COMPARATIVE PROFITABILITY AND TECHNICAL EFFICIENCY OF FISH FARMING IN SELECTED LOCAL GOVENRMENT AREAS OF KADUNA STATE, NIGERIA

BY

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DECLARATION

I hereby declare that this thesis entitled "**Comparative Profitability and Technical Efficiency of Fish Farming in Selected Local Government Areas of Kaduna State, Nigeria"** has been written by me and that it is a record of my own research work. No part of this work has been presented in any previous application for another degree or diploma at any institution. All borrowed information has been duly acknowledged in the text and a list of references provided.

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Yahaya Abdulhadi AMIN **Date**

CERTIFICATION

This thesis entitled "**Comparative Profitability and Technical Efficiency of Fish Farming in Selected Local Government Areas of Kaduna State, Nigeria"** by Aminu Yahaya Abdulhadi meets the regulations governing the awards of the degree of Doctor of Philosophy of Ahmadu Bello University, Zaria, and is approved for its contribution to knowledge and literary presentation.

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DEDICATION

This work is dedicated to my first mentor Sa’adatu Adamu; my dear mother.

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ABSTRACT

This study was carried out to provide empirical information on the economic viability of fish farming in Kaduna State across various scales of production. The specific objectives of the study were to describe the socio-economic characteristic of fish farmers in the study area; determine costs and returns of fish farming at various scales; determine the technical relationship between production inputs and output in fish farming; quantify the level of technical efficiency of fish farmers operating at various scales of operation; determine the factors influencing technical efficiency of fish farming and describe the constraints limiting efficiency of fish farming in the study area. Primary data were collected with the aid of structured questionnaire administered to 115 fish farmers in 18 out of the 23 Local Government Areas of the State. The 115 fish farmers were identified through a pilot study of existing farms in the state. Descriptive statistics, farm budgeting technique and stochastic frontier production function were used to analyze the data while ANOVA was used to test hypothesis. The results showed that 42.6% of the fish farmers were within the productive age bracket of 40-49 years and the enterprise was male dominated (with 70.4%), while 57.4 of the farmers had only vocational education. The farming experience of 74.8% of the farmers was between 1 and 5 years indicating that majority of farmers are new in the enterprise. The study found out that fish farming was profitable at various scales of production with returns to investments of 1.97 and, given the current level of technology at the disposal of the fish farmers, they have a scope of improving on their current level of technical efficiency by 37%. The study also found that there was existence of economy of scale in fish farming in the study area as the average cost per stock was N86.35, N127.66 and N154.74 for the large, medium and small scale fish farmers, respectively, and the difference was statistically significant at 1% probability level. The study found that the return to scale in fish farming was less than unity (0.6971) indicating a positive decreasing return to scale. However it was observed that labor is over utilized. The ANOVA results show a significant difference in the profitability and efficiency of the fish farmers with F values of 8.24 and 21.11 respectively, both at 1% probability level. The major inefficiency factors were age and education which were statistically significant at 10% and 5%, respectively. The major constraints were pilferage, flooding and stunted growth. Part of the recommendation of the study is that fish farmers should be encouraged to join fish farmers' association so as to have access to fisheries inputs and knowledge on improved farming practices. It is also recommended that there is need to improve the technical knowhow of the fish farmers through workshops as they are yet to attain frontier level.

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CHAPTER ONE

INTRODUCTION

1.1 Background to the Study

Throughout the centuries, fish has been an important component of human diet in many parts of the world. Fish catches increased rapidly over the past hundred years due to improved technology which provided more powerful fishing engines and equipment. This led to over fishing and caused a worldwide decrease in wild stocks and the need to increase fish production by fish farming (aquaculture) (Carballo *et al*., 2008). The term ‘aquaculture’ covers all forms of cultivation of aquatic animals and plants in fresh, brackish and saltwater. Aquaculture has the same objective as agriculture, namely, to increase the production of food above the level that would be produced naturally.

Nigerians are high fish consumers and offer the largest market for fish and fisheries products in Africa. Fish farming has thus become an important venture in the quest for food security and eradication of malnutrition especially among infants (Awotide, 2012). With an annual fish demand in the country of about 2.66 million tonnes, and a paltry domestic production of about 780,000 tonnes, the demand-supply gap stands at a staggering 1.8 million tonnes. Despite the popularity of farming in Nigeria, the fish farming industry can best be described as being at the infant stage when compared to the large market potential for its production and marketing (Nwiro, 2012). Although aquaculture in Nigeria has the potential for satisfying the increased demand for protein and has been experiencing unprecedented growth during the last decade, question remains regarding the sustainable development of the industry(Adeogun, 2012).

Fish farming activity in Nigeria started about 50 years ago, with the establishment of a small experimental station at Onikan Lagos and an industrial farm about 20ha at Panyam in Plateau State by the Federal Government of Nigeria (Olagunju, 2007). This generated a lot of interest in fish farming with the involvement of other levels of government and some private establishments.

In recent times, Nigeria has witnessed an unprecedented interest by entrepreneurs in fish farming. This is largely due to scarcity of fish in the local markets in addition to the high export potentials of our local shell fish species in international markets. The use of high technology in catfish farming is the latest in aquaculture system that has attracted numerous investors due to its tremendous success.

The Nigerian aquaculture industry, driven mainly by catfish farming, is seen as the fastest growing sub-sector in the Nigerian fish industry. Fish farming is rapidly gaining grounds in the northern part of Nigeria since the 1990s. Suffice to note however, that the rate of development has hastened right from 2005 when the Bird Flu scourge laid its deadly hands on the poultry industry. This made many poultry farmers to wisely diversify into or change their businesses to fish farming which has much less risk and yet a shorter production period, less consumer resistance, a wider market and much more revenue yielding. Prior to this period, the Sahel and Sudan Savannah Zones of the upper North, according to popular belief, are the most unlikely areas to raise fish in Nigeria. With very hot days and very cold nights, little or no surface drainage, intense sunlight, low rainfall and very low relative humidity, the area is indeed a difficult place to raise fish. However, in view of the current trend in development and evolution of aquaculture science and technology, fish farming is now very possibleanywhere, even in arid environments (www.businessday.com, 2008).

Fish farming has great potentials for the production of high quality food for domestic use and export. However, it is still relatively new and on small scale especially in the Northern parts of the country. This problem is compounded by the increasing encroachment of the Sahara desert (almost two kilometers a year); ageing and perennial drying up of rivers and streams; the rising diurnal heat: extensive situation and shrinking of the Lake Chad and consequent low fish catches (Sharon, 2008). However, even with the enormous potential for fish farming in the north, the problem of protein deficiency has continued unabated. The need therefore arose, to explore aquaculture as a means of curbing this menace. It is against this background that this research is embarked upon with a view to explore the investment potential in aquaculture in Kaduna State.

1.2 Problem Statement

According to the Federal Department of Fisheries Statistics (1991-2000), the total fish production in Nigeria for ten-year period (1991-2000) averaged about 420, 000 metric tonnes (MT), whileproduction from aquaculture during the same period ranged from 15,840 to 25,720 metric tonnes. Aquaculture therefore accounted for only 5.3 % to 6.2 % of total fish production (Business Daily Online, 2008).As a maritime nation with a vast population of over 160 million people and a coastline measuring approximately 853 kilometres, fish production as an enterprise possesses the capacity to contribute significantly to the agricultural sector of Nigeria (Osagie, 2012).

Out of 35 grams of animal protein per day per person recommended by F.A.O, less than 7 grams is consumed by Nigerians on the average. As a result of this, many Nigerians suffer from protein deficiency due to low protein intake. In order to meet up with domestic fish need, Nigeria has become one of the largest importers of fish in the developing world, importing about 600,000 MT annually. This is a real burden onthe limited foreign exchange (FAO, 1991).

Spaulding *et al*. (1997) observed that the major constraints to fish farming were related to environmental impacts of aquaculture operations such as water pollution, inadequate supply of fingerlings, inadequate information and feeds supply. Fish pond aquaculture production is currently very low, estimated at below 10,000 MT per annum from a total water surface area of about 5, 500 hectares. It has been estimated that if Nigeria is to be self-sufficient in fish production through aquaculture, a total of about 900,000 MT of fish a year is required i.e. estimated at a minimum production of one metric tonper hectare per year.

Since fish culture is basically a commercial venture, private investors are being encouraged to go into this business. Banks and commercial houses are currently showing increased interest in granting investment loans for such ventures following the sudden decline in the poultry industry due to the high cost of feeds and the menace of bird flu (FAO, 2007). Nigerian investors have been forced to explore new possibilities, particularly in animal husbandry and aquaculture. Aquaculture has attracted much interest on account of assumptions that there is limited risk in terms of mortality from natural sources, and that the feeding of fish is not as complicated as that of poultry and may not require imported feed concentrates with high foreign exchange needs. Based on these assumptions, some investors have plunged headlong into this new field of animal farming with little or no in-depth knowledge of fish farming or supporting information on its feasibility and the consequence is risk of dismal failure in the venture (FAO, 2007).

It is pertinent to note that the issue of economic analysis is very crucial in project conception and implementation. For this reason, this study was conceived with the aim of providing empirical information on the economic viability to prospective investors on fish farming (aquaculture) in Kaduna State across the various scales of production. The following research questions were addressed in this study:

i. What are the socio-economic characteristics of fish farmers operating at various scales of production in the study area?
ii. What are the costs and returns (profitability)of fish farming at various scales of operation?
iii. What is the technical relationship between production inputs and output in fish farming?
iv. What is the level of technical efficiency of fish farmers operating at various scales?
v. What are the factors influencing technical efficiency of fish farming?
vi. What are the constraints limiting efficiency of the existing fish farming in the study area

1.3 Objectives of the Study

The main objective of the study wasto analyze the scale efficiency and profitability of fish farming in selected Local Government Areas of Kaduna State, Nigeria. The specific objectives were to:

i. describe socio-economic characteristics of fish farmers in the study area;

ii. determine the costs and returns (profitability)of fish farming at various scales of operation;

iii. determine thetechnical relationship between production inputs and output in fish farming;

iv. quantify the level of technical efficiency of fish farmers at various scales;

v. identify the factors influencing technical efficiency of fish farming;

vi. describe the constraints limiting efficiency of the existing fish farming in the study area.

1.4 Justification of the Study

Based on the current trend in development and evolution of aquaculture science and technology, fish farming is now very possible anywhere, even in arid environments. Prior to this evolution, the Sahel and Sudan Savannah zones of the upper North, were the most unlikely areas to raise fish. The increasing encroachment of the Sahara desert (almost two kilometers a year); ageing and perennial drying up of rivers and streams; the rising diurnal heat; and shrinking of the Lake Chad have caused relative scarcity of fish, and this therefore called for the need to improve on fish production through aquaculture (Sharon, 2008).

The fledgling aquaculture industry in the northern States surely could have terrific potentials to develop, expand and generate wealth and jobs, particularly in rural communities with limited economic alternatives. Progress in this direction clearly looks very promising. Wealth from aquaculture has brought economic prosperity to rural dwellers in many developing countries such as Thailand, Indonesia, India, Malaysia, Taiwan and China. Employment in the sector is growing faster than population and it isnot only a source of wealth but of heath; aquaculture is playing significant role in eliminating hunger, promoting health and reducing poverty.More than ever before, aquaculture and fisheries has become a source of food, employment and income, as well as providing raw materials for production fertilizer and other farm inputs, and domestic products in the Developing World (FAO, 2014).

It is hoped that the findings of this dissertation will be of immense benefits to potential investors, farmers, extension workers and financial institutions to provide the most viable options for investment and opportunities for wealth creation. This research will also be useful to policy makers to develop strategy for development of a robust aquaculture industry to complement the livestock and agricultural cash crop productions that could translate into the much needed industrial growth for the country.

1.5 Hypotheses

The following hypotheses were tested in the study:

i. There is no significant difference in the Profitability between the small, medium and large scale fish farmers in the study area

ii. There is no significant difference in technical efficiency between the small, medium and large scale fish farmers in the study area

CHAPTER TWO

LITERATURE REVIEW

2.1Fish Production Trend in Nigeria

The performance of the fisheries sector in Nigeria is below expectation as is evident in the fact that Nigeria still imports fish into the country to supplement fish production (Ele *et al*., 2013). Aquaculture, was introduced to Nigeria in the early 1950s and fish production through aquaculture has risen steadily from a few hundred kilograms to about 800,000 MT in 2014 (Adesina, 2014).

Despite the abundance of fisheries resources and the relatively high consumption of fish in Nigeria that is the largest single consumer of fish products in Africa (FDF, 2005; 2008), its domestic output of 620,000 MTstill falls short of demand of 2.66 million metric tonnes (FDF, 2008). Figure 1 shows that the production of fish in Nigeria increased from 1970 to 1980 and declined from 1981 to 1986. It increased steadily from 1987 to 2005 and had a substantial increase in 2006. It rose gradually from 2007 to 2010. Despite the increase in fish production in Nigeria, it falls short of demand. Nigeria spends N100 billion on fish importation annually and the current fish demand in Nigeria stands at over 2.66 million tonnes per annum, while the present importation rate is over 750,000 metric tonnes (Oota, 2012).

Despite the popularity of farming in Nigeria, the fish farming industry can best be described as being at the infant stage when compared to the large market potential for its production and marketing (Nwiro, 2012).The Niger Delta contributes more than 50 per cent of the entire domestic Nigerian fish supply, being endowed with abundance of both fresh, brackish and marine water bodies that are inhabited by a wide array of both fin fish and non-fish fauna that supports artisanal fisheries(Akankali and Jamabo, 2011).

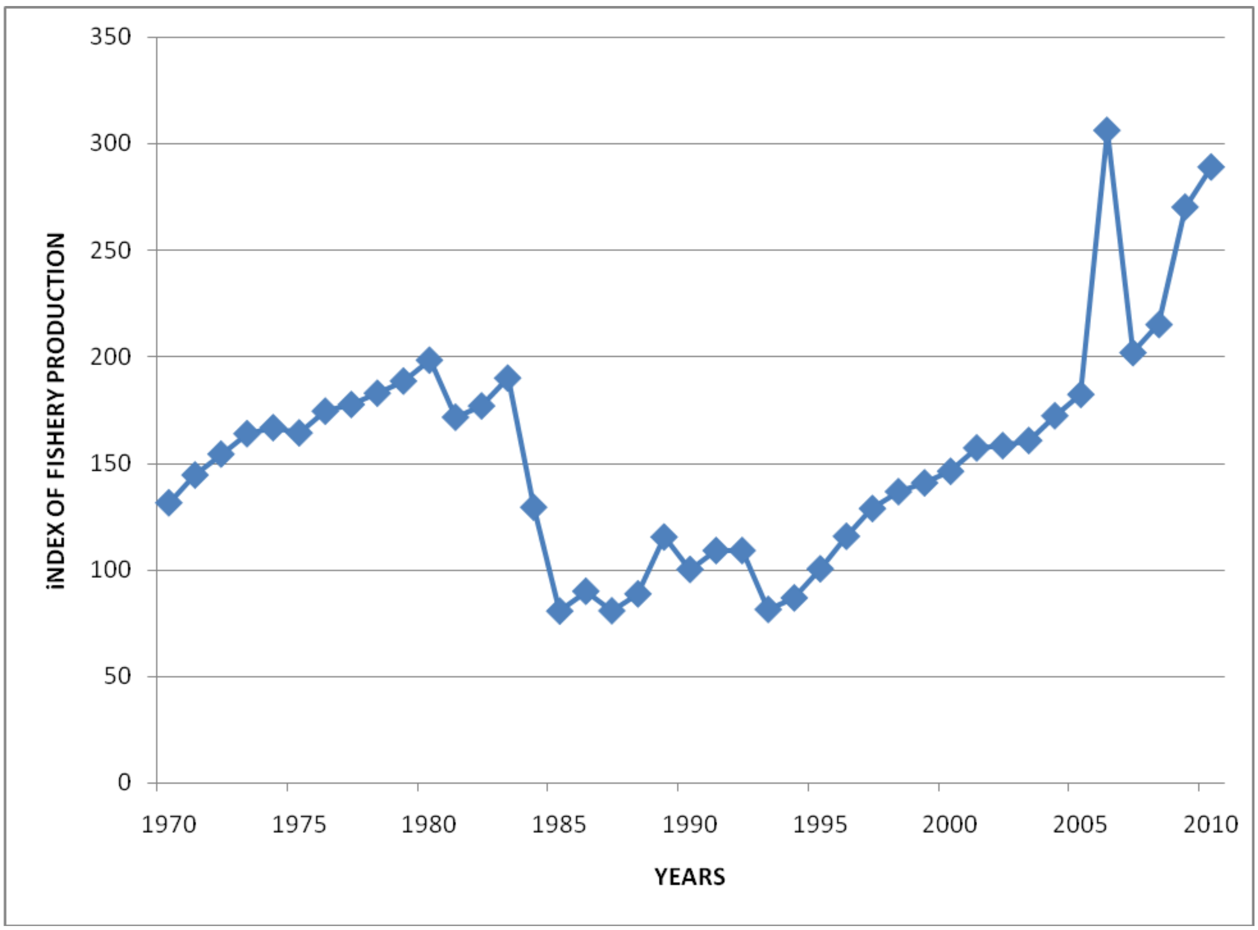

Figure 2.1: Fishery production trend in Nigeria (1970 – 2010)
Source: CBN (2008; 2011)

Nigeria has become one of the largest importers of fish in the developing world, importing some 600,000 metric tonnes annually (Olagunju *et al*., 2007). The awareness on the potential of aquaculture to contribute to domestic fish production has continued to increase in the country (Adewuyi *et al*., 2010). This stems from the need to meet the much needed fish for domestic consumption and export. Fish species which are commonly cultured include *Tilapia spp, Heterobranchus bodorsalis, Clarias gariepinus, Mugie spp, Chrysichthys nigrodigitatus, Heterotis niloticus, Ophioce- phalus obscure, Cyprinus carpio and Megalo spp.*

The practice of culturing fish in ponds developed because growing fish in ponds is a more useful practice for some purposes, than trying to catch fish from lakes, rivers, or streams (Sharon, 2008). For example, many interested people discover that building a fish pond close to home is possible and far more convenient than going to the nearest market or river. It is easier to get fish out of a pond and can be controlled. But it is very difficult to know how many fish can be caught in a river or stream or lake at any one time. The fish can be fed extra food to make them better for market; natural enemies can be kept from killing the fish.

Fish culture is the growing of fish in ponds. Growing fish in ponds, from which they cannot escape, allows feeding, breeding, growing and harvesting the fish in a well-planned way. Fish culture is one form of aquaculture. Aquaculture is the science which deals with methods of growing (cultivating) animal and vegetable life in water. Some other kinds of aquaculture are concerned with growing frogs, oysters, seaweed, and even rice (Sharon, 2008).

Monoculture is the practice of culturing only one species of fish in one or more pond units. Under monoculture the farmers may grow for example only Tilapia or Clarias in a pond. One disadvantage of this practice is that the farmer will only know more about the management of that fish than other species that can be cultured. Growing one type of fish could limit the maximum exploitation of natural and supplementary food in the pond, thereby affecting pond optimal utilization.

The practice of culturing more than one species of fish in the same pond is known as poly culture, e.g. Clarias and Tilapia. Fish yield under polyculture can be high because food items in the pond are properly utilized since the different fish species exploit food at different levels. Well managed ponds under polyculture can be highly profitable since food utilization is maximized and lower risk of project failure is assured.

Integrated Culture involves rearing fish with other animals or vegetable gardening. Integration of fish culture with livestock/gardens can maximize production space and productivity. Understanding of the know-how of managing such integration is important for a farmer to maximize the profit of this kind of system.

2.2 Policy and Strategy of AquacultureDevelopment in Nigeria

Several policy measures have been put in place to stimulate local fish farming and till date, the results from the colossal investment and policy have not yielded the desired results (Oluwemimo and Damilola, 2013). Recognizing the benefits of fish farming and the existing potentials, the government of Nigeria has shown its interest through setting up various national programmes and projects such as the Aquaculture and Inland Fishery

Project (AIFP), National Accelerated Fish Production Project (NAFPP), Fishing Terminal Projects (FTP), Fisheries Infrastructures Provision/Improvement (FIP), and the Presidential Initiative on Aquaculture (PIA), (FAO, 2005a). Part of the plan of government is to distribute fingerlings to small scale fish farmers free while large scale farmers will be subsidized up to 50% of the cost, this is in addition to sensitizing Nigerians to the various methods of fish farming (FMAWR, 2008).Increasing fish production in Nigeria requires embarking on pond fish farming. This has prompted the Federal Government of Nigeria to package the Presidential Initiative on Fisheries and Aquaculture Development in 2003 to provide financial and technical assistance to government programmes and projects encouraging fish production (Ugwumba and Chukwuji, 2010).

Regardless of these efforts of Government, fish production has remained low in Nigeria (Ugwumba and Chukwuji, 2010). This has been attributed to inadequate supplies from the local fish farmers due to the use of poor quality fish seeds, inadequate information, high cost of feeds, traditional techniques, small size of holdings, inefficiency in resource use, poor infrastructural facilities, lack of credit, high cost of industrial feed, lack of extension agents, lack of veterinary doctors, lack of fish production equipment and low capital investment (Adeogun *et al*., 2007)

In order to bridge the demand-supply gap, an aquaculture transformation agenda plans to increase annual fish production from the current production of 0.78 million metric tonnes to 3.0 million metric tonnes in order to achieve self-sufficiency in fish production and supply by the year 2015 (Tijani, 2011).

Nigeria can be fully self-sufficient in fish production, while local capacity can potentially turn the country from being a net importer of fish and fish products to a net exporter. In order to effect this reversal, the Aquaculture Value Chain Group has focused attention on (intensive) aquaculture as the best mode of production to bridge the wide chasm between latent demand and local production. While open water fishing activities continue to supplement fish supplies in the country, global trends point clearly in the direction of targeted aquaculture as the best approach to meeting growing world demand for fish.

The fish value chain is essentially made up of 3 sub-categories; production, processing and ancillary. Fish fingerling hatching, fish production, fish feed production, fish farm supplies are some of the activities which make up the production category, while fish processing includes filleting, drying, gutting, scaling and deboning, smoking, production of fish paste and production of fish oil. Ancillary activities include storage, packaging, warehousing, marketing, haulage, distribution, freighting and export related activities.

With a target to produce over one million tonnes of fish per annum within five years, the transformation of the fish industry would involve virtually all other sectors of the economy including air and road transport, education, agriculture, finance, science and technology, energy and telecommunications. However, the socio-economic benefits of a successful transformation process will more than justify the immensity of the task at hand.

This transformation process, is expected to marks turning point in the history of the agriculture sector as a whole and the fishery sub-sector in particular (Aquaculture Value

Chain Group, 2011). According to theAquaculture Value Chain Group, the goal, objectives and expected outcomes of aquaculture transformation agenda are as follows:

2.2.1 Goal of aquaculture transformation agenda

To create an enabling environment for the increased and sustainable production of over one million metric tonnes of aquaculture fish and to generate five hundredthousand jobs within five years.

2.2.2 Objectives of aquaculture transformation agenda

a) Development of the various products along the aquaculture value chain

b) Establish the chain linking up the market to consumers

c) Establish, maintain and enforce quality standards along all the value chains backed up by appropriate regulation for the purpose of fish farmscertification

d) To reduce/eliminate importation of aquaculture products and inputs

e) To increase production of aquaculture products to arrive at over one million metric tonnes in 5 years

f) Employment generation for food security of Nigerians

g) To improve cultural, social and economic benefits from Nigeria's aquaculture resources

h) To generate foreign exchange through export of aquaculture products

i) To create enabling environment for small scale fish farmers to be part of the value chain

j) To encourage clusters of farmers to produce fish that will service fishprocessing and packaging plants

2.2.3 Expected outputs of aquaculture transformation agenda

a) 1.25 billion fish seeds per annum

b) Production of 400,000MT of fish feed per year

c) Production of 250,000MT of table size fish in a year

d) Create 100,000 jobs per annum for the next five years

2.3Theoretical Framework

2.3.1 Production efficiency

Efficiency is a very important factor for productivity growth. In an economy where resources are scarce and opportunities to use new technologies are limited, inefficiency studies indicate the potential possibility to raise productivity by improving efficiency without necessarily developing new technologies or increasing the resource base (Bifarin *et al*., 2010).

Efficiency, as defined by the pioneering work of Farrell (1957), is the ability to produce at a given level of output at lowest cost. He proposed a division of this concept into technical, allocative and economic efficiency. Technical Efficiency, TE, is a measure of the effectiveness of a farmer in the use of inputs. A farmer is considered technically efficient if he/she is able to either produce the maximum possible output from a given level of inputs (output-oriented approach) or use as little input as possible for a given level of output (input-oriented approach). Allocative Efficiency, AE, refers to use of the input mix to maximize a farm's revenue, given output prices. It may not be a suitable measure of farmer efficiency because, in agriculture, prices of inputs and outputs are heavily distorted through such government interventions as subsidies and price legislations.

Economic or total efficiency is the product of technical and allocative efficiencies. An economically efficient input-output combination would be on both the frontier function and the expansion path. It is achieved when the producer combines resources in the least combination to generate maximum output (technical) as well as ensuring least cost to obtain maximum revenue (allocative) (Chukwuji, *et al.,* 2006). This study, therefore, examined TE because it can be measured even without price data and without having to impose behavioral objective on the farmers (Kumbhakar and Lovell, 2000).

It is possible to have either technical or allocative efficiency without having economic efficiency. Therefore economic efficiency combines the two concepts. It is achieved when the producer combines resource in the least combination to generate maximum output (technical) as well as ensuring least cost to obtain maximum revenue (allocative). Efficiently combining inputs to yield output is the primary task of farm management (Kareem *et al*., 2008). When two firms in an industry use the same inputs and employ the same technology, yet produce different quantities of output, the implication is that at least one firm is producing inefficiently.

The focus of this study is on the technical efficiency of fish farming in different scales of operations in the study area.

2.3.2 Concept of technical efficiency

The concept of efficiency is concerned with the relative performance of the process of transforming inputs to outputs. Bhasin (2002) defined technical efficiency as ability of the farmer to obtain maximum output for a given set of inputs under a given technology. Technical efficiency is achieved when a high level of output is realized given a similar level of inputs. It is therefore, concerned with the efficiency of the input to output transformation. In other words, the production function which traces out the maximum quantities of inputs under a given technology. In the primal approach, the production function, in most cases Cobb-Douglas, is directly estimated by Ordinary Least Square (OLS) method. After obtaining the parameter estimates, marginal products (MP) of each endogenous input is calculated.Works along this line include Akinwumi (1970), and Umoh and Yusuf (1999).

The dual approach involves estimating the profit function along with the input share (in profit) equation.Technical efficiency is obtained from the error term (e_i). The e_i is an error term made up of two components: v_i is a random error having a zero mean as (0;σ_v^2) which is associated with random factors such as measurement errors in production and weather, which the farmer does not have control over, μ_i is a *non-negative* random variable associated with farm-specific factors which leads to the ith farm not attaining maximum efficiency of production. μ_i is associated with technical inefficiency of the farm and ranges between zero and one.

There are several important reasons for measuring the farm level technical efficiency of agricultural production. Firstly, if farmers are not making efficient use of existing technologies, then efforts designed to improve efficiency would be more cost effective than introducing a new technology as a means of increasing output (Shapiro, 1983).

Secondly, measuring efficiency leads to sustainable resource savings, which has important implications for both policy formulation and farm management (Bravo-Ureta and Evenson, 1994). Thirdly, it is only through measuring efficiency and separating its effects from the effects of the production environment that one can explore hypotheses concerning the sources of efficiency differential. Fourthly, identification of sources of inefficiency is important to the institution of public and private policies designed to improve performance of agriculture (Bozoglu and Ceyhan,2007). For a farm to be called technically efficient, it has to produce at the frontier or "best" level. However, this is not always the case due to random factors such as bad weather, animal destruction and/ or farm specific factors which lead to producing below the expected frontier (Battese and Coelli, 1995).

Efficiency measurement therefore, attempts to identify those factors that are farm specific which hinder production along the frontier. The above proposition sounds like technical efficiency is similar to productivity measurement since the former is concerned with input- output transformation. This however is not the case since efficiency goes beyond evaluation based on average production to one that is based on best performing among a given category (Battese and Coelli, 1995).

2.3.3 Some approaches to measuring production efficiency

The theoretical definition of a production function expressing the maximum amount of output obtainable from given input bundles with fixed technology has been accepted for decades. And for almost as long, econometricians have been estimating average production functions. It has only been since the pioneering work of Farrell (1957) that serious consideration has been given to the possibility of estimating so-called frontier production functions, in an effort to bridge the gap between theory and empirical work**.** Review of literature on approaches in resource use efficiency measurement revealed various methods but the commonly used approach are parametric and non-parametric frontier otherwise called Stochastic Frontier Production Function Analysis (SFPFA) and Data Envelopment Analysis (DEA).

2.3.3.1 Data envelopment analysis (DEA)

In a simple term, DEA approach is a data envelopment analysis. The formal development of DEA is attributed to Edwardo Rhode (1978). DEA is a nonparametric (i.e. non statistical) or mathematical programming approach for considering optimum solutions relative to individual units. DEA has been widely applied to problems in which answers about optimum input levels, their characteristics, and output levels are desired.

There are two primary orientations of the DEA approach to assess technical and economic efficiency, capacity, capacity utilization, capital utilization, and input utilization: input- and output-oriented. The input based measure considers how inputs may be reduced relative to a desired output level. The output-based measure indicates how output could be expanded given the input levels. There is also a non-orienting DEA measure in which the frontier output and various concepts of technical and economic efficiency may be determined without being conditional on input or output levels being held constant.

DEA is purely deterministic and thus cannot accommodate the stochastic nature. The approach relative to the frontier approach easily permits an assessment of a multiple input, multiple output technology. It also recognizes or can accommodate both discretionary and nondiscretionary inputs and outputs. The approach can facilitate temporal analysis using what is called a Windows technique (Charnes *et al*., 1995). Technical change as well as network or dynamic assessments can easily be accommodated with DEA (Fare and Grosskopf, 1996). A recognized limitation of using the DEA to assess technical efficiency is since DEA is an extreme point technique; noise (even symmetrical noise with zero mean) such as measurement error can cause significant problems. Unlike stochastic frontier production function, it is very difficult to use in statistical hypothesis tests since it is nonparametric technique.

The main strengths of the DEA include: its ability to accommodate multiple inputs and outputs; it does not require explicit *a priori* determination of a production function; and it measures efficiency of eachdecision making unit, DMU, relative to the highest observed performance of all other DMUs rather than against some average (Coelli *et al.,* 2005). Furthermore, by incorporating many inputs and outputs simultaneously in the estimation, the DEA provides a straightforward way of computing efficiency gaps between each DMU and the efficient producers (Haji, 2006).

However, DEA has some limitations: deterministic frontiers do not account for measurement errors and other sources of stochastic variation, and hence do not permit hypothesis tests on TE estimates; and effective incorporation of the random term in estimation of stochastic DEA is usually hampered by computational complexities (Coelli *et al*., 2005). By failing to account for errors, the DEA estimates tend to exhibit greater variability compared to stochastic frontiers.

2.3.3.2 Stochastic frontier production function (SFPF)

Stochastic frontier production function is a method of economic modeling. It has its starting point in the stochastic production frontier models simultaneously introduced by Aigner*et al*. (1977) and Meeusen and Van den Broeck (1977).

The main feature of the stochastic production frontier is that the disturbance term is composed of two parts: a symmetric and a one-sided component. The symmetric component vi captures the random effects due to the measurement error, statistical noise and non-symmetric influences outside the control of the firm. It is assumed to have a normal distribution.

The one-sided (non-negative) component, ui ≥ 0, captures the technical inefficiency relative to the stochastic frontier. This randomness is under the control of the farmer; its distribution is assumed to be half normal or exponential. The $v_i$is assumed to be independently and identically distributed as; N (0, ∂v^2) random variables, independent of $u_{i.}$

This is typically specified as:

Y_i = $f(x_{ij};\beta) + v_i - u_i$ (i=1,2,n) …………………………………………… (1)

Y_i = Output of the i^{th} firm

X_{ij} = Vector of actual j^{th} input used by i^{th} farm;

β = Vector of production coefficients to be estimated

v_i = Random variability in the production that cannot be influenced by the farmer

u_i = Deviation from maximum potential output attributable to technical inefficiency

The model is such that the possible production Y_i, is bound above by the stochastic quantity $f(x_i,\beta) \exp(v_i)$ when $u_i = 0$, hence the term stochastic frontier.Direct estimates of the parameters can be obtained by either the Maximum Likelihood Method (MLM) or the Corrected Ordinary Least Square method (COLS). However, the MLM estimator has been found to be asymptotically more efficient than the COLS (Coelli, 1995). Thus, the MLM has been preferred in empirical analysis (Umoh, 2006).

In the context of the stochastic frontier production function, the technical efficiency of a firm is defined as the ratio of the observed output to the corresponding frontier output conditional on the level of inputs used by the firm. Thus the technical efficiency of the firm is defined as:

$T_{ei} = \exp(-u_i)$ ………………………………………………………………………….. (2)

i.e.

$T_{ei} = Y_i/Y^* = f(x_i;\beta) \exp(v_i-u_i)/f(x_i;\beta) \exp(v_i) = \exp(-u_i)$

Where,

T_{ei} = Technical efficiency of farmer *i*

Y_i = Observed output from farm *i* and

Y^* = Frontier output

T_{ei} ranges between 0 and 1. Maximum efficiency has a value of 1.0 lower value represent less than maximum efficiency in production. The most common functional forms used in parametric frontiers are the Cobb– Douglas, constant elasticity of substitution (CES) and translog production functions. Non-parametric frontiers use linear programming approaches, DEA being the most popular. DEA has gained popularity in productivity and efficiency analysis especially in circumstances where multi-output production is relevant, and where price data are lacking.

Parametric frontiers, unlike non-parametric frontiers, are sensitive to misspecification, omitted variables and measurement errors (Jacob, *et al,* 2006). Nonetheless, results of the two approaches do not differ significantly. The advantage of using stochastic frontier models are: (1) it introduces a disturbance term representing statistical noise, measurement error and exogenous shocks beyond the control of production units which would otherwise be attributed to technical inefficiency, and (2) it provides the basis for conducting statistical tests of hypothesis regarding the production structure and the degree of inefficiency

2.3.4 Measurement of Profitability

Profitability analysis involves the determination of the total variable cost and gross revenue and determining the difference between the two (Emokaro *et al*., 2010). An enterprise could be adjudged profitable in the short run, if the gross revenue is greater than the total variable cost. This measurement enables investors to decide whether to invest in fish farming business or not. Hence, such an estimate would serve as a general guide in the choice of investment opportunity in the study area.

2.3.4.1 Gross margin analysis

Gross margin (GM) is the difference between thegross farm income and the total variable cost (Olukosiand Erhabor, 1989). Gross margin is a very useful tool in situations where fixed capital is a negligible portion of the farming enterprise as in the case of subsistence agriculture. According to Agboola (2011), gross margin of fish farming is the difference between the total value of production (total revenue) and the variable costs of production.

The total revenue refers to the gross income accruing to fish farms from the sales of table-sized fish. This is obtained by multiplying the unit price of average table-sized fish by the quantity sold. The variable costs are those costs that vary with the level of output.Therefore;

GM = GFI – TVC…………….……..………………………………………………….. (3)

Where GM = Gross margin (Naira)

GFI = Gross farm income (Naira)

TVC = Total variable cost (Naira)

Empirical studies that utilized gross margin analysis in estimating profitability of fish farming include Olagunju *et al.* (2007); Agbebi (2012); Ele *et al*. (2013); Anyanwu *et al.* (2009).

2.3.4.2 Net farm income analysis

Net farm income is the difference between thegross farm income and the total cost of production (Olukosiand Erhabor, 1989).The general model for the Net Farm Income is as follows:

NFI = GI – TC …………………..…………………..………………………………..

(4)

Where:

NFI = Net farm income (Naira)

GI = Gross farm income (Naira)

TC = Total cost (Naira)

Total cost = Total variable cost (TVC) + Total fixed cost

Empirical studies that utilized net farm income in estimating profitability of fish farming are as follows; Kudi *et al*. (2008); Oladeji (2010); Agboola (2011); Dawang *et al.* (2011); Awoyemi (2011); Akegbejo-Samsons and Adeoye (2012); Olasunkanmi (2013), Henri-Ukoha (2012); Williams *et al.* (2012); Baruwa *et al.* (2012); Olaoye *et al.* (2013); Olayemi *et al.* (2013); Oluwemimo and Damilola (2013); Penda *et al.* (2013); Olasunkanmi and Yusuf (2014); Adeogun *et al.* (2014).

2.3.5 Concepts of economies of scale in agriculture

2.3.5.1 *The law of diminishing returns*

This law assumes a given production function, homogeneity of inputs and product and that some other resources are held constant. The law is stated in terms of the total physical product(TPP), average physical product(APP),and marginal physical product(MPP). In terms of TPP, the law states that: "given a set of fixed inputs, if we apply successive equal increments of a variable input, the physical output first increases at an increasing rate, then increases at a decreasing rate, reaches a maximum and then declines".TPP is the total output measured in physical terms (Olukosi and Ogunbile, 1989).

TPP is the total measure of output in physical terms. The *APPis the total physical product divided by the quantity of the variable input used. This is given as follows:*

$APP=\frac{TPP}{X}$…………………………………………………………………………..… (5)

Where:

X is the quantity of variable input.

The Law of Diminishing Returns in terms of APP states that: "given a set of fixed inputs, if we apply successive, equal increments of variable input, the average physical product increases, reaches a maximum (when it equals the marginal physical product), then decreases henceforth". The MPP is the addition to the total product resulting from one unit increase in the use of a variable input. It can be expressed as:

$MPP = \frac{\Delta APP}{\Delta X}$……………………………………………………………….... (6)

Where:

ΔAPP is change in average physical product

ΔX is change in variable input used

In terms of MPP the Law of Diminishing Returns states that: "given a set of fixed inputs, if we apply successive, equal increments of variable input, the marginal physical product first increases, reaches a maximum, decreases to zero (when physical product is at maximum), and then becomes negative."

2.3.5.2*Elasticity of production*

Elasticity of production (Ep) measures the response of output to changes in the variable input. It is defined aspercentage change in output (Y) divided by percentage changed in input (X_1). In stage I of production, MPP lies above APP, hence, throughout the stage Ep>1, meaning that the percentage change in output is greater than the percentage change in variable input. At the beginning of stage II and end of stage I, elasticity of production is equal to 1 (Ep=1). In stage II, the elasticity of production lies between 0 and 1 and in stage III, it is negative. (Olukosi and Ogunbile, 1989) In other words, Ep can be expressed as ratio of average and marginal product, APP and MPP, and is positive if APP and MPP are positive. Ep of an input X, will be greater than, equal to, or less than unity as its MPP is respectively greater than, equal to, or less than its APP.

2.3.5.3 *Return to scale*

This refers to the change in output as all factors change by the same proportion. The returns to scale associated with particular production system is given by the sum of the elasticities of the factors of production (Koutsoyiannis, 1979). Return to scale is constant, decreasing, or increasing when output increases by the same proportion as increase in input, by less than proportionate increase in input or by more than proportionate increase in input, respectively.According to Diewart et al, (2011) if the sum of elasticities of factors of production (γ) = 1, then there are constant returns to scale; any proportional change in all inputs results in an equiproportionate change in output. If γ>1, there are increasing returns to scale. If γ<1 (though not less than 0, given the possibility of free disposal), then there are decreasing returns. Return to scale also imply economy of scale because of duality in production theory (Jehle and Reny 2001).

2.4 Review of Empirical Studies

2.4.1 Socioeconomic characteristics of fish farmers in Nigeria

The socioeconomic characteristics of fish farmers from empirical findings on fish farming in different parts of Nigeria reviewed are as follows:

Age: Awoyemi (2011) in a study conducted in Osun State revealed that the fish farmers whose ages fall between 31 and 40 years constituted the majority and on the whole, 80.0% fall into the economically active group of 20 – 50 years. The result of Ele *et al.* (2013) shows that the farmers that are actively involved in fish farming in Cross River State fall within 40 - 50 years and this means that the farmers still have the strength to run the business. Olasunkanmi (2013) revealed that the mean age of fish farmers was 40 years. Akegbejo-Samsons and Adeoye (2012) revealed that the average age of the fish farmers in South West Nigeria was 43.5 years, with 55.5% between 36 and 45 years age category, and 27.5% in 16-35 years category. According to Henri-Ukoha (2012), majority of the fish farmers in Abia State fell in the age bracket of 41 – 50 years with a mean of 43 years.

The result of Jatto *et al.* (2013) showed that 40% of the fish farmers in Ilorin were within the age range of 26-35 years, indicating that they are relatively young and are still in their active age and these farmers are likely to adopt new innovation faster than the older ones. The result of Olayemi *et al.* (2013) showed that majority of the catfish farmers in Ibadan metropolis were within the ages of 30-49 which represents about 71.1%of the total respondents in the study area with mean age of 42.66.

In the work of Anyanwu *et al.* (2009), the youths in range of 10-30 years participated least actively in fish production and accounted for 8.75 percent of respondents. This may be attributed to migration to the urban areas for white-collar jobs. Those within the age ranges of 31-40 and 41-50 participated more actively in fish production constituting 32.5% and 36.25%, respectively. The fishermen within the ranges of 51-60 years and above were the less active in fish production. They constituted 22.5% of the respondents. May be due to their old age they could no longer engage more in fishing.

The result of Oluwemimo and Damilola (2013) revealed that 60% of the fish farmers were less than or just 40 years of age while another 20% aged between 41 and 50 years. The remaining 20 percent were over 50 years. The mean age of fish farmers was 38.9 years with a standard deviation of 12.4 years. Apata (2012) in a study conducted in South-Western Nigeria found that majority of the respondents (76.4%) were below 50 years of age. This implies that the respondents were still in their active age and they were relevant to the study. The mean age of the respondents was 43.1 years with 6.532 standard deviation.

Olagunju *et al*. (2007) found that majority (55%) of the fish farmers in Oyo State fall within the age bracket of 40 and 60 years with a mean age of 49years. The results of Aphunu and Nwabeze (2012) revealed that 27.5% of the respondents in Delta State were between the age bracket of 31 and 40 years. The mean age was 39.4 years. This shows that they were still young and are in their active productive years and can still actively adopt effective measures for cushioning the impacts of climate change. In the work of Nwosu and Onyeneke (2013) majority (45.00%) of the fish farmers were 60-69 years old. The average age of the fish farmers was 59.7 years. This implies that fish farming in the zone was being manned by relatively elderly people which will affect the productivity and output of fish farming negatively.

Nwaobiala and Ebeniro (2012) in a study conducted in Edo State revealed that majority (40.0%) of the respondents were in the age range of 51-60 years, while 11.66% fall in the range of 61-70 years. This implies that young and energetic youths in the study area seemed not to be actively involved in homestead fish farming.

Gender: Ele *et al.* (2013) revealed that the males (81%) were actively involved in fish farming than the females (19%) in Cross River State. In a study carried out in Osun State, only few women (8.3%) were involved in fish farming in the state (Olasunkanmi, 2013). He further reiterated that there was need for extension services that would encourage more women to be involved in fish farming so that similar mistake made in Chibote, Zambia where fish farming was seen as an activity for male youth would not occur in the State.

Olaoye (2013) reported that the fish farmers in Oyo State were largely males (84.2%) and the females were few (15.8%). In the work of Simitoyin and Sanda (2013), most (79.3%) of the fish farmers in the study area were males while only 20.75% were females.

According to Agboola (2011) in a study conducted in Osun State, majority (95.6%) of the respondents were male while the female constituted only 4.4%. This shows the extent of gender sensitivity in occupation like farming. This could be attributed to the fact that agricultural production is faced with a lot of risk and uncertainties and women are risk averse. Another reason could be the drudgery that is associated with aquaculture business.

The report of Anyanwu *et al*. (2009) revealed that male respondents had a frequency of 80 representing 100 % while female had a frequency of zero. Therefore, the total sample was all male. Apata (2012), in a study conducted in South-Western Nigeria, found that majority (64.0%) of the fish farmers were male implying fish farming in the study area was male dominated.

Adewuyi *et al.* (2013) in a study carried out in Ogun State also found that male fish farmers constituted about 87.7% as compared to the female farmers that represented 12.3%. This indicates the dominance of men in fish production in the study area. The findings of Aphunu and Nwabeze (2012) in a study conducted in Delta State showed that majority (78.8%) of the respondents were males while 21.3% were females. This indicates that more males are engaged in fish farming than females. The male dominance implies the laborious nature of fish farming operations which too very tedious for females to handle.

The results of Olagunju *et al.* (2007) showed that majority (80%) of the fish farmers in Oyo State were males. Olasunkanmi and Yusuf (2014) in a study undertaken in Osun State showed that majority of the respondents were male. The higher percentage of male to female catfish farmers indicates that fish farming activities are gender biased. This shows that catfish farming in the study area was gender sensitive.

According to Joshua *et al.* (2006), in a study carried out in Nassarawa State, majority of the respondents were male (86.7%) while 13.3% of the respondents were female. In the study undertaken by Williams *et al.* (2012), it was observed that the fish farming enterprise in Lagos State was male-dominated. More than half of the respondents were males (60%) while the female constituted barely 40 %.

Marital status: The findings of Awoyemi (2011) showed that majority (67.7%) of the fish farmers were married in Osun State. In a similar study, Olasunkanmi (2013) reported that fish farmers in Osun State Nigeria were mostly married (97.2%).The report of Agbebi (2012) on the marital status of fish farmers in Ekiti State showed that most (78.9%) of the fish farmers were married. This suggests that there may be high demand for food and additional income as the family size increases. Few percentages (15.6%) of the respondents were single and this indicates that they were youths and they still had strength to work on the pond without hiring labour. Those that were widowed were 3.3% and 2.2% were divorced. Okoedo-Okojie and Ovharhe (2012) in a study conducted in Delta State discovered a higher proportion (47.3%) were single. This could be attributed to the young age of respondents, and implication that marital status was not a bias in fish farming in the study area. Apata (2012) in a study conducted in South-Western Nigeria found that majority (60.0%) of the fish farmers were married.

In the work of Nwosu and Onyeneke (2013), majority (85.00%) of the fish farmers were married. An implication of this result is that there could be more support from the spouses and children of the farmers with a view to improving and increasing fish production. The high proportion of the respondents who are married is therefore an indication that family labour could be available for fish production in the study area.

The findings of Williams *et al.* (2012) in a study conducted in Lagos State revealed that 92 percent of the respondents were married. Four (4) percent were widowed while the remaining 2 percent were single. This implies that the respondents would have access to family labour in their fish farming business. In the study undertaken by Kareem *et al.* (2013) in Ogun State, the marital status results also showed that majority of the fisherfolks were married with 98.5%. This result implies that more family labour would be available for the fishing activities.

Household size: According to Akegbejo-Samsons and Adeoye (2012), in a study conducted in South West Nigeria, the mean household size of the fish farmers was 8 persons. Henri-Ukoha (2012) reported that most (63.3%) of the fish farmers had household size of 1 to 5 persons with a mean household sizes of 5 persons. Olaoye *et al.* (2011) in a study conducted in Ogun State revealed that most (80%) of the fish farmers had household sizes of 2 to 6 persons. Olaoye *et al.* (2013) in a study conducted in Oyo State revealed that majority (68%) of the fish farmers had household sizes of 4 to 7 persons with a mean of 6 persons and standard deviation of 0.563.

Okoedo-Okojie and Ovharhe (2012), reported that majority (48.7%) of the respondents had household sizes of 1-5 persons, with a mean household size of 4 persons. This is a reflection of the age respondents,which may result in young families and low household size. Simitoyin and Sanda (2013) reported that majority (68%) of the fish farmers in Osun State had small household sizes of 1 – 5 persons. Olayemi *et al.* (2013) reported in a study conducted in Ibadan that majority (60%) of fish farmers studied had household sizes that ranged between 4-6 with a mean of 4.84.This shows that there were enough hands (family labour) to carry out fish farming operations.

The result of Oluwemimo and Damilola (2013) revealed that family sizes were very small with 78% of the farmers having between 1 and 5 members while average family size was only 3.8 members. Olagunju *et al.* (2007) found that majority (53.3%) of the fish farmers in Oyo State had household size of 5 – 10 persons. The findings of Aphunu and Nwabeze (2012) revealed that majority of the respondents had family sizes of between 1 and 5 persons in their households.

Penda *et al.* (2013) in a study undertaken in Benue State revealed that the average household size was 5 members. This funding indicates a fairly large family size with the implication that more family labour will be readily available. Tsue *et al.* (2013) in a study conducted in Benue State revealed that the household size of catfish farmers showed a mean of about 7 people. The implication of this is that family labour would be readily available when needed in any catfish farming operation. Large size of catfish farmers' household manifests in high use of family labour in catfish production activities which stood at an average of 828.25 man-days. .

In the work carried out by Dawang *et al.* (2011) the average family size was 8.05, with a standard deviation of 6.27 while the maximum number was 35 and minimum was 03.00. This result shows there may be enough labour in an average household for fishing work daily from family labour.

Education: The findings of Ele *et al.* (2013) in Cross River State revealed that all the respondents are learned and highly educated as all of them had tertiary education. This means that fish farming is a highly technical enterprise that requires learned farmers. According to Olasunkanmi (2013), fish farmers in Osun State, Nigeria, were well educated (52.8% having tertiary education) and were mostly married (97.2%). Agbebi (2012) revealed that Majority (83.3%) of the fish farmers in Ekiti State had one form of tertiary education or the other, while 11.1% and 4.4% had secondary and primary education, respectively. Just 1.1% had no formal education. This means that fish farming is dominated by the educated class with tertiary education. This is so because fish farming requires a lot of technical and scientific knowledge.

In the work of Agboola (2011), majority (43%) of the fish farmers had tertiary educational qualification while few (13.3%) had primary educational qualification. Anyanwu *et al*. (2009) reported that most of the fish farmers had secondary school education. Fifty one and 31 % of the fishfarmers had secondary and primary education, respectively. The overall picture is that more than 70% of the fish farmers attended one level of education or another so, they would be able to understand the importance and the application of new improved technologies involved in fish production. The sum of percentage of those that attended primary school (31.3%) and higher school (2.5%) was less than those that had secondary education (41%). Only a few (2%) felt they should attend higher education if their focus is to be fulltime fish farmers. This will help in the business as they could introduce innovations in the production due to their educated faculties.

The educational attainment of the fish farmers in Oyo State as reported by Olagunju *et al.* (2007) revealed that 63.3% had tertiary education. The high level of education might be due to the metropolitan nature of the study area and its implication is that the respondents will be very receptive to new innovations in their methods of production.

According to Adewuyi *et al.* (2010), a large proportion (68%) of fish farmers in Ogun State had formal (tertiary) education implying that the farmers could therefore be said to be literate since only small proportion of them had no formal education. Olasunkanmi and Yusuf (2014) revealed that the largest percentage of the respondents (67%) had tertiary education, 17% had secondary, 11% had primary while 5% had no formal education. This shows that the respondents were more likely to adopt innovations and had the ability to manage the business better.

Solomon *et al*. (2013) in a study carried out in Lagos State revealed that majority (91.5%) of fish farmers spent between 11 and 20 years in formal institutions of learning, while those who spent between 5 and 10 years were only 6.8 per cent. Consequently, higher percentage (93.2%) of them had education up to tertiary level. This was followed by 6.8 per cent who had education to secondary school level. Also, majority (73.3%) of fish farmers spent less than 11 years in formal institution of learning while 26.2 per cent of fish farmers spent between 11 and 20 years in formal educational institutions. Consequently, 73.3 per cent of the fish farmers had education up to secondary school level.

The findings of Baruwa *et al*. (2012) showed that most of the farmers have access to formal education. About 51.4 percent of the respondents among the artisanal farmers had secondary education while 22.9 percent of the aquaculture farmers attended secondary and tertiary institutions. According to Ufuoku *et al.* (2006), in a study undertaken in Delta State, majority (46.7%) of the fish farmers had secondary education, 44.0% had tertiary education, 6.7% primary education and 2.7% had no formal education. This result revealed that most of the small-scale fish farmers were educated.

Farming experience: Olaoye *et al.* (2013) in a study conducted in Oyo State revealed that 40.5 % of the fish farmers had fish farming experience ranging between 11 and 15 years, 35.6 % had between 5 and 10 years, and 15.8 % had less than 5 years while 8.1 % had above 15 years of experience in fish farming. As a result, the respondents with the highest number of years of experience should have good skill and better approaches to fish farming business. The respondents with longer years of experience were also able to forecast market situation in which they sell their products at higher prices. Those with less years of experience, especially with less than 5 years faced many risks in the early days of their fish farming business.

Most (60%) of the fish farmers in Abia State as reported by Henri-Ukoha (2012) had 13 and above years of fish farming experience with a mean of 10 years. Agbebi (2012) revealed that as for fish farming experience in Ekiti State, 62.2% of the respondents had been involved in fish farming for less than 5years and 2.2% for above 15years. This connotes that fish farming diffused very slowly among the farmers in the study area but involvement of farmers in fish farming in the last 5years had greatly increased.

Olaoye *et al.* (2011) reported that most (95%) of the respondents in Ogun State had 1-10 years of experience in fish farming and 2% had 31-40 years of experience. Jatto *et al.*

(2013) revealed that majority (55%) of the fish farmers in Ilorin had fishing experience ranging from 1-5years. In the work of Olayemi *et al.* (2013) majority (54.4%) of the respondents had 1-5 years of experience with a mean value of 5.97. This shows that the catfish farmers were relatively new in the enterprise. The result of Anyanwu *et al.* (2009) showed that the fishermen in Onitsha started the enterprise at a very early age. Out of a total sample of 80 fishermen 40% had fishing experience of 11-21 years while 30% had 22-30 years of experience, 16% and 3.7% had 32-40 years and 42-51 years of fishing experience, respectively.

In the study of Oluwemimo and Damilola (2013), fish farming was reported to be a recent phenomenon as 83% had just been involved only in the last five years. Fourteen had been farming for between 6 and 10 years while the remaining 3% had been involved for more than 10 years. The mean experience of fish farming in this study area was 3.6 years.

Olagunju *et al.* (2007) found that majority (63.3%) of the fish farmers in Oyo State had fish farming experience of 1 – 5 years. In the work of Nwosu and Onyeneke (2013), majority (65.00%) of the farmers had fish farming experience of 4-6 years while the average fish farming experience of the farmers was 5.4 years.The farmers have had an experience about the fish farming which implies that they have knowledge of managing the enterprise for the purpose of maximizing production. Experience of farmers increases their farm production. Nwaobiala and Ebeniro (2012) in a study conducted in Edo State revealed that 45.0% of respondents had between 11 and 15 years of fish farming experience, while 43.34% had experience of 6 -10 years .

According to Ufuoku *et al.* (2006), in a study undertaken in Delta State, the fish farming experiences of the small-scale farmers showed that most (30.7%) of them had 6–10 years of experience, while those who had 1–5 years of experience constituted 26.7%, those with less than one year of experience made up 12%. The fish farmers that had 11–15 years of experience made up 6.7%, 16–20 years of experience, 9.3%, 20–25 years of experience, 8.0% and 26–30 years of experience, 6.7%. The result indicated that fish farming is just becoming popular in the study area.

In the study undertaken by Kareem *et al.* (2013) in Ogun State, majority (about 53%) started fishing business between 21-30 years, followed by 11-20 years and the least being 41-50 years. The mean years of experience and the standard deviation was 23.8 ± 7.05 and the modal years of experience was 42 years. The result implies that the fisher farmers are experienced.

Membership of association: According to Olasunkanmi (2013), most of the fish farmers (72.2%) in Osun state did not belong to any fish farmers' association. Agbebi (2012) revealed that majority (58.9%) of the fish farmers in Ekiti State did not belong to any social group while 27.8% subscribed to co-operative societies. Those engaged in monthly contribution constituted 8.9%of the respondents, while 4.4% of them held membership of Fish Farmers Association. Those that did not belong to any social group were many because majority of the farmers in the study area lacked knowledge on the benefits of those social groups.

Olaoye *et al.* (2011) revealed that most (83%) of the fish farmers in Ogun State did not belong to any association with only 17% of the fish farmers belonging to a fish farmers'association which was largely Zion Faith Farmers Association as indicated by 90% of fish farmers who belonged to a fish farmers' association. Okoedo-Okojie and Ovharhe (2012) found that most of the respondents (80%) belonged to associations and membership of association could prove useful in sourcing and utilizing of the relevant agricultural information, and make the work of extension workers easier and more effective.

The findings of Aphunu and Nwabeze (2012) revealed that majority (43.8%) of the fish farmers in Delta State belonged to fish farmers Association for the purpose of credit and accessibility to information. Solomon *et al*. (2013) in a study carried out in Lagos State revealed that majority (86.7%) of the fishers did not belong to any fishery association while 13.3 per cent belonged to a fish association. In the study undertaken by Kareem *et al.* (2013) in Ogun State, most of the respondents (83%) did not belong to any cooperative society. This probably implies that the fishing business does not allow for too much social interactions.

Access to credit: According to Henri-Ukoha (2012), majority (63.3%) of the fish farmers in Abia State had no access to credit. The study carried out by Agboola (2011) showed that majority of the farmers did not have access to credit.A good proportion of the respondents (40%) began by using their own savings, sales and gifts or loan from families and relatives as well as friends. This is due to the fact most banks charged high interest rates and most farmers, had no collateral. Because of this poor access to credit, farmers could not expand their scope of business. Baruwa *et al.* (2012), in a study conducted in Lagos State, reported that artisanal fish farmers obtained credit mostly from friends and relatives, while most aquaculture fish farmers cultivated fish using their personal savings. Adinya *et al.* (2011) in their study undertaken in Rivers State reported that most (76.7%) of the fish farmers did not have access to credit facilities.

Access to extension: Adewuyi *et al.* (2010), in a study carried out in Ogun State, revealed poor extension visits to fish farmers as 78% of the fish farmers had no access to extension in the study area. Solomon *et al.* (2013) in a study carried out in Lagos State indicated that majority (85%) of the fishers reported that they had no agricultural extension contact in their artisanal fishery operations. Also, 69.5 %of fish farmers claimed they had no agricultural extension contact. All (100%) of those that were visited by extension agents indicated that they were visited once a while. The low contact of agricultural extension agents may be due to poor funding of agricultural extension in the State. In the work carried out by Dawang *et al.* (2011) the average number of extension contact was 18.57 with a standard deviation of 11.68. The large average of extension contact indicated by the farmers is a reflection of the fact that local government extension agents were working and such extension education should be made more relevant considering the dual needs of benefit to fishers and environmental quality through sustainable fishing.

Pond size/number of ponds: According to Adewuyi *et al.* (2010), the average pond size inOgun State was 335 m^2. Aphunu and Nwabeze (2012), in a study small scale fish farmers who engaged in fish farming for the purpose of augmenting household incomes in Delta State, majority (73.8%) of the respondents had between 1 and 5 fish ponds.

Nwaobiala and Ebeniro (2012) in a study conducted in Edo State showed that majority (61.67%) of the fish farmers produced catfish in medium size ponds ($90.4m^2$ – $175.6m^2$), while majority (83.33%) had fish ponds ranging between 3 and 4. Penda *et al.* (2013), in a study undertaken in Benue State, revealed that most (78.8%) had pond sizes of 0.1 – 0.4ha with an average pond size of $35m^2$.

Essien *et al*. (2010) in a study carried out in Akwa Ibom State reported that 70% of the fish farmers had small ponds of 10 x 8m size. Ufuoku *et al.* (2006), in a study undertaken in Delta State, revealed that most (48%) of the fish farmers had ponds ranging between 100 and 150 m^2 in size, 46.7% between 151 and 200 m^2, 4.0% between 201 and 250 m^2, 1.3% 251–300 m^2 while none had pond above 300 m^2 in size. Most (82.7%) fish farmers had between 1 and 10 fish ponds in their farms, 10.7 percent 11-20 ponds, 4.0 percent 21–30 ponds, while 2.7 percent had 31-40 ponds and none had ponds above 40 in number. This implies that most of the respondents were small– scale fish farmers.

According to Joshua *et al.* (2006) in a study carried out in Nassarawa State, majority (43.3%) of the fish farmers had pond sizes of about 1-400m^2, followed by (40%) of the farmers who had 401-800m^2 pond size, while about 16.7% of them had the largest pond sizes of about 801-200m^2. Results further showed that (40%) of the respondents had number of fish pond ranging between 1 and 2 ponds, while 3.3% of the fish farmers had between 11 – 15 ponds. This may largely be as a result of the level of the financial capability of most of the fish farmers.

Adinya *et al.* (2011) in their study undertaken in Rivers State reported that majority (75%) of the fish farmers in the study area had small pond sizes of 0.1 – 5 ha. Tsue *et al.*

(2013) in a study conducted in Benue State revealed that the average pond size of farmers' catfish farm was 186.50 m² with a standard deviation of 389.02. This shows that catfish farming in the study area was still on a small scale level. This was further confirmed by the mean number of fingerlings (1298.9) and the mean quantity of feed consumed (245.29kg).

2.4.2 Input-output relationship of fish farming in Nigeria

The result of Awoyemi (2011) showed that fish output in Osun State was significantly determined by pond size ($p<0.05$), cost of feeds ($p<0.01$), cost of lime ($p<0.01$) and cost of fingerlings ($p<0.01$). The result of Olasunkanmi (2013) showed that fish output was significantly influenced by fertilizer ($p<0.01$), labour ($p<0.01$) and cost of fingerlings ($p<0.05$) while lime and feeds were not significant. He further reported that the summation of all the production coefficients for the function was greater than 1 meaning an increasing return to scale. According to Ele *et al.* (2013) the quantity of feed used in Kg, was significant at 5% and had a positive relationship with output meaning that as feed (Kg) used increases, output increases. Stocking density was significant at 1% level and had a positive relationship with output, meaning that as farmer uses the proper stocking density, output increases.

The findings of Adewuyi *et al.* (2010) in a study carried out in Ogun State revealed that fish output was significantly determined by pond size ($P<0.05$), cost of feeds ($p<0.01$), cost of lime ($p<0.01$) and cost of fingerlings ($p<0.01$). The degree of responsiveness of the value of fish output to changes in the independent variables showed that a percent increase in the values of pond size, labour, feeds, fertilizer, lime, fixed input and fingerlings will lead to 0.029%, 0.057%, 0.005%, 0.534%,0.007% , 0.79% and 0.001% in the value of fish produced, respectively.The findings of Nwosu and Onyeneke (2013) in Owerri, Imo State,revealed that four regression coefficients (pond size, feed consumed, start-up capital and stock rate) were significantly and positively related to fish farming output. The result further showed that pond size, feed consumed and stock rate were significant at 1% probability level while start-up capital was significant at 5% probability level. The results of Penda *et al*. (2013) from Stochastic frontier production function revealed that fish output in Benue State was significantly determined by cost of feeds (P<0.05), pond size (p<0.01) and quantity of fingerlings (p<0.01). The degree of responsiveness of the value of fish output to changes in the independent variables shows that a percent increase in the value of pond size, feed, fingerlings, labour, fertilizer will lead to 0.29%, 0.177% , 0.516%,0.394%, and 0.09% in value of fish produced respectively.

The estimated translog stochastic frontier function of Oguoma *et al.* (2010) in a study conducted in Imo State showed that at 5% probability level, the coefficients for pond size, feed, water, fertilizer, fingerlings, capital and labour were positively related to fish output.

Adinya *et al.* (2011) in their study undertaken in Rivers state revealed that the coefficients of fish pond size, feed, fingerlings and credit were significant at 5% level for mandarin and clown fish. Labour was not significant for both mandarin and clown fish. Feed appears to be one of the important variables with elasticity of 0.09 and 0.07 for mandarin and clown respectively. It implies that increasing feed by 10 percent would lead to about 0.9% and 0.7% increase in output of mandarin and clown. The sum of elasticity of 1.36 and 1.25 for mandarin and clown, respectively, indicates that mandarin and clown fish farmers in the study area were operating in the inefficient stage.

Onoja and Achike (2011), in a study undertaken in Kogi State, reported that all production function parameters except labour were statistically significant. Labour had negative sign contrary to *a priori* expectations. This however implies that this resource was being over-utilized. Since double–log model was applied, coefficients represent elasticity of fish output with respect to each input. Fish feeds administered which had the greatest elasticity (1.59%) had the highest contribution to fish output followed by farm size (stock size) with elasticity of 0.47 %. This may not be surprising as feeds are very necessary for the growth, health and output size of fish to be sold. The positive and relative increase in stock size implies that farmers with higher number of stockseemed to benefit from economy of scale in their farm production. The third significant variable, capital had an elasticity of 0.88 indicating that the contribution of capital towards technical efficiency of the farms was increasing probably through the proper use of capital resource in the business. With appropriate mix of investment increase on farm scale (stock size) and other variables, there could be a positive return on investment on capital.

Itam *et al.* (2014) in a study carried out in Cross River State reported that the inputs that significantly influenced the output of the fish farmers were feeds ($p<0.01$), stock size ($p<0.01$), labour ($p<0.05$) and capital ($p<0.05$). Also, feeds and stock size were positively related to the output of the fish farmers while labour and capital were negatively related to the output of the fish farmers.

According to Osawe *et al.* (2008) in a study conducted in Oyo State, the variables that were significant include pond size, total quantity of feed used and the stocking rate all at 1 % level of significance. The positive coefficient of stocking rate and total quantity of feed used with respect to fish production implies that the higher the stocking rate and consequently the quantity of feed used, the higher the total level of fish production at an optimal labour supply. The total labour used positively influenced the total output of fish but the labour used must be kept at optimal level after which farmers will be operating at sub-optimal level. Also, there was a negative relationship between the level of output of the fish farmers and the pond size. This unexpected negative relationship was probably because with larger ponds, the farmers would require more capital to increase the stock to optimally utilize the capacity of the pond.

Tsue *et al.* (2013) in a study conducted in Benue State revealed that the estimated elasticities of the independent variables revealed that pond size of catfish farm (0.29), quantity of feed (0.37), number of fingerlings (0.41) were statistically significant at 1% level. More specifically, the result showed that the number of fingerlings and quantity of feed were the most important factors increasing the quantity of output of catfish in the study area as every 10 percent increment in the number of fingerlings used and quantity of feed consumed, increased the quantity of catfish output by 4.1 and 3.7%, respectively. However, labour use (-0.11) had decreasing influence on the quantity of catfish produced. This is likely a reflection of over-utilization of the input.

2.4.3 Technical efficiency of fish farming in Nigeria

The results of Penda *et al.* (2013), in a study conducted in Benue State, revealed that the mean technical efficiency was 0.619. This implies that on the average the fish farmers were able to obtain 61.9% potential output for a given mix of production inputs. Oguoma *et al.* (2013) in a study carried out in Imo State reported that about 97.52% of the farmers had a technical efficiency index of above 50.0%, with an individual technical efficiency ranging between 48.37% and 96.13% and a mean of 75.49%.

Adinya *et al.* (2011) in their study undertaken in Rivers State reported a technical efficiency range from 0.48-0.99 and 0.55-0.99 for mandarin and clown fish farmers, respectively. The mean estimates were 0.73 and 0.61 for mandarin and clown fish, respectively. The efficiency distribution had shown that mandarin (16.07%) and clown (11.61%) had less than 0.50 efficiency level. The result of the study shows that mandarin fish farmers were more efficient than clown fish farmers.

Onoja and Achike (2011), in a study undertaken in Kogi State, reported that the predicted technical efficiency of the sample fish farmers ranged widely from 0.521 to 0.999 (i.e. approximately 52% to 100%). The mean technical efficiency is estimated to be 0.71. The mean farm efficiency of 0.71 (71%) recorded in the farms studied leaves rooms for farm efficiency improvement in the state by 29% in order to bring the fish farmers to the frontier of their technology.

Adeogun *et al.* (2014) estimated the technical efficiency of fish farmers in Lagos State based on their rearing techniques and the results showed that the mean technical efficiencies of the fish farmers were 0.86, 0.95, 0.84 and 1.00 in earthen pond, concrete tank, plastic tank, and fibre tank, respectively. The degree of technical efficiency scores indicated that all the rearing techniques operate close to the frontier. The estimated mean overall was 0.94 which means that 6.0 % increase in production is possible with the present state of the rearing techniques. Itam *et al*. (2014) in a study carried out in Cross River State reported that the minimum, maximum and mean technical efficiency of the fish farmers were 41%, 98% and 89%, respectively.

According to Osawe *et al.* (2008) in a study conducted in Oyo State, the predicted farm specific technical efficiencies (TE) ranged between 0.51 and 0.998, with a mean of 0.906. Thus, in the short run, there is a scope for increasing fish production by about 9.4 %, on the average, by adopting the technology and techniques used by the best-practice fish farms. One of such measures is addressing the issue of negative elasticity of pond size used. The deciles range of the frequency distribution of the efficiencies show that about 65.9 % of the farmers had TE exceeding, 0.901 about 34.1 percent had TE ranging between 0.501 and 0.900.

In the study undertaken by Kareem *et al.* (2013) in Ogun State, the mean technical efficiency (TE) was estimated to be 0.77, indicating that the realized output could be increased by about 23% by adopting the practices of the best fisherfolks. Tsue *et al.* (2013), in a study conducted in Benue State, revealed that the technical efficiencies of farmers ranged between 0.29 and 0.94 with a mean of 0.82. The results further shows that about 95% of the farmers had technical efficiency exceeding 60%. The results imply that majority of the respondents operated close to their production frontier. Thus, in the short-run, there is scope for increasing catfish production to about 18% by adopting the technology and techniques used by the best- practice catfish farms.

The result of Dawang *et al.* (2011) in a study carried out in Plateau State indicated that about 78% of fishermen were operating at 80% or more technical efficiency levels and that about 90% of fishers were operating at a technical efficiency level of 70% or more. The results further revealed that technical efficiency ranges between 20.74-94.57% with a mean technical efficiency of 83.19%. This suggests a relatively high technical efficiency level existing in the fisheries.

2.4.4 Determinants of technical inefficiency of fish farming in Nigeria

The sources of technical inefficiency of fish farmers in Benue State as reported by Penda et al. (2013) were age ($p<0.05$), farming experience ($p<0.05$), household size ($p<0.01$) and income ($p<0.05$). Adinya *et al.* (2011) in their study undertaken in Rivers State reported that the coefficient of fish farmers' educational level, farming experience, credit access, membership of cooperative had the expected positive signs and significant at 5% in both mandarin and clown fish farms. This implies that fish farmers' efficiency will increase with increase in their years of schooling, farming experience, membership of cooperative and access to credit.

Onoja and Achike (2011) in a study undertaken in Kogi State reported that farm area of the fish farms and water supply system employed by the farmers were the only significant variables influencing the level of inefficiency. Farm area returned a negative sign indicating that as farm area increased inefficiency in the fish farm decreases. This variable was significant at 1 %. The second significant variable, which gave a positive sign indicates that as more fish farmers adopt the water trough system, inefficiency tend to decrease in the farm. These results are in line with *a priori* expectations. The rest eight variables tested were not significant even at 10% level.

Adeogun *et al.* (2014) estimated the determinants of technical inefficiency of fish farmers in Lagos State based on their rearing techniques The results showed that, education, age, experience, fish farm management, water and feed management index had significant impact on technical inefficiency of fish farmers among the rearing techniques while pond area had significant impact on the technical inefficiency of the fish farmers using concrete and plastic tanks. In a similar vein, machinery had significant impact on fish farmers using concrete and fibre tanks while primary activity was only significant on the fish farmers using fibre tank.

Experience had a positive and highly significant impact on efficiency in concrete, plastic and fibre tanks, while its effect on fish farmers' inefficiencies for earthen pond was negative but significant. While fish farm management, water and feed management index were negatively associated with technical inefficiency and significant for fish farmers using fibre tank, the variables were positive and significant for fish farmers using earthen pond, concrete and plastic tanks.

Itam *et al.* (2014) in a study carried out in Cross River State reported that gender, family size, experience and education were significant in influencing the technical inefficiency of the fish farmers at 1% probably levels. Gender and family size were negatively related to the technical inefficiency of the fish farmers while experience and education were positively related to the technical inefficiency of the fish farmers.

According to Osawe *et al.* (2008), in a study conducted in Oyo State, the coefficients of feeding regime was positive, indicating that this factor led to increase in technical inefficiency or decrease in TE of fish production in the study area. Also, the coefficients of educational level, years of experience, pond type and cooperative membership were negative, indicating that these factors led to decrease in technical inefficiency or increase in technical efficiency. Similarly, tertiary education was significant at 1 % level, secondary education and cooperative membership were significant at 5 percent levels of significance.

In the study undertaken by Kareem *et al.* (2013) in Ogun State, the results showed education, age, gender and mode of operations to be positive while years of experience, household size and gender were found to be negative. A negative sign means that the variable increases efficiency while positive coefficient means a decrease in efficiency level. The negative coefficient of the years of experience for instance has influence on catch efficiency. This implies that with increase in the number of years in fishing, the fisherfolks tend to be more efficient.

Tsue *et al.* (2013) in a study conducted in Benue State revealed that the factors that were found to exert statistical influence on inefficiency of farmers include age of farmer (-6.22), years of educational attainment (-0.27) and size of farmers' household (0.95). However, experience was found not to exert statistical significance on the level of farmers' inefficiency. The stochastic frontier production function inefficiency analysis result of Dawang *et al.* (2011) indicated the coefficients of experience, extension contact and educational status were all negative and statistically significant. This result suggests that increasing these variables will decrease technical inefficiency i.e. increase technical efficiency. Specifically, for every extra year of schooling that a fisher gets, there is a 9% increase in the chance or probability of being technically efficient. The negative coefficients of education and extension contact indicate that these factors can lead to increase in technical efficiency of fishers in the study area.

2.4.5 Profitability of fish farming in Nigeria

According to Awoyemi (2011), an average total cost of ₦ 371, 486.35 was incurred per annum by fish farmers in Osun State while gross revenue of ₦ 791, 242.52 was realized with a gross margin of ₦ 574, 314 and a profit of ₦ 419, 756.17. The rate of return on investment of 0.58 implies that for every one naira invested in Fish production by farmers, a return of ₦ 1.5 and a profit of 58k were obtained.

The costs and returns analysis of Kudi *et al.* (2008) indicated that, variable cost constituted 97.63% of the total cost of fish production in the study area, while the fixed cost constituted 2.37%. Amongst the variable inputs, fingerlings/juveniles (42.82%) and feed (34.70%) constituted the highest cost item in fish production, while hired labour constituted 16.91%. The cost of production was ₦ 571, 231.79, the total revenue of ₦ 5, 853, 625.64 and the net income was ₦ 5, 282, 393.85 indicating that fish production was highly profitable.

Akegbejo-Samsons and Adeoye (2012) reported that the cost of fish fingerlings accounted for the largest proportion (45.3%) of the cost of fish farming in a study conducted in South West Nigeria. This is followed by cost of fish feeds (42.0%) and that the total costs of fish farming in the study area amounted to ₦ 587, 500.00, while the total revenue was ₦ 1, 102,500.00. Other usual variable costs such lime, fertilizer, medication, fuel, transportation were not accounted for in most of the sampled fish farms. The computed Net Farm Income (NFI) was ₦ 615, 000, while the Net return on Investment was 1.05.

Henri-Ukoha (2012) revealed in a study on profitability of fish farming in Abia State revealed that the total variable cost was ₦ 535,055 and the revenue was ₦810,000 giving a gross margin of ₦274, 945/pond. Meanwhile, the net farm income was ₦263,890. However, the rate of return on the business was 1.48. This implies that for every one naira spent in the fish farming business 48k was returned.

Olaoye *et al.* (2013) in a study conducted in Oyo State revealed that the average total cost (TC) of ₦ 2,883, 515.08 was incurred, total revenue (TR) of ₦ 4,873,521.29 was realized and with a gross margin (GM) of ₦ 2,376,616.36. The profitability ratio gave a benefit-cost ratio of 1.69, rate of return of 0.69 gross revenue ratio (GRR) of 0.59 and expense structure ratio (ESR) of 0.15. This is an indication that fish farming was profitable in the study area. Olayemi *et al.* (2013) in a study conducted in Ibadan metropolis estimated that the total cost incurred was ₦ 931,559.06 and the total revenue was ₦ 1, 505, 671.20 with a gross margin of₦ 982,962. 14 and profit of ₦ 574,112.14.

Anyanwu *et al.* (2009) in a study conducted in Onitsha reported that a gross margin of N96, 002.29 and net enterprise income of ₦ 63, 192.14 was realized by the fish farmers in a production cycle. The cost and returns of fish farming in Osun State reported by Oluwemimo and Damilola (2013) showed that the average variable cost was ₦ 480, 755.55, constituting about 78% of the total cost of production while the fixed cost was just ₦ 138, 687 out of the total of₦ 610, 442.55 incurred on production. The average revenue of farmers was N938, 083.30 which gave an average net revenue of ₦ 318, 640.75. This gave a monthly income of ₦ 26, 553.40 which was higher than the ₦ 19, 000 (US$126.67) national minimum wage. The gross margin to enterprise was also ₦ 457, 327.75, indicating the enterprise was able to recover all variable costs during the production period. The benefit-cost ratio was 1.5 indicating that for every ₦1.00 invested, the enterprise yielded additional 50k.

Olagunju *et al.* (2007) in a study on economic viability of fish farming reported that the average total cost per kilogram of fish produced was ₦ 204.00 while the average total revenue per kilogram of fish raised was ₦308.00. This gave a gross margin of ₦ 194.60 per kilogram, of fish. Benefit cost ratio (BCR) was 1.50 and since the ratio is greater than one, it shows profit and indicated that the enterprise was profitable even with small capital invested. It was, therefore, possible to have higher value of BCR with increased capital and skilled labour. The Gross Ratio (GR) was 0.662 implying that from every ₦ 1.00 return to the enterprise, ₦0.662 was being spent. The Rate of Return (ROR) was 51%. This showed that for every ₦ 1.00 invested, 51 kobo was gained. The Expense Structure Ratio (ESR), (ratio of fixed cost to the total cost of production)was 0.43 which implied that about 43% of the total cost of production was made up of fixed cost component. This made the business worthwhile since increase in the production with variable cost would increase the total revenue, leaving the fixed cost unchanged.

The result of Adewuyi *et al.* (2010) in a study undertaken in Ogun State was that an average total cost of ₦ 394,380 was incurred per annum by fish farmers while gross revenue of ₦ 715, 030.30 was realized with a gross margin of ₦ 574, 314 and a profit of ₦ 320, 650. The rate of return on investment of 0.55 implies that for every one naira invested in Fish production by farmers, a return of ₦ 1.55 and a profit of ₦ 0.55 were obtained.

In the study carried out by Olasunkanmi and Yusuf (2014) in Osun State, an average fish farmer spent about 45% of the variable costs on feed while 39.96% was spent on labour. In sum, feed and labour constitute about 85% of total variable costs while land acquisition and pond construction constitute about 41% and 29% of the fixed costs, respectively. In absolute terms, an average catfish farmer in the study area makes a gross margin of ₦ 578, 414.75 and net revenue of ₦ 382, 846.85. Judging from the above it can be said that small scale catfish production in the study area was profitable. The return per naira invested was 1.67 which means that for every one naira spent, a profit of 67k was realized. Since the ratio was greater than one, it showed profit and indicates that the enterprise was profitable.

Penda *et al.* (2013) in their study conducted in Benue State reported that an average total cost of ₦ 302, 614. 25 was incurred per annum by the respondents while a mean gross revenue of ₦ 466, 610.84 was realized thereby returning an average gross margin of ₦ 284, 800.00 and a profit of ₦ 163, 995.59. The rate of return on investment (ROI) of 0.65 implied that for every one naira invested in fish production in concrete ponds by the farmers, a return of ₦ 1.65 and a profit of ₦ 0.65 were obtained. In a study conducted in Lagos State by Baruwa *et al.* (2012), a gross margin of ₦ 104, 392.07 was estimated for aquaculture fishery while ₦ 271, 175 was estimated for artisanal fishing. The net farm income of ₦ 102,120.04 and ₦ 255,761.59 was recorded for the aquaculture and artisanal fishing, respectively. The benefit cost ratio for aquaculture fishing implied that for every

₦ 1 spent on the enterprise, ₦ 1.34 profit was returned while for artisanal fishing ₦ 1.36 was returned as profit for every ₦1 expenditure.

Oguoma *et al.* (2013) in a study carried out in Imo State reported the profitability of the fish farmers in the three agricultural zones of the State as follows: in Owerri Agricultural Zone, the sum of ₦596, 910/tonne/year was earned per farmer as average total revenue and, with an average total cost of production of₦ 160, 279.30, the sum of ₦ 436, 630.70 was earned as net return with a return on investment of 2.72; In Okigwe Agricultural zone, average total revenue of ₦ 621,440/tonne/year was earned per farmer with an average total cost of production of ₦ 186, 414.51, giving a net return of ₦ 435,025.49 and 2.35 as return on investment; In Orlu Agricultural Zones average total revenue of ₦ 650, 560/tonne/year was earned per farmer with a total cost of production of ₦ 188, 155.80 per tonne, giving estimated net revenue of ₦ 462, 404. Although this result shows fish production to be profitable in the state, it suggests that it was most profitable in Orlu Agricultural Zone, followed by Owerri Agricultural Zone, and then Okigwe Agricultural zone.

2.4.6 Constraints of fish farming in Nigeria

Despite the increase of fish production in Nigeria, production level is still very low and this has been attributed to high cost of input, lack of credit to fish farmers at low interest rate, lack of skilled manpower and an ineffective aquaculture extension service system(Oota, 2012).

Adewumi and Olaleye, (2011) found out that a number of problems confront the production of catfish; being a major specie in Nigeria. Prominent among these are: Poor management skills, inadequate supply of good quality seed, lack of capital, high cost of feed, faulty data collection, lack of environmental impact consideration and marketing of products. If the associated problems of production, especially the twin issue of feed production and fingerling supply are tackled, Nigeria will soon become a world exporter of catfish

According to George *et al.*(2010), the major problem hindering the promotion and development of the aquaculture industry in Nigeria has been the scarcity of fish fingerlings and that the major factors militating against the production of high quantity of fish seed are energy and water quality related problems arising from skills gap in the industry. Nwiro, 2012 also reported inadequate supply of fingerlings as a constraint to fishery subsector amongst other factors such as inadequate information and feed supply.

According to Olasunkanmi (2013), the fish farmers in Osun State were confronted with one problem or the other and most of the farmers identified more than one problem and that the most important problem identified in this study is that of cost of feed (66.7%). Kudi *et al.* (2008) reported that the most important problems encountered in fish production in Kaduna State were capital, marketing and diseases and pests as indicated by as many as 98%, 82% and 57% of the respondents, respectively. Also, 21% faced water supply problem, which, however was not severe.

According to Akegbejo-Samsons and Adeoye (2012), there are many constraints hindering efficient production of fish by the farmers. The two most serious problems in the study area indicated by all the respondents (100%) were high price of fish feeds and high mortality of stocked fish.Ninety five percent of the respondents opined that the acute shortage of fry and fingerlings was a major problem when they wanted to re-stock their ponds after each cycle of production. Eighty five percent of the farmers complained of lack of skilled workers needed for daily production routine and lack of capital needed for expansion of the business.

Olaoye *et al.* (2013) reported that majority of the fish farmers (94.6% and 96.0%) in Oyo state claimed that poaching/predators and high cost/lack of construction equipment respectively were one of the major challenges facing aquaculture development in the study area. It was also shown that all (100%) of the respondents considered market price fluctuation and high cost of fish feed as a problem facing fish production. Some other factors militating against aquaculture production included; water shortage during dry season (92.3%), diseases and pest infestation (32.4%) and lack of technical know-how (42.4%).

In the work of Agboola (2011) twenty and twenty one of the farmers, respectively, claimed that poaching and the menace of the predators were their problems, forty five complained of paucity of fund as a major factor inhibiting their productivity as well as future expansion. Eighteen of the respondents claimed that shortage and high cost of fingerlings constituted a problem to them, while twenty nine and twenty one, respectively, complained of high cost of feed and market price fluctuation. Eleven complained of problem of preservation/storage/processing while four claimed that problem of land acquisition constituted a cog in their wheel of progress. Other problems included disease/pest infestation which five of them indicated as well as problem of water shortage during the dry season which two farmersindicated that they faced. It is very important to note that the problems were not exclusive but interwoven.

Olayemi *et al.* (2013) in a study conducted in Ibadan metropolis categorized constraints militating against fish farming into “not a constraint”,” mild constraint” and” severe constraint”. Inadequate finance was indicted by the respondents as the most serious constraint to catfish production with mean score of 1.68 and was ranked first. The second serious constraint was lack of encouragement from the government with a mean score of 1.47 and it was ranked second. High cost of feeds was ranked third and was indicted by the respondents as a constraint to catfish production with mean score of 1.40. Other constraints and their mean values include inadequate electric power supply (0.44), water pollution (0.88), predators (0.86), inappropriate research on aquaculture (0.83), poor experiences of past attempts at developing aquaculture (0.76), theft (0.73), flood problems (0.70) , inadequate storage facilities for feeds and drugs (0.64), inconvenient source of drugs and chemicals (0.58), limited market sales(0.57) and inadequate harvesting and transportation equipment (0 52) and they were ranked fourth, fifth, sixth, seventh, eighth, ninth, tenth, eleventh, twelfth, thirteen and fourteen, respectively.

In the work of Anyanwu *et al.* (2009) all the fishermen were of the view that cold room and other storage facilities were major problems. These would increase fish spoilage which will reduce their income. Other problems encountered by the fish farmers were lack of credit facilities and poor funding. The credit facilities, which they needed, could aid them to get more of fishing nets, outboard engine and boats. This will improve fishing activities and enable them adopt new technologies.

Oluwemimo and Damilola (2013) reported that the major challenges confronting all the fish farmers in Osun State were lack of access to credit and high cost of inputs like feed and fingerlings. There were few sources of fingerlings and other inputs which raises production cost. If the farm business is to be economically viable, fish farmers must have access to viable, efficient and cheaper input sources. In addition, none of the farmers was able to access credit from the commercial and/or specialized banks. Another 78% of the farmers faced the challenge of poor extension services which deprived them expert advice in the area of pond construction, maintenance and management. Forty nine per cent complained about the problem of predators disturbing their ponds while 46% were affected by pollution from upstream. Forty two per cent complained of inadequate supply of fingerlings as well as the viability of the ones they got from private sources while 40% were adversely affected by shortage of water resulting from climatic variability. Finally, 32% complained of the problems of acquiring land for their enterprise.

The findings of Nwosu and Onyeneke (2013) in Owerri, Imo State, revealed that majority (60.00%) of the pond fish farmers reported inadequate finance as a major problem challenging pond fish farming in the area. The second serious problem was the problem of high cost of feed as reported by 52.50% of the farmers. The scarcity of commercial pelleted and floating fish feed mills and problems associated with production and distribution of fish feeds could be the main reasons for the hike in feed prices. Lack of good sources of fingerlings is the third serious problem reported by 50.00% of the pond fish farmers. This could be due to the nearly inexistence of local supplies of pond fish fingerlings in the study area. The fourth serious problem to pond fish production reported by 45.00% of the farmers was high cost of transportation. This is due to the inadequacy of motorable roads in the area.

Olasunkanmi and Yusuf (2014) in a study carried out in Osun State identified the most important factor inhibiting farmers' productivity in the study area as lack of support from extension officers during site selection (22.13%) for construction of pond or any other farm activities, insufficient fund (15.69%), absence of government assistance (10.64%), high cost of feed and other inputs (11.77%), market price fluctuation (10.36%) and flooding during the raining season (5.60%).

Nwaobiala and Ebeniro (2012) in a study conducted in Edo State found that majority of the respondents (70.0%) claimed that unimproved fingerlings is their major problem, while 40.0% identified poor quality feeds as another problem. Thirty three point three three per cent and 26.67% of the catfish farmers indicated that irregular supply of feeds and fingerlings and government policy on fisheries development are their problems respectively. Finally, 16.67% of the respondents identified poor water quality as their problem as a result of water salinity.

Baruwa *et al.* (2012) in a study conducted in Lagos State highlighted epileptic electricity supply, insufficient capital, high cost of inputs, high-cost of labor and water pollution as the constraints encountered by the fish farmers. Out of all these, the three most prevalent problems for artisanal enterprise are: water pollution, fund inadequacies and high cost of input while for aquaculture enterprise, fund inadequacies, epileptic electric power supply and high cost of labor were the principal limiting factors. In general, insufficient fund (43.75%) ranks highest of the three constraints followed by water pollution (31.25%) and epileptic electric power supply (12.50%). However, the frequency of the other two factors, high cost of inputs and high cost of labor were equally significant and cannot be totally ignored in designing the appropriate policy to tackle the constraints to fishery production in Lagos, Nigeria.

Ufuoku *et al.* (2006) identified high cost of fish farming (18.7%), lack of credit facilities (16%), inadequate extension services (13.3%) and poaching (theft) (26.7%) were the constraints mostly faced by the small-scale fish farmers confronting fish farmers in Delta State. Other problems included high cost of equipment (8.0%), pollution (10.7%) and ecological problems such as over- flooding (6.7%).

Result of 4-points Likert Scale Ranking of the constraints of catfish farming in Nassarawa State by Joshua *et al.* (2012) revealed that problem of water supply with mean of 3.27 was rated highest. The scale further indicated that problem of fingerlings supply (2.79) comes next while the problem of feed unavailability with mean of a 2.45 was rated as the least problem confronting the fish farmers in the study area.

Adinya *et al.* (2011) in their study undertaken in Rivers State reported that lack of credit, high cost of industrial feed, lack of extension agents, lack of veterinary doctors and lack of fish production equipment occupied 26.67%, 18.33%, 5.83%, 45.83%and 3.33 %, respectively, for mandarin fish farmers. There was also a corresponding 25%, 22.50%, 5%, 41.67% and 5.83 %, respectively, for clown fish farmers in the study area.

In the study carried out by Williams *et al.* (2012) in Lagos State, the summary of problems encountered by fish farmers in the study area showed that 44 % of the respondents agreed that unstable electricity constituted a major problem associated with running of the business enterprise, 16 % of the respondents encountered management problems, 14 % of the respondents have security problems, 10 % agreed that proximity to perennial water was a constraint and 4 % of the respondents had problem of mortality.

CHAPTER THREE

METHODOLOGY

3.1 Description of the Study Area

The study covered18 out of the 23 Local Government Areas (LGA) of Kaduna State. Kaduna State lies in the Sudan Savannah agro-ecological Zone of Nigeria and is bounded in the west by Niger State while it shares boundary with Zamfara State at the north western flank, Katsina State in north, and Kano State at the north eastern end. In a similar vein, Bauchi and Plateau States are located at the eastern bearing of the State while the Federal Capital Territory and Nassarawa States flank it at the southern end.

Kaduna State has a vast landmass of about 48,000 square kilometres and has one major river (River Kaduna) and its tributaries, which runs across the State through Niger and

Kwara States and empties itself as a major tributary to River Niger in Kogi State. The vast lands, the presence of freshwater bodies and favourable climatic conditions, with average rainfall of about 1066mm, afford the residents of Kaduna State the opportunity to practice fish farming in addition to crop and livestock agriculture.Rainfall is heaviest in the southern part of the state and decreases northwards.The state experiences both wet and dry seasons with the wet season commencing in the month of April in the southern part of the state and between May and June in the northern part of the state. The rainfall lasts from May to October. The dry season sets in immediately after the rainy season and is characterized by harmattan period with a temperature ranging from 18^0C to 26^0C and the heat period with a temperature that ranges from 32^0C to 39^0C

Kaduna State lies between Latitudes $09^0$02'N and 11^0 32'N and between longitudes $06^0$15'E and $08^0$06E. Its population was put at 6, 066, 526 people in 2006 (NPC, 2006) and had a projected population of 7, 563,065 people in 2014using an annual growth rate of 2.8%.

The vegetation in the state is divided into Northern guinea savannah in the northern part of state and southern guinea savannah in the southern part of the state, while politically, the State is divided into 23 Local Government Areas and three Senatorial zones (Figure 3.1). The main Ethnic groups are Hausa, Fulani, Gbagyi, Bajju, Kagoma, Ninzo, Kahugu, Kagoro and Moro'a. The main crops are Guinea corn, millet, maize, rice, yam, potatoes, ginger, groundnuts, chillies, sheanuts, beni-seed and soya beans. The predominant liverstock are cattle, sheep, goats, poultry and fisheries.

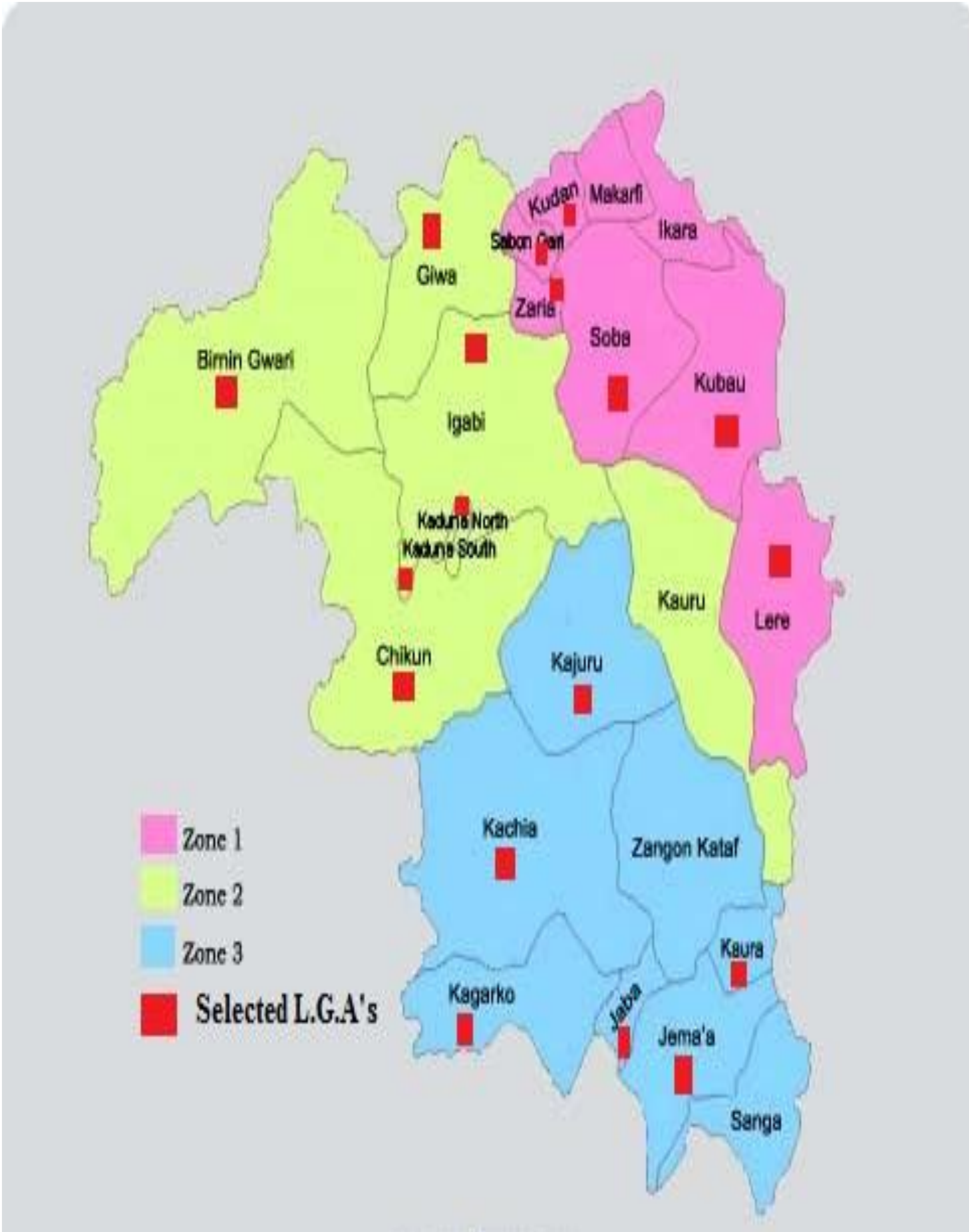

Figure 3.1: Map of Kaduna State showing the selected local government areas

3.2 Sampling Procedure and Sample Size

Apilot survey of existing fish farms was conducted in Kaduna State and this formed the basis for the sample frame employed in the study.A total of 115fish farms were identified in 18 (Zaria, Sabon-Gari, Soba,Kubau, Lere, Kaduna North, Kaduna South, Kudan, Chukun, Igabi, Kajuru, Giwa, Jama'a, Kachia, Kagarko, Jaba and Kauru) out of the 23 Local Government Areas of the State.The fish farmers were identified through the Agricultural Extension Units of the Local Government Council. All the fish farmers identified during the pilot survey constituted the sample size of the study and therefore, the sample size of the study was 115 fish farmers. The distribution of the fish farmers is given in Table 3.1

Table 3.1: List of fish farmers in selected local government areas of Kaduna state

S/No	Local Government Area(LGA)	Number of fish farmers
1	Zaria	2
2	Sabon-Gari	8
3	Soba	4
4	Kubau	6
5	Lere	8
6	Kaduna North	8
7	Kaduna South	15
8	Kudan	3
9	Chukun	7
10	Igabi	2
11	Kajuru	7
12	Giwa	6
13	Birnin Gwari	5
14	Jama'a	8
15	Kachia	11
16	Kagoro	4
17	Jaba	5
18	Kauru	6
	Total	115

3.3 Method of Data Collection

Primary data were employed in the study. Data werecollected with the aid of structured questionnaire administered to the fish farmers by trained enumerators from Kaduna State Agricultural Development Project (KADP). Data on socioeconomic variables (age, education, fish farming experience, household size, extension contacts and membership of fish farming association), production variables (type of pond, scale of operation, type and quantities of inputs used, prices and technique of production), output variables and constraints affecting fish farmers,and fish farm management practices were collected from the fish farmers.

The fish farms were further classified according to scale of operations (small scale, medium scale and large scale) based on the range of holdings of the farmers.The scale was generated from the number of fingerlings; 1 – 5000 = small scale; 5001 – 10,000 = medium scale and >10,000 = large scale. This classification was adapted from the work of Ufuoku *et al*. (2006) as the basis for classification of fish enterprise into small, medium and large based on the population of fingerlings.

3.4 Analytical Technique

Various analytical techniques were used for this study to achieve the various objectives. These include descriptive statistics, farm budgeting techniques, stochastic frontier production function and ANOVA.

3.4.1 Descriptive Statistics

Descriptive statistics wereused to have a precise description of the data collected from the field. These involve the use of measures of central tendencies, frequency distribution, ratios, percentages, cross tabulation to describe socioeconomic characteristics of the farmers and constraints in fish farming. This tool was used to achieve objectives i and vi of the study.

3.4.2 Farm Budgeting Techniques

Net Farm Income**:**The Net farm income as a tool of partial budgeting was used in achieving objective ii. The Net farm incomewas used because fish farming has sizeable fixed cost elements such as cost of pond construction, land (purchase) taxes and rents; pumps/tanks and accessories and other farm equipment; farm structure (buildings, pond structure, etc); and depreciations on assets. The components of variable cost in fish farming include: cost of feed, medication, fertilizer, liming, labor and fingerlings/juveniles.

The General model of the farm budget is as follows:

NFI = GI – TC …………………………………………………………………. (7)

Where:

NFI = Net Farm Income (₦)

GI = Gross Farm Income (₦) i.e. this is the total fish output (kg) multiplied by the unit price of the product.

TC = Total Cost (₦)

TC = Total Variable Cost (TVC) + Total Fixed Cost (TFC)

Return to Investment (RTI) also known as profitability ratio was used to determine the profit obtainable for every one naira invested in fish farming. This was estimated by dividing net farm income by the total cost of farming (NFI/TC).NFI was calculated for each scale of operation and the pool data using the straight line depreciation method.

3.4.3 Stochastic Frontier Production Function

The stochastic frontier production function was used to estimate the technical relationship between inputs and output in fish farming and also to quantify the technical efficiency of fish farmers operating at various scales of production (objectives iii and iv).

Direct estimates of the parameters can be obtained by either the Maximum Likelihood Method (MLM) or the Corrected Ordinary Least Square method (COLS). However, the MLM estimator has been found to be asymptotically more efficient than the COLS (Coelli, 1995). Thus, the MLM was used to estimate the parameters for empirical analysis.

3.4.3.1 Model Specification

Assuming a production technology specified by Cobb-Douglas production frontier, the stochastic frontier model is defined as:

$$\ln Y_i = \ln \beta + \sum \beta i \ln X_{ij} + v_i - \mu_i \qquad (8)$$

Where:

Y_i = Fish output (kg) from ith farmer

X_{ij} = Vector of farm input, and i=1, 2, 3,….n farms; j=1,2,3,…,m inputs.

Where:

X_1 = Quantity of feeds in kg

X_2 = Number of fingerlings/juveniles

X_3 = Stocking density (Number of fish/m^2)

X_4 = Labour (mandays)

β = Intercept

β_{ij} = Vector of production function parameters to be estimated; i=1, 2, 3,…,n farms; j=1,2,3,…,m inputs.

v_i = Random variability in the production that cannot be influenced by farmer.

μ_i = the deviation from maximum potential output attributable to technical inefficiency.

3.4.3.2. Estimation of determinants of technical efficiency

In the context of the stochastic frontier production function, the technical efficiency of a firm is defined as the ratio of the observed output to the corresponding frontier output conditional on the level of inputs used by the firm. Thus the technical efficiency of the firm was defined as:

$TE_i = \exp(-u_i)$ ………………………………………………………..……………....... (9)

$TE_i = Y_i/Y^* = f(x_i;\beta) \exp(v_i-u_i)/f(x_i;\beta) \exp(v_i) = \exp(-u_i)$

Where:

TE_i = Technical efficiency of farmer *i*

Y_i = Observed output from farm *i* and

Y^* = Frontier output

TE_i ranges between 0 and 1. Maximum efficiency has a value of 1 while lower values represent less than maximum efficiency in production.

The factors hypothesized to influence the technical efficiencies of fish farmers in the study area include: age of respondents (years), educational status (number of years spent in school), household size, years of farming experience, loan obtained in naira and number of extension visit. Membership of association was left out in the model because it considered to be insignificant because of the small number of respondents.

The inefficiency model is specified for objective (5) as:

$$\mu_i = a_0 + a_1Z_1 + a_2Z_2 + a_3Z_3 + a_4Z_4 + a_5Z_5 + a_6Z_6 \text{ ....} (10)$$

μ_i= technical inefficiency effect of the i−th farmer

Z_1 = Age of respondent (years)

Z_2 = Education (years of formal schooling)

Z_3 = Household size (number of household members)

Z_4 = Years of experience in fish farming (years)

Z_5 = Credit obtained (naira)

Z_6 = Extension visits (number of visit/month)

The δ are unknown parameters to be estimated along with the variance parameters δ^2 and γ. The variance of the random error δv^2 and that of the technical inefficiency effect $\delta^2 u$ and the overall variance of the model are related as follows:-

$$\boldsymbol{\delta^2 = \delta v^2 + \delta u^2} \text{ and, } \boldsymbol{\gamma = \delta u^2/\delta^2}$$

γ measures the total variation of the production (output) from the frontier which can be attributed to technical inefficiency (Battese and Corra, 1977).

3.4.4 Analysis of Variance

The Analysis of Variance was used to test the hypotheses i and ii of the study. The ANOVA model for the test of hypothesis i of the study is presented as follows:

$$F^* = \frac{[\sum e^2 p - (\sum es^2 + \sum e^2 m + \sum eL^2)]/k}{(\sum es^2 + \sum e^2 m + \sum eL^2)/(n_1 + n_2 + n_3)} \text{ ....} (11)$$

Where:

$\sum e^2 p$ = unexplained variation of the profitability of pooled farmers

$\sum e^2 s$ = unexplained variation of the profitability of small scale farmers

$\sum e^2 m$ = unexplained variation of the profitability of medium scale farmers

$\sum eL^2$ = unexplained variation of the profitability of large scale farmers

K = total number of estimated parameters

S, M, L, P = Small, Medium, Large and Combined three scale farmers, respectively.

The hypothesis tested is

$H_O = NFI_S = NFI_M = NFI_L$. There is no significant difference in the NFI of the three groups

$H_a = NFI_S \neq NFI_M \neq NFI_L$. There is significant difference in the NFI of the three groups.

The ANOVA model for the test of hypothesis ii is presented as follows:

$$F^* = \frac{[\sum e^2 p - (\sum es^2 + \sum e^2 m + \sum eL^2)]/k}{(\sum es^2 + \sum e^2 m + \sum eL^2)/(n_1 + n_2 + n_3)} \quad \text{...…. (12)}$$

Where:

$\sum e^2 p$ = unexplained variation of the technical efficiency of pooled farmers

$\sum e^2 s$ = unexplained variation of the technical efficiency of small scale farmers

$\sum e^2 m$ = unexplained variation of the technical efficiency of medium scale farmers

$\sum eL^2$ = unexplained variation of the technical efficiency of large scale farmers

K = total number of estimated parameters

S, M, L, P = Small, Medium, Large and Combined three scale farmers, respectively.

The hypothesis tested is

$H_O = TE_S = TE_M = TE_L$. There is no significant difference in the TE of the three groups

$H_a = TE_S \neq TE_M \neq TE_L$. There is significant difference in the TE of the three groups.

CHAPTER FOUR

RESULTS AND DISCUSSION

4.0 Introduction

This chapter presents the results and the discussion of findings in line with the stated objectives of the study. Hence, the chapter is divided into 4.1 (Socioeconomic characteristics of fish farmers at various scales of production), 4.2 (Costs and returns of fish farming at various scales of production), 4.3 (Technical relationship between production inputs and output), 4.4 (Level of technical efficiency of fish farmers operating at various scales of production) 4.5 (Factors influencing technical efficiency of fish farming) and 4.6 (constraints limiting efficiency of the existing fish farming).

4.1 Socioeconomic Characteristics of Fish Farmers in the Study Area

4.1.1 Age of fish farmers

The results presented in Table 4.1 show that a large proportion of the small scale fish farmers (49.5%) were within the age bracket of 40 – 49 years with a mean age of 48 years. In the case of the medium and large scale fish farmers, 40% and 55.6%,respectively,were within the age bracket of 50 – 59 years with an average of 50 years (medium scale) and 52 years (large scale). This result indicates that there was variation in the age distribution of the fish farmers on the basis of their scale of production. The small scale fish farmers were relatively younger than the medium and large scale farmers. The implication of farm size increasing with age is that older farmers are likely to be more experienced and would also have more resources to invest in the fish farm business.

The Coefficient of Variation (CV) was estimated to be 21.3% and this implies that the variation in the age of the fish farmers was low. The pooled result of the fish farmers in the study area shows that 42.6% of the fish farmers were within the 40 – 49 years age bracket with a mean age of 49 years. This implies that the fish farmers are within their economically productive age bracket and hence, can be very much involved in the day to day activities of their fish farms. This compares favourably with the mean age of 47 years for fish farmers in Benue State as reported by Tsue *et al*. (2013) in a study on catfish farmers in Benue State, Nigeria.

Table 4.1: Frequency distribution of fish farmers based on age

Age (years)	Small scale	Medium scale	Large scale	Pooled
30 – 39	15 (15.8)*	2 (13.3)	0 (0.0)	17 (14.8)
40 – 49	45 (49.5)	2 (13.3)	2 (22.2)	49 (42.6)
50 – 59	19 (20.9)	6 (40.0)	5 (55.6)	30 (26.1)
60 – 69	9 (9.9)	5 (33.3)	0 (0.0)	9 (7.8)
> 69	3 (3.3)	0 (0.0)	2 (22.2)	5 (4.3)
Total	91 (100)	15 (100)	9 (100)	115 (100)
Mean	48	50	52	49
Std. Dev.	15.024	17.212	13.677	10.453

CV (%)	31.3	34.4	26.3	21.3

*Values in parentheses are percentages

4.1.2 Gender

The result of the gender distribution of the fish farmers in Table 4.2 shows that majority of the small scale fish farmers were males (64.8% small scale, 100% medium scale and 77.8% large scale). This result implies that fish farming in the study area is a male dominated farming enterprise as about 70% of the pooled fish farmers were males. This is in consonance with the finding of Olaoye *et al*. (2013) who also reported that fish farming was male dominated as indicated by 84.2% of the fish farmers in a similar study in Oyo State, Nigeria. Also, Agboola (2012) reported that 95.6% of the fish farmers in a similar study in Osun State, Nigeria were males. However, the involvement of women in fish farming was prominent among small scale fish farmers. This could be attributed to the fact that most of the women were part-time fish farmers.

4.2: Frequency distribution of the fish farmers based on gender

Gender	Small scale	Medium scale	Large scale	Pooled
Male	59 (64.8)*	15 (100)	7 (77.8)	81 (70.4)
Female	32 (35.2)	0 (0.0)	2 (22.2)	34 (29.6)
Total	91 (100)	15 (100)	9 (100)	115 (100)

*Values in parentheses are percentages

4.1.3 Occupationof fish farmers

The distribution of the fish farmers based on occupation is presented in Table 4.3. The result shows that the primary occupation of a large percentage of the small scale farmers (about 50%) and medium scale farmers (40%) was civil service. In the case of the large scale fish farmers, majority (about 56%) were traders. The result of the pooled fish farmers shows that the fish farmers'primary occupation was largely civil service as indicated by 45.2% of the fish farmers in the study area. This finding corroborates the finding of Ideba *et al.* (2013) who also reported that a large proportion (50%) of the fish farmers were civil servants in a study in Calabar, Cross River State, Nigeria.

Table 4.3: Frequency distribution of the fish farmers based on occupation

Occupation	Small scale	Medium scale	Large scale	Pooled
Primary occupation:				
Crop farming	13 (14.3)*	2 (13.3)	2 (22.2)	17 (14.8)
Fish farming	5 (5.5)	1 (6.7)	0 (0.0)	6 (5.2)
Civil service	45 (49.5)	7 (40.0)	0 (0.0)	52 (45.2)
Trading	12 (13.2)	5 (33.3)	5 (55.5)	22 (19.1)
Teaching	5 (5.5)	0 (0.0)	2 (22.2)	7 (6.1)
Retired	4 (4.4)	0 (0.0)	0 (0.0)	4 (3.5)
Others	7 (7.7)	0 (0.0)	0 (0.0)	7 (6.1)
Secondary occupation:				
Crop farming	19 (20.9)	8 (53.3)	5 (55.5)	32 (27.8)
Fish farming	47 (51.6)	1 (6.7)	4 (44.4)	52 (45.2)
Civil service	18 (19.8)	6 (40.0)	0 (0.0)	24 (20.9)
Trading	4 (4.4)	0 (0.0)	0 (0.0)	4 (3.5)
Teaching	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Retired	1 (1.1)	0 (0.0)	0 (0.0)	1 (0.9)
Others	2 (2.2)	0 (0.0)	0 (0.0)	2 (1.7)
Total	91 (100)	15 (100)I	9 (100)	115 (100)

*Values in parentheses are percentages

This result implies that the fish farmers in the study area were largely part-time fish farmers and may, therefore, not be fully involved in the day to day routine activities of their farms. The result equally shows that fish farming was the secondary occupation of majority (51.6%) of the small scale fish farmers while crop farming was the secondary occupation of a large proportion of the medium scale fish farmers (53.3%) and the large scale fish farmers (55.5%). For the pooled fish farmers in the study area, fish farming was the secondary occupation of a large proportion of the farmers as indicated by 45.2% of the fish farmers. This result implies that fish farming was the major secondary occupation of fish farmers in the study area and hence, fish farming contributes to the income of the farmers and invariably their general wellbeing.

4.1.4 Household sizeof fish farmers

The result presented in Table 4.4 shows that a large proportion of the small scale fish farmers (68.2 %) had household size of 1 – 10 persons with a mean of 5, persons while a large proportion of the medium scale farmers (66.6%) had household sizes of more than 10 persons with a mean of 11 persons. In the case of the large scale fish farmers, majority of the farmers (55.6%) had household size of 11 – 15 persons with a mean of 10 persons. The result of the pooled fish farmers in the study area shows that majority of the fish farmers (61.7%) had household size of 1 – 10 persons with a mean household size of 8 persons. The result shows that household size tended to increase with farm size. This could be due to age which also increased with farm size.This shows that the fish farmers had relatively large household sizes and hence, the contribution of family labour for fish production will tend to be high leading to a decrease in demand for hired labour by the fish farmers especially for the small scale fish farmers.

The mean household size does not corroborate the finding of Ekunwe and Emokaro (2009) who reported that the mean household size was 5 persons, in a study in Kaduna, Nigeria. The coefficient of variation of the fish farmers' household size was estimated to be 64.2% and this implies that there is a relatively high variation in the household size of the fish farmers in the study area.

Table 4.4: Frequency distribution of the fish farmers based on household size

Household size	Small scale	Medium scale	Large scale	Pooled
1 – 5	32 (35.2)*	3 (20.0)	0 (0.0)	35 (30.4)
6 – 10	30 (33.0)	2 (13.3)	4 (44.4)	36 (31.3)
11 – 15	17 (18.7)	5 (33.3)	5 (55.6)	27 (23.5)
> 15	12 (13.2)	5 (33.3)	0 (0.0)	17 (14.8)
Total	91 (100)	15 (100)	9 (100)	115 (100)
Mean	5	11	10	8
Std. Dev.	7.355	13.442	9.630	5.141
CV (%)	147.2	122.2	96.3	64.2

*Values in the parentheses are percentages

4.1.5 Education of fish farmers

The result presented in Table 4.5 shows that a large proportion of the small scale fish farmers (52.7%), the medium scale fish farmers (73.3%) and the large scale fish farmers

(77.8%) had vocational educational qualification. This was followed by university educational qualification with 28.6%, 26.7% and 22.2% of the small scale, medium and large scale fish farmers respectively having university educational qualification. None of the fish farmers was found to have no formal education. This result suggests that the fish farmers were educated and are better equipped to be able to understand improved farming practices for fish production towards enhancing their productivity.

Table 4.5: Frequency distribution of the fish farmers based on education

Education	Small scale	Medium scale	Large scale	Pooled
No formal	0 (0.0)*	0 (0.0)	0 (0.0)	0 (0.0)
Koranic	0 (0.0)	0 (0.0)	0 (0.0)	0 (0.0)
Primary	1 (1.1)	0 (0.0)	0 (0.0)	1 (0.9)
Secondary	6 (6.6)	0 (0.0)	0 (0.0)	6 (5.2)
Post-secondary	10 (11.0)	0 (0.0)	0 (0.0)	10 (8.7)
University	26 (28.6)	4 (26.7)	2 (22.2)	32 (27.8)
Vocational	48 (52.7)	11 (73.3)	7 (77.8)	66 (57.4)
Total	91 (100)	15 (100)	9 (100)	115 (100)

*Values in parentheses are percentages

4.1.6Fish farming experience

The result presented in Table 4.6 shows that a large proportion of the small scale fish farmers (79.1%), the medium scale fish farmers (60.0%) and the large scale fish farmers (55.6%) had between 1 – 5 years of fish farming experience. For the pooled fish farmers in the study area, 74.8% of the fish farmers had between 1 – 5 years of fish farming experience with a mean of 4 years and this compares favourably with the mean years of experience of 5 years by fish farmers in Benue State (Tsue *etal*., 2013). This result indicates that fish farming is not an age long farming enterprise engaged in by the farmers in the study area as they had relatively low years of fish farming experience and hence, there is the tendency of them having little practical experience to face challenges involved in fish production and this could influence their farm management decision and productivity.

Table 4.6: Frequency distribution of the fish farmers based on farming experience

Farming experience	Small scale	Medium scale	Large scale	Pooled
1 – 5	72 (79.1)*	9 (60.0)	5 (55.6)	86 (74.8)
6 – 10	18 (19.8)	3 (20.0)	4 (44.4)	25 (21.7)
> 10	1 (1.1)	3 (20.0)	0 (0.0)	4 (3.5)
Total	91 (100)	15 (100)	9 (100)	115 (100)
Mean	4	2	4	4
Std. Dev.	2.112	2.533	3.031	2.866
CV (%)	52.8	126.5	75.8	71.7

*Values in parentheses are percentages

The estimated coefficient of variation of the farming experience of the fish farmers was 71.7% and this implies that there was high variation in the years of farming experience of the fish farmers in the study area.

4.1.7Formal trainingof fish farmers

The result of the distribution of the fish farmers based on their engagement in formal training on fish production is presented in Table 4.7. The result shows that a large proportion of the small scale fish farmers (69.2%), medium scale fish farmers (73.3%) and large scale fish farmers (55.6%) had no formal training on fish production. The result of the pooled sample of the fish farmers shows that majority of the fish farmers (68.7%) had no formal training on fish production and this implies that a larger proportion of the fish farmers had no access to some vital technical know-how on fish management practices and this could negatively influence their productive capacity.

This finding agrees with that of Adewuyi *et al*. (2012) who noted that majority of the fish farmers (69.5%) in Ogun State had no formal training in in fish production but contradicts the finding of Penda *et al*. (2012) who reported that a larger proportion of the fish farmers (77.6%) in Benue State had formal training in fish production

Table 4.7: Frequency distribution of the fish farmers based on formal training

Formal training	Small scale	Medium scale	Large scale	Pooled
Yes	28 (30.8)*	4 (26.7)	4 (44.4)	36 (31.3)
No	63 (69.2)	11 (73.3)	5 (55.6)	79 (68.7)
Total	91 (100)	15 (100)	9 (100)	115 (100)

*Values in parentheses are percentages

4.1.8Membership of association

Membership of farmers' association is an important variable that influences the production efficiency of farmers as it offers them the opportunity of exchanging ideas and learning from one another on improved farming practicesand to have timely access to inputs and credit facilities. The result presented in Table 4.8 shows that majority of the small scale fish farmers (83.5%), medium scale fish farmers (86.7%) and large scale fish farmers (66.7%) did not belong to any farmers' association. The result of the pooled sample of the fish farmers in the study area shows that a large proportion of the fish farmers (82.6%) did not belong to any farmers' association and hence, the benefits of being members of farmers' association must have eluded them and this could have implication on their production efficiency.

This finding is not in line with the finding of Olaoye *et al*. (2013) who reported in a similar study that the majority of the fish farmers (62.2%) were members of cooperatives. Sequel to the high start-up capital of fish farming in the study area which could serve as a disincentive for would-be resource-poor fish farmers, thus resulting to fewer people engaging in fish production, membership of cooperative becomes really important as an avenue to access credit facilities in cash and in kind.

Table 4.8: Frequency distribution of the fish farmers based on membership of association

Membership of association	**Small scale**	**Medium scale**	**Large scale**	**Pooled**
Yes	15 (16.5)*	2 (13.3)	3 (33.3)	20 (17.4)
No	76 (83.5)	13 (86.7)	6 (66.7)	95 (82.6)
Total	91 (100)	15 (100)	9 (100)	115 (100)

*Values in parentheses are percentages

4.1.9Access to extension

The result of the distribution of the fish farmers based on access to extension is presented in Table 4.9. The result shows that majority of the small scale fish farmers (60%) and large scale fish farmers (66.7%) had no access to extension while most of the medium scale fish farmers (93.3%)had access to extension services. However, the result of the pooled sample of the fish farmers shows that a relatively large proportion (52.2%) of the fish farmers in the study area had access to extension and this could influence the adoption of improved fish farming practices.

This is in line with Sanni *et al*.(2009) opined that in order to use fisheries/aquaculture management as an entry point to achieving the millennium development goals of combating hunger and reducing poverty in Nigeria, proper management of the extension component of fisheries is imperative.

Table 4.9: Frequency distribution of the fish farmers based on access to extension

Access to extension	**Small scale**	**Medium scale**	**Large scale**	**Pooled**
Yes	40 (44.0)*	14 (93.3)	6 (66.7)	60 (52.2)
No	51 (60.0)	1 (6.7)	3 (33.3)	55 (47.8)
Total	91 (100)	15 (100)	9 (100)	115 (100)

*Values in parentheses are percentages

4.1.10Farmers' reasons for fish farming

The fish farmers in the study area had different reasons for venturing into fish farming as presented in Table 4.10. The analysis reveals that a larg proportion of the small (79.1%), medium (93.3%) and large scale fish farmers (66.7%)are into fish farming for income. From the result of the pooled sample of the fish farmers in the study area, a large proportion (82.6%) were into fish farming for the purpose of making income while 0.9% of the fish farmers were into fish farming for the purpose of conservation of nature. This result suggests that the major drive for fish farming in the study area isincome generation as fish farming is perceived to be a profitable farming enterprise in the study area. This could be attributed to the high demand for fish by consumers in the study area.

This finding corroborates the finding of Olaoye *et al*. (2013) who noted that the major reason for fish farming was to make profit as indicated by 89.2% of the fish farmers in a similar study.

Table 4.10: Frequency distribution of the fish farmers based on reasons for fish farming

Reasons	**Small scale**	**Medium scale**	**Large scale**	**Pooled**
Source of income	72 (79.1)*	13 (93.3.7)	10 (66.7)	95 (82.6)
For recreation	7 (7.7)	2 (13.3)	0 (0.0)	9 (7.8)
To generate employment	11 (12.1)	5 (33.3)	3 (33.3)	19 (16.5)
For food	11 (12.1)	0 (0.0)	2 (22.2)	13 (11.3)
For research	2 (2.2)	0 (0.0)	0 (0.0)	4 (3.5)
For conservation	1 (1.1)	0 (0.0)	0 (0.0)	1 (0.9)
Total	104	20	15	141

NB: Multiple responses allowed and hence the total responses of the farmers are above the expected total frequency of the farmers. *Values in the parentheses are percentage

4.1.11 Distribution of the fish farmers based on pond type

Pond type used for fish farming varies in the study area as presented in Table 4.11. Majority of the small scale fish farmers (48.4%), the medium scale fish farmers (80%) and the large

Table 4.11: Frequency distribution of the fish farmers based on pond type

Pond type	**Small scale**	**Medium scale**	**Large scale**	**Pooled**

Concrete	44 (48.4)*	12 (80.0)	7 (77.8)	63 (54.8)
Embankment	1 (1.1)	0 (0.0)	3 (33.3)	4 (3.5)
Earthen	29 (31.9)	2 (13.3)	0 (0.0)	31 (27.0)
Diversion	0 (0.0)	2 (13.3)	0 (0.0)	2 (1.7)
Plastic	20 (22.0)	0 (0.0)	0 (0.0)	20 (17.4)
Tarpaulin	6 (6.6)	0 (0.0)	0 (0.0)	6 (5.2)
Total	100	16	10	126

NB: Multiple responses allowed and hence the total responses of the farmers are above the expected total frequency of the farmers. *Values in the parentheses are percentages

scale fish farmers (77.8%) made use of the concrete pond while only few of the farmers in the three groups used diversion pond, plastic and tarpaulin. The use of concrete pond might be due to its convenience, easy to clean and manage, and ease of harvesting and draining. This result is in contrast with the findings of Ogundari and Akinbogun (2010) who reported that earthen pond was the major pond type used by fish.

4.1.12Fish species grown

The result presented in Table 4.12 shows that the species of fish grown by farmers in the study area varied. Majority of the small scale fish farmers (89%) and the large scale fish farmers (77.8%) and all the medium scale fish farmers (100%) raised Clarias sp. From the result of the pooled sample of the fish farmers in the study area, 89.6% raised Clarias sp while the least was spotted cat fish as indicated by 0.9% 0f the fish farmers in the study area.

Table 4.12: Frequency distribution of the fish farmers based on fish species grown

Fish species	Small scale	Medium scale	Large scale	Pooled

Clarias sp	81 (89.0)*	15 (100.0)	7 (77.8)	103 (89.6)
Tilapia	0 (0.0)	5 (33.3)	0 (0.0)	5 (4.3)
Mud cat fish	4 (4.4)	0 (0.0)	4 (44.4)	8 (7.0)
Common carp	2 (2.2)	0 (0.0)	0 (0.0)	2 (1.7)
Spotted cat fish	1 (1.1)	0 (0.0)	0 (0.0)	1 (0.9)
Grey cat fish	6 (6.6)	0 (0.0)	0 (0.0)	6 (5.2)
Hetrobronchus	3 (3.3)	4 (26.7)	0 (0.0)	7 (6.1)
Total	98	24	11	132

NB: Multiple responses allowed and hence the total responses of the farmers are above the expected total frequency of the farmers. *Values in the parentheses are percentages

This result indicates that Clarias sp is the most widely grown fish species in the study area and this could be attributed to the high consumer preference for Clarias sp relative to the other fish species in the study area. This is in line with Olagunju *et al*. (2007) who noted that catfish is the most cultured in Nigeria based on; its higher market value which is two to three times that of tilapia. However, Oguntola (2008) posited that fast growth rate; ability to survive on both natural and artificial food and environments are some of the favourable traits that makes it popular.

4.1.13Number of ponds

The result presented in Table 4.13 shows that most of the small scale fish farmers (93.4%) had between 1 – 5 ponds while the medium scale fish farmers(40%) had between 1 – 5 ponds and 6 – 10 ponds, respectively. A larger proportion of the large scale fish farmers (55.6%) had between 6 – 10 ponds. The result of the pooled sample of the fish farmers shows that majority of the fish farmers (80.9%) had between 1 – 5 number of ponds and only about 0.9% had above 15 ponds with a mean of 4 ponds suggesting that the number of ponds owned by the fish farmers in the study area is relatively low.

This result compares favourably with that of Penda *et al*. (2012) who reported that the average number of ponds of the fish farmers in Benue State was 4. The estimated coefficient of variation (CV) of the fish farmers was 107.3% and this implies that there is a very high variation in the number of ponds of the fish farmers in the study area. Although, there is a very high variation in the number of ponds of the fish farmers in the study area, this does not necessarily imply a wide variation in the pond size of the fish farmers as the result shows that the fish farmer with more than 15 fish ponds was a small scale fish farmer.

Table 4.13: Frequency distribution of the fish farmers based on number of ponds

Number of ponds	Small scale	Medium scale	Large scale	Pooled
1 – 5	85 (93.4)*	6 (40.0)	2 (22.2)	93 (80.9)
6 – 10	4 (4.4)	6 (40.0)	5 (55.6)	15 (13.0)
11 – 15	1 (1.1)	3 (20.0)	2 (22.2)	6 (5.2)
> 15	1 (1.1)	0 (33.3)	0 (0.0)	1 (0.9)
Total	91 (100)	15 (100)	9 (100)	115 (100)
Mean	2	4	7	4
Std. Dev.	2.511	6.392	15.04	4.291
CV (%)	125.5	159.8	21.4	107.3

*Values in parentheses are percentages

4.1.14Fish culture

The result of the distribution of the fish farmers based on the fish culture they practiced is presented in Table 4.14. The result shows that majority of the small scale fish farmers (87.9%), medium scale fish farmers (60%) and all the large scale fish farmers (100%) practiced monoculture. The result of the pooled sample of the fish farmers in the study area shows that majority of the fish farmers (85.2%) practiced monoculture while very few of the farmers (1.7%) practiced integrated fish culture. The result suggests that monoculture is the predominant fish culture in the study area. The predominance of monoculture in the study area could be attributed to the high consumer preference for clarias sp in the study area and therefore, the fish farmers tend to grow clarias sp. This compares favourably with Ogundari and Akinbogun (2010) who also reported similar result even though none of the farmers practiced integrated fish farming.

Table 4.14: Frequency distribution of the fish farmers based on fish culture

Fish culture	**Small scale**	**Medium scale**	**Large scale**	**Pooled**
Monoculture	80 (87.9)*	9 (60.0)	9 (100.0)	98 (85.2)
Polyculture	9 (9.9)	6 (40.0)	0 (55.6)	15 (13.0)
Integrated	2 (2.2)	0 (20.0)	0 (22.2)	2 (1.7)
Total	91 (100)	15 (100)	9 (100)	115 (100)

*Values in parentheses are percentages

4.1.15Start-up capital for fish farming

Capital is an important requirement for fish farming. The result in Table 4.15 shows that majority of the small scale fish farmers (56%) used a start-up capital of between ₦ 1000 and ₦ 200, 000. In the case of the medium scale fish farmers (53.3%) and large scale fish farmers; majority (77.8%) used a start-up capital of more than ₦ 1, 000, 000. This result is in line with *a priori* expectation as the start-up capital increases with increase in the scale of production.

The result of the pooled sample of the fish farmers in the study area shows that majority (45.2%) of the fish farmers employed a start-up capital of between₦ 1000 and ₦ 200, 000 and the smallest proportion of the fish farmers (3.5%) employed a start-up capital of between ₦ 601, 000 and₦800, 000 with a mean of ₦ 578, 045.87. This start-up capital is on the high side and hence, could be a disincentive to potential fish farmers in the study area. The estimated coefficient of variation was 195.5% and this implies that there was a very high variation in the start-up capital of the fish farmers in the study area and this is not unconnected to their varying scale of production.

Table 4.15: Frequency distribution of the fish farmers based on start-up capital

Start-up capital (₦)	Small scale	Medium scale	Large scale	Pooled
1000 – 200000	51 (56.0)*	1 (6.7)	0 (0.0)	52 (45.2)
201000– 400 000	17 (18.7)	3 (20.0)	0 (0.0)	20 (17.4)
401000 – 600000	13 (14.3)	3 (20.0)	0 (0.0)	16 (13.9)
601000 –800000	4 (4.4)	0 (0.0)	0 (0.0)	4 (3.5)
801000 – 1000000	4 (4.4)	0 (0.0)	2 (22.2)	6 (5.2)
> 1000000	2 (2.2)	8 (53.3)	7 (77.8)	17 (14.8)
Total	91 (100)	15 (100)	9 (100)	115 (100)
Mean	86350.22	395785.02	1156378.34	578045.87
Std. Dev.	82443.971	437560.663	1511422.351	1129808.074
CV (%)	95.5	110.6	130.7	195.5

*Values in parentheses are percentages

4.1.16Farmers' major source of start-up capital

The result of the distribution of the fish farmers based on their major source of start-up capital is presented on Table 4.16. The result shows that majority of the small scale fish farmers (76.9%), medium scale fish farmers (100%) and the large scale fish farmers (77.8%) obtained start-up capital from their personal savings. Although there was variation in the source of start-up capital of the pooled fish farmers in the study area, majority (80%) sourced start-up capital from their personal savings while the smallest proportion (3.5%) of the fish farmers used of start-up capital from other sources such as loans from cooperative and money lenders.

This result corroborates the finding of William *et al*. (2012) who reported that personal savings accounted for a large proportion (80%) of the source of capital to the fish farmers in Lagos State. The result of this study also shows that bank loan as a source of start-up capital was low (4.3%) and this could as a result of excessive bureaucracy in obtaining loan from the financial institutions or it could be as a result of high rate of interest which discouraged farmers.

Table 4.16: Frequency distribution of the fish farmers based on major source of start-up capital

Source of start-up capital	Small scale	Medium scale	Large scale	Pooled
Personal savings	70 (76.9)*	15 (100.0)	7 (77.8)	92 (80.0)
Bank loans	5 (5.5)	0 (0.0)	0 (0.0)	5 (4.3)
Loan from relatives/friends	12 (13.2)	0 (0.0)	2 (22.2)	14 (12.2)
Others	4 (4.4)	0 (0.0)	0 (0.0)	4 (3.5)

Total	91 (100)	15 (100)	9 (100)	115 (100)

*Values in parentheses are percentages

4.1.17Land acquisitionfor fish farming

Land is a vital resource for fish production especially for fish farmers with concrete, earthen, embankment and diversion pond types. The result presented in Table 4.17 shows that a larger proportion of the small scale fish farmers (30.8%) acquired land from their family. The medium and large scale fish farmers as indicated by 66.7% and 77.8%, respectively, acquired their land through purchase. The result of the pooled sample of the fish farmers shows that land acquisition was mainly through purchase as indicated by 37.4% of the fish farmers and the smallest proportion (4.5%) of the fish farmers in the study area acquired their land from government. This result agrees with the finding of William *et al*. (2012) who reported that a larger proportion (64%) of the fish farmers obtained their land for fish farming through purchase in a similar study. Also, Oluwemimo and Damilola (2012) had similar result.

Table 4.17: Frequency distribution of the fish farmers based on land acquisition

Land acquisition	Small scale	Medium scale	Large scale	Pooled
Purchase	26 (28.6)*	10 (66.7)	7 (77.8)	43 (37.4)
Rent	22 (24.2)	0 (0.0)	0 (0.0)	22 (19.1)
Family	28 (30.8)	2 (13.3)	0 (0.0)	30 (26.1)
Government	5 (7.7)	0 (0.0)	0 (0.0)	5 (4.3)
Inheritance	19 (20.9)	6 (40.0)	4 (44.4)	29 (25.2)

Total	93	18	11	141

NB: Multiple response allowed and hence the total responses of the farmers are above the expected total frequency of the farmers. *Values in the parentheses are percentages

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4.1.18Sources of waterfor fish farming

Fish production is highly dependent on water. The sources of water for fish production in the study area are presented in Table 4.18. The result of the distribution of the fish farmers based on their source (s) of water shows that a larger proportion of the small scale fish farmers (71.4%) and the medium scale fish farmers (73.3%) sourced water from well/borehole. In the case of the large scale fish farmers, 55.6% of them each had their source of water from well/borehole and stream. The result of the pooled sample of the fish farmers in the study area shows that majority of the fish farmers (70.4%) sourced water from well/borehole and only a small proportion (4.3%) used rain water for fish farming. The reliance on rain water by only a small proportion of the fish farmers could be attributed short duration of rainfall in the study area. This result conforms to that of Ogundari and Akinbogun (2010) who reported that borehole/shallow wells as indicated by 87% of the fish farmers in Ondo State was the major source of water.

Table 4.18: Frequency distribution of the fish farmers based on source of water

Source of water	Small scale	Medium scale	Large scale	Pooled
Well/borehole	65 (71.4)*	11 (73.3)	5 (55.6)	81 (70.4)
Stream	18 (17.8)	7 (46.7)	5 (55.6)	30 (26.1)
Rain water	5 (5.5)	0 (0.0)	0 (0.0)	5 (4.3)

Tap water	10 (11.0)	0 (0.0)	0 (0.0)	10 (8.7)
Total	98	18	10	126

NB: Multiple responses allowed and hence the total responses of the farmers are above the expected total frequency of the farmers. *Values in the parentheses are percentages

4.1.19 Fish farmers' sales point

The result presented in Table 4.19 shows that a larger proportion of the small scale fish farmers (84.6%), the medium scale fish farmers (80%) and the large scale fish farmers (77.8%) usually sell their fish at their respective pond site (farm gate). The result of the pooled sample of the fish farmers in the study area shows that most of the fish farmers (83.5%) sold their fish at the pond site.

This result implies that most of the fish farmers did not incur the cost of transportation, loading and off-loading of their fish as they mostly sell at the pond side and hence, their profit margin is not affected by the cost of transportation, loading and off-loading. Very few of the fish farmers (5.2%) had shops where they sell their fish.These fish farmers can be said to be vertically integrated as they do not only produce fish but have integrated further to own shops for selling fish thereby enhancing their scope of operation and market power.

Table 4.19: Frequency distribution of the fish farmers based on sales point

Sales point	**Small scale**	**Medium scale**	**Large scale**	**Pooled**

Pond site	77 (84.6)*	12 (80.0)	7 (77.8)	96 (83.5)
Market	4 (4.4)	0 (0.0)	3 (33.3)	7 (6.1)
Shop	3 (3.3)	0 (0.0)	3 (33.3)	6 (5.2)
Restaurant	3 (3.3)	0 (0.0)	5 (55.5)	8 (7.0)
Others	3 (3.3)	4 (26.7)	0 (0.0)	7 (6.1)
Total	104	16	18	124

NB: Multiple responses allowed and hence the total responses of the farmers are above the expected total frequency of the farmers. *Values in the parentheses are percentages

4.1.20Frequency of sales

The result of the distribution of the fish farmers based on frequency of sales is presented in Table 4.20. The result shows that a large proportion of the small scale fish farmers (48.4%), the medium scale fish farmers (40%) and the large scale fish farmers (44.4%) usually sell their fish on daily basis to their customers and this was made possible by rearing fish of different sizes in various ponds. The result of the pooled sample of the fish farmers in the study area shows that majority (47%) of the fish farmers usually sell their fish on daily basis while very few (5.2%) sell their fish on monthly basis. This result implies that although the fish farmers largely sell their fish on daily basis, there was still a variation in the frequency of sales of their fish ranging from daily to annually. The variation in the frequency of sales of the fish farmers could be attributed to the variation in the production cycle (4 – 6months) of the species of fish grown by the fish farmers in the study area.

Table 4.20: Frequency distribution of the fish farmers based on frequency of sales

Frequency of sales	Small scale	Medium scale	Large scale	Pooled

Daily	44 (48.4)*	6 (40.0)	4 (44.4)	54 (47.0)
Weekly	12 (13.2)	0 (0.0)	3 (33.3)	15 (13.0)
Fortnightly	21 (23.1)	3 (20.0)	4 (44.4)	28 (24.3)
Monthly	3 (3.3)	3 (20.0)	0 (0.0)	6 (5.2)
Quarterly	9 (99.9)	1 (6.7)	0 (0.0)	10 (8.7)
Biannually	5 (5.5)	3 (20.0)	2 (22.2)	10 (8.7)
Annually	17 (18.7)	0 (0.0)	0 (0.0)	17 (14.8)
Total	111	16	15	141

NB: Multiple responses allowed and hence the total responses of the farmers are above the expected total frequency of the farmers. *Values in the parentheses are percentages

4.2 Costs and Returns of Fish Production in the Study Area

The result presented on Table 4.21 shows the average cost and returns of fish production in the study area per production cycle. In the cost component of fish production, the cost of fingerlings constituted the largest proportion of the variable cost component for the large and small scale fish farmers with cost of fingerlings of ₦ 656, 666.67 and ₦ 197, 996.70 respectively.

This finding agrees with that of Ideba *et al*. (2013) and Adewuyi *et al*. (2010) but disagrees with Olaoye *et al*.(2013), Emokaro *et al*.(2010), and Awoyemi,(2011). The high cost incurred on fingerlings is largely due to the shortage of hatchery that produces fingerlings to meet the demand for fish farms in the study area. The high demand for fingerlings and inadequate supply results in increased price of fingerlings and consequently, justifying the

Table 4.21: Average costs and returns of fish production per production cycle

Items	Large-scale	Medium-scale	Small-scale	Pooled sample
Variable cost				
Cost of Fingerling	656,666.67	202,000.00	197,996.70	352, 2211.12
Cost of Medication	7,250.00	7,766.67	3,550.37	6,189.01
Cost of Lime	8, 310.00	1, 800.00	2,250.00	4,120.00
Cost of Fertilizer	12, 650. 00	7,166.67	3,000.00	7,605.56.00
Cost of Feeds	473,800.00	635,449.88	126,926.48	412,058.79
Cost of Labour	124,500.00	143,075.00	82, 350.02	116, 641.67
Total Variable Cost (TVC)	1,283,176.67	997, 258.22	416,073.55	898,836.15
Average cost/fingerling	86.35	127.66	154.74	122.92
Fixed cost				
Interest payment	0.00	0.00	15,000.00	5000.00
Depreciation	130, 230.00	85,295.00	27,000.00	80,841.67
Salaries	90,000.00	31,500.00	29,800.00	50,433.33
Aerators	99,000.00	32,666.67	16,666.67	49,444.45
Ponds	350,000.00	584,000.00	190,074.07	237,085.11
Pumps	199,200.00	45,000.00	38,000.00	37,4691.36
Total Fixed Cost (TFC)	868, 430.00	742, 461.67	316, 540.74	64,2477.47
Total Cost (TVC + TFC)	2,151,606.67	1,739,719.89	732, 614.29	1,541, 313.62
Returns				
Gross farm income (GI)	7,850,445.00	4,626,335.71	987,484.65	4,488,088.45
Gross margin (GI – TVC)	6,567,268.33	3,629,077.49	254,870.36	3,483,738.73
Net farm income (GM – TFC)	5, 698,838.33	2,886,615.82	539,937.35	3,041,797.17
RTI (NFI/TC)	2.65	1.66	0.35	1.97

high cost of fingerlings in the study area. For the medium scale fish farmers, the cost of feeds (₦ 635, 449.88) constituted the highest variable cost of production and this agreeswith that of Penda *et al.* (2013) who also reported that the cost of feeds accounted for a large percentage of the total cost of fish production.

The costs of medication, fertilizer and lime constituted the least of the variable costs incurred by the small, medium and large scale fish farmers respectively. For the pooled sample of fish farmers in the study area, the largest component of the variable cost of fish production was cost of feeds (₦ 412,058.79).

The least cost was cost of lime (₦4,120.00) and this agrees with the finding of Williams *et al*. (2012) and Emokaro *et al*. (2010) who also reported that the cost of liming material was the least of the variable cost incurred in fish farming in their respective studies. A total variable cost of production of ₦898,836.15 was incurred by the fish farmers. The average cost per stock was estimated to be ₦ 86.35, ₦127.66 and ₦ 154.74 for the large, medium and small scale fish farmers respectively. This indicates that as the scale of operation increases, the average cost per stock decreases and vice-versa, and therefore shows that the farming are enjoying economy of scale.

The highest fixed cost of production for the small, medium and large scale fish farmerswas incurredon construction of ponds,(₦190,074.07, ₦548, 000 350, 000 and ₦350, 000 respectively). The lowest cost incurred on fixed cost of fish production for the large scale and medium scale fish farmers were on salaries (₦ 90, 000 and ₦ 31, 500 respectively) while for the small scale fish farmers, it was on interest payment (₦ 15, 000.00). From the result of the pooled sample of the fish farmers, the highest fixed cost of production (₦237,085.11) was on construction of ponds while the lowest cost (₦5, 000.00) was on interest payment. The total cost of production of the large, medium and small scale fish farmers were₦2,151,606.67, ₦1,739,719.89and ₦732, 614.29respectively while the gross income was ₦7,850,445.00, ₦4,626,335.71and ₦987,484.65respectively giving a gross margin of ₦6,567,268.33, ₦3,629,077.49and 254,870.36respectively.

The net farm incomes were estimated to be ₦5, 698,838.33, ₦2,886,615.82and ₦539,937.35for the large, medium and small scale fish farmers respectively. The return to naira invested in fish farming by small, medium and large scale farmers were 0.35, 1.66 and 2.65 respectively. The implication of this is that a naira invested in fish farming gave a return of ₦ 0.35, ₦1.66 and ₦2.65 in small, medium and large scale fish farming respectively. This result indicates that fish farming was profitable in the large, medium and small scale though the level of profitability increases with an increase in the scale of operation. From the result of the pooled sample of fish farmers in the study area, the total cost of production was ₦1,541, 313.62while the gross farm income was ₦4,488,088.45giving a gross margin of ₦3,483,738.73, a net farm income of ₦3,041,797.17and a return to naira invested of 1.97. This implies that fish farming is a profitable farming enterprise in the study area. This result agrees with Penda *et al*. (2013) who reported that fish farming was profitable in Benue State with an average gross margin of ₦ 255,280.00 and a profit of ₦ 156,138.91

4.2.1 Test of hypothesis one of the study

The ANOVA result for testing the hypothesis which states that there is no significant difference in the Net farm income of the large scale, medium and small scale fish famers is presented in Table 4.22. The result revealsthat the calculated F value of 8.24 was statistically significant at 1% probability level. This implies that there was significant difference in the profitability of the large, medium and small scale fish farmers in the study area. Also, the average cost per stock of the three groups of fish farmers in the study area was compared and the result is presented in Table 4.23.

The result revealsthat the calculated F value of 5.82 was statistically significant at 1% probability level. This implies that as the number of stocks increases, the average cost per stock decreases suggesting that there was economies of scale in fish farming in the study area. Therefore, as the number of stock increases, the average cost of production per stock decreases.

Table 4.22: ANOVA result for determining significant difference inprofitability of the farmers

	Sum of squares	Df	Mean square	F value	Sig.
Between Groups	2.89E+10	2	1.44E+10	8.24	.000
Within groups	1.96372E+11	112	1.75E+09		
Total	2.25E+11	1114			

Table 4.23: ANOVA result for determining economies of scale in fish farming

	Sum of squares	Df	Mean square	F value	Sig.
Between Groups	98874.82	2	49437.41	5.82	.004
Within groups	951805.94	112	8498.27		
Total	1050680.76	114			

4.3 Input-output Relationship in Fish Farming in the Study Area

The maximum likelihood estimates of the Cobb-Douglas stochastic production frontier model presented in Table 4.24 shows that the major drivers of the output of the fish farmers in the study area were feed, fingerlings, stocking density and labour.

The estimated coefficient of feed (0.2102) is an indication that the quantity of feed was positively related to the output of the fish farmers and this was statistically significant at 1% probability level. This implies that one percent increase in the quantity of feeds will increase the output of the fish farmers by about 0.21 per cent *ceteris paribus*. Hence, an increase in feeds has an increasing influence on output of the fish farmers. This finding conforms to that of Hussain *et al*. (2012) who reported the feeds was positively related to output and was significant at 1% probability level.

The estimated coefficient of fingerlings (0.3299) implies that the quantity of fingerlings was positively related to the output of the fish farmers in the study area and was statistically significant at 1% probability level. This means that one percent increase in the number of fingerlings will increase the output of the fish farmers by 0.33 percent*ceteris paribus*. Therefore, the elasticity of fingerlings had an increasing influence on output of the fish farmers. This finding is consistent with Penda *et al.* (2013) who reported that the quantity of fingerlings was positively related to output of fish farming in Benue State and was significant at 10% probability level.

Table 4.24: Maximum likelihood estimates of the stochastic frontier production function

Variable	Coefficient	Standard error	T value
Production model			
Constant	5.0866	0.5249	9.69
Feeds	0.2102***	0.0613	3.43
Fingerlings	0.3295***	0.0728	4.53
Stocking density	0.3369***	0.1018	3.31
Labour	-0.1795***	0.0673	2.67
Inefficiency model			
Constant	-1.3378	1.7514	-0.76
Age	0.0815*	0.0441	1.84
Education	-0.3014**	0.1187	-2.54
Household size	0.0102	0.2535	0.04
Farm experience	0.1197	0.0812	1.47
Credit	0.3463	0.5783	0.60
Extension	0.1025	0.8074	0.13
Variance parameters			
Sigma squared	0.7595***	0.2159	3.52
Gamma	0.7161***	0.2015	3.55
Lamda	1.4415***	0.2867	5.03
Log likelihood	-99.118		

NB: *** P<0.01, **P<0.05, P<0.1

The estimated coefficient of stocking density (0.3369) implies that this variable was positively related to output and was statistically significant at 1% probability level. This suggests that one percent increase in the number of fish/m^2(stocking density) will increase their output by 0.34 percent*ceteris paribus*. Hence, stocking density had an increasing influence on output of the fish farmers. This finding is in line with Hussain *et al*. (2012) who reported that stocking density was positively related to the output of fish farmers in Lagos State but was however not significant.

The estimated coefficient of labour (-0.1795) is an indication that the quantity of labour was inversely related to the output of the fish farmers and was statistically significant at 1% probability level. This suggests that one percent increase in the quantity of labour will decrease the output of the fish farmers by 0.18 percent *ceteris paribus*. Hence, labour had decreasing influence on output of the fish farmers.

This result is in line with Tsue *etal*. (2013) who reported that the elasticity of labour use (-0.11) with respect to catfish output has decreasing influence on the quantity of catfish produced in a similar study but disagrees with Ekunwe and Emokaro (2009) who reported that labour was positively related to output. This result could be attributed to the incidence of over utilization of labour in fish farming in the study area and hence, there is the need for the farmers to ensure efficient labour utilization which could be achieved through the use of labour saving devices.

4.3.1 Return to scale of fish farming in the study area

The elasticities of frontier output with respect to feeds, fingerlings, stocking density, and labour of the fish farmers were estimated at the means of the input variables to be 0.1478, 0.2102, 0.3295, 0.3396 and -0.1795 respectively as shown in Table 4.25. The sum of elasticities of the coefficients, which is a measure of return to scale in fish production, was less than unity (0.6971) indicating a positive decreasing return to scale. Thus, the fish farmers were in stage II of production which is considered to be the rational stage of production. This implies that an increase in quantity of all inputs employed in the production of fish will result in less than proportionate increase in quantity of fish output produced. Thus, fish farmers in the study area can expand their production through additional use of inputs. This result is in agreement with the works of Ogundari *et al*. (2006), Emokaro and Ekunwe (2009) and Tsue *et al*. (2013) who reported a return to scale of 0.81, 0.66 and 0.96 in a study of aquaculture in Oyo State, Nigeria, catfish farmers in Kaduna State, Nigeria and catfish farmers in Benue State, Nigeria respectively.

Table 4.25: Return to scale in fish farming

Variables	Elasticities
Feeds	0.2102
Fingerlings	0.3295
Stocking density	0.3369
Labour	-0.1795
Return to scale (RTS)	**0.6971**

4.4 Technical Efficiency of Fish Farmers operating at various Scales

The result of the frequency distribution of the technical efficiency of the fish farmers presented in Table 4.26 shows that 57% of the pooled fish farmers in the study had technical efficiency of between 61% and 80% while the least (4.35%) had technical efficiency of more than 60% and less than 5% had technical efficiency ranging from 0.01 – 0.2. This implies that although all the fish farmers were yet to attain frontier output, a good number of them (65) were relatively efficient. The mean technical efficiency of the large, medium and small scale fish farmers were 97%, 78% and 57% respectively as shown in Table 4.27. This result implies that the large, medium and small scale have opportunities of improving their technical efficiencies in the short run by 3%, 12% and 43% respectively through efficient utilization of their available resources.

The result also reveals that the medium scale fish farmers had a higher standard deviation (0.2294) and this implies that there was higher variation in the technical efficiency of the medium scale fish farmers compared to the large and small scale fish farmers. For the pooled sample of the fish farmers in the study area, the mean technical efficiency was 63% and this implies that the fish farmers have a scope of improving on their current level of technical efficiency by 37% through efficient utilization of their available resources. The mean technical efficiency of 63% in the study area was below the mean technical efficiency of 83% reported by Ekunwe and Emokaro (2009) in the same study area.

Table 4:26: Frequency distribution of the technical efficiency of the fish farmers

Technical efficiency	Frequency	Percentage
0.01 – 0.20	5	4.35
0.21 – 0.40	20	17.39
0.41 – 0.60	25	21.74
0.61 – 0.80	34	29.57
0.81 – 1.00	31	26.96
Total	115	100.00

Table 4:27: Technical efficiency of the fish farmers at various scales of operation

Scale	Mean Technical Efficiency	Standard deviation
Small scale	0.5659	0.2064
Medium scale	0.7779	0.2294
Large Scale	0.9727	0.0204
Pooled	0.6294	0.2372

4.4.1 Test of hypothesis two of the study

The ANOVA result presented on Table 4.28 shows that the calculated F value of 21.11 was statistically significant at 1% probability level. This implies that there was significant difference between the technical efficiency of the large, medium and small scale fish farmers in the study area. Hence, the null hypothesis of no significant difference between the technical efficiency of the large, medium and small scale fish farmers in the study area is rejected and the alternative is accepted.

Table 4.28: ANOVA result of the comparison of technical efficiency of the scale of production of the fish farmers

	Sum of squares	Df	Mean square	F value	Sig.
Between Groups	1.8688	2	0.9344	21.11	.000
Within groups	4.4877	112	0.0404		
Total	6.3566	114			

4.5 Factors Influencing Technical Efficiency of Fish Farming

The results of the maximum likelihood estimates of the Cobb-Douglas stochastic frontier production function reveals the presence of technical inefficiency among fish farmers in the study area. This means that the traditional frontier model estimated with ordinary least square, (which is estimated without the inefficiency effects), is not the adequate representation of the data, hence Cobb-Douglas stochastic frontier model which described farm specific inefficiency effects fits this data better. Furthermore, gamma (γ) estimate of this model (0.7161) was statistically significant at 1% probability level. This implies that the one-sided random inefficiency component strongly dominates the measurement error and other random disturbance indicating that about 72% variation in actual output from maximum output (production frontier) between farms mainly arose from differences in farmers' practices and management rather than random variability. The estimated sigma squared for the fish farmers (0.7595) was statistically significant at 1% probability level. This indicates a good fit and the correctness of the specified distributional assumption of the composite error terms in the estimated model.

The estimated lambda (λ) shows the relationship between the variance of (u_i) and (v_i). Ogundari and Akinbogun (2010) noted that a value larger than one suggests that the variation in (u_i) is more pronounced than the variation in the random component (v_i). Hence, the estimated lambda (1.44) implies that the technical efficiency differences among the fish farmers were responsible for the variation of fish production efficiency in the study area.

Age had an estimated coefficient of 0.0815 and this implies that the age of the fish farmers was positively related to the technical inefficiency of the fish farmers in the study area and was statistically significant at 10% probability level. This means that a unit increase in the age of the fish farmers will increase their technical inefficiency by a magnitude of 0.0815. Therefore, the older the fish farmers, the lower their technical efficiency and this could be attributed to the inability of the fish farmers to be fully involve in the day to day farming activities of their farms as they grow old and hence, their farms tend to be less efficient than it ought to be, if they were to be much younger and well involved in the operations of their farms.

The estimated coefficient of education (-0.3014) indicates that the educational status of the fish farmers was negatively related to the technical inefficiency of the fish farmers in the study area in line with *a priori* expectation and was statistically significant at 5% probability level. This implies that a unit increase in the education of the fish farmers will decrease their technical inefficiency by a magnitude of 0.3014. Therefore, the more educated the fish farmers, the lower their technical inefficiency and this also implies that education enhances the technical efficiency of the fish farmers. This is because the more educated the fish farmers, the better will be their managerial ability in handling the operations of their fish farms and also, education enhances their ability to acquire technical knowledge with respect to adoption of technologies geared towards increasing their efficiency. Therefore, the educational level of the fish farmers can be exploited as an important policy variable towards enhancing the technical efficiency of fish farms in the study area.

The estimated coefficient of household size was 0.0815 and this implies that the household size of the fish farmers was positively related to the technical inefficiency of the fish farmers in the study area but was not statistically significant. This finding is in line with that of Penda *et al*. (2013) and Hussain *et al*. (2012) who also reported similar results.

Farming experience had an estimated coefficient of 0.1197 and this implies that the farming experience of the fish farmers was positively related to the technical inefficiency of the fish farmers in the study area but was not statistically significant. This result is in line with that of Tsue *et al*. (2013) who reported that the coefficient of farming experience (0.68) was positive but not significant in influencing the technical efficiency of catfish farmers in Benue State.

The estimated coefficient of credit was 0.3463and this implies that the amount of credit obtained by the fish farmers was positively related to the technical inefficiency of the fish farmers in the study area but was not statistically significant.

Extension had an estimated coefficient of 0.1025 and this implies that the number of extension contacts of the fish farmers was positively related to the technical inefficiency of the fish farmers in the study area but was not statistically significant.

4.6 Constraints Limiting Efficiency of the Fish Farmers in the Study Area

The constraints limiting the efficiency of fish farming as indicated by the small, medium, large and pooled sample of the fish farmers in the study area are presented in Tables 4.29, 4.30, 4.31 and 4.32,respectively. The result in Table 4.29 reveals that the most severe problem limiting the efficiency of the small scale fish farmers in the study area was the problem of pilferage as indicated by about 84% of the small scale fish farmers. This was followed by the problem of flooding (82.4%) and insecurity (79.1%). For the medium scale fish farmers, the most severe problem limiting their efficiency was insecurity (66.7%). This was jointly followed by flooding and pilferage as indicated by 53.3% of the medium scale fish farmers. For the large scale fish farmers, flooding, insecurity and pilferage were indicated by all the large scale fish farmers as very severe problems limiting their efficiency in fish farming.

The result for the pooled sample of the fish farmers on Table 4.32 shows that pilferage was the most severe problem of the pooled sample of the fish farmers in the study area as indicated by about 81% of the fish farmer. This was followed by flooding (80%) and insecurity (79.1%). This result clearly shows that pilferage, flooding and insecurity were the major constraints limiting the efficiency of the fish farmers in the study area. The problem of insecurity of fish farms was also reported by Williams *et al*. (2012) as one of the major constraints encountered in fish farming in a similar study. The problem of disease was reported by Agboola (2012) and Kudi *et al*. (2008) as one of the major constraints encountered in fish farming by fish farmers in Osun and Kaduna States, respectively. The problem of theft/pilfering was reported by Adebayo (2013) and Adewumi *et al*. (2012) as one of the major constraints encountered in fish farming by fish farmers in Ibadan metropolis and Kwara State, respectively.

Table 4.29: Constraints limiting efficiency of the small scale fish farmers in the study area

Problems	**Rating of problems**			
	Very severe Freq (%)	**Severe Freq (%)**	**Not severe Freq (%)**	**No such problem Freq (%)**
Mortality	23 (25.3)*	42 (46.2)	5 (5.5)	6 (6.6)
Stunted growth	42 (46.2)	34 (37.4)	3 (3.3)	7 (7.7)
Cannibalism	35 (38.5)	37 (40.7)	3 (3.3)	6 (6.6)
Flooding	75 (82.4)	3 (3.3)	0 (0.0)	1 (1.1)
Security	72 (79.1)	2 (2.2)	5 (5.5)	2 (2.2)

Pilferage	76 (83.5)	6 (6.6)	0 (0.0)	0 (0.0)
Infection/diseases	34 (37.4)	45 (49.5)	3 (3.3)	4 (4.4)

*Values in the parentheses are percentages

Table 4.30: Constraints limiting efficiency the medium scale fish farmers in fish farming

Problems	**Rating of problems**			
	Very severe Freq (%)	**Severe Freq (%)**	**Not severe Freq (%)**	**No such problem Freq (%)**
Mortality	3(20)*	7 (46.7)	4 (26.7)	0 (0.0)
Stunted growth	3 (20)	4 (26.7)	4 (26.7)	3 (20)
Cannibalism	3(20)	5 (33.3)	3 (20)	1 (6.7)
Flooding	8 (53.3)	0 (0.0)	2 (13.3)	1 (6.7)
Insecurity	10 (66.7)	0 (0.0)	0 (0.0)	1 (6.7)
Pilferage	8 (53.3)	3 (20)	0 (0.0)	1 (6.7)
Infection/diseases	6 (40)	5 (33.3)	0 (0.0)	1 (6.7)

*Values in the parentheses are percentages

Table 4.31: Constraints limiting efficiency of the large scale fish farmers in the study area

Problems	**Rating of problems**			
	Very severe Freq (%)	**Severe Freq (%)**	**Not severe Freq (%)**	**No such problem Freq (%)**
Mortality	2 (22.2)*	7 (77.8)	0 (0.0)	0 (0.0)
Stunted growth	4 (44.4)	5 (55.6)	0 (0.0)	0 (0.0)
Cannibalism	0 (0.0)	9 (100)	0 (0.0)	0 (0.0)

Flooding	9 (100)	0 (0.0)	0 (0.0)	0 (0.0)
Insecurity	9 (100)	0 (0.0)	0 (0.0)	0 (0.0)
Pilferage	9 (100)	0 (0.0)	0 (0.0)	0 (0.0)
Infection/diseases	4 (44.4)	2 (22.2)	0 (0.0)	0 (0.0)

*Values in the parentheses are percentages

Table 4.32: Constraints limiting efficiency of the pooled sample of fish farmers in the study area

Problems	**Rating of problems**			
	Very severe Freq (%)	**Severe Freq (%)**	**Not severe Freq (%)**	**No such problem Freq (%)**
Mortality	37 (32.2)*	56 (48.7)	9 (7.8)	6 (5.2)
Stunted growth	49 (42.6)	43 (37.4)	7 (6.1)	10 (8.7)
Cannibalism	38 (33.0)	51 (44.3)	6 (5.2)	7 (6.1)
Flooding	92 (80.0)	3 (2.6)	2 (1.7)	2 (1.7)
Insecurity	91 (79.1)	2 (1.7)	5 (4.3)	3 (2.6)
Pilferage	93 (80.9)	7 (6.1)	0 (0.0)	1 (0.9)
Infection/diseases	44 (38.3)	52 (45.2)	3 (2.6)	5 (4.3)

*Values in the parentheses are percentages

CHAPTER FIVE

SUMMARY, CONCLUSION AND RECOMMENDATIONS

5.1 Summary

This research was carried out to analyze the production efficiency and profitability of fish farmers operating at various scales of production in selected Local Government Areas of Kaduna State, Nigeria. The specific objectives were to describe socio-economic characteristics of fish farmers in the study area, determine the profitability of fish farming, determine the technical relationship between production inputs and output in fish farming, quantify technical efficiency of fish farmers operating at various scales of operation, identify factors influencing technical efficiency of fish farming and describe the socio-economic and technical constraints limiting efficiency of the existing fish farming in the study area.

A pilot survey of existing fish farms was conducted in Kaduna State in 2008 and this formed the basis for the sampling frame employed in the study. A total of 115 fish farms were identified in 18 out of the 23 Local Government Areas of the State. All the fish farmers identified during the pilot survey constituted the sample size of the study. The data employed in the study were collected from fish farmers in the study area with the aid of structured questionnaire. The fish farms were further classified according to scale of operation. The scale was generated from the number of fingerlings; 1 – 5000 = small scale, 5001 – 10,000 = medium scale and > 10,000 = large scale. Various analytical techniques were used for this study to achieve the various objectives. The tools of analysis employed in the study were descriptive statistics, farm budgeting technique, stochastic frontier production function and ANOVA.

The pooled result of the fish farmers in the study area shows that 42.6% representing the largest proportion of the fish farmers were within the 40 – 49 years age bracket with a mean age of 49 years. This implies that the fish farmers were within their economically productive age bracket and hence, can be very much involved in the day to day activities of their fish farms. Majority of the small scale fish farmers were males (64.8%), all the medium scale fish farmers were males and also, for the large scale fish farmers, a large proportion (77.8%) were males. This result implies that fish farming in the study area is a male dominated farming enterprise as about 70% of the pooled fish farmers were males. Majority, 74.8% of the fish farmers had between 1 – 5 years of farming experience with a mean of 4 years. Majority of the fish farmers (68.7%) had no formal training on fish production.

The study also revealed that majority of the fish farmers (82.6%) did not belong to any farmers' association and hence, the benefits of being members of farmers association must have eluded them. A relatively large proportion (52.2%) of the fish farmers in the study area had access to extension. It was also observed that majority of the fish farmers

(56.5%) were into fish farming for the purpose of earning income. Majority of the fish farmers (54.8%) made use of the concrete pond type with pond number ranging from 1 – 5 as indicated by 80.9% of the farmers. About 85.2% of the farmers practiced monoculture. Majority (45.2%) of the fish farmers employed a start-up capital of between ₦ 1000 – 200, 000 and few number of the fish farmers (3.5%) employed a start-up capital of between ₦ 601, 000 – 800, 000 with a mean of ₦ 578, 045.87.

The total cost of production of the large, medium and small scale fish farmers were₦2,151,606.67, ₦1,739,719.89and ₦732, 614.29,respectively,while the gross income were₦7,850,445.00, ₦4,626,335.71and ₦987,484.65, respectively,giving a gross margin of ₦6, 567, 268.33, ₦3,629,077.49and ₦254,870.36,respectively. The net farm incomes were estimated to be ₦5, 698,838.33, ₦2,886,615.82and ₦539,937.35for the large, medium and small scale fish farmers, respectively. The return to naira invested in fish farming by small, medium and large scale farmers were 0.35, 1.66 and 2.65, respectively.

The estimated coefficient of feeds (0.2102), fingerlings (0.3299) and stocking density (0.3369) indicates that feeds, fingerlings and stocking density were positively related to the output of the fish farmers and significant at 1% probability level. This implies that a unit increase in the quantity of feeds would increase the output of the fish farmers by 0.21%, 0.33%, and 0.34% respectively. The estimated coefficient of labour (-0.1795) implies that the quantity of labour was inversely related to the output of the fish farmers and was statistically significant at 1% probability level. This suggests that a percent increase in the quantity of labour would decrease the output of the fish farmers by 0.18 percent. The sum of elasticities of the coefficients, which is a measure of return to scale in fish production, was less than unity (0.6971) indicating a positive decreasing return to scale and hence, the fish farmers were in stage II which is considered to be the rational stage of production.

The mean technical efficiency of the large, medium and small scale fish farmers were 97%, 78% and 57% respectively. This result implies that the large, medium and small scale farms had opportunities of improving their technical efficiencies in the short run by 3%, 12% and 43%, respectively, through efficient utilization of their available resources. For the pooled sample of the fish farmers in the study area, the mean technical efficiency was 63% and this implies that the fish farmers have a scope of improving on their current level of technical efficiency by 37% through efficient utilization of their available resources.

The results of the maximum likelihood estimates of the Cobb-Douglas stochastic frontier production function revealed the presence of technical inefficiency among fish farmers in the study area. Age had an estimated coefficient of 0.0815 and this implies that the age of the fish farmers was positively related to the technical inefficiency of the fish farmers in the study area and was statistically significant at 10% probability level. This means that a unit increase in the age of the fish farmers will increase their technical inefficiency by a magnitude of 0.0815. The estimated coefficient of education (-0.3014) indicates that the educational status of the fish farmers was negatively related to the technical inefficiency of the fish farmers in the study area in line with *a priori* expectation and was statistically significant at 5% probability level. This implies that a unit increase in the education of the fish farmers will increase their technical inefficiency by a magnitude of 0.3014.

Household size, farming experience, credit and extension were not significant in influencing the technical efficiency of the fish farmers in the study area.

The constraints limiting the efficiency of existing fish farms in the study area were mortality, stunted growth, cannibalism, flooding, security, pilferage and infection/diseases. The result revealed that the most severe problem limiting the efficiency of the small scale fish farmers in the study area was the problem of pilferage as indicated by about 84% of the small scale fish farmers. This was followed by the problem of flooding (82.4%) and insecurity (79.1%). For the medium scale fish farmers, the most severe problem limiting their efficiency was insecurity (66.7%). This was jointly followed by flooding and pilferage as indicated by 53.3% of the medium scale fish farmers. For the large scale fish farmers, flooding, insecurity and pilferage were indicated by all the large scale fish farmers as very severe problems limiting their efficiency in fish farming.

5.2 Conclusion

Based on the findings of the study, it can be concluded that fish farming is profitable at various scales of production and can be a major source of income for both full and part-time fish farmers in view of the wide demand-supply gap for fish in the study area and Nigeria at large. This implies that vast opportunities exist in fish farming for employment especially for the teeming unemployed youths in the study area. Given the current level of technology at the disposal of the fish farmers, they have a scope of improving on their current level of technical efficiency by 37% through efficient utilization of their available resources and also, addressing the issues of pilferage, flooding and insecurity which were the major constraints limiting the efficiency of the fish farmers in the study area.

5.3 Recommendations

In the light of the findings of the study, the following recommendations are made:

i. The study has shown that majority (82.6%) of the fish farmers did not belong to any association/cooperative. In the light of this, it is recommended that fish farmers in the study area should be encouraged to join farmers association especially fish farmers association so as to enable them pool their resources in order to have access to fisheries inputs and knowledge on improved fish farming practices. This is very important as membership of cooperatives aids the adoption of improved fisheries technologies towards enhancing efficiency of fish farmers.

ii. The result of the study has shown that fish farming in the study area is highly male dominated. In the light of this, it is recommended that females should be encouraged to engage in fish farming in the study area as a means of generating income and improving their standard of living.

iii. Although the fish farmers in the study were largely educated, there is the need to improve on the technical know-how of the fish farmers through seminars and workshops as they are yet to attain frontier level. This is necessary especially for those fish farmers who were not originally trained as fish farmers.

iv. In order to further enhance the profitability of fish farming in the study area, efforts should be made to bring down the cost of feeds which accounted for a larger proportion of the total variable cost of fish production in the study area.

This can be done, by exploring alternative sources of feeds and this could be achieved through well-funded researches on fishery nutrition.

v. Given the level of profit that accrues to fish farmers in the study area and the existing production potential in view of the demand-supply gap for fish, unemployed youths should be encouraged to take up fish farming as a means of livelihood. This will invariably reduce the incidence of social vices by youths in the study area.

5.4 Contributions of the study to knowledge

i. Fish farming is profitable at various scale of production in the study area as the net farm incomes were estimated to be ₦5, 698,838.33, ₦2,886,615.82and ₦539,937.35for the large (9 farmers), medium (15 farmers) and small scale (91 farmers)fish farmers respectively with return to naira invested of 0.35, 1.66 and 2.65 respectively. However, large scale fish farming was established to be more profitable among the three groups.

ii. There is the existence of economies of scale in fish farming in the study area as the average cost per stock was 86.35, 127.66 and 154.74 for the large, medium and small scale fish farmers respectively and the difference was statistically significant at 1% probability level.Therefore, as the number of stock increases, the cost of production decreases thereby increasing profitability.

iii. The mean technical efficiency of the large, medium and small scale fish farmers were 97%, 78% and 57%, respectively,and this result implies they have opportunities of improving their technical efficiencies in the short run by 3%, 12% and 43% respectively through efficient utilization of their available resources.

iv. The return to scale in fish farming was less than unity (0.6971) indicating a positive decreasing return to scale. Thus, the fish farmers were in stage II of production which is considered to be the rational stage of production. This implies that an increase in quantity of all inputs employed in the production of fish will result in less than proportionate increase in quantity of fish output produced.

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APPENDICES

QUESTIONNAIRE

COMPARATIVE SCALE EFFICIENCY AND PROFITABILITY OF FISH FARMING IN SELECTED LOCAL GOVERNMENT AREAS OF KADUNA STATE, NIGERIA

A. BACKGROUND INFORMATION

CODE	
Date	
Local Government Area	
Location/name	

B. SOCIOECONOMIC CHARACTERISTICS OF FISH FARMER

1) Age: …………………………………………………………………………..

2) Gender: ………………………………………………………………………………

3) Marital status:

i. Married ( ) ii. Single ( ) iii. Divorced ( ) iv. Widowed ( ) **v.** Separated ( )

4) Primary occupation: ………………………………………………………………

5) Secondary occupations: ………………………………………………………….

6) Household size: …………………………………………………………………

7) Educational status:

i. No formal education ( )
ii. Koranic education ( )
iii. Primary education ( )
iv. Secondary education ( )
v. Post secondary education ( )
vi. University education ( )
vii. Vocational Education ( )

C. EXPERIENCE IN FISH FARMING:

1) How many years of experience do you have in fish farming:

………………………………………………………………………………………

.

2) Do you have any formal training in fish farming? Yes ( ) or No ( )

3) If yes, please give details:

Type of training	**Organizers of training**	**Date/period**	**Benefits of the training**

4) Are you a member of any fish farming association: Yes ( ) or No ( )

5) If yes, give the name(s):

……………………………………………………………………………………………

……

6) If no, why not? ....

D. OBJECTIVES OF FISH FARMING:

Why do you engage in fish farming? Please tick as appropriate:

a. For profit ( )
b. To supplement income ( )
c. For recreation/hobby ( )
d. To generate employment ( )
e. For food/protein supplement ( )
f. For research ( )
g. For conservation ( )
h. Other reason(s) (please specify):
i. ……………………………………………………………………….

E. INITIAL CAPITAL:

1) Please give details of how much capital you started with :

Amount	**Source(select from a to f below)**	**Year**	**No of ponds**	**Total stock**

a. Personal savings ( )

b. Bank loan ( )

c. Cooperative loan ( )

d. Governmental agency loan ( )

e. Loan from relatives/friends ( )

f. Other sources (specify)

2) If you started with borrowed funds, have you paid back? Yes ( ) No ( )

3) Please give summary of loan repayment, if applicable:

Amount borrowed	Repayment Year 1	Repayment Year 2	Repayment Year 3	Repayment Year 4	Repayment Year 5

F. OWNERSHIP OF LAND:

How did you acquire the land?

1) Purchase ( )
2) Rent ( )
3) Family ( )
4) Government ( )
5) Inheritance ( )
6) Communal/ cooperative ( )
7) Others (specify)…………………………………………………………

G. FISH CULTURE PRACTICES

Please indicate the fish culture that you practice:

Type	Number of ponds
a. Monoculture[1]	
b. Polyculture[2]	
c. Integrated[3]	

H. WATER/POND MANAGEMENT

What techniques do you use in water/pond management?

(1) Source(s) of Water

i. Well/borehole ( )

ii. Stream/tidal water ( )

iii. Rain water ( )

iv. Tap water ( )

v. Others (specify) ……………………………………………………….

(2) Water/pond Treatment

i. Liming ……………………………………………………………….

ii. Fertilizing:

a. Organic ……………………………………………………….

b. Inorganic ……………………………………………………….

[1]Practice of culturing only one specie of fish in one or more pond units.
[2]Practice of culturing more than one species of fish in the same pond unit
[3]Involves rearing fish with other animals or vegetable gardening

iii. Monitoring of water quality (frequency) ……………………….

iv. Other activities (specify) ……………………………………………

(3) Pond Draining Method:

Method	*frequency*
i. Stagnant Pond System (SPS)	………………………………….
ii. Flow through system (FTS)	………………………………….
iii. Semi Flow through System (SFTS)	………………………………….
iv. Water Re-circulatory System (WRS)	………………………………….

v. Others (specify) ……………………………………………………………

(4) Other pond management practices (purpose, materials used, etc):

i. Fencing………………………………………………………………

ii. Shading………………………………………………………………

iii. Control of weeds

………………………………………………………………..

iv. Lightening…………………………………………………………..

v. Others (specify)…………………………………………………………

I. SALES

What are your sales strategies?

1. Frequency of sales

i. Daily ( )

ii. Weekly ( )

iii. Fortnightly ( )

iv. Monthly ( )

v. Quarterly ( )

vi. Biannually ( )

vii. Annually ( )

2. Period of sales

i. Seasonal ( )

ii. Cyclical ( )

3. Point of sales

i. Farm gate/pond side ( )

ii. Market ( )

iii. Shop ( )

iv. Restaurant ( )

v. Others (specify): ………………………………………………………………

1. Buyers

i. Consumer ( )

ii. Middleman/dealer ( )

iii. Processor ( )

iv. Others (specify) ………………………………………………………………

2. Problems

What are the problems that you encounter in selling your fish?

………………………………………………………………………………………

………………………………………………………………………………………

J. PROCESSING ACTIVITIES

What kinds of processing activities do you engage in?

Type of Activity	*Quantity of fish processed*	*Cost of Material used ₦/kg of fish*	*Additional cost ₦/kg of fish*	*Value added* ₦
Smoking				
Freezing				
Filleting				
Grilling				
Packaging				
Others (specify) ……				

K. EXTENSION SERVICES

1. Do you employ the services of a consultant? Yes ( ) No ( )
2. If yes, what is the designation of your consultant?
   i. veterinary doctor ( )
   ii. animal scientist ( )
   iii. Others, specify……………………………………………….
3. How often does your consultant visit your farm?
   i. Weekly ( )
   ii. Monthly ( )
   iii. Bi- monthly ( )
   iv. Others, specify………………………………………………
4. What kind of services does your consultant render to your farm?

……………………………………………………………………………….

5. .Where do you get your drugs? ……………………………………………….

6. Who recommends them……………………………………………………….

7. Have you noticed any positive change since the consultant started visiting your farm ……………………………………………………………………….

8. If yes, what kind of change? ....

9. How much does he/she charge you for services rendered…………………….. ..

10. Do you have access to public extension services? Yes ( ) No ( )

11. If yes, please state the public agency……………………………………………..

12. Please give details of the services you benefit

…………………………………………………………………………………….

L. PROBLEMS

1) Do you encounter problems do you encounter on you fish farm? Please rank them below:

Nature of problem	*Rating of the problem*			
	Very Severe	*Severe*	*Not severe*	*No such problem*
Mortality				
Stunted growth				
Cannibalism				
Flooding				
Security				
Pilferage				
Infection/diseases				

Others (specify)……..				

4. Suggest possible solutions to these problems:

   ……………………………………………………………………………………

   ……………………………………………………………………………………

   ……………………………………………………………………………………

   ……………………………………………………………………………………

   ……………………………………………………………….

M. TYPES OF FISH PONDS

What types of fish pond do you have? Please give the details below:

Types of ponds	*Number of ponds*	*Stock of fish*
a. Concrete pond		
b. Embankment pond		
c. Earthen pond		
d. Diversion pond		
e. Plastic pond		
f. Tarpaulin pond		
g. Others (specify)		
h. TOTAL		

N. TYPE AND QUANTITY OF FISH SPECIES

What are the types and quantities of fish species in your farm?

Type/specie	*Quantity*
a. Clarias	
b. Tilapia	
c. Mud cat-fish	
d. Common Carp	
e. Spotted cat-fish	
f. Grey cat fish	
g. African carp	
h. Hetro-branchus	
i. Others, (specify)………………………	

O. STOCKING (INPUT):

Pond/type	Size Dimension m^3	Species	Date of stocking	Age at stocking time* **(wks)**	Source of stock	Quantity	Unit cost ₦/fish	Average water level maintained
1								
2								
3								
4								
5								
6								
7								
8								
9								

10								
11								
12								
13								
14								
15								
Total								

*fryers = day old; advanced fryers = 2 wks old; fingerlings = 4 wks old; post fingerlings = 6 wks old; juveniles = 8 wks old; jumbo = above 8 wks

P. STOCKING DENSITY:

Pond no	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Stocking density															

Q. FEEDING PRACTICES:

Feed type	Brands	Sources	Total quantities used/kg	Average price/kg	Feeding frequency/day
Floating					
Pelleted sinking					
Compounded Powder					
Fowl droppings					
Agric bye products					

Animal offal					
Food product waste					
Kitchen waste					
Growth hormones/feed boosters					
Others (specify) …………					

R. SOURCES OF STOCK AND FEEDS

Please comment freely on the reliability of the source(s) of your stock and feeds………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………………………………………………………………………………………

……………

S. FIXED COSTS OF PRODUCTION:

What is your fixed cost of production?

Type	Quantity	Unit price (₦)	Total cost (₦)
a. Ponds			
b. Pumps			
c. Vehicles			
d. Aerators			
e. Salaries			
f. Depreciation			
g. Interest payment			
h. Others (specify)…………………			

T. OPERATING COST:

Type	Unit price (₦)	Quantity	Total
a. Labour			
I Hired labour			
ii. Family labour			
b. Juveniles/Fingerlings			
i. Tilapia			
ii. Clarias			
iii. Others (Pls specify): …………………………			

c. Feeds			
d. Fertilizer			
e. Lime			
f. Medication			
g. Others			

U. HARVESTING (OUTPUT):

Pond/type	Specie	Date of harvest	Age at harvest (months)	Quantity	Average wt (kg)	Total wt (kg)	Average price ₦/kg	Value ₦
1								
2								
3								
4								
5								
6								

7								
8								
9								
10								
11								
12								
13								
14								
15								
TOTAL								

V. HARVESTING STRATEGY

Strategy	Quantity	Percentage
Complete		
Staggered		
Other strategies (specify): …………………………………..		

SECTION TWO (*Please fill for each pond on your farm)*

1) Farm ID no……………………………….Pond no……………………………..

2) Type of pond………………………………………………………………………

3) Size/Dimension in M^2……………………………………………………………

4) Quantity of stock:

Type/specie	*Quantity*
Tilapia	
Mud cat-fish	
Common Carp	
Spotted cat-fish	
Grey cat fish	
African carp	
Hetro-branchus	
Others, (specify)………………………	

5) Average water level maintained (in meters): ………………………………..

6) Stocking density: …………………………………………………………

7) Date of stocking: ……………………………………………………………

8) Age at time of stocking: ……………………………………………………

9) Source of stock…………………………………………………………………

10) Reliability……………………………………………………………………..

**fryers = day old; advanced fryers = 2 wks old; fingerlings = 4 wks old; post fingerlings = 6 wks old; juveniles = 8 wks old; jumbo = above 8 wks*

11) Feeding Practices/medications:

Feed type/brand	*Brands*	*Sources*	*Total quantities used/kg*	*Average price/kg*	*Feeding freq/day*
Floating					
Pelleted sinking					
Compounded					

Powder					
Fowl droppings					
Agric bye products					
Animal offal					
Food product waste					
Kitchen waste					
Product enhancing Inputs:					
Medications:					
Others (specify)					

12) Operating cost:

Type	*Unit price(N)*	*Quantity*	*Total*
h. Labour			
I Hired labour			
iii. Family labour			

i. Seed/Fingerlings			
ii. Tilapia			
iv. Clarias			
v. Others (Pls specify): …………………………			
j. Feeds			
k. Fertilizer			
l. Lime			
m. Medication			
n. Others (specify)…………………			

13) Date of harvest: ………………………………………………………………………

14) Season: ……………………………………………………………………………..

15) Age at harvest: ………………………………………………………………………

16) Summary of output:

Specie(s)	*Qty*	*Average wt/kg*	*Price ₦/kg*	*Value*	*Remarks*

TOTAL					

17) Harvesting Strategy:

Strategy	*Quantity*	*Percentage*
Complete		
Staggered		
Seasonal + complete		
Seasonal + staggered		
Cyclical + complete		
Cyclical + staggered		
Others (specify): ……………		

CROSS SECTION OF FISH FARMS SURVEYED


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