CHALLENGES AND INVESTMENT OPPORTUNITIES FOR LARGE-SCALE AQUACULTURE FARMERS IN NIGERIA

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ABSTRACT

Fisheries sector plays an important role in Nigeria economy. Contribution of the sector to the nation's economy can be increased if challenges in the industry are minimized and the opportunities explored. Large scale aquaculture, an economic activity earning people a living is a very important industry encompassing fish traders, fish processors, fish farmers etc. The sector supports many Nigerians directly and indirectly. However fish importation is much more in quantity and value. 80% of aquaculture production in Nigeria is manned by small-scale farmers, except for few commercial ventures. Nigeria is blessed with numerous opportunities for large-scale aquaculture; however the challenges seem to override these opportunities. Constraints to production in the industry have been identified as recurrent high cost fish feed, poor water quality management, poor quality fish seed, technical know-how etc. Beyond the constraints to production are more pertinent factors responsible for un-sustainability of fish farm operation as business ventures. This paper focuses on the investment opportunities in large scale aquaculture and the current challenges that the farmers are facing in Nigeria. The paper shows that unprofitable operation of fish farms in Nigeria could be broadly attributed to two factors: poor production planning and inadequate technical know-how. The paper recommends the need to commercialize the industry through broad government fiscal efforts and sectorial re-organization in Nigeria.

INTRODUCTION

Aquaculture plays an important role in the development of many national economies and a key role in the socio-economic resilience of rural areas, potentially offering valuable and skill-based employment opportunities, and in some cases stabilizing the economic base of otherwise fragile communities (Edwards, 1999; Haylor and Bland, 2001; Muir, 1999). It provides livelihood options in rural areas of the developing world, as well as income and employment in both remote regional and more developed economies.

Though aquaculture has grown strongly in most regions of the world where the potential exists, it has not done so in Sub-Saharan Africa. In spite of various efforts since the 1950s, returns on government and international aquaculture investments appeared to be insignificant (FAO, 2004) with less than 5% of the suitable land area being used. Sub-Saharan Africa contribution to world aquaculture production is less than 1% (Hecht 2006). To support future needs, capture fisheries will need to be sustained and if possible enhanced, and aquaculture developed rapidly, to increase by over 260% i.e. an annual average of more than 8.3% by 2020 in sub-Saharan Africa alone (Muir, 2005), which is significantly higher than recent levels.

In Nigeria, fish consumption accounts for about 35 percent of animal protein consumption. Recent data show that Nigeria produced just over 600,000 metric tons of fish in 2007 (Table 1). Consumer demand, on the other hand, was reported at 2.66 million metric tons, and was met only in part by imports of about 740,000 metric tons in year 2007 (Table 2). With rising population of Nigeria is attendant increase in fish demand and its projection (Table 3). Thus, there is a national demand supply gap with fish importation making up the short fall at a cost of almost 0.5 billion US dollars per annum (FDF, 2010). This leads to resultant foreign exchange drain on the nation’s economy. It is not sustainable. However, the long term solution to the domestic fish supply gap still lies in boosting domestic production through sustainable aquaculture practices (Aihonsu, 2001).

Today, the story of aquaculture in Nigeria is essentially the story of catfish culture and the hope of fish supply in Nigeria hangs on its development and culture. Adewunmi *et al*, (2004) reported monoculture of catfish as predominant practice in Nigeria. Thus, the growth of aquaculture in Nigeria now is largely being boosted by a steady rise in catfish culture. African catfish is popular in the market and has great potentials to boost the rapidly growing Nigerian aquaculture.

Though, aquaculture has been the fastest growing food-producing sector globally, its contribution to Nigeria’s total fish production is still insignificant. Since the story of aquaculture in Nigeria is basically the story of catfish culture, thus constraints to catfish production are also constraints to Nigeria aquaculture development and production. The

major constraints identified as being responsible for the low production from aquaculture include shortage of inputs (fingerlings and feed), lack of knowledge resulting in poor management practices, inadequate funding, theft and direct involvement of government in production (Anetekhai *et al*, 2004). Use of poor quality catfish seeds, inadequate information, high cost of feeds, traditional techniques, small-size holdings poor infrastructural facilities and low capital investment are also factors reported to be limiting the growth of aquaculture in Nigeria (Ugwumba, Ugboaja and Orji, 2006; Adeogun *et al*, 2007; Ugwumba & Nnabuife, 2008). Ugwumba and Chukwuji (2010) on the other hands arranged the constraints to catfish production in descending order of severity as high cost of feeds, lack of capital, scarcity of fingerlings, lack of modern technologies, high cost of transportation, high cost of labour, lack of land, poaching, inadequate water supply, mortality of fish and lastly poor storage facilities.
Nath *et al* (2000) stated that there is still a great need for practical scientific knowledge, economic and profitability studies and knowledge of potential areas for site selection, development and expansion. In this respect, reliable analytical tools for use in decision making are key need in planning expansion. Thus, greater improvement in catfish production can be achieved with a proper analysis that will lead to knowledge of the level of profitability of catfish farming and constraints to production. This constitutes the basis for this study.

METHODOLOGY

Description of study area

The study was conducted in Ogun State, Nigeria. Ogun State is a state in South-western Nigeria. Ogun state lies within longitude $2^{0}\,45'$ E and $3^{0}\,35'$ E and latitude $7^{0}\,01'$ N and 7^{0} 8'N in the tropics. It is bordered in the South by Lagos State and Atlantic Ocean. It is bordered in the North by Oyo and Osun States. It is bordered in the East by Ondo State and bordered in the West by Republic of Benin. Abeokuta is the capital and largest city in the state. The State covers a land area of 16,762 km^2; less than two percent of the country's landmass. Ogun state has a population of 4,054,272 (NPC, 2005). The areas of study are the four Extension Zones created by Ogun State Agricultural Development Programme (OGADEP) which are: Abeokuta, Ijebu, Ikenne and Yewa Zones (Figure 1).

Data collection and analysis

The data was obtained with the aid of structured questionnaire to collect information on:

i. **Socio-economic characteristics of the farmers**. Socio-economic data included educational background of the farmers, age, sex, marital status, household size, farming experience, technical know-how and frequency of contact with extension agents.
ii. **Production variables**: Biological and economic inputs and output parameters of the catfish production. Production variables considered were production units (concrete tank or earthen pond), production inputs and their costs (farm size (number of catfish seeds stocked), labour, fertilizer, lime, medication, fuel cost, transportation and feed), production output (yield and price of product).

iii. **Production constraints**. Data considered were severity of high cost of feed, inadequate fund (capital), scarcity of catfish seeds, scarcity of quality fish seed (fingerlings/ juveniles), high cost of transportation, high cost of labour, lack of space (land), poaching (theft), inadequate water supply, poor storage facilities, disease outbreak, poor pricing by customers, flooding, post-harvest loss, prompt marketing after harvest; and lack of technical know-how.

Sample Procedure

Multistage sampling procedure (involving purposive and simple random sampling technique) was adopted in this study. The first stage was the purposive selection of the four agricultural zones (Abeokuta, Ijebu, Ikenne & Ilaro) in the State. Two extension blocks were randomly chosen from each of the zone. The third stage involved the random selection of twenty fish farmers from each of the block. A total of one hundred and sixty (160) respondents were therefore selected from the four extension zones of the State. The selected fish farmers were interviewed with the aid of structured questionnaires. The total number of questionnaires used for the analysis represented 86.25% (138) of the total numbered of sampled fish farmers as 22 were discarded due to incomplete information.

Method of Data Analysis

Descriptive statistics was used to summarize and interpret data gathered on socio-economic characteristics.

Cost and return analysis was used to determine the profitability level of catfish production in the two production systems; earthen pond production system (EPPS) and concrete tank production system (CTPS).
Total Cost (**TC**) = Total Fixed Cost (**TFC**) + Total Variable Cost (**TVC**)

Where:

TFC consist of depreciated values of concrete tanks, earthen ponds, borehole/ well, generator, pelleting machine, drying oven, drag net, other farm machineries & equipments.

TVC consist of costs of fish seed (fingerlings/ juveniles), lime, fertilizer, fish feeds, hired labour, medication, fuel, transportation, and miscellaneous.
Gross Revenue **(GR)** consists of receipts from total sales. It is the product of quantity harvested for sales and unit market price of fish per kilogram.
Gross Revenue = Quantity Harvested (kg) X Unit Market Price

Net Profit This was determined by deducting total cost of production (TC) from the gross revenue (GR)
Net Profit = Gross Revenue – Total Costs
Rate of Return on Investment (**RRI**) was determined by dividing net returns by total cost of production
Rate of Return on Investment = Net Returns/ Total Costs

Depreciation For this analysis, straight line method (SLM) which assumed salvage value of zero was used. The formula is specified as:
Ds = (OC – SV)/ L
Where:
Ds = Annual depreciation
OC = Original cost
SV = Salvage value
L = Expected or useful life (year)

Duncan Multiple Range Test was used for ranking of production constraints in order of severity.

Stochastic Production Function The Cobb-Douglass function form for the catfish farms in the study areas is specified as follows for the production function:
$Y_i = \beta_0 + \beta_1 InX_{1i} + \beta_2 InX_{2i} + \ldots + \beta_7 InX_{7i} + V_i - U_i$
Where:
Y = Catfish output (kg)
X_1= Lime quantity (kg)
X_2= Fertilizer quantity (kg)
X_3= Feed input (kg)
X_4=Medication
X_5= Labour input (man days)
X_6= Fuel input (litres)
X_7= Farm size (number of fish seeds stocked)
V_i = random variable which assumed to be independently and identically distributed (iid) $N(0,\sigma_v^2)$ and independent of U
U_i = non-negative random variable associated with technical inefficiency in production and is assumed to be independent and identically distributed half normal (iid) $N(0,\sigma_u^2)$ where the conditional mean μ is assumed to be related to farm and farms-related socioeconomic characteristics as follows:
The Inefficiency Model is specified thus,
$\mu = \delta_0 + \delta_2 W_1 + \delta_2 W_2 + \ldots + \delta_5 W_5$
Where,
W_1 = Level of education of fish farmers
W_2 = Farmer's age (years)
W_3 = Farming experience of fish farmers (years)
W_4 = Length of production cycle (months)
W_5 = Stocking rate (number of fish/ m^2)

RESULTS AND DISCUSSION

Socio-economic characteristics of the catfish farmers

According to figure 2, 68.84% of the farmers operate earthen pond production system (EPPS) while 31.16% operate concrete tank production system (CTPS) for catfish production. This might not be unconnected to the fact that fishes thrive well in their natural environment. The socio-economic characteristics of the farmers in the study area are presented in Table 4. 44.2% of the farmers operating EPPS and CTPS were between the ages of 41-50 years. 10.5% of EPPS operators are between the ages of 61-70 years while 7.0 % of those farmers operating CTPS are above 70 years of age. However, 49.72±8.19years represent the mean age of farmers operating EPPS and 51.44±11.20years for those operating CTPS. This distribution shows that majority of the fish farmers are active and therefore have the capacity for high productivity. This result is in agreement with Aromolaran *et al* (2008).

82.1% and 76.7% of the farmers operating EPPS and CTPS respectively are males. This result shows dominance of men in fish farming occupation in the study area. However, more females (23.3%) operate CTPS than females (17.9%) involved in operation of EPPS. For catfish farmers operating EPPS; 93.7% were married, 24% were single, 2.1% were widower, 1.1% divorced and 1.1% widow. However, farmers operating CTPS, 83.7% were married, 9.3% were widow, 4.7% were single and 2.3% divorced. Since most farmers sampled are married, it can be inferred that since marriage allows for procreation and thereby providing access to use of family labour in fish farming business. Household size of EPPS operators ranges from 1-20 people with an average of 7±3 people per household. 53.7% have 6-10 people per household, 31.6% have 1-5 people per household, 12.6% have 11-15 people per household and 2.1% have 16-20 people per household. However, an average of 6±3 people per household was observed among farmers operating CTPS. 55.8% have 1-5 people per house hold, 37.2% have 6-10 people per household, 4.7% have 11-15 people per household and 2.3% have 16-20 people per household. This implies that fish farmers can have access to use of family labour should there be scarcity of hired labour at any time.

Among farmers operating EPPS, 44.2% have secondary school education, 35.8% have tertiary education, 14.7% have primary education, 3.2% have no formal education at all and 2.1% have adult education. However, among farmers operating CTPS 55.8% have tertiary education, 34.9% have secondary education, 4.7% have primary education and 4.7% again have adult education. Fish farmers are fairly well educated and this has implication for productivity through easy acceptability of new innovation from extension workers. Years of fish farming experience of farmers operating EPPS ranges from 1-20 with an average of 8±4.9 years. 47.4% have 6-10 years experience, 32.6% have 1-5 years experience, 14.7% have 11-15 years experience and 3.2% have above 20 years experience. However, an average of 6.1±3.7 years of experience was observed among farmers operating CTPS. 48.8% have 1-5 years of experience, 39.5% have 6-10 years of experience, 9.3% have 11-15 years of experience and 2.3% have 16-20 years of experience. Based on contact with extension agent, EPPS operators were distributed as follows; 73.7% had fortnight contact, 21.1% had monthly contact, 3.2% had occasional contact and 2.1% had quarterly contact with extension agent. For operators of CTPS however, 55.8% had fortnight contact, 14% had occasional contact and 4.7% had quarterly contact with the extension agent.

Cost and return analysis of the catfish farmers

The cost and return analysis of catfish farmers in the study area is presented in Table 5. The catfish farmers incurred several costs in the course of catfish production. These costs include both variable and fixed costs of production. The variable costs involved in the production include catfish seeds (fingerlings), lime, fertilizer, catfish feeds, labour, medication, fuel, transportation and miscellaneous costs. The fixed cost items are made up of depreciation values of earthen pond/ concrete tank, water pump, borehole, generator, pelleting machine, drying oven, dragnet and others.

The total cost of production for farmers operating EPPS was N981, 720.79 ($5,890.32). Out of this amount, the overall variable costs accounted for N919, 357.87 (93.65%), an equivalence of $5,516.15 while only N62,392.92 (6.35%), an equivalence of $374.36 was incurred on fixed cost items. Cost of feeds alone constituted about 61.98% (N608,435.60, an equivalence of $3,650.61) of the total cost of production. This is followed by labour cost of N179,441.00 (18.28%) an equivalence of $1,076.65 with a miscellaneous percentage of 0.44 (N4,275.00, an equivalence of $25.65)

The total cost of production of farmers operating CTPS was N835,342.77k ($5,012.06). Out of this amount, the overall variable costs accounted for 94.48% (N788,933.08, an equivalence of $4,733.60) while only 5.52% (N46,409.69, an equivalence of $278.46) accounted for the fixed cost items. Cost of feed alone constituted 73.24% (N615,540.50, an equivalence of $3,693.24) of the total cost of production. This is followed by cost of fingerlings of 8.65% (N72,654.76, an equivalence of $435.93) while the least is cost of fertilizer of 0.12% (N991.88, an equivalence of $5.95).

It should be noted however that there was no significant difference at five percent level in the net profits of the two production systems. This is supported by Ugwumba and Chukwuji (2010) who concluded that what matters in catfish production profit is not pond type (concrete or earthen) per say but stock size (number of fingerlins stocked), intensive feeding and sound management practices. However, Kareem *et al* (2008) and Adebayo and Adesoji (2008) in their comparative study of catfish rearing in concrete tank and earthen pond system reported that fish growth is greater in earthen pond than in concrete tank and hence their profitability too. On the other hand, Ugwumba and Okoh (2010) revealed that catfish production using either production system is profitable.

Stochastic production function estimation for the two catfish production systems

Table 6 shows the stochastic production frontier estimates for the two fish production systems. In EPPS, the results revealed that all the variables except lime returned positive sign. Fertilizer, feed and farm-size were the variables which significantly affect output of fish in the EPPS while lime, labour, medication and fuel were not significant. All the significant variables (fertilizer, feed and farm size) had positive sign and were significant at 1% level. This implies that increase in each variable will increase output of fish. Since the production function is in the Cobb-Douglass form, the coefficients also represent elasticities of production with respect to the specific input. In the light of this, the elasticities of fish output with respect to fertilizer, feed and farm size are 0.248, 0.372 and 0.108. This implies that a 1% change (increase) in the quantity of fertilizer, feed and farm size will result in 0.248%, 0.372% and 0.108% increase respectively in the output of fish. In other words, a 100% increase in the quantity of fertilizer, feed and farm size will result in 24.8%, 37.2% and 10.8% change (increase) respectively in fish output.

The gamma value of 0.089 implies that 8.9% of the total variations in the output of fish farmers using EPPS were due to difference in the inefficiency levels. The inefficiency model estimation revealed that stocking rate was the only significant inefficiency variable. The variable returned a negative sign and was significant at 1% level. The implication of this is that increase in stocking rate reduces inefficiency which means that it increases efficiency.

For CTPS, the results revealed that all the variables except labour and fuel returned positive sign. Feed, medication and farm size were the variables which significantly affect output of fish in the CTPS while fertilizer, labour and fuel were not significant. All the significant variables (feed, medication, and farm size) had positive sign and were significant at 5%, 10% and 1% levels respectively. This implies that increase in each of these variables will increase fish output.

Also, the coefficients here represent elasticities of production with respect to the specific input. Thus, the elasticities of fish output with respect to feed, medication, and farm size were 0.221, 0.227 and 0.903 respectively. The implication is that a 1% change (increase) in the quantity of feed, medication and farm size will result in 0.221%, 0.227% and 0.903% increase respectively in the output of fish. In other words, a 100% increase in the quantity of feed, medication, and farm size will result in 22.1%, 22.7% and 90.3% change (increase) respectively in fish output.

The gamma value of 0.699 implies that 69.9% of the total variations in the output of fish farmers using CTPS were due to difference in the inefficiency level. The inefficiency model estimation revealed that educational level and stocking rate were the only significant inefficiency variables. The variables (educational level and stocking rate) returned a negative sign and were significant at 10% and 1% levels respectively. This implies that increase in educational level and stocking rate reduces inefficiency of CTPS and consequently increases CTPS efficiency.

This result is supported by Ogundari and Akinbogun (2010), Ugwumba and Chukwuji (2010), Olawumi *et al* (2010) and Adewuyi *et al* (2010) who also submitted that fish output is significantly influenced by fish feed as the most important input among others. Kareem *et al* (2008) using stochastic frontier production function models revealed that pond area, quantity of lime used, and number of labour used were found to be the significant factors that contributed to the technical efficiency of concrete pond system while pond, quantity of feed and labour are the significant factors in earthen pond system. They therefore concluded that only years of experience is the significant factor in concrete pond system in the inefficiency sources model.

Technical efficiency estimates of catfish farmers

Table 7 and 8 shows frequency distribution of the technical efficiency estimation of catfish farmers in the two production systems in the study area. For farmers operating EPPS, majority (65.3%) of the farmers have technical efficiency score ranging from 0.8-0.9, while 11.6% of the farmers have above 0.9technical efficiency score. The mean technical efficiency score of the farmers is 0.84 with a minimum value of 0.72 and a maximum of 1.0. The mean efficiency score still show some inefficiency in EPPS. Thus, there is still potential for increasing catfish output at the given level of inputs being used.

Majority (18.6%) of farmers operating CTPS have technical efficiency score ranging from 0.5-0.6. However, the mean technical efficiency score of the farmers is 0.61 with a minimum value of 0.03 and a maximum value of 0.96. Mean technical efficiency score of 0.61 shows that there is substantial inefficiency in CTPS catfish farming in the study area. This implies that there is potential for increasing output at the given level of inputs being used.

Kareem et al 2008 revealed that concrete pond system has 88% mean technical efficiency while earthen pond system has 89%. Similarly, allocative efficiency results revealed that concrete pond system was 79 percent while earthen pond had 85%. Also, Ekunwe and Emokaro (2009) in their study on technical efficiency in Kaduna metropolis, Kaduna State, Nigeria used stochastic frontier production function analysis. Their results showed that the estimated farm level technical efficiency ranged from 47.0 percent to 97.1 percent with a mean of 85.4 percent. About 90 percent of the farmer had technical efficiency exceeding 0.71. Fingerling, labour and pond size were efficiently allocated as their estimated coefficient value range between zero and one.

Production constraints of the catfish farmers

The ranking of catfish farmers' production constraints is presented in Table 9. The constraints were ranked from one to six; one being the most severe and six being the least severe rank. In EPPS, high cost of feed and inadequate fund (capital) was ranked the most severe constraints to catfish production. Scarcity of fish seed (fingerlings/ juveniles) and post-harvest loss was ranked least. Also in CTPS, high cost of feed was ranked most severe, inadequate fund (capital) second and a group of flooding, disease outbreak and post-harvest loss were the least ranked constraints to production.

This result is supported by Ugwumba and Chukwuji (2010) who also arranged the constraints to catfish production in descending order of severity as high cost of feeds, lack of capital, scarcity of fingerlings, lack of modern technologies, high cost of transportation, high cost of labour, lack of land, poaching, inadequate water supply, mortality of fish and lastly poor storage facilities.

CONCLUSION

Judging by the Nigeria fish supply demand gap, aquaculture potential to bridge the gap and proven profitability study of aquaculture, there exist enormous investment opportunities for large scale aquaculture venture in the country. Foreign investors can target the pressing areas of constraints identified (cheap and quality feed production especially) for investment. It is therefore recommended that government should intervene through broad government fiscal efforts and sectorial re-organisation in Nigeria.

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FIGURE & TABLES

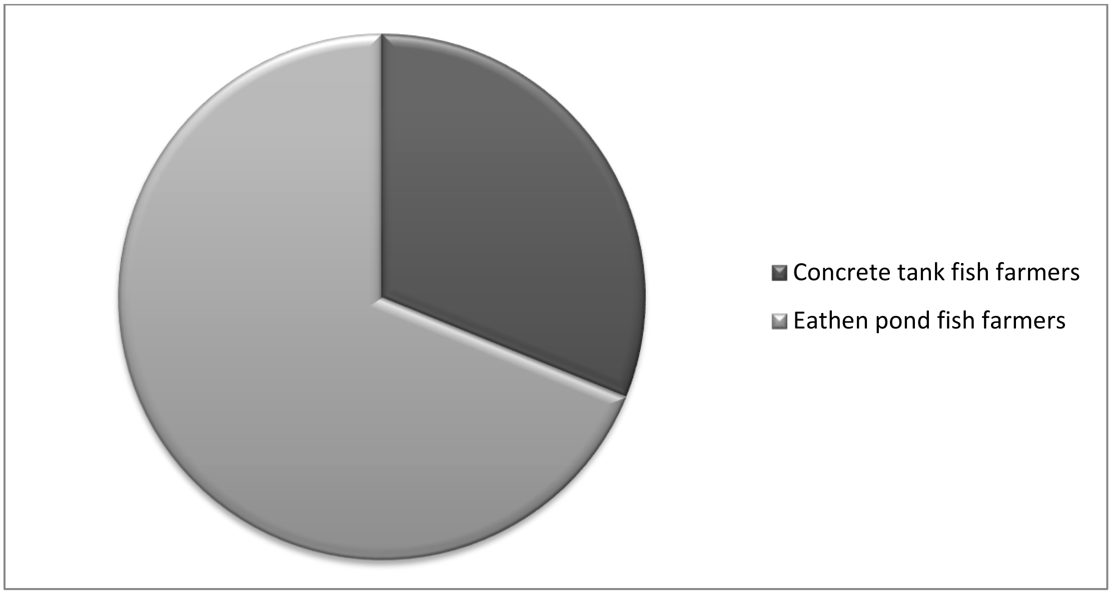

Figure 1. Catfish farmers' distribution by aquaculture production system

Table 1. Nigeria domestic fish production by sectors (2001-2010) in tonnes

Sector/ Year	2001	2002	2003	2004	2005	2006	2007	200	2009	2010
Artisanal	433,537	450,965	446,203	434,830	490,594	518,537	504,226	511,382	598,211	616,981
Aquaculture	24,398	30,664	30,677	43,950	56,355	84,533	85,087	143,207	152,796	200,535
Industrial	28,378	30,091	33,882	30,421	32,595	33,778	26,193	29,986	29,698	31,510
Total Fish Production	**486,313**	**511,720**	**510,762**	**509,201**	**579,544**	**636,848**	**615,506**	**684,575**	**780,705**	**849,026**

Source: Source: Federal Department of Fisheries, 2008

Table 2. Nigeria fish imports

Year	Import (tonnes)	Value '000 $
1995	266,448.00	140,308.75
1996	403,273.00	290,351.31
1997	382,442.00	158,632.74
1998	373,043.70	190,098.05
1999	444,840.00	209,958.64
2000	557,884.00	241,066.54

2001	648,196.60	368,188.84
2002	681,151.80	375,027.92
2003	663,179.52	403,485.89
2004	648,033.00	425,080.23
2005	611,520.45	485,925.98
2006	646,484.98	450,140.79
2007	739,666.12	594,373.69

Source: Federal Department of Fisheries, 2008

Table 3. Proposed population and fish demand from 2010-2025

Year	Population (million)	Fish demand (million tonnes)
2010	158.8	3.02
2011	163.9	3.11
2012	169.1	3.21
2013	174.5	3.32
2014	180.1	3.42
2015	185.9	3.53
2016	191.9	3.65
2017	198.0	3.76
2018	204.3	3.88
2019	210.9	4.01
2020	217.6	4.13
2021	224.6	4.27
2022	231.7	4.40
2023	239.2	4.54
2024	246.8	4.69
2025	254.7	4.4

Source: Federal Department of Fisheries, 2007

Table 4: Socio-economic characteristics of catfish farmers in Ogun State, Nigeria

	Earthen pond production system		Concrete tank production system	
	Frequency	**Percentage**	**Frequency**	**Percentage**
Age (years)				
≤30	1	1.1	0	0
31-40	10	10.5	5	11.6
41-50	42	44.2	19	44.2
51-60	32	33.7	11	25.6
61-70	10	10.5	5	11.6
Above 70	0	0	3	7.0
Total	**95**	**100.0**	**43**	**100.0**
Mean±SD	**49.72±8.19years**		**51.44±11.20years**	
Gender				
Female	17	17.9	10	23.3
Male	78	82.1	33	76.7
Total	**95**	**100.0**	**43**	**100.0**

Marital status				
Divorce	1	1.1	1	2.3
Married	89	93.7	36	83.7
Single	2	2.1	2	4.7
Widow	1	1.1	4	9.3
Widower	2	2.1	0	0
Total	**95**	**100.0**	**43**	**100.0**
Household size (persons)				
1-5	30	31.6	24	55.8
6-10	51	53.7	16	37.2
11-15	12	12.6	2	4.7
16-20	2	2.1	1	2.3
Total	**95**	**100.0**	**43**	**100.0**
Mean	**7.32±3.14**		**5.98±3.10**	
Educational level				
Adult education	2	2.1	2	4.7
No formal education	3	3.2	0	0
Primary school	14	14.7	2	4.7
Secondary school	42	44.2	15	34.9
Tertiary education	34	35.8	24	55.8
Total	**95**	**100.0**	**43**	**100.0**
Experience (years)				
1-5	31	32.6	21	48.8
6-10	45	47.4	17	39.5
11-15	14	14.7	4	9.3
16-20	3	3.2	1	2.3
Above 20	2	2.1		
Total	**95**	**100.0**	**43**	**100.0**
Mean	**7.99±4.85**		**6.13±3.66**	
Contact with extensionists				
Fortnightly	70	73.7	24	55.8
Monthly	20	21.1	11	25.6
Occasionally	3	3.2	6	14.0
Quarterly	2	2.1	2	4.7
Total	**95**	**100.0**	**43**	**100.0**

Table 5: Cost and return analysis of catfish farmers in Ogun State

	Earthen pond production system	**Concrete tank production system**
	Amount(Naira)	**Amount (Naira)**
FixedCost (Depreciation)		
Pond (depreciation)	8,902.48	16,575.06
Pumping Machine	2,906.40	2,610.38
Borehole	8,446.43	10,808.61
Generator	6,937.27	4,790.90
Pelleting Machine	7,579.55	5,491.11
Drying oven	25,000.00	656.25
Dragnet	1,949.82	1,096.23
Others	640.97	4,381.15
Total Fixed Cost (TFC)	**62,362.92**	**46,409.69**
Variable cost		
Seed	51,433.33	72,654.76
Lime	5345.4	-
Fertilizer	24,512.20	991.88
Feed	608,435.60	615,540.50
Labour	179,441.00	41,637.93

Medication	10,140.63	10,500.00
Fuel	18,608.43	19,472.50
Transport	17,166.28	18,135.48
Others	4,275.00	10,000.00
Total Variable Cost (TVC)	**919,357.87**	**788,933.08**
Total Cost	**981,720.79**	**835,342.77**
Revenue	**1,535,653.00**	**1,498,956.00**
Net Profit	**553,932.21**	**663,613.23**
Rate of Return on Investment	**0.56**	**0.79**
Mean net profit±SE	**553,932.21±222,956[a]**	**663,613.23±121,681[a]**

Figures in each row with similar superscript are not significantly different (P>0.05) N.B. $1=N154.894

Table 6: Stochastic production function estimation for the two production systems

		Earthen Pond System		Concrete Tank System	
Variable	**Parameter**	**Coefficient**	**T-Ratio**	**Coefficient**	**T-Ratio**
Constant	β_0	2.483	3.295	0.985	0.886
Lime	β_1	-0.031	-0.508		
Fertilizer	β_2	0.248***	3.531	0.050	0.883
Feed	β_3	0.372***	24.947	0.221**	2.116
Labour	β_4	0.018	0.345	-0.087	-0.94
Medication	β_5	0.052	0.567	0.277*	1.698
Fuel	β_6	0.037	0.717	-0.009	-0.089
Farm size	β_7	0.108***	3.121	0.903***	4.683
Inefficiency model					
Constant	θ_0	0.609	1.439	3.386	2.395
Educational level	θ_1	-0.011	-1.188	-0.106*	-1.804
Age	θ_2	-0.003	-0.359	0.019	1.358
Farming experience	θ_3	-0.005	0.466	-0.037	0.657
Production length	θ_4	-0.025	-0.561	-0.282	-1.542
Stocking rate	θ_5	-0.007***	-3.6981	-0.041***	-3.771
Sigma-squared	$\sigma^2 = \sigma_u^2 + \sigma_v^2$	0.187	6.183	0.307	2.627
Gamma	$\gamma = \sigma_u^2 / \sigma^2$	8.901	1.115	0.699	5.817
Log likelihood function	LLF	-44.685		-22.066	

***significant at 1% **significant at 5% *significant at 10%

Table 7: Predicted technical efficiency of earthen pond fish farmers

Efficiency Range	Frequency	Percent
0.7001-0.8000	22	23.2
0.8001-0.9000	62	65.3
Above 0.9000	11	11.6
Mean	0.8378	
Minimum	0.72	
Maximum	1.00	

Table 8: Predicted technical efficiency of concrete tank fish farmers

Efficiency Range	Frequency	Percent
≤ 0.3	4	9.3
0.3001-0.4000	6	14.0
0.4001-0.5000	6	14.0
0.5001-0.6000	3	7.0
0.6001-0.7000	6	14.0
0.7001-0.8000	4	9.3
0.8001-0.9000	8	18.6
Above 0.9000	6	14.0
Mean	0.6084	
Minimum	0.03	
Maximum	0.96	

Table 9: Perceived ranking of Ogun State catfish farmers' production constraints

	Earthen pond production system	Concrete tank production system
Production constraints	**Level of severity**	**Level of severity**
Scarcity of fish seed (fingerlings/ juveniles)	6	5
Scarcity of quality fish seed (fingerlings/ juveniles)	4	3
High cost of feed	1	1
Inadequate water supply	5	4
Inadequate fund/ capital	1	2
Flooding	5	6
Disease outbreak	5	6
Poor pricing by customers	2	2
High cost of transportation	3	3
Post-harvest loss	6	6
Poor storage facilities	4	4
Prompt marketing after harvest	3	4
Lack of technical know-how	5	4
High cost of labour	2	3
Lack of space/ land	5	4
Poaching/ Theft	4	5

*1 being the most severe and 6 being the least