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RESOURCE PRODUCTIVITY IN SMALL-SCALE CATFISH (*Clarias gariepinus)* FARMING IN RIVERS STATE, NIGERIA: A TRANSLOG MODEL APPROACH

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ABSTRACT
This study employed the Translog form of Stochastic Frontier Production Function in empirical analysis of efficiency of resource-use among rural fish farmers in Rivers State, Nigeria. Thirty (30) fish farmers each were randomly selected from three (3) Local Government Areas giving a total sample of 90 farmers. Three inputs significantly determined the production efficiencies of the farms in the area. Fish feeds had the greatest elasticity (1.59%) followed by farm size (stock size) with elasticity of 0.47 % followed and capital (0.88). Production elasticity estimates indicated that the farmers were experiencing increasing returns to scale (2.66). Significant inefficiency determinants recorded were farm area and water supply system. The mean efficiency of the farms was 71%. The study concluded that the productivity of the factors can be improved by purchasing high quality fingerlings, training existing staff or employing more skilled labour, and also through utilization of the capital on high quality feeds among other managerial improvement strategies such as farm area expansion.

KEY WORDS: Fish Farming, Productivity, Translog model, Stochastic Frontier Model

INTRODUCTION
The bourgeoning human population and reports of large numbers of undernourished or starving people, especially in the developing countries, have made the need for food production a major worldwide issue of concern. There are three main groups of activities that contribute to food production: agriculture, aquaculture and fisheries. Recent knowledge shows that the world's natural stocks of fish and shell fish, though renewable, have finite production limits, which cannot be exceeded even under the best management regimes (Okechi, 2004). For most of our lakes, rivers and oceans, the maximum sustainable fishing limit has been exceeded (FAO 2000). Therefore, fish production will depend on aquaculture to bridge the gap of fish supply (Tacon 2001). In Nigeria despite all efforts of past agricultural policies to fight food insecurity there is worsening nutritional deficiency, which is manifesting in widespread hunger and malnutrition due to the inability of the county's food production rate of 2.5% to meet the food demand rate of 3.5% in the face of the ever rising population rate of 2.83% (Ojo and Fagbenro, 2010). There are indications that the development of efficiency of fish farming in Nigeria can be a bridge towards solving this problem of nutritional imbalance and low income especially among farmers in the country (Emokaro and Ekunwe, 2009 and Ojo and Fagbenro, 2010). Nigeria fishery output is inadequate and this is partly responsible for the current low daily animal protein intake per head per day of 10 grams compared to the FAO recommended intake of 36 grams. This may not be unconnected with low efficiency of fish farms in Nigeria. More recently researchers have applied the use of the translog Stochastic Frontier Production Model (SFPM) in estimating efficiency of

resource-use for specific agricultural enterprises (Tijani, 2006; and Boshrabadi, Villano and Fleming, 2008).

Related studies on fish farming viability in the past such as Onoja (1996) and Emokaro, Ekunwe and Achille (2010) dwelled more on profitabilities of fish farming without any recluse to the technical efficiencies of the fish farming enterprises. Hence the need for this study which is primarily designed to ascertain the technical efficiencies of small scale fish farmers and their production elasticities. The main objective of this study is to identify any gaps that may exist in the current level of technology employed by fish farmers in Rivers State, Nigeria, through the use of the appropriate econometric technique in the estimation of the efficiency of resource-use and production elasticities among fish farmers. This is expected to provide empirical evidence of gaps that may exist in the farmers' current level of technology. These gaps would serve as policy intervention points which would assist in enhancing the productivity and profitability of the farmers, as well as an impetus to gear up their current level of output so as to bridge the current shortfalls in local supplies and manage their scarce resources efficiently.

Nigeria has a high potential of developing fish culture to meet up with its bourgeoning fish demand that is costing the nation at least $400 million annually. The development of fish farming especially in Kogi State where fishery infrastructure and adequate water resources (including the two major rivers in Nigeria, Rivers Niger and Benue) abound can help the country diversify its economic base by boosting growth of the non-oil sector (especially agriculture) at a time when the country's economy has almost turned monolithic, relying largely on crude oil while the agricultural sector remained abandoned. Improving the productivity of fish culture can go a long way in providing adequate protein rich food and additional income that can improve the poverty level of the mass of food insecure Nigerians who are languishing especially in the rural areas of the country and incapable of embarking on large investments. This enterprise development can also reduce loss of biodiversity usually inherent in fish hunting. Meeting these challenges would help small-scale farmers break away from their poverty trap. It will also require data-base built on evidence-based research that can communicate the true status of fishery productivity to policy makers and stake holders from the private sector that are ready to develop this important sub-sector of the economy. Scholars of business, fishery, economics and agriculture will also benefit from the findings of this study.

Theoretical Framework

Two major constraints to the establishment of fish culture enterprises in Nigeria include lack of initial capital input and the acquisition and ownership of land (Afolabi & Fagbenro 1998). Most importantly, the value of rental price of land that satisfies the technical requirements of modern and conventional pond fish culture varies with its quality and alternative uses. It becomes prohibitive and unaffordable especially in urban centres where competing and conflicting uses with earthen pond fish culture exists.

Despite the high rental price of land, its availability in urban centres is limited to commercial, industrial, residential and recreational uses with little or no consideration for agricultural food production (Imoudu 1999). Family-scale (backyard) aquaculture in peri-urban and rural areas have been recommended in Nigeria (Fagbunro 1999; Anyanwu, Ezenwa and Uzukwu, 1989) as an economical method of producing fish where the homestead concrete tank has been developed as an alternative and suitable enclosure for backyard fish culture. However of much importance in the establishment of these farms, like any other business, is its viability or productivity which can be measured from its efficiency.

Farrel (1957) proposed that efficiency of a firm consists of two components, ***technical efficiency***, which reflects the ability of a firm to produce a maximal output from a given set of inputs and *allocative efficiency* which reflects the ability of the firm to use the inputs in optimal proportions given their respective prices. These two measures are combined to give a measure of total *economic efficiency.*

According to Coelli and Prasado Rao (2003) majority of past productivity studies used cross-sectional data to estimate a Cobb-Douglas production technology using regression methods. The focus was generally on the estimation of the production elasticities and the investigation of the contributions of farm scale, education and research in explaining cross-country labour productivity differentials. They noted that the development of new empirical techniques to analyse cross sectional and panel data such as the data envelopment analysis (DEA) and stochastic frontier analysis (SFA) techniques, described in Coelli, Rao and Battese (1998) [in Coelli and Prasado Rao, 2003] and a desire to assess the degree to which the green revolution and other programs, did improved agricultural productivity analysis in developing countries lately.

Research Objectives

This study was designed to specifically: 1.) determine the technical efficiency of small-scale rural fish farms in the study area; 2.) ascertain the major determinants of technical efficiency among the rural small-scale fish farmers in the study area; and 3.) determine the factors influencing farm level inefficiency among the farms surveyed in the study.

RESEARCH METHODOLGY

Study Area: The study area is Rivers State, one of Nigeria’s 36 States. The State is located between latitudes 4˚15N and 5˚45N and longitudes 5˚22E and 7˚35E . The strategic importance of Rivers State in the economic equation of Nigeria earned it the name, Treasure Base of the Nation. The State is bounded on the south by the Atlantic Ocean, on the North by Imo and Abia States, the East by Akwa Ibom State and the West by Bayelsa and Delta States. Rivers State, which is in the Niger Delta, has a topography of flat plains with a network of rivers and tributaries. These include New Calabar, Orashi, Bonny, Sombreiro and Bartholomew rivers (Rivers State, 2010). With a tropical climate, numerous rivers and vast areas of arable land, the people of Rivers State have lived up to their tradition of agriculture, especially fishing and farming, commerce and industry (Rivers State, 2010).

Sampling Method: The sampling technique used for this research was the simple random sampling technique in which 30 fish farmers (producing mainly catfish) were randomly selected from three LGAs in the study area giving a total sample size of ninety (90).. These LGAs include Ikwerre, Emohua and Obio/Akpor Local Government Areas (LGAs).

Data Collection: The study depended mainly on primary data. The sampling frame for this study was obtained from the Ministry of Agriculture and Natural Resources and Rivers State Agricultural Development Programme (RSADP) and Fish Farmers Association in the State. This frame contained the list and addresses of registered fish farmers in the State. The primary data were collected with the aid of well-structured sets of questionnaire, administered through personal interviews and observation so as to elicit the required information from the targeted fish farmers. Secondary data utilized in the study came from learned journals, text books and online research materials.

Data Analysis (Analytical Technique): The empirical translog production function was specified following Christensen, Jorgenson and Lau (1973) and Boshrabadi, Villano and Fleming, (2008) thus:

$$\ln Y_{i(k)} = \beta_{0(k)} + \sum_{j=1}^{4} \beta_{j(k)} \ln X_{ij(k)} + \frac{1}{2} \sum_{j=1}^{4} \sum_{s=1}^{4} \beta_{js(k)} \text{ x } \times \ln X_{ij(k)} \ln X_{is(k)} + V_{i(k)} - U_{i(k)} \quad \ldots 1$$

where j represents the j-th input (j = 1, 2, . . .4) of the i-th firm (1, 2, . . . Nk) in the k-th group (k=1, 2, . . . 5); $\beta ij(k) = \beta ji(k)$ for all j and k; Yi represents the number of fish output from each farm unit (count); Xi 1 is the stock size (count); Xi 2(k) represents total amount of labour in mandays; Xi 3(k) represents the value of capital employed in Naira; and Xi 4(k) the quantity of feed fed in kilogrammes/pond. All variables are mean-corrected to zero, which implies that the first-order estimates of the model represent the corresponding elasticities. Estimated values of β in Equation 1 above indicate the elasticities of the inputs or their relative importance in the output of fish in the farms studied. Error term (Vi) is assumed to be independently and identically distributed and captured random variations due to factors beyond the control of fish farmers in the area. The error term (Ui) captures technical inefficiency in the production systems. This term is assumed to be firm specific, nonnegative random variables assumed to be independently distributed. The technical inefficiency effects, (Ui) are assumed to be a function of some explanatory variables (Zs) and an unknown vector of coefficients (δ). The ratio of the observed output of any farm relative to the potential output estimated by equation 1 gives the total efficiency (TE) of that farm.

$$TE_i = \exp(U_i) = \exp(-\delta Z_i) \qquad (2)$$

If Ui = 0, the farm is 100% technical efficient. Maximum likelihood estimates of the parameters were estimated using Frontier 4.1c developed by Battese and Coelli (1995) and Coelli (1996). The following inefficiency variables (Zs) were estimated: farm area (in hectares); age of farmers; years spent on formal education; years of farming experience; gender (dummy 0.01 =female, 1 =male); volume of credit accessed in Naira; pond unit (dummy: 0.01=concrete and 1 = earthen); pond feeding system (dummy, extensive = 0.01 and intensive = 1); and water supply system (dummy; water trough = 0.01; stagnant water =1).

RESULTS AND DISCUSSION

Maximum likelihood results of stochastic frontier (translog function) analysis are presented in Table 1.0 below. All production function parameters except labour are statistically significant. Labour had negative signs contrary to a priori expectations. This however implies that this resource was being underutilized. Since double –log model was applied coefficients represent elasticities of fish output with respect to the respective inputs. Fish feeds administered which had the greatest elasticity (1.59%) had the highest contribution to fish output followed by farm size (stock size) with elasticity of 0.47 %. This may not be surprising as feeds are very necessary for the growth, health and output size of fish to be sold. The positive and relative increase in stock size implies that those stock higher number of stocks or have larger farm size appears to be benefitting from economy of scale in their farm production. The third significant variable, capital had an elasticity of 0.88 indicating that the contribution of capital towards technical efficiency of the farms were increasing maybe through the proper use of capital resource in the business. With appropriate mix of investment increase on farm scale (stock size) and other variable there could be a positive return on investment on capital.

Table 1.0 Estimated Maximum Likelihood Parameters for the Farm Units Surveyed

Variables	*Parameters*	*Elasticities*	*Standard-error*	*T Ratios*	*Remarks*
Intercept	β_0	-4.367	1.930	-2.780	***
ln stock_size	β_1	0.469	0.135	2.745	***
ln Labour	β_2	-0.340	0.875	-0.265	NS
lnCapital	β_3	0.878	0.457	1.942	**
ln Feeds	β_4	1.593	0.689	3.88	***
lnLabour*lncapital	β_5	0.059	0.105	0.560	NS
Lnlabour*lnlnfeeds	β_6	0.063	0.116	0.543	NS
lncapital*lnlnfeeds	β_7	0.090	0.085	1.052	NS
lnlabour^2	β_8	-0.018	0.103	-0.172	NS
lncapital^2	β_9	-0.025	0.013	-1.867	**
lnfeeds^2	β_{10}	-0.170	0.065	-2.615	***
Lnfarmsize**lnlabour	β_{11}	0.001	0.001	-0.846	NS
Lnfarmsize*lncapital	β_{12}	0.033	0.001	-0.796	NS
Lnfarmsize*lnfeeds	β_{13}	0.011	0.011	1.239	NS
lnfarmsize^2	β_{14}	0.012	0.001	0.472	NS

Source: Data Analysis Based on Field Survey (2011) using Frontier 4.1c Programme.

Highly significant gamma statistic indicates the presence of a high systematic inefficiency and implies that 100% of the variation in fish production could be attributed to inefficiencies. Table 2.0 shows the formal test for the hypothesis on existence of inefficiency effects in the model. According to this table, the null hypothesis was rejected. Farm area of the fish farm and water supply system employed by the farmers were the only significant variables influencing the level of inefficiency of the model. Farm area returned a negative sign indicating that as farm area increased inefficiency in the fish farm decreases.

Table 2.0 Parameter Estimates of the Inefficiency Model

INNEFFICENCY MODEL

Variables	*Parameters*	*Coefficients*	*Standard errors*	*t-ratios*	*Remarks*
δIntercept	δ_0	0.429	0.125	2.167	**
δfarm_area	δ_1	-0.003	0.000	-14.307	***
δage	δ_2	0.002	0.001	-0.272	NS
δeducation_yrs	δ_3	-0.002	0.003	-0.271	NS
δfarming_experience	δ_4	-0.001	0.003	-0.447	NS
δhousehold_size	δ_5	-0.002	0.010	-0.204	NS
δgender	δ_6	0.020	0.069	0.294	NS
δcredit_access	δ_7	0.014	0.040	0.359	NS

δpond_unit	δ_8	-0.056	0.072	-0.783	NS
δPond_feeding_system	δ_9	0.026	0.075	0.353	NS
δwater_supply_system	δ_{10}	0.132	0.102	1.293	*
DIAGNOSIS					
Sigma Squared	δ^2	0.018	0.003	6.127	***
Gamma	γ	1.000	0.000	3642.874	***
Log likelihood function	L			134.6	
Test of Log likelihood of one-sided error				**24.555**	***l
Mean Technical Efficiency				**0.76**	High
Returns to Scale				2.66	Increasing

(***) = Significant at 1%; (**) figures significant at 5%; and (*)S figures significant at 10 %. *Source: Field Survey (2011) Analysis output from Frontier 4.1c.*

This variable was significant at 1 %. The second significant variable, which gave a positive sign indicates that as more fish farmers adopt the water trough system, inefficiency tend to decrease in the farm. These results are in line with a priori expectations. The rest eight variables tested were not significant even at 10% level. The results of the study as could be seen from Table 1.0 also indicated that there exists increasing returns to scale in the sample (2.66). This implies that farmers were at Stage I of their production cycle characterized by positive or increasing returns to scale. This result is in contrast with the findings of Emokaro and Ekunwe (2009) in their study of cat fish efficiency in Kaduna State of Nigeria.

Table 3.0 Hypotheses tests about the existence of inefficiency among the farmers

Null Hypotheses *tested:*	***Assumptions of the test***	***Log likelihood under Null Hypotheses***	***Number of restrictions***	***LR Test Stastics***	***Chi Square Critical Values at 5% and 1% respectively***	***Decis-ions***
$\gamma = \delta_0 = \ldots \delta_{10} = 0$	Inefficiency does not account for variations in output	134.6	9	28.55***	16.92 (0.05) and 21.67 (0.01)	Reject Null

(***) = Significant at 1%; *Source: Field Survey (2011) Analysis output from Frontier 4.1c.*

Table 4.0 Ranges of Technical Efficiency Estimates

Ranges of Efficiencies	***Frequency***	***Percent***
>0.5 - 0.6	9	10.00
>0.6 - 0.7	13	14.44
>0.7 - 0.8	19	21.11
>0.8 - 0.9	30	33.33
>0.9 - 1	19	21.11
Total	**90**	**100.00**

Source: Field Survey (2011) Analysis output from Frontier 4.1c.

Table 4 shows efficiency distribution of the farms surveyed. The predicted technical efficiency of the sample fish farmers ranged widely from 0.521 to 0.999 (i.e. approximately 52% to 100%). The mean technical efficiency is estimated to be 0.71.

CONCLUSION

The mean farm efficiency of 0.71 (71%) recorded in the farms studied leaves rooms for farm efficiency improvement in the state by 29% in order to bring the fish farmers to the frontier of their technology. Except labour and capital, all of the elasticities models are positive. This implies that increasing input resources other than labour and capital would cause increase in fish yields obtained per unit of output of fish in the sample farms. Since quantity of fish feed is the variable resource having the greatest coefficient (hence elasticity) among other resources (or variables), it is still the most important input to be considered when the intention of management is to increase fish production. Another implication of these findings is that policies aimed at developing the fish culture from their small-scale levels to commercial levels should address the issue of farm credit access and availability so that fish farmers can produce at a more efficient level thus increasing their economies of scales and its attendant boost on their profit and farm income levels. Labour input usage was not optimal according to results but there are glaring indications that if investors or farmers can increase their stock size, improve the feed quality and farm area, which are dependent on the level of capital available for them to invest in their farms the possibility of attaining a more commercially based and efficient fish farm could be realized.

The returns to scale was 2.66 which signifies a positive increasing return to scale and that fish production in the study area is still in stage I of production is a sign that fish farming holds great potentials for improving livelihoods of farmers via its potential for increased productivity The negative returns being recorded in the study also implies that labour should be made to be more efficient maybe by employing fewer but more skilled workers who are experts in aquaculture in the farms in the area. More capital resource can be directed to more productive areas like buying of high quality feeds and fingerlings so as to increase the stock size and be able to feed the increased stock for optimal results. Inefficiency in the management of the farms can be decreased if the farm areas are increased and the water supply system improved. There is also the need to train existing staff to make them more productive. Generally there are lots of prospects for fish farming development in Rivers State of Nigeria. It really holds the potential for solving the problem of protein deficiency and food security in the State if well promoted.

REFERENCES

Afolabi, J.A. & Fagbenro, O.A. (1998) Credit financing of coastal artisanal aquaculture in Nigeria, in A.Eide & T. Vassdal (eds.) *Proceedings of the Ninth Conference of the International Institute of Fisheries, Economics and Trade*. International Institute of Fisheries, Economics and Trade, Tromso, Norway. pp. 12-14

Anyanwu, P., Ezenwa, P. & Uzukwu P. (1989) fish culture in homestead tanks in Nigeria: practices, problems and prospects. Aquabyte 2(3): 8-10.

Battese, G. E. & Coelli, T. J. (1995). A model for technical inefficiency effects in a stochastic frontier production function for panel data. *Empirical Economics.* Vol. 20.

Boshrabadi, H. M., Villano, R. & Fleming, B. (2008). Technical efficiency and environmental-technological gaps in wheat production in Kerman province of Iran. *Agricultural Economics* Vol. 38. pp. 67–76.

Christensen, L.R., and Greene, W.H. (1976). Economies of scale in U.S. electric power generation, *Journal of Political Economy*,84, 655-676.

Coelli, T. J. (1996). A guide to Frontier Version 4.1 : a computer program for stochastic frontier production and cost function estimation. CEPA Working Paper 96/08, University of New England. No. 7/96. Retrieved 28th April, 2008 from http://www.une.edu.au/econometrics/cepawp.htm

Coelli, T. J. and Prasada Rao, D.S. (2003). Total factor productivity growth in agriculture:A Malmquist Index Analysis of 93 Countries, 1980-2000. Centre for Efficiency and Productivity Analysis (CEPA) Working Paper Series No. 02/2003. pp.1-3.

Emokaro C.O. and Ekunwe, P.A. (2009). Efficiency of resource-use and elasticity of production among catfish farmers in Kaduna, Nigeria. *Journal of Applied Sciences Research* 5(7): 776-779.

Emokaro C.O., Ekunwe P.A.& Achille A 2010. Profitability and viability of catfish farming in Kogi State, Nigeria. *Research Journal of Agriculture and Biological Sciences*, 6(3): 215-219.

Fagbenro, O.A. & Salami, A.A. (1996) Studies on the control of tilapia recruitment using tilapia-predator polyculture systems in southwest Nigeria.p.542, in R.S.V. Pullin, J. Lazard, M. Legendre, J.B. Amon Kothias & D. Pauly (eds.) *Third International Symposium on Tilapia in Aquaculture (ISTA III).* ICLARM Conference Proceedings 41, Manila, Philippines.

Food and Agricultural Organization (FAO). (2000). FAO Yearbook. Fisheries statistics: aquaculture production 1998. Vol. 86/2. FAO Fish. Ser. No. 56, FAO Stat. Ser. No. 154. Rome, 169p.

FAO (2007). State of world fisheries & aquaculture h t t p : / /www. f a o .o r g / f i / s t a t i s t /fisoft/fishplu.asp.

Farrell, M. J. (1957). The measurement of productive efficiency. *Journal of the Royal Statistical Society* – Series A (General) 120 (3): pp 253–290.

Federal Ministry of Agriculture &Water Resources, 2008. National Programme for Food Security. Federal Ministry of Agriculture and Water Resources (FMA&WR), Abuja, 107.

Imoudu, P.B. (1999) Sustainable agriculture and poverty alleviation: reality or illusion. 17th Inaugural Lecture delivered at the Federal University of Technology, Akure, Nigeria on October 12, 1999. 45pp.

Ojo, S. O. & Fagbenro, O. A. (2010). Efficient production of tilapia: a panacea for alleviation of nutritional poverty in Nigeria. Retrieved on 26th May, 2010 from http://ag.arizona.edu/azaqua/ista/ISTA8/Abstracts_Papers/Tilapia%20a%20good%20candidate.doc

Okechi, J. K. (2004). Profitability assessment: a case study of African catfish *(clarias gariepinus)* farming in the Lake Victoria basin, Kenya. Fisheries Training Programme. The United Nations : Iceland.

Onoja, A. O. (1996). Investment and Profitability potentials in Pisciculture: A case Study of Kogi State, Unpublished M.Sc. dissertation submitted to the Department of Agricultural Economics, University of Nigeria, Nsukka.

Rivers State (2010). Ministry of Information and Communication, Rivers State, Nigeria.

Tacon, A.G.J. (2001). Increasing the contribution of aquaculture for food security and poverty alleviation. In R.P. Subasinghe, P. Bueno, M.J. Phillips, C. Hough, S.E. McGladdery & J.R. Arthur, (eds.) Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium, Bangkok, Thailand, 20-25 February 2000. pp.63-72. NACA, Bangkok and FAO, Rome.

Tijani, A. A. (2006). Analysis of the technical efficiency of rice farms in Ijesha land of Osun State, Nigeria. *Agrekon,* Vol 45, No 2 (June) pp 126-135.