PRODUCTIVE EFFICIENCY OF SMALL SCALE SAWMILLING INDUSTRIES IN MUFINDI DISTRICT, TANZANIA

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ABSTRACT
This study was carried out to examine the productive efficiency of small-scale sawmills in Mufindi District. The specific objectives were: (i) to assess the relative efficiency of small-scale sawmills in Mufindi, (ii) to identify factors for variation in the small scale sawmill's relative efficiency and (iii**)** to provide policy recommendations for efficiency improvement in utilization of forest resources. A structured questionnaire was used to collect data from 80 small-scale sawmills in Mufindi District. Data were analysed using descriptive as well as quantitative methods. Technical, scale and allocative efficiency score of sawmills were computed using data envelopment analysis programme developed by Coelli. Censored regression models were estimated to identify factors for inefficiency of small-scale sawmills. Results showed a mean technical efficiency of 84% (CRS model) and 92% (VRS model), allocative efficiency of 84% (CRS model) and 89% (VRS model) and cost efficiency of 70% (CRS model) and 81 % (VRS model). Furthermore, results from the censored regression model revealed that Owners/manager's education, experience, the size of the sawmill timber yard and partnership ownership had positive effects on sawmill's efficiency while machine age had a negative effect on sawmill's efficiency. Recommendations for enhancing small-scale sawmills production efficiency are: Strengthening extension services to increase sawmilling experience, and insistence on partnership ownership of sawmills. Since mill size positively enhanced sawmills' relative efficiency, an increase of the size of mills must receive priority. Squeezing sawmill area as a result of increased number of sawmills leads to inefficiency. Lastly but not least, the use of sawmilling by products particularly chips, saw dusts and slabs should be promoted as it is a way of increasing efficiency in sawmilling.

INTRODUCTION
Tanzania is a well-endowed country from a natural resources point of view; with its area of more than 945 000 km^2 of which about 55% is estimated to be forests and woodlands (Table 1 (MNRT, 2014). According to MNRT (2014), the other area is covered by cultivated land (about 24%), Grassland (10%), bush land (about 7%) while open land, water and other areas covers about 4.5%. There are a number of rivers and lakes, mostly fed from the catchment forests of Tanzania. Tanzania has several distinct climatic zones which provide a wide range of opportunities. The main forest types are the extensive miombo woodlands in lowland areas across the central and southern parts of the country, the Acacia woodlands in the northern regions, the coastal forest/woodland mosaic in the east, mangrove forests along the Indian Ocean shoreline, and closed canopy forests on the ancient mountains of the Eastern Arc (MNRT, 2014).

Table 1 Land Distribution[4] (in %) by Vegetation Types in Tanzania

Primary Type	Eastern	Southern	S. Highlands	Central	Lake	Western	Northern	Total
Forest	8.7	4.9	4.4	0.5	2.5	2.4	5.9	4.3
Woodland	53.1	67.2	52.5	41.0	28.1	59.2	40.9	50.2
Bushland	8.0	3.7	5.0	17.1	2.8	3.1	14.6	7.0
Grassland	13.8	2.1	9.4	5.6	21.3	5.2	16.7	10.3
Cultivated land	12.1	18.9	24.4	32.1	40.6	27.0	18.8	24.4
Open land	0.5	0.2	0.3	0.2	0.3	0.2	0.6	0.3
Water	1.5	1.6	1.4	1.7	1.2	1.1	0.4	1.3
Other areas	2.4	1.4	2.6	1.8	3.3	1.9	2.0	2.2
Total	100	100	100	100	100	100	100	100

Source: MNRT, 2014 It should be understood that not all the resources can be available for extraction. For example, Protection forest and Wildlife reserves are not accessible legally to local communities for timber, charcoal and other products harvests. According to Table 5, production forests accessible for forest products harvests is 1,134,173,000 m^3 (MNRT, 2014).

[4] Due to rounding the figures do not necessarily sum up to precisely 100%

The total gross area of forest plantations in Tanzania is estimated to be up to 250 000 ha (Chamshama and Nshubemuki, (2010); Ngaga, 2011). Out of this area, government owns about 85 000 ha, privately owned plantations are estimated to be 40 000 ha, out-grower schemes and woodlots occupy between 80 000 and 140 000 ha in total. The most important industrial plantation species are pines (*Pinus patula, P. elliottii* and *P. caribaea*), cypress, eucalyptus and teak. Pines are the dominant species in most of the government and private plantations with about 78% of the total area planted and the remaining 22% is shared among hardwoods and other softwood species (Ngaga, 2011).

Government plantations are the major source of wood raw material and Sao Hill Forest Plantation (SHFP) alone is currently supplying over 85% of raw material consumed by industries. Given the age structure and current harvesting levels, it is predicted that after 2017 there will be severe deficits for some ten years to come. Only after 20 years from today the harvesting can come back to current levels. Individual/private plantations/woodlots, also known as non-industrial private forests (NIPF), are currently supplying an estimated 200 000 - 250 000 m^3 of round wood.

The forest based industry in Tanzania is largely dominated by sawmilling, woodworks/furniture marts and joinery. Other industries include paper, sawmilling and poles treatment plants. The capacity for production of treated transmission poles in Tanzania is about 350 000 poles annually. Mufindi Paper Mills (MPM) produces some 40 000 tonnes of kraft paper annually and is expected to expand its production to 100 000 tonnes/year.

The number of sawmills has increased from about 140 in 1998 to 367 registered in 2005 to 512 surveyed in 2008 (Ngaga 1998; FBD 2005; FBD 2008). More than 400 of the sawmills are small scale wood machinery (locally fabricated circular saw or roller bench with rails or micro-mills) most of which are found around the SHFP. Overall, therefore, over 70% are micro-mills ("dingdongs") and 25% small (Kara type) and only 5% are medium size mills. The micro-mills are characterised by simple mobile technology, powered by a diesel engine, and an all manual operation. Inadequate financing, very small investments in equipment and low level of maintenance lead to poor quality timber products. For example, out of over 200 mills found at SHFP, 100-150 are micro-mills. Each of these micro-mills employ about 4-5 persons. The mills are using good quality sawlogs to produce low quality sawn wood at fairly low recovery rate (33%), resulting in a lot of sawdust.

Other small scale types of sawmills (Kara/Amec, Laimet, CVT, Forester; in all, there are about 50 of these at SHFP) have a log inputs not exceeding 5 000 m^3/year and employ about 5 to 8 persons. Also, there are a few medium sized sawmills, like Sao Hill sawmills, TANWAT and KVTC which produce over 20 000 m^3 of sawn wood annually with fairly good recovery rates (over 40%) and good quality sawn wood. It has also been noted that most of the small scale sawmills do not have the required technical staff as per forest regulations (INDUFOR 2011).

There is a persistent view among the smaller producers will get much lower supply of wood compared to large size industries who will be owning private plantations (Ngaga, 2011). Significant upfront investments allow these operators to achieve higher yield or recovery from the same raw material. This is contrary to micro scale saw millers whose initial investment is relatively smaller and lower quality and recovery rates. Although the wood price very is competitive in Tanzania, the low recovery rate causes the actual wood cost to be high. Given actual sales prices for untreated, ungraded sawn timber, the operating profit is about 1.5% or USD 4 daily.

The sawmilling industry in Tanzania can contribute much more to the economy of the country given sound operational situation. Among key setbacks in achieving this level of contribution is insufficiency of reliable empirical information on the productive efficiency of these sawmills. As indicated earlier, the forestry processing industry sector is dominated by micro-scale (dingdongs) privately owned sawmills with (URT 2001; Ngaga 2011). Up to date information on the number of sawmills, their production efficiency and operational status are scantly known. Production efficiency data is vital for informing stakeholders who include the government and the business sector for improvement in order to minimize losses and sustain the industry.

METHODOLOGY

Description of the study area

The study was conducted in Mufindi District, which is one of the three districts in Iringa region of Tanzania. The district lies between Latitude 08° 42" S to 9° 11" S and longitude 34° 08" E to 35°20"E. Mufindi district is divided into two zones namely the eastern and the western zones. The eastern zone which lies at altitude ranging from 1 700 to 2 200 meters above sea level is also termed as the highland zone. This zone is wet, having the annual rain fall of 1 000 - 1 200 mm. Its annual temperature ranges from 15° C to 20°C with minimum temperature of 13.5° in June. The zone consists of Kibengu, Ifwagi and Kasanga divisions. The Western zone comprises of Malangali and Sadani divisions; it lies at altitude ranging from 1 000 to 1 600 meters above sea level with the maximum temperature of 20° C in February and the minimum of 13° C in July. Unlike the Eastern zone, this zone is dry with annual rainfall that ranges from 600 to 750 mm per year. Administratively, the district consists of five divisions namely Kibengu, Kasanga, Malangali, Ifwagi and Sadani. The district has 28 wards, 135 registered villages and 582 sub-villages. The rationale for selecting Mufindi district for the study is the large number of small-scale sawmilling industries and availability of high quantity of raw material supply. Moreover, Mufindi District is the only district in Tanzania where forest activities rank second to agriculture in terms of income generation (URT 2005). Although there has been an increase in number of small scale private saw millers in recent years, their productive efficiency has not been fully examined. Information on productive efficiency is relevant for sustainability of the forest resources in the area.

Sampling Procedure

The target population for the study was the small scale sawmilling industries operating in Mufindi District. There are several criteria for categorising sawmills in Tanzania. For instance, according to MNRT (2004), a sawmill is considered to be small if it has it has a processing capacity of up 1000 m^3 per annum; medium with processing capacity from 6001 to 10 000 m^3 and large with processing capacity of over 10 000 m^3 per year. Sige *et al.* (2005) classified sawmills with an installed capacity of less than 6000 m^3 per annum as small scale, and mills with installed capacity of between 6000 and 10 000 m^3 and over 10 000 m^3 per annum as medium-scale and large- scale respectively. This study employed categorization used by Sige *et al*. (2005). The sampling frame was obtained from the forest products dealers register in the district. From the 445 registered mills, a sample of 80 sawmills was selected randomly to obtain representatives of small-scale saw millers in the District.

Data Collection

Primary data

Primary data were collected from small-scale saw millers using structured questionnaires. The questionnaire contained both open and close ended questions. The questionnaire included information on two main categories i.e.: i) Sawmill characteristics i.e., number of workers, age, education, experience in sawing, skills, timber storage area, source of raw materials, work force composition; ii) Various timber production data i.e., total production cost, inputs logs, fuel, lubricants, electricity use, labour, supervision, food consumed in work, services), volume of output and price. Furthermore, to supplement data obtained in the interview particularly those entailed the amount of input (logs) used per day, a lumber stack dimensions produced per day was measured, hence timber volume produced per day was obtained. The obtained timber volume produced per day was then used to estimate the number of logs sawn per day by dividing by the log conversion rate in the district which is 30% (Sigel *et al.* 2005).

Secondary data

Secondary data were collected by reviewing documents and reports from Iringa Regional Commissioner's Office, SHFP, Mufindi District Council Office, Green Resources Ltd, National Bureau of Statistics and Sokoine National Agricultural Library (SNAL).

Data Analysis

The data collected was analysed in two stages: in stage one, the deterministic and non-parametric Data Envelopment Analysis (DEA) was applied to obtain efficiency score for the small-scale saw millers. The choice of DEA was based on the fact that the mathematical programming procedure used in the approach is comparatively robust and can handle multiple data input and output scenarios (Seiford and Thrall 1990). In the second stage of analysis, censored regression was used to determine the influence of some variables on the sawmills' efficiency obtained by the DEA analysis in the first stage.

Data envelopment analysis-determining relative efficiency

Data envelopment analysis uses linear programming methods to construct a non-parametric piece-wise frontier over the data and individual efficiency are calculated relative to that frontier. The general linear optimization problem which has to be solved can be derived by using duality in linear programming as follows:

$$\min_{\theta,\lambda}\theta \quad -yi + Y\lambda \geq 0 \text{ , ...(1)}$$

$$\theta xi - X\lambda \geq 0,$$

$$\text{subject to} \qquad N1'\lambda = 1$$

$$\lambda \geq 0$$

where y_i and x_i denote output and input of the *ith* production unit and Y as well as X are the corresponding vectors. θ is a scalar and λ is an N x 1 vector of constant. The value of θ obtained will be the efficiency score for the *ith* firm and will satisfy θ ≤ 1 with a value of 1 indicating a point on the frontier and, hence, a technically efficient firm. The linear programming problem in (1) must be solved N times, once for each firm in the sample and a value of θ is finally obtained for each firm. Although DEA is a relatively new methodology for determining efficiency of productive units of Decision Making Units (DMU), several softwares are available. This study used DEAP-Version 2.1 developed by Coelli (1996). $N1'\lambda=1$ is the constraint assuring the formation of a concave hull of intersecting plane enveloping the data points more tightly to disentangle Variable Return to Scale (VRS) from Constant Returns to Scale (CRS) as pointed out by Banker *et al.* (1984) and Charnels *et al.* (1978) respectively. Measures of scale efficiency (SE) for each firm are obtained by conducting both CRS and VRS analysis. Then possible scale inefficiency is calculated from the difference between the VRS and CRS TE scores as in equation 2:

$TE_{CRSi} = TE_{VRSi} * SEi \rightarrow SE = TE_{CRS}i / TE_{VRSi}$......................(2)

Hence, the CRS technical efficiency measure is decomposed into 'pure' technical efficiency and scale efficiency. With respect to the case of VRS cost minimisation, the input-oriented DEA model (equation 3.) is conducted to obtain values of technical efficiencies (TE). Furthermore, the solution of the cost minimisation DEA model in (equation 3) is required.

$\min_{\lambda, x_i} w' x^*$

subject to $-y + Y\lambda \geq 0$

$X^* - X\lambda \geq 0$

$N1\lambda = 1$

$\lambda \geq 0$ ....(3)

where w_i is a vector of input prices for the ith sawmill and x_i* is the cost- minimizing vector of input quantities for the ith sawmill, given the input prices w_i and output levels y_i. The total cost efficiency, CE, of an ith sawmill is computed as:

$CE = w_i x_i^* / w'_i x_i$ ....(4)

$_i$and allocative efficiency (AE) as

$AE = CE / TE$...(5)

Hence, the deterministic and nom-parametric DEA approaches are applied to obtain technical as well as cost efficiency measures by one-stage model using linear programming techniques. Measure of allocative efficiency is obtained by calculation. Referring to the objective of the present study, i.e. to determine the productive efficiency of small-scale sawmills, variables used in the first stage of analysis to determine the relative efficiency were: sawn timber produced as output variable, and logs, labour and fuel used as the input variables. To determine the relative allocative efficiency the total cost of timber production as well as the price of the inputs were used.

Tobit model for analysis of factors affecting efficiency

In order to assess the sources of efficiency of the small-scale sawmills a censored regression model (Tobit model (1958)) was applied. The present study used Tobit model because the dependent variable- the relative technical or cost efficiency values are by definition bounded between 0 and 1meaning that it is a censored variable. Since a censored variable is not observed over its entire range, therefore violates the normality assumption of linear regression. It was Tobin (1958) who devised the Tobit model which is also referred as to censored normal regression model for situation in which *y* is observed for values greater than zero but not observed for values of zero or less. The general Tobit model is written as:

$y_i^* = x_i \beta + \varepsilon_i$

$y_i = y_i^*$ if $y_i^* > 0$

$y_i = 0$ if $y_i^* \leq 0$..(6)

where y_i is the latent dependent variable, y_i is the observed dependent variable, $\mathbf{x}_i$ is the vector of the independent variables, ß is the vector of coefficients, and the ε_is are assumed to be independently normally distributed: $\varepsilon_i \sim N(0, \delta)$ (and therefore $y_i \sim N(x_i \beta, \delta)$). Note that observed 0s on the dependent variable can mean either a "true" 0 or censored data. At least some of the observations must be censored data, or y_i would always equal y_i^* and the true model would be linear regression, not Tobit.

Experiments revealed that OLS estimates of β and σ for censored data are biased downwards (Greene 2005). Therefore, the present study used maximum likelihood function to estimate β and σ for the Tobit model used in the analysis of source of inefficiency. The basic idea of maximum likelihood is quite simple: the best model is most consistent with the observations. Consistency is measured statistically by the probability that the observations should have been made. If the model is changed to make the observations more probable, the likelihood goes up, indicating that the model is better. It could also be said that the model agrees better with the data, but bringing in the idea of probability defines "agreement" more precisely.) The probabilities have to include the effects of all sources of error, including not just measurement errors but also errors in the model itself. As the model gets better, its errors clearly get smaller, which means the probabilities become sharper. The sharpening of probabilities also increases the likelihood, as long as they are no sharper than appropriate. Mathematically, the likelihood is defined as the probability of making the set of measurements. If there are N observations of different quantities x_j, for instance, then the likelihood is defined as:

$$L = P(X_1, X_2, X_3 ....X_N) \quad ....(7)$$

Notice (as indicated by the commas) that this is a joint probability distribution of all the measurements. Often the measurements will be independent of one another, in which case the joint probability is simply the product of all the individual probabilities:

$$L = \prod_{J-1}^{N} P(X_j) \quad ....(8)$$

The assumption of independent probabilities certainly makes life simpler, because joint distributions can be extremely difficult to work with. But something may be lost if the errors are correlated, so it is important to be careful. Since sums are easier to deal with than products (and the product of a lot of small numbers may be too small to represent on a computer), so generally the log of the likelihood is used. The log varies monotonically with its argument (*i.e.* ln(x) increases when x does and decreases when it does), so the log of a function will have its maximum at the same position. Usually, the interest is in finding the position of the maximum of the likelihood function (equation 9).

$$LL = InL = \sum_{j-1}^{N} In\left[p(X_j)\right] \quad ....(9)$$

In fact, to make analogy with least-squares more obvious, the minus log likelihood is often minimised. Although the basic ideas behind maximum likelihood are quite simple, the difficult part is working out the probability of making an observation. This allows calculation of the probability of any possible set of measurements. Finally, the actual measurements are brought in and observed how well they agree with the model.

Applied to the objective of the present study, the censored model for the second stage analysis was:

$$EFF_i^* = \beta_1 + \beta_2 MAGMT + \beta_3 EXPERIE + \beta_4 EDUCATI + \beta_5 TIMBYRSIZE + \beta_6 FOROWNSH + + \beta_7 MACHAGE + \beta_8 MACHOWNSHP + \varepsilon_i \quad (10)$$

Where MAGMT denotes a dummy for management of the sawmill, it has a value of one if the sawmill is managed by the owner, otherwise it is zero. EXPERIE reflects the sawmilling experience of the sawmill owner or manager defined in number of years involved in sawmilling. EDUCATI is the level of formal education of the sawmill owner or manager proxied by the number of years in formal schooling. TIMBYRSIZE denotes sawmill's timber yard size. FOROWNSH is dummy variable for form of sawmills ownership it has a value of one if it is owned by partnership, otherwise zero. MACHAGE is the age of the machine denoted by the number of years since it was made. MACHOWNSHP is a dummy for machine used in sawmills: some mills use self owned machine and others uses hired machine in sawmilling, it had a value of one if uses hired machine, otherwise zero (Table 2).

Table 2: Determinants of Technical Efficiency

Variable	Hypothesized relationship to technical efficiency
Owner's management =1 otherwise 0	Positive
Owner's experience in sawmilling	Positive
Education of the sawmill owner or manager	Positive
The sawmill's timber yard size	Positive
Ownership partnership =1 otherwise 0	Positive
Age of the machine used in the sawmills	Negative
Mills using hired machine=1 otherwise 0	Negative

The censored regression problem in the second stage of analysis in the present study was solved using Limdep Version 8. To test hypotheses guiding this study, generalised likelihood-ratio tests statistic was computed using the equation proposed by Green as follows:

$$-2\log[L(H_o)] - \log[L(H_1)] \quad (11)$$

where L (H_0) and L (H_1) are the likelihood function values under the null and alternative hypotheses respectively. In most cases, this statistic has chi-square distribution with degrees of freedom equal to the difference between the number of parameters of H_o and H_1, if H_0 is true.

RESULTS AND DISCUSSION

Socio-economic characteristics of respondents

About 91% of sawmills owners/ and or managers were male (Table 3). About 71% of the sampled sawmill owners/ managers had only primary education, 25% had secondary education while only 3.7% attained advanced level education. Majority of the respondents were adults whose age ranged from 28 to 60 years. As indicated in Table 3. The age composition shows that respondents aged between 18-27 years constituted only 26.6% while those between 28-60 years accounted for 68.9% and 5% aged over 60 years.

Table 3: Socio-economic characteristics of the respondents

Variable	Category	Frequency	Percentage
Age	18-27	21	26.6
	28-38	27	33.8
	39-49	23	28.8
	50-60	5	6.3
	> 60	4	5
	Total	80	100
Gender	Male	73	91.2
	Female	7	8.8
	Total	80	100
Marital status	Single	11	13.8
	Married	64	80
	Divorced	3	3.8
	Widow	2	2.4
	Total	80	100
Education level	Primary	57	71.3
	Secondary	20	25
	A- level	3	3.8
	Total	80	100

Table 3 indicates that the majority (80%) of respondents were married, 13.8% were single, while 2.4% were widows and 3.8% were divorced . Majority of the respondents are married most likely because they are adults. Being married impose a sense of responsibility to people because they need to raise money to run a family. In this way majority of such people tend to settle more or less permanently in an area unlike singles that have more freedom of movement. Being settled implies sustainability of the prevailing economic activities. Sustainability of the wood industry in this study area is therefore of paramount importance.

Characteristics Sawmills

Sawmills in Mufindi District were in general small and labour intensive (Table 4). Although the number of registered sawmills in Mufindi District was 445, sawmills actually in operation during data collection for the present study were 180 out of which 174 were small-scale sawmills. Most of the small-scale sawmills uses simple roller-bench mounted on water pump (Fig. 1). These machines are commonly known as Armec, and were run by diesel engine called Dingdong. The total volume of processed logs in Mufindi district in the year 2009 was estimated at 1million m^3 (Sige *et al*. 2005). The installed capacity of sawmills ranges from 500m^3/year to 250 000 m^3/year. The average output of the small-scale sawmills in the district is about 344.560 m^3/. Most small-scale sawmills in the area were relatively new, the average age of a surveyed 80 mills is 4 years. The oldest mill was established in 1994. The technology employed is simple and labour intensive. Small size, labour intensiveness, as well as poor layout, poor saw-doctoring and feeding systems were the cause of low recovery rate. The average recovery rate ranges from 20 to 43% (Sige *et al*. 2005).

Table 4: Type of sawmills

Type	Number
Large mills	4
Medium –scale	2
Small-scale	439
Total	445

Figure 1: Simple roller-bench mounted on water pump

Sawmill ownership

The results in Table 5 indicates that most sawmills in the study area were privately owned. Form of ownership of firms has important implication in firm's ability to acquire capital necessary for improvement of production technology especially in developing countries where majority of the rural population are poor.

Table 5: Form of ownership of sawmills

Ownership type	Frequency	Percent
Individual	72	90
Partnership	8	10
Total	80	100

Type of management

Most of the sawmills were managed by managers hired by owners as shown in Table 6. Managers were generally paid 5 000 - 10 000 TZS per day . Besides the daily payments to the managers, they are also given slabs as incentives based on their performances. Majority of managers were relatives of the sawmill owners(43 72% of hired managers were relativesof sawmill owners). Most of the owners/managers were males. Female owners/ managers were only four out of the 80 mills owners/ managers i.e 5%.

Table 6: Type of management in Sawmills

Type of management	Frequency	Percent
Hired manager	67	83.75
Owners manager	13	16.25
Total	80	100

Table 6 shows the details of the managers/owners training in the sawmilling industry and business administration. The results show that only a few managers had training in sawmilling and related work. Thirteen out of 80 sawmill managers/owners had special training on business administration. About 86.3% of the sawmill owners/managers indicated that they just depend on long experience of working in the sawmilling busness as their families have been doing it for generations (Table 7).

Table 7: Training received by managers/owners

	Saw-milling Industry		Business Administration	
	No. Responded	Percentage	No. Responded	Percentage
Training	11	13.8	13	16.2
No training	69	86.3	67	83.8
Total	80	100	80	100

As shown in the Table, managers/owners were relying on experience they have to manage the sawmilling industry. Over 88% of the mill owners/managers had more than five years experience in sawmilling.

Capital source

The results in Table 8 reveal that the contribution of the banking sector was very minimal as most saw millers depend on their own source capital. This might be accounted for by low sawmill owners understanding on project write up, high interest rate (over 20%), and lack of collateral demanded by banks. Bank loans have a significant contribution in establishment and development of any economically viable project and increase their efficiency. . Bank loans may enable firms (such as sawmills) to acquire modern working tools and technology to facilitate their production.

Table 8: Source of capital for sawmill establishment

Capital source	Frequency	Percent
Own	55	68.8
Family	2	2.5
Bank loan	23	28.8
Total	80	100

Timber storage area

Majority of sawmills in Mufindi District were mobile and depended on raw material supplied from SHFP. In most cases, these mills hire land from the surrounding villages at 125 000TZS / ha per month. As a result, most mills minimise the area they occupy to reduce production cost. The results in the present study show that most mills have less than half a ha of mill area. Reducing sawmill area leads to reduced timber storage area which could have implication to sawmill's productive efficiency. Nyrud *et al.* (2002) mentioned timber storage area to be among the factors influencing productive efficiency of sawmills.

Age of the machines

Table 9 indicates that almost half (46%) of the machines in the study area were old (> 15 years). The age of machines is an important factor in sawmills' productive efficiency as frequent breakdowns of such machines was obvious. Notwithstanding the old age of the machines, MNRT (2004) reported that most of these machines were locally fabricated producing 0.714 m^3 of sawn wood per hour. Most sawmill owners/ managers reported that modern machines are expensive both in buying and running cost (Table 10). Competent mechanics are not locally available; they have to be called from distant townships. Also availability of spare parts is another challenge because they are imported and therefore expensive and some are rare and would take a lot of time before the order is delivered. From these two reasons saw millers are perhaps reluctant to use modern machines.

Table 9: Age of Machine

Age	Frequency	Percent
1-5	6	7.5
6-10	31	38.8
11-15	15	7.5
> 15	37	46
Total	80	100

Furthermore, according to the manufacturer's user manual for KARA and LAIMET (medium sawmills machines), they produce 10 – 15 m^3 of sawn timber per day. This study shows that these machines were producing only 6m^3 per day, probably because the existing machines are very aged.

Table 10: Reasons for not using modern machines

Reason	Frequency	Percent
Not available	2	2.5
Expensive	61	76.3
Difficult to maintain	17	21.3
Total	80	100

Despite little use of modern machines in the study area, results indicate that 61% of saw millers had access to extension services. Results in Table 11 show that 71 out of 80 sampled sawmill use owned machines while 9 saw millers hire the machines. Notwithstanding the factor that large percent uses self-owned machine yet very few sawmills are self sufficient in terms of necessary equipment needed in sawmilling. For instance, a sawmill may have only the sawing machine but no vehicles for log transportation which is true for most sawmills in the study area. Hiring of sawmilling equipment may affect productive efficiency of sawmills especially when the nature of the contracts are not long term.

Table 11: Distribution of machine used in sawmilling

Type	Frequency	Percent
Self-owned	71	88.8
Hired	9	11.3
Total	80	100

Labour force

Due to having poor saw milling machine, the sawmilling sector in Tanzania is labour intensive. This is true also for sawmilling industries in Mufindi. Survey data (Table 12) indicates that the small-scale sawmills employ an average of 15 workers per mill, most of them being males. The number of workers indicated in Table 12 include all workers in every section of the sawmill:

tree felling crew, log loading and unloading crew, saw machine operators, and timber stacking crew. These results differ from a report by MNRT (2004) that the number of workers per sawmill was six. The difference could be due to the fact that MNRT considered only the saw machine operating crew.

Table 12: Descriptive statistics for sawmill's workers

Variable	Minimum	Maximum	Mean	Std deviation
Male workers	7	20	12.24	2.09
Female workers	0	6	2.46	1.48
Total number of workers	11	22	14.71	2.35

Female workers were very few (about 9%) in the sawmilling industries perhaps due to the nature of the job itself and gender job allocation in the area. Jobs requiring excessive manual work in the study area were considered as men's domain (Fig. 6). Sigel *et al.* (2005) reported that female workers in sawmilling industries in Tanzania were less than 50%.

Figure 2: Excessive manual works in logs feeding into machine

Figure 2 indicates the situation of workers in the study area, where most of the small sawmills did not posses safety accessories such as riving knife and top cover. In addition, feeding mechanism were manually done by pushing logs and planks to the saw using hands. This poses danger to the operators. Most workers lacked protective gears such as overalls, helmets and boots and sawing operations were done in the open.

Sawmilling Process

Raw material source and sawmills sustainability

Logs are key resources for any sawmill, and therefore sustainability of any sawmill depends on constant supply of wood. The most important source of logs for most sawmills in Mufindi District is SHFP. Registered saw millers are habitually offered with plots to harvest annually after payments of royalties and other taxes. The ability of the state owned plantations to meet the demand of wood based industry has been predicted to decline over the past two to three decades and suggestions are to strategise means of getting supplies from individual/private growers (Ngaga 2011).

However, signals for reducing reliance on SHFPl as the only source of raw materials was vivid. The truth of this statement is grounded on the fact that there are enormous reforestation efforts in the study area currently. Figure 3 shows that there was a remarkable tree planting effort in 2006 in the study area. For instance, the reforested area doubled in area from 3740 ha in 2005 to 10 048 ha in 2006, an increase of 6 308 ha in a single year (Green Resource 2007; 2008). Sawmilling activities in the district had a positive contribution to environmental conservation as it motivates the local people to plant trees to reduce dependence on natural forests for raw materials.

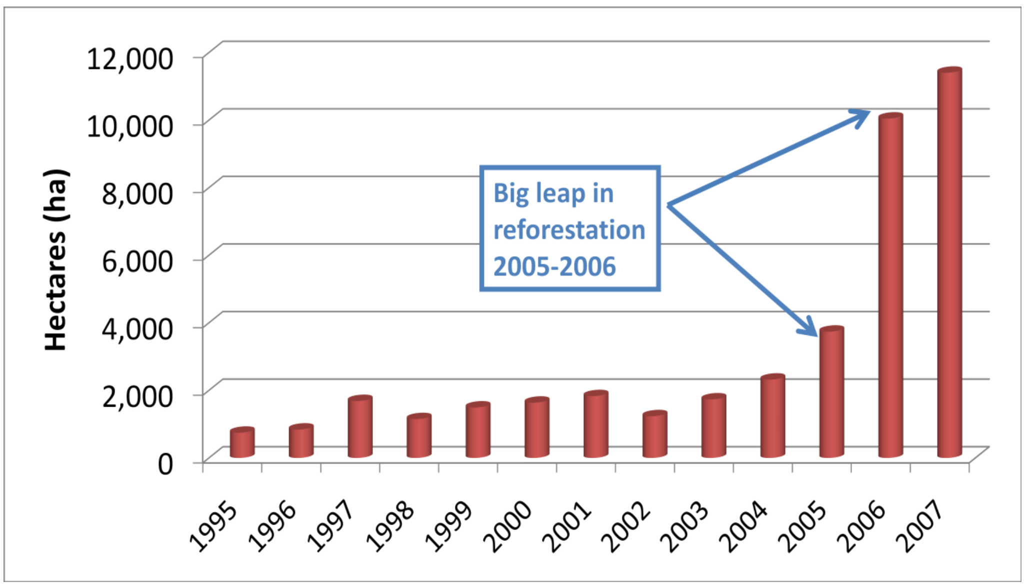

Figure 3: Reforestation effort in Mufindi District

Labour cost

Table 13 & 14 shows forest products royalty change and labour cost for various sawmilling activities in the study area. The labour cost per day varies due to various reasons. Perhaps the most significant reason was the man-day payment unit applied, where it is measured in terms of productivity. In tree felling operation, the man-day unit applied varies depending on the number of trees felled per day and whether the equipment (Chain saw) used is owned by the mill or hired. In most cases it belonged to the worker. A labourer owning a chain saw was paid TZS 500 per felled tree, and such a labourer could earn up to TZS 50 000 per day if they managed to fell100 trees. A labourer using a chain saw owned by a mill was paid TZS 100 per felled tree.

The same man-day payment scheme applied in the other forest operations, for example cross cutting and stacking the unit applied was the number of stacks per day. For sawing and timber stacking, the man-day rate was determined based on the number of timber pieces sawn/produced per day. In sawing operation, the payment varied from TZS 80 per piece up to TZS 700 depending on the size of the sawn timber and whether the machine was hired.

In the case of hired machine, payment is per sawn timber piece. Likewise, for stacking sawn timber, the same man –day payment scheme is applied, and the pay was per piece basis. The man- day payment system applied in the study area was like a carrot and stick approach to enhance productive efficiency of the small-scale sawmills in the area.

Table 13: Change in Forest Products royalty in Tanzania, 2002 & 2007

Species	Fee in TZS/ m^3 2002	Fee in TZS/ m^3 2007
All soft wood except Juniperus procera		
Class 1 (DBH < 10 cm)	**To be sold as firewood**	**To be sold as firewood**
Class II (DBH 11-20 cm)	1500	2000
Class III (DBH 21-25 cm)	2000	4000
Class IV (DBH 26-30 cm)	3000	10 000
Class V (DBH 31-35 cm)	3500	17 300
Class VI (DBH > 35 cm)	4500	19 200
Juniperus procera		
All sizes	50 000	50 000

Table 14: Descriptive statistics for labour cost /day for various activities in sawmill

Variable	Minimum(TZS)	Maximum(TZS)	Mean(TZS)	Std. Deviation
Tree felling	12 000	69 000	45 425	11 576.68
Cross cutting	48 000	123 500	81 325	18 204.55
Sawing	20 000	290 000	40 472.50	29 556.43
Stacking	2800	10 000	5649	1380.83

Log hauling cost

Log transportation constituted a huge industrial running cost even when raw material comes from a concentrated source such as SHFP. For instance, the cost of moving logs from the source plantation to factory area was found to be TZS 1,252/m^3. When this is factored by the amount of volume produced per day, it accounts for one third of sawmill running cost per day.

Source of power

Most sawmills in the study area used diesel, only large sawmills use electricity. The small-scale sawmills in the study area were found to use 19.98 litres of diesel per day on average which is about 4 litres/m^3, the minimum fuel consumption was 10 litres (2 litres/m^3) and the maximum was 30 litres (6 litres/m^3).

Small-scale sawmills profitability

Results revealed that small-scale sawmills in the study area produced 5m^3 of sawn timber per day. This result is similar to the report by MRT (2004) that on average small-scale sawmills produce 0.714 m^3 per hour, this figure if converted to per day basis assuming eight effective working hours per day it amounts to 5.712 m^3. Given timber price in the study area saw millers were found to earn TZS 1 000 000 per day at TZS 200 000 / m^3. However, this is gross revenue, if the running cost is deducted from the gross revenue, sawmill owners could earn about TZS 400 000 per day. Small-scale sawmill owners usually sell to buyers at mill site and therefore they do not incur timber transportation cost. Table15 present a summary of descriptive statistics for small-scale sawmills.

Table15: Summary of descriptive statistics for small-scale sawmills

Variable (unit)	Mean	Std. Deviation	Minimum	Maximum
Output (m^3)/day	4.948	1.175	2.440	7.100
Labour(no)	15.000	2.350	11.000	22.000
Male (no)	12.000	2.094	7.000	20.000
Female(no)	2.000	1.483	0.000	6.000
Logs(m^3)/ day	16.490	3.921	8.150	23.650
Land(TZS)/ month	53 813.500	17 740.102	25 000	150 000.000
Fuel(litres)/day	19.980	2.373	10.000	30.000
Lubricants (litres)/day	0.560	0.216	0.500	1.500
Experience(yrs)	22.31.000	16.371.000	5.000	46.000
Education(yrs)	7.673	2.142	7.000	13.000
Ownership	1.100	0.301	1.000	2.000
Age machine(yrs)	15.140	2.837	4.000	20.000
Management	0.620	0.317	0.000	1.000
Machine type	0.586	0.496	0.000	1.000
Capital source	1.6	0.908	1.000	3.000
Storage area	1.862	0.496	1.000	3.000

Productive Efficiency Results

DEA efficiency scores

Results revealed a mean technical efficiency of 84% (CRS model) and 92% (VRS model). The fact that sawmills had an average efficiency of 84 % indicates their observed output constitutes 84% of their potential output given by the best performance of the mills. This shows that there is still a room for improvement on the performance of sawmills in Mufindi District. Small-scale sawmills' production could be improved by further 16% through more efficient use of their given inputs (Table 16).

Table 16: Efficiency scores

Variable(model)	Mean	Std. deviation	Minimum	Maximum
TE(CRS)	0.84	0.09	0.63	1
TE(VRS)	0.92	0.06	0.78	1
AE(CRS)	0.84	0.06	0.63	1
AE(VRS)	0.89	0.06	0.76	1
CE(CRS)	0.70	0.07	0.55	1
CE(VRS)	0.81	0.09	0.66	1
SE	0.91	0.08	0.65	1

The mean allocative efficiency of the small-scale sawmills was about 84% (CRS) and 89% (VRS). The higher average allocative efficiency shows that most small-scale saw millers use inputs in proportions that minimise production cost, even though they could still adjust their inputs mix so as to minimise further the production cost by 16%. On average, overall economic or cost efficiency per sawmill was found to be about 70% (CRS) and 81% (VRS, respectively. The values for relative scale efficiency finally vary from 65% to 100% with a mean scale efficiency of about 91% (Table 16).

Table 17 shows that 6.5% of the small-scale sawmills had technical efficiency scores which were less than 70%. More than 90% of the small-scale sawmills had efficiency score of more than 70%. There was a slight increase in return to scale for the majority of the small-scale sawmills in the study area with average of 0.804 and standard error of about 0.78 for CRS model. Fig. 8, 9 and 10 shows sawmill efficiency distribution (CRS model), (VRS model) and scale efficiency distribution respectively.

Table 17: Frequency Distribution of DEA Technical Efficiency Scores

Efficiency	Number of sawmills	Percent
60 -70%	5	6.25
71 - 80%	27	33.75
81 -90%	26	32.50
91 – 100%	22	27.5
Total	80	100

In addition, the results in Appendix 3 indicate that out of the 80 mills surveyed, 5 mills were technically efficient. A total of 59 sawmills showed increasing returns to scale while 16 mills exhibit decreasing returns to scale, this means that only 5 mills are on the frontier. This implies that most sawmills in the study area are not efficient.

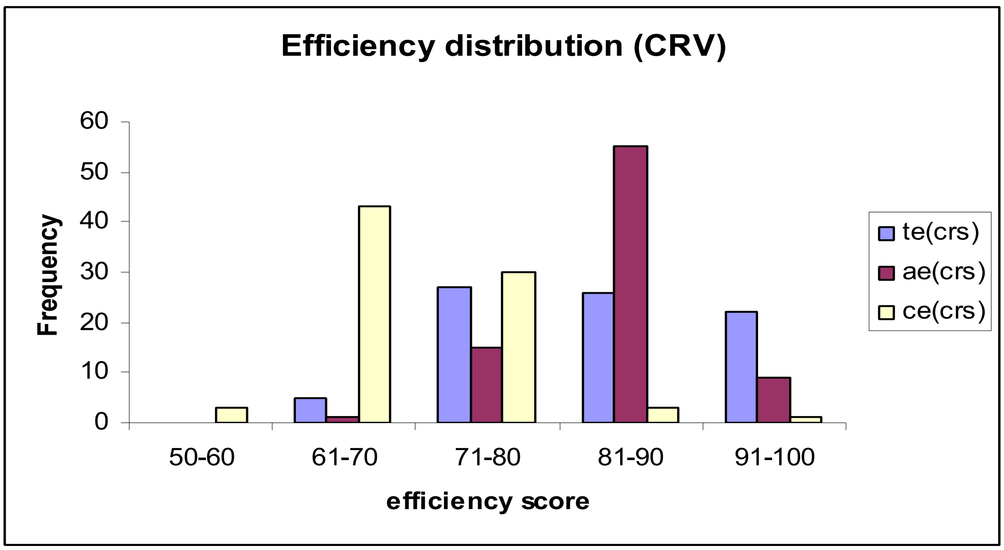

Figure4: Relative frequency distribution of small-scale sawmill

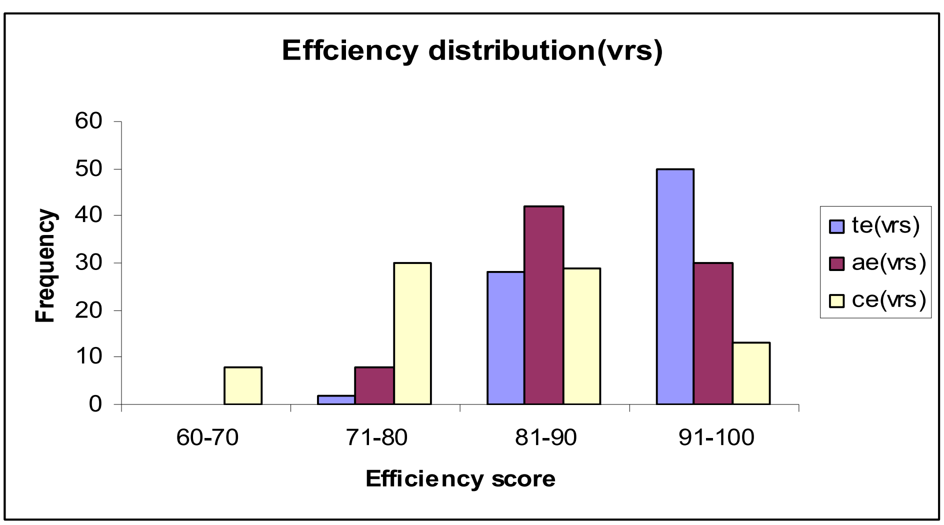

Figure 5: Relative frequency distribution of efficiencies of small-scale sawmills

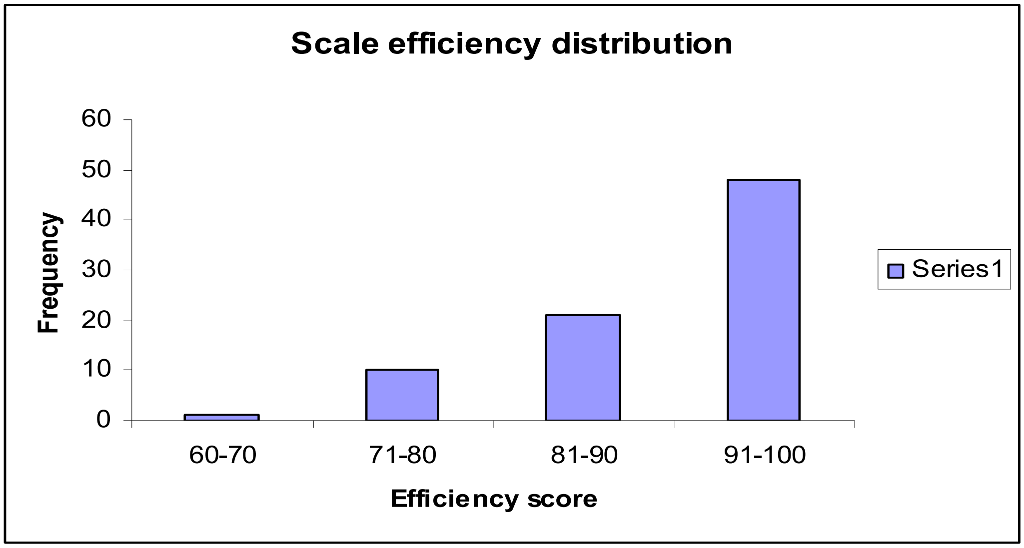

Figure 61: Scale efficiencies distribution of small-scale sawmills

Source of inefficiency

The coefficient for education of mill owner/and or manager is positive with ‘t’ value greater than one showing that mills managed by more educated managers are more efficient. This result is in keeping with those reported by Gunatilake *et al*. (2002). The coefficient for the type of mill ownership is also positive with computed ‘t’ value greater than zero, indicating that mills owned by partners/ groups are more efficient than those owned individually perhaps because a company might have high chance of enhancing their sawmilling skills and strategies as they have large think tank. Table 18 shows maximum likelihood estimates for parameters of inefficiency.

Table 18: Maximum likelihood estimates for parameters of inefficiency

Variable	Coefficient	.|P[|Z|>z]	T
CONST	0.507	0.0000	11.456
EDUCOFRE	0.556	0.0002***	3.696
OWNERSHIP	0.720	0.0044***	2.896
TIMBERYA	0.812	0.0000***	4.288
WORKERSE	0.405	0.02221**	2.288
MANAGEME	0.333	0.0784*	1.760
MACHAGE	-0.561	0.0000***	-4.704
MACHSOR	0.828	0.0012***	3.228
Variance parameters			
δ	0.728	0.0000	12.490
Log. Likelihood function	75.711		

* significance at (p<0.05), ** significance at (p<0.01), *** significance at (p<0.0001)

The coefficient for timber yard size (storage) facility is positive as expected and statistically significant at 1% as an important factor for sawmilling productive efficiency in the study area. The result in Fig. 7 shows that mills with large timber storage area were more efficient as also observed by Nyrud *et al*. (2002).

Likewise, the coefficient for experience is positive and statistically significant indicating that sawmill manager/ owner education and experience had a positive influence on sawmill's efficiency as expected (Fig.8& 9). It was reported by Sauer and Abdallah (2007), Alvarez and Crespi (2003) that experience had a positive effect on production unit efficiency. The coefficient for machine age is negative and statistically significant at 1%, indicating that productive efficiency of a mill decreases with increasing machine age (Fig.10). Using hired machines had positive influence on efficiency. This is surprising, may be mills using hired machines utilise the machine more efficiently.

To test the hypothesis guiding the present study (All small-scale sawmills are efficient), restriction was imposed on the model defined in equation 18 ($EFF_i^* = \beta_1 + \beta_2 MGMT + \beta_3 EXPERE$ $\beta_4 EDUCATI + \beta_5 TMBYSIZE + \beta_6 FOROWNSH$ $\beta_7 MACHAGE + \beta_8 MACHOWNSHP$). To check whether this restriction is valid or not, the generalised likelihood ratio test was used. The null hypothesis tested was: H_o "All sawmills are efficient" if the hypothesis is true, it means there are no inefficiency effects in small-scale sawmills. The omission of inefficient effect is equivalent to imposing the restriction specified in the null hypothesis:

H_o: $\gamma = \beta_1 = \beta_2 = \beta_3 = ... = \beta_8 = 0$ ....(20)

When the restriction was imposed on the model represented by equation 18, the value of log likelihood function was reduced severely to -119.63. This provides generalised ratio test statistic of 477.26 which is very large compared with the critical value range of 5.14 to 13.40. Thus, the null hypothesis that "All small-scale sawmills are efficient" is rejected.

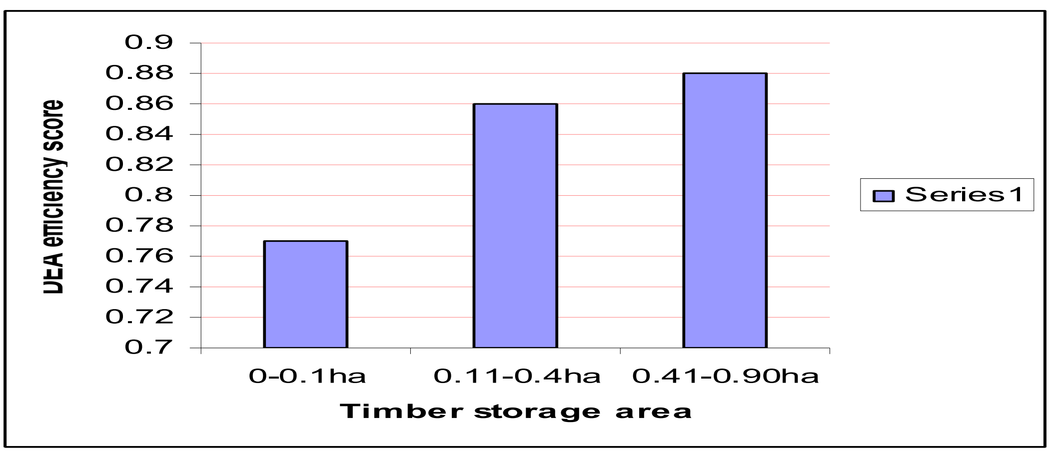

Figure 7: Efficiency score against timber storage area index

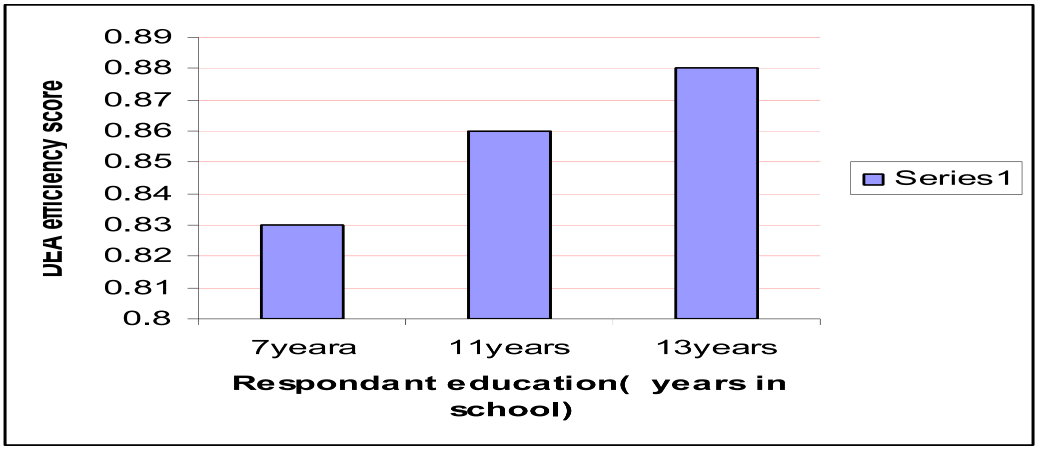

Figure 8: Efficiency score against education index

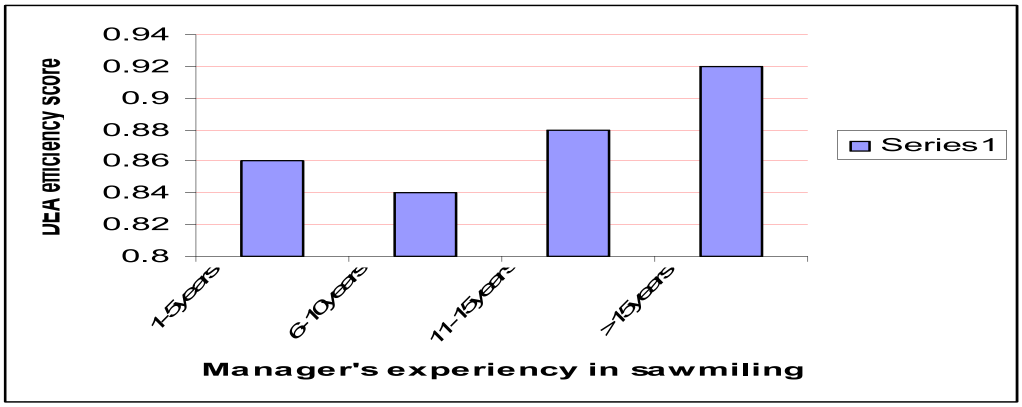

Figure 9: Efficiency score against experience index

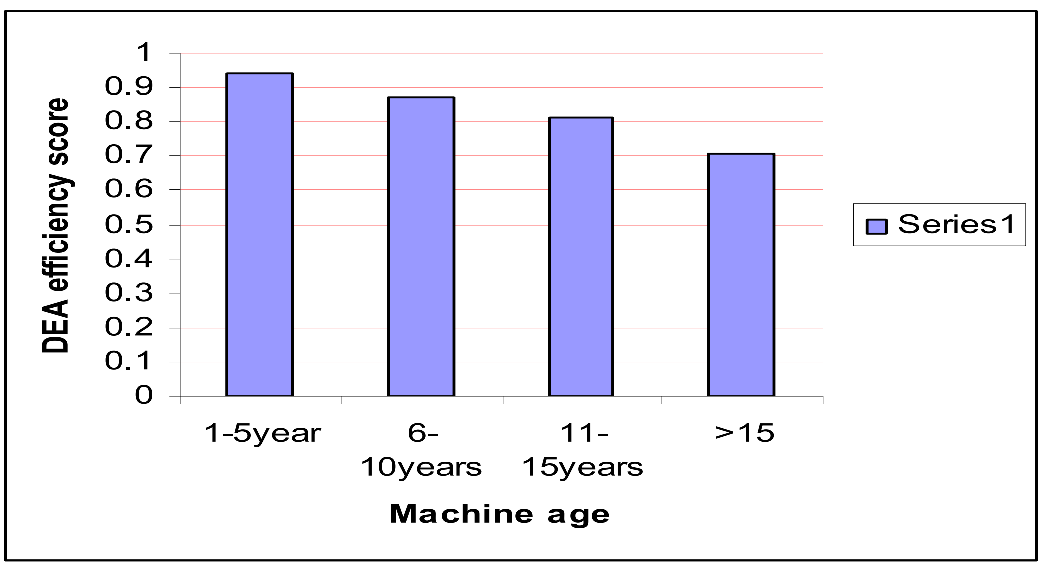

Figure 10: Efficiency score against machine age Index

CONCLUSION AND RECOMMENDATION

The study concludes that the sawmilling industry in Mufindi is dominated by small scale- labour intensive 'dingdong 'sawmills. Inefficiency is high and is attributed to old age of the machines, scarcity of genuine spare parts, low managerial and labour skills, high running costs (e.g. hauling, labour and diesel costs) and small-sized yards. The study recommends that there is room for increasing the efficiency if the above mentioned attributes are addressed. The government should support the saw millers by creating an enabling environment such as improved transport infrastructure and promotion of private plantation establishment. The saw millers must strive to employ professional sawmill managers and skilled labourers or introduce on-job training schemes. Associated with inefficient recovery rates is the fact that most of the machines are old with difficulties in obtaining genuine parts. Efforts should be made by both the government and the business sector so that new machines are obtained in line with supply of genuine parts. His can be done through introduction of tax relief, improved awareness of businessmen, blocking imports of fake parts, etc.

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