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Perception and uptake of aquaculture technologies in Kogi state, central Nigeria: imperative for Improved Management practices for sustainable aquaculture development

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The drivers of perception and adoption of aquaculture innovations were studied. Data obtained from 300 aquaculture operators, were analyzed using Heckman Probit sample selection model. Results revealed that perception and adoption of aquaculture innovations were high. Education (a=0.281), extension contact (a=0.149), experience (a=0.021), gender (a=0.440) and information source (a=0.145) increased the likelihood of positive perception of innovations, while age (a=-0.456), primary occupation (a=-1.54) and distance to urban center (a=-0.55) were negatively signed. Technical know-how (b=0.116), "other income" (b=1.17-e06), education (b=0.115) and gender (b=0.11) were drivers of adoption. Access to credit (b=-0.074), age (b=-0.095), pond size (b=-0.094) and Information source (b=-0.05) were negatively related to adoption. Adoption of innovation will rely on policies involving on these relationships. In doing these, attention should be paid to variables with conflicting influences on perception and adoption. Electronic sources may be employed in introducing an innovation, followed by personal contacts with experienced fish farmers. Furthermore, assisting fish farmers to increase incomes from other sources might be a better funding alternative for innovation adoption than credit. Provision of practically oriented education will elicit adoption. Provision of productive resources and reduced domestic burdens on female folks will increase their likelihood of innovation perception and adoption.

Key words: Drivers, perception, adoption, aquaculture, innovation, Heckman Probit.

INTRODUCTION

World apparent yearly fish per capita consumption increased steadily from 9.9 kg in the 1960s to 16.4 kg in 2005 (FAO, 2008). Recent data from FAO (2018) show that from 2011 to 2016, the figure had increased from 18.5 to 20.3 kg. The Nigerian per capita fish consumption has remained far below the world average. Per capita fish consumption in Nigeria declined from 13 kg per capita in the 1980s through 9.68 kg in 2007 to about 8 kg in 2009

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(Amire, 2010), before increasing to 11.0 kg in 2016. Data from Central Bank of Nigeria indicate that Nigeria's Annual fish production from 1960 to 2016 was at an average of 3.6 kg per capita. In contrast, global production of fish has stabilized at an average of 9.0 to 10 kg of fish per capita for 5 decades (FAO, 2001). According to FAO records, between 2011 and 2016, world per capita production rose from 22 to 24 kg. Nigeria's per capita production for the same period staggered between 5.3 and 6.1 kg.

Nigerian consumption of this commodity continues to remain at levels below production fueling huge loss of foreign exchange. In 2016 only 30% of her demand of 2.7 mmt was met by local production. Part of balance was imported at an estimated cost of 125 billion naira (408,496,732 USD). This is in contrast to some other African countries like Cote-d'voire, Ghana and Egypt that produce 33, 50 and 70.8% of their demand (Proshare, 2016, World fish center, 2016). Table 1 shows that Nigeria trails some selected countries in per capita consumption of fish.

While world per capita aquaculture production trended progressively from about 9 to about 11 kg between 2011 and 2016, Nigeria's per capita aquaculture production remained below 2 kg during the same period (FAO, 2018). In addition to low level of consumption, and loss of foreign exchange (which negatively impacts development in other sectors), low production level have also constrained the ability of the sector to generate income through the marketing chains. To elicit development, fish production has to greatly improve. Improvement in fish production is also necessary to guarantee future supply of animal protein.

According to USAID SPARE (undated), the estimated increase in world consumption of fish from 2017 to 2030, implies that the world will need 1500 to 160 million tons of aquatic food. Of this, the capacity of capture aquatic food is limited to 100 million tons, in which case aquaculture will need to provide a good portion of the supply. This is especially as livestock production as well as capture fisheries systems are reaching their productive limits (USAID SPARE, undated). Thus aside its role in making up for the inability of the capture fish, aquaculture will have to assume a prominent role as animal protein source. This role is enlivened by the advantage it enjoys over capture fish and livestock. For instance, Aquaculture is relatively more efficient mass producer of animal proteins than an array of animal protein sources (Costa-Pierce, 2002). For example, production efficiencies of edible mass for aquaculture range from 2.5 to 4.5 kg dry feed/kg edible mass compared with 3.0 to 17.4 kg for conventional terrestrial animal production systems (USAID SPARE, undated).

In Nigeria, the role of aquaculture as key supplier of fish is gradually becoming prominent as the capture fish has also been declining. Data on Nigerian fish production indicate that the aquaculture sector had steeper slope. Evident from the data also is the fact that total supply, which had overlapped with capture fish supply all along – up till the late 1990s, (owing to the negligible contribution of aquaculture) had begun to deviate from capture fishery owing to increased contribution from aquaculture. Consequently, the gap between capture fish and aquaculture supplies is being bridged. Point is, in recent times, aquaculture has begun to assume a prominent role.

Per capita Aquaculture production in Nigeria has been trending positively since 1960 at an average of 6.1%. Aquaculture contribution to total fish supply, though on the increase as well, has been low, providing only about 12.56% on the average with capture fish accounting for the bulk of fish protein supply**.** In the last 2 decades, aquaculture has accounted for up to 18.1% of total fish production in the country. More recent data from FAO, CBN and NBS show that between 2011 and 2015, contribution from aquaculture averaged 28.2%. This is an improvement from the contribution of 4.8% between 1960 and 2007. This recent improvement owes much to the support provided for aquaculture by the recent civilian administrations. The increased production may also have stemmed from supply responses to increased economic growth under these administrations (Onuche et al., 2015a). Within the last few years however, the steady growth enjoyed under the last 20 years has been waning. In fact by 2016, a negative growth rate had been recorded after the subsector experienced a decline from 317mmt in 2015 to 307 mmt (FAO, 2018). This follows from the recession in the economy, beginning 2016. Generally however, aquaculture holds great promise.

The potentiality of this subsector however needs focused policy attention to achieve sustainability in production. FAO (2018) data indicate that despite recording a generally encouraging growth and outperforming artisanal fisheries in terms of growth rate in recent years; its growth rate has declined. Conscious sustained efforts are therefore required to enable it provide the bulk of fish supply in the future. Such efforts will have to rely on sustained production and cost efficiency (Ekunwe and Emokaro, 2009; Ogundari, 2008; Awoyemi and Adekanye, 2005). But to attain increased efficiency levels in production and costs, improved production techniques and materials are important.

Nigeria's aquaculture resources are enormous and can provide up to 2.5 mmt (FAO, 2006, Federal Department of fisheries (FDF), 2008), that is, about 93% of Nigeria's 2016 fish needs. But capacity utilization has been very poor, providing only 28% of total supply in recent time; although, second to Egypt in Africa, Nigeria's production (based on 2016 estimate) of 307 mmt is about just 22.4% of Egypt's 1371 mmt.

Aquaculture in Nigeria is basically small scaled-ranging from homestead concrete ponds of 25 to 40 m^2 to small earthen ponds of 0.02 to 0.2 ha (FAO**,** 2005). Compared to southern Nigeria, the volume of fish farming

Table 1. Per capita fish consumption in selected countries.

Country	Per capita consumption (kg)	Year of estimate
China	48.3	2016
Europe	27.0	2016
Korea	78.5	2016
Nigeria	11.0	2016
Malaysia	58.6	2016
Egypt	23.5	2014
Cote d'voire	13.5	2016

Source: Authors' compilation from miscellaneous data sources.

in central and northern Nigeria is low. Fish farming in Kogi state is particularly nascent. Aquaculture in the state is basically on a homestead mono culture basis, except for a handful of commercial fish farms. Production takes place 2 to 3 times yearly and it is characterized by high production cost and low profit (Ogbe et al., 2018). According to FAO (2007), a 2004 data indicated that Kogi state had 32 (1.2% of the number of) fish farms across Nigeria. Edo state in the south had as high as 420 fish farms while Borno state in the north had just two. Fingerlings are sometimes sourced from the wild while feeds are most locally sources although foreign feeds are more reliable. Technological investment in the subsector (except for a few farms) is thus generally poor. Farmed fish species in Nigeria at present include, Catfish, Tilapia and Carp. Prominent among these three is Catfish (*Clarias gariepinus* or *Heterobrancus longifilis*) due to its higher market value which is two to three times that of tilapia (Olagunju et al., 2007). Faster growth rate, adaptability to changes in production conditions and its wide acceptance are other reasons why catfish production has received the most attention. While growth in the subsector has been generally heartwarming in the last 2 decades (albeit with some discouraging trend in recent times), the gap needed to be covered by aquaculture remains enormous. Reducing this gap has to be through conscious proactive policy formulation and implementation investment in the subsector. These investments have to be made in the areas of technologies and techniques. Proven innovations exist across the globe but the level of investment in adoption in Nigeria leaves much to be desired. Poor management practices leading to technical inefficiency identified for crop agriculture (Kolawole and Ojo, 2007, Ogundari, 2008; Iheke and Nwaru, 2015) also persist in aquaculture (Tsue, 2010; Ekunwe and Emokaro, 2009). The level of technology in the production process has remained the bane of the Nigerian agricultural sector, aquaculture inclusive. This is has constrained the sustainability of aquaculture (Ogbe et al., 2018).

Sustainable aquaculture production will guarantee food sufficiency, provide employment opportunities and reduce the pressure of on our foreign reserves. Hence, there is the need to develop the subsector. Efforts to boost production in the past have been basically focused on provision of equipment, materials and credit. These have not elicited much result. Sustainable aquaculture will have to be built on an improved management and application of improved technologies. But how do aquaculture practitioners perceive and adopt improved management skills and technology? To adopt a technology, a farmer needs to have perceived the innovation, that is, perception precedes uptake of innovation (Asrat and Simane, 2018) based on a need to be met (Damanpour and Schneider, 2006), e.g. a better alternative. And if a farmer knows that an innovation is more profitable than the current alternative, he makes effort to adopt it. Adopting innovations is also dependent on some socio-cultural factors (Asrat and Simane, 2018). For instance, a positive response, of increased production may be intended but could be hampered by lack of resources (Muchapondwa, 2009, Onuche et al., 2015a). In fact, Alomia-Himojosa et al. (2018) reported that adoption decisions in Nepal were hampered by labour scarcity, cultural preferences and poor access to inputs.

Adoption could be planned (where government policies and programmes push for implementing a project) or autonomous (at individual small scale level). Country wise agricultural adoption has not been successful in the Nigerian agriculture. This is largely because the Macro-Meso-Micro agricultural economic framework is not completely unified (Akinyosoye, 2005). Although these tiers have similar aspirations in agricultural development, the federal, States and local governments are not in concert as regards approaches to agricultural development. Hence, innovation adoption has been largely limited to the autonomous domain.

Individual farm level autonomous adoption of innovation requires the succinct understanding of the drivers of innovation adoption. This will help engender sustainable and productive policy targets. As Asrat and Simane noted in 2018, an empirical understanding of the perception and adoption of new techniques in aquaculture, and their determinants provides clear information and hence, better insight into how policies can be adjusted to help address the challenges of sustainable development (Boston University, 2018). Furthermore, acquaintances with elements of innovation adoption will scale up developmental process (Mottaleb, 2018) since this will lead to improved uptake of other innovations (Wisdom et al., 2014). The understanding of the drivers of adoption will provide encouragement for innovators and further engender development.

Certain low level improved technologies have been introduced in Nigerian aquaculture subsector in the past few years. These include fingerlings from certified hatcheries as against fingerlings in the wild, pelleted floating feed as against unpelleted and pelleted sinking feed, use of drugs/chemicals in fish ponds to reduce pollution and use of mobile ponds. Fingerlings from certified Hatcheries have advantages of higher growth rate and productivity over fingerling sourced in the wild. Similarly, floating pelleted feeds enjoy the advantage of eliciting low level of pollution as the level of non-floating feeds are usually visible, allowing the farmer to adjust the feeding frequency. Finally, the use of some drugs (antibiotics) has been shown to reduce the level of water pollution, thereby reducing the frequency and, in essence, the cost of changing water. The fourth is mobile ponds which has the advantage of flexibility in location. These innovations are cost saving and production increasing measures. They are usually disseminated through personal contacts and a skeletal extension delivery system. They are also cheaper and easy to adopt relative to other innovations. We concentrate on these cheap, easy-to-use and easy-to-adopt technologies since the area is resource poor (Kogi state is one of the poorest state of the federation and is plagued perennial issue of nonpayment of staff salaries) and aquaculture is an up an coming venture there. Other (more expensive/more technical) innovations relevant to fish farming include: Automated feeders, Aquaponics (a combination of aquaculture and hydroponic), water re-circulatory system, aeration and cage culture.

Works on adoption in agriculture have shown various drivers of adoption. Wandji et al. (2012) applied univariate dichotomous Logit to data on farmers' perception and adoption of new aquaculture technologies in the west high lands of Cameroon. Ainembabazi (2014) investigated the role of farming experience on the adoption of agricultural technologies by small holder farmers in Uganda. Mudombi (2015) investigated the adoption of improved sweet potato in Wedza community of Zimbabwe while Alomia-Hinojosa et al. (2018) explored farmer perceptions of agricultural innovations for maize legume intensification in Nepal. Deresa et al. (2011) have also studied the perception of and adoption to climate change by farmers in the Nile basin of Ethiopia. Guteta and Abegaz (2015) studied factors influencing on scaling up of agro forestry based spatial land use integration for soil fertility management in southwestern Ethiopia. Asrat and Simane (2018) investigated the perception of climate change and adaption strategies in dry lowland and wet lowland areas of Dabus watershed of North-West Ethiopia, using the Heckman sample selection model.

Empirical reports from primary efficiency studies have relayed the management level of aquaculture in the country and the attendant impact on production. These studies have not treated how aquaculture practitioners perceive and adopt innovations. This study focused on the perception and adoption of innovation by aquaculture practitioners in Kogi State, Central Nigeria. The following questions guided the study: How do aquaculture practitioners perceive new technologies and management skills? What is the level of uptake of these innovations? And what factors influence their perceptions and uptake? Thus the objectives of the study were to: (1) analyse the perception and adoption of the innovations and (2) determine the drivers of perception and uptake of the innovations in Kogi State.

MATERIALS AND METHODS

Study area

Kogi State lies between latitude 6°30'N and 8°48'N and line of longitude 5°23'E and 7°48'E in central Nigeria (Figure 1). It consists of twenty one government areas. Kogi state consists of a timbered grassland region bisected by the southward-flowing Niger River. The confluence of Benue and Niger is found within the capital town. The Benue watercourse, a significant tributary of the Niger, forms a part of the state's northeastern border. The total land area of the state is 28,313.5 km^2 and consists of a wide stretch of arable land for farming, good grazing ground for livestock and large bodies of water for fishing (Encyclopedia Britannica). Agriculture is the mainstay of the economy and provides employment for the majority of the population who are involved with the production of yams, cassava, rice, sorghum, beans, maize, pea nutty and cotton. Homestead husbandry, aquaculture and fisheries activities also are undertaken within the space. Data from www.citypopulation.de (2017) indicate that the population of the state increased from 3.3 million in 2006 to about 4.5 million in 2016. Kogi climate is marked by 2 distinct seasons: The wet season (mid-April to October) and the dry season that spans through (November to mid-April).

Sample and data

The sample for this study was generated from the register of Aquaculture Association of Kogi State. All known practicing aquaculturist (307) in 2018 were interviewed. It was considered in the study that since only 307 of the less than 500 registered practitioners in the area were in operation when the survey was conducted, sampling will further decrease the number of respondents. Hence, total enumeration was embarked on. Data on socio-economic characteristics, perception and adoption of innovation were generated using FGD and structured questionnaire.

Following Asrat and Simane (2018), the use of any 2 or more of the identified 4 common innovations as an adoption was noted in this study. In this case, a fish farmer who adopted at least 2 of the 4 innovations scored 1 in the Probit model. Adoption of one or none of the adoptions scored 0. This method was also applied to the data on perception. In order to analyse perception, the respondents were asked if they felt that the innovations were likely to have positive impact on their productivity (and by implication profit). Perception was treated as a dichotomous variable: An individual either perceives an item - as being useful or does not. In this study, a

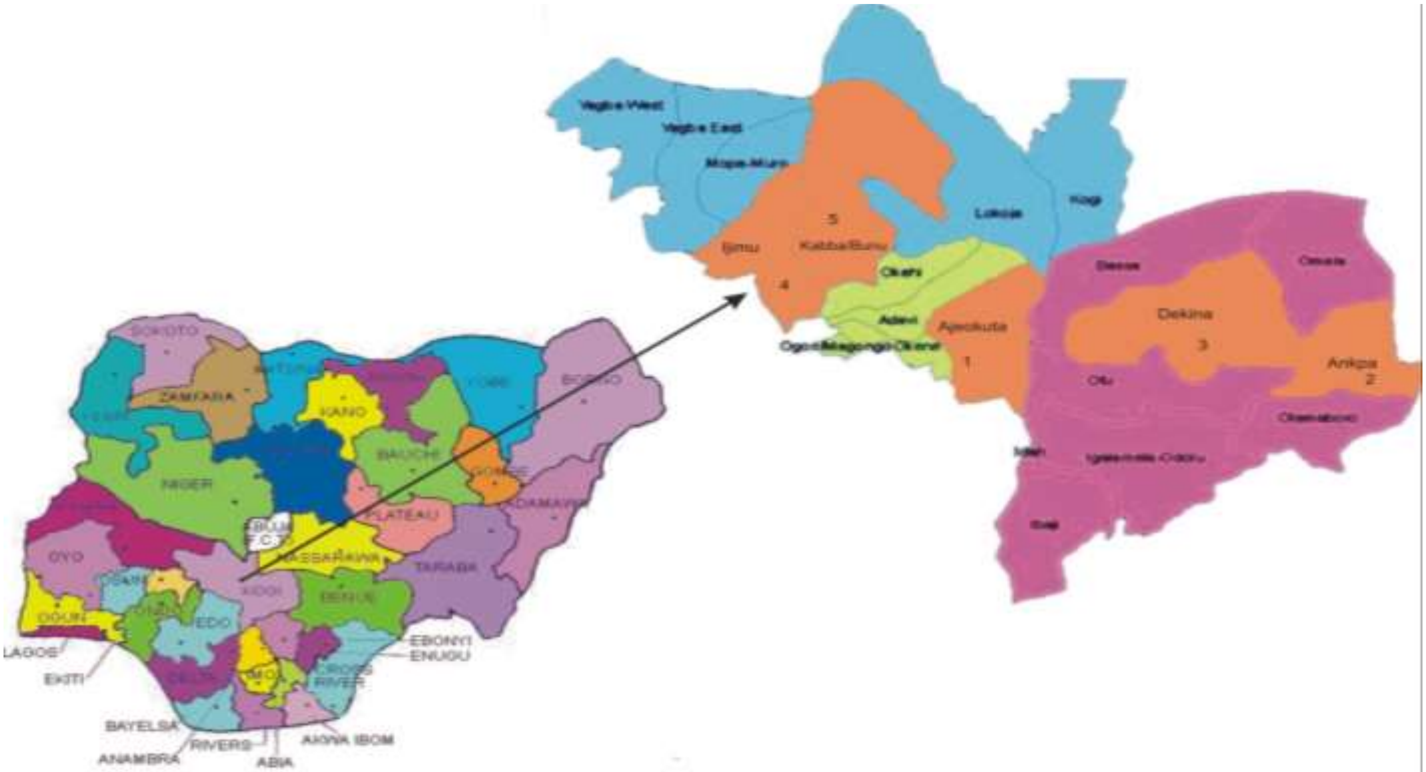

Figure 1. Map of Nigeria showing Kogi state (enlarged).

positive response implies perception (1), otherwise zero. The scores generated were used as the dependent dichotomous variable of the ith respondent in a double Probit model (Heckman's sample selection model). Seven copies of the questionnaire were either not returned or not valid for data extraction. Hence, analysis was restricted to 300 copies.

Method of data analysis

Descriptive statistics and the Heckman sample selection model were employed in the analysis of the data. While the descriptive were used to analyse socioeconomic variables, perception and adoption, the Heckman sample selection model was used to determine factors influencing perception and adoption. The working of the Heckman sample selection model is based on Heckman (1976) as quoted by Asrat and Simane (2018), where sample selection is deemed important in the event that the farmer's adoption decision involves more than one step. First the farmer needs to perceive that the innovation is of superior advantage to his present method/tool. In this case, two-step regressions, such as Heckman's sample selection, are appropriate to correct for selection bias generated during the decision making processes. The model relies on the assumption that due to the farmer's utility/profit maximizing behaviour, he will only adopt an innovation if it is perceived that the derivable utility profit is significantly greater than his prevailing alternative (Asrat and Simane, 2018).

It is possible that the second sample (that is, a sub- sample of the first) which consists only of the fish farmers that adopted the innovation is non-random and necessarily different form the first (which include those who did not perceive the innovation as well as those who did). This leads to sample selection bias (Deresa et al., 2011) which has to be corrected. This correction is undertaken by the use of the Heckman's maximum likelihood procedure (Asrat and Simane, 2018).

Heckman's sample selection model is given by:

$$y_i=bQ_j + u_{1j} \quad (1)$$

In which case, we observe only the binary outcome in the probit model as:

$$y_i^{prob}=(y>0) \quad (2)$$

The dependent variable (assumed to be influenced by Q) is observed only if j is observed in the selection equation given as:

$$y_i^{select}= aX_j + u_{2j}>0 \quad (3)$$

Where y_i^{select} is the model which concerns whether a fish farmer has perceived an innovation or not, X_i is the vector of independent variables assumed to have influence on perception and, a and b are regression coefficients. Equation 3 represents the first stage of the Heckman's two-step model. u_1 and u_2 are error terms assumed to have the standard econometric properties of random distribution, null mean and unity variance.

Equation 1 is the outcome model otherwise noted as $Y_{outcome}$, which analyses whether the aquaculturist adopted the innovation ($Y_{outcome}$=1) or not ($Y_{outcome}$=0), and is dependent on Equation 3, the perception model where Y_{select} = 1 if the ith farmer perceived the innovation and Y_{select}=0, otherwise. Explicitly, the equations are given as:

Outcomemodel:$Y_{outcome}= b_0+b_1techknowhow +b_2accesscredit+b_3costofadopt+b_4otherincom+b_5edu+b_6extcontact+b_7age+b_8ponds+b_9gen$

Table 2. Descriptive statistics of key demographic variables of fish farmers in Kogi State.

Variable	Mean	Std. Dev.	Minimum	Maximum
Monthly income	26275	17172.09	1200	70000
Number of pond	2.27	1.08	1	5
Extension advise (contact)	1.02	1.66398	1	3
Experience	4.3	3.34	2	15
Family size	6.7	4.6	2	12
Age (years)	51.24	19.56	21.2	75
Education (years of schooling)	15.3	9.5	5	23
Gender				
Male	277(92.3%)			
Female	23(7.7%)			

Source: Authors' computation from field survey data, 2018.

der+ b_{10}primaryoccup+ b_{11}exp + b_{12}distan+ b_{13}inforsource +u_1 (4)

Selection model $Y_{select}=a_0+a_1edu+a_2extcontact+a_3age+a_4gender+a_5 primaryoccu+a_6exp+a_7distan + a_8inforsource + u_2$ (5)

Where: Techknowhow=Technical know-how (1 if positive, 0 otherwise); Accesscredit=access to credit (1 if positive, 0 otherwise); Costofadopt= cost of adoption ('000 Naira); Otherincom= other income i.e income from sources other than fish farming ('000 Naira); Edu= education (years of formal education); Extcontact= extension contact (number of contacts with extension personnel for advice); Age= age of fish farmers (years); Ponds =pond size (square meter); Gender= gender of fish farmer (male =1, female=2); Primaryoccup= primary occupation; Exp= experience in fish farming in years; Distan= distance from fish farm to urban center (km); Inforsource: sources of information (1 interpersonal, 2=extension worker, 3=prints, 4= electronic); The interdependence of error terms, u_1 and u_2 (that is $\rho \neq 0$), leads to biased estimates from the standard Probit technique (Asrat and Simane, 2017). As such the Heckman Probit will provide consistent and asymptotically efficient estimates for all the parameters in the model.

RESULTS AND DISCUSSION

Table 2 presents the summary of key demographic variables. The mean average income suggests high level of income poverty in the area. This reflects also on the size of the ponds which relays the small scale nature of the venture in the area. Extension contact was very low. This low level of extension contact could impact perception and adoption and greater number of extension contact will elicit favourable disposition to the adoption of innovations. The table also shows that the fish farmers in Kogi state were moderately educated (average years of education = 15.3). The population of fish farmers in the area is an ageing one with a mean of 51 years. Average household size is about the national household size and extension visits to fish farmers in the area is very low. The venture is also male dominated in the area. Ogbe et al. (2018) have documented the socioeconomic and production characteristics of catfish farmers in Kogi state.

Table 3 presents the perception and adoption of aquaculture innovations in Kogi state. The use of pelleted feed recorded the highest adoption level followed by use of fingerlings from certified hatcheries. Use of mobile pond is the least adopted. Accordingly, the use of pelleted feed was the most adopted while the use of mobile ponds was the least adopted. This is probably due to the relatively higher cost implication. Aggregate data indicate that more than half of the fish farmers in the area perceived these innovations while only 38% was recorded for adoption. This buttresses the point that although perception precedes adoption, it does not necessarily translate to adoption.

Result of the Heckman sample selection Probit model is presented in Table 4. The null hypothesis of no dependence of error terms is rejected since the rho (0.58) is statistically greater that zero (Wald $\chi2$ =4.16, p<0.05). That is, there is the presence of sample selection problem. This supports the suitability of the procedure. Furthermore, the likelihood function of the Heckman Probit model was significant (Wald $\chi2$ = 132.16, P < 0·0001), implying that it has a strong explanatory power. Result of the selection model indicate that education (a=0.281), extension contact (a=0.149), experience (a=0.021), gender (a=0.440) and information source *(a=0.145)* increased likelihood of positive perception of the identified innovative practices. Education improves understanding of a concept and thus enhances correct perception. Niles and Mueller (2016) submitted that effective adaptation requires knowledge (education) and understanding. Extension contact on its own part provides knowledge and is also key to understanding and perceiving innovations. Extension contact frequency was found to be positive in influencing the uptake of aquaculture innovation in Cameroon by Wandji et al. (2012) and Alomia-Hinojosa et al. (2018). As Tripathi and Mishra (2017) summed the connect between education and extension contact in their submission that right perception is dependent on knowledge and ease of access to information, and that knowledge depends on the educational attainment and experience of the person.

Table 3. Perception and adoption of aquaculture innovation in Kogi state.

Innovation	*Perception	*Adoption
Patronage of certified hatcheries	139 (46.3%)	81(27.0%)
Use Pelleted feed	147(49.0%)	98(32.7%)
Use of drugs for water treatment	96(32.0%)	65 (21.7%)
Mobile ponds	65(21.7%)	25(8.3%)
Aggregate*	171 (57%)	114(38%)

Source: Authors' computation from field survey data, 2018. *Multiple responses were analysed.

Table 4. Heckman Probit selection model for the uptake of aquaculture innovations.

Explanatory variable	Outcome model				Selection model			
	Regression		Marginal effect		Regression		Marginal effect	
	b	Z	b*	Z	A	Z	a*	Z
Technknowhow	0.116**	2.28	0.116**	2.28				
Credit access	-0.074*	-3.95	-0.074*	-3.95				
Costofadopt	-0.030	-0.76	-0.030	-0.76				
Otherincom	1.17-e06*	7.18	1.17-e06*	7.18				
Education	0.115*	4.51	0.115*	4.51	0.281*	4.18	.0764*	4.49
Extension advice	0.010	0.55	0.010	0.55	0.149**	2.26	.0404*	2.33
Age	-0.095**	-2.25	-0.095**	-2.25	-0.456*	-3.88	-0.124*	-4.08
Pond size	-0.094*	-3.12	-0.094*	-3.12				
Gender	0.110*	2.88	0.110*	2.88	0.440*	3.41	0.119*	3.62
Pri occupation	-0.049	-1.54	-0.049	-1.54	-0.152**	-2.12	-0.042**	-2.16
Experience	0.0004	0.15	0.0004	0.15	0.021*	2.51	0.006*	2.58
Distance	-0.022	-0.55	-0.022	-0.55	-0.484*	-3.61	-0.132*	-3.83
Inforsource	-0.050*	-2.88	-0.050*	-2.88	0.145*	2.48	0.040*	2.54
Constant	-0.012	-0.05			-1.323**	-2.08		
Observation	300							
Censored	129							
Unsensored	171							
Wald chi-square (zero slopes)	132.16 (P < 0·0001)							
Wald chi square (independent equations)	4.16 (P <0.05)							
Rho: 0.597, lambda: 0 .191, Sigma: 0.329								

^{a}**and* ^{b*} marginal effects of regression coefficients a and b respectively. Source: Authors' computation from field survey data of 2018.

Furthermore, experience with particular techniques may enhance the attention poor farmers give to understanding new methods. Experience was found to exert a positive on adoption by Ainembabazi (2014) in the study of the role of farming experience on adoption of innovation among small holder farmers in Uganda. Again, that the likelihood of perception seems to be higher with male folks may not be unrelated to the disadvantaged position of the female folks. Finally, perhaps, electronic sources have greater appeals in and thus, their higher likelihood for enhancing perception.

Results on perception also indicated that age (a=-0.456), primary occupation (a=-1.54) and distance to urban center (a = -0.55) were negatively related to perception of the innovation. Age has generally been found to diminish to agricultural prospects. Furthermore, if primary occupation was something other than fish farming, the likelihood of non-perception increases. Having an aquaculture firm as the primary occupation implies commercial orientation. Wandji et al. (2012) reported a positive relationship between commercial orientation and innovation adoption. The negative relationship may probably be due to lesser attention an operator gives to the fish farm when it is not the primary venture. This could be because income from these sources may be sufficient for them they may not need to any serious improvement on their fish farms. Finally, distance from urban center implies rural settings. Such settings are less likely to have good information flow, regular extension visits, and poor markets for products. These may diminish any interest in further developing the aquaculture.

Results of the outcome model also presented in Table 4 indicate that Technical know-how (b=0.116), Other income (b=1.17-e06), Education (b=0.115) and gender (b=0.11) had significantly positive influence on aquaculture innovation adoption in the study area. The finding on Technical know-how implies that the ability of a fish farmer to use a particular innovation plays significant role in the farmer’s decision to adopt the innovation. Analysis of marginal effect of Technical know-how on the adoption of aquaculture innovation revealed that a unit increase in the level of technical know-how increases adoption by 11.6%. Mudombi (2015) in a study of improved sweet potato adoption in Wedza community of Zimbabwe found that technical training plays a positive in the adoption of the innovation. On farm extension trials which promotes the acquisition of technical know-how was also found by Alomia-Hinojosa et al. (2018) to be positively related to adoption of maize legume intensification in Nepal.

A 1000 naira increase in “other incomes” increases the likelihood of aquaculture innovation adoption in the area by a minimal 0.017%. The implication is that fish farmers are likely to commit some little part of their incomes to adoption of aquaculture innovation. In Asrat and Simane (2018), while results from dry lowland area disagree with this finding, findings from wet low land areas are in support of the positive influence of other income sources. Perhaps aquaculture participants in the area see additional “other income” as opportunity for adoption of innovation so as to elicit sustainable development in their aquaculture venture, instead of perceiving it as an improvement in income which is capable of making them less dependent on aquaculture

Further marginal effect estimates indicate that adoption of aquaculture innovation increased by 11.5% for an additional year of formal education. A higher level of education confers a greater reasoning and comprehension capability on an individual and also makes for easier understanding of accessed information. The finding in this study is in tandem with those found elsewhere. Wandji et al. (2012) found a positive influence of education by in a study of aquaculture innovation uptake in west high lands of Cameroon. Asrat and Simane (2018) also found a similar result in a study of perception and adoption of climate change mitigation strategies in Dabus region of Ethiopia

Male folks have a higher likelihood of adoption aquaculture innovation than female folks in the area. Guteta and Abegaz (2015) and Asrat and Simane (2018) also reported similar results. These studies argued that women are so encumbered with a plethora of chores that they hardly find time to investment in innovations. Moreover, since they are less likely to have access to productive resources, it is usually difficult for them to invest in adoption of innovation. This scenario plays out in the lager part of underdeveloped African countries, including central Nigeria.

Conversely, access to credit (b=-0.074), age (b=-0.095), pond size (b=-0.094) and information source (b=-0.05) negatively influenced adoption. Since fish farmers in the area may be willing to invest some of their income from other sources in adoption of innovation, it would have been easy to conclude that access to credit will increase their adoption of aquaculture innovation. But this is not so. The likelihood of innovation adoption by fish farmers in the study area decreased by as much as 7.4% for an addition increase in access to credit. It is possible that fish farmers in the area will want to invest accessed credit in some other ventures in a bid to diversify income bases.

Age, as in the case the selection model, showed a negative influence on adoption. Marginal effect analysis indicate that the likelihood of adopting aquaculture innovation the area decreased by 9.55 for any 1 year increase in age. This disagrees with the finding of Asrat and Simane (2018). Many ageing aquaculture practitioner in the area are civil servants or retirees (Onuche et al., 2015b) and may not see the need to adopt innovation due to their guaranteed income or due to the vigour associated with knowledge seeking and practical demonstration of innovations.

Increase in ponds size by a square meter reduced the likelihood of adoption 9.4%. This implies that smaller aquaculture farms are more likely to adopt an innovation. This may not be unrelated to the fact that sizes of agricultural enterprises have financial implications that may hinder adoption. Deresa et al. (2011) reported similar findings. A reduction in likelihood of adoption was observed when the information source is less sophisticated print and electronic, implying preference for personal contact at the adoption stage.

CONCLUSION AND POLICY RECOMMENDATIONS

This investigation was undertaken to explore the drivers of the perception and adoption of some aquaculture innovations in Kogi State, central Nigeria. The goal was to identify those factors that evoke perception and adoption, for policy engendering in order to achieve sustainable aquaculture production. Findings might also be useful in promoting other aquaculture innovations, including those of other sectors. The study found that adoption of aquaculture innovation in the area was high and could be enhanced by embarking on policy frameworks built around the identified perception and adoption drivers in the area. Education, extension contact, experience, gender, and information source were identified as the drivers of perception. The drivers of adoption on the hand include Technical know-how, “other income", education and gender. Policy mixes will have to tinker with certain variables or related variables that have conflicting influences in perception and adoption, in addition to the identified drivers. For instance, the study noted that while electronic sources enhanced perception, adoption relied more on personal contact with innovators and extension personnel, indicating the need to combine the two categories of information sources at different points. Also, proper understanding of the how to finance adoption is vital as we found that credit did not drive adoption but fish farmers were willing to commit a part of income from other sources to adoption. Thus attention may be better focused on assisting participants increase their incomes from other sources rather than granting them access to credit. Closely related to this was the fact that primary occupation other than aquaculture exerted negative influence but fish farmers were inclined to committing a little part of their incomes from those occupations to adopting innovations. Furthermore, although extension contact positively influenced perception, it was not significant in influencing adoption. The low intensify of extension activity in the area may not have been impactful enough in inspiring adoption. Thus, while extension contact may be viable in eliciting perception, more contacts will be required to reduce adoption. Higher intensity of extension contacts should also be implemented to provide training on "technical know-how" to elicit higher levels of adoption. Policy engendering must also consider the issue of gender, as it was noted that the female folks were disadvantaged in perceiving and adopting innovation

From the foregoing, the following recommendations are proffered. First, emphasis may be place more on electronic sources during the introduction stage of the innovation while more practical oriented information sources like the personal contacts should be exploited thereafter. Second, assisting aquaculture practitioners increase their incomes from other sources through increased wages/pension, increased credit for expansion, or price adjustment might be a better alternative to funding adoption than providing them with credit for aquaculture. Next, increased impact of extension delivery system will be achieved by paying more attention to practical training to enhance the acquisition of requisite techniques that will assist in improving the likelihood of adopting aquaculture innovations. Finally, a case was made for gender consideration in policy mixes as the female folks appear disadvantage in perceiving and adopting aquaculture innovation in the area. Special arrangements like more access to productive resources and reduction of their domestic burdens will improve on their chances of perceiving and adopting innovations.

CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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