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*Full Length Research Paper*

# Efficiency of resource-use and elasticity of production among catfish farmers in Kaduna, Nigeria

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**This study employed the use of the Stochastic Frontier Production Function in the empirical analysis of efficiency of resource-use and elasticity of production among catfish farmers in Kaduna, Nigeria. The simple random sampling technique was employed in selecting 60 catfish farmers drawn from the sampling frame obtained from the list of list of Agricultural Development Programme (ADP) contact farmers in the four Local Government Areas (LGAs) of Chikun, Igabi, Kaduna and Kaduna North, which made up the study area. Empirical estimates from the analysis showed Marginal Physical Product (MPP) values ranged from -430.850 for catfish feed to 1.004 for labour. It was equally established in this study that catfish farmers in the study area were not efficient in their use of production inputs, based on VMPi/Pxi ratios that ranged from -426.71 for catfish feed to 3.46 for labour, with none approximating to unity (which would have indicated that the farmers were optimally efficient in their use of production inputs). Also, production elasticity estimates indicated that the farmers were in stage 2 of the production process, with a return to scale of 0.664. These estimates indicate the existence of intervention points for relevant stakeholders in the bourgeoning catfish business in Kaduna.**

**Key words:** Efficiency of resource-use, food crisis, elasticity of production, maximum likelihood estimates, ordinary least squares, return to scale, stochastic frontier production function.

## INTRODUCTION

The Federal Ministry of Agriculture and Water Resources (FMAWR, 2008) estimated that local fisheries supplies in Nigeria is inadequate and this is partly responsible for the current low daily animal protein intake per head per day of 10 g compared to FAO recommended 36 g. Nigeria is currently the largest fisheries producer in Africa, with an annual output of over 635,379 tonnes (FMAWR, 2008). However, about $400 million is still spent annually on imports of about 560,000 tonnes to augment shortfalls in domestic supplies (FAO, 2007). In the wake of a looming "global food crisis" that Nigeria is not isolated from, more emphasis is now being placed on increased domestic supplies. One sure way of doing this is by ensuring the efficiency of catfish farmers in their use of production inputs, catfish being the most commonly cultivated species of fish because of its superior market value (FAO, 1993). A more efficient use of production inputs would ultimately impart positively on productivity and by extension, farmers' profitability, *ceteris paribus*.

These resource-poor smallholder farmers (Emokaro and Erhabor, 2006a), who contribute more than 90% of agricultural output in Nigeria in particular (FMAWR, 2008) and Sub-Saharan Africa in general (Spencer, 2002), must be assisted to rise beyond the level of subsistence to higher levels of profitability through more efficient use of their production resources. Thus, the main objective of this study was to identify any gaps that may exist in the current level of technology employed by catfish farmers in Kaduna through the use of the Stochastic Frontier Production Function (SFPF) in the estimation of the efficiency of resource-use and production elasticities among catfish farmers in the study area. This would provide empirical evidence of gaps that may exist in the farmers' current level of technology. These gaps would serve as intervention points that would assist in enhancing the productivity and profitability of the farmers, as well as encouraging them to beef up their current level of output so as to bridge the current shortfalls in local supplies.

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Researchers in the past have applied the use of the SFPF in estimating efficiency of resource-use for specific agricultural enterprises (Utomakili, 1992; Emokaro and Erhabor, 2006a; Ogundari et al., 2006). The uniqueness of this current effort is however in the fact that this is the first time the SFPF would be used in estimating the efficiency of resource-use and production elasticities among catfish farmers in Kaduna.

## MATERIALS AND METHODS

### Study area

This study was conducted in the metropolis of Kaduna, a City in North Western Nigeria, capital of Kaduna state. Kaduna State comprised 23 Local Government Areas (LGAs) with a land area of about 46,053 $km^2$ and an estimated population of 6,066,562 (Census, 2006). Kaduna State is bordered by Sokoto, Katsina, and Kano State to the North, Bauchi to the East, Plateau to the East and South, Niger to the West and Abuja to the South. Kaduna is made up of four LGAs namely: Chikun, Igabi, Kaduna North and Kaduna South. These LGAs will constitute the area of study for this research

### Sampling procedure

The simple random sampling technique was used to select 60 respondents from the list of Kaduna State Agricultural Development Programme (ADP) contact farmers in the study area. Fifteen (15) catfish farmers were selected at random from Chikun LGA, twelve (12), twenty (20) and thirteen (13) from Igabi, Kaduna South and Kaduna North LGAs, respectively. The primary data used in this study were collected between December 2007 and March 2008, through personal interviews with respondents and the use of sets of well – structured questionnaire.

### Analytical techniques

The SFPF was used to determine the production function in this study (CEPA, 2003).

### Frontier model

$$\text{Log } Y = \beta_0 + \beta_1 \log X_1 i + \beta_2 \log X_2 i + \beta_3 \log X_3 i + \beta_4 \log X_4 i + (v_i - \underline{u}_i) \quad (1)$$

The subscript i denotes the ith farmer; Where Log = natural logarithm, Y = total value of catfish output in kilogrammes, $X_1$ = number of fingerlings, $X_2$ = man-h of labour used in respect of catfish production, $X_3$ = feed consumed by catfish in kilogrammes, $X_4$ = pond size in meters square, $\beta_1$ to $\beta_4$ = regression coefficients, $v_i$ = a random error term or "white noise", assumed to be independent of $\mu_i$, identical and normally distributed with zero mean and constant variance N (0, $\delta^2_v$ ), intended to capture events beyond the control of the farmers, like topography, weather, uncertainties etc. $\mu_i$ = disturbance terms, which are assumed to be independent of $v_i$. They are non-negative truncations at zero or half normal distribution with N (0, $\delta^2\mu$). i = 1, 2, 3, …N, $\beta_i$ (where i = 1…4), $\delta^2_v$, $\delta^2\mu$, $\delta^2$ are unknown scalar parameters to be estimated.

## RESULTS AND DISCUSSION

The estimated results of the Ordinary Least Squares (OLS) and the Maximum Likelihood Estimate (MLE) for catfish farmers in Kaduna are presented in Table 1. The OLS model provides an "average" production function while the MLE model provides estimates of the SFPF.

The sigma squared ($\delta^2$) shows a 'good fit' and the correctness of the specified distributional assumptions of the composite error term. The gamma estimate of $\gamma$ = 0.856 indicates that 85.6% variation in output for catfish farmers in Kaduna, is due to the inefficiency factor ($\mu_i$). The ratio of the likelihood function, which compares the joint effect of efficiency parameters on the output of farmers, was also estimated. The results of the diagnostic statistics (the computed chi-square was 25.04 and the critical value of the chi-square at 5% level and seven degree of freedom was 14.067) confirm the relevance of the SFPF using the Maximum Likelihood Estimator. The results of the estimated parameters show that feed consumed had a negative coefficient. This implies that feed contributed negatively to output of catfish, whereas the other variables (fingerlings, labour and pond size) contributed positively to catfish output. The analysis also showed that only labour was statistically significant at 5% level of significance.

This result agrees with the findings of Oladeebo and Ambe-Lamidi (2007), who applied the use of SFPF to measure input elasticities and economic efficiency in poultry production in Osun State, Nigeria in which it was shown that some of the coefficients of the estimated parameters i.e. family and hired labour including expenses on chemicals, had negative signs in the MLE functions. It however contrasts the findings of Ogundari et al. (2006) and Emokaro and Erhabor (2006a) where positive coefficients were recorded for all the estimated parameters.

The Marginal Physical Product (MPP) for each of the production inputs was estimated from the regression coefficient of the SFPF. This was used in determining the Value of the Marginal Products (VMPs) at the geometric mean of inputs (Doll and Orazem, 1978; Henderson and Quandt, 1980; Sankhayan, 1988; Olayemi, 1998). From this, the efficiency of resource-use of the inputs was estimated as presented in Table 2.

Within the limits of statistical reliability, these values provide a measure of the efficiency of resource-use of the production inputs prevailing on the average, in catfish production in Kaduna. A production input is efficiently utilized if the ratio of the VMP/ input price equates to unity, a ratio less than unity indicates over-utilization of production inputs while a ratio greater than unity shows that resources are under-utilized (Utamakili, 1992, Olayemi, 1998; Emokaro and Erhabor, 2006a). Based on this theory, labour and fingerlings were shown to be under-utilized, with ratios of 3.46 and 2.51 respectively. Pond size was over-utilized with a ratio of 0.001 while catfish feed was grossly over-utilized, with a ratio of -426.71. These estimates indicate inefficiency in the use of production inputs by catfish farmers in the study area. These findings compare favourably with the findings of

**Table 1.** Estimates results of the SFPF for catfish farmers In Kaduna.

| Variable | Parameter | Model 1 average OLS | Model 2 frontier mle |
|---|---|---|---|
| Constant Term | $\beta_0$ | 0.197 (0.059) | 1.517 (0.527) |
| Fingerlings ($X_1$) | $\beta_1$ | -0.010(-0.054) | 0.032 (0.237) |
| Labour ($X_2$) | $\beta_2$ | 0.980 (4.689)* | 0.30 (4.639)* |
| Feed Consumed ($X_3$) | $\beta_3$ | -0.194(-1.808) | -0.141 (-1.729) |
| Pond Size ($X_4$) | $\beta_4$ | 0.032 (0.831) | 0.008 (0.279) |
| Sigma Squared | $\delta^2$ | 0.0477 | 0.092 (1.176) |
| Gamma | $\gamma$ | | 0.856 (6.229)* |
| Log likelihood function | | 8.774 | 21.294 |
| Log Ratio | | | 25.040 |

Numbers in parentheses are t-ratios.
*Significant at 5% level.
Source: Computed from field survey Data, 2008.

**Table 2.** Ratio of $VMPx_i$ to input prices at geometric mean of input

| Variables | $\beta_i$ | $MPPx_i$ | VMPxi (₦) | Mean input price (Pxi) | VMPxi/Pxi | Interference |
|---|---|---|---|---|---|---|
| Fingerlings ($X_1$) | 0.032 | 0.010 | 43 | ₦ 20.00 | 2.15 | Under utilized |
| Labour ($X_2$) | 0.765 | 1.004 | 432 | ₦ 125 | 3.46 | Under utilized |
| Feed consumed ($X_3$) | -0.141 | -430.85 | -185,266 | ₦ 434.17 | -426.71 | Grossly over utilized |
| Pond size ($X_4$) | 0.008 | 0.032 | 14 | ₦ 23,000.00 | 0.001 | Over utilized |

Source: Computed from field survey data, 2008.

**Table 3.** Elasticities of production and return to scale.

| Variables | Elasticities |
|---|---|
| Fingerling | 0.032 |
| Labour | 0.765 |
| Feed Consumed | -0.141 |
| Pond Size | 0.008_ |
| Return to Scale | 0.664_ |

Source: Computed from field survey Data, 2008

Utamakili (1992), in an estimation of production function and marginal productivities in the fish farming industry, were it was shown that fish farmers were not efficient in their use of production inputs in Nigeria.

Estimates of the dependent variables of the general model presented in Table 3 show that fingerlings, labour and pond size were positive decreasing functions to the factors, indicating that the allocation and utilization of the variables was in the stage of economic relevance of the production function, i.e. stage 2. The elasticity of feed consumed was however a negative decreasing function to the factor, indicating gross over-utilization of the input which characterizes stage 3 of the production process.

The return to scale was 0.664, signifying a positive decreasing return to scale and that catfish production in the study area is still in stage 2 of production. The productivity of the factor can be improved by either reducing the amount spent on feed and pond size or by increasing the amount of man-hours of labour usage or fingerling stock at the existing level of feeding in order to move the variables (feed consumption and pond size) to stage 2 of the production process. Again, this result is in consonance with the findings of Ogundari et al. (2006), who reported a return to scale of 0.841 in a study of aquaculture in Oyo State, Nigeria.

## Conclusion

It was shown in this study that catfish farmers in Kaduna were not efficient in their use of production resources. While labour and fingerlings were under-utilized, pond size was over-utilized and catfish feed grossly over-utilized. This result is further confirmed by the positive decreasing return to scale as evidenced by the return to scale estimate, indicating that catfish production in the study area is still in stage 2 of the production process. This suggests the existence of intervention points by relevant stakeholders in the current production technology of catfish farmers in the study area. Such effort would aid in the transfer of more economically efficient production technologies that would enhance the current level of efficiency of catfish farmers in the study area. Such interventions include special funding targeted towards the development of cheaper alternative sources of production inputs like catfish feed and construction of

economic-size ponds.

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