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Full Length Research Paper

Economic Effect of Improved Fish Production Technology on the Output of Fish Farmers in Otukpo Local Government Area of Benue State, Nigeria

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ABSTRACT: The study examined the economic effect of improved fish production technology on the output of fish farmers in Otukpo Local Government Area of Benue State, Nigeria. Data were obtained from 100 fish farmers using multi-stage sampling procedure, and analyzed using descriptive and inferential statistics. The study revealed that the mean age, household size and fish farm experience were 43 years, 5 persons per household and 4 years respectively. Most used improved fish production systems had a mean of 30 persons. The multiple linear regression analysis result showed that quantity of lime used, quantity of fertilizer used, improved labour, number of improved fingerlings stocked and cooperative membership had a significant influence on the fish farmers' output. The difference in the mean number of fingerlings stocked after improved technology is 6666 while the difference in the mean output of fish after improved technology is 28073. Gross margins for traditional and improved fish production were ₦106803.7 and ₦323919 respectively, while the profits from the traditional and improved fish production technology were ₦13083.7 and ₦115718 respectively. The profitability ratios for traditional and improved fish production technology gave a benefit-cost ratio of 1.10 (traditional) and 1.17 (improved), expense structure ratio of 1.30 (traditional) and 0.42 (improved), rate of return of 0.10 (traditional) and 0.17 (improved), gross ratio (GR) of 0.93 (traditional) and 0.86 (improved) and expense structure ratio (ESR) of 1.10 (traditional) and 1.17 (improved). The results indicate that improved fish production in the area is viable and profitable. The major constraint to fish farming in the area was disease outbreak. The study therefore recommends, sustained provision of extension services for improved fish farm practices, fish farmer membership of Fish Farmer Associations for accrued benefits, and Government provision of credit facilities at low interest rate, improved inputs at low costs in the area.

Keywords: Profitability, fish production, improved technology, fish output, Otukpo

INTRODUCTION

Fish indicates fish, crustaceans, molluscs and other aquatic animals. The global demand for fish and fish products shows no signs of abating (FAO, 2018). The significant and growing role of fish in providing food, nutrition and employment cannot be underestimated. It is an important and cheapest source of animal protein. Out of the required 35g/individual/day of animal protein, recommended by FAO (1986), fish should account for about 8g/person/day (Oluseye and Damilola, 2019). Fish farming is also an important source of employment to a lot of people both rural and urban dwellers. With the growing reputation of fish as a healthy diet, low in calories and cholesterol, and high in protein, demand for it has grown throughout time (Oluseye and Damilola, 2019). In 2017, fish accounted for about 17 percent of total animal protein, and 7 percent of all proteins consumed globally. In 2018, it provided about 3.3 billion people with almost 20 percent of their average per capita intake of animal protein globally (FAO, 2018). Harvesting of aquatic resources and production is done either in the wild (capture fisheries) or in controlled environments (aquaculture) (FAO, 2021). The fisheries and aquaculture sector significantly expanded in the past decades and total production, trade and consumption reached an all – time record in 2018 (FAO, 2018). However, since the early 1990s, the majority of output growth in the industry as a whole has been largely constant, with a portion of expansion primarily attributable to inland capture.

In 2018, total global capture fisheries production reached the highest level ever recorded at 96.4 million tonnes – an increase of 5.4 percent from the average of the previous three years. The increase was mostly driven by marine capture fisheries, with production from marine areas increasing to 84.4 million, up from 81.2 million in 2017. Top capture producers were China, Indonesia, Peru, India, Russia, USA and Vietnam. These countries accounted for almost 50 percent of total global capture production (FAO, 2018).

World aquaculture attained an all – time record high of 114.5 million tonnes in live weight in 2018, with a total farmgate sale of USD 263.6 billion. The total production consisted of 82.1 million tonnes of aquatic animals, 32.4 million tonnes of aquatic algae and 26,000 tonnes of ornamental seashells and pearls. Inland aquaculture produced 51.3 million tonnes of aquatic animals, accounting for 62.5 percent of the world's farmed food fish production. This refers to aquaculture produced either from inland natural water sources, such as rivers and lakes, and fish farms. Aquaculture is the farming of aquatic animals, including finfish, crustaceans, molluscs and aquatic plants, mostly algae, using or within freshwater, seawater, brackish water and inland saline water. World aquaculture production of farmed aquatic animals has been dominated by Asia, with an 89 percent share in the last two decades or so. Among major producing countries, China, India, Indonesia, Vietnam, Bangladesh, Egypt, Norway and Chile, have consolidated their share in regional or world production to varying degree over the past two decades (FAO, 2018). Despite an acceleration of the growth in Chinese production over the second half of the outlook period, China's share of global aquaculture production is expected to decrease slightly from 57% in 2018-20 to 56% in 2030. Regionally, Asia is expected to maintain its position as the largest producer, with the share of global production from the region accounting for 88% in 2030, with strong production growth expected in other major Asian producers: India (+24.7%), Indonesia (+30.5%), Viet Nam (+20.4%) and Thailand (+30.0%) (OECD/FAO, 2021).

After strong growth in 2018, with overall production, trade and consumption reaching historic peaks, the global fisheries and aquaculture declined slightly in 2019. Aquaculture production continued to expand by 2 percent, while capture fisheries declined by about 4 percent due to lower catches of certain species including cephalopods, cod and selected small pelagic species (OECD/FAO, 2022). Total fish production is expected to expand from 179 million tonnes in 2018 to 204 million tonnes in 2030. Aquaculture is projected to reach 109 million tonnes in 2030, an increase of 32 percent over 2018. Apart from accessibility, the share of fish production for human consumption is estimated to grow, reaching 89 percent by 2030. The main factors behind this increase are represented with high demand due to rising urbanization and income, improvements in processing and distribution which strengthen the commercialization of fish. In per capita terms, world fish consumption is expected to reach 2.5kg in 2030, up from 20.5kg in 2018 (FAO, 2020).

Africa is behind in fish production. Given that 38 of Africa's 54 States are coastal and island nations, it is ironic that the continent is behind in the fisheries sector. Capture fisheries (all kinds of harvesting of naturally occurring living resources in both marine and freshwater environments) in Africa currently have an output at 10m tonnes (NewAfrican, 2020). The total gross value – added of the fisheries in Africa is estimated at $21bn (Kabukuru, 2020). Although African aquaculture production is significantly increasing with large – scale investments in Egypt, Nigeria, Uganda and Ghana producing substantial quantities of fish (Cai *et al*., 2017; FAO, 2018), the region's contribution to world aquaculture production is still insignificant (2.7%) (Halwart, 2020; Adeleke *et al.*, 2021). However, in sub-Saharan Africa, in the period between 2017 and 2018, the volume of fish production amounted to roughly 7.7 million metric tonnes. Compared to a decade prior, the volume of production of fish incremented by over two metric million metric tons. Furthermore, it is projected that by 2029, the population of fish in the sub – region will continue to increase, reaching around 8.3 million metric tonnes (Galal, 2022).

Between 2010 and 2015, Nigeria produced 5.7 million tonnes of fish. The year 2014 saw the highest number of tonnes of fish, totaling 1.1 million tonnes. The second biggest amount of fish produced was in 2015, while the lowest amount was in 2010. Furthermore, data on fish production by sector revealed that 5 million tonnes of fish were produced between 2011and 2015. The second highest tonnes of fish produced by sector were recorded in 2013, while the least were recorded in 2011 (NBS, 2017). Despite being the largest producer of fish in Africa, Nigeria currently records a 2.5 metric tonnes of fish deficit, a situation that may have jeopardized protein intake among Nigerians. The total fish production in Nigeria is about 1.123 million metric tonnes while the annual consumption is about 3,6 million metric tonnes. The total fish production including imports in Nigeria still does not satisfy the total fish demand (Oritse, 2021). Globally, fish production in ponds, lakes, flood plains, oxbow lakes and semi - closed water bodies are increasing day by day due to adoption of modem aquaculture technology by the fish culturists (Alam *et al*., 2017). In the natural body, the capture fisheries are diminishing day to day due to agrochemicals, dike construction, flood, siltation, industrial effluents (Chakraborty, 2009).

However, in Nigeria and Otukpo Local Government Area of Benue State in particular, the present state of the fishery sector is very poor. Rogers (2003) and Olaoye (2017) stated that the present condition of the fishery sector in the country cannot guarantee the sustainable supply of fish to the nation and hence require that efforts be made at encouraging fish farmers in taking up the modern means of fish production through the use of improved fisheries and aquaculture technologies. It is on the basis of this obvious fact that this study becomes imperative.

Past literature on fish production in most States in Nigeria has focused mainly on the economic analysis of fish farming, investment and the factors affecting the investments, neglecting the economic effect of improved fish production technology on the output, especially in Benue State, including Otukpo Local Government Area of the State. For instance, Oladejo (2010) examined the economic analysis of small-scale catfish farming in Ido Local Government Area of Oyo State, Nigeria; Akangbe *et al*. (2015) examined the effects of improved fish production technology on the output of fish farmers in Ilorin, Kwara State, Nigeria; Olaoye (2017) worked on Adoption of Improved Fisheries Technologies among Fish Farmers in Ogun State, Nigeria; Salau *et al*. (2014) examined the adoption of improved fisheries technologies by fish farmers in southern agricultural zone of Nasarawa State, Nigeria; Oluseye and Damilola (2019) examined the Profitability of Investment in Fish Farming Enterprise inIbadan Metropolis, Oyo State, Nigeria. To fill this gap, this study seeks to economically examine the effect of improved fish production technology on the output of fish farmers in Otupko Local Government Area of Benue state, Nigeria. Specifically, the objectives of this study are to:

i. describe the socio-economic characteristics of fish farmer respondents in the study area;
ii. identify the type of fish production systems engaged in by fish farmers in the study area;
iii. determine the effect of improved fish production technology on fish farmers' output in the study area;
iv. examine the profitability of traditional and improved fish production technology in the study area; and
v. identify the factors that affect the output of fish production among the respondents in the study area.

METHODOLOGY

Study area

This study was carried out in Otukpo Local Government Area (LGA) of Benue State. Otukpo is one of the oldest LGAs inBenue State, Nigeria located in the middle belt region of zone C on $7^{0}13^{1}$N & $8^{0}9^{1}$E and $7^{0}21^{1}$N & $8^{0}15^{1}$E. It is equally bounded in the North by Apa and Ohimini local government areas, Ado local government in the South and Olamaboro local government area in Kogi state in the West (Figures 1 and 2). The LGA came into existence in 1923, with its headquarters at Otukpo. It also doubles as the traditional headquarters of Idoma people where its paramount Chief, the Och'Idoma has his palace.

In addition to metropolitan Otukpo town, other prominent places in the LGA include Ogobia, Upu, Otukpoicho, Otobi, Adoka, Oyagede and Akpa-Igede. The area is mainly populated by Idoma speaking tribe. The major dialects are Idoma, Igede, Agatu and Akpa. It has an estimated landmass of about 390 sq. km, and with an estimated population of 266,411 (NPC, 2006). The major occupation of the people is farming. However, most of the farming activities in Otukpo are done using traditional methods which have led to high shortage of supply of the agricultural produce. It is on this note that this study sought to enlighten the people about the profitability of improved method of farming.

Population and sample size selection

The study population comprises all the fish farmers in Otukpo Local Government Area of Benue State.
Multi-stage sampling technique was used to select the fish farmer respondents in the study area. First, four council wards were purposively selected based on their popularity in fish farming. At stage two, a preliminary survey was conducted across the four selected council wards to find the total number of fish farms in the wards. In the final stage, 50 percent of the identified fish farms who had stocked their farms in each of the four council wards were purposively selected. This gave a total of 100 fish farms selected for the survey (Table 1), with the managers of the fish farms as their respondents.

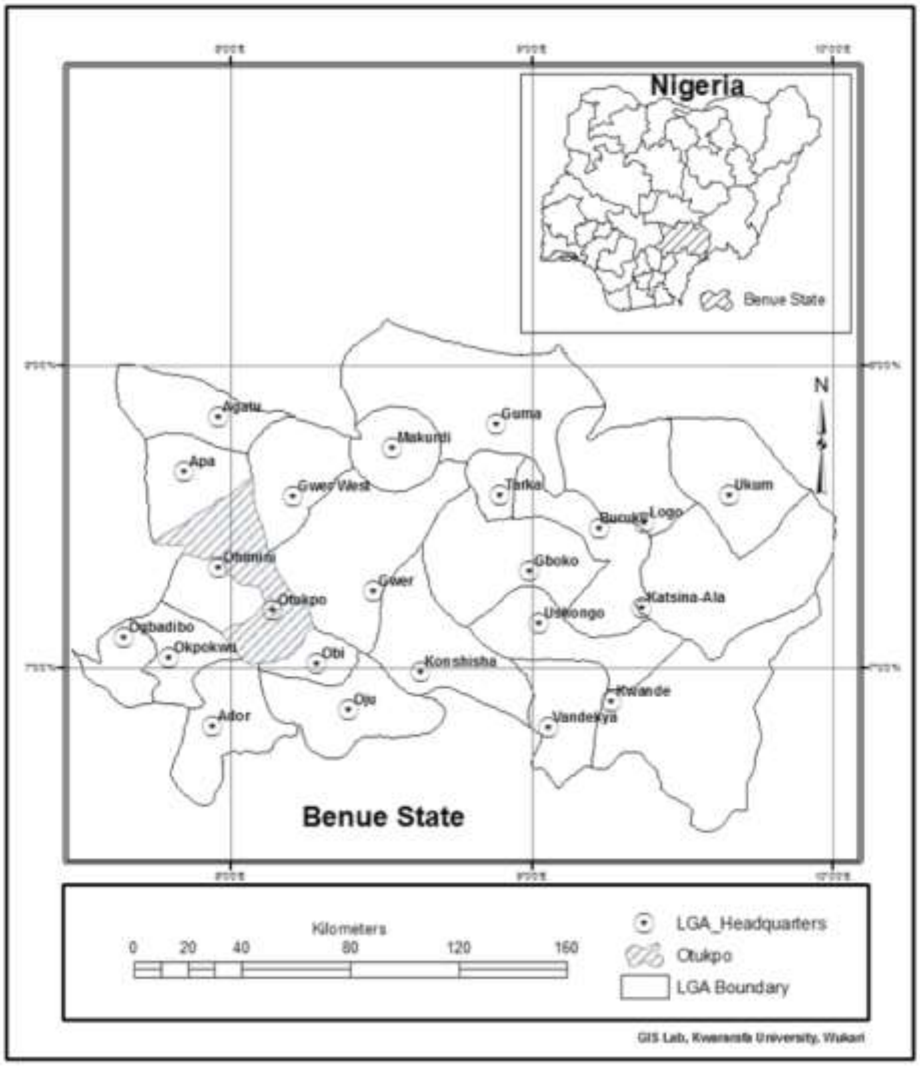


Figure 1: Map of Benue State showing the study area

Data analysis

Both descriptive and inferential statistics were employed in this study. The descriptive statistical tools such as frequencies and percentages were used to analyze objectives 1, 2, 3 and 5. Inferential statistics such as budgetary techniques and profitability and efficiency ratios were used to analyze objective 4 and multiple regression model was used to analyze objective 3.

Model specification

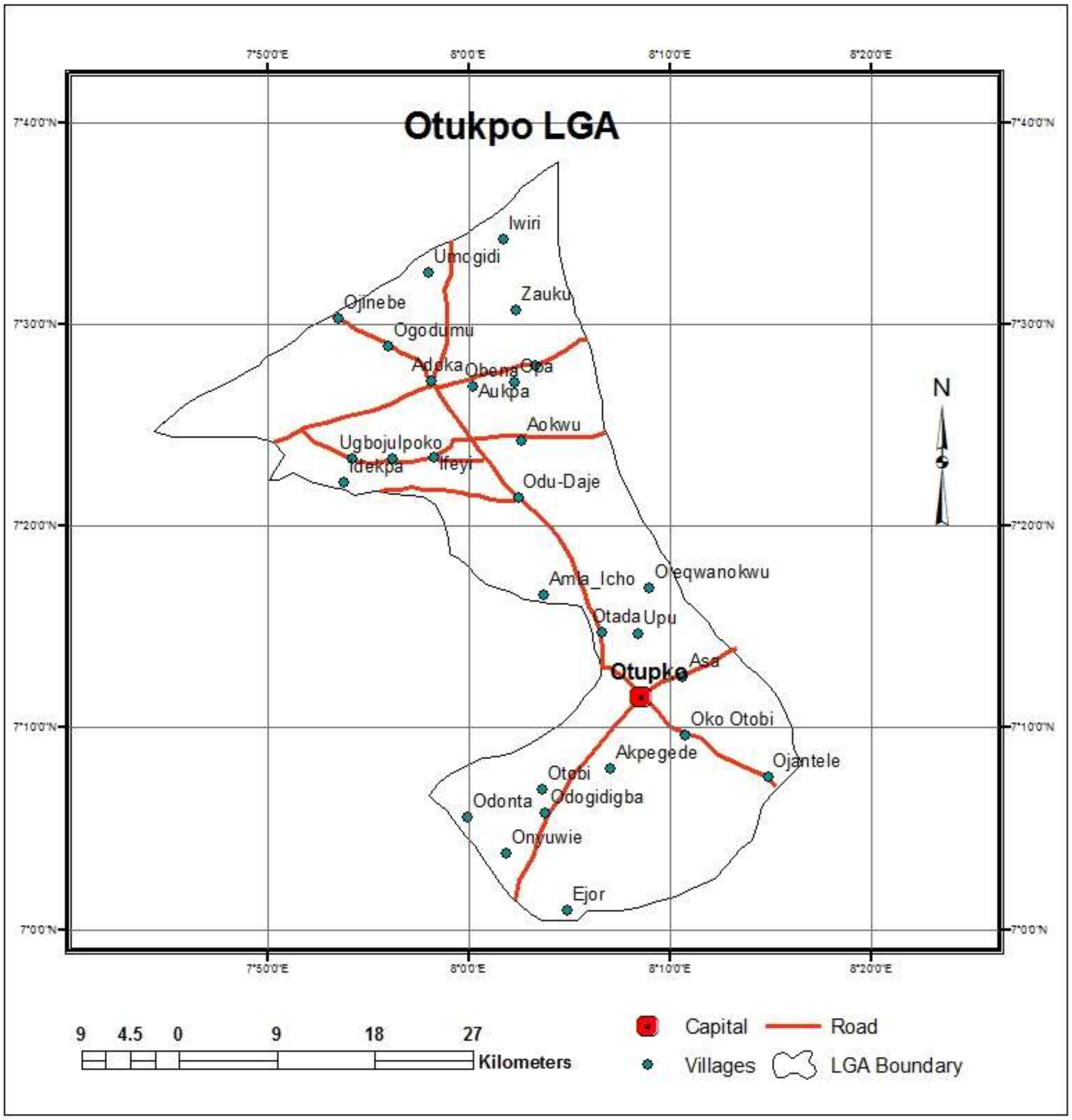
Budgetary technique

Budgetary technique covers the analysis of costs such as average fixed cost and average variable costs and production income (that is, total income or total revenue). In this study, production income refers to the monetary value of the output obtained by the fish farmer.

It is expressed as TI = PQ (1)

Where, TI is the total income, P is the price per unit and Q is the quantity of output.

Production costs or the total costs refer to the total expenditure or expenses incurred during a given period on a specified enterprise by the fish farm firm. It includes rent on land, pond construction cost, and cost of fingerlings, feed cost, cost of veterinary and drugs, transportation cost amongst others. Depreciation, which is a cost on fixed assets consumed during a given period.



GIS Lab., Kwararafa University, Wukari, Taraba State, Nigeria

Figure 2: Map of Otukpo the study area

The common fixed assets used by small-scale fish farmers are water pump, fishing equipment. Quantitatively, profitability model was expressed as follows:

TI=QxP (2)
TC=TVC+TFC (3)
GM=TI–TVC (4)
π=GM–TFC (depreciated value) (5)
Where,
TI = Total Income;
Q = Quantity;
P = Price;
TC = Total cost;
TVC = Total variable cost;
TFC = Total fixed cost;
GM= Gross margin;
π = Profit.

Profitability and Efficiency Ratio

Various ratios were computed to ascertain the extent of the profitability of fishing farming enterprise, namely:

BCR = TI / TC (6)
ESR=FC/VC (7)
ROR=NR/TC (8)
GR=TC/TR (9)

Where,

BCR = Benefit Cost ratio;
ESR = Expense Structure Ratio;
ROR =Rate of Return;
GR = Gross Ratio

Multiple regression model

This was used to analyze objective 3 i.e. to determine the effect of improved fish production technology on fish output in the study area.
The implicit model of the regression was specified as follows:

$Y = f(X_1, X_2, X_3, X_4, X_5, X_6, X_7, X_8, X_9)$
Explicitly, it si given as:

$Yi = \beta_0+\beta_1X_1 + \beta_2X_2 + \beta_3X_3 + \beta_4X_4 +\beta_5X_5 + \beta_6X_6 +\beta_7X_7 + \beta_8X_8 +\beta_9X_9 + ei.$
Where,

Y = the total fish output in kg
X_1 = quantity of improved feed used in kg/ culture time
X_2 = quantity of fertilizer used in kg
X_3 = quantity of lime used in kg
X_4 = improved labour in man-hour
X_5 = number of improved fingerlings stocked
X_6 = Educational status (qualification obtained)
X_7 = Annual income
X_8 = Cooperative membership
X_9 = Household size
ß1… ß9 = regression coefficients
ei = error term

Where: *Yi* is the dependent variable and *Xi* (i=1 to 9) are independent variables, *β* are the parameters to be estimated, and *ei* is the error term.

Apriori Expectation: Variables such as education, household size, improved labour, cooperative membership, number of improved fingerlings, quantity of improved feed used, annual income, quantity of fertilizer used and quantity of lime used were expected to positively influence total fish production while Household size was expected to have a positive or negative impact on total fish production.

RESULTS AND DISCUSSION

Socio – economic characteristics of fish farmers in the study area

The results of the socio-economic characteristics of respondents are presented in (Table 2). The results revealed most (47%) of the respondents were within the age brackets of 31 to 45 years. The mean age of the respondents was 43 years. The finding is in agreement with the findings of Okwu *et al*. (2011), who found out that most of the fish farmers were in their economic active years. Most (45%) of the respondents got the land they are using for fish farming through inheritance. The mean years of fish farm experience of the respondents were 4 years. This shows that most of the fish farmers are fairly new in the enterprise and are in the process of attaining the level of experience required for best management practices in their fish farming enterprises. Majority (55%) of the fish farmers were males. This shows that fish farming enterprises seem to be a male dominated activity in the study area. This corroborates the study of Okwu *et al*. (2011) who affirmed that males dominate fish farming. Majority (70%) of the respondents were married. This shows that most of the fish farmers are with responsibilities that would make them willing to seek innovations so as to increase their income and improve their standard of living. The results on household size showed that majority (70%) of the respondents had 1 to 5 household members with a mean household size of 5 persons. This indicates that majority of the farmers had family labour for fish pond management practices. Majority (56%) of the respondents had no formal education. They slightly lack the level of education required to adopt new technologies in order to improve fish farming.

The result also revealed that majority (53%) of the fish farmers were able to raise their capital from personal savings and only 14 percent had access to bank loans. The major annual farm income range of the respondents was N601000 and above with a mean annual farm income of N191655. This implies that fish farming is a profitable enterprise. Also, all the respondents in the area revealed that their reason for embarking on fish farming was to make profit. This result is in line with the finding of Salau *et al*. (2014) who reported that fish farming was a profitable venture which provided self – employment for the people in Nasarawa State. Majority (78%) of the fish farmers did not belong to any cooperative.

Types of fish production systems/practices engaged in by fish farmers

The results of fish production systems/practices used by the fish farmer respondents are presented in (Table 3). Majority (68%) of the respondents reared Clarias spp.

Table 1: Sample size selection plan.

	Council ward	No. of fish farms identified	Selected Sample Size (50%)
1	Apka	49	(50/100*49) =24
2	Otupkpo	53	(50/100*53)=26
3	Adoka	48	(50/100*48) =24
4	Ogboju	52	(50/100*52) =26
	Total	202	100

Source: Field preliminary Survey (2021).

Table 2: Distribution of Respondents by the Socio-economic Characteristics of Fish Farmers (n = 100)..

Variable	Frequency	Percentage (%)	Mean
Age (years)			
15-30	12	12	
31-45	47	47	43
46-60	33	33	
61 and above	8	8	
Sex			
Male	55	55	
Female	45	45	NA
Marital Status			
Single	30	30	
Married	70	70	
Household Size (number)			
1-5	70	70	
6-10	30	30	5
Educational Qualification (years)			
No Formal Education	56	56	
Formal Education	44	44	NA
Farm Experience (years)			
1-5	88	88	
6 - 10	12	12	4
Annual Farm Income (₦)			
300000-400000	4	4	
401000-500000	15	15	
501000-600000	15	15	
601000 and above	56	56	191655
Mode of Land Acquisition			
Purchase	44	44	
Lease/Rent	11	11	NA
Inheritance	45	45	
Cooperative Membership			
Yes	22	22	NA
No	78	78	
Source of Finance			
Personal Savings	53	53	
Friends/Relatives	13	13	NA
Cooperatives	20	20	
Bank Loan	14	14	
Reason for Fish Farming			
For Profit	100		NA

Source: Field Survey, 2021; NA = Not Applicable

Most (40%) of the respondents owned concrete ponds. This finding agrees with that of Salau *et al*. (2014) and Nwachukwu and Onuegbu (2005) who observed that most fish farmers in Nigeria operated small – scale farms ranging from homestead concrete to small earthen ponds. About 50 percent of the respondents practiced either monoculture or polyculture. Majority (68%) of the respondents got their fingerlings from own fish farm. This disagrees with the finding of Salau *et al*. (2014) who found that majority of the respondents in Nasarawa State obtained their fingerlings from commercial hatcheries. Also, in the study area, majority of the respondents had a

Table 3: Distribution of fish farmer respondents according to fish production systems/Practices (n = 100).

Variable	Frequency	Percentage
Rearing Structure/Facilities		
Earthen pond and concrete tank	37	37
Concrete pond only	40	40
Earthen pond only	23	23
Types of Culture		
Monoculture	50	50
Polyculture	50	50
Types of Cultured Specie		
Clariasspp	68	68
Clarias and Tilapia spp	32	32
Source of Fingerlings		
Own Fish Farm	68	68
Fish Hatchery	32	32
Culturing Period		
5 Months	9	9
6 Months	70	70
More than six months	21	21
Harvesting Period (year)		
Once	3	3
Twice	85	85
Thrice	12	12

Source: Field Survey, 2021

Table 4: Distribution of fish farmer respondents according to type (s) of improved fish production technology engaged in.

Improved Technology	Frequency*	Mean	Percentage	Percentage Ranking
Floating	13			
Standard feeding regimes	13			
Improved breeds of fingerlings	13			
Provision of inlet and outlet devices in pond	13			
Soil testing before site selection	13			
Water testing kits for oxygen, acidity and fertility	13			
Construction of modern fishing gears.	13			
Formal training in fish production technology	13			
Total	104	13	26	4^{th}
Frequent change of water	17			
Regular sampling/sorting of fish	17			
Daily sanitation and record-keeping practices	17			
Prevention and control of fish diseases	17			
Total	68	17	17	3rd
Optimum stocking rate	27			
Improved techniques in pond construction and maintenance	27			
Fertilization and liming of fish pond	27			
Techniques of hatchery and fingerling production	27			
Total	108	27	27	2nd
Fish preservation and storage techniques	30			
Techniques of improving water quality in fish culture	30			
Integrated fish farming for increased fish production	30			
Aerated containers for transporting fingerlings to reduce stress and mortality	30			
Total	120	30	30	1st

Source: Field Survey, 2021; *Multiple Response

fish culturing period of six months (70%) and harvested twice in a year (85%).

Types of improved fish production technology used by fish farmers in the study area

The results of type (s) of improved fish production technology used by the fish farmer respondents in the study area are presented in (Table 4). The results revealed that most (30%) of the respondents, with a mean value of 30 used fish preservation and storage techniques, techniques of improving water quality in fish culture, integrated fish farming for increased fish farming and aerated containers for transporting fingerlings to reduce stress and mortality, in fish production. This result disagrees with the finding of Akangbe *et al*. (2015) who

Table 5: Multiple regression estimates of improved factors influencing fish farm output in the study area.

Variable	Coefficients	Standard Error	t Stat	P-value
Constant	3007.7	307.27	9.7884	0.0000
Quantity of Improved feed	-12.802	2.9925	-4.2780	0.0000*
Quantity of lime	-1.5986	0.6592	-2.4251	0.0173**
Quantity of fertilizer	1.7074	0.6007	2.8424	0.0055*
Improved labour	50.040	19.493	2.5671	0.0119**
No. of improved fingerlings stocked	48.654	13.608	3.5755	0.0006*
Educational qualification	36.816	36.875	0.9984	0.3208
Annual income	0.0001	0.0000	4.6405	0.0000*
Cooperative membership	89.058	44.571	1.9981	0.0487**
Household size	52.273	10.411	5.0211	0.0000*

Significant at 1% and 5% (**P < 0.05, *P < 0.01)
Multiple R = 0.7078 R^2 = 0.5009 Adjusted R^2 = 0.4510 F = 10.038
Source: Field Survey, 2021

reported that majority of the fish farmer respondents in Kwara State used improved technology such as floating feeds, standard feeding regimes, improved breeds of fingerlings, provision of inlet and outlet devices in pond and frequent change of water in fish production.

The effect of improved fish production technology on fish farmers' output in the study area

The results of the multiple linear regression analysis on the effect of improved fish production technology on fish farmers' output in the study area are presented in (Table 5). The coefficient of multiple correlation (R) equals 0.7078 (71%). It means that there is a very strong direct relationship between the explanatory variables and the fish farmers' output. The R^2 is 0.5009. This suggests that 50 percent of the variability in the outputs of the respondents is jointly explained by variations in the specified independent variables considered in the model. The adjusted R^2 is 0.4510 (45%). The F-Value obtained (10.038) indicates that the overall equation is statistically significant at 1 percent (p<0.01). The results showed annual income, household size, quantity of fertilizer used, improved labour, number of improved fingerlings stocked and cooperative membership were the positive and statistically significant factors that influenced fish farmers' output in the area. These are in line with a priori expectation. Quantity of lime used and quantity of improved labour used were statistically significant but negatively signed and therefore in contrast to a priori expectation. Educational qualification was positive in conformity with a priori expectation but not statistically significant.

The coefficient of quantity of improved feed (-12.802) was negative and statistically significant at 1 percent level. This implies that an increase in the use of improved feed by the fish farmers for fish production decreases the output by 1280.2 at the 0.01 level of significance. This could either be due to diminishing returns or the fish farmers' inability to purchase adequate quantity of the improved feed for fish production as a result of its high cost. The coefficient of quantity of lime used (-1.5986) was negative and statistically significant at 5 percent level. This implies that an increase in the quantity of lime used by the fish farmers in fish production decreases the output by 159.86 at the 0.05 level of significance. This could happen if the lime used is not equal to the recommended rates. The coefficient of quantity of fertilizer used (1.7074) was positive and statistically significant at 1 percent level. This implies that an increase in the quantity of fertilizer used by the fish farmers in fish production as per recommended rates would increase the fish output by 170.74 at the 0.01 level of significance. This result agrees with the findings of Musaba and Namanwe (2020) that fertilizing fish ponds even with chicken manures increases fish production. The coefficient of household size (52.273) was positive and statistically significant at 1 percent level. This indicates that an increase in the fish farmers' household size which constitutes family labour increases the output by 5227.3 at the 0.01 level of significance.

The coefficient of improved labour (50.040) was positive and statistically significant at 5 percent level. This implies that an increase in the use of improved labour by the fish farmers in fish production increases the output by 5004.0 at the 0.05 level of significance. The coefficient of number of fingerlings stocked by the fish farmers (48.654) was positive and statistically significant at 1 percent level. This implies that an increase in the number of fingerlings stocked by the fish farmers in fish production would increase the output by 4865.4 at the 0.01 level of significance. This indicates that a low stocking rate would result in low output. This agrees with the findings of Salau *et al.* (2014) who associated low stocking rate with small – scale farmers who found it difficult to adopt technologies that are capital - intensive and high – yielding. The coefficient of annual income (0.0001) was positive and statistically significant at 1

Table 6: Distribution of respondents by average quantity of fingerlings stocked in pond and output per production cycle before and after adoption of improved technology.

Item	Before Adoption of Technology	After Adoption of Technology
Average Quantity of fingerlings stocked in pond (Number)	509	7175
Average Quantity of fish Output (Number)	3151	31224

Source: Field Survey, 2021

Table 7: Gross margin and profitability analysis of traditional and improved fish production technology per production cycle/last cropping season in the study area.

Item	Traditional (Mean Amount, ₦)	Improved (Mean amount, ₦)
Variable costs		
Fish Feed	6488	239700
Labour	3188	7640
Fish seed/fingerlings	3870	85550
Lime	1420.3	15687.5
Fertilizer	-	15312.5
Prevention/control of fish disease	45000	112000
Source/frequent change of water	12350	11580
Transportation	630	-
Formal training in fish production Technology	-	5865
Total Variable Costs (TVC)	72946.3	493335
Revenue		
Total Revenue (TR)	179750	817254
Gross Margin (GM) = TR-TVC	106803.7	323919
Total Fixed Costs (TFC)	93720	208201
Profit (#) = GM - TFC	13083.7	115718

Source: Field Survey, 2021

percent level. This shows that an increase in the fish farmers' income would increase the fish output by 0.01 at the 0.01 level of significance.

The coefficient of cooperative membership (89.058) was positive and statistically significant at 5 percent level. This implies that an increase in the fish farmers' involvement in cooperatives would increase the fish output by 8905.8 at the 0.05 level of significance. This is because cooperatives serve as avenues through which farmers access inputs, improved inputs, credit and training even in fish production and improved technology adoption is accelerated. This result agrees with the findings of Wabbi (2002) and Salau *et al*. (2014) who reported that membership of social groups accelerates the adoption of improved technologies which by implication, results in high output.

Average quantity of fingerlings stocked in pond and output per production cycle before and after adoption of improved technology in the study area

The results of the average quantity of fingerlings stocked in pond and output per production cycle before and after the adoption of improved technology in the study area are presented in (Table 6). The results showed that the mean number of fingerlings stocked before improved fish technology was 509 and the mean output (harvest) without improved technology was 3151 in the study area. After the adoption of improved technology, the mean stocking was 7175 fingerlings and the mean output (harvest) 31224 in the study area. The difference in the mean number of fingerlings stocked after improved technology is 6666 while the difference in the mean output of fish after improved technology is 28073. This indicates that there is an appreciable increase in the output after the adoption of improved fish technology. The implication is that the use and adoption of improved technology has positive influence on production output of fish farmers in the study area. This result is consistent with the finding of Akangbe *et al*. (2015) and Ashaolu *et al.* (2006) who observed that fish farming is profitable.

Profitability, viability and efficiency of traditional and improved fish production technology in the study area

The results of Gross Margin and profitability analysis of

Table 8: Distribution of respondents by efficiency/viability ratios of fish production in the study area.

Items	**Fish farmers' value**	
Ratio	Traditional	Improved
Benefit Cost ratio	1.10	1.17
Expense structure ratio	1.30	0.42
Rate of returns	0.10	0.17
Gross ratio	0.93	0.86

Source: Field Survey, 2021

Table 9: Mean Distribution of Respondents according to Problems Affecting Fish Production in the Study Area.

Variable	**Mean (M)**	**Ranking**
Inadequate capital	0.79	5th
High cost of feed	0.87	2nd
High cost of fingerlings	0.83	4th
Poor extension service	0.75	8th
Water scarcity	0.74	9th
Poor managerial skill	0.67	13th
Poor transport facility	0.78	7th
Lack of technical skill	0.71	11th
High cost of land	0.28	14th
Poor marketing structure	0.79	5th
Disease outbreak	0.91	1st
Lack of commercial hatchery	0.72	10th
High cost of acquiring improved technology	0.86	3rd
Illiteracy	0.69	12th

Source: Field Survey, 2021

traditional and improved fish production technology in the study area are presented in Table 7. The results revealed that the average total variable costs (TVC) of traditional and improved fish production are ₦72946.3 and ₦493335 respectively. Total revenues from the sale of traditional and improved fish outputs were ₦179750 and ₦817254 respectively. Gross margins for traditional and improved fish production were estimated at ₦106803.7 and ₦323919 respectively, while the profits from the traditional and improved fish production technology were estimated at ₦13083.7 and ₦115718 respectively during the lasting cropping period. This result indicates that fish production is profitable but improved fish production technology is more profitable than the traditional fish production technology in the study area. This result agrees with the finding of Oluseye and Damilola (2015) who reported that the business of fish farming was profitable in Oyo State. The results of the viability/efficiency ratios of fish production in the study area are presented in (Table 8). The results revealed that Benefit – Cost Ratio (BCR) is greater than 1 for fish production enterprises irrespective of their pond typology, whether traditional or improved. The values of the expense structure ratios were 1.30 (traditional) and 0.42 (improved). This implies that about 130 percent (Traditional) and/or 42 percent (improved) of the total cost of production were made up of the fixed cost component of the fish farmers. The rates of return were 0.10 (traditional) and 0.17 (improved). This shows that for every N1.00 invested by a concrete-pond farmer, 10 kobo (traditional) and/or 17 kobo (improved) are/is gained by the respondent. The gross ratios were 0.93 (traditional) and 0.86 (improved). This implies that for every 1.00 return to the enterprise, 93 kobo (traditional) and/or 86 kobo (improved) are/is spent. These measures of performance indicate that improved fish farming enterprise in the study area is viable and the business is profitable. This result agrees with the findings of Oluseye and Damilola (2015) who reported that fish farming enterprise is viable and the business of fish farming was profitable in Oyo State.

Problems encountered by fish farmers in fish production in the study area

The results of problems encountered by fish farmers in fish production in the study area are presented in (Table 9). The results revealed that disease outbreak which ranks first, is the major problem affecting fish production in the study area. Serious constraints to increased fish production in the study area are disease outbreak (M = 0.91), high cost of feed (M = 0.87), high cost of acquiring improved technology (M = 0.86) and high cost of fingerlings (M = 0.83). This result partially agrees with the finding of Salau *et al*. (2014) who reported that high cost of feed, inadequate capital, poor storage and processing facilities and high cost of fingerlings are the serious problems affecting fish farming in Nasarawa State.

Conclusion and Recommendations

The study found that fish farmers in the study area had increased their output of fish by using fish-improved technology. The following factors played a significant role in determining farmers' output as a result of improved technology: the amount of lime used, the amount of fertilizer used, enhanced labour, the quantity of improved fingerlings stocked, and cooperative membership. Second, the study area's fish production is comparatively profitable and viable. However, if production technology is improved, fish farming might be more profitable and feasible in the region. Finally, it is clear that fish farming may raise people's standards of living and create jobs while also increasing revenue. However, the main issues that fish producers in the research area reported were disease outbreaks, high feed costs, high acquisition costs for new technologies, and high fingerling costs. On the basis of the study's findings, the following suggestions were made: Provision of extension services to train farmers on improved fish farming and management practices should be increased and strengthened; Fish farmers should be encouraged to join Fish Farmer Associations in the study area for training, workshops, seminars, easy access to land, sources of funding at minimal interest rate, feeds at an affordable rate, and to facilitate fish marketing. To encourage fish farmers and increase fish productivity, government should provide to them credit facilities at low interest rate, improved fish feeds and fingerlings at subsidized costs, and other improved fish production technology at affordable costs.

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