supply of timber has moved the campaign for efficient conversion and use of resources to minimize the depletion of timber resources by resource planners and policy makers. With increase in recent economic drives in Nigeria, policies have been developed by government to ensure that there is a boost in economic activities. In the policy statement, more emphases are placed on efficiency and productivity (Ogundare, 2010). To attain elongated sustainable development with increasing productivity and returns for sawmillers, timber resource needs to be efficiently use by adding monetary value to the residues generated (Ajibefun, 2007). With respect to sawmilling, achieving efficiency in resource utilization at the level of individual mill will have significant effect on employment and investment nationwide. The ripple effect is the facilitation of progress technologically with huge shifts in timber supply and larger impact on national income. Therefore, it is essential to evaluate the value of volume of the wood residues generated from sawmill for use as substitute raw material for innovative production. Studies (Sanwo *et al*. 2007, Lekan *et al.* 2013, Akande *et al.* 2007 and Larinde 2006) have been conducted on the monetary value obtained from products (bio-oil, particle board, books etc) developed from sawmill residues in Port-Harcourt, Oyo, Calabar, Lagos, Minna, Ogun, but none included data from Delta State. Also, none of these studies actually valued the wood residues as it remains unknown, and the basic raw material for the production of these products. This study therefore examined the value of wood residues and determined the level of willingness of sawmillers to invest in Forestry given the value of these waste.

MATERIALS AND METHODS

The research work was conducted in some selected sawmills in Delta State, Nigeria. The states location is longitude 5°00' and 6°45' E and latitude 5°00' and 6°30' N. The land area and population of Delta State is 16,842km^2 and 4,098,291 respectively (Delta State University Meteorological Station, Asaba 2008). Thirty two (32) sawmills were randomly selected from the seventy five (75) sawmills in the state with a forty three percent (43%) sampling intensity. Measuring tape was used to obtain the length and diameter of the log in the mill while information on the level of access to raw material, prices of sawn-wood as well as willingness of sawmillers to invest in plantation establishment was obtained with structured questionnaire. The volume of log before conversion, volume of sawn-wood processed and wood residues generated were collected using the procedures of Ohwo *et al*. (2018). The monetary value of wood residues was obtained using surrogate valuation method (surrogate market). Surrogate market is use in the absence of a market for the goods under study by obtaining information from related market goods to determine the used value of non-marketed goods. If X volume of wood is sold for ₦X, an equivalent volume of residues will also be sold at the same price all things being equal using this method. Contingent valuation method was used to estimate the mean willingness of respondents to invest in forest plantation establishment (equation 1, 2, 3).

$$\ddot{x} = \frac{\Sigma VWI}{TNR} \ldots\ldots\ldots\ldots\ldots \text{ equation (1)}$$

Where,
ẍ = mean willingness to invest; VWI= total value willing to invest; TNR= total number of respondents

$$ALE = \sum TAR \div TNR \ldots\ldots \text{Equation (2)}$$
Where,
ALE = Area of land to establish; TAR = Total area of land;

$$WTI = \ddot{X} \times TNR \ldots\ldots\ldots\ldots \text{Equation (3)}$$
Where
WTI = Willingness to invest

The respondents were willing to invest ₦X on X hectare of land given the increased revenue from the potential sale of wood residues.

RESULTS AND DISCUSSION

The study revealed that sawmill is dominated by male (81.4%) in their youthful stage of life (71.9%) (Table1). This is as a result of the tedious nature of the business. In terms of educational qualification, majority (46·9%) of the respondent had primary education while respondent that are graduate had the least percentage of 9·3%, with majority (43·8%) having family size between 6-10 persons. This finding corroborates that of Sekumande and Oluwatayo, (2011) that in Nigeria most of the capital intensive and hard works are mainly dominated by male and the involvement of saw millers of youthful age makes the day job moves faster. Ohwo and Ogoha (2017) reported that sawn-wood marketers have family size of similar range.

Access to Raw Materials and Machine used for Conversion

The sources of raw materials and the type of machines used for sawing logs are presented in Table 1. The results showed that majority (62·5%) of the respondent obtain their logs from natural forest within the state (28.1%) and outside (71.9%); while 12.5% of the respondent obtain their logs from plantations. The high rate of dependence on adjoining states for logs is an indication of the depletion of the rain forest estate existing in Delta State. This corroborates the finding of Environmental Resources Management (2001), Arowosoge *et al.*, (2008) and Sekumande and Oluwatayo (2011), that forests in some states are unable to supply logs needed to sustain the wood based industries therefore these industries imports logs from adjoining states and country leading to additional cost of transportation which is often reflected in lumber prices. Furthermore, the entire respondent in the sampled sawmills use band saws for converting logs into board (primary conversion of logs).

Volume of Wood Residues Generated

The results for the volume of wood residues generated in sawmills is presented in Table 2. It revealed that the volume generated in the selected sawmills in the state ranged from 3.09m^3 (sawmill 17) to 16·11m^3 (sawmill 30). Several factors (poor doctoring, size of saw kerf (medium), inefficiency of the machines to convert small sized logs, low technical knowhow of the operator, size and shape of the bole of the tree) were responsible for the generation of 246.71m^3 residues from 549.79m^3 of logs processed in the mills. The implication is that the output was low, income affected and increased pressure on the forest estate to supply logs is inevitable further increasing the rate of deforestation. These findings agree with the observation of Ogunsanwo *et al.* (2007) and Kukogho *et al.* (2011), who stated that wood species, technology, heading process and machine used by the operator have direct impact on the conversion efficiency obtained during log processing; and that small log diameter, kerf width of the saw machine are reasons why sawmills have more wastes respectively.

Monetary Estimate of Wood Residues

The estimated monetary value of wood residues from sawmill in Delta State is presented in Table 3. Using surrogate valuation technique, a m^3 of sawnwood sells for ₦42,424 in 2019, an equivalent volume of wood residue also command the same value all things being equal (Boyle, 2003). A total value of ₦10,466,425 will be generated from 246.71m^3 wood residues. In other words, the return of sawmillers in the state is decreased by ₦10,466,425 as a result of wood residues generation and lack of established wood residues market. This corroborates the finding of Egbewole *et al.*, (2011) who stated amongst other factors that the lack of bankable studies on economic returns from wood residues processing affects its purchase and utilization.

Table 1: Demographic Characteristics, Raw Material Sources and Conversion Machine

Variables	Frequency	Percentage (%)
Age		
0-8	-	-
19-30	12	37.5
31-40	11	34.4
41 and above	9	28.1
Total	**32**	**100**
Gender		
Female	5	15.6
Male	27	81.4
Total	**32**	**100**
Religion		
Christianity	32	100
Islam	-	-
Total	**32**	**100**
Marital Status		
Single	11	34.4
Married	18	56.3
Widowed	3	9.3
Divorced	-	-
Total	**32**	**100**
Family Size		
2-5	10	31.2
6-10	14	43.8
10 an above	8	25.0
Total	**32**	**100**
Education		
No Formal Education	7	21.9
Primary	15	46.9
Secondary	7	21.9
Tertiary	3	9.3
Total	**32**	**100**
Source of logs		
Plantation	4	12.5
Natural forest	20	62.5
Plantation/Natural forest	8	25.0
Total	**32**	**100**
Area of Collection		
Within Delta State	9	28.1
Outside Delta State	23	71.9
Total	**32**	**100**
Machine for conversion		
Band Saw	32	100
Circular Saw	-	-
Total	**32**	**100**

Source: Field survey (2019)

Table 2: Volume of Waste Generated in the Sawmill

S/N	Volume of Log (m^3)	Volume of Lumber (m^3)	Volume of Waste (m^3)
1	9.75	5.70	4.31
2	18.36	12.57	6.79
3	11.92	6.57	5.35
4	11.85	7.03	4.82
5	18.58	10.35	8.23
6	13.46	8.12	5.34
7	22.39	10.54	11.85
8	12.43	6.95	5.48
9	14.68	8.41	6.21
10	12.01	8.61	3.40
11	15.37	11.24	4.13
12	14.68	9.53	5.15
13	17.12	10.47	6.65
14	13.16	8.03	5.13
15	11.45	6.50	4.95
16	24.43	16.15	8.28
17	21.16	18.07	3.09
18	8.44	5.09	3.35
19	16.83	6.43	10.4
20	23.34	10.13	13.21
21	10.16	6.92	3.24
22	16.52	7.31	9.21
23	15.41	9.06	6.35
24	20.15	12.12	8.03
25	34.62	19.87	14.76
26	17.44	6.25	11.19
27	32.48	17.87	14.61
28	26.96	15.75	11.21
29	29.33	16.44	12.89
30	35.23	19.12	16.11
31	19.52	12.13	7.39
32	22.62	17.02	5.60
Total	549.79	303.08	246.71

Source: Field survey (2019)

Table 3: Value of Wood Residues in Monetary Terms

Sawmill	Volume of residues (m^3)	Monetary value (₦)
1	4.31	182,847.44
2	6.31	267,695.44
3	5.35	226,968.40
4	4.82	204,483.68
5	8.23	349,149.52
6	5.34	226,544.16
7	11.85	502,724.40
8	5.48	232,483.52
9	6.21	263,453.04
10	3.40	144,241.6
11	4.13	175,211.12
12	5.15	218,483.60
13	6.65	282,119.60
14	5.13	217,635.12
15	4.95	209,998.80
16	8.28	351,270.72
17	3.09	131,090.16
18	3.35	142,120.40
19	10.4	441,209.60
20	13.21	560,421.04
21	3.24	137,453.76
22	9.21	390,725.04
23	6.35	269,392.40
24	8.03	340,664.72
25	14.76	626,178.24
26	11.19	474,724.56
27	14.61	619,814.64
28	11.21	475,573.04
29	12.89	546,845.36
30	16.11	683,450.64
31	7.39	313,513.36
32	5.60	237,574.40
Total	**246.71**	**10,466,425**

Source: Field survey (2019)

Willingness of Sawmillers to Invest in Forest Plantation

The result for willingness of sawmillers to invest in forest tree establishment is presented in Table 4. It showed that the majority (56.2%) of the respondent were willing to invest their returns in plantation establishment. However, majority (81.3%) of the respondents do not have vacant land and are not willing (75.0%) to purchase land for establishment of trees. Only 25.0% of the respondents were willing to purchase a piece of land for forest tree establishment. Out of the 25.0% respondents willing to purchase land, 15.6% were willing to purchase 1-2 acre of land, 6.3% were willing to purchase 1-2 hectares of land while the respondent with the least percentage (3.1%) were willing to purchase 3 hectares and above. The result further revealed that respondents (18.8%, 15.6%, and 9.4%) were willing to invest ₦200,000, ₦400,000 and above ₦1,000,000 naira respectively in forests tree establishment. The mean willingness to invest in forest tree establishment revealed that sawmillers were willing to invest ₦193,750 on 0.345 hectares of land. The low level of willingness of respondents to invest in tree establishment is similar to the report of Agrawal, Cashore, Hardin, Shepherd, Benson, and Miller (2013) who stated that the benefits generated from forestry business is often diverted to other sector. Willingness to invest was stimulated by the potential increased revenue from sale of wood residues. This will not only lead to increased profit of the sawmillers but also will ensure sustainability of the

sawmill industry as there will be continuous access to raw materials.

Various factors were discovered to hamper the respondent willingness to invest. These factors include: long gestation period of forest trees, high rate of deforestation and lack of Government interest and investment in Forestry sector. This corresponds with the findings of Woodlall, (1992) who reported that in countries like Nigeria, weak political-will permit continuous deforestation because of its social and economic safety value, with funds generated often diverted to other sector leaving the Forestry sector behind. It also agreed with the findings of Adedayo, (2003) who reported that many efforts of Environmental Resource Management in Nigeria has failed because Government pays inadequate attention to the various stakeholders involve in Forestry.

Mean Willingness to Invest

$$\ddot{x} = \frac{\Sigma VWI}{TNR}.$$

Where,
ẍ = mean willingness to invest
VWI is total value willing to invest = ₦6,200,000
TNR is total number of respondent = 32
Therefore,
Ẍ = 6,200,000 ÷ 32 = ₦193,750

$$ALE = \sum TAR \div TNR$$

Where,
ALE = Area of land to establish
TAR = Total number of area =11 hectares
TNR = Total number of respondent = 32
Therefore, ALE =11 ÷ 32 = 0.345 hectare

Table 4: Willingness to Invest in Forest Tree Establishment

Variables	Frequency	Percentage (%)
WTI in forest tree establishment	14	43.8
Not WTI in forest tree establishment	18	56.2
Total	**32**	**100**
Availability of land		
Vacant land	6	18.75
No vacant land	26	81.25
Total	**32**	**100**
Purchase of land		
Willing to purchase land	8	25
Not willing to purchase land	24	75
Total	**32**	**100**
Area of land		
1-2 acres	5	15.6
1-2 hectares	2	6.3
3 hectares & above	1	3.1
None	24	75.0
Total	**32**	**100**
Capital investment (₦)		
200,000	6	18.8
400,000	5	15.6
1,000,000 & above	3	9.4
None	18	56.2
Total	**32**	**100**

Source: Field Survey, (2019)

CONCLUSION AND RECOMMENDATION

Economic valuation of sawmill wood residues in Delta State showed that millions of naira can be generated from residues if there exist an established market for its sale. This only will not enhance the recycling and innovative industrial development, reduction in carbon footprint but also the income of sawmillers. However, majority of saw millers were unwilling to invest the net return in plantation establishment majorly because of the long gestation period of trees and changing political climate. The implication on sustainable forest management is that the forest estate will continually be under pressure to supply the logs needed for the saw mills with less afforestation measures. This will further encourage deforestation and depletion of the forest estate.

It is recommended that modern machine that can convert small diameter logs be employed in order to minimize wood residue generated in the mills; market for wood residues should be established in lieu of value addition to wood; wood residue industrial clusters should be provided with adequate technology to enhance the utilization of wood residues; trees trust fund be taxed on the saw millers to ensure that resources are available to sustain the

forest through various afforestation and regeneration activities and policy that encourage the involvement of sawmillers in plantation establishment should be developed.

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