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Research Article

Analysis of Technical Efficiency of Fish Hatchery Enterprises in Osun State, Nigeria: An Application of Two-stage DEA Approach

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Abstract

In spite of the great potentials of fish hatchery enterprise, factors such as low technical know-how and high cost of fish hatchery inputs have limited the contribution of the enterprise in enhancing food security. Also, inefficiency of available resources has remained an unanswered question in the quest for increasing fish production in Nigeria. This study therefore estimated the technical efficiency of fish hatchery enterprise in Osun State Nigeria using data envelopment analysis and multiple regression analysis. A multi-stage sampling procedure was employed to select 227 fish hatchery farmers from three agricultural zones in the study area. Findings showed that technical efficiency varied from 0.36 to 0.97, with a mean of 0.75. These varying indices of efficiency in the fish hatchery enterprises indicate great potential to achieve productivity growth through improved efficiency, using existing technologies. Results of the multiple regression indicated that age, household size, level of education, fish hatchery experience and access to credit were significant and positively related to technical efficiency. These results suggest that increase in fish hatchery experience and access to credit could jointly contribute to an improvement in efficiency of fish hatchery production in the study area. Fish hatchery farmers should explore the opportunity of cooperative associations to pool resources together by organizing seminars/workshops on improved innovations in relation to fish hatchery business so as to improve efficiency of the enterprise.

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Introduction

Nigeria fisheries subsector comprises industrial/commercial fisheries, artisanal fisheries and aquaculture (Ogunsola, 2019). The country has coastal line of about 860 km and over 14 million hectares of freshwater out of which 75% is relatively suitable and about 112,000 km^2 is considered to be very suitable for fish farming (Federal Ministry of Agriculture and Rural Development (FMARD), 2017). Fishing activities is abundant in areas that are naturally endowed with water bodies (Ogunsola, 2019) and freshwater fish species of Nigeria are the richest in West Africa (Ashley-Dejo, 2016).

Globally, Nigeria is ranked 64th within the group of countries in regards to fish consumption per capital (Ashley-Dejo, 2016). Nigeria commands a place of pride in fish production in Africa second to Egypt whose fish products target Nigeria market has its major destination. However, Bolorunduro (2016) stated that Nigeria was the largest aquaculture producer in south of the Sahara and currently is believed to be at par with Egypt. In Africa, only Egypt and Nigeria are the two countries which are listed among 25 leading aquaculture producers in the world (Bolorunduro, 2016).

In 2017, fish consumption per capita in Nigeria rose up to 13.3 kg, although below the world's average of 20.5 kg (FAO, 2018). With this, fish production is not on the same level with the rapid population growth of about 200 million (the most populous country in Africa) and is projected to reach above 260 million in 2030, as the fifth most populous country in the world (Ashley-Dejo et al., 2019). Nigeria fish demand and supply between 2008 and 2017 was 12 million tons and 9 million tons respectively. This implies that domestic fish production in Nigeria; for each year, the Nigeria fishery sub-sector is unable to satisfy about 24% (2.9 million tons) of the aggregate fish demand within the economy (Nwokedi et al., 2020). Also, Ashley-Dejo (2016) reported that by 2025 Nigeria fish demand, domestic supply and deficit

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will be around 17.5 million tons, 15.2 million tons and 2.3 million tons respectively. The gap of 461.737 million USD between fish import and export finances represent excess fiscal resources spent in fish import over export per year is more than double the budgetary allocation of 225.9 million USD.

Domestic fish production is not keeping pace with its growing demand, this has resulted to shortage of fish and this is aggravating on a daily basis due to increase in human population (Ashley-Dejo and Adelaja, 2022). To salvage this unpleasant situation, there is urgent need to improve natural fish habitats and fish farms with high yield fish species to boost its local production. This will be of help in meeting the domestic demand for fish but availability and accessibility of good quality fish seed is of paramount.

Good number of fish farmers are engaged in fish seed production to bridge the country fish deficit thus, availability of big size, healthy broodstock/parent stock, and in-breeding are seriously becoming a major concern. There is tendency of using small, immature, unhealthy and undesirable broodstock/parent stock consequently, resulting to poor quality fish seed. Poor-quality fish seed is characterized with high mortality rate, poor growth rate, poor feed conversion ratio, highly susceptible to disease etc, at the long run the aim is adversely jeopardized.

Technical inefficiency of fish hatchery farmers poses another problem. Therefore, increase in the number of fish hatchery farmers may not necessarily solve the problem of fish deficit, fish hatchery farmers must be able to explore the fullest production potential.

Several authors have carried out series of studies on technical efficiency of catfish farming in Nigeria (Ajao, 2012; Inon et al., 2017; Ogunmefun and Achike, 2018; Oluwatayo and Adedeji, 2019). Not many of such studies have focused on technical efficiency of fish hatchery enterprise. Study relating to technical efficiency of fish hatchery enterprise in Nigeria received less attention from researchers. This study aims at investigating into the aspects of technical efficiency of fish hatchery enterprise, so that level of inefficiency, if any, exists can be identified. Thus, this study is expected to provide meaningful insights into the level of technical efficiency of the fish hatchery enterprise along with factors affecting inefficiency.

Research Methodology

Study area, sampling procedure and sample size

This study was carried out in Osun state, southwest Nigeria. The State shares boundaries with Kwara, Kogi, Ondo and Ogun State. Administratively, Osun State is divided into thirty local government areas with estimated population of 3,423,535 (Ashley-Dejo, 2016).

A multi-stage sampling procedure was adopted for this study which includes purposive and simple random sampling techniques. Firstly, purposive sampling technique was employed to select 324 fish hatchery farmers from 3 agricultural zones in the study area. namely: Iwo, Osogbo, and Ife/Ijesa zone, in which Iwo zone consist of seven blocks, Osogbo zone consist of thirteen blocks and Ife/Ijesa zone consist of eleven blocks. Furthermore, 70% of the fish hatchery farmers were selected from each zone using simple random sampling technique. This gave a total of 227 fish hatchery enterprises to be sampled (Table 1).

The study made use of primary data which were collected from 227 fish hatchery enterprises in the three agricultural zones of the state using close and open-ended questionnaire. The questionnaire was designed to collect information on unit price of fingerlings/juvenile, quantity of fingerlings/juvenile produced per breeding cycle, price and quantity of feed used, cost of medication and vaccines, cost of production equipment, relevant information concerning management of the hatchlings, mortality rate, quantity of fingerlings/juvenile stocked and given out as gift, number and types of hatchery unit used, quantity of water used per day in litres, number and total cost of hired labour and family labour input per day by gender, cost of electricity and fuel. Information on the socioeconomic characteristics of the producers such as age, educational status, gender and years of fish hatchery farming experience, household size and major occupation were also collected.

Table 1. Osun State Agricultural Development Programme zonal structure (showing sampling procedures and sample size)

Zone	Local Government Area (LGA)	Number of registered fish hatchery farms (Purposive sampling)	Number of fish hatchery farms sampled (Simple random sampling technique)
Iwo (Zone I)	7	94	66
Osogbo (Zone II)	12	163	114
Ife/Ijesha (Zone III)	11	67	47
Total	**30**	**324**	**227**

Analytical techniques

For this study, descriptive statistics, Data Envelopment Analysis (DEA) and multiple regression analysis were employed.

Data Envelopment Analysis (DEA)

Data envelopment analysis (DEA) and stochastic frontier are the two most common methods of evaluating efficiency. The DEA method was originally developed by Charnes et al. (1978) (hence is often referred to as the CCR model). DEA is a non-parametric technique, while the other method which is stochastic frontier is parametric. These two techniques were compared by Coelli et al. (2005) and it was established that the advantage of stochastic frontier method is the capacity of the model to unravel stochastic noise and the integration of statistical hypothesis tests relating to production construction. Several authors (Ajao, 2002; Khan and Alam, 2003; Inoni, 2007; Dey et al., 2010; Khan 2012; Ogunmefum and Achike, 2018; Ashley-Dejo et al*.,* 2019, Khan et al., 2021) have exploited technical efficiency (TE) using the stochastic frontier technique because of the benefits indicated above while efficiency measurement of fish hatchery production is limited using DEA particularly in Nigeria. For this study, DEA approach was used to determine the level of efficiency of fish hatchery enterprise, identify causes of inefficiencies and formulate policy. This study also examined association between the characteristics of fish hatchery farmers and the calculated technical and allocative efficiency indices in a single phase by adopting a single step procedure (Coelli et al*.,* 2005).

Slack variable analysis identifies the efficiency of the use of resources; it helps farmer to identify the best level of resources use to achieve a maximum output level. It is also used in analysing resources efficiency and output efficiency. Several authors have identified fish feed as the most important and most expensive components of fish farming constituting the highest percentage of cost of production (Alam, 2011; Iliyasu et al., 2016a; Iliyasu et al., 2016b; Sarker et al., 2016; Ashley-Dejo et al., 2017; Mukta et al., 2019; Mitra et al., 2020).

Technical efficiency (TE) is the evaluation of the performance decision-making unit in relation to other decision-making units within the same contest. In this study, technical efficiency (TE_j) was defined as follows (Iliyasu et al., 2016a; Iliyasu et al., 2016b):

$$\frac{u_1 y_{1j} + u_2 y_{2j} + \cdots\ldots u_n y_{nj}}{v_1 x_{1j} + v_2 x_{2j} + \cdots\ldots v_m x_{mj}} = \frac{\sum_{r=1}^{n} u_r y_{rj}}{\sum_{s=1}^{m} u_s y_{sj}} = TE_j \ldots\ldots\ldots (1)$$

Where, u_r, was the weight given to output n; y_{rj}, was the amount of output n; v_s, was the weight given to input n; x_s was the amount of input n; r, was number of outputs (r = 1, 2, ..., n); s, is number of inputs (s = 1, 2, .., m) and j, represents j *th* of DMUs (j = 1, 2, ..., k).

Equation (1) is a fractional problem, so it can be translated into a linear programing problem as follows:

$$\text{Maximize } \theta = \sum_{r=1}^{n} u_r y_{rj}$$

Subjected to $\sum_{r=1}^{n} u_r y_{rj} - \sum_{s=1}^{m} u_s y_{sj} \leq 0$

$$\sum_{s=1}^{m} v_s x_{sj} = 1 \quad \text{--} \ (2)$$

Ur ≥ 0, vs ≥ 0, and (I and j = 1, 2, 3.....k)

Where: θ is the TE

Equation 2 is known as the input oriented CCR DEA model which assumes constant return to scale. Technical and scale efficiencies could be separated by pure technical efficiency, which could be computed under variable return to scale conditions. This model was employed because of its unique advantage. Input oriented CCR model (based on scale theory of Variable Return to Scale) which is the decision-making units of fish hatchery farms in the study area were estimated using the overall technical efficiency (TE_{CCR}) and pure technical efficiency (TE_{BCR}). Input oriented CCR model composed of costs of feeds, labour, brood stocks, medication and electricity/fuel as inputs and income from sales of fingerlings/juveniles as output.

Multiple regression analysis

This was used to determine the factors that influence the technical and allocative efficiency of fish hatchery enterprises in the study area. The explicit form of the regression model was given as:

$$Y = \beta_o + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \Sigma \quad \text{--} \ (3)$$

where

Y = efficiency score (technical and allocative, scale) of the fish hatchery farmers (mean efficiency scores)

X_1 = age of the manager (years)

X_2 = gender (dummy: 1 for male, 0 for female)

X_3 = marital status of the manager (dummy: 1 for married, 0 for single)

X_4 = household size of the manager (number of members of the household)

X_5 = level of education of the manager (years of formal schooling/education)

X_6 = experience of the manager in fish hatchery enterprise (years)

X_7 = membership of association (years)

X_8 = access to credit (0 = No and1 =Yes);

β_o = constant term

$\beta_1 - \beta_8$ = coefficients of the independent variables

Σ = error term.

Results and Discussion

Technical efficiency (TE) of fish hatchery production farms

Table 2 reveals the result of the estimated CCR model. It was observed that pooled TE_{CCR} of the fish hatchery farms ranged from 36% to 100% with an average efficiency of 75%. This implies that the overall technical efficiency of the fish hatchery farms in the study area is relatively high, despite having average technical efficiency of two third ($^2/_3$) there is still opportunity to increase their overall technical efficiency by 25% this could be achieved by efficient resource utilization given the present level of fish hatchery technology. Also, it was observed that TE_{CCR} of the fish hatchery farms ranged from 36% to 100%, 39% to 100%, and 32% to 100% with a mean TE_{CCR} of 72%, 80% and 73% in Iwo, Osogbo and Ife/Ijesha zones respectively. This denotes that fish hatchery producers in the study area are not fully efficient in the use of available resources.

Pure technical efficiency (TE_{BCC}) ranged from 42% to 100%, 49% to 100% and 43% to 100% with mean TE_{BCC} of 86, 88 and 82% in Iwo, Osogbo and Ife/Ijesha zones respectively. The mean scores of pure technical efficiencies across the three agricultural zones were greater than the overall mean scores of technical efficiencies except for Ife/Ijesha zone. TE_{BCC} in Iwo, Osogbo and Ife/Ijesh zones could be increased by 14, 12 and 18% respectively through efficient use of production inputs. For pure technical efficiency (TE_{BCC}), the minimum TE_{BCC} generated was 45% while the maximum was 100% with mean of 85%. This indicates that in spite of the high pure technical efficiency fish hatchery farms in the study area can still increase their efficiency by 15%. The result shows undoubtedly that the mean TE_{BCR} was 85% which is greater than the overall mean of technical efficiency (TE_{CCR}) with 10%. This variation could be attributed to the existence of scale inefficiency denoting that not all the fish hatchery farms in the study area operate at optimal scale. This finding was in line with the rule of thumb stating that if there is a difference between efficiency scores of technical efficiencies under Constant Return to Scale (CRS) and Variable Return to Scale (VRS), the difference indicates scale inefficiency.

Table 2. Technical efficiency estimates of fish hatchery production under CCR and BCC DEA

Zone	TE_{CCR}				TE_{BCR}			
	Min	Max	Mean	CV (%)	Min	Max	Mean	CV (%)
Iwo (Zone I)	0.36	1.00	0.72	18.74	0.42	1.00	0.86	15.53
Osogbo (Zone II)	0.39	1.00	0.80	19.41	0.49	1.00	0.88	16.05
Ife/Ijesha (Zone III)	0.32	1.00	0.73	17.83	0.43	1.00	0.82	17.07
Pooled	**0.36**	**1.00**	**0.75**	**18.66**	**0.45**	**1.00**	**0.85**	**16.22**

TE_{CCR} = overall technical efficiency, **TE_{BCR}** = pure technical efficiency

Table 3 shows the frequency distribution of technical efficiency measure under CRS DEA and VRS DEA Model. Technical efficiency under CRS and VRS under normal circumstances in fish hatchery enterprise was 30.4% and 34.8% respectively if fully efficient. The estimated mean TE measure for fish hatchery production farms under CRS and VRS approaches were 75% and 84% respectively. Significant inefficiency was observed and this shows that not the entire fish hatchery producers in the study area operate at efficient scale, though improvement could be attained in the overall efficiencies provided the hatchery farmers adjust their scale of operations. From the models, it was observed that substantial inefficiencies occurred in the fish hatchery production activities in the study areas during the study indicating that there is significant opportunity to lessen production cost and hence achieve output gain through improving efficiency. This result agreed with the findings of Oluwatayo and Adediji (2019) where he obtained similar results.

The frequency distribution of technical efficiency scores for CRS shows that 28.19% representing 64 fish hatchery farmers were operating below 71% technical efficiency. About 41.41% representing 94 fish hatchery farmers are operating between 71% to 90% technical efficiency. Also, 30.4% representing 69 fish hatchery farmers were found to be operating between 91.0% to 100% technical efficiency. This shows that there exists inefficiency in the operation of the fish hatchery producers in the study area under CRS. The model also revealed that 16.3% representing 37 fish hatchery farmers were operating below 71% technical efficiency, 48.9% representing 111 fish hatchery farmers were operating between 71 to 90% technical efficiency. Also, 34.8% representing 79 fish hatchery farmers were found to be between 91.0% to 100% technical efficiency. This also implies that the fish hatchery farmers in the study area were operating at inefficient level.

Table 3. Frequency distribution of technical efficiency measure under CRS DEA and VRS DEA Model

Efficiency level	CRS		VRS	
	Frequency	%	Frequency	%
0.31 – 0.40	5	2.20	-	
0.41 – 0.50	10	4.41	4	1.76
0.51 – 0.60	28	12.33	13	5.73
0.61 – 0.70	21	9.25	20	8.81
0.71 – 0.80	43	18.94	49	21.59
0.81 – 0.90	51	22.47	62	27.31
0.91 – 1.00	69	30.40	79	34.80
Total	227	100	227	100
Mean	0.75		0.85	
Maximum value	1.00		1.00	
Minimum value	0.32		0.42	
Standard deviation	0.16		0.14	
CV (%)	18.66		16.22	

Values in parentheses are percentages; (-) implies not applicable
Constant Return to Scale (CRS), Variable Return to Scale (VRS)

Input slacks for inefficient fish hatchery production under technical efficiency

Result in Table 4 revealed the cost by which the expenditure on specific input could be reduced by inefficient fish farms without altering the production level and the contribution of each input to cost saving in commercial fish hatchery production. On average, feed, labour, brood stocks, fuel/electricity, and hormone and medication cost could be reduced by 20.11USD, 10.45 USD, 12.39 USD, 2.35 USD and 2.33 USD respectively without decreasing the current production level in the study area. This indicates that if the aforementioned inputs could be reduced by those units, the same level of output will be achieved.

It was also observed that a total cost of 47.61 USD could be saved from the original total cost of 244.50 USD incurred as expenditure on input cost by inefficient fish hatchery farms and therefore, 196.89 USD could be used to achieve the same level of production using the present total cost of 244.50 USD. The inefficient farms are presently under utilizing their resources as they are yet to optimize their output using the current level of inputs and hence, incurring the present total cost of 244.50 USD on these inputs, more output can be produced from the fish hatchery farms in the study area. The findings also revealed that costs of feeds contributed the largest percentage (42.23%) to the cost saved while hormone and medication cost contributed the least cost (4.89%) to the cost saved. This agree with the findings of Alam (2011), Iliyasu et al. (2016a), Iliyasu et al. (2016b) and Ashley-Dejo et al. (2017) who discovered that feed cost contributed to over 50.0% of the total variable cost.

Parameters of water quality (dissolved oxygen, temperature and pH) are well observed and maintained at optimum level, uneaten feeds are flushed out as the water keeps moving, also stocking density is high because of high dissolved oxygen, and feeding level is well controlled. In this type of system, incidences of disease outbreak rarely occur minimising the cost of medication. Cost of feed could be reduced by feeding the hatchelling's with planktons (phytoplankton and zooplankton) alongside with commercial feeds instead of depending only on commercial feeds which is expensive. It was discovered that fish hatchery farms that use both planktons and commercial feeds were robustly efficient and had reduced feed costs than their counter parts that depend solely on commercial feeds.

Table 4. Distribution of expenditure input slacks for fish hatchery production per production cycle

Input cost	Original cost (USD)	Projected Cost (USD)	Cost saving (USD)	Input contribution to cost saving (%)
Feed	74.80	54.69	20.11	42.23
Labour	71.04	60.59	10.45	21.94
Brood stocks	50.76	38.37	12.39	26.01
Fuel/electricity	10.04	7.69	2.35	4.93
Hormone and medication	37.88	35.55	2.33	4.89
Total	**244.50**	**196.89**	**47.61**	**100.00**

1USD = 361 Naira (Nigeria currency).

Factors influencing technical efficiency of fish hatchery production

Factors influencing technical efficiency of fish hatchery production in the study area were presented in Table 5. It was revealed that the adjusted R^2 was 0.631 which indicates that the variables listed in the model were essential and also indicated 63.0% variation in technical efficiency. This implies that the model is of good fit with good predictive ability. Also, F-ratio (26.71) shows significant relationship at 1.0% level with the independent variables. This adequately explained the variation in the dependent variable.

The result revealed that age and fish hatchery experience are important and significant at 1.0% level. It was also revealed that household size had positive relationship and significant at 5.0% level while level of education and access to credit also had positive relationship and significant at 10.0% level. This means that increase in age, household size, level of education, fish hatchery experience and access to credit would result into an increase in technical efficiency equal to value of coefficient of these significant variables individually. The estimated coefficient (1.383) of age was positive and significant at 1.0% level, holding other factors constant; a unit increase in the age of the fish hatchery farmers will increase technical efficiency by a magnitude of 1.383. This implies that as farmer's age increases the farmer becomes more efficient. This is acceptable because the older the fish hatchery farmers, the more the experience they acquire on best management practices of fish hatchery production and hence, enhancing their technical efficiency in fish hatchery production. The result in Table 5 also revealed that household size also had a positive relationship with the technical efficiency of the fish hatchery farmers in the study area, with estimated coefficient value of (0.187) significant at 5% probability level. The estimated coefficient value implies that a unit increase in household size of the fish hatchery farmers will increase their technical efficiency by a magnitude of 0.187 ceteris paribus. The implication of increase in the technical efficiency of the fish hatchery farmers as a result of an increase in the size of their households is that increase in house hold size will provide available labour to assist in fish hatchery production.

Table 5. Regression estimates of factors influencing technical efficiency fish hatchery production

Variable	Parameters	Coefficient	Standard error	*t*-value	*p*-value
Intercept	β_o	3.742	1.311	2.854	0.0082
Age (X_1)	β_1	1.383***	0.512	2.701	0.0011
Gender (X_2)	β_2	-0.531	0.505	-1.051	0.3261
Marital status (X_3)	β_3	0.017	0.021	0.810	0.6208
Household size (X_4)	β_4	0.187**	0.072	2.597	0.0318
Level of education (X_5)	β_5	0.183*	0.097	1.887	0.0641
Fish hatchery experience (X_6)	β_6	0.362***	0.139	2.604	0.0016
Membership of association (X_7)	β_7	0.171	0.289	0.592	0.7621
Access to credit (X_8)	β_8	1.032*	0.549	1.880	0.0801
R - square (R^2)		0.692			
Adjusted R^2		0.631			
F-values		31.84***			

***P<0.01, **P<0.05, *P<0.10

There exist a positive and significant relationship at 10% level between educational qualification and technical efficiency. The estimated coefficient of 0.183 shows that a unit increase in educational level will lead to consistent increase in technical efficiency of fish hatchery farmer which is in conformity with *a priori* expectation. From this, it could be deduced that education is an important criterion which can be used to improve the technical efficiency of fish hatchery farmers towards ensuring food security. Education has been understood to be a tool that enhance the acquisition, utilization and adoption of improved technology in fish hatchery management practices. This finding conforms with the study of Tunde et al. (2015) and Ashley-Dejo et al. (2017) who observed that educational qualification enhances productivity and increases fish farms ability to understand, assess and efficiently exploit improved fish farming technologies which will equally boost their productivity. Farming experience was positively related and significant at 0.01% level.

The estimated coefficient was 0.362 indicating that a unit increase in experience of fish hatchery farmer will increase their technical efficiency by of 0.355 ceteris paribus. This is because continuous practice of fish hatchery production for a period of time will make the farmer to be well acquitted with efficient resource utilization and eventually improve productivity. The finding was in conformity with the study of Nwaobiala (2014) and Ashley-Dejo et al. (2017) who reported that a unit increase in farmer experience will result to increase in fish farmers output which will invariably affect the technical efficiency positively.

Access to credit was positive with estimated coefficient of (1.032) and significantly influencing technical efficiency of fish hatchery farmers at 10% probability level. The estimated coefficient implies that technical efficiency of fish hatchery farmers will increase by a magnitude of 1.032 as access to credit increase by one unit. Source of finance in any agribusiness is an important factor that could boost the technical efficiency of farmer. Better access to source of finance would result to expansion of the business and invariably affect technical efficiency positively Ashley-Dejo, 2016). This agrees with Ashley-Dejo et al. (2017) who opined that access to credit is an essential tool to improve production fish farmer's productivity.

Multicollinearity Test

Multicollinearity test was carried out to validate regression analysis used in this study. This was done using variance inflation factor (VIF) and tolerance value. The VIF signifies the level at which the standard error was inflated due to existence of multicollinearity problem while the extent of variance of an independent variable that was not explained by the other independent variables is called tolerance value. According to Hair et al. (2010) multicollinearity becomes a problem when the value of VIF is greater than 10 and tolerance value is lower than 0.1. The result of multicollinearity test was presented in Table 6 this shows that there was no problem of multicollinearity as VIF and tolerance values for all the variables were less than the cut-off point of 10 and 0.1 respectively. Also, mean VIF (1.86) is less than 10, indicating that multicollinearity issues did not exist.

Table 6. Multicollinearity using Variance Inflation Factor

Variable	Variance Inflation Factor (VIF)	Tolerance (1/VIF)
Age (X_1)	2.53	0.40
Gender (X_2)	1.74	0.57
Marital status (X_3)	2.15	0.47
Household size (X_4)	2.69	0.37
Level of education (X_5)	1.04	0.96
Fish hatchery experience (X_6)	1.82	0.55
Membership of association (X_7)	1.54	0.65
Access to credit (X_8)	1.33	0.75
Mean VIF	1.86	

Conclusion and Recommendations

The result of the technical efficiency of the fish hatchery enterprise revealed that the overall technical efficiency is relatively high, although there is still opportunity to improve the overall efficiency through efficient resource utilization given the present level of technology. Some farms were more robustly efficient than others by exhibiting better operating practices and hence the number of times the efficient farms appear in the referent set of the inefficient farms was higher. Hence, with the growing demand for fish in Nigeria, exiting fish hatchery farms must strive to achieve better efficiency to make investment in fish hatchery production a more viable agribusiness and attractive for income, job and food security. Membership of association prove to be a significant contributor to influence technical efficiency thus there is need for fish hatchery farmers to explore the opportunity of cooperative associations by pooling resources together to organise seminars and attend workshops/trainings on fish hatchery related techniques.

Authors Contribution

ASS developed the concept, designed the research questionnaire, analyzed data and develop the manuscript.

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Competing Interests

The author declares no competing interest.

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