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Research Article

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Technology Adoption by Small Holder Fish Farmers in Oyo State, Nigeria

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Abstract

New technologies in aquaculture are seen as an important route out of poverty and means to ensure rural development and food security in most of the developing countries in Africa including Nigeria. Numerous initiatives have been directed at technological innovation and transfer but the rate of adoption of these technologies has remained low in African continent leading to low aquaculture production and therefore inadequate to achieve transformational change envisaged to impact food security. This study therefore aims at examining the factors that influence fish farmer's perceptions, and behaviors toward adoption of modern technology and to determine the perceived effect of adopted technologies on farmers' production and food security.

A multi stage sampling technique was used to select 200 respondents' base on ADP zoning. Primary data was collected with the aid of well-structured questionnaires administered to the sampled fish farmers while secondary data was obtained from the internet, textbooks, journals etc. The questionnaire was used to obtain information on the socio economic characteristics of the fish farmers, their level of adoption of technology in aquaculture, the impact of the technology adopted and their challenges. Descriptive analysis (mean, frequency distribution, simple proportion and percentage) and inferential analysis (Chi square and Multiple linear regression Analysis) was used to analyze the data obtained.

The gender distribution shows that 88% of the respondents were male with mean age of 43.6± 8.972 years, 67% have tertiary education while the household size of 4-6 members with mean 6.05±2.406 was in the majority. Only 13.5% were into fish farming as primary occupation while 67% had fish farming as secondary occupation. The size of fish farm shows that 54.5% of the respondents have less than 0.5 hectares' size fish farm. The result of the Chi-squared analysis shows that there is a significant association between adoption of recommended aquaculture production technologies and educational level (X2 = 16.12, p<0.05), marital status (X2 = 15.94, p<0.05) and occupation (X2 = 13.12, p<0.05). High cost of acquisition of technology with mean value of 2.850 was identified as a major limiting factor to Technology adoption followed by poor access to capital with mean value of 2.825. The result of the regression analysis show that the determinants of adoption of aquaculture production technologies were age, educational status, fishing experience and income. These coefficients were positive and statistically significant for the fish farmers at 10%.

To facilitate uptake of technologies and good practices by fish farmers, cost of acquisition of technology should be reduced, low cost adaptive technology should be encouraged while access to capital should be facilitated.

Keywords: Technology, Adoption, Smallholder, Fish Production

Introduction

Fish is an essential source of animal protein for billions of people across the globe, with little or no religious barrier; it is very essential in the nutrients of pregnant women, little children and elderly people. Fish is readily digestible, easily utilized, and help in lessening the risks of disease in human. Capture fisheries and aquaculture are playing vital role in provision of about 20 percent of animal protein to 2.9 billion people [1]. Capture fisheries is known to be dominating the world fish production, however, it yields is gradually reducing as a result of climate change, overexploitation, illegal fishing and advancement in fishing gears. Aquaculture on the other hands is growing rapidly with about 5.8% annual growth rate during the period of 2001–2016 and presently contributing up to 47% of global fish production. This sector which has been termed a panacea for household food security, rural development, and poverty reduction in Africa, is no longer enjoying the high annual growth rates (average 8.8%) as occurred in the 1980s and 1990s [2]. Food security according to the United Nations' Committee, is defined that all people, at all times, have physical, social, and economic access to sufficient, safe, and nutritious food that meets their food preferences and dietary needs for an active and healthy life. (FAO, 2002). While Technology adoption is the successful integration of new technology into fisheries and aquaculture business. Also, it is the sociological model that describes the adoption or acceptance of a new product or innovation, according to the demographic and psychological characteristics of defined adopter groups. It is believed that technology developments have played an important role in the global aquaculture development and increase in productivity. Different initiatives have been directed at technological innovation and transfer in Africa, although, farmers' adoption level of these technologies is very low and thus make it incapacitated for transformational change predicted in the 2030 Agenda for sustainable development. Diverse technologies are expected to help in tackling the four dimensions of food security. Take for instance, genetic modification, methods for improving soil fertility, and irrigation technologies can boost food availability. Post-harvest and agro-processing technologies can address food accessibility, bio fortification can improve food nutrient level, while climate-smart solutions fasten in science, technology and innovation (STI) – such as the use of precision agriculture and early warning systems – can alleviate food instability. However, harnessing the potential of such technologies for food security requires investments in research and development, human capital, infrastructure and knowledge flows, to enable proper adoption [3].

New and existing technologies should be adopted to combat biotic and abiotic stresses, raise productivity, improve water availability, to increase food production. Storage, refrigeration, transport and agro-processing innovations can address the dimension of food accessibility. Science to produce high-nutrient staple crops can reduce malnutrition and improving food utilization and use [3]. Improved feeds are nutritionally balanced with protein contents of 28-35 percent. They are extruded to float and, thus, facilitate easy feeding and reduce feed wastages. Though, they are expensive, Engle and Neira explains that the use of improved feed technology results in cost-effective aquaculture ventures [4]. Amankwah recorded that the adoption of improved aquaculture technologies such as feed can be seen as a pathway to increasing productivity and improving the living conditions of smallholder households in Kenya, he reported further that it helps to increases farmers' income and reduces poverty among fish farming households. Obiero et al. reported that less than half of fish farmers in his study area in Kenya were categorized as high adopters of modern technologies, this shows that there are gaps in technical skills hampering adoption of innovative technologies that could leads to massive fish production [5, 6]. According to Nwachukwu and Onuegbu, less than fifty percent of the farmers adopted the aquaculture technology in Imo state, because of inadequate funds needed to maintain their small ponds and to purchase the necessary feed and other necessities for aquaculture Table 1 [7].

Table 1: Innovative technology for food security

Food security	Challenge	Examples of science technology and innovation
Food availability	Biotic stresses	Disease- resistant fish seeds, Pesticides and Herbicides
	Abiotic stresses	Climate-resistant seeds
	Improving fingerling productivity	Conventional breeding and advanced genetic engineering
	Improving livestock agriculture (in general)	Low-cost diagnostic toolkits for livestock veterinarians, tissue engineering for laboratory-grown animal products and low-cost veterinary pharmaceuticals (ideally thermostable)
	Lack of water availability	Water storage technologies (aquifers, ponds, tanks, low-cost plastic water tanks, natural wetlands, reservoirs), water lifting (hand-powered mechanical pumps, treadle pumps, solar power irrigation pumps, hydrogen-powered pumps, electric and fossil fuel pumps), rainwater harvesting mechanisms, wastewater reuse and portable sensors for groundwater detection
	Need for accurate integration, scheduling of inputs	Drones, internet and farm management software and applications
	Urban farming	Indoor farming, aquaponics and low-cost greenhouses
	Power and control-intensive operations	Tractors and robotic technologies
Food access	Post-harvest loss (storage, refrigeration, transport)	Efficient processing technology, nanotechnology, innovative packaging, cool stores, cleaning, grading, and packing technology, off-grid refrigeration, low-cost refrigerated vehicles and low-cost solar dryers, vacuum or hermetic sealing
	Need for harvest and agro-processing equipment	Agro-processing technologies (meat, dairy products, fish)
	Lack of information on healthy diets	Dissemination of nutrition information (e.g. health mobile applications)

Food stability	Inability to predict when and how to farm	Weather-forecasting technologies and hyperspectral imaging, based on drones and satellites
	Lack of financial mechanisms to ensure income	Index-based insurance

Source: UNCTAD, 2017

Status of Fish Production in Nigeria

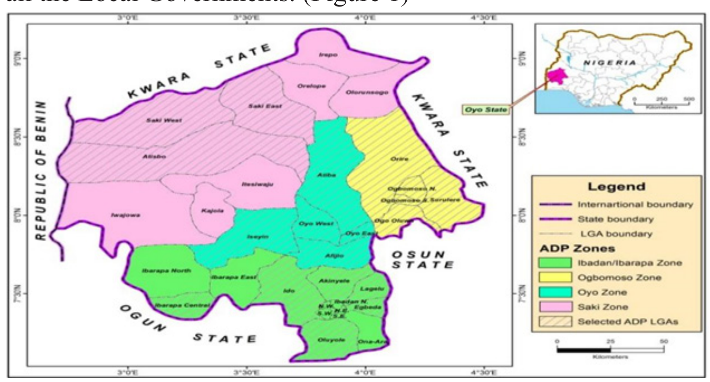
Nigeria is an important country in Africa with an estimated population of over 200 million, with a rapid development of peri-urban commercial aquaculture she has her aquaculture production grew from 20,458 tons in 1998 to 291,233 tons in 2018, because of her highest fish demand in Africa [8, 9]. Nigerian government is saddled with the responsibility of given a favourable business environment, while the entire aquaculture value chain expansion is determined by the private sector initiatives (FDF 2012). The nation has an enormous aquaculture potentials and development in freshwater aquaculture; she has a projected yearly fish demand of 3 million tons and local production of 1.1 million tons in 2017. Yet, there is thus a colossal gap of nearly 2 million tons of fish demand which is somewhat bridged by importation [10]. The demand-supply gap is due to some challenges such as expensive fish feed, unavailability of quality fish seeds from dependable hatcheries, inaccessibility of suitable land and inconsistency of quality water source, poor disease management, lack of favourable environment for fish production and marketing of aquaculture products [11]. Sustainability of food production requires technical innovation to attain maximum production. It is therefore necessary to ensure that modern technologies are properly and adequately adopted, to help mitigate the above challenges as a means of sustaining aquaculture for sufficient production.

The adoption literature recorded that traditionally, theories dealing with decision-making processes have highlighted the role of extrinsic variables grouped into three categories: characteristics of the farmer, characteristics of the external environment, and characteristics of the innovation [12]. A recent review by Kumar et al. who identified several factors driving aquaculture technology adoption to be: (i) farmers' socio-demographic (ii) farm characteristics, (iii) source of information, (iv) economic factors, and (v) characteristics of the technology [13]. However, there are still relatively few attempts to make predictions about adoption outcomes using these factors [14]. Additionally, only a few studies have analyzed the factors influencing fish farmer's perceptions, attitudes, and behavior [15, 16]. It is therefore necessary to do a deeper study of the factors influencing fish farmer's perceptions, attitudes, and behavior towards adoption of innovative technologies and the impact of adopted ones on production. This paper therefore aims to: (1) examine the factors that influence fish farmer's perceptions, and behaviors toward adoption of modern technology; and (2) to determine the perceived effect of adopted technologies on farmers' production and food security.

Methodology

Study Area

Oyo State, the study area is located in Southwestern Nigeria. It is one of the thirty-six states of the Federal Republic of Nigeria consisting of 33 Local Governments and 29 Local Council Development Areas with a population of 7,840,864. The topography of Oyo state is of gentle rolling low land with vegetative pattern of rainforest in the south and guinea savannah in the north with 28,454 km² in land area (OYSG, 2017). It is bounded in the South by Ogun State and North by Kwara State, while in the West by the Republic of Benin and East by Osun State (Figure. 1) with Latitude 8° 7' 10.4412" and Longitude 3° 25' 10.3908". The Climate is equatorial, notably with dry and wet seasons with relatively high humidity. The dry season lasts from November to March while the wet season starts from April and ends in October. An average daily temperature ranges between 25 °C and 35 °C, almost throughout the year. The annual rainfall varies from 1,200 mm at the onset of rainy season to 1,800 mm at its peak in the Southern part of the State with an average rainfall of between 800 mm and 1,500 mm at the northern parts of the State (Olagunju et al., 2007). The State is divided into four Agricultural Development Project (ADP) operational zones (Ibadan/Ibarapa, Ogbomoso, Oyo and Saki) covering all the Local Governments. (Figure 1)



Source: Geography Department, University of Ibadan

Figure 1: Map of Oyo State ADP showing zones and blocks

Sampling Procedure and Sample Size

A multi stage sampling technique was used to select respondents' base on ADP zoning. The stages are from State to ADP zones to blocks and to cells/circles. The four agricultural development zones from the Oyo State Agricultural Development Program namely: Ibadan Ibarapa, Ogbomoso, Oyo and Saki were chosen. Forty percent extension blocks from each of the four zones to give a total of 11 blocks were purposively selected for the study. The blocks selected were those with higher and active participation in fish farming. From each of the blocks, snowball approach was used to select 200 fish farming households throughout the four extension zones. Primary data was collected with the aid of well-structured questionnaires administered to a sample of 200 fish farmers while secondary data was obtained from the internet, textbooks journals etc. The questionnaire was used to obtain information on socio economic characteristics, level of adoption of technology in aquaculture, impact of the adopted technology and the constraints to adoption of the technology. Descriptive analysis (mean, frequency distribution, simple proportion and percentage) and inferential analysis (Chi square and Multiple linear regression Analysis) was used to analyze the result obtained.

Regression Model

The multiple linear regressions were used to explain the relationship between one continuous dependent variable and two or more independent variables. The independent variables can be continuous or categorical. Every value of the independent variable x is associated with a value of the dependent variable Y.

A multiple linear regression was used to analyse the relationship between the determinants of adoption of recommended aquaculture production technologies and socio economic characteristics of the respondents.

Given, $Y = \beta_0 + \beta_1 (X_1 + X_2 + X_3 + X_4 + X_5 + X_6 + X_7) + e_{it}$

Where:

Y = is the dependent variable.

X = are the explanatory / dependents variables.

β_0 = is the y-intercept (constant term).

β_1 = are the slope coefficients for each explanatory variable.

e_{it} = is the model's error term (also known as the residuals).

X_1 = Age (in years)

X_2 = Sex (Male=1, Female=0)

X_3 = Marital status (Married = Yes=1, others =No=0)

X_4 = Household size (Number).

X_5 = Level of education (Yes = 1, No =0)

X_6 = Fishing Experience (in years).

X_7 = Income (₦).

Result and Discussion

Introduction

The results of the analysis of the survey on "Technology adoption in Aquaculture Production in Oyo State" is as reported in Tables 2-10 and Figures 2-7.

Socio-Demographic Information of Respondents

Table 2 depicts the Socio-Demographic information of the respondents.

The result of the age distribution of the respondents shows that 12% of the respondents fall between the age group of 21-30 years, 27.5% between the age group of 31-40 years, 39.5% between 41-50 years' age group, 20% fall between the age group of 51-60 years while the remaining 1% fall above 60 years of age. The mean age of 43.6± 8.972 years show that majority of the fish farmers were in their middle or productive age. This is similar to the work done by Omitoyin and Oladeji [17]. The gender distribution of the respondents shows that eighty-eight percent (88%) of the respondents were male while 12% were female. Thus, there are more males than female respondents. The marital status of the respondents revealed that only 9% of the respondents were single, 90.5% married while 0.5% were separated / divorced. Marriage is seen as a symbol of responsibility and maturity which is held in high esteem in the study area. The Educational Status of the Respondents shows that 0.5% of the respondents have no formal education, 5.5% have primary education, 27% have secondary education and 67% have tertiary education which consist of those with Diploma (25.5%), HND (20%), B.Sc./B. A/B.Ed. (18%) and PG (3.5%). The level of literacy in the study area is high. The respondents are educated thus should be able to adopt new technology easily. The respondents have more of the nuclear family (78%) household type set up with only 29% from extended family. The household size of 4-6 members was the majority (61.5%) with mean household size of 6.05± 2.406. The result of the analysis on primary occupation of the respondents shows that about 36% of the respondents choose "civil servant" as their main primary occupation, followed by crop farming (24.5%), trading (18.5%) and then fish farming (13.5%) while the analysis on secondary occupation revealed that most (67%) of the respondents are involved in fish farming. The size of fish farm shows that 54.5% of the respondents have less than 0.5 hectares' size fish farm, 37.5% have between 0.5 – 1.0 hectares, 3.5% have between 1.0 – 3.0 hectares, 2.5% have between 3.0 – 5.0 hectares while only2% have more than 5.0 hectares of land. This show that majority of the fish farmers are small holders fish farmers.

Table 2: Distribution of the socio-economic characteristics of respondents

Variable	*Categories*	*Frequency (%)*	*Mean / Mode*	*SD*
Age (years)	21-30 years	24 (12.0%)		
	31-40 years	55 (27.5%)		
	41-50 years	79 (39.5%)		
	51-60 years	40 (20.0%)		
	Above 60 years	2 (1.0%)		
	Total	**200 (100.0%)**	43.6	8.972
Gender	Male	176 (88.0%)		
	Female	24 (12.0%)		
	Total	**200 (100.0%)**		
Marital Status	Single	18 (9.0%)		
	Married	181 (90.5%)		
	Divorced	1 (0.5%)		
	Total	**200 (100.0%)**		

Educational Status	No formal education	1 (0.5%)		
	Primary education	11 (5.5%)		
	Secondary education	54 (27.0%)		
	Diploma	51 (25.5%)		
	HND	40 (20.0%)		
	B.Sc / B.A / B.Ed	36 (18.0%)		
	PG			
	Tertiary	7 (3.5%)		
	67%			
	Total	**200 (100.0%)**		
Household Type	Nuclear Family	156 (78.0%)		
	Extended Family	44 (22.0%)		
	Total	**200 (100.0%)**		
Household Size	0-3	18 (9.0%)		
	4-6	123 (61.5%)		
	7-9	45 (22.5%)		
	10-12	9 (4.5%)		
	≥13	5 (2.5%)		
	Total	**200 (100.0%)**	6.05	2.406
Primary Occupation	Fish farming	27 (13.5%)		
	Civil Servant	72 (36.0%)		
	Trading	37 (18.5%)		
	Crop farming	49 (24.5%)		
	Animal husbandry	9 (4.5%)		
	Artisan	5 (2.5%)		
	Others	1 (0.5%)		
	Total	**200 (100.0%)**		
Secondary Occupation	Farming	36 (18.0%)		
	Fish farming	134 (67.0%)		
	Blacksmith	2 (1.0%)		
	Politician	2 (1.0%)		
	Trading	14 (7.0%)		
	Crop Farming	5 (2.5%)		
	Animal Husbandry	6 (3.0%)		
	Others	1 (0.5%)		
	Total	**200 (100.0%)**		
Size of Fish Farm	< 0.5 hectares	109 (54.5%)		
	0.5 – 1.0 hectares	75 (37.5%)		
	1.0 – 3.0 hectares	7 (3.5%)		
	3.0– 5.0 hectares	5 (2.5%)		
	>5.0 hectares	4 (2.0%)		
	Total	**200 (100.0%)**	<0.5 hec	0.839

Source: Field Survey, 2018

Form of Communication Technology

Table 3 shows the result of the form of communication technology used by the fish farmer with 99% of the respondents stating that they use one form of communication technology or another. About 18.7% of them use radio, 17.2% use television, 58.1% use phone with internet facilities, 0.5% use other form of communication technology like YouTub while 5.6% use a combination of all. Communication tools is important in promoting adoption of new technology. Ndeti et al, establish the effectiveness of Phone internet in reaching the fish farmers in Kenya [18].

Table 3: Use and forms of communication technology

Variable	*Do you use communication technology?*	*Yes*	*No*	*Total*
Form of communication technology used	Nil	0 (.0%)	2 (100.0%)	**2 (1.0%)**
	Radio	37 (18.7%)	0 (0.0%)	**37 (18.5%)**
	Television	34 (17.2%)	0 (0.0%)	**34 (17.0%)**
	Phone with internet facility	115 (58.1%)	0 (0.0%)	**115 (57.5%)**
	Others (YouTube)	1 (0.5%)	0 (0.0%)	**1 (0.5%)**
	All of the above	11 (5.6%)	0 (0.0%)	**11 (5.5%)**
	Total	198 (100.0%)	2 (100.0%)	**200 (100.0%)**

Source: Field Survey, 2018

Figure 2 shows the distribution of the respondents by their membership of social organization. It was observed that 74% were members of different social groups and organisations such as fish farmer's associations, cooperative society. This should enhance their ability to adopt new technology as information could be easily disseminated and technology demonstrated. Kulviwat et. al. 2007 concluded in their study that both social influence and adoption attitude have positive effects on consumer intention to adopt an innovation.

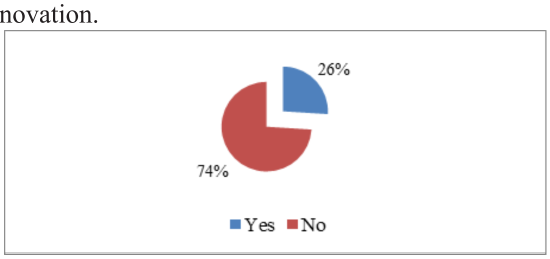


Figure 2: Diagrammatic representation of respondents who are members of any organization

Years of Fish Farming and Numbers of Ponds On Farm

In Table 4, the respondents experience in fish farming ranges from less than one-year experience to 20 years with a mean of 4.775± 3.542. Majority of the fish farmers are small scale holders with 24.5% owning one (1) while 48.0% own two (2) ponds. The remaining 27.5% was shared between those with three to twenty (20) ponds. The analysis of the source of fish stocked shows that 8.5% of the respondents sourced their fish seed from their own farm hatchery while 91.5% sourced their fish seed from other farm hatchery. The type of Cultured System used by the respondents revealed that 79.5% use "earthen ponds", 14.5% use "concrete tanks", 1.5% use "fiber glass tanks, 4% use "flow through system" and 0.5% use "collapsible tank.

Table 4: Distribution by fish farming years of experience, number of ponds owned, and type of cultured system used

Variable	*Categories*	*Frequency (Percentage)*	*Mean / Mode*	*SD*
How long have you been into fish farming?	<1	3 (1.5%)		
	1	1 (0.5%)		
	2	67 (33.5%)		
	3	31 (15.5%)		
	4	11 (5.5%)		
	5	28 (14.0%)		
	6	15 (7.5%)		
	7	6 (3.0%)		
	8	8 (4.0%)		
	10	19 (9.5%)		
	11	2 (1.0%)		
	12	5 (2.5%)		
	15	1 (0.5%)		
	20	3 (1.5%)		
	Total	**200 (100.0%)**	4.775	3.542
How many ponds are on your farm?	1	49(24.5%)		
	2	96 (48.0%)		
	3	19 (9.5%)		
	4	12 (6.0%)		
	5	12 (6.0%)		
	6	5 (2.5%)		
	8	4 (2.0%)		
	10	1 (0.5%)		
	20	2 (1.0%)		
	Total	**200 (100.0%)**		
What is the source of your fish stock?	From your farm hatchery	17 (8.5%)		
	Other farms hatchery	180 (90.0%)		
	Total	**197 (98.5%)**		
What type of culture system do you use?	Earthen Pond	159 (79.5%)		
	Concrete Tanks	29 (14.5%)		
	Fiber glass tanks	3 (1.5%)		
	Flow through system	8 (4.0%)		
	Collapsible Tank	1 (0.5%)		
	Total	**200 (100.0%)**		

Source: Field Survey, 2018

From Figures 3, 4 and 5 the result of the survey reveals that 90.5% (181) of the respondents have received information on aquaculture technology, with the universities (46.1%) and Research Institute (35.9%) leading the trail. Also, 81% of the respondents are aware and have information on the different technologies from these organizations. Figure 6 shows that three fish species are basically cultured in the study area with catfish taking the lead followed by Tilapia and then Heterolalias. Most of the farmers in Tilapia fish farming culture mainly all male or GIFT Tilapia which are products of adopted technology so as to get very good growth rate. The frequency at which water quality check was carried out is presented in Figure 7 with 35.5% checking their water quality every two weeks, 32% once in production cycle, 18% monthly and 14.5% weekly. The major water quality parameters include: Dissolve Ox ygen, temperature, pH, Ammonia, Nitrite and Nitrate. This technology if properly harnessed will minimize disease outbreak and increase fish production Table 5.

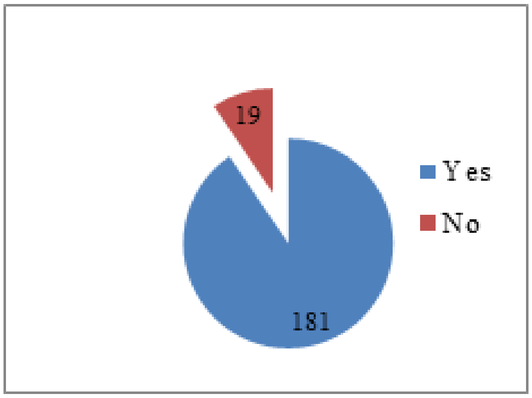


Figure 3: Number that Received Information on Aquaculture Technology

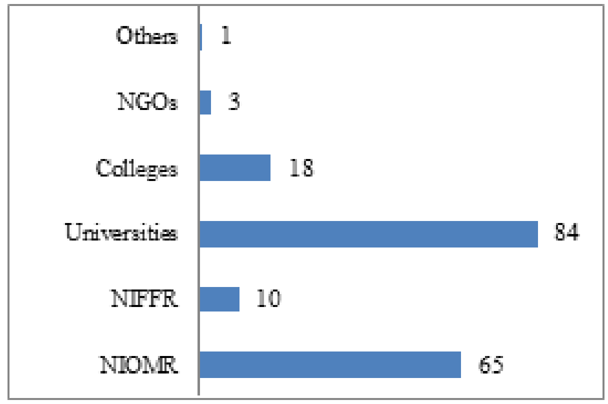


Figure 4: Forms of Research Organization

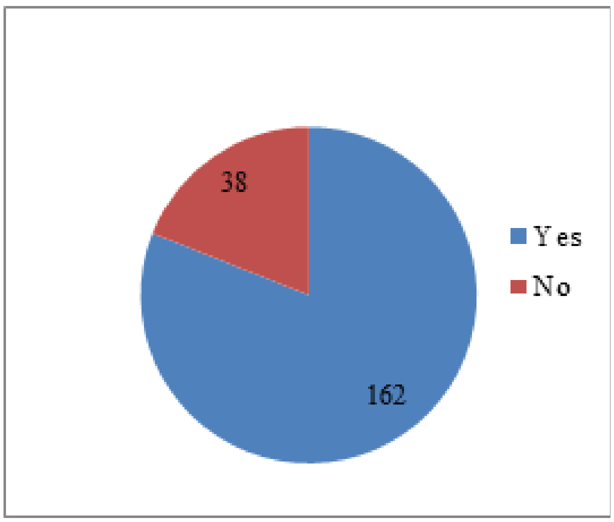


Figure 5: Information on technologies from any of these research organizations

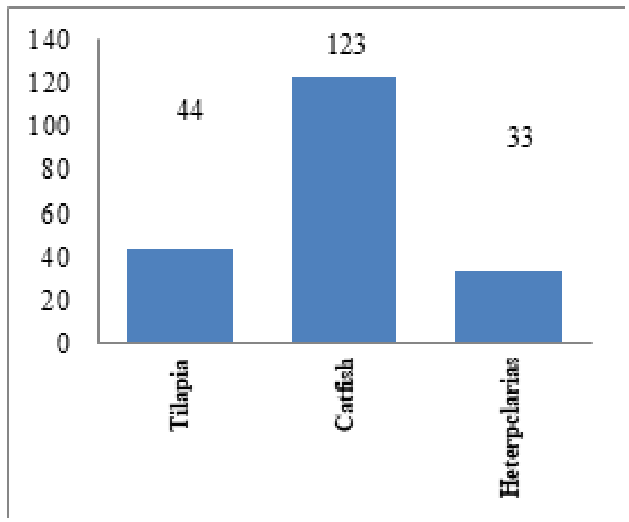


Figure 6: Fish species cultured by fish farmers

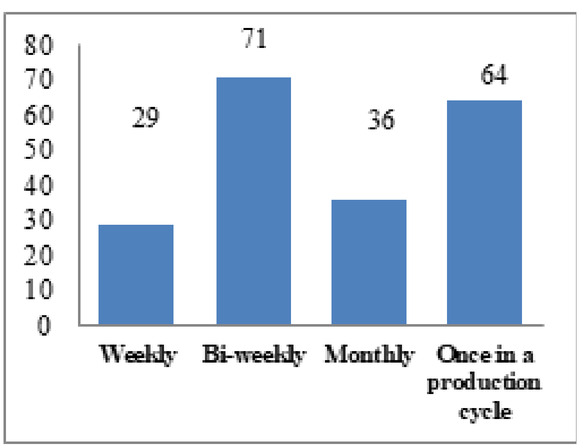


Figure 7: Water Quality check

Table 5: Technology considered in this manuscript

		Technology Developed
i	Biotechnology	a) Cryopreservation (milt preservation), b) Sex reversal c) Ablation (surgical removal)
ii	Culture facilities	a) Earthen pond, b) Concrete tanks, c) Hapa net, d) Tarpuline, e) Re-circulatory system , f)Fiber glass tank
iii	Fish feed production	a)Live feed , b) Pelletized feed, c) Extruded feed
iv	Pond preparation	a) Pond liming: i. Wood ash, ii. Lime, iii. Salt b) Pond fertilization: i. Poultry dropping, ii. Cow dung, iii, Pig dung
v	Cultured method	a) Monoculture, b) Polyculture, c) Integrated
vi	Genetically modified fish Species of fish cultured	a) Pure Clarias , b) All male Tilapia, c) Heteroclarias
vii	Harvesting techniques	a) Total harvesting ,b) Partial harvesting (cropping)
viii	Gear technology	a) Active gears: i.Drag net, ii. Basket/ hand picking b) Passive gears: i. Trap, ii. Hook and line
ix	Water quality parameters	a)Dissolved oxygen, b) Temperature, c)Turbidity, d) pH
x	Feeding method	a)Automatic feeder, b) Demand feeder c)Spot feeding , d)Broadcasting method
xi	Value addition	a) Freezing, b) Smoking, c) Filleting, d) Gutting
xii	Marketing strategy	a) Advertisement, b) Social media, c) Sales outlet d) Home delivery
xiii	Disease prevention and control	a) Stocking density b)Stocking rate c) Biosecurity measure d)Water reuse

Table 6 depicts the adoption of the technology deployed. For the adoption of the bio-technologies by the fish farmers, the result shows that 51.5% of the fish farmers adopted "ablation", 59.5% adopted "cryopreservation while 34% adopted sex reversal method. On the other hand, 84.5% of these fish farmers agreed that these bio-technologies have improved their yields. The respondents' views on the different cultured method adopted confirmed that 91% of the respondents adopted monoculture technique, 52% adopted polyculture while 47% adopted integrated cultured method.

The respondents' opinion on the form of technology adopted from pond preparation show that 73.5% adopted wood ash, 92% adopted lime, 78% adopted salt pond liming method. For pond fertilization, 85% adopted poultry dropping, 62% adopted cow dung and 48% adopted pig dung. Also, 98% of the respondents agreed that the pond preparation technique have improved their production. The result is similar to the findings of Nwachukwu and Onuegbu (2007) who observed that less than half of the respondents adopted the technology in there study on the Adoption of Aquaculture Technology by Fish Farmers in Imo State of Nigeria. Also, Ogunremi and Oladele, (2012) in their study in Lagos State observed that fish farmers adopted mainly three aquaculture technologies out of nine introduced by extension agents

Table 6: Response on Technology Adoption

	Marketing strategy	Adopted (not improve the production)	Adopted (need more information)	Adopted (it improved the production)	Not adopted	Not adopted (need more information)
1	**Biotechnology**					
	Ablation (surgical operation)	14(7.0%)	32(16.0%)	57(28.5%)	80(40.0%)	17(8.5%)
	Cryopreservation (milt preservation)	6(3.0%)	30(15.0%)	83(41.5%)	70(35.0%)	11(3.5%)
	Sex reversal	9(4.5%)	20(10.0%)	39(19.5%)	92(46.0%)	40(20.0%)
2	**Culture method**					
	Monoculture	13(6.5%)	38(19.0%)	131(65.5%)	18(9.0%)	0(0.0%)
	Polyculture	13(6.5%)	32(16.0%)	59(29.5%)	77(38.5%)	19(9.5%)
	Integrated	11(5.5%)	38(19.0%)	45(22.5%)	71(35.5%)	35(17.5%)

3	**Pond preparation**					
	Pond liming a)Wood ash b)Lime c)Salt	 18(9.0%) 13(6.5%) 14(7.0%)	 60(30.0%) 55(27.5%) 53(26.5%)	 69(34.5%) 118(59.0%) 89(44.5%)	 45(22.5%) 11(6.5%) 39(19.5%)	 8(4.0%) 3(1.5%) 5(2.5%)
	Pond fertilization a)Poultry droppings b)Cow dung c) Pig dung	 5(2.5%) 7(3.5%) 11(5.5%)	 50(25.0%) 40(20.0%) 48(24.0%)	 115(57.5%) 77(38.5%) 37(18.5%)	 27(13.5%) 67(33.5%) 84(42.0%)	 3(1.5%) 9(4.5%) 20(10.0%)
4	**Culture facilities**					
	Earthen pond	9(4.5%)	29(14.5%)	144(72.0%)	18(9.0%)	0(0.0%)
	Concrete tanks	9(4.5%)	36(18.0%)	78(39.0%)	71(35.5%)	6(3.0%)
	Hapa net	2(1.0%)	34(17.0%)	31(15.5%)	101(50.5%)	32(16.0%)
	Recirculatory system	3(1.5%)	28(14.0%)	32(16.0%)	91(45.5%)	46(23.0%)
	Tarpaulin	3(1.5%)	27(13.5%)	28(14.0%)	92(46.0%)	50(25.0%)
	Fiber glass tank	4 (2.0%)	26(13.0%)	20(10.0%)	96(48.0%)	54(28.0%)
	Flow through system	3 (1.5%)	31(15.5%)	29(14.5%)	89(44.5%)	48(24.0%)
5	**Fish feed production**					
	Live food	4(2.0%)	29(14.5%)	99(49.5%)	60(30.0%)	8(4.0%)
	Pelletized feed	2(1.0%)	23(11.5%)	160(80.0%)	14(7.0%)	1(0.5%)
	Extruded feed	1(0.5%)	26(13.0%)	65(32.5%)	78(39.0%)	30(15.0%)
6	**Gear technology**					
	Active a)Drag net	5(2.5%)	24(12.0%)	150(75.0%)	18(9.0%)	3(1.5%)
	b)Basket/ hand picking	7(3.5%)	28(14.0%)	87(43.5%)	59(29.5%)	19(9.5%)
7	**Feeding method**					
	Automatic feeder	3(1.5%)	15(7.5%)	24(12.0%)	128(64.0%)	30(15.0%)
	Demand feeder	2(1.0%)	10(5.0%)	46(23.0%)	101(50.5%)	41(20.5%)
	Spot feeding	1(0.5%)	23(11.5%)	95(47.5%)	65(32.5%)	16(8.0%)
	Broadcasting method	7(3.5%)	22(11.0%)	137(68.5%)	33(16.5%)	1(0.5%)
8	**Value Addition Technologies**					
	Freezing	12(6.0%)	13 6.5%)	52(26.0%)	104(52.0%)	19(9.6%)
	Gutting	10)(5.0%)	9(4.5%)	47(23.5%)	110(55.0%)	24(12.0%)
	Filleting	7(3.5%)	19(9.5%)	32(16.0%)	98(49.0%)	44(22.0%)
	Smoking	11(5.5%)	10(5.0%)	152(76.0%)	27(13.5%)	0(0.0%)
9	**Marketing strategy**					
	Advertisement	13(6.5%)	16(8.0%)	70(35.0%)	84(42.0%)	17(8.5%)
	Home delivery	12(6.0%)	16(8.0%)	76(38.0%)	69(34.5%)	27(13.5%)
	Social media	10(5.0%)	14(7.0%)	71(35.5%)	72(36.0%)	33(15.5%)
	Sales outlet	12(6.0%)	19(9.5%)	137(68.5%)	31(15.5%)	1(0.5%)
	Interpersonal marketing	14(7.0%)	17(8.5%)	83(41.5%)	72(36.0%)	14(7.0%)
10	**Disease control/ prevention**					
	Stocking density	5(2.5%)	24(12.0%)	150(75.0%)	18(9.0%)	3(1.5%)
	Stocking rate	11(5.5%)	10(5.0%)	152(76.0%)	27(13.5%)	0(0.0%)
	Biosecurity measure	10(5.0%)	14(7.0%)	71(35.5%)	72(36%)	33(15.5%)
	Water reuse	1(0.5%)	23(11.5%)	95(47.5%)	65(32.5%)	16(8.0%)

Source: Field Survey, 2018

Technology Adoption on Fish Production

Table 7 shows the perceived impact of technology adoption on production. It was observed that the respondents affirmed that technology adoption had positive impact on their fish production. In all the technology examined, more than 75% of the fish farmers confirmed that all the technology in view improved their production. This is similar to the accretion of Kasirye, that adopters of improved technologies increase their productions, leading to constant socio-economic development [20]. Adoption of improved agricultural technologies has been associated with: higher earnings and lower poverty; improved nutritional status; lower staple food prices; increased employment opportunities as well as earnings for landless laborers. It was also reported that adoption of improved technologies is believed to be a major factor in the success of the green revolution experienced by Asian countries [20, 21]. Also Kumar *et al*, affirmed that Technology adoption has played a key role in the global development and increase in agricultural productivity but not all technologies have been adopted readily by farmers [13].

Table 7: Impact of Technology Adoption on Fish Production

	Does the adoption of the following have impact on fish production	**Yes**	**No**
1	Biotechnology (improves yield)	169 (84.5%)	31(15.5%)
2	Culture facilities (improves production)	197 (98.5%)	3 (1.5%)
3	Fish feed production (improved feed quality, growth and development of fish)	183(91.5%)	17 (8.5%)
4	Pond preparation (improves production)	196(98)	4 (2%)
5	Cultured method	182(91%)	18(9%)
6	Species of fish cultured	156(78%)	44 (22%)
7	Harvesting techniques **reduces stress of harvesting and improve your catch**	150 (75)	50(25)
8	Gear technology (reduces stress of harvesting)	194 (97%)	6 (3%)
9	Water quality parameters (improves growth and yield)	151 (75.5%)	49 (24.5%)
10	Disease prevention (reduce disease outbreak)	197 (98.5%)	3 (1.5%)
11	Feeding method (reduce feed wastage)	195 (97.5%)	5 (2.5%)
12	Value addition (improves taste, palatability & shelf life)	196 (98%)	4 (2%)
13	Marketing strategy (increase sales and profit)	196 (98%)	4(2%)

Source: Field Survey, 2018

Factors Limiting Technology Adoption

This section presents the different factors limiting Technology adoption in Oyo State, Nigeria. Based on their level of importance, the respondents have identified "high cost of acquisition" as a major limiting factor to Technology adoption with mean value of 2.850 followed by "poor access to capital" with mean value of 2.825. However, the least problem is the lack of source of good information. This follows the assertion of Kumar et al, 2018 who concluded that Fish farmers tend to adopt technologies that are perceived to be more advantageous than others in terms of productivity, cost efficiency, and ease of management. Price of aquaculture products and profit expectations from business ventures were key economic factors in influencing adoption decisions. Also Betanzo-Torres et al, observed that the main obstacles in the use of biofloc technology (BFT) are due to the following: low academic level, limited administrative capacity, scarce technological equipment in facilities, diversified productive activity, and obsolete regulations while Jaji et al, observed in their study among fish farmers in Lagos State that the low level of adoption was attributed to the complexity and cost of the technologies, low extension contacts, level of education, age, income and farm size all of which influenced the adoption of aquaculture technologies Table 8 Figure 8 [22, 23].

Table 8: Factors limiting Technology adoption

Factors limiting Technology Adoption	Less Important	Important	More Important	Most Important	Total	Mean
Lack of technical man power	54(27.0%)	25(12.5%)	54(27.0%)	67(33.5%)	200(100.0%)	2.670
Poor access to capital	22(11.0%)	48(24.0%)	73(36.5%)	57(28.5%)	200(100.0%)	2.825
Access to information	24(12.0%)	61(30.5%)	73(36.5%)	42(21.0%)	200(100.0%)	2.665
High cost of acquisition	20(10.0%)	41(21.5%)	88(44.0%)	51(25.5%)	200(100.0)	2.850
Lack of technical knowhow/ expertise	31(15.5%)	53(26.5%)	60(30.0%)	56(28.0%)	200(100.0%)	2.705
Uncertainty/fear of unknown	29(14.5%)	57(28.5%)	81(40.5%)	33(16.5%)	200(100.0%)	2.590
Lack of source of good information	43(21.5%)	52(26.0%)	75(37.5%)	30(15.0%)	200(100.0%)	2.460
Improper demonstration of aquaculture technology	22(11.0%)	51(25.5%)	77(38.5%)	50(25.0%)	200(100.0%)	2.775
Non conformity with convectional practices	30(15.0%)	62(31.0%)	71(35.5%)	37(18.5%)	200(100.0%)	2.575
Non availability of inputs required for the technology	22(11.0%)	51(25.5%)	77(38.5%)	50(25.0%)	200(100.0%)	2.775
Improper handling techniques	30(15.0%)	40(20.0%)	83(41.5%)	47(23.5%)	200(100.0%)	2.735
Others (Culture)	26(13.0%)	59(29.5%)	78(39.0%)	37(18.5%)	200 100.0%)	2.630

Source: Field Survey, 2018

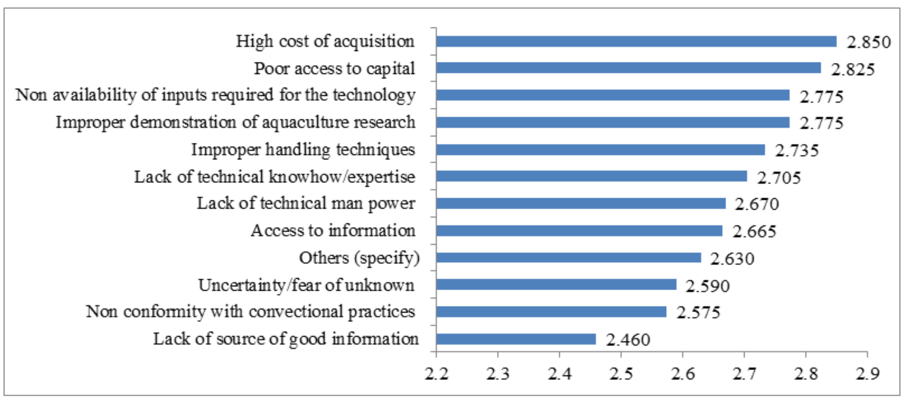


Figure 8: Factors limiting Technology adoption

Hypothesis Testing

This section shows the relationship between some of the independent variables and dependent variable

Ho1: There is no significant association between socio-economic characteristics of the fish farmers and adoption of recommended aquaculture production technology

Table 9 presents the analysis of whether the socio-economic characteristics of the respondents are significantly related to adoption of recommended aquaculture production technologies. The independent variables considered were: sex, educational level, marital status and occupation which was tested with Chi-squared Analysis. The result shows that there is a significant association between adoption of recommended aquaculture production technologies and educational level (X^2 = 16.12, $p<0.05$), marital status (X^2 = 15.94, $p<0.05$) and occupation (X^2 = 13.12, $p<0.05$). However, there is no significant association between sex of the respondents and adoption of technology (X^2 = 0.56, $p>0.05$).

Table 9: Chi-Square Analysis of Respondents' Socio-economic characteristics and adoption of recommended aquaculture production technology

Variables	X^2	Df	Probability value	Decision
Sex	0.561	1	0.454	NS
Educational level	16.120***	6	0.013	S
Marital Status	15.937***	2	0.000	S
Occupation	13.117**	6	0.041	S

Source: Field Survey, 2018

Note: X^2 = chi-squared calculated value; df = degree of freedom; S = significant; NS = Not Significant

Determinants of the Adoption of Innovation

The Multi Linear Regression model was employed to examine the determinants of adoption of recommended aquaculture production technologies among the respondents in the study area (depicted in Table 10). The result shows that the coefficients of age, educational status, fishing experience and income are positive and statistically significant for the fish farmers. This means that these variables are the determinants of adoption of innovation. However, sex, marital status and household size were not significant.

Table 10: Regression Result of the determinants of adoption of innovation in aquaculture among fish farmers

Variable	Coefficient	Standard Error	t-Test	Probability value
Constant	-0.083	0.611	-0.136	0.892
Age (X_1)	0.036***	0.011	3.371	0.001
Gender (X_2)	-0.279	0.197	-1.418	0.158
Marital status (X_3)	0.165	0.250	0.661	0.510
Educational Status (X_4)	0.189***	0.052	3.633	0.000
Household Size (X_5)	-0.014	0.031	-0.462	0.644
Fish farming Experience (X_6)	0.068***	0.022	3.143	0.002
Income (X_7)	5.688***	0.000	3.408	0.001
R	**0.533**			
R-Squared	**0.284**			
F-Statistics (Prob. Value)	**10.899 (0.000)**			

Source: Field Survey, 2018
"*", "**" and "*" represent significance at 1%, 5% and 10% respectively**

Thus, household with formal education, higher fish farming experience and good income are more likely to adopt the recommended aquaculture production technologies than those with no formal education and less fish farming experience. This is because education, experience and availability of income enhance the potential of respondents and makes them grab available opportunities with little or no stress. This finding is similar to the observation of Kapanda et al, in their work in [24]. Malawi who found a significant positive relationship between age of the household and the probability of adoption of fish farming (p<0.10) and Kamar et al, 2018 who grouped these factors into five broad categories in no particular rank order: (1) source of information, (2) characteristics of the technology, (3) economic factors, (4) farm characteristics, and (5) socio demographic and institutional factors [13, 25-28].

Conclusion

To facilitate uptake of technologies and good practices by fish farmers, affordable, home grown technology which is readily available and accessible should be given a priority while access to capital should be facilitated. Gaps in technical skills hindering adoption of innovative technologies and best management practices should be reduced to the minimum while a range of aquaculture-related extension and communication materials, including posters, short video presentations, and radio features, should be commissioned to support the smallholder farmers.

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