ENVIRONMENTALLY SOUND WOOD HARVESTING IN OMO FOREST RESERVE, OGUN STATE, NIGERIA.

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ABSTRACT

The depletion of the nation's forest reserves through improper wood harvesting methodss is alarming and threatening. The trend has been giving all stakeholders serious concern and it has become imperative for a research to be undertaken to find an alternative and better logging method that is environmentally sound and acceptable. A work study was therefore carried out to assess and compare damages and productivity in both Conventional Logging System (CLS) and Reduced Impact Logging (RIL) in a Nigerian forest reserves. Data for the study were collected on damages to residual plants and productivity per time per harvesting method using a time study and work analysis approach. The data so collected were then subjected to both descriptive and inferential statistical processing.

Results show that RIL can reduce damages to residual stand by close to 50 percent when compared to CLS. Result of time study show that the average time required for felling of a tree in RIL and CLS are 9.91 and 7.52 minutes respectively. The productivity in RIL is 78.58m^3/hour while it is 89.25m^3/hour for CLS.

Statistical analyses show that productivity in RIL is not significantly different from productivity in CLS but largely depends on the volume of the harvested tree. It is recommended that RIL be adopted and encouraged in wood exploitation to promote environmentally sound wood exploitation in Nigerian forest estates.

Key words: Reduced impact logging, time study, productivity, wood exploitation

INTRODUCTION

Wood harvesting systems started from conventional crude methods of manual felling and bucking, characterized by heavy damages and stress to the operatives. In this method, logging damages may be so severe and extensive that it will require longer fallow period for the forest to recover. This has led to a clamour for change over the years with emphasis on systems that are ecologically, economically and ergonomically sound. The primary objective is to minimize damages to existing biodiversity and reduce risk of accidents. The damages and the risk associated with conventional timber harvesting methods have led to various attempts by researchers in the area of wood exploitation at finding ways of reducing these problems. A long list of reported scientific investigations is available on this. (Bertault and Sist 1995, Marsh et al 1995, Elias 1998, Poore *et al* 1989, Dykstra and Poschen 1998, Omole 2000 and Omole *et al* 2005). In all the studies a major shift from the conventional harvesting methods to a more environmentally friendly method of wood exploitation in the form of reduced impact logging (RIL) has been proposed as an alternative.

Reduced impact logging (RIL) as described by Hendrison (1990) is based on forest prospecting prior to harvesting and use of the data so collected to design a layout of felling compartments and inventory units, and also to plan the timber extraction operations. In this harvesting method, logging activities are properly planned and controlled. The relative advantage of reduced impact logging (RIL) over the conventional logging system (CLS) has been investigated in many studies using ecological measures such as the magnitude of incidental damage to the soil and residual stands, improved rate of regeneration and conservation. (Elias, 1998., Dykstra and Poschen, 1998 and Omole, 2010).

In spite of the ability of RIL to minimize damages to biodiversity, there are some arguments against the total adoption of RIL. A major criticism is that the total cost difference in CLS is lower that the total cost in RIL.This is because there is need to acquire better technology and that more time is required for proper execution of the job. Howard *et al.* (1996) reported a net loss of short-term profit of 35% to 67% due to the adoption of more sustainable harvesting regimes with the incremental cost of RIL operations in the extensive planning and pre-harvesting stand management activities. A potential additional cost of $27 to $72 per hectare over CLS was reported by Quiros *et al* (1997) and Johns *et al* (1996)

The study is therefore carried out to assess productivity in the two methods with a view to determining if the productivity in CLS is significantly different from productivity in RIL.

MATERIALS AND METHODS

Study area

Omo Forest Reserve (OFR) is situated approximately between Latitude $6^0\ 35^1$ and $7^0\ 0^1$ and longitude $4^0\ 40^1$ of Southwestern Nigeria. The reserve is bounded in the North by Ago-Owu, Shasha (Osun State) and Oluwa (Ondo State) forest reserves and drained by Shasha and Oni rivers. The topography of the area is gently undulating with intershuttling hills within thick jungle and the soil is well drained. (Odebiyi 1979, Hall 1979). Annual temperature ranges from an average minimum of 20^0C in January to an average maximum of 33^0C in March. The rainfall pattern is bimodal, starting from April and end in July for the first season and late August to November in the second season. Mean annual rainfall is between 1,500 and 3,000mm. The natural vegetation is mixed and is of lowland rainforest type with abundant forest tree species of different families and genera.

Data Collection.

Materials

The materials for data collection were the same for the two methods and they include diameter tape, 30m linen tape, power chain saw, cutlasses winch cables and a crawler tractor.

The study was carried out in a Twenty-five (25) year old *Gmelina arborea* plantation within the reserve. Data on productivity per unit time and degree of damage to residual stand for the two methods were collected in accordance with the model proposed by Heinrich (1997) and Elias (1998). Four hectares of the stand were demarcated with each hectare later subdivided into 4 equal blocks of 50m X 50m, giving a total of 16 blocks for the study. CLS was carried out in four blocks while RIL was also carried out in the other four blocks. Before the commencement of logging operations in the two methods, an inventory of the stock was carried out for harvestable trees within the each sample plot.

Although Fox (1968) proposed the cutting of climbers months before actual felling operations to minimize or reduce the possibility of felled trees pulling over neighboring trees, for RIL in this study, cutting of climbers was carried out four weeks before felling. This is because the climbers in this plantation are not as big and strong as climbers in the natural forests. A skid-trail plan and construction were put in place to facilitate easy skidding of felled logs. A direction felling was later carried out in such a way that the felling direction was towards or opposite the skid-trail. This is necessary to minimize incidental damages to the residual stand. Skidding of logs was later carried through the pre-planned skid- trails markings. However, for CLS, felling operations were carried our immediately after the inventory was concluded. In this case, there was no cutting of climbers and construction of skid-trails. The operators were allowed to use their discretion in determining the felling direction. Trees were felled at random and measurements were taken *in-situ*.

Analytical Tools

The productivity or technical efficiency of the two methods was examined by conducting a detailed time study and work analysis of all the phases of the harvesting operations. The productivity was calculated using the formula

$P\ (m^3/hr) = V/t$

Where

P = *productivity per unit time* (m^3/hr)
V = *volume of harvested wood* (m^3)
t = *effective working time (hour)*

While residual stand damage was calculated using the model developed by Elias (1998) which is stated as $^0k = R / P\text{-}Q\ (100\%)$

Where

^0k = *degree of residual stand damage*
R = *number of damaged trees with dbh of* $\geq$ *10cm after logging*
P = *number of trees with dbh of* $\geq$ *10cm after logging*
Q = *harvesting intensity (harvested trees/ha)*

Analytical Tools

Data collected on productivity were subjected to statistical analysis using simple regression analysis and the model is specified as:

$(P = a_0 + a_1D + a_2L + a_3V + a_4T)$

Where;

a_0 = *intercept*
D = *(diameter at breast height) i.e dbh(m)*
L = *merchantable length of the tree(m)*
V = *volume of wood* (m^3)
T = *work time (hr)*

Student's T –test was later employed to test for the statistical difference between the mean productivity for RIL and CLS, specified as:

$$T\ \alpha/2df = \frac{|P1 - P2|}{\sqrt{S^2P(1+1)}}$$

$$SP^2 = \frac{(n_1 - 1)S_1^2 + (n_2 - 1)S_2^2}{n_1 + n_2 - 2}$$

where

t = *student's t*
n_1, n_2 = *sample size*
SP^2 = *pooled variance*

$P_1, P_2 =$ *productivity (CLS & RIL)*
$S_1^2, S_2^2 =$ *variance*

RESULTS AND DISCUSSION

From Table 1, it is observed that average diameter at breast height (dbh) of harvested trees for both conventional logging and reduced-impact logging ranged between 1.71 and 1.76m. The difference in the average dbh of the trees harvested are quite close because the stand from which the study took place is even-aged and the average diameter at breast height (dbh) of the trees only slightly varied. The average volume per tree as observed from Table1, in the conventional logging and reduced-impact logging was close and ranged between 10.95 and 11.75m^3 due to the slight variation in dbh of the trees.

The average time required for felling of a tree per method as observed from Table 1 ranged between 7.52 and 9.91 minutes for conventional logging and reduced-impact logging respectively. The difference arose from the fact that reduced-impact logging required more time to plan before felling i.e. planning the felling direction etc. The productivity in m^3/hour ranged between 78.58 and 89.25 m/hour for the reduced-impact logging and conventional logging respectively. The productivity of felling in reduced impact logging is lower than that of conventional logging by 20.32%. This arose from the fact that more time is required for felling in RIL than CLS i.e more time was required in planning the felling pattern and extraction routes in RIL than CLS. This observation is in line with the report of the studies carried out by Elias (1998) in the tropical natural forests of Indonesia and Omole *et al* (2005) who also reported similar range in a Nigerian Gmelina plantation

Table1: Productivity per unit time in conventional and reduced-impact wood harvesting

No.	Harvesting method	Average dbh	Average Vol./tree (m)	Ave. Time(minutes)	Productivity (m^3/hour)
1.	CLS	0.54	10.95	7.52	89.25
2.	RIL	0.56	11.75	9.91	78.58

Table 2: Degree of residual stand damage in the two methods

S/no	Harvesting Methods	Degree of residual stand damage(^{0}K)
1	CLS	47.83%
2	RIL	25.36%

A wide variation exists in the degree of residual stand damage in the two methods (table 2). The degree of residual stand damage observed in CLS was 47.83% while the observed value in RIL was 25.63%. This shows a reduction of about 50% in residual stand damage in RIL compared to CLS. This finding compared favourably with the findings of Fox (1968), FAO (1989), Marsh *et al* (1995), Moura-Costa (1995) and Elias (1998).

Statistical Analysis

Also, the regression analysis as shown in table 3 reveals that the relationship between the dependent variable (productivity) and the regression variables is significant at 5% probability level. This indicates that the independent variables (dbh, time, length and volume) contribute significantly to productivity in both logging methods. Performance asssessment of the models using student t-test reveals the actual factor(s) contributing to productivity and their level of influence and the results are as presented on table 4.

Table 3: Summary of regression model performance on productivity in Conventional Logging and Reduced-Impact Logging

Criteria	Conventional Logging	Reduced Impact Logging
R^2	.9851	.9940
Adjusted R^2	9840	.9933.
Standard Error of Estimate	2.8352	.8608
F. Calculated	859.79	1295.5
F. Tabulated	3.65	4.02

Table 4: Summary of full regression model for productivity in conventional logging

Independent Variable	Beta Regression	Std. Error	Beta Coefficient	t-calculated
Constant	-	16.9091	92.056	5.442*
DBH	-.308	9.5400	-4.035	-4229ns
Length	-.0603	2.0985	-1.075	-5123ns
Volume	.8370	2.5451	9.061	5.8646*
Time in hours	-.5619	21.2831	-687.443	-32.2999**

R2 = 98.51, t-tabulated = 2.01, * = significant, ns =not significant

T-test on table 4 shows that only the tree volume and time taken to fell are factors determining productivity. These two factors contribute 98.51% to productivity.

The full regression model is specified as follows: $P_1 = a= + a=D + a_2L + a_3V + a_4T$

Therefore, $P1 = 92.056 - 4.035D - 1.075L + 9.061V - 687.433T$.

Since only two factors contribute significantly to productivity, the full regression model can therefore be modified to contain only the two significant variables as:

$P_1 = a_0 + a1V + a_2T$

$$P1 = 92.056 + \underset{(1.5451)}{9.061V} - \underset{(21.2831)}{687.443T}$$

( ) – subscripts are standard errors

Table 5: Summary of full regression model for productivity in reduced – impact logging

Independent Variables	Beta Regression	Std. Error	Beta Coefficient	t-calculated
Constant	-	16.2182	-13.108	-.8082^{ns}
DBH	.6354	9.2679	52.624	5.6781*
Length	.6575	1.9235	9.545	4.9624*
Volume	-.1613	1.3915	-1.395	-1.0024^{ns}
Time in hours	-.6461	10.4058	-438.023	-42.0943**

R^2 = 99.41, t-tabulated = 2.04

* = significant, ns = not significant

Table 6: Summary of regression model performance on productivity Conventional Logging and Reduced-Impact Logging

Criteria	Conventional Logging	Reduced Impact Logging
R2	.9851	.9940
Adjusted R2	9840	.9933 -
S. E of estimate	2.8352	.8608
F value	859.79	1295.5

T-test on table 5 shows that only the tree dbh, length and time taken to fell are factors determining productivity. These three factors contribute 99.41% to productivity.

The full regression model is as follows: $P_2 = a_0 + a_1D + a_2L + a_3V + a_4T$

Therefore $P_2 = -13.108 + 52.624D + 9.54L - 1.395V - 438.023T$.

Since only three factors contribute significantly to productivity, the full regression model can therefore be reduced to contain only the three significant factors as:

$P_2 = a0 + a1D + a2L + a3T$

$$P_2 = -13.108 + \underset{(9.2680)}{52.624D} + \underset{(1.9235)}{9.454L} - \underset{(10.4058)}{438.023T}$$

( ) – subscripts are standard errors.

The Summary of regression model performance on productivity in Conventional Logging and Reduced-Impact Logging is as presented in table 6. The result of statistical analysis comparing productivity in terms of harvested volume per unit time using t-test shows that the difference in productivity is significant at 5% probability level.

CONCLUSION AND RECOMMENDATIONS

Ground skidding timber harvesting is the most common timber harvesting system in use in the study area. It is assumed that in the future the system will be continually operated in the tropical natural forests in Nigeria.

As compared to conventional timber harvesting, reduced-impact timber harvesting can minimize damage up to about 50% or more without a significant decrease in productivity per unit time. This is through a series of timber harvest plans and techniques, such as: cutting of vines before felling, regulation of felling direction, proper skidding and an overall timber harvesting efficiency.

The result of statistical analysis comparing productivity in terms of harvested volume per unit time using t-test, revealed that the difference in productivity was not significant at 5% probability level.

Research results demonstrate, that reduced-impact timber harvesting is not necessarily more expensive than conventional timber harvesting because the value of timber damage caused by conventional timber harvesting is almost twice the value of timber damage caused by reduced-impact timber harvesting and the latter will consequently enhance future forest productivity and reduce the cost associated with potentially adverse off-site consequences of timber harvesting. When using the reduced-impact logging system, it is important that operations be well supervised and the quality, as well as the quantity of work controlled for meaningful result.

The study demonstrated that harvesting operations which are adequately planned and supervised, and carried out by trained, well supervised and motivated personnel can satisfy requirements for sustainability while simultaneously reducing harvesting costs by a substantial margin as compared to conventional operations. The impediments to immediate implementation of the reduced-impact logging practices used in this study as identified by Marn and Jonkers (1982), Kollert *et al.* (1995) are that many foresters are willing to accept poor logging practices because they don't really believe that environmentally, logging is possible at a level of cost that will permit an economically viable forest industry because they seldom encounter harvesting operations that can objectively be described as "environmentally sound", and because conventional wisdom says that environmental protection always costs more. However RIL can be less costly compared to conventional logging due to better planning, better supervisory control, and better utilization of felled timber.

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