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Analysis of Technical Efficiency of Small Scale Fish Farming in Maiduguri Metropolitan Area of Borno State, Nigeria

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ABSTRACT
The study determined the technical efficiency and its source of small scale fish farmers in Maiduguri Metropolitan Area of Borno State. Two stage sampling techniques were used to select the respondents. The instrument for data collection was structured questionnaire. The data collected was analysed through the use of descriptive statistics and stochastic production frontier. The result of stochastic frontier production revealed mean efficiency of 0.89%. The coefficient of fingerlings, feed and labour were positive and significant, while agro-chemical was negative but not significant in fish production. Therefore, it was recommended that the extension agent should improve to play active role in disseminating useful information and farming, a practice that will increase the farmers' productivity, the younger people should be encouraged to practice fish farming and the necessary inputs like fingerlings and feed should be provided by the government at a subsidized rate. Similarly the government should encourage research on modern technology and practices that would enhance efficiency and productivity.

Key Words: Fish, Technical, Efficiency, Determinants, Stochastic, Frontier, Approach

INTRODUCTION

Fish farming is the rearing or production of fish in a controlled environment like a pond, cage, tank, irrigated canals, reservoirs and other types of enclosures (Ayodele and Ajani, 1995). It provides employment opportunities and cash income for many people in the nation. Fish farming is regarded as an important source of the much needed high quality animal protein in the human diet. It serves as a cheap source of animal protein, mainly to the poorer segment of the community (Tacon, 2001). It is responsible for as much as 40 percent of all animal protein available in the developing world (FAO, 1990). It accounts for about one-fifth of the World's total supply of animal protein. Fish has also been medically recommended for pregnant women, children and adult because of its high-level of protein digestibility, lack of cholesterol and a preventive recipe for heart attack or failure (FAO, 1991).

Nigerian with a population of about 160 million people constitute one of the largest consumer of fish in the world with an estimated at about 7.5 kg per capita consumption. However, the domestic fish production in the nation which was estimated at about 551, 700 metric tons is much lower than the estimated demand

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of about 1.2 million tons resulting in a huge deficit (Agbola, 2011). This deficit is bridged through the importation of 680, 000 metric tons annually, costing about ₦ 50 billion of foreign exchange earnings (Ojo and Fagbenro, 2004 and Raufu *et al.*, 2009). Similarly, the consumption rate of 19.38 g/ caput/day is much lower than the 65g/caput/day recommended by the Food and Agriculture Organization (FAO) for the maintenance of good health. (Adewuyi et *al*., 2010).

The tasks of bridging the wide gap between demand and supply of fish product in the nation remain enormous. It was reported that fish output would have to increase by 267 percent by 2020 to maintain the current level of fish consumption in the country (Delgado *et al*., 2003). The target of increasing the animal protein supply in the nation could be achieved through improving the productivity and efficiency of farms. The underlying principle behind much of the research in efficiency is that farmers are not making efficient use of existing technology. Most experts of efficiency studies agree with the view that effort designed to improve efficiency should be more cost-effective rather than introducing new technologies as a means of increasing agricultural output (Belbase and Grabowski, 1985; Huynh *et al*., 2008 and Adeleke *et al.*, 2008). Hence, there is the need to encourage an efficient use of resources by farmers through appropriate policy formulations.

There is a growing interest in the measurement of technical efficiency of the fisheries sub - sector. This interest arose as a result of the need to identify the underlying factors of efficiency (Kirkley *et al*., 1998) and to assess the effects of management measures on technical efficiency and potential output. Fish farmers could improve technical efficiency by constraining the use of certain inputs or alternatively by expanding these inputs (Pascoe and Nardle, 2001).

Efficiency is the relative performance of the processes used in transforming inputs into output (Lissitia and Odening, 2005). Technical efficiency is the extent to which the maximum possible output is achieved from a given combination of inputs or the ability of a firm to obtain maximal output from a given set of inputs (Coelli *et al*., 2005). Farrell (1957) defined technical efficiency as the ability to produce a given level of output with a minimum quantity of inputs under certain technology.

Few studies were conducted in fish production Maiduguri Metropolitan Area in Borno State. The few studies cover the economics of fish marketing Ibrahim *et al.* (2006); economic analysis of cultured fishery (Mohammed *et al.,* 2011) and determinants of efficiency and income distribution in fish production (Sulumbe *et al.* 2014). Sulumbe *et al.* (2014) used DEA which is a non-parametric approach with its inherent weaknesses which undermine its usefulness to some extent. Some of the weaknesses DEA approach include there is no room for random error, it ignores price information, it is difficult to find out whether the output being produced is optimal without valuable information on the outputs and it focuses on technological rather than the economical optimization (Berger and Mester, 1997).

This study applies a stochastic frontier approach to determine the technical efficiency of fish farmers in the study area. The stochastic frontier approach has the advantage of making inference possible (Coelli *et al.*, 2002). The strength of the stochastic frontier approach is that it deals with the stochastic noise and permit statistical test of hypothesis pertaining to the structure and the degrees of inefficiencies. (Coelli *et al.*, 2002).This study was conducted to estimate technical efficiency and examine the sources of inefficiency in small scale fish production in Maiduguri Metropolitan Area of Borno State with a view to suggest appropriate policy measures that could improve the quantity and quality of the product.

METHODOLOGY

Study area

The study was conducted in Maiduguri Metropolitan area of Borno State, Nigeria. Metropolitan area occupies a total mass of about 50,778 square kilometres. It lies between latitude $11^{0}15^{'}$ 45 ‘N and longitude $11^{0}3^{'}5^{'}$E (NPC, 2006). Maiduguri Metropolitan Area shares common boundaries with Konduga to South and Jere local government area to the northeast. Maiduguri metropolitan area has an estimated population of 521,492 people based on 3.2% growth rate (NPC, 2006) and the projected population is 655,009.952 with a population density of 1,738 people per square kilometre.

Maiduguri Metropolitan area is characterized by distinct dry and rainy season. The annual temperature ranges between 31^0 C – 40 ^{0} C, and a rainfall ranging between 500mm – 6000 mm. The rainfall lasts for 3 – 4 months from June to September. Farming is the main occupation. The main crops grown are maize, millet, sorghum, cowpea and groundnut as well as livestock such as cattle, sheep, goat poultry and fish production (Sulumbe, 2012).

Sampling technique and data collection

Two stage sampling technique was used for this study. In the first stage ten awards were purposively selected out of the fifteen wards based on the dominance of the fish farmers. In the second stage, simple random sampling was used to select five fish farmers from each of the selected wards, giving a sampling size of 50 respondents.

Primary data were employed in the study. The primary data were used through interview method with the aid of a structured questionnaire Data gathered comprises of information on the socioeconomic variables such as age, years of experience, farm size, family size, access to extension and formal credit facilities. Others are data on inputs used and their cost and output, and output prices of the small scale fish farmers.

Analytical techniques

The analytical technique used was the stochastic frontier production function to determine the technical efficiency of the small scale fish farmer and source of technical inefficiency. It was explicitly expressed as:

$$\text{In}Y_i = \ln \beta o + \beta_1 \text{In}X_1 + \beta_2 \text{In}X_2 + \beta_3 \text{In}X_3 + \beta_4 \text{In}X_4 + \beta_5 \text{In}X_5 + V_i - U_i \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots 1$$

Where:

Y = Fish Yield (kg)

X_I = Hire labour input (man day)

X_2 = Pond size (ha)

X_3 = Family labor (Man-day)

X_4 = Agro-chemical (litres)

X_5 = Feed (kg)

β_1-β_5 = Unknown scalar parameters to be estimated

V_i = Random errors

U_i = Technical inefficiency effect predicted by the model is expressed as:

$$U_i = \alpha_o + \alpha_1 Z_1 + \alpha_2 Z_2 + \alpha_3 Z_3 + \alpha_4 Z_4 + \alpha_5 Z_5$$

Where:

U_I = Technical inefficiency of the fish farmers

α_o = Constant or intercept

Z_1 = Age of farmers (years)

Z_2 = Household size (number of person)

Z_3 = Farming experience (years)

Z_4 = Educational quaspendingation (years of spent in school)

Z_5 = Extension contact (dummy)

α_1-α_9 = Are the scalar parameters to be estimated

RESULTS AND DISCUSSION

Technical efficiency of small-scale fish farmers

Table1 revealed the maximum likelihood estimate (MLE) of the parameters for the frontier production function and the variable parameters of the model. The result revealed that the variance parameter sigma square (δ) was 0.113 and significant (P< 0.01). This indicates a good fit and correctness of the distributional form of assumption for the composite error term. The gamma (γ) which is the proportion of deviation from the frontier that is due to inefficiency was 0.937 and significant (p< 0.01). This means that more than 93% of the variation of the fish farmers' output are due to their difference in technical efficiency.

The coefficient of fingerlings (0.754) was positive and significant (p< 0.05). This implies that 1% increase in the quantity of fingerlings would lead to 0.76% increase in the yield of the fish. The coefficient of feed (0.157) was positive and significant (p< 0.05). This implies that 1% increase in the quantity of feed will lead to 0.15% increase in output. This indicates that feed constitute the most important input in fish farming The quantity and the quality of feed influence the performance and the size of the fish. Similar findings were reported by Olagunju *et al.* (2007) and Mohamed *et al*. (2011) in their respective studies.

The coefficient of labour (0.574) was positive and significant (p< 0.05). This implies that 1% increase in labour use would result in a 0.57 % increase in the fish output. This could be as a result of the ready availability of labour. The coefficient of agro chemicals (-0.335) was negative but not significant. This implies that increase in quantity of chemicals can decrease output, probable due to suffocation and other harmful effect of chemicals. Similar findings were reported by Ogundari *et al*. (2006) on technical efficiency of aquaculture production in alleviating poverty in Oyo State of Nigeria and Ojo *et al*. (2006) on the technical efficiency in artisanal fisheries production in Nigeria.

Table 1: Maximum likelihood estimate of stochastic production frontier function in small scale fish production in Maiduguri Metropolitan

Variable	Parameter	Coefficient	T-ratio
Constants	β_o	0.148	4.241^{***}
Fingerlings	β_1	0.754	6.566^{***}
Feed	β_2	0.157	2.816^{***}
Labor	β_3	0.574	1.472
Agro-chemicals	β_4	-0.335	-1.366
Sigma square	δ	0.113	3.027^{***}
Gamma	γ	0.937	2.045^{***}
Log likelihood function		0.236	
LR test of the one sided error		0.179	
Mean efficiency		0.894	

Source: Field Survey, 2014

Frequency distribution of technical efficiencies of fish farmers

The frequency distribution of technical efficiencies of the small scale fish farmers in the study area is presented in Table 2. The result revealed that the technical efficiency ranges between 0.385 and 0.972 with a mean value of 0.894. This implies that there exists the scope of improving technical efficiency on the average by about 11% in the study area. About 94% of the fish farmers have technical efficiency exceeding 0.81. The result indicates that for an average fish farm in the study area to achieve technical efficiency of the most efficient fish farmer, they could realize a 11 % reduction in inputs, usage and least farmer will have a 63 % reduction in inputs usage to achieve the efficiency level of most efficient counterpart in the study area.

Table 2: Frequency distribution of technical efficiency of fish farmers in Maiduguri Metropolitan

Efficiency Ranges	**Frequency**	**Percentage (%)**
≤ 0.50	1	2.9
0.51-0.60	-	-
0.61-0.70	1	2.9
0.71-0.80	-	-
0.81-0.90	13	37.1
0.91-100	20	57.1
Minimum	0.385	
Maximum	0.972	
Mean	0.894	

Source: Field Survey, 2014

Determination of technical inefficiency of small scale fish farmers

Table 3 presents the determinants of technical inefficiency of the fish farmers in the study area. The result revealed that the estimated coefficient for the educational level (- 0.436) was negative and significant (p< 0.01). This implies that farmers with high level of education tend to be more technically efficient. This might be possibly due to the fact that educated farmers are more receptive to improve farming techniques and practice. The coefficient of farming experience (-0.134) was negative, but not significant therefore decrease technical efficiency. This implies that increase in number of years in fish production increase technical efficiency. This agrees with the findings of Egwu (2003) that years of experience were negative and significant (p< 0.10) among rice farmers in Ebonyi State Nigeria.

The coefficient of extension contact (0.310) was negative therefore indicate a positive effect on the efficiency. The result implies contact with extension worker is positively correlated with adoption of improving technology and technique of production that enhance technical efficiency. This agrees with the work of Kudi *et al.* (2008) who found that extension contact increase productivity among sesame farmers in Jigawa State.

The coefficient of age (0.599) was positive and significant (p<0.01) indicating a negative effect of efficiency. This implies that the younger the fish farmers the more active they will be. The coefficient of farm size (-0.605) was negative and significant (p<0.01) this implies a positive effect on technical efficiency. This implies that the larger the farm the more the quantity of fingerlings and output will be obtained.

Table 3: Determinant of technical inefficiency in small scale fish production in Maiduguri Metropolitan

Variable	**Parameter**	**Coefficient**	**t-ratio**
Age	Z_1	0.5991	0.2174^{**}
Farming Experience	Z_2	-0.1348	-0.3546^{***}
Extension Contact	Z_3	-0.3106	-0.13211
Education	Z_4	-0.4365	-0.1247
Farm Size	Z_5	-0.6058	-0.1109
Pond Size	Z_6	0.1057	0.1298

Sources: Field Survey, 2014

Conclusion and recommendations

This study established that fish production in the study area exhibited a high technical efficiency of 89%. However, there exists the scope of improving the efficiency level by about 11%. The study revealed that higher level of education, farming experience, extension contact and farm size increase the level of technical efficiency of the fish farmers in the study area. Hence, it is recommended that extension services should be strengthened to play active role in disseminating useful information and farming practice that will increase the farmers' productivity. Also the younger people should be encouraged to practice fish farming as a fulltime occupation. Furthermore, the necessary inputs like fingerlings and feed should be provided by the government at a subsidized rate. Government should encourage research on modern technology and practices that would enhance efficiency and productivity.

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