Investigating the Controlled Wood Harvesting Efficiency of Logging Operation in Akure Forest Reserve

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ABSTRACT

This study attempts to investigate the controlled wood harvesting efficiency in Akure Forest Reserve in Ondo State. Specifically, the study determined the efficiency of the harvesting method being adopted in the study area. A reconnaissance survey and measurement were carried out in the study area, where data on fifty (50) trees felled were randomly selected. Tree growth variables such as the height and diameter at the base, middle, and top of both the standing trees and the extracted logs were obtained using a Spiegel relaskop and measuring tape, as well as the effective working time using a stopwatch. The diameter of the standing trees to be harvested was grouped into classes of <30cm, 30-40cm, 41-50cm, 51-60cm, 61-70cm, and >70cm. The volume, efficiency, and productivity were estimated along the different diameter classes. The collected data were analysed using descriptive statistics. Our results showed that the efficiency of the harvesting method adopted at Akure Forest Reserve was about 52%, with an average volume of 0.68m^3 per log, an average effective working time per log of 0.029 hours, and a productivity of 27.43 m^3/hour. The harvesting efficiency recorded was reasonably high compared to other values obtained from the previous studies for other forest reserves in Nigeria. This result can be attributed to some factors that include the experience of the operator, the equipment condition, and the environmental condition during the operation. The study, therefore, concludes and recommends that efficiency can be improved by investing in human capacity building and institutional strengthening in order to increase output, which will in turn help to meet the demand for wood products from forests.

Keywords: Akure forest reserve, efficiency, logging, wood

INTRODUCTION

Logging is the process of cutting, processing, and moving trees to a location for transport. It may include skidding, on-site processing, and loading of trees or logs onto trucks or skeleton cars (Ogbonnaya, 2002). This involves tree extraction, de-branching, cross-cutting, skidding, loading, and primary transportation. In Nigeria, logging produces a great deal of profit and provides employment opportunities for many Nigerians. The activity associated with logging has reasonable effects on securing the necessities of life. The predominant form of logging in Nigeria, which is the selective system of felling, involves cutting down selected trees in a forest so that the growth of other trees is not affected. Mature trees of the intended economic species are identified and removed. In the reserve, logging is controlled by laws and policies enforced by the State Department of Forestry, and this must be strictly obeyed by both loggers and forest owners. The issuance of permits or licences is controlled by the government in free areas (Adetula, 2008). Currently, the extraction of timber occurs in an indiscriminate way, without following the rule of law or paying appropriate fees and levies. Such an act is referred to as ‘illegal.

In addition, felling operations are major causes of increased deforestation and forest degradation in Nigeria, which affects natural eco-system, biodiversity and climate. Adeyoju (2001) observed that the country's total forest estate, which stood at 20% of total land, has reduced to 7%. Uneke (2008) estimated that annual Nigeria's deforestation rate was about 3,984 sq.km per annum. Therefore, sustainable logging that will foster ecosystem is necessary and desirable to attain an appropriate and socially acceptable level of deforestation. The forms of damage caused are aggravated through insufficient planning, improper operational techniques, lack of operational skill, loggers' level of competence and lack of serviceable modern felling tools (Eroglu *et al*, 2009).

Forest soil, forest trees and seedlings are severely damaged due to inadequate planning, improper operational techniques and lack of control of operations on timber harvesting" (Akay *et.al*, 2007; Eroglu *et.al* , 2009). The motorized or power chainsaw is the only available felling tool in Nigeria, but dragging of felled trees, packing into gantries and loading into Lorries are generally done manually with chains and winches. These processes are unsophisticated and tiresome, and have the ability to disturb the ecosystem (Olajide and Udo, 2005). Thus proper forest harvesting, well-planned logging techniques, review, execution and enforcement of logging policies and adoption of reduced impact logging are essential for achieving sustainable forest management in Nigeria.

This will substantially reduce the impact of logging on the vulnerable environment. Wood harvesting involves felling, extracting on site/landing processing and loading of trees, logs or other parts on to trucks. Harvesting has a lasting effect on forest structure and eco-system functioning. Environmentally sound forest harvesting and transport operations are therefore important element of sustainable forestry. Good practices begin with careful planning, trained and motivated personnel with technically competent supervisors. Six areas are particularly vital from a sustainability standpoint. They are planning, roads, extraction, long-distance transport and post-harvest assessment. Planning is broadly done at three levels, the strategic, tactical and operational levels.

Experience is a major tool in analysing the effectiveness and efficiency of forest harvesting (Silverside and Sundberg, 1987). Understanding how these costs and other costs of harvesting timber affect technical efficiency will enhance the efficiency of individual forest operators (Alao and Kuje, 2010). According to Standbridge (1993), effectiveness is a process by which a piece of work is accomplished, while efficiency is a process by which a task is accomplished appropriately. On the other hand, performance is doing the right task efficiently. Therefore, performance is subject to efficiency, effectiveness, excellence, novelty, and success (Sink and Tuttle, 1989).

Therefore, there is a need for the availability of more sophisticated machines or technology, which can subjugate the effect on the observed logging system in Nigeria. This study is therefore initiated to access the harvesting efficiency of timber within Akure Forest Reserve with a view to determining the factors that could be manipulated for improved timber recovery and thus enhancing efficiency in the Nigerian Forestry Reserve.

Rationale for the study

Forest has been the major source of livelihood of most Nigerians. Timber production has been a significant means of revenue generation to the government, through timber exports. "Of all the Nigerian exports, wood products command the highest range of international currencies" (Adeyoju, 1974). Similarly various wood products are being generated from timber such as furniture, papermaking, construction etc.

Despite the laudable contributions of these trees to several sectors in the country, the challenges posed by the scarcity of timber species in most of her forest estates, including Akure Forest Reserve, have made the demand for timber and wood products greater than its supply. This high wood demand has been for timber and wood products and has been equally corroborated by the exponential rate of population growth.

Several factors have been attributed to the scarcity of timber and wood products, which include population pressure, illegal felling of trees, logging frequency, inefficiency of the operators, etc. Adekunle (2006) noted that one of the most prevalent threatening activities in the reserve is indiscrimination and reckless logging of timber. The unsustainable harvesting methods and practices also contribute to the increasing exploitation of the available timber resources in the reserve. Most valued hardwood species in the reserve are usually harvested before they attain the minimum allowable girth (48cm) for harvest as specified by the policy in Nigeria (Adekunle, 2006).

In spite of the growing harvesting in the reserve, there is still a paucity of information about its harvesting pattern and efficiency, which previous studies failed to uncover. Based on this, this study therefore aims to assess the wood harvesting efficiency and productivity in Akure Forest Reserve with a view to contributing towards sustainable timber harvesting and management in the reserve..

The research outcome of this study will help assess the productivity and efficiency of wood harvesting and its methods in the forest reserve in order to enhance better sustainable management approaches towards the felling of the stands such that more volumes and resultant products could be realized. Also, the economic efficiency of the forest management as well as the harvesting process could be optimized.

The objective of the study

The main objective of the study is to investigate the controlled wood harvesting efficiency of logging operations in Akure Forest Reserve with a view to enhancing the sustainability of the forest reserve. Specifically, the study:

1. classifies the extracted logs into diameter class
2. determines the harvesting efficiency at Akure Forest Reserve
3. assesses the factors affecting efficiency at Akure Forest Reserve
4. determines productivity of the operation in relation to the diameter classes

MATERIALS & METHODS

Study Area

The study area is conducted in Akure Forest Reserve, in Akure South Local Government Area (LGA) of Ondo State, Nigeria. The LGA is geographically located in the rainforest zone of southwestern Nigeria between latitudes 7°16’ and 7°18’ north of the equator and longitudes 5°9[1] and 5°11[1] east of the Greenwich Meridian (Figure 1). It was constituted as a reserve in 1936 and covered 69.93 km2, but 2.463 km2 was selected for the study. The relief pattern is low-lying; elevation ranges from 216 to 504 m above sea level. It has gentle undulating lowland in the southern part, while the northern part has hilly rock outcrops occurring at close intervals. The underlying rock is crystalline gneiss. It is slightly neutral, with a pH of 6.7–7.3, and sandy-loam in nature. The dry season lasts from November to March, while the wet season commences in April and ends in October, with the highest rainfall recorded between July and August (Ogunrayi et al., 2016; Adeoye et al., 2020). The average daily temperature ranges between 21°C and 29°C almost throughout the year (Adejoba et al., 2014). The mean annual rainfall varies from 2,000 m in the southern area to 1,500 m in the northern area, with a relative humidity of 80–85% annually experienced in the Southwest (NiMET, 2016).

It shares a boundary with Osun State in the northeast, being surrounded by five local government areas of

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Ondo State, namely: Ile-Oluji, Oke-Igbo, Ifedore, Akure South, Idanre, and Ondo East (Figure 1). The Aponmu and Owena Yoruba-speaking communities owned the forest. However, it is surrounded by settlements, which include Ipogun, Kajola/Aponmu, Kajola, Ago Petesi, Akika Camp, Owena Town, Ibutitan/Ilaro Camp, Elemo-Igbara-Oke Camp, and Owena Water New Dam.

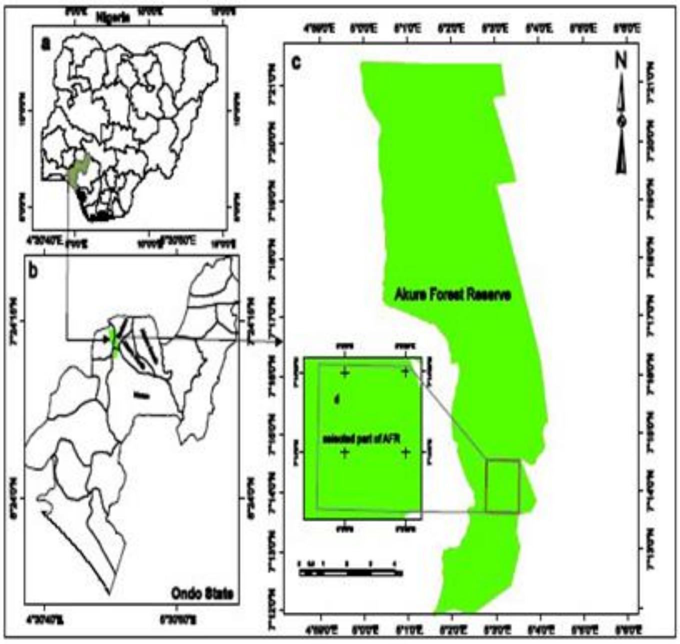

Figure 1: Map of Akure Forest Reserve in Ondo State, Nigeria

Source: Adapted from Adeoye et al. (2020)

Instruments and Data Collection

The materials used were pen, measuring tape, field book, Spiegel relaskop, jungle boot, stopwatch, jungle uniform, Engineering cap, nose mask.

The primary data were obtained through the use of job profile forms and checklist to collect data on wood harvesting in the study location. Data were collected on volume of harvested logs, duration of the operation such as diameter, height, time for preliminary operation before, time for felling and time for cross-cutting. The area where logging activities took place was marked and measured (expressed in hectares). A total of fifty job profile form and checklists were used to collect data which was selected based on the logging activities within the established sample plots. Interview schedule were administered to the operators to gather information on the logging methods adopted in the study area. Purposive sampling was adopted to select trees to be felled which is primarily standing with DBH more than 30cm and the data was obtained from them using Spiegel relaskop for measuring diameter and height at different point along the trees, stopwatch for timing different operation carried out during logging activities, diameter tape to measure the girth of the tree, DBH stick (1.3m above the ground) and meter rule for measuring the plots established.

2.4 Method Data Analysis

The study used

(i) Tree Volume Estimation

In determining the tree volume, the diameter of each tree was measured at three different levels with the aid of a Spiegel relaskop and diameter tape. The volume of each tree was estimated before and after the felling operation using Newton's formula which state thus:

$$V = \frac{\pi H}{24}(D_b^2 + 4D_m^2 + D_t^2) \qquad (1)$$

Where,

V = volume of tree (m^3)

H = height of tree (m)

D_b = diameter at the base of the tree (m)

D_m = diameter at the middle of the tree (m)

D_t = diameter at the top of the tree (m)

Productivity

The productivity or technical efficiency of the wood harvesting operation was determined by conducting a detailed time study and work analysis of all phases. The productivity efficiency was calculated using the formula in equation 2:

$$P\ ({}^{m^3}/_{hr}) = {}^{v}/_{t} \qquad (2)$$

Where,

P = productivity per unit time (m^2/hr)

V = volume of harvested wood (m^3)

t = effective working time (hour)

Harvesting Efficiency

Harvesting efficiency of the conventional logging system was calculated using;

$$\text{Harvesting efficiency \%} = \frac{V_E}{V_S} \text{x } 100\% \qquad (3)$$

Where;

V_E = Volume of extracted logs (m^3)

V_S = Volume of standing trees (m^3)

RESULTS AND DISCUSSION

Results

Productivity and harvesting efficiency of clear-felling logging system

The results were obtained from an even-aged stand of *Gmelina arborea in the* Akure Forest Reserve (OFR using the clear-felling harvesting method. In clear felling logging, harvesting operations were planned, and the loggers worked under supervision. Productivity (m3/hour), harvesting efficiency (%), and the effective working time (in hours) were determined.

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Table 4. Average of variables assessed based on diameter class

Diameter	Volume (m^3)	Effective Working Time	Efficiency	Productivity
<30	0.1153	0.033	39.96	4.97
31-40	0.2682	0.025	40.54	11.86
41-50	0.548	0.027	53.08	21.7
61-70	1.0168	0.0323	80.24	32.6
>70	1.4578	0.026	44.69	65.59
Average	0.681	0.029	51.7	27.34

Source: Field survey data, 2022

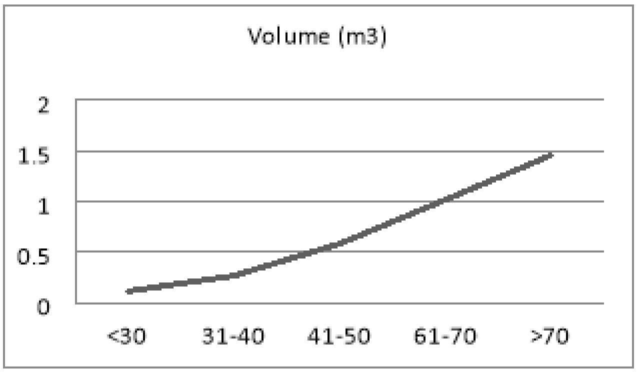

Figure 1: Diameter distribution of the extracted logs against their volume

Source: Field survey data, 2022

As displayed in Figure 1, it was observed that the highest extracted volume of 1.46 m3 was recorded for trees that fall between the diameter range of 70cm and above, while the least extracted volume of $0.12m^3$ was recorded for trees that fall between 30cm and below. This is to say that there are more mature trees than saplings, which is expedient or essential, and it is the right time to harvest.

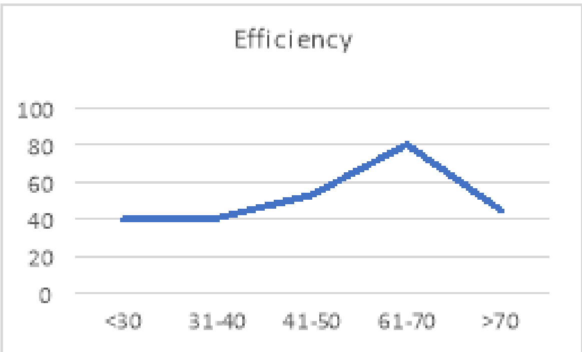

Figure 2: Diameter distribution of the extracted logs against their efficiency

Source: Field survey data, 2022

From Figure 2, the efficiency obtained from the harvesting operation was the highest in the diameter class of 61–70 cm, with an efficiency of 80.24%, while logs with a diameter less than 30cm have the least efficiency of 39.96%. This result shows that efficiency can be improved with an increase in the diameter of a tree; however, a tree with a diameter of more than 70cm recorded a very low efficiency, which can be attributed to defects found in most of the large trees.

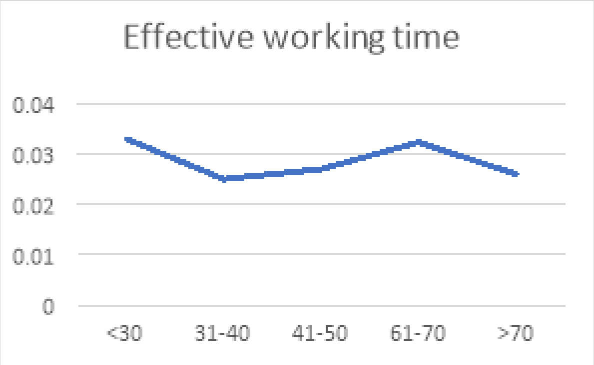

Figure 3: Diameter distribution of the extracted logs against their effective working time a

Source: Field survey data, 2022

From Figure 3, it was observed that the trend does not show a significant pattern between the effective working time and the diameter class in such a way that trees that fall below 30cm recorded a working time of 0.33 hours, followed by trees that fall between 61 and 70cm of 0.032 hours, while trees that fall between the diameter classes of 31 and 40cm recorded an effective working time of 0.025 hours. We can presume that the effective working time is not influenced only by the diameter of the trees but also by the ecosystem property and the forest structure.

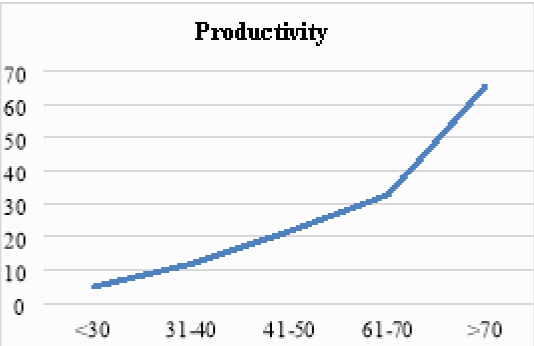

Figure 4: Diameter distribution of the extracted logs against productivity

Source: Field survey data, 2022

From Figure 4, the trend shows a positive relationship between productivity (M^3/hr) and the diameter classes as it was observed that trees with the largest diameter (>70cm) has the highest productivity of 65.59cm^3/hour which decreases with a decrease in the tree diameter. Furthermore, the least productivity value was recorded for the diameter class of less than 30cm with a value of 4.97m^3/hour. Productivity is a function of diameter as obtained in the result.

Discussion

The diameter distribution of a stand gives vital information about the productivity and the silvi cultural management applied to the stand; however, the minimum allowable cut in Nigeria is 48cm for any logging operation. The diameter distribution from the result shows that this regulation is being violated in most of the Nigerian forest, as just 15% of the harvested trees in Akure Forest Reserve met this regulation. Most of the harvested trees fall within the diameter distribution of 31–40 cm, which corroborates the findings of

Ogana (2017) that most of the *Gmelina arborea fall* within this diameter class. Adeyemo (2018) also reported in his study that the average diameter of trees being harvested in Omo Forest Reserve for *Gmelina arborea* was 31 cm, with the same diameter recorded for Akure Forest Reserve. The efficiency and productivity of a forest stand can be improved by harvesting trees with a higher diameter, as reported by Omole (2011), as well as ensuring the stability of the stand.

The volume of both harvested and standing trees has been reported to be an indication of the fertility and fecundity of a forest stand, and there is a huge correlation between the volume of a tree or stand and the diameter of the stand as well as the height. The study revealed that for every increase in unit diameter, there will be an increase in the volume obtainable, which in turn will increase productivity. The efficiency of a logging operation is influenced not only by the diameter of the tree but also by different factors such as equipment and technology, silvicultural system, weather, size, skill, and capability of personnel, which will determine the profitability of the investment. The efficiency has been established with this study as a function of diameter, where a positive correlation was obtained; however, the case may not be the same when there are other factors acting in synergy with the diameter of the tree, such as the experience of the operator, the forest condition, the tree species, the condition of the harvesting equipment, and the harvesting method adopted. In some cases, the diameter may not be the sole factor determining the efficiency, citing the result from this study, as the trees with the largest diameter have a lower efficiency value compared with the lesser diameter class, which can be attributed to the presence of defects in the woods. The efficiency can be improved with increased diameter, an experienced operator, excellent equipment, and improved harvesting methods.

The effective working time of a logging operation can be defined in terms of the productive time during the operation without considering the resting periods. Furthermore, the effective working time can be affected by some factors that were observed during this study, which include the weather condition, the worker, and the working condition, as they play a huge role in the overall productivity measured in m^3/hour. The irregular trend observed when the effective working time was plotted against the diameter shows that the diameter of the felled tree plays a minor role in the time required for felling a log and that the worker and the working condition are the major factors determining the productivity of a forest operation.

Productivity is the key to the economic and social development of a country. The productivity measurements are of great importance for the forest technicians and the logging companies (Korkmaz, 2011; Savelli *et al*., 2010). The productivity of a forest operation will determine the overall profitability of a logging operation; however, productivity is a function of the volume of a tree, the diameter of a tree, and the effective working time, as these variables are reported to influence the overall outcome of a logging operation. Omole (2011) reported that volume and effective working time determine the productivity of a logging operation; hence, there is a need to harvest large trees that fall within the allowable minimum cut in order to meet the ever-increasing demands for wood.

CONCLUSIONS

The study reveals that the average diameter at breast height (dbh) requirement for harvesting in the study area was 26 cm, which is far less than in other tropical environments. The harvesting efficiency recorded for the conventional logging system was about 51.70%, which is averagely good when compared to other values gotten for other tropical forest environments. This can also be improved by institutional strengthening.

The study also found that the diameter at breast height, length of the extracted logs, effective working time, volume of extracted logs, skill of the operator, transportation cost, condition of the machine used, and the harvesting method adopted are factors affecting harvesting productivity. Clear felling harvesting has many potential advantages, including reducing stand damage, increasing diameter growth, increasing productivity, reducing the impact of logging on the regeneration capability of a forest, and so many more.

Based on these findings, it is recommended that the minimum felling diameter requirement of 48cm be strictly adopted in order to increase harvesting efficiency and productivity. Logging intensity should be low because residual stand damage reduces with decreasing logging intensities, which not only improves regeneration and growth of the residual stands but also the long-term ecological sustainability of the forest. There should be proper maintenance of the equipment used for logging operations so as to improve the condition of such equipment so as to achieve sustainability, and experienced operators should be used to perform logging operations so as to achieve improved harvesting efficiency.

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