APPLICATION OF IMPROVED AQUACULTURE PRACTICES BY FISH FARMERS IN NIGER STATE, NIGERIA

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MTECH/SAAT/2017/7463

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A THESIS SUBMITTED TO THE POSTGRADUATE SCHOOL OF FEDERAL UNIVERSITY OF TECHNOLOGY MINNA, NIGER STATE, NIGERIA IN PARTIAL FULFILMENT OF THE REQUIREMENS FOR THE AWARD OF THE DEGREE OF MASTER OF TECHNOLOGY IN AGRICULTURAL EXTENSION AND RURAL DEVELOPMENT

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ABSTRACT

The study assessed application of improved aquaculture practices by fish farmers in Niger State, Nigeria. Multi-stage sampling technique was employed to select a total number of two hundred and thirty one (231) fish farmers. Data were collected from primary source using structured questionnaire complemented with interview schedule. Data collected were analyzed using both descriptive statistics such as (means, percentages and frequency distribution) and inferential statistics such as (multiple regression and linear regression).The results showed that majority (93.1%) of the fish farmers were males with mean age of 40 years. Majority (82.7%) were married, while mean experience of fish farmers was 9.2 years. Majority (96.5%) belonged to one or more cooperative. Also, 95.2% had formal education while the mean household size was 10 persons. Further findings revealed that fish farmers applied medication to treat stress, control pest and disease($\bar{X}$ =2.79), sorting density to separate jumpers ($\bar{X}$ =2.77), use of ash to control acidity in pond ($\bar{X}$ =2.72) and use of organic and inorganic fertilizer ($\bar{X}$ =2.68). Also, fish farmers agreed that the use of aquaculture practices can greatly improve farmers' skills($\bar{X}$ =4.78), improved practices provide higher yield/income than the old ones ($\bar{X}$ =4.68) and training is required to correctly apply the improved practices ($\bar{X}$ =4.61). The coefficient of age (-.1649953), experience (.56634), cooperative (17.70519) household size (-.7542798) extension services (1.590344) output (.0006172) had significantly influenced the application of improved aquaculture practices. Moreover, the coefficient of fingerlings (.0000825), feed (.000154), fertilizer (.0013279), depreciation (-3.38e-06) labour (-.0012519) and age (-.0046984), education (.0067926) and household size (.010459) had significant effects of improved aquaculture practices application on fish farmers' output. Further findings showed that environmental pollution($\bar{X}$ =3.0), unfavorable weather conditions for fish growth($\bar{X}$ =2.95) and flooding of pond($\bar{X}$ =2.90) were the major constraints to application of improved aquaculture practices. Further findings showed a significant relationshipbetween application of improved aquaculture practices and perception of the fish farmers.It is recommended that women should be encouraged to embrace aquaculture practices in order to enhance their livelihood. Regular popularization, training and empowerment for effective conviction of the fish farmers should be ensured to further level of awareness, perception and application of aquaculture practices and fishermen should put in place every measure to avert environmental pollution such as use of gamalin and other hazardous chemicals that are toxic to fishes.

TABLE OF CONTENTS

CHAPTER THREE

CHAPTER FOUR

LIST OF TABLES

LIST OF FIGURE

CHAPTER ONE

1.0 INTRODUCTION

1.1 Background of the Study

The nutritional and health benefits from fish have been recognized for its superior nutritional profiles with quality protein as source of a polyunsaturated fatty acids Food and Agriculture Organization (FAO, 2008). Nigeria consumed more than 1.36 million metric ton of fish while fish imports make up about 740, 000 MT annually(FAO, 2013). This ever increasing demand for fish is due to a number of factors such as high population, growth rate, increasing national income and increasing high costs of other sources of animal protein such as livestock. Fish occupies a very significant position in the primary sector, providing employment for over a million people and contributing about 50% of the annual protein intake in Nigeria particularly the riverine communities (Federal Department of Fisheries, 2011).

Fish as a veritable source of high quality protein, essential vitamins and minerals is also crucial to human in the context of institutional development and change protein calorie malnutrition are widely recognize as important health hazards, leading to poor health, working efficiency, low productivity and overall economic retrogression (Ipinmoroti and Adesina, 2011); fish is also adjudged as cheaper source of animal protein with an indispensable role in world protein supplies, particularly in the developing countries, where fish equally provides energy, fatty acids, vitamins and minerals and this is quiet true in the tropical countries like Nigeria where animal protein is seriously inadequate (Ajayi, 2013).

In addition to the present demand – supply deficit of over 60%, there is a steady decline in capture fisheries resource leading to renewed desire to evolve programmes by the government that could enhance greater productivity of fish in the natural water bodies of Nigeria and fostering sustained livelihood for the people whose lives depend on such environment. Meanwhile, a good number of projects were initiated, funded and implemented by the National Institute for Freshwater Fisheries Research(NIFER), New Bussa in collaboration with the German Technical Corporation. Niger State is one of the major beneficiaries of these projects with special attention on the communities at the shore lines of Niger State and other neighboring communities. Apart from the increased fishers' population, different fishing methods were introduced to fishermen and some of the fishing methods had detrimental effects on the fish population dynamics. Available fisheries statistics in Niger State indicated a sharp decline from 32, 474 tons annual fish yield in 1995 to 9, 248 tons in 2004 (Lawal and Adekunle, 2007).

These efforts were to improve the utilization of fisheries resources at sustainable level assure the livelihood of fishing communities, protecting consumers and the conservation of aquatic resource. However, the level of awareness of fishing policies of the resource poor fisher folk I low because of lack of understanding of the benefits (Lawal and Adekunle, 2007). Also the high cost of implementation and the control of illegal fishing continue to be a problem, hence an apparent ineffectiveness of the intervention programme.Improving farm production through nitrating modern practices into the existing farming system is essential for the enhancement of household food and income security (Wetengere, 2009). All these were extended to the public through NIFFR extension guides, regular sensitization in aquaculture, and farm visits (Lawal and Adekunle, 2007).

As a result of application of improved aquaculture practices, people in Katcha, Bosso and Borgu communities have recognized a new paradigm shift to aquaculture as a viable panacea to sustained livelihood in Niger State. The use of aquaculture practices to strengthen production has proven potentials to revising the trend of importation. The application of aquaculture practices in Niger State has assumed a popular dimension in recent years starting from immediate communities around the NIFFR, New Busa and spreading by trickle-down effect to communities far and wide along the shorelines and hinterlands of Niger State. This understanding therefore, provided the basis for the assessment of the factors influencing application of aquaculture practices among the communities of Niger State.

1.2 Statement of the Research Problem

Fish provides a valuable source of animal protein, representing about 40% of such supplies and remains the cheapest source of animal protein (Fapohunda, 2005). Fish yield of most inland waters in Nigeria are generally on the decline largely due to increasing national population; dwindling output arising from imminent stagnation of inland capture fisheries and use of noxious fishing methods in Nigeria's natural and man-made water bodies (FDF, 2011). The inland fisheries subsector operates mainly in the remote rural areas where over 3.0 million people are engaged in artisanal fish production which contributes about 86% of the domestic fish production (Ahmed and Vincent, 2014).

Despite the importance of fish to man and the society at large, Nigeria is not producing enough fish for consumption mainly due to the fact that fish production from marine and traditional artisanal fisheries have not yet developed substantially to the extent of bridging the gap between demand and supply to cater for the ever-increasing Nigerian population. Application of appropriate aquaculture practices therefore, has a lot of prospectus in alleviating under nutrition and poverty as well as promoting foreign exchange for Nigeria.

Fish supply in the domestic market has been face with over whelming demand and relatively unaffordable prices as Nigeria requires approximately 1.5 to 2 million tons annually to meet fish demand whereas domestic supply is estimated to be 0.7 million tons including massive importation which gulps over ₦90 billion annually making the country the largest importer of frozen fish in Africa (Federal Department of Fisheries, 2011; National Institute of for Marine and Oceanographic Research(NIOMOR,2012).

However, aquaculture, being the fastest growing industry among the agricultural sub-sectors with increasing awareness on pond fish culture still suffers growing challenge in terms of scaling up production to sustainable level (FDF, 2011 and FDF,2013). Nigeria is among the low users of inputs in farm production and by extension fish farming. It was observed that despite high potential that fish farming demonstrates, the level of technologies application is characterized by low level of inputs, small-sized ponds, poor quantity and quality seeds and low cash income due to infrequent harvests. Therefore, the challenge of attaining food fish sufficiency has been through the expansion of manageable fish farms nationwide and this has permitted the nooks and crannies of many communities especially the resource poor peasants and even fishermen now employing low level practices (Ajayi *et al.,* 2014).

Despite this fact, most farmers are not applying the existing practices in aquaculture properly coupled with the fact that farmers lack the required currency of knowledge and that the existing practices needs to be constantly reviewed and farmers needs to be consistently updated. Therefore, the need to probe into the factors which determines the application behavior of the fish farmers in aquaculture production to establish the need for sustainable and environmentally friendly production practices. A good number of aquaculture practices have been transferred to the end users through various channels and sufficient studies have not been conducted to understand the peculiarities of the users of such practices in terms of social, economic, cultural religious environmental and institutional characteristics of the farmers in relation to their responses to the aquaculture practices. It is against this background that this study attempt to answer the following research questions;

i. What are the socio-economic characteristics of the fish farmers in Niger State?
ii. What is the application level of improved aquaculture practices by the fish farmers in the study area?
iii. What is the effect of the improved aquaculture practices application on fish farmers output?
iv. What are the perceptions of the fish farmers on the application of improved aquaculture practices?
v. What are the factors influencing the fish farmers application of the improved aquaculture practices?
vi. What are the constraining associated with application of improved aquaculture practices?

1.3 Aim and Objectives of the Study

The aim and objectives of the study is to assess the application of improved aquaculture practices by fish farmers in Niger State, Nigeria. The specific objectives are to;

i. describe the socio- economic characteristics of fish farmers in the study area;
ii. examines the application level of improved aquaculture practices;

iii. examine the effects of the improved aquaculture practices application on fish farmers' output,

iv. assess the perception of the fish farmers on the application of aquaculture practices;

v. determine the factors influencing the application of the improved aquaculture practices by fish farmers;and

vi. examine the constraining associated with improved aquaculture practices application in the study area.

1.4 Hypotheses of the Study

The hypotheses of the study stated in the null form are;

Ho_1: There is no significant relationship between selected socio-economic characteristics of the respondents and their application of improved aquaculture practices in the study area.

Ho_2: There is no significant relationship between the perception of the fish farmers' and their application of improved aquaculture practicesin the study area.

1.5 Justification of the Study

The study of application of aquaculture technologies by fish farmers would be considered vital to Small scale fish farmers**.** Small scale fisheries have been shown to be an important component of the informal welfare mechanisms still widely functioning in many rural societies and still maintains its position in providing livelihood safety net for the most vulnerable households. Many communities in Niger State engage directly in fishing, others in gear production and maintenance, craft construction and repairs, fish processing and preservation as well as marketing and distribution. Fish farming practices change continually as farmers build on their own experience and that of their neighbours to refine the way they manage their farms; changes in natural conditions, resource availability, and market development also present challenges and opportunities to which farmers respond.

In addition, farmers learn about new practices from various organizations, programs and projects dedicated to research extension, or rural development. The study will provide guidance to agricultural administrators and researchers for enhancing research-extension linkage in promoting application of relevant practices aquaculture. The added knowledge on which factors have the greatest influence on aquaculture practices application will help the government and other stake holders in making more informed decisions on how to promote application. Also because of the significance of fisheries aquaculture, it is expected that technological spill overs are likely outside of the study area and application of aquaculture practices in the study area could therefore be projected. Therefore, the study is justified based on the following reasons. The study will help to investigate the key technology types which shall be used to boast farmer's income. It will reveal the state of technology transfer between the fresh water research institute and the fish farmers. More so, it will enhance the public awareness on the appropriateness on the best practices that will suit their domain. Finally, the results obtained from this study will add to existing data and information for the purpose of academic discourse.

CHAPHTER TWO

2.0 LITRATURE REVIEW

2.1 Concept Definition and Framework

2.1.1 Aquaculture development in Sub-Sahara Africa

African aquaculture has come a long way since it was first introduced over five decades ago. However, aquaculture development in Africa has followed a long bumpy road. Initial interest in the innovation of framing fish rapidly dwindled during the 1960s as over – expectation were not met and many enterprise were abandoned (Brummet and Williams, 2000). The above observations about African aquaculture apparently go in tandem with the findings of other researchers. In comparison to the rest of the world, aquaculture I Africa is insignificant as the entire continent contributed a mere 0.4% to the total world aquaculture production between 1984 and 1995 (FAO, 2000 and Hecht, 2000). This corresponds to 60% increase over the previous decade. Similarly, FAO (2013) described Africa's aquaculture production at global level as insignificant as it accounts for about 0.9% (404571t) of the global aquaculture production in 2000. This lack of development exists against a backdrop of conditions that would benefit greatly from the rapid development of aquaculture on the continent namely high incidence of poverty, malnutrition and unemployment (Hecht, 2000).

2.1.2 Aquaculture developmentin Nigeria

Aqua-culturists manipulate certain components of the environment to achieve a greater control over production of aquatic organisms than is normally possible in nature. The primary aspects of rearing fish include controlled breeding and grow out. Interest in depopulation in wild fish caused by the increase in the number of anglers able to move about quickly and use of more sophisticated tackle, as well as harm done by pollution and industrialization of water courses for navigation or for hydro power. Fish culture is practice principally in ponds, which are easy to manage with respect to such things as breeding, determination of stocking rate stocking and maintenance (Omotosho and Fagbenro, 2004).

According to Omitoyin (2005), the aim of fish culture is principally to produce quality fish food for human consumption. It is also to enhance culture base fishery by providing enough fingerlings for livestocking open waters like natural and artificial lakes, reservoir and running stream in order to prevent the extinction of commercially important species of fish especially when there is over-exploitation.

2.1.3 Aquaculture in Nigeria historical perspective

Fish culture is an age-old practice particularly in developing countries of Asia. The delayed recognition of aquaculture in Africa is probably due to pattern of prioritization with crop agriculture an animal husbandry (Fagbenro *et al.,* 2004). Aquaculture Nigeria occurs mainly inland and only recently has the coastal region been the focus of development. Nigeria has coastline of about 960km bordering a coastal zone that is an extensive mangrove ecosystem comprised of lagons, estuaries, wetlands and series of interconnecting creeks. The coastal zone covers an estimated one million ha and offers considerable potential for commercial aquaculture (Fagbenro *et al.*, 2004).

In essence, this potential provided the impetus for the subsequent government involvement and interest in aquaculture. Thus, the history of aquaculture in Nigeria dated back to (a) 1951, a small experimental farm was established in Onikan (Lagos state) where various tilapia species were raised (Omitoyin, 2005). Following the disappointing results with the Tilapia, modern pond culture started with the establishment of pilot fish form of about 20ha, in Panyan (Plateau state) for raising common/mirror carp, Cyprinuscarpo. (b) early 1920's when the first traces of fish farming was practiced by some white missionaries in Ilora, Oyo state were fish was raised to supplement the protein intake of pregnant women.

2.1.4 Prospects of aquaculture in Nigeria

Nigeria's aquaculture produced over 300,000 tons of various freshwater and brackish water fish in 2000 and is based mainly on herbivorous and omnivores tilapia species and Omnivorous or carnivorous catfishes cultivable under intensive (commercial) and semi-intensive (artisanal) production systems. Food and Agriculture Organization (FAO, 2000) reported that despite this current activity, the potential for aquaculture is insignificant given the nation's natural and environmental qualities. Available records shows that in Nigeria alone fish contributes on the average 20 – 25% per caput animal intake and could be as high as 80% in coastal and riverine communities.

Omitoyin (2005) therefore observed that there is the need not only to maximize the exploitation of our fishery resources but to concentrate more on aquaculture development which has the greatest potential to increase fish production for local consumption and export. In Nigeria aquaculture has gained increasing attention and focus due to its importance in employment creation and income generation, particularly on the socio-economically weaker communities of fishermen, which represents the poorest sections of the society in many developing counties (National Informatics Centre, 2007). Total fish production is estimated at 30% of demand, thus scarce foreign exchange is devoted to the importation of large volumes of frozen fish (The Fish Site, 2009). As a result, aquaculture has assumed the fastest growing food production system world-wide as is particularly important in bridging the gap between fish demand and supply in Nigeria (FAO, 2008).

2.1.5 Technology application in aquaculture

Aquaculture has become an important sector in the Nigerian economy and is considered a means of bridge the gap between the supply and demand for fish especially as the wild stock is the fast declining (Olaoye and Olorutoba, 2010). Success in aquaculture and attendant breakthrough is subject to availability and application of improved aquaculture technologies. Fish farmers believe in the practices because they give good efficiency in terms of high yield, affordable price and more benefits (Olaoyeand Oloruntoba, 2010). According to Ingold(2002), practices differ widely, depending on whether the intent is to embrace the totality of human works, in all societies and during all epochs. A technology or innovation is thus an idea, practice or product that is perceived as new by the potential adopters or users (Adekoya and Tologbonse, 2011).

2.1.6 Awareness of innovation practices

Awareness is said to be the first stage in application process and involves the individual learning of the existence of practices innovation. It is however observed that at this stage, the farmer has limited knowledge about the practices. In this process the farmer might want to know more about the information after having heard it from other family members, friends, and neighbours, the mass media extension agents, researchers, sales promoters and local cooperative organization (Ekong, 2003). Exposure to information about new practices significantly affects farmers' choice about it. (Olaoyeand Oloruntoba, 2010) however posited that sometimes in application process, interest may precede awareness especially in a situation where fish farmers may need to control a new and unknown fish disease or pest.

2.1.7 Concept of perception

Perception is defined as the process by which we receive information or stimuli from our environment and transform it to psychological awareness. It is more or less permanent feelings, thoughts and pre-dispositions a person a person has about certain aspects of this environmental. Like attitude it has three components: knowledge, feeling and inclination to act. It is an evaluated disposition towards some subject or object, which has consequences on how a person will act vis-à-vis the object being perceived (Ekong, 2003) shows that an increase in knowledge will lead to change in perception, which In turn influences behavior.

2.1.8 Gender concerns and application

Gender issues in agricultural production and practice application have been investigated for a long time. Most show mixed evidence regarding the different roles men and women play in technology application. In most recent studies, Doss and Morris (2001) in their study on factors influencing improved maize technology application in Ghana, over field and Fleming studying coffee production in Papua New Guinea show insignificant effect of gender on application. The socio-economic features of fish farmers have been known to have bearing on farmers' application of innovations as exemplified by various finding: in management – intensive high-risk industries such as fish farming, farmers' technology application becomes a deciding factor between success and failure. Application is, in turn, largely a function of farmer's age and education as well as his experience and degree of involvement in fish farming (Wetengere, 2009).

Socio-economic and institutional factors that relate to application and non- application of fisheries and aquaculture practices are essentially similar to those factors which affect application of other practices in either crop or livestock farming. They include farmer's personal and socio-economic characteristics such as age, formal education farm income, size of farm, tenure status, level of living and complexity of the practice, community prestige and sources of information used (Sanni, 2009). Elsewhere, various socio-economic factors have been identified to show relationship with application. For instance, Dey *et al.* (2002) observed that sex is an important variable with application of aquaculture practice in the Asian countries of Bangladesh, Indonesia, China, Philippines, India and Vietnam. Similarly, Paul *et al*. (2000) observed that sex is an important variable in application of aquaculture practices in the Asian countries of Bangladash, Indonesia, China, Philippines, India and Vietnam. Similarly, Paul *et al.* (2000) in a study on the impacts of aquaculture extension on pond operators and the rural community in central Bangladash found extension contact to be positively and significantly correlated with application of aquaculture technologies.

Other application studies in areas other than fisheries and aquaculture showed interesting result on the relationships between socio-economic variables and application of farm innovations. For instance, in a study on the application of yam minisett technology by women farmer in Abia State, Ironkwe*et al.*, (2007) reported that farming experience, significantly related to application. Dey*et al.*, (2002) found negative but significant relationship between ownership of land and application of yam minisett in eastern Nigeria. (Sanni, 2009) reported that cooperative membership increases the probability of the respondents participating in social capital formation which confirm with the *a priori* expectations. Similarly, Ironkwe *et al.* (2007) who carried out study of farmer's participation in poultry production technology in Saki. Agriculture Zone of Oyo State found age, education, awareness, attitude toward participation sources of finance to be positively related to application. It is therefore believed that the interplay between these socio-economic and institutional factors, would explain causality of application behaviour of a fish farmers in term of knowledge, skill acquisition, fish production, farm income and level of living.

However, there are number of other factor that influence the extent of application of practices and these includes, according to (Wetengere, 2009), characteristics or attribute of the adopters or clientele which is the object of change, the change agent and socio-economic, biological and physical environment in which the practices takes place. (Wetengere, 2009) had observed that farmers have been seen as major consultant in development process. They are either innovators or laggard. Thus, socio-physiological trait of farmers is important, the age, education attainment, income, family size, tenure status, credit use, value system and beliefs were positively related to application. Other, according to Rogers (2003) include the personal characteristics of the extension worker such as credibility, his/her good relationship with farmers, intelligence, emphatic ability, sincerity, resourcefulness and ability to communicate with farmers.

2.1.9 Socio-economic and culture issues in application of aquaculture practices

Transfer of successful aquaculture practices from one place to another is a major challenge for aquaculture. Many of the practices developed for use in developing countries have been developed by institution in the west often under experimental and laboratory conditions. Even those that have been developed under field condition may fail to meet expectation upon transfer from research institutes to the farmers in different part of the world. Very often the constraints are not related to the available practices since the science of aquaculture is at stage where it is probably technically feasible to produce fish almost anywhere Rogers (2003). The socio-economic features of fish farmers have established bearing with farmers' to adopt technologies as exemplified by various research findings in Management – intensive, high-risk industries such as fish farming farmers' application is a deciding factors between success and failure as application is largely a function of farmer's income, age and education as well as his experience, perception, custom/traditions and degree of involvement in fish farming (Wetengere, 2009).

2.1.10 Concept of adoption of practice/innovation

Rogers (2003) defined adoption as the decision/ to make full use of an innovation as the best course of action. In analyzing data on application studies, some researchers consider a farmer to have adopted a practice if he uses it to any extent in his farm. Sanni (2009) therefore defined the rate of application as the relative speed with which an innovation is adopted by members of a social system. It is measured as the number of individuals who adopt a new practice in a specified period. Extent (level) of adoption on the other hand is concerned with number of practices without any consideration to the speed of application. An innovation or practices is thus an idea, practice or product that is perceived as new by the potential adopters or users (Adekoya and Tologbonse, 2011). In the context of this study, an innovation could be improved method of pond construction, pond water management, fish stocking rate, fish feeding and feed formulation etc. In aquaculture there are two principal types of practice/innovation.

2.1.11 Concept of adoption and diffusion

It is useful to distinguish between adoption, which is measured at one point in time, and diffusion, which is the spread of a new technology across a population over time (Garson 2001 and Rogers, 2003). Much of the literature on diffusion assumes that the cumulative proportion of application follows an S-shaped curve in which there is slow initial growth the use of the new technology, followed by a more rapid increase and then a slowing down as the cumulative proportion of application approaches its maximum (which may be well below 100% of the farmers). The most common function used to portray the curve is the logistic function. For technology adoption, the y-axis represents the proportion of farmers of the area adopting practices and the x-axis represents time.

2.1.12 Expected benefits of application practices

It is less likely that farmers, especially small-scale farmers will adopt the new practices. Farmers may receive little long-term benefits from application, which negatively influences application. A higher percentage of total household income coming from the far m through increased yield tends to correlate positively with application of new technology (Jackline, 2002).The availability of time is an important factor affecting technology application. It can influence application in either a negative or positive manner. Practices that heavily draw on farmer's leisure time for other sources of income accumulation may promote application. In such cases, as well as in general, income from off-farm labour may provide financial resources required to adopt the new technology.

2.1.13 Conceptual framework

The following shows the explanation of the conceptual framework which guides the arrangement of this study. With references to this study, the model has five main aspects. These include the antecedent, independent, intervening, dependent and impact variables. The factors under investigation, namely, the socio-economic variables (personal and institutional characteristics of the farmers), awareness, perception, attributes of technology and farmers' fish production constraints come under the independent variables include government policies, cultural/religion factors, and technology delivery mechanisms, technological change and market forces. There is also the independent variable i.e application of aquaculture technologies which is influenced by the independent variables. Lastly the impact variables represent the possible the possible outcome of the overall relationships in the model showing the proposed effects of the influenced of dependent and intervening variables on aquaculture technology application. These effects are knowledge acquisition, skill acquisition that further influence fish production, fish farm income and level of living.

The independent variable include farmer's age, education, experience in fish farming, pond size, income level, exposure to other fish farms, access to market extension contact access to capital, source of information, professional membership, closeness to fisheries research institute, availability of infrastructure. Others include farmers' awareness of technology, their perceptions type of technology their perception, type of technology and farmers' production constraints. Three different types of arrows are used to indicate the relationship between the five various aspects of the model. These include single one directional arrow; double headed arrow and one directional dotted arrow.

In the model, the direction of the arrows points from a combination of the farmers' socio economic characteristic; awareness and perception, attributes of the innovation to application indicating the influence of these factors on application. The first types (single one directional arrow) shows cumulative effect of the independent variables on the dependent variable (application) while the double headed arrow shows the interaction and influence among variables. Similarly, the dotted, one directional arrow shows the influence of intervening variables but these effects are not rigorously investigated in the study.

However, the intervening variable or factors, might similarly affect the farmers' potential to adopt or not to adopt aquaculture technologies. The influence of the variable exogenous to farmers' capacity to adopt the aquaculture technologies. Theses intervening variables include government policies; cultural/religious factors; technology delivery mechanisms, environmental concern; technological change and market forces. These variables according to Adeokun*et al.*(2008) could also act as barriers to application of innovation in any aspect of agriculture. Again the direction of the arrow moves from these variables and pointing to application as their influences may accelerate or retard application. In developing the model of this study (Figure 1), emphasis was placed on the major factor influencing aquaculture technologies and the ultimate effects (consequences). In the model attempt was made to highlight the background problems regarding the status of fisheries in lake Kainji, the initial position of aquaculture visa vis the tendency to support fish supply with imports and the economic implications on the balance of trade. This is summarized as over-exploitation of water bodies, declining capture fisheries, primitive aquaculture practices, dearth of fisheries resources, low animal protein consumption, fish importation, negative balance of trade, low technology application and poor knowledge of application and poor knowledge of application behaviour of fish farmers. Against this background, the casual relationship in the model starts with the antecedent variables in the context and perspective of changes requiring attention of the stakeholders (e.g individuals, research and other governmental/non-governmental institutions) in the fisheries subsector. Resolving the challenges requires probing into certain verifiable factors/variables as farmer as farmers' socio-economic characteristics such as farmers' age, educational level, fish farming experience, pond size, household size, farmers' income and farmers' level of exposure to other fish farm and the socio-psychological factors (e.g, awareness and perception). Each of these is believed to have influence on the status of application of aquaculture technologies either directly or indirectly.

Similarly, institutional factors such as extension contact, access to capital source of information, membership of professional association, closeness to fisheries research institute and availability of infrastructure influences application and also determines fish farmers' decision to adopt or not to adopting any technological innovation. On the attributes of technological innovations (e.g. cost of technology, case of use and durability). The attribute readily determines who adopts or rejects any particular aquaculture technologies because the farmers are sensitive to any technology that is amendable to their socio-economic conditions. The overall effect of these variables leads to impact variables which directly affect technology application on the social system. The proposition is that the farmers' characteristics, awareness and perception, the attributes of the technological innovations and institutional factors determines the application, which in turn determines the ultimate outcomes, in term of the number of ponds owned by the farmers and farmer's income from fish production as well as skills and improvement in knowledge gained.

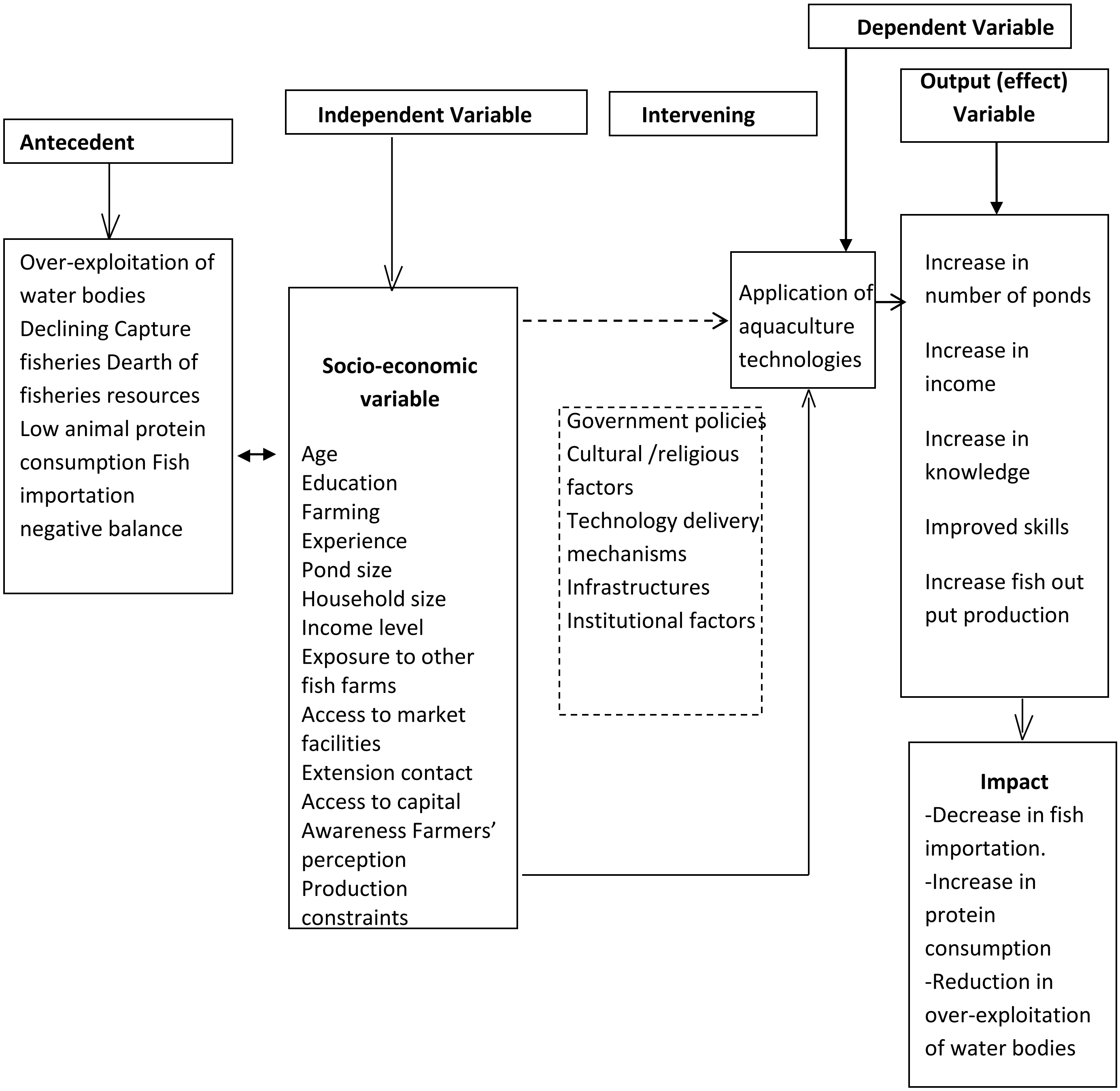

Figure 2.1: Conceptual framework of factors influencing application of improved aquaculture practices.

→ Arrows showing cumulative effects of independent variables on dependent variable
↔ Arrows showing interaction between variables
--> Variables whose effects were postulated but not seriously examined.

Source: Adopted from Sanni, (2019)

2.2 Theoretical Framework

2.2.1 Theories of social change

Social change according to Rogers (2003) and Adeokun et al., (2004) is the process by which alteration occurs in the structure and functions of a social system. According to Haralambos, (2003), the concept connotes the alteration of goals, structure or processes in a social system. An adequate working definition was provided by Rogers (2003) where he described social changes as the term used to describe changes in social and economic life style and values of people in relation to technological innovation and institutions. According to Ekong (2003), social changes may assume either of the following forms: Modification in human attitude and behavioural pattern as a result of education (formal or informal extension education of fish farmers). For example, and educated fish farmers could be more disposed to the values and benefits of technological advancement in aquaculture and therefore, decide to change or improve his old way of fish production as a result of extension activities (Adeokun *et al.,* 2008). Here the fish farmers as a group constitute the social system. The theories that were reviewed in relation to social change in this clientele controlled management theory, application theory and diffusion theories which are all about changes as it applies to the farmers in the context of this study.

2.2.2 Clientele controlled management theory

The antecedent conditions regarding the scarcity of fish in Nigeria's water bodies leading to poor socio-economic situation and unhealthy living condition of the rural fishing family calls for paradigm shift to aquaculture on the farmers and other end users of technologies in fisheries. The social behavior of aqua culturists' determination to improve the economic wellbeing through application of relevant technologies constitute change in norms, value system and requisite skills to make a reasonable outcome in the peoples' life. It is therefore a significant alternation of social structure including consequences and manifestation of such structures embodied in the norms, value and cultural conducts of the fish farming population under study. The fish farmers in this study are the clientele who actually initiated the desire to change their production system for the better through their request for government through the research society to intervene by means of appropriate and demand – driven technologies in aquaculture calls the application of the theory of clientele controlled management system of social change in the dissemination of improved technologies in aquaculture.

In a similar vein, fish farmer's perception and attitude could modified or improved upon as a result of human personal characteristics such as age, farming experience, household size, pond/farm size, extension contact, and change in status, income level, improved credit opportunities and social participation (Ekong, 2003). Other forms of social change includes alternation in social conditions as a result of changes in government policies; technological changes, changes in material culture, reforms in major legal and functional system of a political and cultural change (Ekong, 2003). This form of change is exemplified and represented in this study as intervening variables are expected to also influence the application of technological innovations in aquaculture. The knowledge of the theory of social change is relevant to this study because a good knowledge of methods of bringing about change and factors inhibiting change is important to making desirable impact on the target of fish farmers. The major sources of change in a society are through invention of appropriate technologies in response to end users' desire (demand-driven), dissemination and diffusion of these technological innovations through research institutions and social institutions such as cooperatives and region institutes, urbanization, government policies and application of science and technology to agriculture in local communities such as Kainji Lake fish farming communities.

2.2.3 Adoption theory

The theory of adoption applies to this study because it is a concept that defines the roles of individual fish farmer as units of the society. Once a technology has been disseminated to the potential adopter, and he/she has passed through the stages of application decision process the aquaculture technology is either accepted or rejected. Thus, the adoption process has been defined by (Rogers, 2003) as the acquisition and processing of information about an innovation followed by a behavioural change. Knowledge-based technology is regarded technical knowledge and management, skills such as pond water management, feeding techniques that will help the farmer to increase production.Agricultural organization such as agricultural research institutes are of the assumptions that as progressive farmers adopt innovations, the less innovative ones get influenced and adopt the innovation and the innovation will spread by trickledown effect to majority of farmers (Agabamu, 2008). Thus the framework that will guide this study therefore, is the application theory that is demand-driven on the path of the clientele (fish farmers). This theory which centers on application of innovations is a multidisciplinary theory of planned social change which I brought about clienteles' request for dissemination of new ideas, practices, processes or technologies through a social system (Rogers, 2003).

Adoption theory as explained in relation to concept of change emphasizes the process of transferring a new idea or innovation from its source of innovation or creation to its ultimate users or adopters. The study also recognizes the modification of existing traditional systems for better and improved productivity. In essence, application is a micro concept referring to the acceptance of an idea, practice or product by a single unit of potential audience (Rogers, 2003).

2.2.4 Diffusion theory

This theory as it applies to application of aquaculture technologies to fish farmers involves the diffusion of ideas within a social system (in this study the fish farming communities adopting aquaculture technologies) based on the concepts of socialization and actualization. The emphasis on the theory is that most ideas, technological innovations, practice and related body of knowledge in fisheries and aquaculture are borrowed and spread in regular patterns and phases by tickle-down effect to other farmers, neighbours or communities through the following process. Therefore, this theory also applies to this study as the process of diffusion gives the desired change as result of diffusion an application across the masses of adopters in the social system under study.

2.3 Review on Past Studies on Application of Improved Practices

2.3.1 Socio-institutional review

Studies that have sought to establish the effect of education on application in most cases related it to years of formal schooling (Wetengere 2009). Generally, education is taught to create a favourable mental attitude for the acceptance of new practices especially of information-intensive and management-intensive practices (Caswell *et al.,* 2001). What is more, application literature (Rogers, 2003) indicates that technology complexity has a negative effect on application. However, education is thought to reduce the amount of complexity perceived in a technology thereby increasing a technology's application. The ability to read and understand sophisticated information that may be contained in a technological packaged is an important aspect of application. Furthermore, distribution of knowledge reduces the risk of adopting a new practice. Increased education is thus expected to improve application. In studies by Daku (2002), Doss and Morris (2001), education positively affected application of most technological innovations

Acquisition of information about a new technology demystifies it and makes it more available to farmers. Information reduces the uncertainty about a technology's performance hence may change individual's assessment from purely subjective to objectives over time (Caswell*et al.*, 2001). Exposure to information about new technologies as such significantly affects farmers' choices about it. Provided a technology is profitable, increased information induces its application. However in the case where experience within the general population about a specific technology is limited, more information induces negative attitude towards its application, probably because more information exposes an even bigger information vacuum hence increasing the risk associated with it. Information is acquired through formal sources like the media, extension personnel, visits, meetings, and farm organization and through formal education. It is important that this information be reliable, consistence and accurate. Thus, the right mix of information properties for a particular technology is needed for effectiveness in its impact on application.

Good extension programs contacts with producers are key aspects in technology dissemination and application as a new technology is only as good as the mechanism of its dissemination to farmers (Ahmed and Lorica, 2002). Most studies analyzing this variable in the context of agricultural technology shows its strong positive influence on application. It is believed that its influence on application. It is believed that its influence can counter balance the negative effect of lack of years of formal education in the overall decision to adopt some technologies. Rogers

(2003) suggest that application of technologies may in effect be enhanced because of complementarities that exist between the technologies.

Gender: Females are less likely to adopt fish farming than males due to: their high workload, they do not own land, are not decision makers, a lot of physical labour is required in pond digging it involves major repairs, and their state of poverty (Wetengere, 2009).

Belief: some religious beliefs prohibit the consumption of certain fish species and using pig manure and brew leftover for fertilization and feeding fish, respectively. Farmers with such beliefs are unlikely to adopt fish farming technology related to such issues.

The application of fish farming is financially demanding fish farmers rich in terms of income are more likely to adopt fish farming that the poor farmers. On the other hand, if the expected contribution of income from fish farming is higher than that from other activities, farmers are more likely to allocate income to fish farming

i. Knowledge and skills: Farmers who have knowledge on fish farming are more likely to adopt it than those who have not acquired the knowledge.

ii. Technology characteristics: According to (Wetengere, 2009) these are the attributes of technology that made it adoptable by the farmers. They include:

iii. Profitability: Profit is defined as the difference between total revenue received and the total cost of in-puts. Farmers are more likely to adopt fish farming technology if the technology promise higher returns to investment than the other farm technologies and vice versa.

iv. Marketability: This is defined as the ease with which a product can be sold relatively to other, competing products. Farmers are more likely to adopt fish farming if farmed fish is more marketable than other competing products and vice versa.

v. Risk: This is defined as a situation in which the probability of obtaining some outcome of an act of an event is not precisely known. Farmers will be interested in adopting technologies that reduce risk in their farming operation and vice versa.

vi. Immediacy of reward: This defined as the speed with which a farmer receives income or fish farming rewards faster than other competing activities it is more likely to be adopted. Resources poor farmers cannot afford to wait for too long to earn a return on their investments.

vii. Complexity: Complexity can be defined as the number of activities that have to be performed to adopt and use the technology relative to other technologies (Batz *et al*., 1999). If application of fish farming requires the application of a number of activities than other technologies do, it is less likely to be adopted and vice versa.

viii. Operational cost: This is defined as day-to-day costs of keeping the activity running. If the costs of running fishes farming are lower than other competing activities, fish farming will likely be adopted and vice versa.

Institutional factors deal with the extent or degree to which institutions impact on technology application by smallholders. Institutions include all the services to agricultural development, such as finance, insurance and information dissemination. They also include facilities and mechanisms that enhance farmers' access to productive inputs and products markers. Institutions also include the embed norms, behaviors and practices in society. Researches and development practitioners should also consider issues that relate to the farmer's exposure to economic, agro-meteorological, biophysical and social shocks in designing technologies for smallholders. Care should be taken to avoid technologies with a high investment cost structure which smallholders cannot afford because they are poor and lack the necessary resources.

Embedded norms, behavior and practices in society can encourage or discourage application of a particular technology by members of that society. For example, the practice that the production of certain types of crops are the preserve of male members of society can limit the application of a particular technology in sub-Saharan Africa if the crop to be promoted is grown mainly by men. This is because women constitute the majority of rural dwellers in this part of Africa. Clearly therefore, an understanding of local cultural practices and preferences is important if they are to benefit from agricultural research (Meinzen-Dick *et al.*,2004).

2.3.2 Farmers' perception of practices

Farmers believe that technologies are good to them. They believe in technologies because they give good efficiency in term of high yield, less pest, and more benefit. In soliciting respondents' subjective perceptions, researchers capture the qualitative aspects that influence farmer's decision probably because farmers' technology choices are based on their subjective probability of a practice choices are based on their subjective probability. Farmers' perceptions are interpreted as perceived profitability of a practice and translate into more resources being devoted to it hence application. Aphunuand Ajayi (2010) applied a five point Likert-type scale ranging from "undecided" (scale 1) to "strongly agree" (scale 5) were used. The level of knowledge and skills gained as a result of the training programme were measured on a four point Likert-type scale ranging from "poor" to "very good" and scale 1 to 4 respectively. Responses on 5 point Likert scale with mean scores below 3.50 or above were classified as good, while those with mean scores below 3.50 were classified as poor. On the other hand, responses on 4 point Likert-scale with mean scores of 2.50 or above were classified as good, while those with mean scores below 2.50 were classified as poor.

In a similar vein, an earlier work by Ajayi (2014) used a 5-point Likert scale o compute the role perception of respondents played by analyzing a number of perception statements to obtain the perception index. This was later categorized into weak perception, strong perception and very strong perception depending on whether the value is less than 0.5, 0.5 or greater than 0.5.

2.3.3 Effect of technology application on the adopters

Aquaculture technology application can produce interesting effects on the fish farmers according to Washington *et al.* (2012) improved agricultural practices have various impacts. In essence increased agriculture productivity and household food security and nutrition can be achieved through application of improved agricultural technology. These are in addition to expansion of rural financial markets, increased household income, increased capital and equipment ownership by rural household, and development of research and extension linkages.

Increased technology development and application can raise agriculture output, hence improved household food intake which in turn serves to improve the functioning of the human body and performance of a healthy, normal life required to promote work output. However, increase technology application may result in high labour demands and less time available for other household activities by women (e.g household chores like child care, and fuel wood and water collection) (Washington *et al.,* 2012). The experience and evidence from countries within and around the sub-Saharan African region indicates that returns to agricultural technology development could be very high and far reaching. This would transform not only the smallholder sector, but also in the entire national economies in the region (Washington *et al.,* 2012).

2.3.4 Social factor influencing application of technologies

Age of adopter: Age is another factor thought to affect application, Age is said to be a primary latent characteristics in application, Age was found to positively influence application (Wetengere, 2009). The effect is thought to stem from accumulated knowledge and with various technologies. In addition, since application pay-off occurs over a long period of time, while cost occurs in early phases, age (time) of the farmer can have a profound effect on technology application. Older farmers, perhaps because of investing several years in a particular practice, may not want to jeopardize it by trying out a completely new method. In addition, farmers' perception that technology development and the subsequent benefits, required a lot of time to realize, can reduce their interest in the new technology because of farmers' advanced age, and the possibility of not living long to enjoy it (Caswell*et al.*,2001; Khanna, 2001). Furthermore, elderly farmers often have different goals other than income maximization, in which case, they will not be expected to adopt that the old that do adopt a technology do so at a slow pace because of their tendency to adapt less swiftly to a new phenomenon (Wetengere, 2009).

2.3.5 Impacts of aquaculture application in developing countries

The development and wider application of aquaculture can be seen as a significant basis for improving household food security and other needed welfare. Being a supplier of food and a commodity for trade, aquaculture has a potential to contribute to the food and nutritional status of people (Ahmed and Lorica, 2002). The contribution of aquaculture to peoples' life is n 3 major linkages.

i. Application – Income Linkages

ii. Application – Employment Linkage and

iii. Application – Consumption Linkage.

2.3.5.1 Application – income linkages

On the first linkages, income and purchasing power have tremendous influence on household demand for food. According to Bouis (2000), empirical evidence suggests that increase in staple food (e.g Cereal or rot/tuber) consumption as income rises is very minimal or nearly zero once a minimum is reached. But in the case of non-staples food (such as fish and vegetable), it rises rapidly in a percentage basis. There is conventional wisdom that income growth has the potential to alleviate caloric intake (Bouis, 2000 and Haddada, 2000).

2.3.5.2 Application–employment linkages

These application-employment linkages to food security are based on the hypothesis that the consumption and nutrition status of household members related to the household's ability to earn income, which in turn depends on the nutritional health of the household labour force. Family labour is by far the most important production factor in developing country agriculture. Therefore, maintenance and enhancement of labour productivity is central to securing and increasing income. Thus aquaculture is expected to increase the marginal productivity of agriculture and hence engender higher earnings for both own-family and hired labor (Ahmed and Lorica, 2002).

2.3.5.3 Application – consumption linkages

This is based on the following hypothesis that (i) adopting households consumes a disproportionately high amount of fish which is reach in micronutrients and hence improvements in nutritional status can be achieve through application-home consumption linkages; and application of aquaculture increases market supply that holds fish price down, and hence increases the intake of micronutrient-rich food-fish (Bouis, 2000).

2.3.6 Constraints to Application in Aquaculture

Several constraints are known to affect fish farmers' capacity to adopt technologies. These include water, institutional credits, low literacy level, cost of feeds and feeds availability, gender issues, marketing constraints, diseases and pest, predators, poaching etc. In analyzing the severity of agricultural constraints, Tologbonse *et al*., (2006) applied the principle of 5-point Likert scale as categorized the constraints as very serious (5) moderately serious (4) serious (3) not serious (2) and undecided (1). To decide which constraints were serious a mean score of 3 was used. The weighted mean score for each problem was obtained by multiplying the frequency score with the point scale for each rating and dividing by the number of the respondents (sample size). In aquaculture any constraint with mean less than or equal to 3 is considered serious while anyone having mean score less than 3 is taken less serious (Okojie and Onemolease, 2009).

Jamu and Ayinla (2013) asserted that there exist a wide variety of production system such as cages ponds, tanks and raceways, which are being, used for aquaculture in agriculture, freshwater and marine environment in Africa. These system are being used in small, medium and large-scale operations and at various levels of intensity (Machena and Moehl, 2001). The future of aquaculture in Africa lies in increasing production efficiencies and intensities so as to produce more fish using less land, water and financial resources, and this will require research o genetic enhancement of aquaculture species to allow for growths and more efficient use of feed. (Jamu and Ayinla, 2013).

The desire to enhance production intensity and efficiency must therefore embrace all vital aspects such as fish feed formulation and overall genetic improvement. Thus, as aquaculture production becomes more and more intensive, fish feeds will be a significant factor in increasing the productivity and profitability of aquaculture. So far as nutrition research has concentrated on the replacement of animal proteins by plant proteins with a view to reducing the cost of supplemental fees.Sanni (2017) reported that research on inexpensive feed ingredient has not contributed to aquaculture development in Niger State, and suggests that more efforts should be put into research on how plant proteins could be used in the feeding of fish.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study Area

This study was conducted in Niger State, Nigeria. The State was created in 1976. It is located in Guinea Savannah Region and range between latitude 6^0 8'E and $8^0$44' N of the equator. The state is boarded to the North by, Kaduna State and Federal Capital Territory (FCT), Kebbi State to the West, Kogi State to the South, and Kwara State to the south – West. Niger State has a common boundary with Republic of Benin along New Bussa, Borgu Local Government Area. The State covers land area of 74,244sq km of 7,424 million hectares covering 8% of the land area of the countries. It has a population of about 3,950,249 (NPC, 2006) and with a growth rate of 3.2%, the State has estimated population of 5,586,000 in 2018 (Niger State Geographical Information System, 2015).

The State experiences distinct dry and wet seasons with annual rain fall which ranges from 1,100mm in the north to 1,600mm in the south and mean rain fall of 1350mm. the raining season last between 120 and 190 days and temperature ranges between 35 and 375 ^{0}C with relative humidity between 60 and 80% in the month of July and 40 and 60% in January. The vegetation in the area is mainly short grasses and shrubs with scattered trees and numerous natural resources notably, goal, marble, limestone, dolomite and columbite.

The major tribes are Nupe, Gwari, and Hausa, while other tribes are Fulani, Kanbari, KakandaDibbo, Kamuku, Ganagana, Ibo, and Yoruba as minorities. The major economic activity is agriculture (farming, fishing and livestock rearing). The State is blessed with numerous natural resources like solid minerals, vast arable land, good weather and water bodies.

Amongst its rich mineral resource is gold, talc, Kyanite, Kaolin, Graphite, Ball clay, Feldspar, marble, manganese, lead and copper, asbestos and iron, silica, sand granite, all of which are found in large deposits. The two major dams for electricity generation in the country are located in the state. The extensive flood plain in the Southern boundary of the State , availability of large water bodies dams and reservoirs offer great opportunity for dry season cultivation of fadama crops, such as rice, sugar cane, maize and other vegetable. The State has ideal condition for livestock production. lts abundant grass land and fodder, favorable weather and abundant water supply as well as control of tsetse fly menace favour rearing of cattle, goats, and sheep among others. (Geographical Statistics 2007).

3.2 Sampling Techniques and Sample Size

The population of the study consists of culture fish farmers in Niger State. Multi-stage sampling was adopted for this study. In the first stage, random selection of one L.G.A from each of the three agricultural zones (Katcha, from zone 1, Bosso from zone II and Borgu from zone III). In the second stage, random selection was used to select three (3) communities from each of the L.G.A selected to get nine (9) communities. The third stage involved proportionate selection of the fish farmers from each of the communities selected using Yamane formula based on the list of registered fish farmers obtained from Niger State Ministry of Livestock & Fisheries to get sample size of 241 respondents representing 13.5% of the sampling frame. However, 231 questionnaires' were recovered out 241 sampled. The Yamane Formula as used by Ibrahim 2016 is presented as follows:

$$n = \frac{N}{1+N(e)^2} \quad (1)$$

n = sample size

N = finite population

e = limit of tolerable error (level of precision at 0.06 probability)

l = constant

Table 3.1: Sample outlay of the respondents

Agric Zone	L.G.A	Communities	Sampling Frame	Sample Size
I	Katcha	Katcha	225	30
		Baddegi	205	28
		Gbakogi	195	26
II	Bosso	Bosso	167	22
		LapaiGwari	185	25
		Togwai Dam	285	38
III	Borgu	New Bussa	170	23
		Monnai	145	19
		Fakun	225	30
Total	**3**	**9**	**1802**	**241**

Source: Niger State Ministry of Livestock & Fisheries, 2019

3.3 Method of Data Collection

Data werecollected from the fish farmers with the use of questionnaire and interview schedules and was administered by the researcher with the assistance of trained enumerators. The interview schedule contained both open and closed ended questions. Data collectedinclude information on the socio-economics variables such as farmers` age, years of formal education, household size, number of contacts with extension agents, fish farming experience, membership of social organizations, major occupation. Others includes, the pond size (in m^2), labour in man-days and cost of feeds (Naira).

3.3.1 Validity and reliability of instrumentof data collection

The questionnaire for data collection was checked to ensure face and content validity by my team of supervisors and professionals colleagues in the field of agricultural extension. The reliability of the instrument was determined by using Crombachs alpha reliability tests, the values obtained was used to determine whether the data collection instrument designed for the study is valid and reliable. The value of Crombachs alpha if it is greater than 0.80, it indicates that the instrument is reliable.

3.4 Measurement of Variables

3.4.1 Dependent variable

The dependent variable Y is number of improved aquaculture practices applied arising from the fish farmers' decision to make full or continuous use of practices as the best course of action. Fish farmers were asked to indicate the technologies disseminated to them by the extension agents and the ones they are using in fish farming. The total scores were then recorded.

3.4.2 Independent variables

(1) Socio-economic characteristics of the respondents

Sex: This refers to whether a respondent is a male or female. Male respondents were scored 1 while female respondent were scored 0. These binary numbers was assigned for the purpose of computation not because male is greater than female or female is greater than Male

Age: (in years) Age refers to the number of years the respondent has spent from birth as at the time of study. The respondents were asked to state their ages in years.

Pond size: (measure in m^2 of ponds area); this is the total area in meter squared occupied by the respondent's fish ponds. Respondents were asked to state the total pond areas measured in m^2.

Household size: this is the number of people per household of the respondent. Each respondent were asked to state the total number of people in his/her household.

Fish farming experience (was measured in years): this is the total number of years spent in fish farming.

Amount of Credit: This is the amount the respondent obtained as loan from any financial institution in the course of fish farming. It was measured in naira.

Membership of professionals association: (member = 1 and none member = 0)

Output: Amount of output measured in Naira that accrues to the respondent’s fish production business in a year. The respondents were asked to state the approximate amount of income accruable to their fish farming per annum.

Application: this was measured using 3 – point Likert scale of highly applied 3, applied 2, not applied 1. These were summed together 3+2+1 and divided by 3 to get a mean value of 2.0. However, any mean value <2 is not applied while ≥2.0 is termed applied.

Sources of information: this was measured based on the number of sources

Distance from the fishery research institute (NIFFR): this is the total distance between the respondent’s farm and the fisheries research institute. It was measured in kilometer

Availability of market outline: [available = 1, not available = 0].

Number of available of infrastructures: This is the Number of infrastructural facilities available in the vicinity of the respondents. It is counted and expressed in whole number as total recorded.

(II) Examining the application of improved aquaculture practices

Application, Awareness, Application and Sources of information about the improved aquaculture practices was measured by asking the respondent to tick the boxes provided in the questionnaire as appropriate.

(III)Determining the perception of the respondent on improved practices

Perception was measured by means of putting a set of perception statements against a continum of 5- point likert scale which ranges from strongly agree (5), agree (4), undecided (3), disagree (2) strongly disagree (1). The cut-off mean was calculated as (1+2+3+4+5)/5 = 3. However, any mean value <3 is termed disagreed while ≥3 is termed agreed.

(I**V) Factors influencing application of improved aquaculture practices by fish farmers**

Likely variables that influences application of improved aquaculture practices were measured appropriately as contained in the questionnaire.

(V) Determining the effects of application on fish farmer output

(Variables such as cost of labour, pond size, fertilizer, fingerlings, capital input and application score were captured in the model as independent variable) while fish income is the dependent variables.

(VI) Examine the constraints to application of aquaculture practices

4-point Likert type rating scale was used to measure the constraints to application of aquaculture practices across a continuum of ‘very serious’ (4) ‘serious’, (3) undecided’ (2), not a constraint (1) A weighted mean score was computed and compared to the cut-off mean i.e (1+2+3+4)/4 = 2.5. However, any mean value ≥2.5 is termed serious constrained while < 2.5 is termed not serious.

3.5 Method of Data Analysis

Descriptive and inferential statistics were used to achieve the objectives of the study. Descriptive statistics includes frequency counts, percentages and mean, while the inferential statistics involves the use of linear and multiple regression.

Objectives i, ii, iv&v: These objectives were achieved using descriptive statistics such as frequency counts, percentages & mean.

Objective iii: This objective was achieved using multiple regression analysis. Regression model.

The implicit form of the model is as follows:

$$FI = f\,(LA, PS, FE, FL, CP, LM, AI) \qquad (1)$$

The explicit form of the model are as specified below:

Linear form

$$FI = \alpha + \beta_1 LA_1 + \beta_2 PS_2 + \beta_3 FE_3 + \beta_4 FL_4 + \beta_5 CP_5 + \beta_6 LM_6 + \beta_7 AI_7 + \mu \qquad (2)$$

Double-log form:

$$In\ Y = \alpha + \beta_1 InL1 + \beta_2 InP1 + \beta_3 InF1 + \beta_4 InFn1 + \beta_5 InCp1 + \beta_6 InLm1 + \beta_7 InAT1 + \mu \qquad (3)$$

Semi-log form

$$Y = \alpha + \beta_1 InL1 + \beta_2 InP1 + \beta_3 InF1 + \beta_4 InFn1 + \beta_5 InCp1 + \beta_6 InLm1 + \beta_7 InAT1 + \mu \qquad (4)$$

Exponential form

$$In\ Y = \alpha + \beta_1 L1 + \beta_2 P1 + \beta_3 F1 + \beta_4 Fn1 + \beta_5 Cp1 + \beta_6 Lm1 + \beta_7 AT1 + \mu \qquad (5)$$

Where;

F1 = Fish Income (in naira)

a = a constant

L_1 = labour (man days)

P1 = pond size (m^2)

F1 = Fertilizer (kg)

Fn1 = Fingerlings (number)

Cp1 = Capital input (naira)

Lm1 = Lime (kgAT1 = Application of technology (application score)

Objective iv: This objective was achieved using OLS regression.

CHAPTER FOUR

4.0 RESULTS AND DISCUSSION

This chapter presents the results and discussion of the analyses of the six research objectives of the study.

4.1 Socio-economic Characteristics of the Fish Farmers

4.1.1 Age

Table 4.1 showed that 36.4% of the respondents were between the age range of 31-40 years while 29.9% were within the age range of 41-50 years, the mean age of respondents was 40 years, implying active, productive and actual age in which aquaculture practices is at peak. This age also represents the active groups who are in their active period of life and are more likely to apply improved aquaculture practices readily and easily than the older age brackets. This confirms the findingof Ajayi (2014) that young and active age groups are more likely to adopt aquaculture practices which requires attention and high sense of responsibility. In a similar vein, the result agreed with the work of Rozana and Roslima (2015) that the mean age of pond fish farmers were below 50 years.

4.1.2 Sex

Table 4.1 showed that 93.1% of the respondents were males while 6.9% were females. This implies there were more males in fish farming in the study area. Also, large percentage of male might be attributed to difficult tasks and laborious routine activities inherent in aquaculture practices which are normally done by men just like is obtained in crop agriculture. This finding agrees with Arowolo *et al*. (2019), who reported that majority of fisher forks in Kainji basin were male.

Table 4.1: Distribution of respondents according to socioeconomic characteristics (n=231)

Variable	Frequency	Percentage	Mean
Age			
< 31	49	21.2	39.9
31 – 40	84	36.4	
41 – 50	69	29.9	
> 50	29	12.6	
Sex			
Male	215	93.1	
Female	16	6.9	
Marital status			
Married	191	82.7	
Single	23	10.0	
Separated	11	4.8	
Divorced	3	1.3	
Widowed	3	1.3	
Experience in aquaculture			
< 6	48	20.8	9.2
6 -10	99	42.9	
11 – 15	62	26.8	
16 – 20	22	9.5	
Cooperative membership			
Yes	223	96.5	
No	8	3.5	
Types of cooperative			
Cat Fish Farmers' Association	30	13.0	
Farmers' Association	185	80.1	
Local Thrift Association	5	2.2	
Religious Association	3	1.3	
Education			
No Formal education	11	4.8	
Formal education	220	95.2	

Sources: Field survey 2019

4.1.3 Marital status

Table 4.1 indicated that majority (82.7%) of fish farmers in the study area were married while 10% were single. Also, 4.8%, 1.3% and 1.3% of fish farmers were separated, divorced and widowed respectively. This implies that majority of fish farmers in the study were married, implying some responsibilities that will enhance practice of aquaculture farming. Also, there would be high tendency for the use of family labour to assist in the series of numerous routine activities that characterize fish farming enterprise from pond construction to harvesting and packaging. This result agreed with the finding by Omitoyin (2005) who reported that larger percentage of fish farmers were married and thus gives opportunity to improved family labouron the long run.

4.1.4 Experience in aquaculture

Table 4.1 indicated that 42.9% of the respondents had fishing experience of between 6-10 years while 26.8% of the respondents had experience of between 11-15 years. The mean experience in aquaculture of the respondents in the study area was 9.2 years which is a relatively appreciable period of time to begin to understand the complexities involved in any aquaculture farming. The finding agreed with that of Olaoye*et al.* (2016) who reported that 5-7 years is enough to begin to understand some technologies and therefore tends to adopt them for improved productivity in aquaculture practices

4.1.5 Membership of cooperative

Table 4.1 indicated that 95.6% of the respondents belong to cooperative while 3.5% were non cooperative members. This implies that majority of the respondents were membership of cooperative society. However, cooperative membership is expected to provide soft loans, ease of input financing and availability of market information on fish farming is better with group than with individual farmers needed for aquaculture production in the study area. This result corroborates the work of Olaoye *et al.* (2016) who reported in his studies that majority of the fish farmers were members of cooperative societies or associations. Membership of association tends to have positive effect on application of aquaculture technologies since it is easier to demonstrate any proven or improved technologies to them as a group than it is for individual fish farmers. Also, 80.1% of the respondents belong to farmers association while 13.0%, 2.6% and 2.2% belong to cat fish farmers association, religious association and local theft association respectively.

4.1.6 Education

Table 4.1 revealed that 95.2% of the respondents had formal education while 4.8% had no formal education. This result implies that majority of the respondents had formal education. Also, 64.9% of the respondents had secondary occupation while 22.5% had tertiary education. Moreover, 7.8% of the respondents had primary education while 4.8% had no-formal. This finding implies high literacy level among fisher forks in the study area, and this is expected to enhance application of aquaculture farming practices in the study area. Also, having basic formal education is an added advantage in aquaculture farming practices where new ideas for improved production are generated from time to time and requires a level of training and intellectual approach to apply such ideas for application. This result is in line with the findings of Arowolo*etal.* (2019) who reported that improved education help fisher forks to understand the various complexities modernization that characterize most aquaculture technologies and decisions that may come about them.

4.1.7 Household size

Table 4.1 revealed that 51.5% of the respondents had household size of between 6-10 persons while 28.1% had household size of between 11-15 persons. The mean household size of the respondents was 10 persons, implying that respondents in the study area had high household size. This is a relatively moderate household size which is expected to provide labour availability for fisher forks in the study area. The result agreed with the findings of Okoronkwo and Ume (2013) that predominantly young and active fish farmers had family size that has positive bearing with application of aquaculture technologies.

Table 4.1b: Distribution of respondents according to socio-economic characteristics (n=231)

Variable	Frequency	Percentage	Mean
Non Formal	11	4.8	
Primary	18	7.8	
Secondary	150	64.9	
Tertiary	52	22.5	
Household size			
< 6	44	19.0	10
6 -10	119	51.5	
11 – 15	65	28.1	
16 – 20	3	1.3	
Primary occupation			
Fish Farming	185	80.1	
Crop/Livestock Farming	15	6.5	
Civil Servant	31	13.4	
Secondary occupation			
Civil Servant	18	7.8	
Crop/Livestock Farming	180	77.9	
Agric-business	23	10.0	
Tailoring	5	2.2	
Driving	10	4.3	
Respondents' access to extension			
Accessible	189	81.8	
Not accessible	42	18.2	

Sources: Field survey, 2019

4.1.8 Primary occupation

Table 4.1 indicated that 80.1% of the respondents had fish farming as primary occupation while 13.4% were civil servants. Also, 6.5% had livestock farming as primary occupation. This implies that majority of the respondents were fish farmers.This distributionimplies that aquaculture has become a major force in employment, job and wealth creation among different age groups in the study area. The result is in agreement with the finding by Olaoye *et al.*, (2016) which revealed that majority of the fish farmers took fish farming as full time enterprise.

4.1.9Secondary occupation

Table 4.1 indicated that 77.9% of the respondents had crop/livestock farming as secondary occupation while 10.0%, 7.8%, 4.3% and 2.2% respectively engaged in agricultural business, civil servant, driving and tailoring as secondary occupation. This finding implies that majority of the respondents had secondary occupation as a means of additional income during the peak period of fish scarcity. This finding agreed with Olaoye *et al.*, (2013), who reported that larger percentage of fish forks in Nigeria also engaged in crop production.

4.1.10 Access to extension services

Table 4.1 showed that 81.8% of the respondents had access to extension services while 18.2% did not have access to extension services. This implies that majority of the respondents had access to extension services. Access to extension will enable fisher forks to access improved knowledge and skills that will enhance the application of aquaculture ptractices. This agrees with Sanni (2017), who showed that majority of fisher-forks in Niger State benefitted from extension agents visitation

4.2 Application Level of Improved Aquaculture Practices

Table 4.2 showed the distribution of respondents based on improved aquaculture practices in the study area. The result revealed that respondents applied the following aquaculture practices; medication to treat stress, control pest and disease ranked 1st with mean value of ($\bar{X}$ =2.79), this was followed by sorting density to separate jumpers with mean value of ($\bar{X}$ =2.77). This implies that medication to treat stress control of pest and disease and sorting density were the most improved practiced applied by respondents in the study area, implying that separation of pest and diseases infestation and sorting were mostly carried out in aquaculture practices in order to enhance productivity. This finding supported Susan and Peter (2014), who reported that sorting practices is needed in aquaculture practices for profit maximization.

Also, use of ash to control acidity in pond was ranked 3rd with mean value of ($\bar{X}$ =2.72) while use of organic and inorganic fertilizer ranked 4th with mean value of ($\bar{X}$ =2.68). This implies that control of acidity and uses of organic and inorganic fertilizer were part of the highly practiced improved aquaculture method in the study area. This finding agreed with Olaoye *et al.*(2013), who reported that control of acidity is a common practice among fish farmers in Nigeria. Other improved aquaculture practices used by the respondents showed that use of threads to control predator birds ranked 5th with mean value of ($\bar{X}$ =2.65), knowledge on rainfall emergence and distribution withranked 6th mean value of ($\bar{X}$ =2.52), water pumping machine ranked 7th mean value of ($\bar{X}$ =2.50), farmers group association ranked 8th mean value of ($\bar{X}$ =2.41), accessibility of credit in banks for farm ranked 9th with mean value of ($\bar{X}$ =2.38), use of fast-growing tilapia, carp and or catfish for stocking ranked 10th with mean value of($\bar{X}$ =2.36), scoop net ranked 10th with mean value of($\bar{X}$ =2.35), proper site selection with good sources of waterranked 12th with mean value of ($\bar{X}$ =2.29), use of local made feed with 40-45% ranked 13th with mean value of($\bar{X}$ =2.28), pond construction such as depth of 75cm – 2m deep ranked 14th with mean value of($\bar{X}$

=2.26), polythene tankranked 14th with mean value of($\bar{X}$ =2.26),ranked 16th with mean value of drag net ($\bar{X}$ =2.23), use of 0.2mm feed at first week ranked 16th with mean value of($\bar{X}$ =2.23), use of 0.5mm feed ranked 18th with mean value of($\bar{X}$ =2.22), feed additivesranked 18th with mean value of ($\bar{X}$ =2.22), use of 2.0mm feed ranked 20th with mean value of($\bar{X}$ =2.19), plastic tank ranked 20th with mean value of($\bar{X}$ =2.19), use of wooden vats ranked 20th with mean value of($\bar{X}$ =2.19), use of 4.0mm feed ranked 22th with mean value of($\bar{X}$ =2.18), proper record keepingranked 23th with mean value of($\bar{X}$ =2.13), proper water inlet and outlet ranked 24th with mean value of($\bar{X}$ =2.11), oxygen bag for fingerlings transportation ranked 25th with mean value of($\bar{X}$ =2.1), ovaprimranked 26th with mean value of ($\bar{X}$ =2.08), agricultural lime at the rate of 2270kg/ha (227g/m2) ranked 27th with mean value of($\bar{X}$ =2.0).

However, the following improved aquaculture practices were fairly applied in the study area hydrated lime $(CaHO)^2$, ranked 28th with mean value of($\bar{X}$ =1.97), limestone at the rate of 1104kg/ha (104.4g/m2) ranked 29th with mean value of($\bar{X}$ =1.89), production of zooplankton and phytoplankton ranked 29th with mean value of($\bar{X}$ =1.89), using DO meter for oxygen level of 5.0-9.5mg/l ranked 29th with mean value of($\bar{X}$ =1.89), use of plastic vats ranked 32nd with mean value of($\bar{X}$ =1.83), pond water heater ranked 33rd with mean value of($\bar{X}$ =1.74), use of tarpaulinsranked 34th with mean value of($\bar{X}$ =1.72), aerator ranked 35th with mean value of($\bar{X}$=1.65). This relatively fairly practice might be due to the series of problems such as inadequate knowledge, environmental factors, poor orientation, lack of equipments and inadequate capital (Olaoye *et al.* 2013). Since most of the farmers are from rural communities, the ease of taking such risks could constitute a draw back in adopting such practices that would enhance their output (Bolorunduro, 2014).

Table 4.2a: Distribution of respondents according to application level of improved aquaculture practices(n=231)

Variables	Highly Applied	Fairly Applied	Not Applied	Sum	Mean	Decision	Rank
Medication to treat stress, control pest and disease	182 (78.8)	49 (21.2)	-	644	2.79	Applied	1st
Sorting density to separate jumpers	181 (78.4)	47 (20.3)	3 (1.3)	640	2.77	Applied	2nd
Use of ash to control acidity in pond	171 (74.0)	56 (24.2)	4 (1.7)	629	2.72	Applied	3rd
Use of organic or inorganic fertilizer	162 (70.1)	65 (28.1)	4 (1.7)	620	2.68	Applied	4th
Use of threads to control predator birds	150 (64.9)	80 (34.6)	1 (0.4)	611	2.65	Applied	5th
Knowledge on rainfall emergence and distribution	160 (69.3)	32 (13.9)	39 (16.9)	583	2.52	Applied	6th
Water pumping machine	116 (50.2)	114 (49.4)	1 (0.4)	577	2.50	Applied	7th
Farmers' group Association	137 (59.3)	51 (22.1)	43 (18.6)	556	2.41	Applied	8th
Accessibility of credit in banks for farm	120 (51.9)	79 (34.2)	32 (13.9)	550	2.38	Applied	9th
Use of fast-growing tilapia, carp and or catfish for stocking	107 (46.3)	100 (43.3)	24 (10.4)	545	2.36	Applied	10th
Scoop net	110 (47.6)	91 (39.4)	30 (13.0)	542	2.35	Applied	11th
Proper site selection with good source of water	93 (40.3)	111 (48.1)	27 (11.7)	528	2.29	Applied	12th
Use of locally made feed with 40-45% crude protein	103 (44.6)	90 (39.0)	38 (16.5)	527	2.28	Applied	13th
Pond construction such as depth of 75cm – 2m deep	99 (42.9)	92 (39.8)	40 (17.3)	521	2.26	Applied	14th
Polythene tank	99 (42.9)	94 (40.7)	38 (16.5)	523	2.26	Applied	14th
Use of 0.2mm feed at first week	91 (39.4)	102 (44.2)	38 (16.5)	515	2.23	Applied	16th
Drag net	91 (39.4)	102 (44.2)	38 (16.5)	515	2.23	Applied	16th
Use of 0.5mm feed	91 (39.4)	99 (42.9)	41 (17.7)	512	2.22	Applied	18th
Feed additives	80 (34.6)	122 (52.8)	29 (12.6)	513	2.22	Applied	18th
Use of 2.0mm feed	85 (36.8)	105 (45.5)	41 (17.7)	506	2.19	Applied	20th
Plastic tank	68 (29.4)	139 (60.2)	24 (10.4)	506	2.19	Applied	20th
Use of wooden vats	79 (34.2)	117 (50.6)	35 (15.2)	506	2.19	Applied	20th
Use of 4.0mm feed	82 (35.5)	108 (46.8)	41 (17.7)	503	2.18	Applied	22nd
Proper record keeping	90 (39.0)	82 (35.5)	59 (25.5)	493	2.13	Applied	23rd

Sources: Field survey, 2019

Table 4.2b: Distribution of respondents according to application level of improved aquaculture practices ((n=231))

Variables	Highly Applied	Fairly Applied	Not Applied	Sum	Mean	Decision	Rank
Proper water inlet and outlet	94 (40.7)	68 (29.4)	69 (29.9)	487	2.11	Applied	24th
Oxygen bag for fingerlings transportation	92 (39.8)	69 (29.9)	70 (30.3)	484	2.10	Applied	25th
Ovaprim	57 (24.7)	136 (58.9)	38 (16.5)	481	2.08	Applied	26th
Agricultural lime at the rate of 2270kg/ha (227g/m2)	51 (22.1)	130 (56.3)	50 (21.6)	463	2.00	Applied	27th
Hydrated lime (CaHO)2,	50 (21.6)	123 (53.2)	58 (25.1)	454	1.97	Not applied	28th
Limestone at the rate of 1104kg/ha (104.4g/m2)	39 (16.9)	127 (55.0)	65 (28.1)	436	1.89	Not applied	29th
Production of zooplankton and phytoplankton	65 (28.1)	76 (32.9)	90 (39.0)	437	1.89	Not applied	29th
Using DO meter for oxygen level of 5.0-9.5mg/l	61 (26.4)	83 (35.9)	87 (37.7)	436	1.89	Not applied	29th
Use of plastic vats	53 (22.9)	86 (37.2)	92 (39.8)	423	1.83	Not applied	32nd
Pond water heater	55 (23.8)	62 (26.8)	114 (49.4)	403	1.74	Not applied	33rd
Use of tarpaulins	35 (15.2)	96 (41.6)	100 (43.3)	397	1.72	Not applied	34th
Aerator	49 (21.1)	53 (22.9)	129 (55.8)	382	1.65	Not applied	35th

Sources: Field survey, 2019

4.3 Perception of the Fish Farmers on Application of Aquaculture Practices

Table 4.3 indicated the distribution of the respondents according to perception on the application of aquaculture practices in the study area. The finding indicated that respondents agreed with the following perception statements; the use of aquaculture practices can greatly improve farmers' skills ranked 1st with mean value of ($\bar{X}$ =4.78), implying that proper utilization of aquaculture practices tend to improve farmers skills in fish farming, this mostly occurred through application of improved aquaculture practices. Also, improved practices provide higher yield/income than the old ones ranked 2nd with mean value of ($\bar{X}$ =4.68), implying that application of improved aquaculture practices will not only enhance the yield but also have positive effect on the income of fisher forks. This finding agreed with Pelemo *et al.* (2020) who reported that increase income is the most noticeable effect of adoption of a given technology. Moreover, training is required to correctly apply the improved practices was ranked 3rd with mean value of ($\bar{X}$ =4.61), implying that training must be applied correctly in order to improve aquaculture practices, the improved practices make use of more inputs to give higher output than the old practice ranked 4th with mean value of ($\bar{X}$ =4.53), implying that improved aquaculture practices has ability of increasing output of fish farmers. This is accordance with Sanni (2017) who indicated that application of improved aquaculture technologies enhance fish output in Niger State, Nigeria.

Moreover, respondents furthered agreed with the following perception statements improved practices meet my satisfaction rank 5th with mean value of ($\bar{X}$ =4.50), signifying that application of improved varieties has the ability to meet satisfaction of farmers in the study area.

Table 4.3a: Perception of the fish farmers on application of improved aquaculture practices(n=231)

Variables	Strongly agreed	Agreed	Undecided	Disagreed	Strongly disagreed	Sum	Mean	Decision	Rank
The use of aquaculture practices can greatly improve farmers' skills	185 (80.1)	42 (18.2)	3 (1.3)	1 (0.4)	0	1104	4.78	Agreed	1st
The improved practices provide higher yield/income than the old ones	172 (74.5)	48 (20.8)	7 (3.0)	4 (1.7)	0	1081	4.68	Agreed	2nd
Training is required to correctly apply the improved practices	153 (66.2)	66 (28.6)	12 (5.2)		0	1065	4.61	Agreed	3rd
The improved practices make use of more inputs to give higher output than the old practice	150 (64.9)	57 (24.7)	21 (9.1)	3 (1.3)	0	1047	4.53	Agreed	4th
Improved practices meet my satisfaction	151 (65.4)	58 (25.1)	9 (3.9)	13 (5.6)	0	1040	4.50	Agreed	5th
The practices are cost effective	95 (41.1)	105 (45.5)	25 (10.8)	6 (2.6)	0	982	4.25	Agreed	6th
Most of the practices are environmental friendly	82 (35.5)	120 (51.9)	13 (5.6)	16 (6.9)	0	961	4.16	Agreed	7th
Most of the practices requires patience to achieve desired result	124 (53.7)	60 (26.0)	4 (1.7)	20 (8.7)	23 (10.0)	935	4.05	Agreed	8th
The recommended practices takes too long a time to pay back investment money	124 (53.7)	26 (11.3)	39 (16.9)	42 (18.2)	0	925	4.0	Agreed	9th
Practices can complement existing practices	30 (13.0)	167 (72.3)	7 (3.0)	26 (11.3)	1 (0.4)	892	3.86	Agreed	10th
They are compatible with culture of the land	64 (27.7)	79 (34.2)	71 (30.7)	17 (7.4)	0	883	3.82	Agreed	11th
The recommended practices is compatible with the existing farming systems	47 (20.3)	106 (45.6)	61 (26.4)	17 (7.4)	0	876	3.79	Agreed	12th
The improved practices can give better guarantee of farm improvement than the old practices	100 (43.3)	63 (27.3)	12 (5.2)	31 (13.4)	25 (10.8)	875	3.79	Agreed	12th
The improved practices are not too technical to understand	42 (18.2)	92 (39.8)	81 (35.1)	16 (6.9)	0	853	3.69	Agreed	14th
It is easy to use the improved practices correctly	52 (22.5)	81 (35.1)	70 (30.3)	28 (12.1)	0	850	3.68	Agreed	15th
The recommended practices are too numerous to adopt	13 (5.6)	142 (61.5)	51 (22.1)	18 (7.8)	7 (3.0)	829	3.59	Agreed	16th
It is easy to get the practices for use on	36 (15.6)	80 (34.6)	87 (37.7)	27 (11.7)	1 (0.4)	816	3.53	Agreed	17th
The recommended practices occupies space	59 (25.5)	46 (19.9)	84 (36.4)	36 (15.6)	6 (2.6)	809	3.50	Agreed	18th
The level of skill required to use the recommended practices is too high	16 (6.9)	135(58.4)	6 (2.6)	71 (30.7)	3 (1.3)	783	3.39	Agreed	19th

Sources: Field survey, 2019

This agreed with Pelemo *et al.* (2018) who posits that adoption of post-harvest technologies have ability of meeting farmers basic needs. Also, respondents agreed thatthe practices are cost effective rank 6th with mean value of ($\bar{X}$ =4.25), this implies that application of improved practices in aquaculture do not require much capital and can survive with small capital. In addition, the respondents agreed that most of the practices are environmental friendly rank 7th with mean value of ($\bar{X}$ =4.16), most of the practices requires patience to achieve desired result rank 8th with mean value of ($\bar{X}$ =4.05), the recommended practices takes too long a time to pay back investment money rank 9th with mean value of ($\bar{X}$ =4.0), practices can complement existing practices rank 10th with mean value of ($\bar{X}$ =3.86), they are compatible with culture of the land rank 11th with mean value of ($\bar{X}$ =3.82),the recommended practices is compatible with the existing farming systems rank 12th with mean value of ($\bar{X}$ =3.79), the improved practices can give better guarantee of farm improvement than the old practices rank 12th with mean value of ($\bar{X}$ =3.79).

The respondents furthered agree that improved practices are not too technical to understand rank 14th with mean value of ($\bar{X}$ =3.69). This implies that it requires little technicality in it operation. Also, it is easy to use the improved practices correctly rank 15th with mean value of ($\bar{X}$ =3.68),the recommended practices are too numerous to adopt rank 16thwith mean value of ($\bar{X}$ =3.59), it is easy to get the practices for use on rank 17th with mean value of ($\bar{X}$ =3.53), the recommended practices occupies space rank 18th with mean value of ($\bar{X}$ =3.50), the level of skill required to use the recommended practices is too high rank 19th with mean value of ($\bar{X}$ =3.39), aquaculture practices are too unfamiliar with fish farmers compared to other agricultural technologies rank 20th with mean value of ($\bar{X}$ =3.37), the recommended practices are too numerous to adopt rank 21st with mean value of ($\bar{X}$ =3.12), the improved practices are too technical to understand rank 22nd with mean value of ($\bar{X}$ =3.10), the recommended practices are not economical to adopt rank 23rd with mean value of ($\bar{X}$ =3.09), low level of skills is required to use the recommended improved practices rank 24thwith mean value of ($\bar{X}$ =3.06), the recommended practices has no bearing with the farmers' prosperity rank 25th with mean value of ($\bar{X}$ =3.0).

However, the respondents disagreed with the following perception statement;the recommended practices add little to farmer's knowledge rank 26th with mean value of ($\bar{X}$ =2.98), improved practices are similar to the existing onesrank 27th with mean value of($\bar{X}$ =2.97), the improved practices are easily practicable by beginners rank 28th with mean value of ($\bar{X}$ =2.95), the skills required to use improved practices cannot be easily acquired rank 29th with mean value of ($\bar{X}$ =2.92), Most of the recommended practices have no bearing with the farmers' needs with rank 30th mean value of ($\bar{X}$ =2.87), adopting aquaculture practices give lower return rank 31st with mean value of ($\bar{X}$ =2.42), the improved practices use more inputs to give less output rank 32nd with mean value of ($\bar{X}$ =2.36), the recommended practices are not compatible with farmers' environment rank 33rd with mean value of ($\bar{X}$ =2.26),the recommended practices are too risky to adopt rank 34th with mean value of ($\bar{X}$ =2.23), the improved practices provide lower yields than the old ones rank 35th with mean value of ($\bar{X}$ =2.18) and the improved practices provide lower yields than the old ones rank 36th with mean value of ($\bar{X}$ =1.85). All these weighted mean scores are less than the cut-off means score of 3.0 which shows that they disagreed with the perception statements because all these statements with mean score less than the cut-off mean of 3.0 were not statements that foster adoption of the improved technologies. Therefore a disagreement with the statements means a favourable disposition to the use of the technologies. It could also imply that farmers are not in support the perception statements or probably have different opinions towards the statements (Pelemo *et al.*,2019).

Table 4.3b: Perception of the fish farmers on application of improved aquaculture practices(n=231)

Variables	Strongly agreed	Agreed	Undecided	Disagreed	Strongly disagreed	Sum	Mean	Decision	Rank
Aquaculture practices are too unfamiliar with fish farmers compared to other agricultural technologies	54 (23.4)	80 (34.6)	15 (6.5)	62 (26.8)	20 (8.7)	779	3.37	Agreed	20th
The recommended practices are too numerous to adopt	6 (2.6)	76 (32.9)	88 (38.1)	61 (26.4)	0	720	3.12	Agreed	21st
The improved practices are too technical to understand	1 (0.4)	118 (51.1)	15 (6.5)	96 (41.6)	1 (0.4)	715	3.10	Agreed	22nd
The recommended practices are not economical to adopt	13 (5.6)	108 (46.8)	38 (16.5)	30 (13.0)	42 (18.2)	713	3.09	Agreed	23rd
Low level of skills is required to use the recommended improved practices	42 (18.2)	34 (14.7)	52 (22.5)	103 (44.6)	0	708	3.06	Agreed	24th
The recommended practices has no bearing with the farmers' prosperity	8 (3.5)	84 (36.4)	58 (25.1)	61 (26.4)	20 (8.7)	692	3.00	Agreed	25th
The recommended practices add little to farmer's knowledge	39 (16.9)	89 (38.5)	6 (2.6)	22 (9.5)	75 (32.5)	688	2.98	Disagreed	26th
Improved practices are similar to the existing ones	64 (27.7)	32 (13.9)	6 (2.6)	91 (39.4)	38 (16.5)	686	2.97	Disagreed	27th
The improved practices are easily practicable by beginners	30 (13.0)	59 (25.5)	17 (7.4)	119 (51.5)	6 (2.6)	681	2.95	Disagreed	28th
The skills required to use improved practices cannot be easily acquired	1 (0.4)	103 (44.6)	32 (13.9)	66 (28.6)	29 (12.6)	674	2.92	Disagreed	29th
Most of the recommended practices have no bearing with the farmers' needs	18 (7.8)	46 (19.9)	55 (23.8)	112 (48.5)	0	663	2.87	Disagreed	30th
Adopting aquaculture practices give lower return	21 (9.1)	20 (8.7)	25 (10.8)	135 (58.4)	30 (13.0)	560	2.42	Disagreed	31st
The improved practices use more inputs to give less output	53 (22.9)	9 (3.9)	15 (6.5)	46 (19.9)	108 (46.8)	546	2.36	Disagreed	32nd
The recommended practices are not compatible with farmers' environment	1 (0.4)	16 (6.9)	50 (21.6)	140 (60.6)	24 (10.4)	523	2.26	Disagreed	33rd
The recommended practices are too risky to adopt	1 (0.4)	19 (8.2)	45 (19.5)	134 (58.0)	32 (13.9)	516	2.23	Disagreed	34th
The improved practices provide lower yields than the old ones	2 (0.9)	56 (24.2)	3 (1.3)	90 (39.0)	80 (34.6)	503	2.18	Disagreed	35th
The improved practices provide lower yields than the old ones	7 (3.0)	28 (12.1)	5 (2.2)	75 (32.5)	116 (50.2)	428	1.85	Disagreed	36th

Sources: Field survey, 2019

4.4 Factors Influencing the Application of Improved Aquaculture Practices

The result of the regression model showing factors influencing the application of the improved aquaculture practicesin the study area is presented in Table 4.4. The result of the linear regression analysis showed R^2 value of 66.8 which implies that 67% variation in the improved aquaculture practices in the study area was explained by the independent variables included in the model.The coefficient of age was negative (-.1649953) but significant at 5% level of probability, this means that as fish farmers grow older, there is likelihood of resistingapplicationof improved aquaculture practices.This agrees with the findings of Arowolo *et al*. (2019) who stated that as farmers grow older, they are likely to resist use of new farm innovation. Also, the coefficient of experience in aquaculture (0.56634) was positive but significant at 1% of probability, this indicates that the more years the farmers spent on fish farming the more the tendencies to gain more confidence in the use and application of aquaculture practices. This finding agreed with Sanni (2017) who reported that that increase in farming experience will enhance application of aquaculture technologies in Niger State, Nigeria.

Also, the coefficient of cooperative (17.70519) was positive but significant at 1% level of probability, implying cooperative membership will increase application of improved aquaculture practices. This might owning to the fact that belonging to cooperative enable fishermen to access capital and other incentives that would create good atmosphere for the application of improved aquaculture practices.The findings agreed with that of Meinzen *et al.* (2004), who stated that cooperatives open avenues for income generation that will enhance farmers' activities. More so, the coefficient of household size (-.7542798) was negative but significant at 1% of level of probability, this showing that farmers with small household will likely practice improved aquaculture farming. This might be to augment inadequate family labour. This finding contradicts that of Arowolo *et al.,* (2019 who reported that increase in household size increases effectiveness of fish farmers in social capital formation. Also, the coefficient of extension services (1.590344) was positive but significant at 1% level of probability, implying that access to extension is expected to improve aquaculture practices because extension grantsfishermen opportunities to new innovations and practices that will enhance their productivity.This is in consonance with Adjornon *et al.,* (2014) who emphasized that access of extension will have positive effect on farmers'knowledge on improved practices.

Moreover, perception scores was positive and significant at 1% level of probability, implying that increase in farmers' perception will lead to application of aquaculture practices. Also, the coefficient of output (.0006172) was positive and significant at 1% level of probability, implying that increase in output is expected to increase aquaculture practices. This agreed with Sanni (2017) who reported that adoption of improved technologies among fish farmers in Niger State played significant roles at increasing their output and income, respectively.

Table 4.4: Regression estimate on factors influencing the application of improved aquaculture practices by fish farmers(n=231)

Variables	Coefficient	t-value
Age	-.1649953	-2.03**
Sex	-.7352663	-0.27
Marital status	.814395	0.35
Experience in aquaculture	.56634	2.83***
Membership of cooperative	17.70519	4.48***
Education	-.1594174	-0.74
Household size	-.7542798	-2.94***
Extension contact	1.590344	3.68***
Perception score	.3435721	3.29***
Output	.0006172	2.58***
Constant	28.61104	2.11**
F-value	23.56	
R-squared	0.6678	
Adj R-squared	0.6345	

Sources: Field survey 2019

Note: *** significant at 1% level of probability, **=Significant at 5% level of probability, *=significant at 10% level of probability

4.5 Effects of Improved Aquaculture Practices Application on Fish Farmers' Output

The result of the regression model showingeffects of the improved aquaculture practices application on fish farmers' output the in the study area is presented in Table 4.5. The result of the multiple regression analysis showed R^2 value of 0.943 which implies that 94% variation in the improved aquaculture practices application on fish farmers' output in the study area was explained by the independent variables included in the model. Four functional forms (linear, exponential, double log and semi log) were tried. Exponential log function gave the best fit. The coefficient of fingerlings (.0000825) was positively significant at 1% level of probability, implying that increase in fingerlings will have significant increase on the output of fish farmers. This agreed with Sanni (2017) who reported that increase in fingerlings increases fish farmers output in Niger State, Nigeria. Also, the coefficient feed (.000154) was positive but significant at 10% level of probability, implying that availability of feed will increase the fish size and have effect on fish farmers output.

Moreover, the coefficient of fertilizer (.0013279) was positively significant at 1% level of probability. This result indicates as it is being applied to the ponds it prepares the pond for fish growth and sustain goodof the edaphic conditions of the ponds. This is in consonance with Wetengere(2016) that observed efforts towards water quality management in aquaculture tends to improve output of the fish and consequently better income. Further findings showed that the coefficient of depreciation (-3.38e-06) was negatively significant at 5% level of probability, implying that reduction in depreciation increase fish farmers output. Also, the coefficient of labour (-.0012519) was negatively significant at 1% level of probability, implying that reduction in labour increase fish farmers income. This finding agreed with Sanni (2017) who reported that reduction in depreciation and labour usage are expected to have positive effect on application of aquaculture technologies.More so, the coefficient of age -.0046984 was negatively significant at 1% level of probability, implying that as farmers get older, their output reduce. This agreed with Pelemo *et al.,* (2018) who reported that as farmers' advances in age adoption of post-harvest practices reduce. This is because at that age they tend to be pessimistic due to the previous experience.

The coefficient of education (.0067926) was positively significant at 1% level of probability, implying that increase in education is expected to increase fish farmers output. This agreed with

Olaoye *et al.,* (2013) who stated that education played important roles in aquaculture production. Moreover, the coefficient of household size (.010459) was positive but significant at 5% level of probability increase in household size will increase fish farmers output. This is in line with Olalekan *et al.,* (2016), who reported that addition of one number to family is expected to increase farmers output. Also, the coefficient of application score was positive significant at 1% level of probability, implying that increase in application score increase farmers fish output.This result is in agreement with the findings of Sanni. (2017) whoobserved that increased productivity and income is a functionof increased and improved adoption of the farmers.

Table 4.5: Regression estimates on the effects of improved aquaculture practices application on fish farmers' output(n=231)

Variables	Linear Coefficient	t-value	Exponential Coefficient	t-value	Cobb douglas Coefficient	t-value	Semi-log Coefficient	t-value
Fingerlings	1.059614	27.06***	.0000825	8.54***	.6313611	22.29***	4996.091	14.39***
Feed	1.046756	2.86***	.000154	1.71*	.101011	4.36***	790.3703	2.78***
Fertilizer	1.785441	4.79***	.0013279	14.45***	.3357481	10.02***	-801.4523	-1.95*
Depreciation	-.0059344	-0.95	-3.38e-06	-2.20**	.0135616	1.25	-21.82472	-0.16
Labour	1.758288	1.85*	-.0012519	-5.35***	-.0420224	-1.19	1328.126	3.06***
Age	2.980272	0.56	-.0046984	-3.59***	.0448217	1.30	-380.9095	-0.90
Experience	-3.243253	-0.25	-.0040727	-1.29	.0592448	3.55***	-288.9718	-1.41
Education	26.27817	2.12**	.0067926	2.23**	.0215306	1.96*	58.52805	0.43
Household size	52.07661	3.07***	.010459	2.50**	.0654611	3.29***	-183.9719	-0.76
Extension	61.39551	1.92*	-.0004376	-0.06	-.0030972	-0.38	14.36661	0.14
Application score	10.05843	2.32**	.0055527	5.19***	.1733559	3.00***	335.6724	0.47
Constant	358.6849	0.82	7.618343	70.76***	1.469293	5.21***	-40299.36	-11.67***
F-value	1%		1%		1%		1%	
R-squared	0.9614		0.9435		0.9747		0.8422	
Adj R-squared	0.9595		0.9407		0.9734		0.8343	

Sources: Field survey 2019

Note: *** significant at 1% level of probability, **=Significant at 5% level of probability, *=significant at 10% level of probability

4.5 Constraints to Application ofImproved Aquaculture Practices

Table 4.6showed the results of constraining factors to improved aquaculture practices application. Itrevealed that the following were serious constraints by respondents in the study area, environmental pollution ranked 1st with mean value of with mean value of ($\bar{X}$ =3.0). This implies that environmental pollution such as use of toxic chemical is a serious constraint to improve aquaculture practices in the study. This was followed by unfavorable weather conditions for fish growth ranked 2ndwith mean value of ($\bar{X}$ =2.95), implying that unpleasant condition of weather condition such as waves and wind were serious constraints to improve aquaculture practices in the study area. This mostly arises when unfavorable weather condition interferes with fishing activities and also exposes fish forks to dangers. These agreed with Arowolo *et al.*(2019), who stated that environmental pollution and unfavorable weather condition were the major constraints affecting fisher forks in Kainji Lake Basin. Also, flooding of ponds during rains was ranked 3rdwith mean value of ($\bar{X}$ =2.90),implying that flood which arise as a result of heavy downpour is one of the major and serious factors to improve aquaculture practices in the study area, flood mostly arise from excessive downpour that wash away fish forks pond together with their fish. This furthered agreed with Arowolo *et al*. (2019), which reported that excessive flooding is serious constraints faced by fishermen in Kainji Lake Basin of Nigeria.

Moreover, lack of technical know-how for the production of zoo planktons was ranked 4thwith mean value of ($\bar{X}$ =2.86), this was followed by no effective policy ranked 5thwith mean value of ($\bar{X}$ =2.85), this implies that lack of technical know-how in the production of zoo-plankton and effective government policy were one of the serious constraint to improve aquaculture practices in the study area. This is consonance with work of Sanni (2017), who reported that lack of technical know-how in the production of zoo-plankton and effective government policy were one of the major constraint to improved fish technologies in Niger State of Nigeria. Furthermore, scarcity of improved fingerlings was ranked 6thwith mean value of ($\bar{X}$ =2.84), this implying that respondents did not access to improve fingerlings that would have possibly enhance their output in the study area. This agreed with Baruwa *et al.*(2015), who reported that majority of Fishermen Lagos State, Nigeria, lacked access to improve fingerlings.

Others serious constraints to improve aquaculture practices in the study area were inadequate power supply ranked 7thwith mean value of ($\bar{X}$ =2.83), poor quality of water ranked 8thwith mean value of ($\bar{X}$ =2.77), lack of good market ranked 9thwith mean value of ($\bar{X}$ =2.74), inappropriate feeds application ranked 10thwith mean value of ($\bar{X}$ =2.72), inadequate capital for farm expansion ranked 11thwith mean value of ($\bar{X}$ =2.67), problem of soil acidity ranked 12th with mean value of ($\bar{X}$ =2.63), application of gamalin 20 by quacks ranked 13thwith mean value of ($\bar{X}$ =2.62), lack of good brood stocks ranked 14thwith mean value of ($\bar{X}$ =2.61), inconsistencies in government policy ranked 15thwith mean value of ($\bar{X}$ =2.57), inadequate good fish feeds ranked 16thwith mean value of ($\bar{X}$ =2.53).

In addition, the following constraining factors to improved aquaculture practices application were not serious inadequate training services ranked 17thwith mean value of ($\bar{X}$ =2.48), implying that training was not a serious constraint to improve aquaculture practices. Other not serious constraints according to respondents were, inadequate technical know-how ranked 18thwith mean value of ($\bar{X}$ =2.45), sales of wild field ranked 19th with mean value of ($\bar{X}$ =2.34), distance from NIFFR research institute too far ranked 20thwith mean value of ($\bar{X}$ =2.34), presence of quacks in the industry ranked 21stwith mean value of ($\bar{X}$ =2.26), problems of predators ranked 22ndwith mean value of ($\bar{X}$ =2.25), machine for floating fish feeds not functional ranked 23rdwith mean value of ($\bar{X}$ =2.12), improved feed are expensive ranked 24th with mean value of ($\bar{X}$ =1.90) and problems of pest and diseases ranked 25th with mean value of ($\bar{X}$ =1.87). In general, the above constraints that are not serious simply implies they are not a constraints and do not affect aquaculture practices in the study area.

Table 4.6: Distribution of respondents according to constraining factors to improved aquaculture practices application(n=231)

Variables	Very serious	Serious	Slightly serious	Not a constraint	Sum	Mean	Decision	Rank
Environmental pollution	82 (35.5)	94 (40.7)	28 (12.1)	27 (11.7)	693	3.0	Serious	1st
Unfavorable weather conditions for fish growth	98 (42.2)	62 (26.8)	33 (14.3)	38 (16.5)	682	2.95	Serious	2nd
Flooding of ponds during rains	73 (31.6)	84 (36.4)	51 (22.1)	23 (1.0)	669	2.90	Serious	3rd
Lack of technical know-how for the production of zoo planktons	53 (22.9)	103 (44.6)	65 (28.1)	10 (4.3)	661	2.86	Serious	4th
No effective policy	81 (35.1)	58 (25.1)	68 (29.4)	24 (10.4)	658	2.85	Serious	5th
Scarcity of improved fingerlings	72 (31.2)	72 (31.2)	65 (28.1)	22 (9.5)	656	2.84	Serious	6th
Inadequate power supply	76 (32.9)	67 (29.0)	60 (26.0)	28 (12.1)	653	2.83	Serious	7th
Poor quality of water	68 (29.4)	53 (22.9)	100 (43.3)	10 (4.3)	641	2.77	Serious	8th
Lack of good markets	64 (27.7)	56 (23.8)	99 (42.9)	13 (5.6)	632	2.74	Serious	9th
Inappropriate feeds application	61 (26.4)	70 (30.3)	74 (32.0)	26 (11.3)	628	2.72	Serious	10th
Inadequate capital for farm expansion	68 (29.4)	57 (24.7)	67 (29.0)	39 (16.9)	616	2.67	Serious	11th
Problem of soil acidity	37 (16.0)	97 (42.0)	71 (30.7)	26 (11.3)	607	2.63	Serious	12th
Application of Gamalin 20 by quacks	38 (16.5)	101 (43.7)	59 (25.5)	33 (14.3)	606	2.62	Serious	13th
Lack of good brood stocks	72 (31.2)	39 (16.9)	78 (33.6)	42 (18.2)	603	2.61	Serious	14th
Inconsistencies in government policy	57 (24.7)	61 (26.4)	69 (29.9)	44 (19.0)	593	2.57	Serious	15th
Inadequate good fish feeds	60 (26.0)	50 (21.6)	74 (32.0)	47 (20.3)	585	2.53	Serious	16th
Inadequate training services	44 (19.0)	60 (26.0)	91 (39.4)	36 (15.6)	574	2.48	Not serious	17th
Inadequate technical know-how	47 (20.3)	70 (30.3)	53 (22.9)	61 (26.4)	565	2.45	Not serious	18th
Sales of wild fish seeds	44 (19.0)	61 (26.4)	56 (24.2)	70 (30.3)	541	2.34	Not serious	19th
Distance from NIFFR research institute too far	43 (18.6)	40 (17.3)	97 (42.0)	51 (22.1)	537	2.32	Not serious	20th
Presence of quacks in the industry	36 (15.6)	60 (26.0)	62 (26.8)	73 (31.6)	521	2.26	Not serious	21st
Problems of Predators	37 (16.0)	56 (24.2)	65 (28.1)	73 (31.6)	519	2.25	Not serious	22nd
Machine for floating fish feeds not functional	13 (5.6)	57 (24.7)	105 (45.6)	56 (24.2)	489	2.12	Not serious	23rd
Improved feeds are expensive	17 (7.4)	18 (7.8)	121 (52.4)	75 (32.5)	439	1.90	Not serious	24th
Problems of pest and diseases	7 (3.0)	29 (12.6)	121 (52.4)	74 (32.0)	431	1.87	Not serious	25th

Sources: Field survey 2019

4.7 Hypotheses Testing

Hypothesis I

The result of hypothesis I from Z-value of linear regression revealed a significant relationship between some selected socio-economic characteristics such as age (-.1649953), experience in fish farming (.56634), cooperative (17.70519), household size (-.7542798), extension contact (1.590344) and application of improved aquaculture technologies. However the null hypothesis that stated that there is no significant relationship between selected socio-economic characteristics of the respondents and their application of improved aquaculture technologies is rejected

Hypothesis II

The results of the hypothesis II in Table 4.7 showed a significant relationshipbetween the application of improved aquaculture technologies and perception of the fish farmers'. Therefore the null hypothesis is rejected.

Table 4.7: Relationship between the perception of the fish farmers' and application of improved aquaculture technologies (n=231)

Variables	Coefficient	Significant level
Perception	0.0182	0.1552*

Sources: Field survey 2019

**=Significant at 5% level of probability

CHAPTER FIVE

5.0 CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Based on the findings, it can be concluded that fishermen in the study were in their middle age and majority of them were males. Also, majority of the respondents were married and members of one cooperative. Moreover, majority of the respondents had formal education and extension contacts. Further findings revealed that practices; medication to treat stress, control pest and disease sorting density to separate jumpers were the most improved aquaculture practices applied by the respondents. Also, respondents agreed that aquaculture practices can greatly improve farmers' skills and improved practices provide higher yield/income than the old ones. Further findings revealed that the coefficient of age, fishing experience, cooperative membership, household size, extension access, perception scores and output had significant influence on the application of improved aquaculture practices. Also, the coefficient of fingerlings, feed, fertilizer, depreciation, labour, age, education level, household size and application score had significant effect on fish farmers' output. The constraints factors to improve practices in the study area were, environmental pollution, unfavorable weather conditions for fish growth and flooding of ponds during rains.

5.2 Recommendations

The following recommendations were made based on the empirical findings of the study

i. Majority of the respondents were males in the study area. However, women should be encouraged by extension agents to embrace aquaculture practices in order to enhance their livelihood.
ii. Regular popularization, training and empowerment should be ensured to further level of awareness, perception and application of aquaculture practices
iii. Environmental pollution is the most constraining factors to improve aquacultures practices in the study area. Therefore, fish farmers should put in place every measure to avert environmental pollution such as use of gamalin and other hazardous chemicals that are toxic to fishes.
iv. Scarcity of improved fingerlings is one of the most serious constraints faced by fish farmers in the study area. However, extension officers and research institutes should ensure that fish farmers adequately access improve fingerlings that will enhance their productivity
v. Inadequate capital is one of the serious constraining factors to improve aquaculture practices. Therefore, there should public- private partnership on the establishment of feed mills with capability of making floating feeds in strategic areas of the basins at affordable rate
vi. It is recommended that young and middle age farmers should be enlightened on the benefits embedded in improved aquaculture practices in order to enhance their output
vii. Inadequate power supply was one of the serious constraining factors to improve aquaculture practices in the study area. However, alternative power supply such as solar power and standby generator must be used byfish farmers in order to correct the problem associated with erratic nature of power supply.

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APPENDIX I

Name of Enumerator (Optional) / Phone Number:______________________________

Name of Respondent (Optional) / Phone Number:______________________________

Community:_____________________________

Questionnaire Number:____________________

Section A:Socio-economic Characteristic of Fish Farmers

1. Age ………………………………………….. (years)
2. Sex: Male ( ) Female ( )
3. What is your marital status?

Married ( ) Single ( ) Separated ( ) Divorced ( ) Widow ( )

4. How long have you been in fish farming? .... (years)
5. Do you belong to any association, or cooperative society?
   (a) Yes ( ) (b) No ( )
6. If yes which association/cooperative do you belong?
   a) Association of cat fish farmers ( )
   b) Farmers' cooperative ( )
   c) Local thrift society ( )
   d) Religious association ( )
   e) Others (specify)……………………………………..
7. (i) Do you have any formal education? (a) Yes ( ) (b) No ( )
8. (ii) If yes how many years did you spend in formal education? …………………(years)
9. What is your level of education?
   (a) No formal education ( )
   (b) Primary education ( )
   (c) Secondary /primary education ( )
   (d) Tertiary education ( )
10. What is the size of your household? –: Male………..Female…………Total…………

11. What is your main occupation?

(a) Fish farming ( )

(b) Crop or livestock agriculture ( )

(c) Non-agriculture ( )

(d) Others (specify) ( )

12. Did you have any contact with extension agent? (a) Yes ( ) (b) No ( )

13. How many times did you have contact with the fisheries extension agents in the last one year? ………………………………..

SECTION B: Level Application of Improved Aquaculture Practices

S/No	IT	HA	MA	LA
	Feeding techniques			
1	Use of 0.2mm feed at first week			
2	Use of 0.5mm feed			
3	Use of 2.0mm feed			
4	Use of 4.0mm feed			
5	Use of locally made feed with 40-45% crude protein			
	Fish Culture Mgt			
6	Use of fast-growing tilapia, carp and or catfish for stocking			
7	Sorting density to separate jumpers			
8	Medication to treat stress, control pest and disease			
9	Use of threads to control predator birds			
10	Use of ash to control acidity in pond			
11	Use of organic or inorganic fertilizer			
12	Knowledge on rainfall emergence and distribution.			
	Fish farm management			
13	Proper site selection with good source of water			
14	Pond construction such as depth of 75cm – 2m deep			
15	Proper water inlet and outlet			
16	Oxygen bag for fingerlings transportation			

17	Proper record keeping			
18	Farmers' group Association			
19	Accessibility of credit in banks for farm			
	Rearing enclosure			
20	Plastic tank			
21	Polythene tank			
22	Use of wooden vats			
23	Use of plastic vats			
24	Use of tarpaulins			
	Liming technique			
25	Hydrated lime $(CaHO)_2$,			
26	Limestone at the rate of 1104kg/ha (104.4g/m^2)			
27	Agricultural lime at the rate of 2270kg/ha (227g/m^2)			
	Water quality and quantity			
28	Pond water heater			
29	Aerator			
30	Production of zooplankton and phytoplankton			
31	Using DO meter for oxygen level of 5.0-9.5mg/l			
	Injectable chemicals			
32	Ovaprim			
33	Feed additives			
	Techniques of Harvesting			
34	Drag net			
35	Scoop net			
36	Water pumping machine			

Key; IT=Improved Technologies; (1); A= Applied (2); U= Undecided (3) N= Not applied

SECTION C: Perception statements on the application of improved aquaculture practices

14. Please tick appropriately

S/ No	Perception statements on improved aquaculture technologies	SA 5	A 4	U 3	D 2	SD 1
1	Improved practices are similar to the existing ones					
2	Improved practices meet my satisfaction					
3	The recommended practices is compatible with the existing farming systems.					
4	Training is required to correctly apply the improved practices					
5	It is easy to use the improved practices correctly					
6	The improved practices are not too technical to understand					
7	Low level of skills is required to use the recommended improved practices					
8	The use of aquaculture practices can greatly improve farmers' skills					
9	The improved practices provide higher yield/income than the old ones					
10	The improved practices make use of more inputs to give higher output than the old practice					
11	They are compatible with culture of the land					
12	The practices are cost effective					
13	It is easy to get the practices for use on					
14	practices can complement existing practices					
15	The practices are easily practicable by beginners					
16	Most of the practices are environmental friendly					
17	The improved practices can give better guarantee of farm improvement than the old practices					
18	The improved practices use more inputs to give less output					
19	The skills required to use improved practices cannot be easily acquired					
20	The level of skill required to use the recommended practices is too high					
21	The improved practices are too technical to understand					
22	The improved practices provide lower yields than the old ones					
23	The improved practices provide lower yields than the old ones					
24	The recommended practices are not economical to adopt					
25	The recommended practices are too numerous to adopt					
26	The recommended practices has no bearing with the farmers' prosperity					
27	The recommended practices are too risky to adopt					
28	The recommended practices are not compatible with farmers' environment					

29	The recommended practices are too numerous to adopt					
30	Most of the recommended practices have no bearing with the farmers' ego					
31	The recommended practices takes place					
32	The recommended practices takes too long a time to pay back investment money					
33	Most of the practices requires patience to achieve desired result					
34	Aquaculture practices are too unfamiliar with fish farmers compared to other agricultural technologies					
35	Adopting aquaculture practices give lower return					
36	The recommended practices add little to farmer's knowledge					

KEY SA (Strongly Agree); A (Agree); U (Undecided); D (Disagree); SD (Strongly Disagree

SECTION D: Effect of Improved Aquaculture Practices Application on Fish Farmer's Output

15. What is your stocking density? ……………………………………………….(kg)
16. What was your yield (tons of fish harvested in kg) the previous year before application of improved practices? …………………………………………………………………
17. What was your yield (in tons) the following year after application of these practices?...
....
18. What was your output(in kg) the previous year before application of these improved practices? ……………………………………………………………………..
19. How much did you spend on the following farm activities in your fish farming enterprise in a production cycle?

Family labour				Hired labour			
Farm operations	No of people	No of days	Cost/person/day	No of days	Cost/person/day	Total cost	
Pond construction							
Pond dressing							

Liming							
Pond fertilizer							
Stocking of fingerlings							
Feeding							
Water replacement							
Fish sampling							
Harvesting							
Transportation							
Others							

20. What is the quantity, cost per unit, total cost and lifespan of the following items in your fish farm business

S/N	Quality	Cost/unit	QTY	Total cost	Time spent	lifespan
	Fixed capital					
1	Land					
2	Vehicle					
3	Pumping machine					
4	Generator					
5	Earthen pond					
6	Concrete pond					
7	Drag net					
8	Weight scale					
9	Wheel barrow					
10	Hose					
11	Digger					
12	Cutlass					
13	Others					
	Working assets					
14	Fingerlings					
15	Imported feed					
16	Compounded feed					
17	Lime					
18	Fertilizer					
19	Drugs					
20	Fuel/lubricant					
21	Water					
22	Others					

SECTION E: Farmer's Constraining

21. Tick as appropriate

S/N	Constraining Factors	Very serious	Serious	Slightly serious	Not a constraints
1	In adequate Capital for farm Expansion				
2	Inadequate power supply				
3	Improved feeds are expensive				
4	Machine for floating fish feeds not functional				
5	Inadequate quality of water				
6	Inadequate good fish feeds				
7	Lack of good brood stocks				
8	Inconsistencies in government policy				
9	Inadequate training services				
10	Distance from NIFFR too far				
11	Problems of pest and diseases				
12	Lack of good markets				
13	Scarcity of improved fingerlings				
14	Problem of soil acidity				
15	Sales of wild fish seeds				
16	Flooding of ponds during rains				
17	Unfavorable weather conditions for fish growth				
18	Environmental pollution				
19	Presence of quacks in the industry				
20	No effective policy				
21	Inadequate technical know how				
22	Problems of Predators				
23	Inappropriate feeds application				
24	Lack of technical knowhow for the production of zoo planktons				
25	Application of Gamalin 20 by quacks				