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Aquaculture Production and Economic Development in Niger State, Nigeria: Sustainable Development of Catfish Production

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Abstract—*The paper investigates the effect of Aquaculture production on economic development keeping in view sustainable development of catfish production in Niger state, Nigeria. Multi-stage sampling technique was employed to selecting 109 current and active catfish farmers drawn from the sampling frame obtained from Niger state Ministry of Livestocks and Fisheries Development which encompasses three LGAs' namely, Bida, Chanchaga and Borgu. Pre-tested questionnaire coupled with interview schedule were the primary instruments used to elicit information from the respondents. Data collection was for 2014 production cycle. Production function analyses which incorporate the conventional neoclassical test of economic and technical efficiencies were used as the analytical technique. Regression results indicated that fingerlings, labour, feeds and pond capacity were the significant determinants of output in catfish production. Production elasticity estimates indicated that the farmers were in stage 1 of the production process, with a return to scale of 1.47. Findings revealed that the farmers were inefficient in the use of all the resources. Generally, inputs such as density of stocked fingerlings and feeds were were under-utilized, while labour and pond size capacity were over-utilized. The results indicate that there is need to make inputs such feeds, hybrid fingerlings affordable and accessible to the farmers so as to improve efficiency. This, in addition to enhanced access to current technical and price information by farmers, will raise output and net returns in catfish farming enterprises. Furthermore, the research calls for intervention by relevant stakeholders in bourgeoning catfish business in the state.*

Keywords*: Aquaculture; Economic; Development; Sustainability; Catfish; Nigeria*

1. INTRODUCTION

Aquaculture occupies a unique position in the agricultural sector of the Nigerian economy. In terms of Gross Domestic Product (GDP), the sub-sector recorded the fastest growth rate in agriculture to the GDP. The contribution of the sub-sector to GDP at 2010 current factor cost rose from N 350 billion to N473 billion in 2014 [6, 2]. Nigerians are large consumers of fish [7] with an annual demand in the country of about 2.66 million tonnes, and a paltry domestic production of about 780,000 tonnes, thereby creating a staggering 1.8 million tonnes demand-supply gap [10]. However, a demand supply gap of at least 0.7 million metric tones exists nationally with import making up the short fall at a cost of almost 0.5 billion US dollars per year [1]. Despite these considerably high potentials, local fish production has failed to meet the country's domestic demand [5]. This industry is at the infant stage when compared to the large market potential for its production and marketing [9]; and remains the most virgin investment in Nigeria compared with the importation of frozen fish in the domestic market [8]. A sure means of substantially solving the demand-supply gap is by embarking on widespread homestead/small scale fish production; raising fish under controlled environment where their feeding, growth, reproduction and health can be closely monitored [3], as such, sources of this effort must be anchored on analysis of fish production. Despite the myriads of information on the integral role of the aquaculture sub-sector to the nation's economy, there exists a dearth of empirical information on the linkage between aquaculture production and economic growth in Nigeria and its perspective for sustainable economic development which ought to form the basis for policy formulation towards enhancing the sub-sector. Therefore, there is the need to fill the existing literature gap by providing empirical information on the synergy between aquaculture production and economic growth in Nigeria for the use of all stakeholders in the sub-sector. In view of the foregoing, this study was carried out to achieve the objective of establishing empirical information on resource optimization in catfish production in Niger state, Nigeria, given that demand for Catfish is high that no matter the quantity supplied to the market, it would be consumed by ready buyers.

2. PRODUCTION FUNCTION IN EFFICIENCY STUDIES

Productivity can be defined as the index of the ratio of the value of total output to the value of the total inputs used in the farm production. Production efficiency means the attainment of production goals without waste. Efficiency is an important factor of productivity growth specifically in developing economies where resources are meager and opportunities for developing and adopting better technologies are limited. Farell [4] derived the three components of efficiency recognized in the economic literature. They include: (i) Technical efficiency (ii) Allocative efficiency, and (iii) Economic efficiency. A firm is said to be technically efficient if it produces as much output as possible from a given set of inputs or if it uses the smallest possible amount of inputs for a given level of output and input mix. The allocative efficiency reflects the ability of a firm to use the inputs in optimal proportions, given their respective prices. The product of these two efficiencies is economic efficiency, which could be defined as the ability of the firm to produce a well-specified output at minimum cost.

The modeling and estimation of production efficiency of a farm relative to other farms or the 'best' practice in an industry has become an important area of economic study. Productivity is generally measured in terms of the efficiency with which factor inputs are converted to output within the production process. According to [11], productivity measures are of two types, partial productivity and total factor productivity (TFP). Partial productivity is measured as the ratio of output to one input. Total factor productivity is the ratio of output to all inputs mixed. Generally, two approaches are used in measuring TFP; growth accounting or index number approach and the econometric or parametric method. The econometric method is based on an econometric estimation of the production function or the underlying cost or profit function. In this study, the production function is used to measure the productivity. From the production function, the conventional neoclassical test of economic efficiency was derived. The rule of this test is that the shape of the production function (MPP) should be equal to the inverse ratio of input price to output price at the profit maximization point. This is given as:

MPPXi = Pxi/Py

Where:

Pxi=the price per unit of resource input used

Py= the output price

MPP = the marginal physical product of resource input used

MPP x Py = MVP

MVP/MFC = r

Where:

MVP = marginal value product

MFC = marginal factor cost/ unit cost

r = numerical constant

In an attempt to substitute the efficiency hypothesis, focus is centered on the estimated value of r and its closeness to unity (1). Efficiency is attained if: MVP = MFC.

3. RESEARCH METHODOLOGY

3.1 Study Area, Sampling Technique and Size

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. Annual rainfall is between 1100mm and 1600mm with average monthly temperature hovering around 23˚C to 37˚C [12]. The range of local climatic and soil conditions, resource availability, and markets allows favourable fish farming practices. Primary data were collected in 2014 production season through administration of pre-tested questionnaire instrument to fish farmers from three Local Government Areas (LGAs) one each from the three Agricultural zones in the state, namely Bida (Zone I), Chanchaga (Zone II) and Borgu (Zone III). These LGAs were purposively selected due to their high involvement in fish farming. The sampling frame obtained from the Niger State Ministry of Livestock and Fisheries Development consists of 182 active farmers out of which 109 (60%) respondents from the population been selected as proportionate representative sampling size for the study. Information were collected on input and output keeping in view the cost involved in carrying out each operation.

Table 1: Sampling frame of catfish farmers in Niger state, Nigeria

Agricultural zones	Selected LGAs'	Population	Sample size
Bida (Zone I)	Bida	55	33
Kuta (Zone II)	Chanchaga	70	42
Kontagora (Zone III)	New-bussa	57	34
Total	3	182	109

Source: NSMLFD, 2014

3.2 Method of Data Analysis*:* The analytical procedure employed was production function analysis. This was used to obtain the parameters for the measurement of resource optimization of catfish farmers. Four functional forms were tried and the lead equation was selected based on economic, econometric and statistical criteria including signs and magnitudes of the coefficients, the magnitude of R^2, T-statistics, F-statistics. The function experimented were linear, semi log, double log and exponential.

3.3.1 Model Specification: The implicit function can be presented by the following equation:

Y=f(X1,X2,X3,X4,X4,X5,X6,X7)…… ……... (1)

Where;

Y = Fish output (kg)

X_1= Pond size (ha)

X_2= Density of fingerlings stocked (number)

X_3= Labour (mandays)

X_4= Lime (kg)

X_5= Fertilizer (kg)

X_6= Medications (litre)

X_7= Feeds (kg)

The following functional forms were evaluated

(a) Linear function

$$Y = b_0 + b_1 X_1 + b_2 X_2 ....+ b_n X_n + e_i \qquad ….(2)$$

MPP= b

Elasticity = b * X/ Y

(b) Semi–log function

$$Y = \log b_0 + b_1 log X_1 + b_2 log X_2 + b_n log X_n + e_i \qquad (3)$$

MPP = b/ X

Elasticity = b/Y

(c) The Cobb Douglas (double log) function

$$Log\ Y = \log b_0 + b_1 log\ X_1 + b_2 log\ X_2 ...+ b_n log\ X_n + e_i \qquad (4)$$

MPP = b* Y/X

Elasticity = b

(d) Exponential function

$$Log\ Y = = b_0 + b_1 X_1 + b_2 X_2 . + b_n X_n + e_i \qquad (5)$$

MPP = b*X

Elasticity = b*Y

Note:

b_0 = Intercept

b_1-b_n = Regression co-efficients

Determining Technical Efficiency of Resource use

The elasticity of production which is the percentage change in output as a ratio of a percentage change in input was used to calculate the rate of return to scale which is a measure of a firm's success in producing maximum output from a set of input.

EP = MPP/APP

Where:

EP = elasticity of production

MPP = marginal physical product

APP = average physical product

If

EP =1: constant return to scale

EP < 1: decreasing return to scale

EP > 1: increasing return to scale

Determining the Economic Efficiency of Resource use

The following ratio was used to estimate the relative efficiency of resource use (r)

r = MVP/MFC

Where:

MFC = unit cost of a particular resource

MVP = value added to fish output due to the use of an additional unit of input, calculated by multiplying the MPP by the price of output. i.e. MPPxi x Py

Decision rule

If r = 1, resource is efficiently utilized,

if r > 1, resource is underutilized, while,

if r < 1, resource is over utilized.

Economic optimum takes place where MVP = MFC. If r is not equal to 1, it suggests that resource was not efficiently utilized. Adjustments could therefore, be made in the quantity of inputs used and costs in the production process to restore r = 1 and the model is given as follows:

Divergence % = (1-1/ri) x100 or [(ri-1)/ri] x100

4. RESULTS AND DISCUSSION

4.1 Estimated Catfish Production Function

The influence of production inputs on output was determined with the aid of production function. On the basis of *a priori* expectations, sample coefficient of determination (R^2), population coefficient of determination (F-statistics), statistical significance of the coefficients (t-statistics), test of normality, test of homoscedasticity and multicollinearity test, the Cobb-Douglas functional form was chosen as the best fit model and lead equation (Table 2). The result of the lead equation shows that the coefficient of multiple determinations (R^2) is 0.81, which implies that about 81% of the variation in the fish output is jointly explained by the variables included in the model, while the remaining 29% may be due to error term or random disturbance in the model. The F-ratio of 59.97 was significant at 1 percent level, implying that the explanatory variables included in the model have strong explanatory power. The F-ratio is a measure of joint significance of all the explanatory variables in the population. From the result it is evidence that four out of seven variables included in the model have significant influence on the output of fish. Except labour that was significant at 5%, other variables were significant at 10% level. The regression coefficients of fingerlings stocked, labour, feeds and pond capacity were positive and significant, which implies that a unit/one percent increase in any of these input will lead to an increase in the output of catfish by 0.46, 0.06, 0.46 and 0.14 percent respectively. Other variables namely medications, lime and fertilizer included in the model were not significant and need no further discussion. The non-significance of these inputs may be attributed to their level of use in the production process. However, at zero input used, 0.53percent will be added to the output.

Table 1: Multiple Regression Estimates of Catfish Production Function

Variables	Coefficient	Standard error	T- value
Constant	0.526*	0.123	4.276
Fingerlings	0.463***	0.255	1.82
Labour	0.055**	0.028	1.96
Medication	0.059NS	0.051	1.157
Feeds	0.460***	0.250	1.84
Pond capacity	0.143**	0.066	2.17
Lime	-0.147NS	0.103	1.43
Fertilizer	0.044NS	0.033	1.33
R2 value	0.81		
R2 Adjusted	0.75		
F-statistics	59.97***		

Source: Field survey 2014 *** ** * : significant at 10, 5 and 1 percent level of probability respectively.
NS: Not significant; ( ): t – ratio computed; +: lead equation

4.2 Elasticity of Productive Resource and Return to Scale.

The sum of elasticities of 1.47 was obtained, this value being greater then unity, means that the farmers are operating at the region of increasing- returns to scale (Table 2). Increasing returns refers to a situation whereby an additional unit of input results in a larger increase in product than the preceding unit. This suggests that catfish famers in the study area can increase their output by increasing the use of some of these key resources, except lime. Therefore, the need for re-allocation of existing resources optimally to maximize returns is recommended. .

Table 2: Estimated Elasticities of Production Resource and Returns to scale

Variables	Elasticity coefficients
Fingerlings	0.463
Labour	0.055
Medication	0.059
Feeds	0.460
Pond capacity	0.143
Lime	-0.147
Fertilizer	0.044
Returns to scale	1.47

Source: Field survey, 2014

4.3 Estimates of Resources-use Efficiency

Table 3 reveals measure of technical efficiency of resource use such as Average Physical Product (APP), Marginal Physical Product (MPP), and Marginal Value Product (MVP) and Marginal Factor Cost (MFC) were derived. The values of the MPP show that the farmers were more efficient in the use of feeds than other resources. This suggests that if additional feed were available, it would lead to an increase in catfish yield by 4.235 kg among the farmers, and it implies that the catfish farmers were more technically efficient in the use of feeds. Of all the resources used, density of stocked fingerlings had the least MPP (0.085kg). This shows inefficiency in the use of available fingerling hybrid. Given the level of technology and prices of both inputs and outputs, efficiency of resource use was further ascertained by equating the MVP to MFC of the productive resources. A resource is said to be optimally allocated if there is no significant difference between the MVP and MFC i.e. if the ratio of MVP to MFC =1 (unit). Furthermore, the result reveals that the ratios of the MVP to the MFC for fingerlings and feeds resources were greater than unity, while the ratios of labour and pond capacity were less than unity except herbicides. This implies that fingerlings and feeds were under-utilized, while labour and pond capacity were over utilized. This implies that catfish output was likely to increase and hence revenue if more of these inputs (fingerlings and feeds) and less of these inputs (labour and pond capacity) were been utilized. The adjustment in the MVPs for optimal resource use indicates that for optimum allocation of resources more than 56.14% increase in density of fingerlings stocked was required, while approximately 88% increase in feeds was needed. However, labour and pond capacity used were over utilized and required more than 143% and 564% reduction for optimal use in catfish production.

Table 3: Estimates of Allocative Efficiency for Resource-use

Variables	MPP	APP	MVP	MFC	MVP/MFC	Divergence %
Fingerlings	0.085	0.184	34.12	15	2.28	56.14
Labour	1.181	21.47	474.04	1163.73	0.41	143.9
Feed	4.235	9.21	1699.9	200	8.50	88.24
Pond capacity	2.151	15.04	863	6000	0.144	564.4

Source: Field survey, 2014

5. CONCLUSION AND RECOMMENDATION

The results of the study have shown that catfish farmers were inefficient in the application of productive resources, and the relatively low technical know-how of catfish 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 the 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 catfish 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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