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Resource Optimization in Small-Scale Fish Farming in Minna Agricultural Zone of Niger State, Nigeria

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Abstract:
The paper examined resource optimization in small-scale fish production in Niger State, Nigeria, using traditional response approach. Multi-stage sampling technique was employed in selecting 65 fish farmers drawn from the sampling frame obtained from Agricultural Development Project (ADP) contact farmers in two local government areas, namely Bosso and Chanchaga LGAs' respectively. Regression results indicated that feeds, fingerlings, water, depreciation on capital items and labour were significant determinants of output in fish production. Production elasticity estimates indicated that the farmers were in stage 1 of the production process, with a return to scale of 1.162. These estimates indicate the existence of intervention points for relevant stakeholders in bourgeoning fish business in Niger state. The index of resource-use efficiency revealed that fish farmers were inefficient in the allocation of productive resources with an allocative efficiency index of 8.0, 1.3, 0.000, -15.3 and 301.1 for feeds, fingerlings, water, and depreciation on capital items and labour respectively. This, in addition to enhanced access to current technical and price information by farmers, will raise output and net returns in small-scale fish farming enterprises.

Keywords: *Resource optimization, traditional response approach, allocative efficiency index, small-scale fish farming, Niger state, Nigeria*

1. Introduction

Aquaculture, the farming of aquatic organisms, including fish, molluscs, crustaceans and aquatic plants, is often cited as one of the means of efficiently increasing food production in food-deficit countries. However, the animal protein consumption in Nigeria is less than 8 g per person per day, which is a far cry from the FAO minimum recommendation (Niang & Jubrin, 2001). The major animal protein sources in the country include cattle, goats, sheep, poultry and fish. Out of these sources fish and fish products provide more than 60% of the total protein intakes in adults especially in the rural areas (Adekoya, 2004). Therefore, the importance of the fishing industry to the sustainability of animal protein supply in the country cannot be over-emphasized. 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. It has been asserted by Adediran (2002) and Ugwumba (2005) that the only way of boosting fish production and thereby move the country towards self sufficiency in fish production is by embarking on fish farming especially catfish farming. 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, 2006), 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. Efficiency or inefficiency of utilisation of available resources for fish farming has remained an unanswered question in the quest for increased fish production in Niger State in particular, and Nigeria in general. An efficient method of production is that which utilises the least quantity of resources in order to produce a given quantity of output.

According to Oh and Kim (1980), allocative efficiency is the ratio between total costs of producing a unit of output using actual factor proportions in a technically efficient manner, and total costs of producing a unit of output using optimal factor proportions in a technically efficient manner. However, a farm using a technically efficient input combination may not be producing optimally depending on the prevailing factor prices. Thus, the allocatively efficient level of production is where the farm operates at the least-cost combination of inputs. According to Yotopoulos and Lau (1973), a firm is allocatively efficient if it was able to equate the value of marginal product (MVP) of each resource employed to the unit cost of that resource; in other words, if it maximises profit. Therefore allocative efficiency measure, quantifies how near an enterprise is to using the optimal combination of production inputs when the goal is maximum profit (Richetti and Reis, 2003). Although a number of studies have been carried out on allocative efficiency in fish farming in Nigeria, example of such studies are Inoni, 2007; Emokaro and Ekunwe, 2009; Anene *et al.*, 2010; Oguoma *et al.*, 2010; Ugwumba and Chukwuji, 2010. . In the fish farming sub-sector in Niger State, crucial information on allocative efficiency in the zone in relation to such critical resources as the land for the pond constructed, labour, capital, water availability, quality of fingerlings, feed and fertilizers have not been adequately reflected in literature. None of these had, in particular, examined the appropriateness of the estimating models adopted and the interaction effect of the variables used in production on fish output; resource use efficiency in small-scale fish farming has not been the focus of recent studies. Given the foregoing scenario, the study intends to identify any gaps that may exist in the current level of technology employed by fish farmers in Niger State, using traditional response approach in the estimation of the efficiency of resource-use among small scale fish 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.

2. Research Methodology

The study area is Niger State of Nigeria. The State is located in North-central Nigeria between Latitudes 8˚20´N and 11˚30´ N and Longitudes 3˚30´ E and 7˚20´E with a total land area of 76,363 square kilometres and a population of 4,082,558 people (Wikipedia, 2008). Annual rainfall is between 1100mm and 1600mm with average monthly temperature hovering around 23˚C to 37˚C (NSADP, 1994). The range of local climatic and soil conditions, resource availability, and markets allows favourable fish farming practices.
This study was conducted in Minna Agricultural zone of Niger state, Nigeria and made use of both primary and secondary data. The main instrument for eliciting the primary data was structured questionnaire. Information were collected on input and output in fish farming and socio-economic characteristics of fish farmers through personal interview. Primary data were supplemented with secondary data from journals, books and publications from National Institute for Freshwater Fishery Research (NIFFR), New-Bussa. A multi-stage sampling technique was used to select a total sample size of 65 fish farmers from the sampling frame obtained from Niger state Agricultural Development Project (NSADP). Data analysis was done using descriptive and inferential statistics.

2.1. Empirical model

The production response function model was expressed implicitly according to Mbanasor and Obioha (2003) thus:
$Y= f(X_1, X_2, X_3, X_4, X_5, X_6, e_i)$
Where;
Y = Fish output (kg)
X_1= Feeds (kg)
X_2= Fertilizer (kg)
X_3= Water volume (m^3)
X_4= Depreciation value on capital (N)
X_5= Density of fingerlings stocked (number)
X_6= Labour (Man days)
X_7= Pond size (ha)
ei = Error term
The following functional forms were evaluated

2.1.1. Linear function
$Y = b_0 + b_1 X_1 + b_2 X_2 ....+ b_n X_n + e_i$

2.1.2. Semi–log function
$Y = \log b_0 + b_1 logX_1 + b_2 logX_2 ....+ b_n logX_n + e_i$

2.1.3. The Cobb Douglas (double log) function
$Log\ Y = \log b_0 + b_1 log\ X_1 + b_2 log\ X_2 ....+ b_n log\ X_n + e_i$

2.1.4. Exponential function
$Log\ Y = = b_0 + b_1 X_1 + b_2 X_2 ....+ b_n X_n + e_i$

Note:
b_0 = Intercept
b_1-b_n = Regression co-efficient
The marginal value product (MVP) was used to determine the productivity of the resources which the ratio of MVP to the marginal factor cost (MFC) was used to determine efficiency use. MFC was either the purchased unit price of the input or the opportunity cost.

3. Result and Discussion

3.1. Socio-economic Characteristics of the Respondents

Socio-economic characteristics of the respondents in the study area (Table 1) show that male fish farmers constituted about 61.5% as compared to their female counterparts (38.5%). Even though men dominate fish production in the study area, the female percentage is a fair representation given the religious background, oppressive land tenure system and lack of interest in the study area. This to certain extent showed a positive change in the trend of women involvement when compared with the assertion of Nigerian Institute of Social and Economic Research (NISER)(2003), who reported exclusion of women in socio-economic activity and agricultural constraints.81% of the respondents were within the age bracket (19-49) defined by FAO as economically productive in a population. 63.1% youth participation in the enterprise is relatively high, indicating attractiveness of the enterprise; hence population succession in present fish food supply is encouraging .This is contrary to the findings of Ifejika *et al.*(2007) who reported low youth participation in fish farming enterprise in Borgu LGA of Niger state. Marital status shows that majority 81.3% of the respondents were married, with 16.2% either single or divorced. It implies that majority of the respondents shoulder lots' of family labour and also have advantage of cheap labour supply. The educational attainment status indicates literate fish farming population with all the respondents having one form of formal education. Frequencies on educational attainment shows secondary-tertiary (95.4%) compared to primary (4.6%). High literacy level of 95.4% is enough to support information on technology use. Experience in fish farming indicates that 52.3% had six years and above in terms of experience, while 47.7% had less than five years. Krause (1995) asserted that experience reduces management risks, while Sevillage (2000); Edwards (2000) and Dey *et al*. (2002) agrees that experience is crucial and contribute significantly to the success of Asian aquaculture. These results compares favourably to certain extent with Ifejika *et. al* (2007) .

Variables	**Frequency**	**Percentage (%)**
Gender		
Female	25	38.5
Male	40	61.5
Total	65	100
Age		
21-30	20	30.8
31-40	21	32.3
41-50	12	18.5
51-60	9	13.8
≥61	3	4.6
Total	65	100
Education level		
Primary	3	4.6
Secondary	26	40
Tertiary	36	55.4
Total	65	100
Marital status		
Married	41	83.1
Single	12	13.1
Divorced	2	3.1
Total	65	100
Experience		
≤ 1-5	30	46.1
6-10	23	35.4
11-15	11	16.9
Total	65	100

Table 1: Socio-economic characteristics of the respondents
Source: Field survey, 2012

3.2. Model estimation and resource use efficiency

The influence of production inputs on output was determined with the aid of production function. On the basis of *a priori* expectations, the statistical significance of the coefficients and the coefficient of determination the exponential functional form was chosen as the lead equation (Table 2).

The result of the lead equation shows that the coefficient of multiple determinations (R^2) is 0.633, which implies that about 63.3% of the variation in the fish output is jointly explained by the variables included in the model, while the remaining 36.7% may be due to error term and other factors that may not be accounted for by the farmers. The F-value of 16.663 indicates that the overall equation is statistically significant at 1% level. From the result it is evidence that five out of seven variables included in the model have significant influence on the output of fish. Except for labour and depreciation on capital items that were significant at 1% and 10% level respectively, other variables have significant influence on fish output at 5% level. The regression coefficients of feeds, fingerlings stocked, water and labour were positive and significant, which implies that a unit increase in any of this input will lead to an increase in the output of fish, while depreciation on capital items which is negative implies that a unit increase will result in a decrease in the output of fish. Other variables namely fertilizer and medications included in the model are not significant and need no further discussion. The non-significance of these inputs may be attributed to the level of use. This result agrees with the findings of Inoni (2007) except for pond size that was not included in the model. The sum of elasticity (1.162) indicates increasing returns to scale (Table 3). This suggests that the fish farmers in the study area can increase their output by employing more of these resources.

3.3. Allocative Efficiency Estimates

The results of the estimates of allocative efficiency in pond fish production are shown in Table 4. However, estimation of resource-use efficiency required the determination of parameters such as marginal physical product (MPP), marginal factor cost (MFC), and marginal value product (MVP). The marginal factor cost of each input was determined as the average farm cost of an input per unit output, according to Chukwuji *et al.* (2006). Estimates of allocative efficiency of production resources employed in fish farming were 8.7, 1.3, 0.000, -15.3 and 301.0 respectively for feeds, fingerlings, water, depreciation on capital items and labour. The indices indicate that apart from water and depreciation on capital items which was over-utilised, all other resources were under-utilised implying sub-optimal resource allocation in fish farming in the study area. The under-utilization of labour in this study is strange contrary to the tendency to over-utilise it in an operation of this scale. The contrary findings may be due to improvision of hired labour. This is contrary to many findings in Nigeria who reported over-utilization of labour (e.g Inoni, 2007; Oladeebo *et al.* 2006; Olarinde and Kuponiyi 2004, and Akanni and Adeokun, 2004)

Inputs	Linear	Exponential (+)	Cob-Douglas	Semi-log
Constant	-213.672 (-1.274)^{ns}	4.368 (7.690)***	-2.888 (-1.808)*	4878.26 (5.972)***
Feed (kg)	2.390 (6.095)***	0.003 (2.555)**	.698 (4.091)***	225.554 (2.585)**
Fertilizer (kg)	8.089 (.645)^{ns}	0.023 (.531)^{ns}	0.282 (1.216)^{ns}	-8.782 (-.074)^{ns}
Water (litres)	0.146 (3.597)***	0.000 (2.373)**	0.653 (2.478)**	489.927 (3.635)***
Depreciation(N)	-14.210 (-0.513)^{ns}	-0.176 (-1.873)*	-0.244 (-0.593)^{ns}	440.983 (2.098)**
Medication (N)	15.664 (.828)^{ns}	0.034 (.537)^{ns}	0.002 (0.011)^{ns}	13.868 (0.120)^{ns}
Labour (man day)	47.272 (1.629)^{ns}	0.296 (3.017)***	0.518 (2.171)**	97.587 (.800)^{ns}
Fingerlings (number)	13.33 (0.324)^{ns}	0.021 (0.432)**	0.012 (0.01)^{ns}	0.134 (0.001)^{ns}
F value	49.419***	16.663***	28.537***	19.289***
R^2	.836	.633	.807	.738

Table 2: Regression Model Estimation

Source: field survey 2012

*Note: *** ** * implies 1%, 5% and 10% level of significance; ns = not significant; ( ) t value*

Inputs	Coefficients
Feed	0.450
Fertilizer	0.381
Fingerlings Water	0.10 0.000
Depreciation on capital items	-0.880
Medications	0.231
Labour	0.880
Sum of Elasticity (Ep)	1.162

Table 3: Elasticity of Production

Output	MPP	MVP	MFC	Efficiency
Feed	1.24	1,044	120	8.7
Fingerlings Water	0.10 0.00	84.2 0.000	65 1.2	1.3 0
Depreciation	102.2	61,260	4000	-15.3
Labour	171.64	102,924	333.33	309.0

Table 4: Indices of Allocative Efficiency of Resources Utilised

4. Conclusion and Recommendations

The results of the study have shown that fish farmers were inefficient in the application of productive resources, the relatively low technical know-how of fish farmers, low output prices and imperfect condition of input markets in the study area may have hampered efficient utilisation of production inputs. Therefore in order to achieve optimality in resource allocation, there is need to increase the quantity of such inputs employed in fish production, as this will raise the productivity of resources, increase output, and consequently improve revenue and net return. For improve efficiency in resource allocation in small-scale fish production, access to current technical and price information is needed by farmers, and the government should facilitate this as a matter of policy.

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