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# TECHNICAL AND ALLOCATIVE EFFICIENCY OF PALM OIL PROCESSING IN BENUE STATE

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**ABSTRACT**

This study investigated the technical and cost efficiency of palm oil processing in Benue State, Nigeria. Primary data were collected randomly from 120 palm-oil processors, during the 2006/2007 cropping season, using structured questionnaire. The collected data were analyzed using descriptive statistics and stochastic production frontier model. Results of the technical inefficiency show that capital, labour and quantity of palm- fruit with coefficients 0.44,0.84 and 0.15 respectively, had significant effect on the quantity of palm oil processed in the study area and that, the producers were producing at an increasing return to scale (1.98). Age and household size with the coefficients of 4.78, and 9.43 respectively, significantly and positively affect the technical efficiency of the palm oil processors while education with coefficient -1.93 had negative significant effect . The result reveals an average technical efficiency of 91 percent showing that the processors actually operate with a level of inefficiency (9%). Moreover, the results show that the cost of palm fruit and labour with coefficients 0.33 and, 0.51 respectively, significantly and positively affect the total cost of palm oil production. Household size and years of processing experience with coefficients of 0.60 and -0.15 respectively, affect the allocative efficiency which varied widely (1.02-1.99) among the palm oil processors in the study area. This suggests that a considerable palm oil production potential remains to be exploited through better use of available resources. The study, therefore, recommends that better access to labour, palm fruits and farm-specific efficiency factors, which include enhanced education will sustain the production of palm oil.

**Keywords:** Technical efficiency, stochastic production frontier, random variability, specific variability. allocative efficiency.

## INTRODUCTION

Palm Oil processing is a major source of income and employment to a large proportion of resource-poor rural population in Nigeria. Palm oil is produced from palm fruits, along with other palm products such as palm kernel and palm kernel cake. Specifically, the oil is produced from the fleshy mesocarp of the palm fruit which contains about 45 – 55 percent oil (F.O.S. 1995). It is used as food as well as an industrial raw material for the manufacture of soap, candle, paints, margarine, biscuits, lubricants for machinery, cosmetic and polishing liquids (Aya,2000).


Fig.1 MAP OF NIGERIA

In Nigeria, (fig.1) the demand for palm oil has risen in tones due to increased income, urbanization and declining domestic production (Nwanze, 2002), Nigeria's output in oil palm production was rising until 1973, when Nigeria lost her foremost place in palm oil exportation. Thus, there was a decline in its output and contribution to Gross Domestic Product (Ohajianya, 2004 and Opeke, 1977).

Nigeria is now a net importer of palm oil (FAO, 2004). Several factors have been identified to be responsible for the declining output in palm oil production in Nigeria. These include poor method of palm oil extraction, lack of access to financial credit, poor power technology and resource management Among these factors, inefficiency in resource use has been identified as the most critical. (Bek-Nielson, 2001).

It is expected that efficient management decisions in the application of scarce resources can lead to increased and sustained output of palm oil in Nigeria. This study, therefore, seeks to estimate the technical and allocative efficiency of palm oil processors in Benue State, Nigeria.

## REVIEW OF THE LITERATURE

### The Concept of Technical and Allocative Efficiency

The efficiency of a firm comprises of two components; technical and allocative efficiency, and the combination of these two components determines economic efficiency. (Farrel, 1957). Technical efficient (TE) is the ability of a firm to obtain maximum output from a given set of inputs in contrast to allocative efficiency which reflects the ability of a firm to use inputs in optimal proportion given their prices. It is divided into pure or physical and scale efficiency

The pure-technical or physical efficiency is the ability to avoid waste by producing as much output as input usage allows for by using as little input as output production allows (Lovell, 1993). It was also defined as the maximization of ratio of output to input (Arene and Okpukpara, 2006). It measures the magnitude of the physical ratio of production output to factor input without taking into consideration factor input and output prices. The biggest the output (Y) relative to input (X), the greater is the technical efficiency. An efficient technique implies that resources are used in a manner that does give maximally efficient product from given resources and this will ensure sustainable output of palm oil production.

Scale efficiency on the other hand exists in a situation where the firm is operating at an optimal scale and taking advantage of economics of large-scale production which consequently leads to increasing returns to scale and reduction in average production cost.

Literature emphasizes two broad approaches to the measurement of technical efficiency: the non-parametric programming and statistical approach, Kedebe (2001) classified these two approaches as the econometric methods and the non-parametric Data Envelopment Analysis (DEA) methods.

Oren and Alemdar (2006) observed that both methods and approaches construct a production frontier indicating maximum production attainable under current technology, and evaluate the production of each unit with respect to this frontier. Distance from the frontier measures efficiency of the production unit. However, each method uses a different approach to construct production frontier.

In agricultural economic literature, use of stochastic frontier analysis is recommended because of the inherent nature of uncertainty associated with agricultural production (Coelli et al, 1998). Studies of sources of technical efficiency are concerned with the role of farm and farmers' characteristics. Obwona (2000) made use of demographic characteristics, resource factors and institutional factors to examine the determinants of technical efficiencies. These include age, sex, education, family size and income level of the farmers. Olukosi and Erhabor (2005) also linked socio-economic and policy variables to technical efficiency.

.Likewise Ajibefun and Daramola (2003) identified age, processing experience education and household size as the socio-economic characteristic affecting technical efficiencies in agricultural production.

**Stochastic Production Frontier Model**

The stochastic production frontier is an econometric method of efficiency measurement in production systems and is built around the premise that a production system is bounded by a set of smooth and continuously differentiable concave production transformation functions for which the frontier offers the limit to the range of all production possibilities. It has the advantage of allowing simultaneous estimation of individual technical efficiency of the respondent farmers as well as the determinants of technical efficiency (Battese and Coelli, 1995). The original specification involved a production function which has two components, one to account for random effects and another to account for technical efficiency.

The model is specified as follows:

$$Yi = f(X_{ki,}\ \beta)\ e^{\varepsilon i}, \quad i = 1 \ldots\ldots, n \quad k = 1 \ldots\ldots\ldots\ldots k \qquad (1)$$

Where

Yi = Output of the ith farmer

$X_{ki}$ = vector of k inputs by the ith farmer

f = a suitable functional form such as Cobb Douglass or translog.

β = vector of parameters to be estimated

εi = the farm specific composite residual term comprising of two

Independent elements: error term Vi and an efficiency component Ui

$$\varepsilon i = Vi + Ui, \quad i = 1 \ldots \ldots\ldots\ldots n \qquad (2)$$

The symmetric component, V is the two-sided normally and independently distributed random term as N $(O,\sigma v^2)$ which accounts for random variation in output due to factors outside the farmers' control such as weather and diseases. A one-sided component U, reflects technical inefficiency relative to the stochastic component and are often assumed to be either normally distributed as truncations at zero of the Normal $(\mu,\sigma_u^2)$ distribution ,though it can also be assumed to be half normally distributed $N(\mu,\sigma_u^2)$. (Dawson, 1990). The maximum likelihood estimated equation (1) yields estimates for β after making assumptions regarding the distributions of Ui and Vi where β was defined as earlier, $\lambda = \sigma_u/\sigma_v^2$ and $\sigma_u^2$ were replaced with $\sigma^2 = \sigma_v^2 + \sigma_u^2$ and output from the frontier attributed to technical efficiency.

Measure of technical efficiency for individual farmer was calculated as:

$$TEi = \exp\ [E\ \{- Ui/\varepsilon\}] \quad i = 1 \ldots\ldots\ldots\ldots\ldots\ldots n \qquad (3)$$

Ui in equation 3 is defined as:

$U = f(Zi, \delta)$ (4)

Where Z is a vector of variables ,which may influence the efficiency of a farm. δ is a vector of parameters to be estimated. The Cobb-Douglas stochastic frontier production function assuming a truncated normal distribution in specifying the technology of the farmers was employed.

## METHODOLOGY

### The Study Area

The study area, Benue State (fig.2) is geographically located in the middle belt of Nigeria, stretches between longitude 6o-10o. The State was created in 1996. It has a landmass of about $180km^2$ and a population of about 42, 19244 people (CBN, 2007).

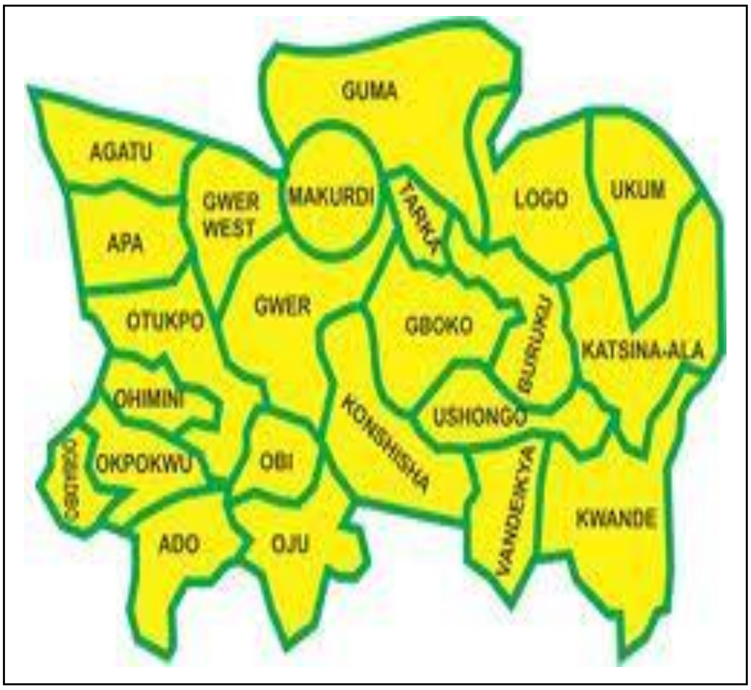


Fig.2 LOCAL GOVERNMENT AREAS IN BENUE STATE

The study was carried out in Obi Local Government of Area of the State .It has a population of about 98,855 people (NPC,2006) and about 45, 854 farm families with over 80 percent of the population engaging in farming. Apart from the cultivation of common arable crops such as yam, cassava, rice, etc., tree crops such as oil palm, coconut and citrus also thrive in the area. Palm oil processing is a major source of income and both men and women are involved in its processing.

## Data Collection

A multi-stage random sampling technique was used in the selection of the respondents. First, four villages were purposively selected for the study, being the palm-oil producing area of the area. Then a random selection of ten palm oil processors was selected, using a compiled list of palm oil processors by the community leaders in each village. This gives a total of 120 palm oil processors as respondents for the study. Primary data were collected from the palm oil processors using structured questionnaire. The questionnaire was was used to obtain information on the level utilization of relevant processing inputs and also the processors' socioeconomic variables.

## Data Analysis

Data were analyzed using the stochastic frontier production function with multiplicative disturbance term following. ( Helfland ,2003).

The empirical model of the stochastic production frontier is specified as:

$$LnY=\beta_o+\beta_1 L_nX_{1ij}+\beta_2 L_nX_{2ij}+\beta_3 L_nX_{3ij}+\beta_4 L_nX_{4ij}+V_{ij}-U_{ij} \quad (5)$$

Where Ln represents Natural Logarithmic to base e; subscripts i and j refer to the ith farmer and jth observation respectively.

$Y$ = quantity of palm oil produced by the processor (litre)

$X_1$ = quantity of palm fruit (kg)

$X_2$ = quantity of labor (mandays)

$X_3$ = Capital (₦)

$X_4$ = Volume of water used (litre)

$V_{ij}$ = a random error term with normal distribution

$U_{ij}$ = a non-negative random variable called technical inefficiency effects associated with technical inefficiency of production of farmers, assumed to be truncated at zero(0).

$\beta_o..\beta_4$ = parameters to be estimated.

The model which assumes that the inefficiency effects are independently distributed having $N(O, \sigma_u^2)$ distribution and mean $U_{ij}$ (Coelli and Battese, 1996) is of the form:

$$U_{ij} = \delta o + \delta_1 l_nZ_{1ij} + \delta_2 l_nZ_{2ij} + \delta_3 l_nZ_{3ij} + \delta_4 l_nZ_{4ij} + \delta_5 l_nZ_{5ij}$$

Where:

$U_{ij}$ = Technical efficiency of the ith palm oil processor

$Z_1$ = Age of the processor (years)

$Z_2$ = Educational Level (years)

$Z_3$ = Household size

$Z_4$ = Years of experience (years)

$Z_5$ = Variety of palm fruit (improved = 1, traditional = 0).

The maximum likelihood estimates of the $\beta$ and $\delta$ were estimated simultaneously using the computer program frontier 4.1 (Coelli, 1996).

The corresponding cost function is derived analytically and defined as follows:

**RESULTS AND DISCUSSION**

**Socio-economic characteristics of Palm Oil Processors**

The summary statistics of the sampled palm oil processor revealed that on the average, a typical palm oil processor is 43.34 years old, with 14.6 years of experience and 5.63 years of educational attainment. (Table 1). A respondent processed about 2,691.83kg of palm fruit using about 997.92 litres of water and employed 13.57 mandays of labour. Average annual production cost was ₦8, 809.10 while annual palm oil output was 104.52 litres. Average annual income realized was ₦14, 755.21. These statistics showed that palm oil processors are relatively young and energetic with long years of experience that are of advantage to the processing industry. However, their low educational levels and annual income hinder them from proper understanding, purchasing and adoption of modern palm oil processing techniques (Ozowa, 1995).

**Technical Efficiency of the Palm Oil processors**

The result indicates that the estimated gamma parameter ($\gamma$) is large (0.95) and significantly different from zero (Table 2). This implies that the variation of processed palm oil output from the maximum output arises mainly from differences in the use of best practice as opposed to random variability. That is, 95 percent of the variation in output among palm oil processors is due to differences in technical efficiency. Furthermore, the estimate of the variance parameter $\sigma_u^2$ is 0.43. This is significant at 1% level, suggesting that the conventional production function is not an adequate representation of the data. Thus, the results of the diagnostic statistics confirm the relevance of stochastic frontier production function, using Maximum Likelihood Estimator (MLE), which indicates that inefficiency effects abounds and influences the productivity of the palm oil processors in the study area.

The results also shows that the coefficients of quantity of palm fruits (0.15) labour (0.84) and capital (0.94) were positive and statistically significant at 1% probability level (Table 2). This means that, increasing the quantity of palm fruits, labour use and capital would result to increase in the output of palm oil.

Moreover, the sum of the coefficients of the inputs is 1.98.This indicates that the palm-oil processors in the study area are operating at an increasing return to scale. This implies that if all the resources are increased in the same proportion, the output will increase more than proportionate.

The result of the inefficiency effects model showed that age (4.78) education (-1.93) and household size (9.43) had significant effects on the level of technical efficiency of palm oil processors. The estimated coefficient of education (-1.93) was negative while that of age (4.78) and household size (9.43) were positive. These results indicated that technical inefficiency effects in palm oil processing declined with increased educational level, increased with age and household size. This implies that while educational attainment has positive effects, age and household size have negative effects on technical efficiency of palm oil processors in Obi LGA of Benue State. Palm oil processors with more years of formal education tend to be more efficient in processing, probably due to their enhanced ability to acquire technical knowledge and make good use of information about processing techniques. These findings agree with that of Coelli and Battesse (1996) and Amaza and Maurice, (2005).

Distribution of the technical efficiency reveals that the estimated technical efficiencies differ substantially ranging between 0.10 – 0.99 percent with a mean technical efficiency of 0. 91. The wide efficiency differential among the palm oil processors is an indication of a substantial potential efficiency improvement in palm oil processing. This result indicates that on the average, productive efficiency of palm oil processors fell by 9 percent from the maximum possible level. Thus, in the short run, there is room for increasing the efficiency by 9 percent, if the improved technologies used by the best processors are adopted. These efficiency results are similar to the results obtained in other works on the estimation of technical efficiency (Battesse, 1992).

**The Allocative Efficiency of the palm oil processors**

The result of allocative efficiency of the palm oil processors (Table 4) showed that the estimated sigma squared (6.75) was statistically significant and different from zero at one percent (1%) probability level. This indicates a good fit and the correctness of the specified distribution assumption of the composite error term. In addition, the magnitude of the variance ratio r, was estimated to be 0.70, suggesting that the systematic influences that are unexplained by the production function are the dominant sources of errors. This means that 70 percent of the variation among the palm oil processors in the study area is due to differences in allocative efficiency. Thus, the results of the diagnostic statistics confirmed the relevance of stochastic frontier production function, using the maximum likelihood estimates.

The coefficients of palm fruit cost (0.33), labour cost (0.51), water cost (0.025), firewood cost (0.38) and tank cost (0.05) were positive. However, only the coefficients of palm fruits cost and labour cost are statistically significant at one percent (1 %) probability level. It therefore follows that as the cost of palm fruit and labour increase, total cost of processing palm oil also increases .The estimated coefficient of household size (0.06) was positive while that of the years of processing experience (-0.15) was negative. These variables household size and years of processing experience were statistically significant at one percent (1%) probability level. This result suggests that allocative efficiency in palm oil processing in Obi Local Government Area increased with increased years of processing experience and decreased with increased household size. This means that the more experienced the processors are in palm oil processing; the more efficient they are in the allocation of resources while the smaller the household size of the processors, the more efficient they are in the allocation of resources in Obi LGA, Benue State. This implies that policies that would encourage processors with long years of experience and small household size to engage in palm oil processing would increase allocative efficiency in the study area.

The allocative efficiency also varied widely among processors ranging between 1.02 and 1.99 with a mean efficiency of 1.05 (Table 5). This result suggests that allocative efficiency in palm oil processing in Obi LGA could be increased by 95 percent through better-cost allocation to resources, given the current state of technology

### Constraints Militating Against Palm Oil Processing

The results of the study identified the various problems which militated against the processing of' pa1m oil in the study area.( Table 6). The top four problems include scarcity of water during the dry season (81.68%), lack of processing machines (80%), scarcity of firewood (power) (65.83%) and transportation problem (62.5%). The processors were also faced with problems of inadequate capital/fund (55%) anprifluctuation of their produce (55%).

## CONCLUSION

The results of this study show that technical efficiency in palm oil processing in Obi LGA of Benue State, ranges from 10 percent to 99 percent with a mean of 91 percent, suggesting that there are more opportunities to increase the efficiency of the processors through more efficient utilization of processing techniques and inputs.

Considering the significance of labor, capital and quantity of palm fruits, policy attention should be directed towards providing labor saving technology to ease palm oil processing. Also, policies to ensure that processors have good access to capital to enhance efficiency should be designed. This will ensure sustainable palm oil production.

With regards to palm oil processors-specific factors, especially age, education and household size which were found significant, policy to promote formal education and encourage younger people to engage in palm oil processing is advocated.

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TABLE 1: SUMMARY STATISTICS FOR THE SOCIO-ECONOMIC CHARACTERISTICS OF PALM OIL PROCESSORS IN OBI LGA, BENUE STATE.

| Variable | Minimum | Maximum | Mean | Standard Deviation |
|---|---|---|---|---|
| Annual Palm Oil Output (litre) | 8.0 | 2,000.0 | 104.52 | 232.31 |
| Annual Income (₦) | 1,440.0 | 240,000.00 | 14,755.21 | 24,110.19 |
| Annual Production Cost (₦) | 1,110.0 | 124,400.0 | 8,809.10 | 13,123.20 |
| Labor (mandays) | 1.70 | 149.40 | 13.57 | 16.96 |
| Quantity of Palm Fruit (kg) | 100.0 | 120,000.0 | 2,691.83 | 11,776.22 |
| Water Volume (Litre) | 35.0 | 62,000.0 | 997.92 | 5652.41 |
| Age (years) | 25.0 | 65.0 | 41.34 | 10.21 |
| Processing Experience (years) | 2.0 | 43.0 | 14.60 | 6.83 |
| Educational Level(years) | 0.00 | 17.0 | 5.63 | 4.76 |
| Valid N (Listwise) = | 120 | | | |

**Source: Field Survey, 2007**

TABLE 2: MAXIMUM LIKELIHOOD ESTIMATES OF COBB-DOGULAS

PRODUCTION FRONTIER MODEL FOR PALM OIL PROCESSORS IN OBI LGA, BENUE STATE

| **Variable** | **Parameter** | **Maximum Likelihood Estimates of the production function** | **t-values** |
|---|---|---|---|
| **Stochastic frontier** | | | |
| Constant | $\beta_0$ | -1.17 | -1.20 |
| Quantity of fruit ($x_1$) | $\beta_1$ | 0.15 | 8.80** |
| Labour ($x_2$) | $\beta_2$ | 0.84 | 2.91** |
| Capital ($x_3$) | $\beta_3$ | 0.44 | 2.38** |
| Volume of water ($x_4$) | $\beta_4$ | 0.55 | 1.24 |
| **Inefficiency Model** | | | |
| Constant | $\alpha_0$ | 7.34 | 1.11 |
| Age ($Z_1$) | $\alpha_1$ | 4.78 | 3.54** |
| Education ($Z_2$) | $\alpha_2$ | -1.93 | 8.50** |
| Household size ($Z_3$) | $\alpha_3$ | 9.43 | 9.06** |
| Years of experience ($Z_4$) | $\alpha_4$ | -0.99 | -1.93 |
| Variety of palm fruit ($Z_5$) | $\alpha_5$ | -0.55 | -1.40 |
| Sigma squared | $\sigma^2$ | 0.43 | 4.81** |
| Gamma | $\gamma$ | 0.95 | 7.31 |
| Log likelihood function = | 50.89 | | |

**Source: Field Survey, 2007**

TABLE 3: FREQUENCY DISTRIBUTION OF TECHNICAL EFFICIENCY IN

PALMOIL PROCESSING

| Technical Efficiency | Frequency (F) | Percentage (%) |
|---|---|---|
| $\leq$ 0.30 | 63 | 52.50 |
| 0.31 – 0.76 | 3 | 2.50 |
| 0.77 – 0.86 | 21 | 17.50 |
| 0.87 – 0.89 | 7 | 5.83 |
| 0.90 – 0.99 | 26 | 21.67 |
| Total | 120 | 100.00 |
| Mean technical efficiency | | 0.91 |
| Minimum technical efficiency | | 0.10 |
| Maximum technical efficiency | | 0.99 |

Source: Field Survey, 2007

TABLE 4: MAXIMUM LIKELIHOOD ESTIMATE FOR THE PARAMETERS IN COST FRONTIER FUNCTION FOR PALM- OIL PROCESSORS IN BENUE STATE, 2007

| Variable | Parameter | Estimate | Std error | t-ratio |
|---|---|---|---|---|
| **Stochastic Frontier** | | | | |
| Constant | $P_O$ | 1.20 | 0.22 | 5.34 |
| Ln (Palm fruit cost) | $P_1$ | 0.33 | 0.22 | 14.98** |
| Ln Labour (cost) | $P_2$ | 0.51 | 0.42 | 12.15** |
| Ln (water cost) | $P_3$ | 0.03 | 0.26 | 0.95 |
| Ln (Firewood cost) | $P_4$ | 0.38 | 0.29 | 1.34 |
| Ln (Tank cost) | $P_5$ | 0.05 | 0.27 | 1.84 |
| **Inefficiency Model** | | | | |
| Constant | $\delta_0$ | 0.13 | 0.60 | 0.21 |
| Age | $\delta_1$ | 0.61 | 0.68 | 0.91 |
| Educational level | $\delta_2$ | -0.63 | 0.99 | -0.64 |
| Household size | $\delta_3$ | 0.06 | 0.20 | 3.03** |
| Years of processing experience | $\delta_4$ | -0.15 | 0.79 | -18.97 |
| Variety of palm fruit | $\delta_5$ | 0.24 | 0.61 | 0.40 |
| Sigma squared | $\sigma^2$ | 6.75 | 0.19 | 3.58** |
| Gamma | $\gamma$ | 0.70 | 0.11 | 6.59** |

Log likelihood functions =50.89

** T-ratio is significant at 1% probability level

TABLE 5: DISTRIBUTION OF PALM OIL PROCESSORS IN OBI LGA BENUE STATE BY ALLOCATIVE EFFICIENCY

| Allocative Efficiency | Frequency (f) | Percentage (%) |
|---|---|---|
| 1.02-1.08 | 103 | 85.83 |
| 1.09-1.15 | 2 | 1.67 |
| 1.16-1.22 | 2 | 1.67 |
| 1.23-1.29 | 1 | 0.83 |
| ≥1.29 | 2 | 1.67 |
| TOTAL | 120 | 100 |
| Mean Efficiency | 1.10 | |
| Minimum Efficiency | 1.02 | |
| Maximum efficiency | 1.99 | |

Source: Field Survey,2007

TABLE 6: CONSTRAINTS OF PALM OIL PROCESSORS

| S/n | Constraints/Problem | *Frequency (F) | *Percentage (%) |
|---|---|---|---|
| 1 | Inadequate capital/fund | 69 | 57.5 |
| 2 | Scarcity of water in the dry season | 98 | 81.67 |
| 3 | Transportation problem | 75 | 62.50 |
| 4 | Scarcity of firewood (power) | 79 | 65.83 |
| 5 | Lack of processing machines | 96 | 80.00 |
| 6 | Palm oil price fluctuation | 66 | 55.00 |
| 7 | Others | 23 | 19.17 |

Source: Field Survey, 2007.

*Analysis includes multiple responses.