

## Evaluation of technical efficiency of sawmills in Udu Local Government Area of Delta State, Nigeria

<sup>1</sup>Ohwo, O. A. \*, <sup>2</sup>Adeyemi, A. A. and <sup>1</sup>Ighofose, E.

<sup>1</sup>Department of Forestry and Wildlife, Delta State University Abraka, Delta State, Nigeria

<sup>2</sup>Department of Forest Resources Management, University of Ilorin, Ilorin, Nigeria

\*Corresponding author (E-mail: oghenekevweabigail@gmail.com)

### ABSTRACT

This study was designed to evaluate the technical efficiency of sawmills in Udu Local Government Area of Delta State. Purposive sampling technique was adopted to obtain information from the thirty (30) sawmills in the study area. Questionnaire and on-the-spot assessment were used to obtain necessary data from the respondents. Data on demographic characteristics were analysed using descriptive statistics such as frequency and percentage. Three hundred (300) logs were measured and the volumes of each species sawn were obtained using Newton's formula. About 21% of the respondents obtained their logs from natural forest within and outside the state, and 73% of them trained their sawyers. All the respondents utilize band saw for sawing logs with 40% having circular saw in addition, for secondary processing. Majority (70%) of the respondents maintained their machines by greasing. Varieties of species including *Gossweilerodendron balsamiferum* (Agba); *Pycanthus angloleusis* (Akomu); *Hallea ciliata* (Abura); *Nesogandonia papaverifera* (Danta); *Poga oleosa* (Oleku) and *Alstonia boonei* (alstonia) were sawn in the various mills with *Poga oleosa* being the most sawn (38.68 m<sup>3</sup>) and *Nesogandonia papaverifera* the least sawn (0.82 m<sup>3</sup>). The result revealed that *Alstonia boonei* has the highest technical efficiency (53%) with *Nesogordonia papaverifera* having the least (32%). The sawmill level of technical efficiency was low (46.5%), indicating that the mill generated a lot of wood wastes. Continuous training of sawyers and replacement of obsolete machines with modern ones to improve efficiency and encouraging industrial outlets to utilize the wood wastes to minimize negative impacts on forests and environment were recommended.

**Keywords:** Technical efficiency, waste reduction, lesser-known species, lumber recovery

### INTRODUCTION

Timber is a very important raw material useful in various works of life (Oguntade *et al.*, 2012). Douglas (1995), noted that prior to the 19<sup>th</sup> Century and till date, timber was, and is the most important material used for construction and energy generation. Over the years, there has been significant harvesting of timber from the forest estate

for sawmilling activities using a variety of machines such as band saw that breaks down logs into desired specification; re-sawing machines for processing the cants and flitches into specified and marketable dimensions (Aina, 2006). A sawmill is said to be efficient when it has high lumber recovery ratio (Badejo 1990).

Inefficiency in the sawmill conversion process and the enormous waste generation is one of the major factors contributing to rapid forest depletion and significant reduction in industrial round wood available in Nigerian forest reserves (Ogunwusi, 2014). The waste generated in the sawmill industry was over 1,000,000m<sup>3</sup> in form of barks, sawdust, trimming, split-wood, planer shavings and sander dust in year 2010 (Ogunwusi, 2014), leading to further degradation of the forest estate with its negative effect on forestry development. Sawmill industry in Nigeria is characterized by small-scale operators, who sourced timber from natural forests and few forest reserves, where the terrain is rough (Adeyoju, 2001). Considerable volume of waste is generated during logging and harvesting operations. Also less than 40% of wood taken out of the forests are actually used at industrial level while the rest waste away.

Lumber recovery in sawmill has been reported to be low by various authors (Olufemi *et al.*, 2012; Ogunwusi, 2014); this makes the current pattern of industrial wood utilization unsustainable, and a source of threat to the forest reserves for continually supplying raw materials to wood industry. There is little or no information on the conversion efficiency of sawmills in Delta State. Most processing industries require the use of good processing plants to maximize output. In sawmills various machines are employed in the production process. Studies by Aina, *et al.* (2006) and Olufemi, *et al.* (2012) have shown that the use of appropriate converting machines maximize the output of any manufacturing industry. However the types of machines employed during processing and the conversion methods employed will determine the volume of waste generated (Wade *et al.*, 1992). Furthermore, the maintenance

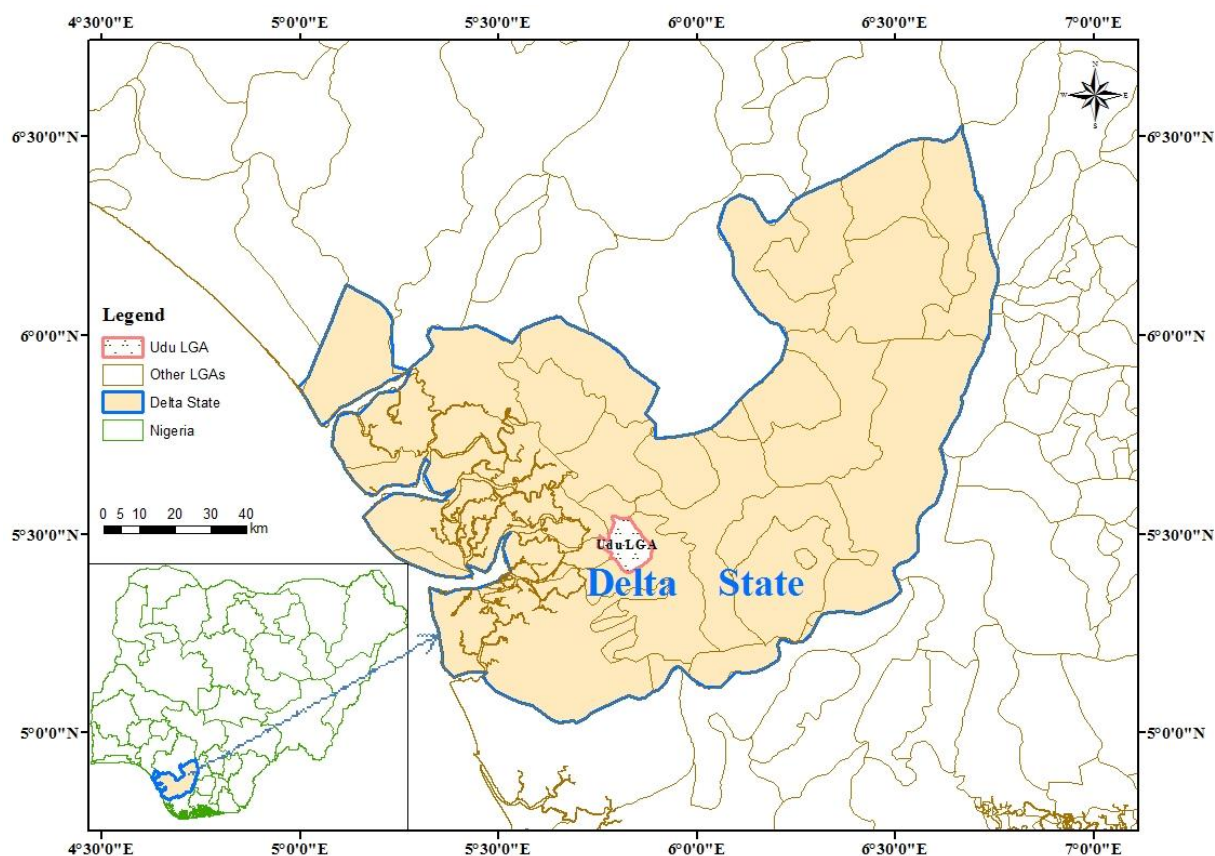
method employed in managing processing plants ensures that the plants operate at maximum rate (Kukogho *et al.*, 2011; Ogunwusi, 2014). There is no information on the type of conversion method, processing plant, machine maintenance strategies as well as the percentage of waste generated from sawmills in the state. Therefore, this study provides information on the types of machines, conversion method adopted and maintenance strategies employed in the study area.

## METHODOLOGY

The study was carried out in Udu Local Government Area (LGA) of Delta State. The LGA is located on latitude 5° 45'N and longitude 5°43'E (Fig. 1). It has a tropical weather and rainforest with evergreen vegetation all year round. Its geographical feature consists of numerous streams that inter-connect into an intricate web of rivers, lagoons, swamps and wetlands. The rainforest is a major source of timber supply to sawmills in the area.

### Sampling Technique and Data Collection

Purposive sampling technique was adopted for the study. The study area was chosen because of the sawmilling activities and the rate of depletion of the rainforest in the LGA. One hundred percent (100%) sampling intensity was used to obtain information from the thirty (30) sawmills in the study area. Girth tape was used to obtain log length, diameter at the large and small ends as well as the middle of the logs to estimate the volumes of logs of different species in the mills while copies of questionnaire were administered to obtain information on the type of conversion methods and access to raw materials. The sawing processes were monitored over a period of twelve weeks.



**Fig. 1:** Map of the study area

### Statistical Analysis

Newton's formula (equation 1) was used to obtain the volume of logs in the mills before conversion. Lumber recovery was used to obtain total volume of the various dimensions of lumbers obtained from logs (equation 2). The total volume of wood wastes obtained from each species from the conversion of logs was estimated using equation (3). The percentage waste was

calculated using equation (4). The efficiency of each of the sampled sawmills was calculated using equation (5). Conversion Ratio (CR) for each species sawn was calculated using equation (6). The types of machine used for conversion and the conversion methods adopted by sampled sawmills were obtained from interviews and field observations. The data were analyzed using descriptive statistics.

### Newton's formula

$$V_1 = \frac{L \times \pi (Db^2 + 4Dm^2 + Ds^2)}{24} \dots \dots \dots \text{equation (1)}$$

Where,

Db = diameter at the large end of log; Dm = diameter at midpoint of log; Ds = diameter at small end of log; L = log length (m).

### Lumber Recovery

$$V_2 = (L \times B \times H)_n \dots \dots \dots \text{equation (2)}$$

Where:

$V_2$ = Volume of lumber; L = length (m); B = breath (m); H = Thickness (m); n = Total number of lumbers obtained from log.

#### Volume of wood waste

$$VW = V_1 - V_2 \dots \dots \dots \text{equation (3)}$$

Where:

VW= Volume of wood waste (m);  $V_1$  = volume of round logs before conversion (m);  $V_2$ = volume of lumbers obtained after conversion (m).

#### Percentage Waste

$$\% \text{ of waste} = \frac{VW}{V_1} \times \frac{100}{1} \dots \dots \dots \text{equation (4)}$$

#### Sawmill Efficiency

$$\Sigma Mill = \frac{V_2}{V_1} \times \frac{100}{1} \dots \dots \dots \text{equation (5)}$$

Where,

$\Sigma Mill$  = sawmill efficiency (%).

#### Conversion Ratio (CR)

$$CR = \frac{XV_2}{XV_1} \dots \dots \dots \text{equation (6)}$$

Where:

$XV_2$  = mean of total volume of lumber obtained after conversion ( $m^3$ );  $XV_1$  = mean of total volume of round logs before conversion ( $m^3$ ).

## RESULTS

### Demographic Characteristics of Respondents

The demographic characteristics of respondents are presented in Table 1. The result shows that the business is dominated by male (90%), who are married (50%) and have tertiary education (50%).

### Lumber Recovery Efficiency

The sources of logs, characteristics of employees, and types of conversion machines as well as maintenance strategies are presented in Tables 2. The result shows that majority (21%) of the respondents obtained their logs from natural forests

(Table 2) with 15% of the logs obtained from outside the state. The number of employees ranged between 5 and 10 persons (56.7%), with 73.3% having trained sawyers and 83.3% of the sawyers having 1-10 years of experience. Furthermore, all the respondents used horizontal band saws and adopted the ‘through and through’ method of sawing. Forty percent (40%) of the respondents have circular saw in addition to the band saws for further logs processing. Respondents having machines with medium saw kerf constituted 43.3%. Majority (70%) of the respondents maintains their machines by greasing.

**Table 1:** Demographic characteristic of respondents

<b>Variables</b>	<b>Frequency</b>	<b>Percentage</b>
<b>Gender</b>		
Male	27	90
Female	3	10
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Marital Status</b>		
Single	9	30
Married	15	50
Widow	4	13.3
Divorced	2	6.7
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Education</b>		
No formal education	4	13.3
Primary	4	13.3
Secondary	7	23.3
Tertiary	15	50
<b>Total</b>	<b>30</b>	<b>100</b>

Source: Field survey (2017)

**Table 2:** Sources of logs, characteristics of employees, types of conversion machines and maintenance strategies

<b>Variables</b>	<b>Frequency</b>	<b>Percentages</b>
<b>Source of logs</b>		
Natural forests	21	70
Plantations	5	16.7
Both	4	13.3
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Location</b>		
Delta State	6	20
Outside Delta State	9	30
Both	16	50
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Number of employees</b>		
5-10	17	56.7
11-15	13	43.3
16-20	0	0
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Trained sawyers</b>		
Yes	22	73.3
No	8	26.7
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Sawyers years of experience</b>		
1-10	25	83.3

11-20	5	16.7
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Conversion machines</b>		
Band saw	18	60
Circular saw	12	40
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Size of the saw kerf</b>		
Small	12	40
Medium	13	43.3
Large	5	16.7
<b>Total</b>	<b>30</b>	<b>100</b>
<b>Machine maintenance strategy</b>		
Greasing	21	70
Sharpen	9	30
<b>Total</b>	<b>30</b>	<b>100</b>

Source: Field survey (2017)

The list of wood species as well as volume of sawnwood processed in the mill is presented in table 3. Three hundred (300) logs from seven of the most sawn-wood species were measured. Danta (*Nesogordonia papaverifera*), a choice species is rarely available in the mill (2 logs) while Oleku (*Poga oleosa*), a lesser-known species that has the characteristics of hard wood in terms of strength, durability and aesthetic, dominated the market with 152 logs. Oleku (*Poga oleosa*) was the most sawn species with log volume of 38.68 m<sup>3</sup>

and 19.24 m<sup>3</sup> of sawn-wood while Danta (*Nesogordonia papaverifera*) was the least sawn with 0.82 m<sup>3</sup> of log and 0.26 m<sup>3</sup> volume of sawn-wood. The total volume of the 300 measured logs and sawn-wood obtained from the sampled mill was 111.14 m<sup>3</sup> and 55.07m<sup>3</sup>, respectively (Table 3). This represents a lumber recovery of 49.6% for the mills studied. The mean volume of individual log, sawn-wood and wood wastes were 3.30 m<sup>3</sup>, 1.552 m<sup>3</sup> and 1.76 m<sup>3</sup>, respectively.

**Table 3:** Volume of logs and sawn-wood (m<sup>3</sup>)

Trade name	Botanical name	N	V log	V sawn-wood	V waste	Xv log	Xv sawn-wood	Xv waste
Oleku	<i>Poga oleosa</i>	152	38.68	19.24	19.44	0.25	0.13	0.13
Alstonia	<i>Alstonia boonei</i>	59	30.35	16.09	14.25	0.51	0.27	0.24
Abura	<i>Hallea ciliata</i>	19	8.12	3.72	4.40	0.43	0.20	0.23
Uwero	N/A	33	17.38	7.91	9.47	0.53	0.24	0.29
Agba	<i>Gosswellerodendron balsamiferum</i>	13	7.50	3.56	3.94	0.58	0.27	0.30
Akomu	<i>Pycanthus angolensis</i>	14	8.29	4.29	4.00	0.59	0.31	0.29
Danta	<i>Nesogordonia papaverifera</i>	2	0.82	0.26	0.56	0.41	0.13	0.28
<b>Total</b>		<b>300</b>	<b>111.14</b>	<b>55.07</b>	<b>56.06</b>	<b>3.30</b>	<b>1.55</b>	<b>1.76</b>

Source: Field survey (2017)

The result of the technical efficiencies and conversion ratio of the sampled species is presented in Table 4. *Alstonia boonei* had the highest technical efficiency (TE) and conversion ratio (CR) of 53.0 and

0.5% while Danta (*Nesogordonia papaverifera*) had the least TE and CR of 31.9 and 0.3%, respectively. The mills had a mean technical efficiency of 46.5%.

**Table 4:** Sawmill technical efficiency

Trade name	Botanical name	Technical efficiency	Conversion ratio	% of waste
Oleku	<i>Poga oleosa</i>	49.8	0.4975	50.3
Alstonia	<i>Alstonia boonei</i>	53.0	0.5303	47.0
Abura	<i>Hallea ciliate</i>	45.8	0.4582	54.2
Uwero	N/A	45.5	0.4549	54.5
Agba	<i>Gosswellerodendron balsamiferum</i>	47.5	0.4747	52.5
Akomu	<i>Pycanthus angolensis</i>	51.8	0.5175	48.3
Danta	<i>Nesogordonia papaverifera</i>	31.9	0.3191	68.1
<b>Total</b>		<b>325.2</b>	<b>3.2522</b>	<b>374.8</b>
<b>Mean</b>		<b>46.46</b>	<b>0.4646</b>	<b>53.5</b>

## DISCUSSION

The dominance of the business by male in the demographic characteristics of respondents corresponds to the findings of Oguntade, *et al.* (2012), Aiyeloja, *et al.* (2013) and Ohwo (2016), who stated that the great involvements of males in the business is as a result of the laborious nature of

moving logs to the machine for sawing and carrying sawn timber to stake after sawing. The high involvement of married and tertiary school graduates gives an indication of the income-generating and job-creation benefits of the sawmill industry. This corroborates the finding of Ogunwusi (2014), who noted that forest industry

provides jobs and income to all stakeholders.

The high dependence on natural forests for logs accounts for the high rate of deforestation observed in the gazetted forest reserves and free areas in the state. The inability of the state's forest to meet the demand for log led to sourcing of logs from outside the state. This is mainly true because of non-involvement of saw-millers in plantation establishments. The level of exposure to training of the employees is important to ensure efficiency in their production activities. This corresponds to the recommendation of Agbonlahor (2010) that staff training and re-organization will lead to increase in firm's level of technical efficiencies and the finding of Olufemi, *et al.* (2012) that the large involvement of trained sawyers in the mills have positive correlation with lumber recovery and technical efficiency. Furthermore, replacement of obsolete machines with modern ones to drastically reduce wastage and increase conversion efficiency of the mills is also very important.

The addition of circular saw in addition to the band saws for further logs processing is in line with the finding of Ogunwusi (2014), who reported that most mills utilize circular saw in addition to the band sawing machines, which further helps to reduce the volume of waste generated as it is used to cross cut chunks of wood that would have been wasted into smaller useful dimensions.

The limited availability of choice species and abundance of lesser known wood species in the mills corroborates the finding of Antwi-boasiako and Boadu (2016), who stated that many lesser-known wood species available in abundant quantity in tropical forests, and can be used in place of choice timber species. The total volume of logs and

sawn-wood obtained from the sampled mill as well as the lumber recovery (49.6%) was a bit higher than that reported by Olufemi, *et al.* (2012), who reported 123.09 m<sup>3</sup> and 56.08 m<sup>3</sup> for logs and sawn-wood, respectively with about 45.6% lumber recovery.

The mean technical efficiency (46.5%) obtained by the mills shows that the efficiency of the sawmill was low and agrees with the finding of Ofoegbu *et al.* (2014), who recorded a recovery efficiency of 46.9% from ten sampled timber species in Cross River State and negates the finding of Olufemi, *et al.* (2012); Egbewole, *et al.* (2011), and Gyimah and Adu (2009), who independently reported higher recovery efficiencies of 53.7%, 56.18 % and 54.5% for sawmills in south western states of Nigeria, Akure and Malaysia, respectively. This may be as a result of the saw kerf used (medium sized kerf), log form and size. Zerbe, *et al.* (2000) stated that wood waste generation increased with increased size of saw kerf. The implication of the lower recovery in the mills is that there will be great demand for logs and deforestation is inevitable because of the high wood wastes generated in the conversion processes. In order to minimize the rate of deforestation in Nigerian forests, Kehinde and Awoyemi, (2009) recommended that timber should be efficiently utilized in sawmills.

The sawmill industry in the state utilizes lesser-known wood species as a result of limited supply of choice species. The utilization of lesser-known species gave an indication of possible scarcity or perhaps, extinction of choice species in the forest. The sawmill level of lumber recovery was low even with the high involvement of trained sawyers in the industry. It is therefore recommended that the obsolete machines be replaced with modern ones; adequate utilization of tariff and licence fee



paid by sawmillers for reforestation project funding in free forest areas to ensure that choice species are raised to prevent their extinction. Given intensive education to saw-millers on the need to establish forest plantation and sustainable utilization of forest resources in order to ensure sustainability of the sawmill industry, and for development of a sustainable forest industry in Nigeria will be efforts in the right direction. Efficient utilization of the associated wood wastes will no doubt help reduce the negative impacts on forests and the environment.

## REFERENCES

- Adeyaju, S.K. 2001. Forestry for National development: A critique of the Nigeria situation. *In: L. Popoola, T.Z. Abu and P.I. Oni, (Eds.), Proceedings of the 27<sup>th</sup> Annual Conferences of the Forestry Association of Nigeria, held on the 17<sup>th</sup> -21<sup>st</sup> September in FCT Abuja, Nigeria. Pp. 34-42.*
- Agbonlahor, M.U. 2010. Productivity dispersion and sources of technical inefficiency in smallholder timber mills in Ogun State, Nigeria. *Journal of Humanities, Social Sciences and Creative Arts* 5(1):49-60.
- Aina, O.M. 2006. Wood waste utilization for energy generation. *In: Stephen Gardner, (Ed.) Proceedings of the International Conference on Renewable Energy for Developing Countries, Thorpe, Cornelia Vutz held in Berlin, 21 October 2006.*
- Aiyelaja, A.A. Oladele, A.T. and Furo, S.B. 2013. Sustaining livelihood through sawn wood marketing in Port-Harcourt, Nigeria. *International Journal of Science and Nature* 4(1):84-89.
- Antwi-Boasiakom, C. and Boadu, K.B. 2016. The level of utilization of secondary timber species among furniture producers. *South-east European Forestry* 7(1):39-47.
- Badejo, S.O. 1990. Sawmill wood residue in Nigeria and their utilization, Invited paper Proceedings of National workshop on forestry management strategies for self-sufficiency in wood production Ibadan 12<sup>th</sup> -15<sup>th</sup> June, 1990.
- Douglas, W.M. 1995. America's Forest: A history of resiliency and recovery. *Forest products Journal* 45 (10):18-28.
- Egbewole, T., Ogunsanwo, O. and Omole, A. 2011. Technical efficiency of lumber recovery from high forest tree species in selected sawmills of south-western Nigeria. *Nigerian Journal of Agriculture, Food and Environment* 7(1):34-41.
- Gyimah, R. and Adu, G.A. 2009. A pilot study on sawnwood conversion efficiency in selected sawmills in Ghana. A draft report presented at a National workshop in Kumasi. 52pp.
- Kehinde, A.L. and Awoyemi, T.T. 2009. Analysis of economic efficiency in sawnwood production in Southwest Nigeria. *Journal of Human Ecology* 26(3):175-183.
- Kukogho, J.E.V., Aghimien, M.O., Ojo, B.A., Adams, B.O. and Akinbosoye, B.S. 2011. Assessment of wood waste generated in some selected sawmills in Kajola Local Government Area of Oyo State. *Continental Journal of Agricultural Economics* 5(2): 8-11.
- Ofoegbu, C., Ogbonnaya, S. and Babalola, F.D. 2014. Sawmill conversion efficiency and wood recovery of timber species in Cross River State, Nigeria. *Journal of Agriculture and Forestry* 60 (1):105-113.

- Oguntade, A.E., Fatunmbi, T.E., and Folayan, J.A. 2012. Productivity of timber processing on Ondo State, Nigeria, *Journal for Sustainable Agricultural Research* 2(1):1-7.
- Ogunwusi, A.A. 2014. Wood waste generation in the forest industry in Nigeria and prospects for its industrial utilization. *Journal of Civil and Environmental research* 6(9):62-69.
- Ohwo, O.A. 2016. Price differences and causal factors in marketing of selected sawn-wood species in Delta State, Nigeria. *Journal of Agriculture and Food Environment* 3 (1):83-92.
- Olufemi, B., Akindeni, J.O., and Olaniran, S.O. 2012. Lumber recovery efficiency among selected sawmills in Akure. *DRVNA INDUSTRIJA* 63 (1):15-18.
- Wade, W.M., Bullard, H.S., Steele, H.B. and Aramon, A.P. 1992. Estimating hard wood sawmill conversion efficiency based on sawing machine and log characteristics. *Journal of Forest Products* 42(11/12):21-26.
- Zerbe, J.I., Erickson, J.R., Ross, J.R. and Wang, X. 2000. Increasing utilization and the reduction of losses and waste throughout the production chain in lumber and plywood manufacturing plants in selected tropical countries. Final report of ITTO PRE-PROJECT PPD 24/99(1). 98pp.