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Profit Function Analysis of Aquaculture Farmers from Selected States in South East, Nigeria using Cobb-Douglas Stochastic Production Frontier Function

Ume, S I[1], Ebeniro, L A[2], Azuine, U A[2], Uche, F O[2]

[1]Department of Agricultural Extension and Management, Federal College of Agriculture Ishiagu, Ivo Local Government Area (LGA) Ebonyi State, Nigeria
[2]Department of Fisheries Technology, Federal College of Agriculture Ishiagu, Ivo Local Government Area (LGA) Ebonyi State, Nigeria

Corresponding Author: Ume, S I

ABSTRACT

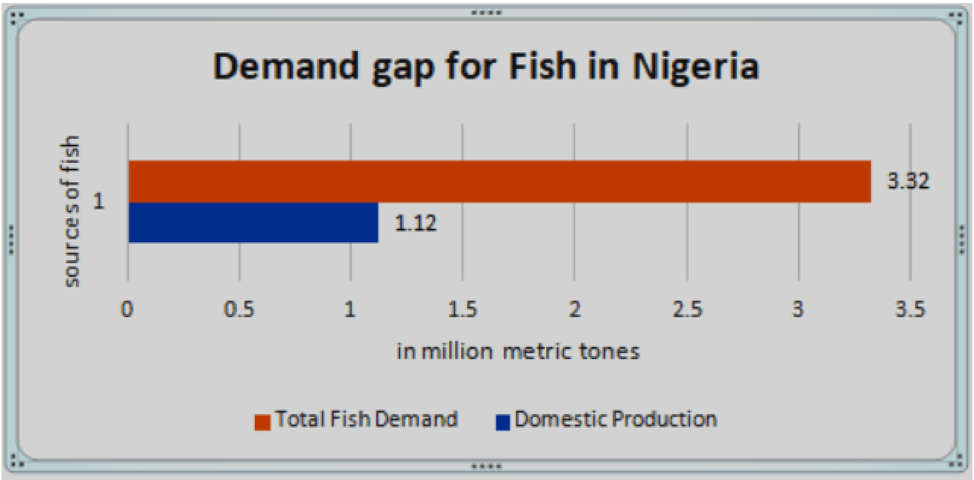
Profit function of aquaculture farmers from selected states in South East, Nigeria using Cobb –Douglas stochastic production frontier function was studied. One hundred and twenty farmers were selected using purposive and multi stage random sampling techniques. A structured questionnaire and oral interview were used to elicit information on primary data. The secondary data were collected using textbook, journals, seminars, workshops and other periodicals. Percentages responses, multiple regression model based on Stochastic Frontier Profit Function which assumed Cobb-Douglass specification form and Inefficiency function model, while Gross margin analysis multiple regression model based on Stochastic frontier profit function which assumed Cobb-Douglass specification form and Inefficiency function model and gross margin analysis were used to address the objectives of the study. The major results of the study showed that the coefficients of prices of feeds, fingerlings, drugs, fertilizer and pond size were positive. Whereas, the coefficient of labour was negative and cut across all States, the coefficient of water was negative among Abia State farmers. Furthermore, the coefficients of age, educational levels, cooperatives and extension services were positive and cut across all States. Also, the coefficient of credit was negative and significance only in Anambra and Ebonyi States. The production of catfish and tilapia was profitable in the study area with high gross margin and Net farm income. The limitations to aquaculture production as well in the study areas were poor access to credit, water problem, poor fish breeds, poor access to extension services, high costs of building materials, feed and labour, and cannibalism. The need to improve farmers' access to credit, extension services, good fish breeds among others were proffered.

Keyword: Profit Function; Aquaculture Farmers; Selected States; South East; Nigeria; Cobb-Douglas; Stochastic Production; Frontier Function.

INTRODUCTION

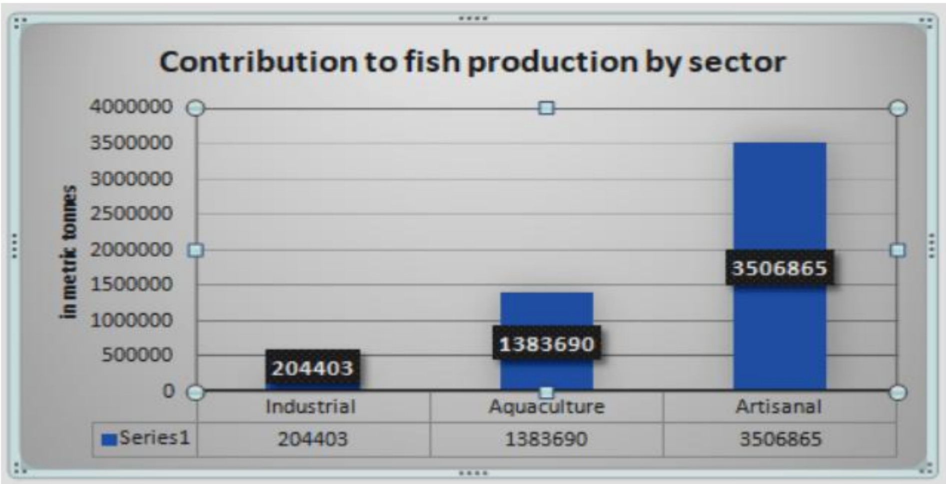
The enormous uses of fish for human consumption, industrial uses, foreign exchange, fashion industry, recreation (sport fishing), ornamental and decorations, employment generation and livestock feed formulation are well acknowledged among literatures (Food Agriculture Organization, FAO, 2012; Adewumi and Olalaye, 2012; Ume and Ochiaka, 2015). Globally, these fish and fishery products are accessed through artisanal, industrial and aquaculture, although at varied proportions (FAO, 2007). In Nigeria, artisanal production from coastal and brackish water in rivers and lakes dominates the Nigerian fishing industries, contributing about 69% of total fish caught in the country, followed by industrial, 27% and the least, 4% from the aquaculture

(Amao *et al.*, 2006).The Federal Department of Fisheries (FDF) and Food and Agriculture Organisation (FAO) estimates on Nigeria's self-sufficiency in fish production revealed that the country had as high as 98.8% in 1983, which drastically reduced to 40% and 19.2% in 2005 and 2014 respectively with mean of 49% (Ume *et al.*, 2016). In recent times, the demand for fish and fishery products in the country has doubled, thus widening the domestic demand and supply gap. The annual fish demand according to FAO, (2016) was estimated at 3.32 million metric tonnes with domestic production of about 1.12 million metric tonnes, whereas the deficit of 2.2 million metric tonnes was supplemented through fish import.



Data source – National Bureau of Statistics; Nigeria's Fish Production (2010 – 2015), February 2017

The increase in fish demand as asserted by FAO,(2016) could be attributed to the relative decline in the supply of animal protein from other sources of fish, increasing population, decline in captured fishes due to pollution and over fishing, government fishing regulations, rampant growth of water plants such as water hyacinth in our rivers that disrupt the free movement of fishing trawlers as well as rampant deforestation of mangrove trees which serve as natural habitats for fishes. Also, the low output from industrial fishing could be owning to the fact that most people in the business cannot afford the vessels and equipment required for intense commercial fishing in the high seas and most current fishing vessels ageing fleet and infrastructure, extensive importation of fish and poor enforcement of government regulations and investment, sea robbery and piracy, pollution, especially oil spillage and biological waste (Emokaro, Ekunwe and Achille, 2015).



Data source – National Bureau of Statistics; Nigeria's Fish Production (2010 – 2015), February 2017

Figure 2 shows the contributions of fish production by three major sectors; with artisanal having 69%, industrial 4%, and aquaculture27%; between 2010 and 2015.

However, with all these aforementioned limitations facing artisanal and industrial fishing, the only avenue left out to boost intake of fish protein by Nigerians especially the poor rural household who could not be able to afford protein of the animal origin, which is very costly, in order to equal to the UN/FAO'S estimated daily per capita intake of fish up to 2025 (Table 1), is through aquaculture production (Nwosu;*et al.*, 2003; Ogundari *et al*., 2006).

Table 1 Projected population and fish demand/supply in 2000-2025.

Year	Population (million)	Fish demand (million tonnes)	Fish supply in domestic production (million tonnes)	Short fall (million/tonnes)
2000	114.40	0.87	0.53	0.34
2001	117.60	0.89	0.57	0.32
2002	121.00	0.92	0.61	0.31
2003	124.40	0.95	0.65	0.30
2004	127.90	0.97	0.69	0.28
2005	131.50	1.00	0.73	0.27
2006	135.20	1.03	0.77	0.26
2007	139.10	1.06	0.81	0.25
2008	143.000	1.09	0.85	0.24
2009	147.10	1.12	0.89	0.23
2010	151.20	1.15	0.93	0.22
2011	155.50	1.18	0.96	0.21
2012	154.78	1.17	0.97	0.22
2013	164.13	1.12	1.04	0.21
2014	169.10	1.29	1.08	0.21
2015	173.90	1.32	1.12	0.20
2016	178.80	1.36	.16	0.20
2017	183.30	1.39	1.20	0.19
2018	189.00	1.44	1.24	0.20
2019	194.40	1.48	1.28	0.20
2020	199.90	1.52	1.32	0.20
2021	205.60	1.56	1.36	0.20
2022	211.40	1.61	1.40	0.21
2023	217.40	1.65	1.44	0.21
2024	223.50	1.70	1.48	0.22
2025	229.80	1.75	1.52	0.23

Source: FAO 2000 (Onumah & Acquah, 2010).

Aquaculture is the farming of aquatic organisms and plants in fresh, brackish or salt water. Galawat and Yabe, (2012) referred aquaculture as breeding, raising, and harvesting fish, shellfish, and aquatic plants in controlled aquatic environments like the oceans, lakes, rivers, ponds and streams. Globally, the contribution of aquaculture in assisting global food security, restoration of threatened and endangered species population, wild stock population enhancement, building of aquaria, fish cultures and habitants restoration, source of employment, control pollution with mollusc and sea weed, curtail sea food trade deficit, option for fuel source and economic growth, as well as to reduce the pressure on the wild harvested fisheries stock in both developed and developing countries cannot be overemphasized (Amao,, *et al.,* 2006; Ume *et al*.,2015). For instance, global fish production peaked at about 171 million tonnes in 2016, with aquaculture representing 47 percent of the total and 53 percent, if non-food uses (including reduction to fishmeal and fish oil) are excluded (FAO, 2016).

The republic of China is the world largest aquaculture producer with about 63.7 million metric tons of traditional aquatic flora and fauna for human consumption. The other high aquaculture producing countries are Indonesia, India, United States of America, Russia, Vietnam, Bangladesh, South Korea, Egypt and Norway (Adewumi and Olalaye, 2012).These countries particularly are using variety of facilities of varying input intensities and technological sophistication, using fresh, brackish and marine water, (FAO, 2012). In Africa, Anyanwu *et al.(*2009) reported that Egypt is the highest producer, followed by Nigeria with production of 44 thousand tonnes of catfish,tilapia and other freshwater species. The common fish species produces in Nigeria are*Clarias gariepinus*, *Clarias lazera*, *Heterobranchus*sp., "*Heteroclarias"*, *Tilapia*, *Oreochromis niloticus*, *Sarotherodon galilaeaus*, *Sarotherodon melonoplura*, *Tilapia zillii*, *Tilapia guineansis*, *Chrysichthys nigrodigitatus*, *CyprinusCarpio* being the most popular for the consumer preference due to their high premium and food productivity (Oladejo, 2010).

Historically, Nigeria has never attained self-sufficiency in aquaculture production despite the nation's endowment with coastline of 853 kilometres bordering the Atlantic Ocean, as well as fresh and mangrove swamps, creeks, coastal rivers, estuaries, bays, and near and offshore waters (Ogudari *et al*., 2006). Furthermore, despite Nigeria government recently directives to fish importers to implement backward integration into commercial aquaculture in order to curtail the nation's import bill and multinationals involvement in aquaculture value chain (fish seeds and seed production technology, fish production and RAS technology and fish feed), the overall aquaculture production cannot be able to quench the Nigerians citizenry for fish consumption. The effect is the nation's resorting to importation of aquatic products in the tune of millions of Dollars in order to augment deficit (gap) between consumption and domestic production **(**Olasunkanmi, 2012)**.**

In the study area, fish production is mostly done on plastic containers, concrete, earthen ponds and tarpaulin (Anyanwu *et al.,* 2009). However, the most common methods used in today's aquaculture landscape, included pond systems, open net pens and submersible net pens (Engle and Neira, 2005).However, aquaculture production in Nigeria is faced with myriads of limitations, included weeds, pests and diseases, high cost of quality inputs such as feeds, seeds and equipment, limited capacity of market/marketing and processing infrastructure, poor access to extension services, water problem, problem of marketing of table sized fish, poor access to credit, presence of technical inefficiency in fish farming and high cost of building materials(Yusuf, Ashiru and Adewuyi, 2002;Kareem, 2006; Ezike and Adedeji, 2010). The ability of aquaculture farmers to adopt improved innovations and attain sustainable production is influenced by their levels of profit efficiency. Profit efficiency is the aptitude of a farm to achieve the highest possible profit given the prices of inputs and levels of fixed factors of that farm and profit inefficiency herein, is the loss of profit from not operating on the frontier by the farmer. Based on the Farrell's frontier concept, Rahman, (2003) opined that the profit efficiency index is the ratio of maximum profit over actual profit of a farm, given input prices and fixed factors. The predicted efficiency indexes as observed by Kolawole, (2007) were regressed against a number of farming household characteristics, in an attempt to explain the observed differences in efficiency among farms. Therefore, determining these household characteristic factors and degree of their influence on aquaculture farm level profit efficiency is the onus that constitutes the experiential questions this research sort to investigate. The specific objectives of the study are to describe the socio-economic characteristics of aquaculture famers, determine the profit efficiency and determinants of profit inefficiency of aquaculture farmers, estimate the costs and return for production of catfish and tilapia fish breeds and to identify the limitations to aquaculture production in the selected States in South east Nigeria.

Map of South East, Nigeria

MATERIALS AND METHODS

The South East Nigeria is the study area and it lies between latitude $5^0$9' and $7^0$75'N of Equator and longitude $6^0$85' and $8^0$46' East of Greenwich Meridian. It has a total land mass of 10,952.400ha. The zone has population of 16,381.729 people (NPC, 2006). The zone is made up of five states viz: Abia, Anambra, Ebonyi, Enugu and Imo States. It is bordered in the North by Benue and Kogi States, in the West by Delta and Rivers States, in the South by Akwa Ibom State and in the East by Cross River State. South east states has two major seasons in the year, the rainy season which lasts from the month of April – October and the dry season that lasts from November to March. The temperature of the area varies between 18^0C – 34^0C. The people are agrarians and involved in non-agricultural activities, including civil service, petty trading, and vulcanizing, driving, carpentry and auto mechanics.

Sample Size and Sampling Procedure

Purposive and multi-stage random sampling techniques were used to select states, Local Government Areas (LGAs), towns and farmers. In the stage 1, three States were purposively selected from five states. The purposive selected States were Abia, Anambra and Ebonyi. This is be because of high number of farmers involved in aquaculture and ease of access to the researcher. In stage two, five LGAs were randomly selected from each States. These brought to a total of fifteen LGAs. In stage three, four towns were selected from each LGAs, making a total of sixty towns. Finally, two rice farmers were randomly selected from each sixty towns. This brought to a total of one hundred and twenty farmers for detailed study.

Method of Data Collection

A structured questionnaire and oral interview were used to elicit information on primary data. The secondary data were collected using textbook, journals, seminars, workshops and other periodicals.

Method of Data Analysis

The objectives i and iv were analyzed using percentage responses and frequency distribution table. The objective ii was addressed using a multiple regression model based on Stochastic Frontier Profit Function which assumed Cobb-Douglass specification form and Inefficiency function model, while Gross margin analysis was used to capture objective iii.

Model Specification

Efficiency of resource use is the relative feat in changing given input into output (Farrell, 1957), Efficiency from production function is of three types – technical, allocative and economic efficiency. Technical efficiency is the production of maximum output from a given set of inputs. Oladeebo and Oluwaranti (2012) described technical efficiency as attainment of production goal without wastage. Technical efficiency, as reported by Ali, (1988) can be measured either as input conserving oriented technical efficiency or output expending oriented technical efficiency.

Allocative efficiency is ability to produce at a given level of output using the cost minimizing input ratio (Okoye and Onyenweaku, 2007). Economic efficiency as opined by Farrel (1957), as capacity of firm to produce a predetermined quality of output at minimum cost for a given level of technology.

Efficiency measurement is estimated separately by estimating technical and allocative efficiency from a production frontier, of which was first explicitly specified in a parametric form. Aigner, Lovell and Schmidt (1977) specified the production frontier using a one-sided error term in which observed variations were said to be endogenous, while weather, wars and droughts were treated as random factors. Battese and Coelli (1995) used stochastic frontier in which a two sided random error term was inculcated into a production function. However, this production functions have limitation of failure to take into control the inefficiencies often ascribed to different factor bequest and input and output prices across farms, as farmers have different socioeconomic characteristics, thus are confronted with varied endowments and diverse best possible operating points. To transform a production function into profit function, Aigner *et al*.,(1977) inculcated the use of specific prices and fixed factors to specific firms. The profit function approach merges the ideas of technical and allocative efficiency in the profit affiliation in such a way that mistakes encountered in the production decision could be tantamount to lesser profits or revenue for the farmers.

Profit inefficiency as asserted by Oguniyi,(2011) is the loss of profit for not operating on the frontier. The benefit of profit function is that it accommodates the assessment of farm specific efficiency scores and the factors elucidating the efficiency disparity among farmers in a single stage estimation procedure. This problem is characteristically happening in the evaluation of production functions (Oguniyi, 2011). This study utilizes the Battese and Coelli (1995) model by hypothesizing a profit function, which is assumed to be synonymous with the stochastic frontier in behaviour. The stochastic profit function is specified as thus

$$\pi^* = \frac{\pi}{\rho} = h(q_t, z) \exp(v_t - u_t) \quad \ldots\ldots\ldots\ldots\ldots\ldots(1)$$

Where: = normalized profit of i-th farmer; = description of the normalized profit, = vector of variable inputs;
Z = vector of fixed input(s); P = output price used to normalize variables in the model; π = farmer's profit defined as total revenue minus total cost of production (Aquaculture revenue comprises of returns from the sales of fish output whilst total cost consists of cost of fingerlings, feed, fertilizer, labour and medicals); ( ) = composite error term.

The profit/economic efficiency (EE) of an individual farmer in the context of stochastic frontier profit function is a ratio of the actual profit to the equivalent envisaged maximum profit (Oladeebo and Oluwaranti, 2012). FTor the best farm given the price of variable inputs and the level of fixed factor(s) of production of the farmer, can mathematically be expressed following Ali, Parikh and Shah, (1994) as:

$$\textbf{Profit Efficiency (EE)} = \frac{Actual\ farm\ profit}{frontier\ profit} = \frac{\pi t}{\pi t*} = \frac{(qt,z)\exp(vt - ut)}{(qt,z)\exp(vt)} \ldots\ldots\ldots\ldots\ldots..(2)$$

Then,

$$\textbf{Profit Efficiency} = \frac{\exp(vt-ut)}{\exp(vt)} = \exp(-u_t) \ldots\ldots\ldots\ldots\ldots...(3)$$

The stochastic disturbance term consists of two independent elements: *"v" and "u"*. The symmetric two sided error term (*v*) account for random variation in profit attributed to factors outside the farmer's control (random effects, measurement errors, omitted explanatory variables and statistical noise). The one-sided component is a non-negative error term accounting for the inefficiency of the farm. Thus, symbolizing the profit deficit from its highest likely value that the stochastic profit frontier will accommodate. Although, when $u = 0$, it entails that the farm profit lies on the efficiency frontier (i.e. 100% profit efficiency) and $u < 0$ connotes that the profit accruingto the farmers' farm happen below the efficiency frontier. Both *v* and *u* are assumed to be independently and normally distributed with zero mean and constant variance.

Stochastic Profit Function Model Specification

A multiple regression model based on the stochastic frontier profit function which assumes Cobb-Douglas functional form was used to verify the profit efficiency of aquaculture farmers in the study area. The frontier model estimation by Ifeanyi and Onyenweaku (2007) was stated as follows:

$$In\pi_i^* = \beta_0 + \sum_{j=1}^{4} \beta_j InX_{ji}^* + \beta_k InX_k + v_i - u_i$$

π = normalized profit computed for i-th farmer,
In = natural log,
X_1= price of Fertilizer (N/kg) normalized by price of paddy,
X_2= price of Water (N/Litres) normalized by price of Aquaculture,
X_3= price of labour (N/manday) normalized by price of Aquaculture,
X_4= price of Drug (N/lt) normalized by price of Aquaculture,
X_5=Price of Fingerling (N/No.
X_K= Plot Size (M_2),
β_0, β1 -4 and βk are parameters to be estimated, *V* represents statistical disturbance term and *U*= signifies profit inefficiency effects of i-th farmer

Profit Inefficiency Function Specification

The determinants of profit inefficiency of aquaculture producers were modeled following particular attributes of the farmers in the study area. From equation 4, the *u* component is specified as follows:

$$\mu_i = \lambda_0 + \sum_{r=1}^{15} \lambda_r w_r + \kappa \quad \ldots\ldots\ldots (5)$$

Where:
= Profit inefficiency of i-th farmer, and are parameters to be estimated, are variables explaining inefficiency effects, r =1,2,3....,n, k is truncated random variable, = Age of the Farmer (Year), = Level of education (Years), = Household size (Number), = Access to extension services (Access =1, no access = 0), = Access to credit (Access =1, no access = 0), = Membership of organization (Membership = 1; Non member; 0), Farming experience (Years.) Both equation (4) and (5) were jointly estimated by maximizing the likelihood

function using the computer program Frontier version 4

RESULTS AND DISCUSSION

Table 2: Socio-economic characteristics of aquaculture famers in selected States in South East, Nigeria .

Characteristics	Abia	Anambra	Ebonyi
Age	42	42	44.5
Education	14	16	7.2
Access credit	23.5	32	17
Extension Services	16	36.2	34
Organization	4	7	10
Farming Experience	26	34	16
Pond Size	16	20	24
Labour	57.4	52.4	48.8
Output	248.22	256.089	57.4

Source; Field Survey; 2018

The result of the socio- economic characteristics of the farmers studied in the selected three States of South East, Nigeria showed that the respondents were in similar age groups, with a mean of 42 years for Abia and Anambra respectively and 44.5 years for Ebonyi State. This age class was youthful and as such usually adoptive and motivational individuals that could supply the much needed labour in accomplishing aquaculture farming activities (Rahman, 2003). In addition, most of the farmers in Abia and Anambra States had similar formal education of 14 and 16 years compare to 7.2 years for Ebonyi State. Educated farmers have better access to information on input and output prices as well as other economic and technical information which could guide towards rational farm management decisions compares to farmers without formal education. This result is in compliance with the findings of Rahman (2003) in Bangladesh, and Ezike and Adedeji, (2010) in Nigeria and Nunoo *et al., (2012)* in Southern Ghana. Additionally, poor access to credit especially from the formal sector was reported across the states as shown in Table 1. The poor credit access by the sampled population could be correlated to the high interest rates as demanded by lending institutionS in the study area (Ezike and Adedeji, 2010).

Moreover, access to extension services were more by Anambra States farmers (36.2), followed by Ebonyi State(24) and the least was Abia State, 16 visits. Extension agents assist farmers in sourcing best aquaculture farm inputs (such as feed, fingerlings and drugs) at affordable prices and marketing channels for the farmers' output (fish) (Ochiaka and Ume, 2015)

This finding is in accordance with Quagraine *et al.,*(2005), who reported on the importance of extension services in disseminating recent improved research results as relates to aquaculture management to farmers in order to boost their profit efficiency.

More so, membership of organization by respondents cut crossed all States, although Ebonyi States topped, 10 memberships with Abia being the least, 4. The high proportion of membership of organizations recorded in Ebonyi State, may perhaps be related to recent promotion of catfish production by the government of the State and some other non-governmental organizations through cooperative societies. Nunoo *et al.,*(2012) reported cooperative society helps in enhancing the profit efficiency of her members on aquaculture production through training by professionals in the vocation. Besides, most aquaculture farmers in Anambra State were well experienced with number of years of experience of 34 years, followed by Abia State, 26 years, while the least, Ebonyi State was 15 years. Sualih (2000) opined that experienced farmers have much practical knowledge to prevail over definite intrinsic aquaculture problems, hence enhancing their efficiency. Also, pond size differed more in Ebonyi State, followed by Anambra State and then Abia state. The size of pond as asserted by Nwosu *et al.,*(2003) is a function of land availability, fund availability and purpose of the fish farming. As well, the male and female farmers in Abia, Anambra and Ebonyi employed an average of 57.4, 52.4 and 48.8 man-days of labour respectively to produce an average output of 248.22kg, 256,089 and 226.5 kg of fish per annum respectively. The low man-days labour could be correlated to the fact that fish farming is low labour intensive but more capital intensive (Kareem, 2006).

Table 3: Maximum likelihood Estimates of Cobb-Douglas Stochastic Frontier profit Function for Selected States in South East, Nigeria

		Abia		Anambra		Ebonyi	
Variable	Parameter	Coefficient	t –value	Coefficient	t –value	Coefficient	t –value
Price of Fertilizer	δ_1	1.42109	1.6580*	0.5543	2.0213**	0.0222	3.0998
Price of Labour	δ_2	1.0085	1.0754*	0.1324	2.0096**	0.0987	1.0098*
Price of Water	δ_3	0.8765	- 1.0421*	0.4390	0.0087	1.0976	0.0076
Price of Feed	δ_4	0.0981	2.0005**	1.5478	1.0816*	0.0091	3.0532***
Price of Drug	δ_5						
Price of Fingerlings	δ_6	0.8760	1.098*	2.0098	2.0098**	0.4421	3.0987***
Pond Size	δ_7	1.1765	2.9134**	0.0085	1.8640*	3.0321	4.6541***
Inefficiency							
Age of the Farmer	β_1	1.0092	1.9002*	0.0093	1.009*	0.0420	1.2309*
Educational Level	β_2	0.3885	2.0985**	2.0098	3.0981***	1.0945	4.1643***
Access to Credit	β_3	0.5432	0.1298	0.7654	-1.0822*	2.0976	1.0983*
Extension Services	β_4	1.9043	0.9871	3.0987	10.4320	0.0053	0.4317
Organisation	β_5	0.8765	1.0321*	2.0932	1.0321*	0.5439	2.0098**
Experience	β_6	2.4178	1.0670*	4.0032	2.2139**	0.9211	3.2211***
Variance							
Sigma – Square	$\delta 2$	0.8643	3.6890***	0.9421	3.7412***	0.4329	3.0021***
Gamma	γ	O.7763	3.3287***	0.7821	4.5009***	0.6190	1.2905*
Log likelihood		-144.256		-157.809		-134.590	
Constant		12.0973	5.9009***	5.04321	6.0932***	5.9654	7.0987***

Source; Field Survey, 2018

The Cobb- Douglas profit efficiency frontier function for the selected states of Abia, Anambra and Ebonyi was estimated using the maximum likelihood estimates and presented in Table 3. The results showed that the parameter estimated of the coefficients of sigma squared and gamma of all the selected States was statistically significant at 1% level. The parameter gamma value were 0.7763, 0.7821 and 3.2190 for Abia, Anambra and Ebonyi States respectively, indicating that 77.63% , 78.21% and 61.90% of Abia, Anambra and Ebonyi States respectively of profit variation is as result of efficiency difference. The remaining 22.37%, 21.79% and 38.10% of Abia, Anambra and Ebonyi States respectively were due to external factors which are taken account of by the model. The variations in fish profit among the selected States could be attributed to random shocks beyond the fish farmers' control. The gamma values for the states considered were significant and close to one, implying the important factors influencing inefficiency.

The table indicates that the coefficients of the estimated parameters of the Cob-Douglas function were positive in all the States considered except the price of labour in all states and price of water in Abia State. This implies that a unit increase in the price of inputs (feed, price of fingerlings, pond size, prices of drugs and fertilizer) with positive coefficients will lead to increase in the Cobb- Douglas profit gained from production of aquaculture and vice-versa. In addition, the coefficient for price of feed had positive value of 0.0981, 1.5478 and 0.0091 Abia, Anambra and Ebonyi States respectively were statistically significant at 5%, 10% and 1% probability levels respectively and this variable is the principal factor influencing the profit efficiency. This could connotes that for 5%, 10% and 1% increase in the price incurred as result of procuring feed by farmers in Abia, Anambra and Ebonyi States respectively, the profits generated from aquaculture production will increase by 0.0981%, 1.5478 % and 0.0091% respectively. The model states that as the price increase through the purchase of feed, the profit obtained by the farmers through the production of more fish will be increased. This finding is in conformity with result estimated by Olagunju *et al.,* (2007), who shared view on the high cost of feed in Nigeria and other developing countries in Africa, as factor responsible for low productivity among aquaculture farmers. The most notable reason for the high cost of fish feed is the competition in grains used in manufacturing of these feeds with man, they added.

The coefficient of pond size for Abia (1.1765), Anambra (0.0085) and Ebonyi (3.0321) was positively signed and significant at 10%, 5% and 1.0%alpha level respectively, implying that aquaculture farmers operate in small scale level. Therefore increasing their pond size will improve profit with all things being equal. Most farmers in the study area and in many developing countries were into small scale fish farming and this could be as result of high cost of materials and labour in constructing earthen and concrete ponds which are the aquaculture production systems predominant in the study area (Onumah & Acquah, 2010). The analysis also revealed that the sign and significance of the coefficient of drug is very crucial in determining the aquaculture farmers' profit level. The implication is that increase in the cost of drugs used, will increase farm profit through its increase in boosting the farm productivity through the protection of the health of the fish for enhanced growth. This finding is also in consistency with result estimated by Nunoo *et al*.,(2012). Studies reveal that veterinary drugs in Nigeria are very costly and most often very substandard because of problems of adulterations. This leads to many farmers using indigenous known Technologies (IKT) which are very often not efficacy (Amao *et al*., 2006). Also, the coefficient of prices of fingerlings for farmers in Abia, Anambra and Ebonyi States were significant at 10%, 5% and 1% probability levels respectively. The implication is that increase in the prices incurred through buying of fish seed will result to the increase in farm level profit in the study area as aquaculture will increase.

The Table 2 also showed that the sign and significant of the estimated coefficient of fertilizer (Abia; 1.42109; Anambra 0.5543; Ebonyi State; 0.0222) is important factor in determining aquaculture farm profit. Herein, the model connoted that as the price increase through the purchase of fertilizer, the profit obtained by the farmers through the production of aquaculture will be increased. This finding of Rahman, (2003) is also in conformity with the result estimated. In the recent time, the cost of fertilizer has been on the rise since the Federal government of Nigeria removal of fertilizer subsidy policy (Ume *et al*, 2015).However, in accordance with a priori expectation, price of labour coefficient (Abia State; 1.008 5, Anambra; 0.1324 and Ebonyi; 0.0987) and price of water coefficient (Abia; 0.8765, Anambra, 0.4390, Ebonyi, 0.0076) had indirect relation with farm profit. The implications are that increase in the prices incurred through hiring of labour and purchasing water will result to the lessening of farm level profit in the study area. The high cost of labour in Nigeria could be related to economic depression in the country as well as scarcity of able- bodied youths who migrated to urban areas for white collar jobs, leaving farming in generally for the aged and their children (Nwosu *et al.,* 2003).The high price of water in many parts of Abia State could be related to breaking down of boreholes and drying up of many boreholes and other sources of water such as streams, rivers and lakes especially during dry season, thus leading to the rise in the prices of water in the area (Ume and Ochiaka, 2015).

Profit Inefficiency Function.

The purpose of estimating inefficiency model was to determine the relationship between profit efficiency and farm household characteristics. The coefficient of the age of the farmer was negative for all the States considered in accordance to apriori expectation and significant at 5% probability level. The correlation between inefficiency and age of the farmer could be associated with the conservativeness of aged farmers towards acceptance of improved innovations, leading to low profit in their ventures. Emokaro *et al.*, (2015) finding was not synonymous with the aforesaid affirmation. They opted that aged farmers could be embodiment of knowledge in management of resources as consequences of their years of farming experiences, leading to enhancement in their profit margins. In addition, the coefficient of credit was negative for farmers from Anambra State at 10% but positive and significant at 10% for farmers in Ebonyi State. The negative sign identity of the coefficient of the variable among farmers in Anambra State could be correlated to the diversion of farm credits to non-farm ventures, thus negatively affecting the farm profit. The findings of Anyanwu *et al*., (2009) and Ezike and Adedeji, (2010) concurred to the above sign identity, while in the findings of Kareem (2006) had divergent view. Farmers with access to credit especially from formal institutions usually put up more efforts in order to ensure that they do not only default in the repayment of the loan but generate the desired profit to sustain the business and their welfare (Ume *et al*., 2015).

Also, the estimated results as regards to education, farming experience and membership of organization coefficients were positive in all the selected States and in consistent with the findings of several researchers (Olagunju *et al*.,2007; Adewusi and Olaleye, 2012; Ume and Ochiaka, 2015), which imply that as the variables increase, the profit inefficiency of fish farmers will increase. Educational status of the farmers as asserted by Njoku & Odoh, (1996) is capable of inculcating into them (farmers) the skills in gathering information and understanding new practices, which in turn improve their efficiencies through higher technical and allocative efficiencies attainment.. On the farming experience's positive association with inefficiency may probable linked to the ability of farmers with long years of farming experience in enhancing their capability of maximizing the output and profit at minimum cost. Ume *et al*., (2016) harmonized to the above statement. They observed that farmers with higher levels of farming experience have high propensity of being prudent in resources use for high efficiency which could tantamount to high profit. This concurred with classical economic theory which discerns that specialization is a key determinant of efficiency. On the sign identity of membership of organization, this could be reasoned to the fact that membership of organization in form of cooperative society assists member fish farmers in acquiring credits at low interest rate and procuring aquaculture inputs such as feed, drugs, fish seeds (fingerling and juveniles) and fertilizer at low cost in order to boost their productivity and profit (Ociaka and Ume, 2015). The finding of Onumah and Acquah (2010) coincided to the above affirmation. They reported that fish farmers who are membership of cooperatives could enhanced their profit through interaction and cross fertilization of ideas on aquaculture production and other related issues.

Table 4: Distribution of profit Efficiency Indices for Aquaculture Farmers in Abia, Anambra, and Enugu States

ProfitEfficiency Range	Abia		Anambra		Ebonyi	
	Frequency	Percentage	Frequency	Percentage	Frequency	Percentage
0.00 – 0.20	10	8.3	10	8.3	12	10
0.21 – 0.40	31	25.8	35	29.2	35	29.167
0.41 – 0.60	28	23.3	30	25	28	23.3
0.61 – 0.80	17	14.2	15	12.5	13	10.8
0.81 – 1.00	34	28.3	30	25	32	26.7
Total	120		120		120	
Mean	0.64		0.66		0.56	
Minimum	0.18		0.24		0.36	
Maximum	0.98		0.97		0.98	

Source: Computed from Field Survey, 2018

As contained in Table 4, about 57.4%,, 62.6% and 62.5% of the farmers in Abia, Anambra and Ebonyi States respectively operated within profit efficiency ranges of 0.001 - 0.60, while 42.5%, 37.5% and 37.5% of the same farmers operated between 0.60 – 1.00. The maximum and minimum profit efficiencies of the aquaculture farmers were 0.98 and 0.18 for Abia State; 0.97 and 0.24 for Anambra State and 0.99 and 0.36 for Ebonyi State. The mean profit efficiency of aquaculture farmers in Abia, Anambra and Ebonyi States were 0.64, 0.66 and 0.54 respectively. These imply that aquaculture farmers in the study areas were not fully profit efficient, showing that their actual output lies 36%, 34% and 46% below the frontier output for Abia, Anambra and Ebonyi States respectively. These figures are their levels of inefficiency in resource use. The aquaculture farmers displayed diverse profit efficiencies varying from 18% to 98%. Nevertheless, the least profit efficient aquaculture farmer requirements efficiency gain of 83.7% (1-0.18/0.98)100 of production for the farmer to attain the profit efficiency of the best efficient farmer in the study area. Similarly for an average profit efficient aquaculture farmer requires an efficiency gain of 44.9% (1-0.56/0.98)100 to achieve the most efficient level of production. In addition, the most profit aquaculture farmers in the study area, requires about 0.058% gains in profit efficiency to be on the frontier profit efficiency.

Elasticity of Production (E_P) and Return to Scale for the selected States(Abia, Anambra and Ebonyi States as shown in Table 4.

Table 4 Elasticity of Production and Return to Scale for the selected States(Abia, Anambra and Ebonyi States)

Variable	Abia; (Elasticity)	Anambra (Elasticity)	Ebonyi (Elasticity)
Fingerlings	0.8760	2.0098	0.4421
Feed	0.0981	1.5478	0.0091
Water	0.8765	0.4390	1.0976
Labour	-1.0085	0.1324	0.0987
Pond Size	1.1765	0.0085	3.0321
Water	0.8765	0.4390	- 1.0976
Fertilizer	1.4210	0.5543	0.0222
Return to scale	4.3161	5.1308	3.6042

Source: Computed from Table 3

The Table showed that in Abia State, pond size (1.1765) and fertilizer (1.4210) had the highest elasticity of production. This implied that they contributed most to farm returns when compared to the other inputs used in that State. Similarly, fingerlings and feed in Anambra State, while in Ebonyi State, pond size and water.

For instance, given the result in this Table on farmers in Abia, Anambra and Ebonyi States, a change in the size of pond by 1 unit brought about a change in the same direction of 1.1765, 0.0085 and 3.0321 units in the profit of aquaculture farmers respectively. In the same way, a change of 1 man-day in the labour use in Abia State, brought a change in opposite direction of-1.0085in the profit of aquaculture farmer, while change in the same direction to farmers in Anambra and Ebonyi States with values of 0.1324 and 0.0987 as revealed in the same Table. The sum of production elasticity were positive in all the states (Abia; 4.3161; Anambra, 5.1308 and Ebonyi; 3.6042), indicating increasing return to scale. The implication was that maximum profit l efficiency was achieved by the farmers in the study area. Kolawole, (2006) confirmed this finding.

The costs and return for production of 2000 Catfish in the study area is shown in Table.

Table 5 shows that the farmers in Abia State had net return/ total cost ratio of 1:29; 1, which connotes that for everyone naira spent in catfish production, could lead to 29 kobo profit. It is worthy to state that the total variable cost constituted about 98.2% of total production cost in that State. This finding concurred with Kareem, (2006) who had 87.7% in his study on a techno economic analysis of aquaculture business in Ogun State, Nigeria, Furthermore, Anambra and Ebonyi States had net return/total cost ratio of 1;35.1 and 1.20; 1 respectively. These implied that for every naira spent in catfish production in Anambra and Ebonyi States, will lead to 35 kobo and 20 kobo profit respectively. The total variable costs for the States; Anambra and Ebonyi comprised about 98.1% and 98.6% respectively of the total cost of production.

Table 5: Costs and Return for Production of 2000 Catfish

			Abia		Anambra		Ebonyi	
Items	**Unit**	**Qty**	**Price/Unit**	**Amount**	**Price/Unit**	**Amount**	**Price/Unit**	**Amount**
Mature life fish	Kg	2000	950	1,900000	975	1,950000	900	1800000
Variable Cost								
Feed	Kg	200	6500	1300000	6300	1260000	6700	1340000
Fingerling	No	2000	25.00	55,000	23.00	46,000	27.00	54000
Labour	M.day	2	6000	36,000	7000	42,000	5000	36,000
Water	Litres	10	4,500	45,000	5000	50000	4200	42000
Transportation				6000		7500		5400
Miscellaneous				12,000		16,000		10,400
TotalVariable Cost				1454000		1421500		1483000
Fixed Cost								
Pond Construction				12107		15000		11,009
Pond Maintenance				8,000		5200		4432
Generator/Machines				6,876		6043		5,980
Total Fixed Cost				26,983		26243		21421
Total Cost (TVC + TFC)				1480983		1447743		1504421
GM (TR-VC)				446000		528500		317000
NFI (GM+TFC)				419017		502,257		295579
Net Return/ Total cost Ratio				1.29		1.35		1.20
Rate of return per capital invested (RORCI)				28.3		34.70		19.65

Source; Field Survey; 2018

The rate of return per capital invested (RORCI) is the ratio of profit to total cost of production. It indicates what is earned by the business by capital outlay (Olasunkanmi, 2012). The result revealed that the RORCI for Abia, Anambra and Ebonyi States were 28.3 %, 34.70% and 19.65% respectively, which are greater than the prevailing commercial lending rate, connoting that fish farming in the study area was profitable. The gross margins for Abia, Anambra and Ebonyi states were 446000, 528500 and 317000 respectively, while, the Net farm incomes were 419017, 502,257 and 295579 for Abia, Anambra and Ebonyi States respectively, implying high profitability. The study collaborates with the finding of Ume *et al.*, (2016), who reported a Gross Margin of 400543 and Net farm income of 349876 in their study in Anambra State of Nigeria.

Table 6 : Costs and Return for Production of 2000 Tiliapia

			Abia		Anambra		Ebonyi	
Items	**Unit**	**Qty**	**Price/Unit**	**Amount**	**Price/Unit**	**Amount**	**Price/Unit**	**Amount**
Mature life fish	Kg	2000	720	1440000	765	1530000	712	1424000
Variable Cost								
Feed	Kg	152	6500	988000	6450	980400	6570	998640
Fingerling	No	2000	20.00	40,000	18.50	37,000	21.00	42,000
Labour	M.day	2	6000	36,000	7000	42,000	5000	36,000
Water	Litres	7.5	4500	33750	5000	37500	4400	33000
Transportation				6000		7000		6400
Miscellaneous				7,000		10000		6,400
TotalVariable Cost				1110750		1113900		1122440
Fixed Cost								
Pond Construction				13107		14000		13,009
Pond Maintenance				5300		5700		5632
Generator/Machines				6,556		6043		5,980
Total Fixed Cost				24,963		25743		24621
Total Cost (TVC + TFC)				1135713		1139643		1147060
GM (TR-VC)				329250		416100		301560
NFI (GM+TFC)				331746		441843		326181
Net Return/ Total cost Ratio				1.26		1.34		1.24
rate of return per capital invested (RORCI)				29.2		39.7		29.1

Source; Field Survey; 2018

Table 6 shows that the farmers in Abia State had net return/ total cost ratio of 1:26; 1, which signifies that for everyone naira spent in tilapia production, 26 kobo profit will be realized.

Furthermore, for Anambra and Ebonyi States had net return/ total cost ratio of 1:34:1 and 1:1:24 respectively, which imply that for every one naira invested in tilapia production in Anambra and Ebonyi States, could tantamount to 34 kobo and 24 kobo profit respectively. The total variable costs for Abia, Anambra and Ebonyi States comprised of 97.8%, 97.7% and 97.9 % of the total cost of production respectively. The rate of return per capital invested (RORCI) for Abia, Anambra and Ebonyi States were 29.2 %, 39.7 % and 29.1% respectively greater than the prevailing commercial lending rate, indicating that tilapia fish farmers were making some reasonable profit in the study area. The gross margins for Abia, Anambra and Ebonyi states farmers were 329250, 416100 and 301560 respectively. Net farm incomes of 331746, 441843 and 326181 for Abia, Anambra and Ebonyi States respectively signifying reasonable level of profitability attained by the farmers. The finding of Engle & Neira, (2005) concurred to the profitability of tilapia

The limitations to aquaculture production in the selected States are shown in Table 7.

Table 7: Limitations to Aquaculture Production in Abia, Anambra, and Enugu States

	Abia		Anambra		Ebonyi	
Variables	**Frequency**	**Percentage**	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Credit Access	102	85	99	82.5	110	91.7
Water problem	95	79.2	72	60	80	66.7
Poor fish breed	78	65	78	65	65	54.2
Poor access to extension services	90	75	96	80	88	73.3
High cost of Building Materials	86	71.7	88	73.3	90	75
High cost of feed	96	80	100	83.3	92	76.7
High cost of Drug	54	45	51	42.5	43	
High cost of Fertilizer	42	35	56	46.7	38	31.7
High cost of Labour.	38	31.7	62	51.7	45	37.5
Cannibalism	89	74.2	92	76.7	82	68.3

**Multiple Responses, Source; Field Survey, 2018*

Table 7 shows that problem of poor access to credit by the farmers in all the selected States with Ebonyi State being the highest (91.7%) and Anambra State being the least(82.5%) was recorded in Table 7. The short periods of grace period and high interest rate as demanded by the lending institutions in the country could be quoted to be responsible for low farmers' access to credit. (Ume, *et al*., 2016). In the same vein, Quagraine *et al.,* (2005) reported on the importance of credit in enhancing fish farmers' access to productive inputs (such as feed, drug and fingerlings) and material inputs (like fishing net, fishing gear, fishing spear and trawl)in order to boost fish production and productivity.

In addition, high cost of feed problem was reported across all the selected States by the farmers, with the problems in descending order; Anambra State (83.3%), Abia State (80%) and Ebonyi State (76.7%). High cost of grains accruing to multiple uses of the resource for human and livestock feed formulation, resulting in most fish farmers using poultry mashes that are lowly in nutrients in feeding the fish, hence making fish farming unproductive (Ochiaka and Ume, 2015). The findings of Anyanwu, *et al*., (2009) were synonymous with the aforesaid assertion. They opined that high cost of feed has been a bane to aquaculture development in Nigeria and many countries in sub -Saharan Africa

Additionally, 75%, 80% and 73.3% of the farmers in Abia, Anambra and Ebonyi States respectively complained about poor access to extension services. The high ratio of extension agent - farmers that characterized most farmers in sub Saharan Africa and poor motivation of the change agent have dwarfed significantly improved innovation disseminated to the farmers by influencing their outputs negatively, thus translating to low profit (Njoku & Odo, 1996). Numerous literatures have reported on poor extension outreach by many farmers in most States of Nigeria, especially since the withdrawal of the World Bank assistances in extension programme in the country, leading to low production and productivity of the farmers (Ume & Ochiaka, 2015). Furthermore, high cost of building materials was encountered by all the farmers in the States under study as shown in Table 7. High cost of building materials such as cement, iron rods and planks may perhaps be upshot of high Naira - Dollar exchange rate and devaluation of the nation's currency(Ezike and Adedeji, 2010).Moreover, in Abia, Anambra and Ebonyi States, the problem of poor fish breed were observed by 65%, 65% and 52% respectively. Poor fish breeds results in low performance and highly uneconomical, thus affecting farmers' profit (FAO, 2012).The need to expose farmers to the skills of fish breeding and the necessary equipment provided at subsidized prices is imperative.

Besides, the problem of water scarcity from the various sources such as streams, rivers, dam and borehole were reported by the farmers in the different States in ascending order Ebonyi State (66.7%), Anambra (72%) and AbiaState (79.2%). The poor water supply to the aquaculture production systems (earthen, concrete, Tarpaulin and other facilities in use) affects greatly the water level of the pond, thus affecting the feeding of the fish with resultant effects of low output and reduced profit, (Nwosu, *et al*., 2003). .Also, the problem of cannibalism was complained by most catfish farmers in the selected States(Abia; 74.2%, Anambra; 76.7% and Ebonyi; 68.3%). The problem of cannibalism is as result of the development of shooters among catfish which prey on younger ones (juveniles and fingerlings), ensuing in meager fish harvest (Emokaro *et al*., 2015).

CONCLUSION AND RECOMMENDATION

The result of the socioeconomic characteristics showed that most farmers were youthful, educated, membership of organizations, had many years of farming experiences, had formal education and owned moderate pond size, .In addition, the coefficients of price of feed, price of fingerlings, pond size, price of drugs and price of fertilizer were positive, whereas, the coefficient of labour was negative and cut across all the States and the coefficient of water was negative among Abia State farmers. Furthermore, the coefficients of age, educational level cooperatives and extension services were positive and cut across all States. Also, the coefficient of credit was negative and significance only in Anambra and Ebonyi States. The production of catfish and tilapia were profitable in the study area with high gross margin and Net farm income. Limitations to aquaculture production in the study areas were poor access to credit, water problem, poor fish breeds, high costs of building materials, poor access to extension services, high cost of feed, high cost of labour and cannibalism.

Based on the results, the following recommendations were proffered;

(i) There is need to improve farmers' access to credit in order to procure the necessary inputs needed to enhance their productivity through commercial and microfinance banks at reduced interest rate.

(ii) On the problem of high cost of feed, farmers were encouraged to learn the skill of commercial feed formulation in order to maximize their profits.

(iii) Policies aimed at encouraging farmers to form cooperative/association should be advocated. Cooperation helps in capacity building, acquisition of credit, training and provision of production inputs to the members at reduced cost.

(iv) More so, the extension agents should be motivated in disseminating catfish innovations to the famers through provision of adequate incentives such as payment of their salaries and local transport allowance at appropriate time and provision of all the necessary logistics in the discharging of their duties.

(v) There is need to enhance farmers' access to education through universal basic education, adult and nomadic educations, workshops and seminars. Furthermore, policies aimed at improving farmer's access to education through aggressive awareness campaign, mass mobilization, agricultural shows and competitions could be pursued in order to improving their productivity.

(vi) There is need to encourage experienced and inexperienced farmers to remain in business through provision of inputs by the concerned government agencies at subsidized prices

(vii) On the problem of fish cannibalism, farmers are advised to sort the fingerlings at the appropriate time.

(viii) The catfish seed industry also needs to be standardized and regulated. Government needs to establish an agency to certify the quality of catfish seeds. This will go a long way in helping newly established hatcheries to secure market for their products as potential customers will have little fear in certified fingerlings.

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